



Contents lists available at <http://qu.edu.iq>

Al-Qadisiyah Journal for Engineering Sciences

Journal homepage: <http://qu.edu.iq/journaleng/index.php/JQES>



Criteria and indicators affecting the most appropriate reuse of heritage buildings in old cities: Mosul old city as a case study

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ARTICLE INFO

Article history:

Received 00 January 0000

Received in revised form 00 February 0000

Accepted 00 May 0000

Keywords:

Conservation
Built heritage Management
Reuse
Most appropriate reuse
Heritage buildings
Mosul Old City

ABSTRACT

For the protection of historic city identity and providing a sustainable benefit to its buildings, the strategy of conserving heritage buildings in old cities through their reuse is complex and crucial. It requires modifying the building while changing its function. The most appropriate mechanism for reuse is the most widely used mechanism for preserving and enhancing the values of heritage buildings. To extend the physical and functional life of heritage buildings and avoid the damage that may be caused as a result of wrong decisions, this study assists decision-makers in making the best decision more accurately, quickly, and effectively to reuse heritage buildings. Due to the lack of knowledge of the criteria and indicators that affect the most appropriate reuse process on a large scale and the extent to which they affect the process of selecting the most appropriate use, this paper aims to extract such criteria and indicators and prove their effectiveness in the process of selecting the most appropriate reuse of heritage buildings in old cities. The procedure of the study includes three phases: the 1st phase analyzes previous related studies and international charters, then extracts the most important criteria and indicators; the 2nd phase deals with expert interviews to provide a criteria assessment according to significance; and the 3rd phase applies these criteria and indicators to historic buildings in Mosul's old city to evaluate the possibility of their use. A decision-making methodology (AHP) is applied using Microsoft Excel. The methodology was applied to Ziadah House and Suleiman Al-Sayegh House, which are among the most important historic buildings in the old city of Mosul. In the results, the application to arrange the optimal alternatives showed that the Ziadah house got the highest value, while the Al-Sayegh house got the lowest value. We can conclude from this that Ziyadah House is the most appropriate option to perform the function of restoration and maintenance of antiquities.

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1. Introduction

Heritage buildings gain their importance and distinctive character from the values they carry, such as social, spiritual, historic, artistic, aesthetic, natural, scientific, and cultural values, as well as from their relationships with the physical, visual, spiritual, and other cultural contexts [1]. The term reuse overlaps with rehabilitation, as many do not differentiate between the two, when the adaptation of the building within use means modifying the building while remaining in the same function and this indicates rehabilitation, but when adaptation across use means modifying the building with a change of function and this indicates to the term reuse [2]. One of the most crucial levels of intervention to preserve

heritage buildings is reuse. It represents the process of upgrading and improving the performance of the building to meet modern standards and changing user requirements while retaining the original building as much as possible [2]. Resorting to reuse as a result of the building's failure that no longer serves viable purposes, changes in the demand for new buildings as a result of social and economic transformations, as well as the type and density of habitations that call for an improvement in the functionality of existing buildings in desirable locations [3]. In addition to helping communities, governments, and developers reduce costs, this policy plays a significant role in the sustainability of the building by extending the useful life of the existing building. It also preserves the heritage building's stock and urban fabric in order to promote values related to history, continuity, identity, and sustainable human development. It encourages dynamic interactions within cities and reduces the amount of time and land needed for building and upkeep. Heritage buildings are appreciated locally and

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abroad by current and future generations and tourists. Making historic buildings functional and accessible is thought to be a practical approach to continuing self-financing, which supports the economic pillar of sustainable development [3] [4] [5] [6].

This study was conducted in phases. The first phase involved an analysis of previous studies and the extraction of the most important standards and indicators. The second phase involved interviews with heritage experts in the old city of Mosul to assist with the aspects and standards extracted from previous studies and international charters and to give an evaluation according to the level of significance to be given. The final phase is to apply these criteria and indicators to heritage buildings in the city of Mosul and test the possibility of applying a specific function to them in order to find the most appropriate building for this function. The decision-making methodology (AHP) is applied using Microsoft Excel. Due to the lack of knowledge of the criteria and indicators affecting the most appropriate reuse process on a large scale and the extent of their effect on the process of selecting the most appropriate use, this study aims to extract the criteria and indicators and prove their effectiveness in the process of selecting the most appropriate reuse of heritage buildings in old cities. In order to extend the physical and functional life of the building and avoid damage due to wrong reuse decisions, this study helps decision-makers make the best decision to reuse heritage buildings more accurately, quickly, and effectively.

2. Reuse Mechanisms

According to the degree of adaptation needed to reuse the buildings and the necessary interventions to maintain them and connect the old with the modern, the reuse policy is divided into a set of mechanisms: first, the adaptive reuse mechanism represents the lowest level of adjustment based on the intervention strategy, where there is a significant level of integration as the new elements completely alter the existence to lose its original integrity [7]; second, the compatible reuse mechanism is the second level of adaptation that depends on the inclusion strategy, which is the process of incorporating a new element into the existing building [7]. Usually, this strategy doesn't damage the site or its cultural significance, does not significantly affect the sustainability of the structure [8], and is done in a manner that respects the place and its cultural significance [9]. Third, the highest and best reuse mechanism is defined as the most profitable destination and refers to uses that are physically and technically feasible, urban, financially sustainable, and economically appropriate [10]; fourth, the sustainable or green reuse mechanism is an environmentally, economically, and socially sustainable use [7], which requires profitability, flexibility, energy efficiency, and environmentally friendly materials [11]; and fifth, the greatest and best level of adaptation—the most appropriate reuse mechanism—depends on the installation approach, which involves adding new components or features to an existing building [7].

