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PRESERVING THE TRADITIONAL WATERMILLS IN WADI ORJAN JORDAN USING AN ANALYTIC HIERARCHY PROCESS

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ABSTRACT

The preservation of the industrial heritage has been a common practice in a number of cities worldwide. These buildings/sites represent the biggest and most visible symbols of the great industrial past, and serving as monuments of social and cultural identities. The aim of this paper is to preserve and sustain of traditional watermills in Wadi Orjan, Jordan. The mills are spread along Orjan's valley and they were part of the production cycle, which is mainly associated with wheat grinding. This heritage, if rediscovered, conserved and enhanced, may play an essential role in the area's socio-economic regeneration. The ongoing decisions on the protection of industrial heritage are taken by various actors, including the government, the private sector, and the local community. In this sense, this paper attempts to rationalize the decision-making process to preserve the industrial heritage. The analytical hierarchy process (AHP) is used to establish a theoretical basis for decision-making. Twenty-six local professionals participated in the analysis to evaluate their views on the relative importance of different factors affecting the decision making. Expert Choice software and Qualtrics survey platform was used to conduct the questionnaire.

KEYWORDS: Industrial Heritage, Watermills, Sustainable development, Analytic hierarchy process, Preservation.

1. INTRODUCTION

According to the International Committee for the Conservation of the Industrial Heritage (TICCIH), "industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value" (TICCIH, 2003). The remains of industrial activity may consist of "buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education" (TICCIH, 2003).

In recent decades, significant issues such as exploring the preservation prospects, investigating the feasibility of regeneration, and proposing re-use solutions for abandoned industrial buildings and areas; have dominated theoretical and applied research in the field of industrial heritage preservation (Nikolić, Drobnjak, & Ćulafić, 2020; Zhang, Cenci, Becue, Koutra, & Ioakimidis, 2020). The focus is not only on physical preservation, but also on the benefits of preservation, such as promoting tourism. (Bujok, Klempa, Jelinek, Porzer, & Rodríguez González, 2015; Vargas-Sánchez, 2015; Zhang et al., 2020).

Jordan 's industrial heritage may not be the first thing that comes to our mind when considering its cultural heritage. The best known history in Jordan is its ancient sites, for example the Jordan River, such as Petra, Jerash, Umm Qais, Mount Nebo and Holy Land. Nevertheless, in common with our Middle East neighbours, Jordan has a long industrial past that is perhaps best represented by agricultural industrialization, with crops grown in the pre-steam era for food production using animals, water, and wind power. Grain mills were built around the water resources and near the origins of their raw materials (McQuitty, 1995).

Government law and policy at national level is influenced by international charters and regulations that guide decisions on how to address the values of the built environment, such as cultural, historical, or industrial value. In 2005 Jordan ratified a Jordanian heritage conservation convention (MOTA, 2005). The convention supports the protection and preservation of buildings and sites of special heritage significance, including industrial heritage. Laws prohibit destruction, demolition or damage to heritage sites. It must be covered by regulatory authorities from any misuse or harm that affects its components and their environment (MOTA, 2005).

Conservation of industrial heritage is one of the key factors in a city's long-term sustainability (Lane et al., 2013; Pickard, 2018). Yet it has never been an easy task due to economic challenges. Tens of millions can be spent to rebuild a historic building and ongoing maintenance costs can also be significant (Pickard, 2018). The financial challenges have undermined the government's capacity to tackle the financial burden of conserving heritage in Jordan. Although heritage tourism is widely proposed (Daher, 2005), little of its revenue is devoted to preserving heritage sites. Along this rationale, the sustainability of cultural sites through archaeometry has been well documented (Liritzis and Korka, 2019; Liritzis et al., 2020).

The selection of a project to be preserved should be based on a systematic evaluation scheme, in particular when taking into account a variety of decision-making factors that should satisfy the needs of the stakeholders of the project, including government officials, conservationists, developers, and the general public. From this perspective, this paper aims to rationalize the industrial heritage conservation decision-making process in Jordan. In fact, many such challenges can be modelled as multi-criteria decision-making (MCDM). In this sense, the MCDM framework is being established in this research to demonstrate how to make credible decisions to protect the industrial heritage. The extension of this framework may involve many applications in the decision-making on heritage conservation.