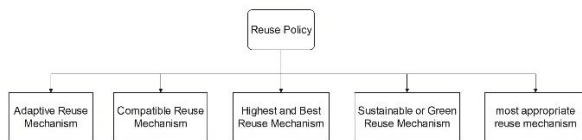


Figure 1. Mechanisms of Reuse Policy (researchers)

2.1 Mechanism Most Appropriate Reuse

Represents the highest and optimal level of adaptation based on the installation strategy, which is the addition of new parts or elements to the existing building, but does not change the infrastructure, [7]. The building is compatible with, promotes, and enhances understanding of the cultural significance of the historic place [8]. Choosing the most appropriate use is most important to reduce the potential conflict between preserving the value of the heritage and adjusting the building to current standards to make it suitable for new use [12]. In the course of the most appropriate reuse, heritage building classification is taken into account to determine the

amount of intervention allowed [13]. Attention is also paid to the needs and desires of the community, the promotion and protection of buildings, the provision of long-term management, the use of disassembly and interchangeable systems, and the provision of amenities for the site with convenient facilities that are closely linked to the urban master plan with design consultations with stakeholders that enhance understanding of local housing business practices [8]. The most appropriate use of a site that has lost its original function is selected based on its importance and preservation status while ensuring that the new use does not cause any damage or change to the original forms, structures, techniques, and materials that reflect the features of the site that reveal its values and that all the measures adopted are reversible when needed, i.e., the site can be returned to its previous status [14]. Appropriate use successfully preserves the architectural heritage [15].

2.2 Restrictions of Most Appropriate Reuse

The most prominent constraints of the most appropriate reuse are the need to distinguish new additions and their lack of impact on the hallmarks of the heritage building, and that changes should be made to the minimum extent possible when internal or external extensions or additions to the building are necessary. It must not alter or damage parts or areas of it. The new function is commensurate with the nature and spaces of the building and is approved in advance by the relevant administrative authorities [8]. and to allow users to easily access all building facilities, meet the desires of owners and users space requirements, preferably throughout the day, with full use of the building and all its floors, in addition to providing the building with the necessary technical equipment without compromising its artistic and historic value [16].

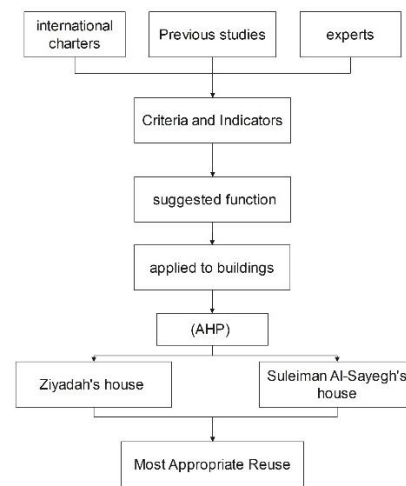


Figure 2. Study methodology (researchers)

3. Criteria and indicators affecting the most appropriate reuse

In order to maximize the use of heritage buildings and protect the cultural and historic legacy of towns and communities, it is crucial to take into account a variety of elements, criteria, and indicators. Benchmarks and indicators are instruments for gauging and assessing a specific performance or circumstance in light of a specified set of values or metrics.

3.1. Physical Aspect

3.1.1 Compatibility

Determining function is one of the most important determinants of architectural integration. It is important to understand the original

relationship between the details and how they are combined with the [11] building when the proposed use is appropriate for the value of the building and its integration with the surrounding community, the surrounding context of the building, the quality of building functions, and accessibility compatible with current planning laws. This balances the building's potential with its needs and community and expresses the characteristics of the area, respect for the physical and spiritual realities of the architecture, the resolution of the surrounding urban problems and development [10] [11] [17].

3.1.2 Integrity

The requirements of the new function and its relevance and impact on the structure and stability are examined [18]. Adaptive reuse contributes to the restoration of the building's architectural shape and the disposal of damaged parts of the building through its restoration and the maintenance and repair of the structure of the building [17]. Reuse should not damage the building as the building is expanded in an adequate and harmless manner, whether horizontal or vertical [19], and maintain the geometric composition of the spaces and their mutual relationships, as well as the possibility of removing these changes and additions when they are no longer needed and returning the building to its original position [20].

3.1.3 Accessibility

Accessibility of the building is one of the most important criteria to be observed by the developers of reuse projects. The pathways leading to the building and its suitability for new use [21], the enhancement of the usability of the building by the community, and the ease of movement between spaces [20]. Providing access to vehicles, pedestrians, and those with special needs is critical to increasing the importance of the building after adaptation and ensuring access for all members of the community, taking into account the importance of the place and not damaging it due to the extensive use of the area by a large number of people causing congestion [16].

3.1.4 Distinguishing

Changes are made in such a way that they do not affect the recipient's ability to visualize the original building and distinguish additions from previously existing [20].

3.1.5 Flexibility

Ease of handling and acceptance of changes and additions to assist in the reconfiguration of the building in a manner that achieves high efficiency in achieving the objective of the new function [22].

3.1.6 Building Characteristics

An assessment of the physical condition of the building is important and should include a detailed survey of the building. The factors in this group are mainly related to the physical characteristics of the building, such as the building's life, current usage, architectural, structural, and physical conditions, and the condition of the exterior fabric. [21]

3.1.7 Cultural Significance

Cultural significance in the Bora Charter means the aesthetic, historic, scientific, or social value of past, present, or future generations. Cultural significance is a concept that helps value places. Places that are likely to be important are those that help to understand the past or enrich the present and are valuable to future generations [23] [24].

3.1.8 Municipal Regulations

Includes the study of the quality of the original construction [25]. Attention is paid to examining the applicability of the building to municipal laws and obtaining the approval of the government agencies responsible for these buildings before commencing any work to preserve the integrity and sustainability of the building's values [6]. The new use of the building must meet the requirements of the existing building law [21].

3.1.9 Use Technologies

Modern technologies are necessary to upgrade heritage buildings, as they allow the integration of new technologies into existing construction elements and maintain the comfort of the building [25] [26]. It promotes the realization of the new function of the historic building while preserving its identity and cultural value [20] and will also help ensure that the work is completed in a timely manner and to the required level of quality [6].

3.2 Cultural Aspect

3.2.1 Intangible Values

Consisting of the preservation of intangible heritage such as social traditions and customs, where the adaptive reuse of the building helped to support this standard [6], buildings in reuse must correspond between the preservation of identity, history, and culture and contemporary lifestyle [15].

3.2.2 Preserving Authenticity

It describes everything that is creative and innovative, with an identity in form and content, heritage buildings no longer in use retain a strong identity of form and content [27]. And represents the primary qualifying factor in relation to values; the provisions of authenticity are linked to the value of a wide variety of sources of information. Aspects of sources may include form & design, material & substance, use & function, tradition, techniques, and workmanship, location & setting, spirit & feelings, and other internal and external factors. The use of these sources allows for clarification of the artistic, historic, social, and scientific dimensions of the cultural heritage under consideration [28].

3.2.3 Minimum Intervention

Represents the possibility of making interventions to the building within the acceptable limit of maintaining the building for as long as possible, allowing the modern use of historic origin without altering its stereotypical and architectural characteristics, such as the strengthening of bearing elements, the addition of barriers and openings, the introduction of maid spaces, and others [10], thereby contributing to the continuation of the activities and practices of the place and the promotion of its cultural significance [23]. As the heritage value is measured in relation to the number of interventions that will be made on the building, which will negatively affect its authenticity [18].

3.3 Social Aspect

3.3.1 Society Living Conditions

The adaptive reuse of historic buildings provides jobs, promotes sustainable environments, generates current revenue from local and international visitors [29], is a catalyst for tourism development of the city, and helps generate income for the community [29]. Local heritage stimulates learning through the direct experience of local and foreign visitors, in addition to creating awareness of the values of physical and intangible heritage among

communities and enhancing local sense of identity. [15] Raising society's awareness and understanding of heritage through learning and its diverse and easy-to-understand means for different generations and societies [30]

3.3.2 Region's Needs

Support for the area is provided through the involvement of users in decision-making to preserve buildings and meet their needs. This contributes to the revitalization and development of the area and is vital to prolonging the life of the reuse project [31].

3.3.3 Society Participation

Heritage is not an autonomous thing. It is a constructive interactive process of which people are increasingly aware of its meaning to them. Heritage cannot continue to be preserved without the community's participation and taking into account the connection between the memories of stakeholders, experts, and space users in making decisions on adaptive reuse. [23] The decision is made more effectively and sustainably through consultation with local populations rather than by experts, and interviews and questionnaires are key ways of ensuring stakeholders' participation in the identification of heritage in adaptive reuse [6] [15].

3.3.4 Social Interaction

Adaptive reuse contributes to the continuity of social life, improving social cohesion, developing the cultural awareness of the population, and improving their behaviour and customs [17], raising society's awareness of the importance, benefits, and opportunities of reuse when implemented [2]. Providing access to all parts of the building leads to a full level of knowledge of heritage and its details [19].

3.3.5 Place Sense

Buildings are part of the place and are therefore important elements in providing the sense and soul of the place [32]. When keeping and reusing buildings, this leads to the continuation of physical history, raising the importance of the assembly memory, the sense of place, and providing benefits to future generations [22].

3.4 Economic Aspect

3.4.1 Local Economy

Expressed through the Reuse Project's association with the surrounding urban context leading to the vitality of neighbouring areas [19] the market demand is linked to the potential need for adaptive reuse of buildings due to the high sale and rental prices of properties [21]. If a historic building is properly planned and the necessary resources are needed for its reuse and may provide benefits to the public, local authorities and the country as a whole, providing strong evidence of an increase in tourist arrivals financial benefits directly to the country [29], and the production of the highest net return to society [10] the adaptive reuse of historic buildings increases the tourist's sense of the impact of visual elements and transfers knowledge to them and creates an enjoyable experience for them [29]

3.4.1 Land Value

If infrastructure is improved and facilities and services are developed in the region in general, the demand for real estate in that area may increase, thus increasing its price. Taking into account the right of members of society to a fair share of the environment's natural resources, this ensures that environmental resources are not used by part of society, leaving the rest of society with unmet needs through remaining resources [6] [11] [33].

3.4.1 Construction Costs

Cost is always an important concern for owners or developers of reuse, as appropriate assessments should be made to reduce the additional costs during the conversion process [21]. The cost is reduced by improving efficiency and reducing energy as well as raw material consumption [21]. The reuse of a particular building is often less costly than demolition and new construction, as well as reducing the time needed to complete the project by up to three-quarters of the time needed to demolish and rebuild a new building with the same space [22].