1.1. Conservation of Orjan's Watermills

As part of tourism promotion, tourism associations in Jordan have created a so-called Jordan Trail, a path that connects northern Jordan with the south. The path passes through 52 sites, villages, and towns on its way, the most important of which is the Orjan Valley, which is characterized by its natural scenery and the presence of ancient heritage sites, the most important of which are the watermills. Preserving watermills would encourage tourism in this area and the sustainability of the region.

The ecosystem around the Orjan valley is both agriculturally very rich and varied. Crops of various kinds are cultivated during the year. Orjan is flanked by two valleys; Wadi Al-Rayyan to the west of the town, and Wadi Kufranja to the south. These valleys have streams of water, and they supply Orjan valley with water. The topography of the area ranges from 1100 m above sea level to 100 m below the sea level. The area is suitable for watermills, as natural vegetation and soils support farming and crop production and ample natural water sources. The presence of more than 20 watermills was confirmed by a survey conducted in the area in 1986 (Schriwer, 2006). Their status varied from destroyed to relatively intact at the time of the survey, but several of these mills have been lost in recent years due to new advances in this area. Figure 1 below show some of these mills in Orjan valley.

Figure 1: Wadi Orjan and the location of some watermills

The recorded watermills in the area are from the horizontal-wheeled mills (McQuitty, 1995) as presented in Figure 2. The water is guided through a channel to a constructed tower, which is 4 to 10 meters high. The water descends inside the tower penstock/tunnel and exits through an opening at the bottom of the penstock. Attached to the penstock tower is a wheel chamber, which houses a wooden or metal wheel mounted horizontally with butterflies moved by the falling water. This wheel is connected to a column that drives the millstone in the upper chamber (grinding chamber) to grind the wheat, the mill grinding up to one and a half tons of wheat daily (McQuitty, 1995).

The raw materials for the construction of the mills were available in the region. The building stones were taken from the nearby rocky fields, and the logs used in the mill's roof were brought from forest trees in the Jabal Barqesh forests. The stone of basalt was transported from the plain of Hawran north of the Jordan, which is famous for its black basalt volcanic rocks.

Horizontal watermills, in particular, require a constant, reliable water source in order to make the milling system more productive. This can only be done by linking the mills to each other or linking them to a wider water source via a network of water channels. The sophistication of these channel networks may vary from region to region, and from country to country. The presence of different water resources characterizes Wadi Orjan as the networks that supplied the mills were connected to the springs and streams inside the valley. Yet as changes took place and water depletion occurred, the operation of the valley mills was greatly impacted.

The lack of optimal use of watermills and the reduction in the number of people working in agriculture led to a decrease in the cultivated area and in the land's productivity. This has contributed to a decrease in the local community's incomes, which explains the migration trends toward the city in search of employment and a decent living. In response to all this, this study addressed these problems by focusing on revitalizing and taking advantage of the hidden treasures on the site: the abandoned mills, which have the spatial potential to develop new urban programs and functions that allow for modern spatial and economic development.