3.5 Financial Aspect

3.5.1 Costs

The owner faces obstacles when deciding to reuse the historic buildings. The most important is the high cost of construction and restoration [21], as well as the multiple ownership of the buildings make it difficult for all owners to reach the decision to reuse the buildings [21], so the building is often owned by the state and the appropriate decision is made in the preservation of the building. Economic efficiency is assessed by the relationship between the amount of economic benefits the adaptation project will produce and the amount of costs related to conversion and construction [18] as the cost of adapting the building to meet current safety standards as well as to meet design requirements in the new function [34].

3.5.2 Incentives

The economic feasibility of new use is one of the obstacles to adaptive reuse. There are some risks and uncertainties related to adaptive reuse. Fiscal incentives can be an engine for and encourage the adaptive reuse of buildings. It is the Government's responsibility to review existing policies and develop supportive fiscal incentives. [21]

3.6 Ecological Aspect

3.6.1 Environmental Conditions

This criterion is achieved through the efficient use of natural resources, the reduction of waste generated, pollution and environmental emissions, the reduction of negative impacts on human health, and the promotion of the use of raw materials [6]. Adaptive reuse extends the productive life of existing buildings at lower costs in relation to materials, transportation, energy and pollution [21]. When buildings are reused, about 95% of the building's energy (energy consumed during construction) is saved and prevented from being wasted, so the reused building is more environmentally sustainable than the new building [35]. Adaptive reuse generates less waste in construction and provides corresponding contributions to greenhouse gas reduction. Adaptive reuse of buildings can contribute to sustainability and climate change by mitigating CO₂ emissions [17] [21]. The use of raw materials is an important objective of the reuse process by exploiting existing resources and reducing negative impacts [29].

3.7 Political Aspect

3.7.1 Government Support

Tax concessions are provided to encourage society to move towards historic building reuse projects rather than demolishing them in addition to conducting training courses for specialized professionals to expand their horizons towards reuse and advanced techniques used in this field [2]. Preparation of proposals for new uses [17], the Government should consider providing relevant advisory services on the evaluation of existing buildings for building owners interested in adaptive reuse of buildings and conducting a detailed survey and assessment of existing buildings in a timely manner, to avoid exceeding the time for adaptation projects [21] [15]. Government departments contribute to the introduction of some procedures to streamline the application process for the reuse of buildings and allow for adjustments to the lease as required, as well as relaxation of relevant regulations and greater flexibility in land use [21]. Finally, the State should provide a study on the relevance and benefits of changes to the

building itself, its surroundings and demonstrate actions taken in reducing the risk of its destruction [30].

4 .Multi Criteria Decision-Making Process

The complicated cognitive process of decision-making results in selecting an approach to action from among the many possible possibilities. It contains a series of stages to arrive at the optimal option: first, identifying the issue, outlining it in precise, quantifiable words so the official may create alternatives, and second, summarizing the benefits and drawbacks of each option. Third, assess it to choose the best option that meets the objectives [36]. The multi-criteria-decision-making process (MCDM), which was created to address decision-making issues in a variety of fields by seeking out the best alternative, aims to enhance the standard of decision-making by making it more rational and effective. Due to the various problem contexts, the methodology for MCDM is divided into two groups: multi-attribute decision-making (MADM), which focuses on problems with a limited number of alternatives and attributes, and multi-objective decision-making (MODM), which solves issues with an unlimited number of alternatives and features [37].

4.1. (AHP) methodology

AHP is a hierarchical analytical method, "analytical" because it analyses the complex decision problem into basic elements, and "hierarchical" because it analyses the problem at different levels of detail, allowing the selection of the most suitable alternative that achieves the best solution compared with the rest of the alternatives based on multiple evaluation criteria [10]. AHP can be implemented with four consecutive steps: analysis of the evaluation problem into criteria and sub-criteria; Set weights for each criterion by comparing all the criteria from the hierarchy with each other in pairs, to determine the importance of the single criterion in relation to the higher level of the hierarchy; Estimate alternatives with respect to individual criteria; Total grades and arrangement of alternatives This step leads to the final result of each alternative and the weight of the relevant criteria, thus obtaining a total score for all alternatives The analysis leads to the ranking of alternatives, from the highest to the lowest. [10] [20]

This study uses AHP methodology to determine the most appropriate alternative to the proposed function and is applied using Microsoft Excel software. The complex decision problem is analysed into crucial elements and at different levels. This study clarified the reuse policy and mechanisms and the importance of the most appropriate reuse mechanism in preserving heritage buildings, extending their operational life, and enhancing their values. noted the actual need for a comprehensive and effective methodology to implement the most efficient reuse mechanism. Due to the lack of knowledge of the criteria and indicators affecting the most appropriate reuse process on a large scale and the extent of their effect on the process of selecting the most appropriate use, this study aims to extract the criteria and indicators and prove their effectiveness in the process of selecting the most appropriate reuse of heritage buildings in old cities. In order to extend the physical and functional life of the building and avoid damage due to wrong reuse decisions, this study helps decision-makers make the best decision to reuse heritage buildings more accurately, quickly, and effectively.

The interview was conducted with 24 experts from the scientific and practical levels, and these experts specialized in the field of heritage preservation. They were carefully selected from a variety of backgrounds and disciplines to ensure comprehensive coverage of the research topic. The group included professors from the College of Architecture and the College of Archaeology, as well as engineers and archaeologists who have experience in restoring and rehabilitating historic buildings in the Old City of Mosul and hold senior positions in municipal departments, Nineveh Antiquities, and urban planning, in addition to the UNESCO office in Iraq. Experts were directed to the aspects and criteria that were drawn from the theoretical study, and their opinions were asked about the level of importance of each aspect and criteria based on their experience and knowledge. In addition, the historic buildings with the highest value were determined based on expert assessments. These buildings represent an

important focus and decision-making area within the research. Finally, the experts were asked to suggest appropriate functions for the identified historical buildings, reflecting practical thinking and the possible utilization of these buildings in reality. This interview is an important source of information and opinions from experts in the field and contributes to directing the research and its conclusions in a deeper and more accurate manner.

The following section analyses two heritage buildings in the old city of Mosul. It tests their ability to accept a function and land use proposed by the Nineveh Antiquities, a training center for the maintenance and restoration of monuments for the Inspectorate's staff and specialists. The functional program for each job within the old city has been identified, ensuring that the requirements of the beneficiary and international standards are met. Steps are represented in the following sequence: In the first stage, the beneficiary was reviewed and negotiated with to find out its needs and requirements for the proposed job. The second stage included studying the amount of space required for each job based on the specific requirements and objectives and reviewing international standards related to architectural design and space planning to ensure compatibility with international best practices. The third stage included a review by professors in architecture to audit the functional program prepared and ensure its suitability and credibility from an architectural point of view. In the fourth phase, the functional program is revised to ensure that needs and requirements are better met based on comments and observations from experts and the beneficiary. Finally, after confirming the functional program, it is approved to measure its suitability with the proposed historical buildings within the old city.

5. The Case study

5.1. Mosul old city

The old city of Mosul is one of the most important historic cities in the Islamic and Arab worlds. It was founded in the eighth century AD and was considered one of the most important cultural and commercial centers in the Islamic world during the Middle Ages. It was characterized by many features that testified to its ancient heritage and culture, including its architectural features, houses, bridges, and mosques. Mosul was an important center for science and education in the Middle Ages and was an important trading port along the old trade routes that linked East and West. [39]. Despite the challenges and difficult circumstances that the city has faced throughout the ages, it has continued to preserve its cultural and historic heritage. The city suffered great damage during the recent conflicts in Iraq, but efforts are still continuing to rebuild it and preserve its rich history.

It was discovered through analyzing the buildings' designs, patterns, and constructions that they were made to accommodate many requirements, including the weather, the demands of the inhabitants, and their way of living. The houses fit in with one another in the neighborhood, even if they are different in size and price. As a result, the locals find it simpler to comprehend and feel a part of their community [40].

Based on the importance of the old city of Mosul and its historical buildings, it was necessary to focus on identifying the buildings of the highest value, preserving them and their cultural identity, and working on restoring and reviving them. This is very important and is considered a vital step for preserving heritage and culture, and it must be preserved on the basis of clear and accurate studies to ensure the continuity of these buildings for future generations.

5.1.1. Ziadah House

Ziadah House 1870, one of the most important heritage buildings in the old city of Mosul, is located in the area of *Bab Al-Bayd*, adjacent to the *al-Zaywani Mosque*, which is one of the great traditional monuments in the area. The Department of Antiquities acquired it in 1981 and settled its owners there, provided that nothing was changed or preserved. This settlement continued until 2014. In 2017, The house was severely damaged, and international organizations, under the supervision of the Nineveh

Antiquities and Heritage Inspectorate, are restoring it as it was before, down to the smallest details.

The building is surrounded from the south by a public road and to the east by a winding alley that connects it to the street that connects *Bab al-Bayd* and Nineveh Street in the locality of *Khazraj*, and across this street is the *al-Zaywani* Mosque, which is on the opposite side of the site of the house. To the north and west, it is surrounded by residential homes, and the house is built on land that rises above the main street. It is about four meters long and has two entrances on the aforementioned secondary alley and a new entrance on the alley leading to the street.

An area of 533 square meters in the middle of the house is a yard with an orchard, and it is surrounded by buildings on each side. In the south, there is a wing consisting of a basement with an *iwana* above it and two rooms attached to the right, including a wardrobe and an attic. Next to this wing is a western wing consisting of a hall, an *iwana*, and two rooms. A group of halls with two floors is located on the north side, and they contain stairs. Under the stairs is the northern basement door, a door leading to the small outer yard, which contains the bathroom and utilities, and an entryway leading to the room of the ground eastern wing and the entrance to the basement. The eastern side of the house contains a basement that extends in the northern half of the yard to the *rahra*, and above it is a room, a kitchen, and a kitchen passage. In front of them is a group of corridors extending to the southern wing, and the main entrance leads to it. On the second floor, above the room, kitchen passage, and *qantara*, there is a double hallway and four rooms [41].