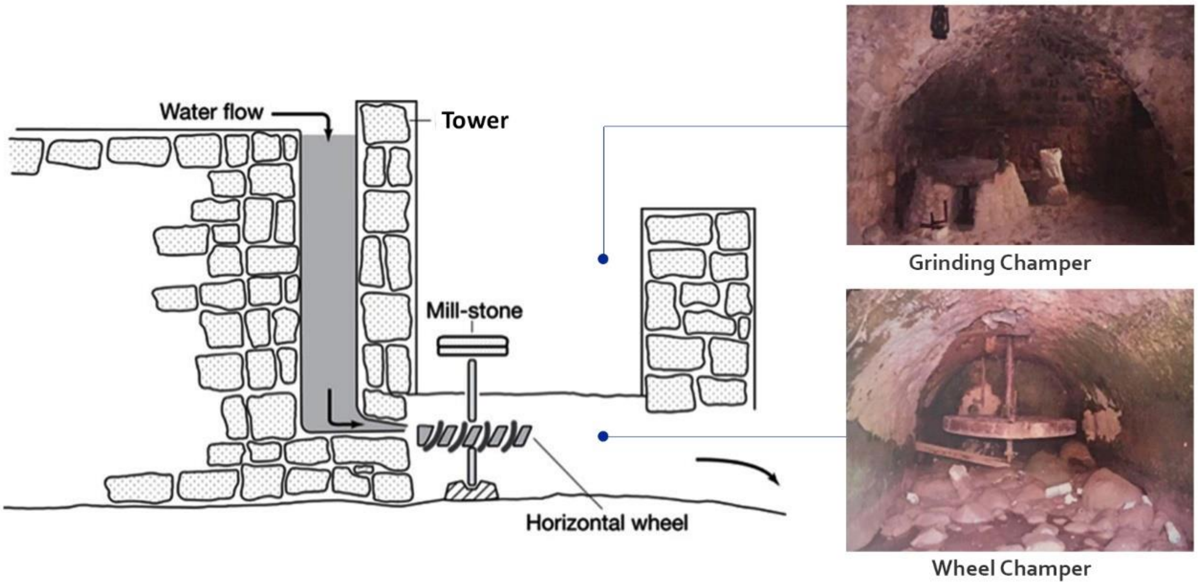

Figure 2: Horizontal watermills, source: (McQuitty, 1995)

Comprehension of the values of watermills is essential for their conservation or creating proposals for their preservation. These values are comprehensively defined in the Nizhny Tagil Charter, which is proclaimed in Article 2 (paragraph ii , iii) (TICCIH, 2003), which are social values, technological and scientific values, aesthetic values, and historical values (TICCIH, 2003).

Social values of industrial heritage are an important part of the identity of the community. They represent part of the collective memory and the history of local residents' industrial development. Technological and scientific values of industrial heritage are reflected in the history of manufacturing, engineering, and construction in the site itself, its materials, its elements, its equipment, and the industrial environment. Historical values have a clear reflection of local identity and are an important driver for regeneration and investment attraction. Aesthetic values are represented in terms of the quality of its architecture, urban design and planning. Industrial sites are urban complexes of very special character in terms of visual quality. Some of them are important because of their unique architectural design which makes them a major urban landmark. Specific spatial structures of industrial landscapes, such as silos, chimneys, conveyor belts and transport structures have great visual and perceptual qualities which make them distinctive, visually-recognizable spatial elements of the whole town.

To date, no evaluation criteria for watermills within the area of the study have been proposed. Based on the understanding of Nizhny Tagil Charter and preliminary analysis of international laws and documentation on the preservation of industrial sites, we created a priority list, which consists of seven main base criteria. The criteria are then divided into sub-criteria as shown in Table 1. The list will be used to study the concerns and opinions shared by a group of experts as elected representatives. The aim is to identify watermills that should be given priority for investments in the preservation process. Therefore, The Analytical Hierarchy Process (AHP) method was utilized to evaluate experts' opinions and to determine the importance of tested criteria and the weighting for each criterion (Saaty, 2008). The AHP approach provides valuable tools to help improve the decision-making process, especially when a broad range of factors are involved (Ishizaka & Labib, 2009; Saaty, 2008).

2. MATERIALS AND METHODS: THE ANALYTICAL HIERARCHY PROCESS (AHP)

The AHP model consists of three main parts, including the hierarchical framework, priority analysis and the consistency test (Saaty, 1990). The hierarchical framework is organized with at least three hierarchical levels, including the research goal, the main factors and sub factors, and the alternatives (Figure 3).

Table 1: The decision-making framework, main factors and sub factors

Goal		Criterion		Sub-criterion
Sustainable preservation of Watermills	1	Visual Quality	1.1	Exterior condition
			1.2	Interior condition
			1.3	Covered materials
			1.4	Aesthetics (form and design)
			1.5	Singular elements
	2	Economic feasibility	2.1	Increasing the value of lands
			2.2	Reducing the financial burden
			2.3	Revive traditional job opportunities
			2.4	Investment opportunities
			2.5	Encouraging tourism
	3	Surroundings rating	3.1	Location and settings
			3.2	Surrounding Landscape
			3.3	Topography of the plot
			3.4	Distance to urban core
			3.5	Views
			3.6	Barrier-free access
	4	Infrastructure rating	4.1	Closeness to Water supply
			4.2	Plumbing and drainage
			4.3	Electrical installation
			4.4	Transport system
	5	State of the building rating	5.1	Structural conditions
			5.2	Maintenance viability
			5.3	Geotechnical concerns
			5.4	Demolition state
			5.5	Dampness/Cracks
	6	Environmental Impact	6.1	Minimize environmental pollution
			6.2	Sustainable development of the area
			6.3	Use renewable resources
	7	Values	7.1	Spirit and Feeling
			7.2	Cultural Value
			7.3	Social Value
			7.4	Historical Value
			7.5	Technical Value

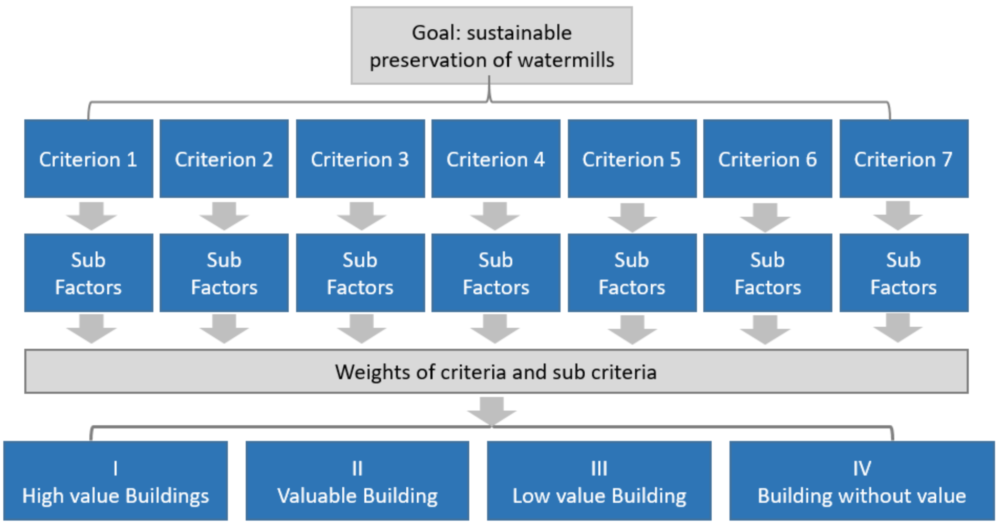

Figure 3: AHP hieratical framework, main factors and sub factors

The AHP allows decision-makers to determine the value of each criterion by integrating pair comparisons to evaluate the relative importance of one criterion, as opposed to another, in achieving the goal of the comparison (Saaty, 1990). The data from the pairwise comparison is displayed in a matrix using a scale of absolute numbers 1-9, or its verbal gradation (Equal importance – Extreme importance) (Saaty, 2001).

The relative weight of each criterion requires the aggregation of different individual preferences in order to produce a single aggregate choice. Weights must capture the dominance of the order expressed in the judgments of the pairwise comparison matrix. Once the assessment of factor importance is done, an assumption is made about matrix consistency or attitude consistency. The value of consistency ratio (CR) — smaller than or equal to 0.1 — is acceptable, indicating accuracy of the matrix. If the value is greater than 0.1, the comparisons can be revisited to improve the consistency (Saaty, 2001, 2008).

2.1. *Data collection and analysis*

We used the Qualtrics (Qualtrics, 2013) survey platform to conduct the questionnaire. For the AHP matrix table query we used the slider question form as a more interactive alternative. Instead of only choosing a scale point, respondents drag a bar to show their preferences (as shown in Figure 4). The link to the survey was sent to the subjects via email. About 26 experts from the Orjan area agreed to participate in the study.