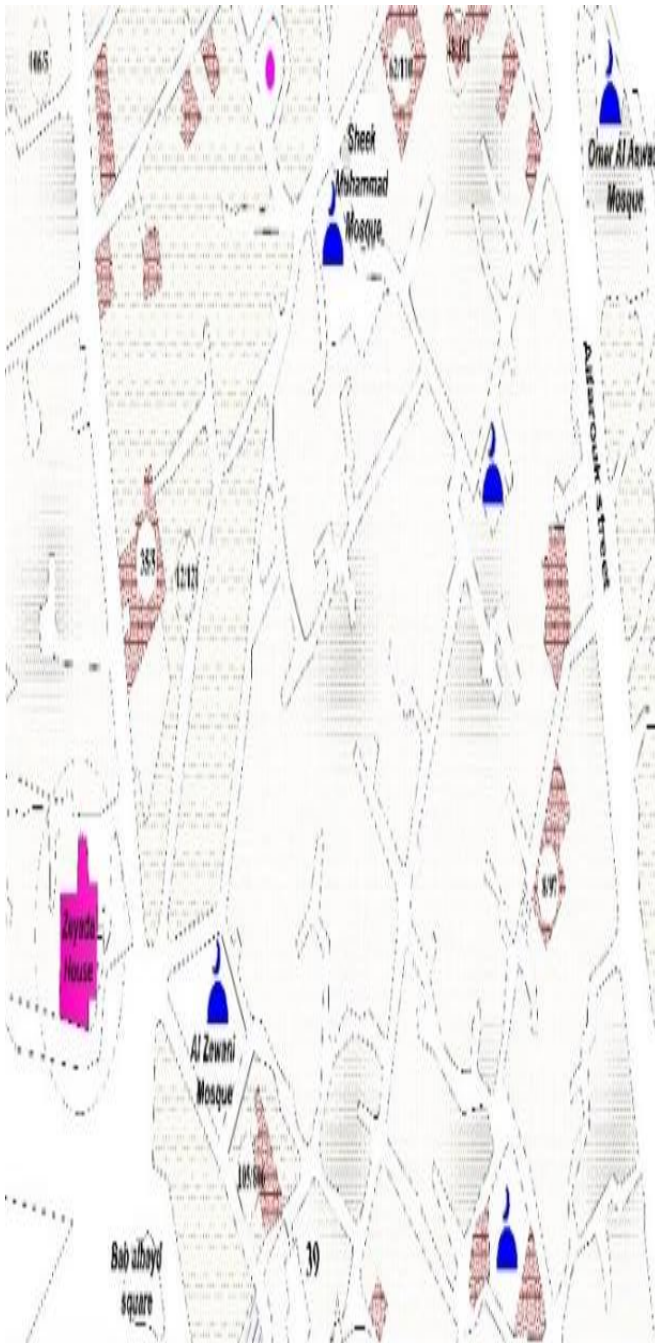


Figure 3. Site plan[42]



Figure 4. Basement floor[42]



Figure 5. Ground floor[42]

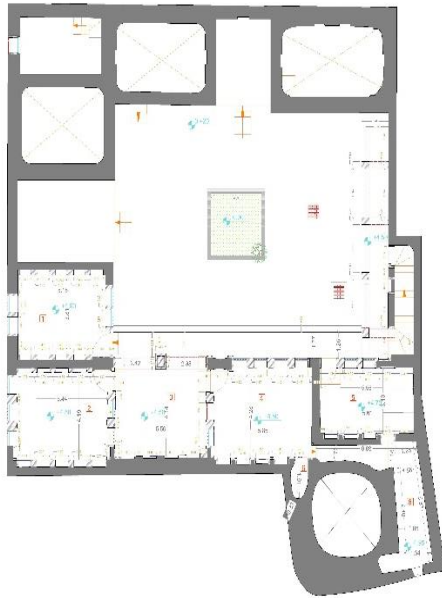


Figure 6. First floor[42]



Figure 9. Interior facades with a courtyard view[42]

5.2. Suleiman Al-Sayegh House

This house belonged to the bishop, writer, and historian *Suleiman Al-Sayegh*, the author of the book *History of Mosul*. The house was then acquired by Nineveh's Antiquities in 1995. It is located in the neighborhood of *Hosh Al-Khan (Al Maidan)* in Old Mosul, near the Church of St. Joseph. It is considered a model of the Mosuli heritage house, as its construction dates back to the beginning of the last century, 1850, and the second phase of its reconstruction dates back to 1915. This led to a variety of construction techniques between the knots and the use of iron, and it is characterized by wonderful carvings on Mosul alabaster, in addition to being the house of respectful Mosulian personality, in addition to its distinctive gate with unique details and decorations. After the liberation operations of 2017, the house was severely damaged. International organizations, under the supervision of the Nineveh Antiquities Authority, rehabilitate it as before. Its area is 300 square meters. It consists of two floors, in the middle of which is a courtyard that contains a *rahra* covering the northern and eastern axes and a basement on the western axis of the house. The ground floor includes an *ivan* and two rooms in the western part to the left of the main entrance to the house. The first floor consists of an *ivan* and five rooms, the alleys in its four facades, and a staircase in the southeastern part.



Figure 7. External Elevation[42]



Figure 8. Openings decoration[42]

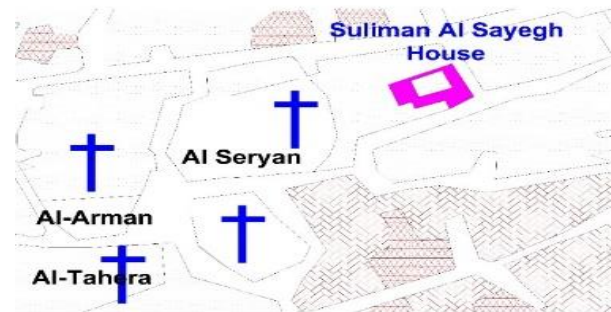


Figure 10. Site [42]

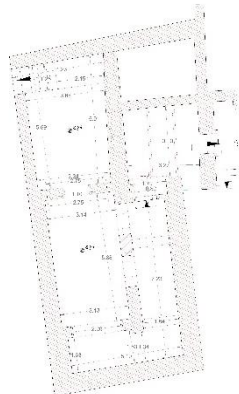


Figure 11. Basement floor[42]

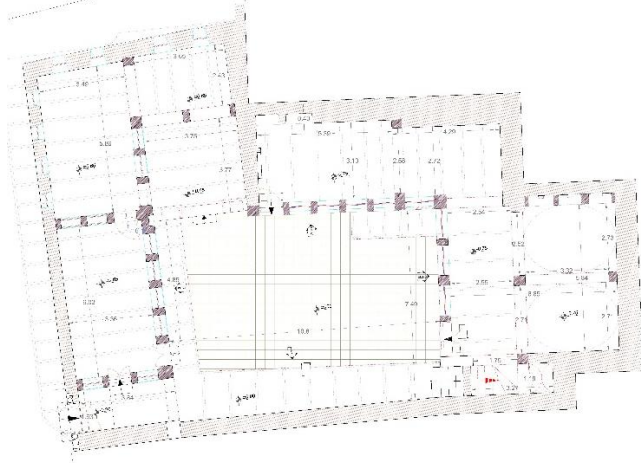


Figure 12. Ground floor[42]

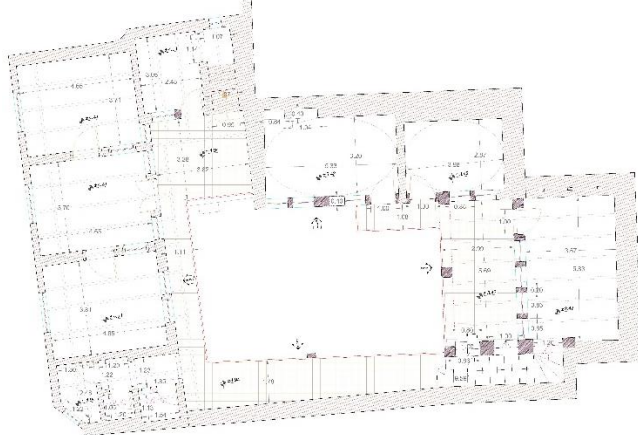


Figure 13. First floor [42]



Figure 14. basement[42]



Figure 15. The Gate[42]



Figure 16. Rahra[42]



Figure 17. Interior facades with a courtyard view[42]

6. Discussion

In order to start the practical application of heritage buildings, it is first necessary to extract the criteria and indicators that directly affect the most appropriate reuse mechanism, then carry out interviews with experts to realize the weights of these criteria and the significance level for each. After presenting and clarifying the aspects and standards that have been extracted from international conventions, previous studies, and expert consultations, it is possible to move on to clarifying the relative importance of these aspects and standards by defining the different degrees of importance for each aspect and standard. Ranking the importance level of aspects and criteria helps guide efforts and make informed decisions. The following mathematical equation was followed to find the importance percentage for each aspect and criterion:

$$X = \frac{\sum_{j=1}^N P}{\sum_{i=1}^n D} \times 100\%$$

X: Percentage level of significance

P: The grand total of each aspect relative to the expert's decision

D: The sum of the aspect

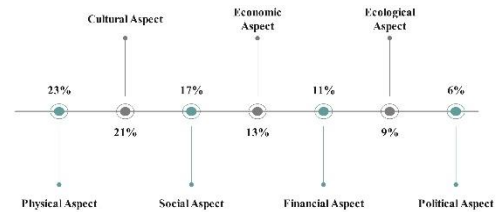


Figure 18. Shows the ratio of significance of the aspects (researchers)

The required function is suggested by the Directorate of Nineveh Antiquities, which was a training center for the restoration and maintenance of antiquities with the aim of organizing training courses for the staff of antiquity inspectorates and specialized engineers in Iraq. The historic buildings in the city of Mosul were identified based on the list issued by the Inspectorate of Antiquities and Heritage of Nineveh and the Municipality of Mosul/Old City Sector. As a result of this huge number of buildings and the difficulty of covering the study of all these buildings, the opinion of experts was guided to determine the buildings of the highest value in the ancient city of Mosul and to propose them for the purpose of conducting the study on them. The experts' decision focused on a specific number of buildings, from which two were selected, Ziyadah House and Al-Sayegh House, and their appropriateness has been experienced for a suggested function.

In the next stage, the decision-making methodology (AHP) was applied and used. The AHP methodology helps decompose a complex decision problem into essential elements with different levels of detail. The equations mentioned in s. are applied to find the ratio of compatibility between the building and the function. In the first step, the process of multiplying the decision value by the value of the criterion weight is done, and the output of the previous process is divided by the number of indicators. In the third step, the result of summing the criteria for each aspect is found and multiplied by the result. With the weight value of the side, in the fourth step, find the sum of all aspects.

Table 1. showing the equations used to find the compatibility value between the building and the function

Aspects	Criteria	Decision	Step 1	Step 2	Step 3	Step 4
Weight-1	Weight-2	Value	$D_i * V_i$	$\sum_{i=1}^a D_i * V / N$	$M * \sum_{i=1}^a D_i * V_i$	$\sum M * \sum_{i=1}^a D_i * V_i$

- M=Weight-1 is the weight of the aspect
- D=Weight-2 is the weight of the criterion
- V = decision value
- N = number of indicators

An example of applying the process to the compatibility standard is illustrated under the physical aspect shown in Figure.

Aspect	Weight-1	Criteria	Weight-2	Indicator	Decision	Step 1	Step 2	Step 3	Step 4	
P	23	C	13	C1	1	13				
				C2	1	13				
				C3	0.5	6.5				
				C4	0	0				
				C5	0.5	6.5				
				C6	0.5	6.5				
				C7	0	0				
				C8	1	13		6.07	11.70	42.15
				C9	0.5	6.5				
				C10	0	0				
				C11	0	0				
				C12	1	13				
				C13	0	0				
				C14	1	13				
				C15	0	0				

Figure 19. The final assessment score for the alternatives (researchers)

After comparing the results of applying the methodology to the two buildings, the results showed that the Ziaeh House obtained 42.15%, while the Al-Sayegh Building obtained 39.89%.

7. Conclusions

Reusing historic buildings in the old city of Mosul after their rehabilitation can have a significant impact on preserving the city's heritage and cultural identity. Historic buildings are not only valuable from an architectural standpoint but also hold a wealth of historical and cultural significance. These buildings often carry the stories and traditions of the past, and their reuse ensures that this history is not lost. They are also a reflection of the local culture and architecture, and their reuse can help maintain a sense of continuity and identity for the community. Also, they can be turned into tourist attractions, cultural centers, or commercial spaces, generating income and creating jobs. Reusing existing buildings can conserve resources and reduce the environmental impact of construction. The new use should respect and complement the building's original purpose and

design, and Following conservation and restoration standards is crucial to ensuring that the integrity and authenticity of the historic buildings are maintained during the rehabilitation process. After classifying, analyzing, and evaluating standards and indicators to achieve the most appropriate reuse of heritage buildings, they have been applied to historic buildings and determined that they can be reused effectively. In this case, it was found that the Ziaeh House building obtained a percentage from the jeweler, so it is more appropriate to convert it into a training center based on the evaluation of these criteria.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Funding source

This study didn't receive any specific funds.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix1: Analysis of previous studies

Appendix2: Part of the aspects, standards and indicators used in the analysis

methodology	aspects	measurement tools	scale of application	study	scope
N/A					
Nara Grid					
green adaptive reuse					
Evaluation Grid					
Shape Grammar					
ARP					
adaptiSTAR					
SARAH					
CSE's					
fuzzy					
Grounded theory					
AHP					
AHP & EVAMIX					
4REs					
Reverse Projection					
cultural					
Financial					
political					
environmental					
economic					
social					
Physical					
Physical					
MCDM methods					
FCS					
AHP Priority					
Choice Expert II					
Rhinoceros					
SPSS					
Microsoft Excel					
questionnaire					
interview					
fabric					
building					
Researcher					
year					
No.					
Ballen & Love				2011	1
Conejes, et al.				2011	2
Tan, et al.				2015	3
Conejes, et al.				2016	4
Eshrafi, et al.				2017	5
Tan, et al.				2018	6
Olman & Eksay				2018	7
De Silva, et al.				2019	8
Shariff & Farahini				2019	9
Ariffin, et al.				2020	10
Abdullah				2020	11
er & Abbas				2021	12
Djebbour & Biara				2021	13
Paulino, et al.				2021	14
Lazou & Gokhale				2022	15
Alhojaily, et al.				2022	16
Yildirim				2012	1
Alhalaf				2013	2
Elsorady				2014	3
Islami, et al.				2016	4
Pinto, et al.				2017	5
Haroun, et al.				2019	6
Ribera, et al.				2019	7
Jandifar & Türker				2020	8
Vehbi, et al.				2021	9
Farjani & Türker				2021	10

Aspects	Criteria	Indicators
Physical	Compatibility	The new functionality is consistent with the history of the building
		Adapting the new function to the values of the building
		The new function is compatible with the old one
		The suitability of the proposed use of the visual character, the architectural form of the building, the interior design, and the elements of vertical and horizontal movement.
		The suitability of the proposed use of the structural elements in the building.
		The new function is consistent with the original building plan
		The new function is compatible with the building structure
		Adaptation of the building space with the new function
		Adaptation of the natural ventilation ratio with the new function
		Adapting the amount of natural light to the new job
		Compatibility of new materials added with old materials
		The elements added to the interior facade match the originality of the building
The elements added to the exterior facade match the originality of the building		
The openings added to the interior facade match the building's originality		
The openings added to the exterior facade match the building's originality		
The materials added to the interior facade match the originality of the building		
The compatibility of the materials added to the external facade with the authenticity of the building		
The new function is compatible with the urban planning of the area		
The new function matches the other functions of the surrounding buildings		
Accessibility	Accessibility	Access to the building is convenient for the new function
		External motion paths are suitable for the new function
		Internal movement paths are suitable for the new function
		Easy access to the building for users with special needs
		Easy access to the building by vehicles and pedestrians
Distinguishing between old and new	Distinguishing between old and new	The ability to distinguish between the new element and the original element
		The ability to distinguish between new and original materials
		Easily distinguish extensions from original parts
		Distinguish between the new and the original function
Flexibility	Flexibility	Using the original spaces in the activities that come with the new function
		Divide the spaces in a way that does not affect the originality of the building
		The possibility of adding spaces without changing the proportions of the building