The questionnaire consists of 10 sections, which are:

- Section 1: Demographic information.
- Section 2: Pairwise comparisons of seven major factors.
- Sections 3-9: Pairwise comparisons of sub-factors for each major factor.
- Section 10: Proposals for preservation.

To collect the participants' responses, the questionnaire was translated into Arabic (as shown in Figure 4).

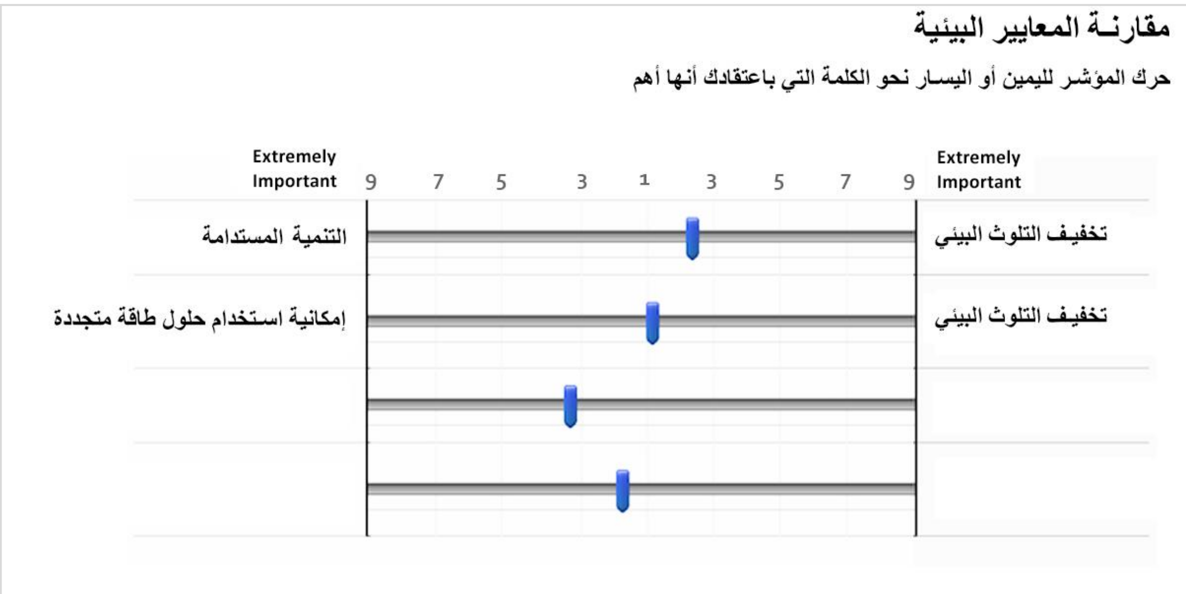

Figure 4: Slider question in Arabic

Experts' responses were analyzed using Expert Choice software, 2000 version (Choice, 2000). The relative importance of each criterion for meeting the objective has been calculated. The computer software will identify the likely sources of inconsistency if the consistency ratio in any level exceeds 0.10 (Ishizaka & Labib, 2009). Without influencing the choice of the interviewee, the interviewee may return to his/her reaction either by taking after the recommendation of the computer program or by filling out the survey once more. The local community responses have been analyzed with simple descriptive analysis using IBM SPSS25 statistical software (Spss, 2017).

3. RESULTS

Twenty-six local professionals participated in the study. Ten (38.5%) were females and sixteen (61.5%) were male participants. They were all over 30 years old. Eleven work in the private sector and fifteen in the public sector.

3.1. *Weight setting and option ranking*

As described above, comparisons were made in pairs on both criterion and sub-criterion levels. At the main factors or criterion level, the seven main decision factors were compared with each other in terms of the relative importance value considered by the practitioners being consulted against the project goal. Then each sub-criterion or factor was compared with each other under the same criteria. The weightings of the criteria derived from different individuals were aggregated into one mathematical mean (Saaty, 1990).

The resultant criterion weightings for pairwise comparisons of seven major factors are summarized in Figure 5. The results indicate that among the seven major decision criteria, building values and environmental impacts had the heaviest weightings, and they play an important role in the preservation decisions. The Consistency Ratio (CR) was 2%, for all responses combined.

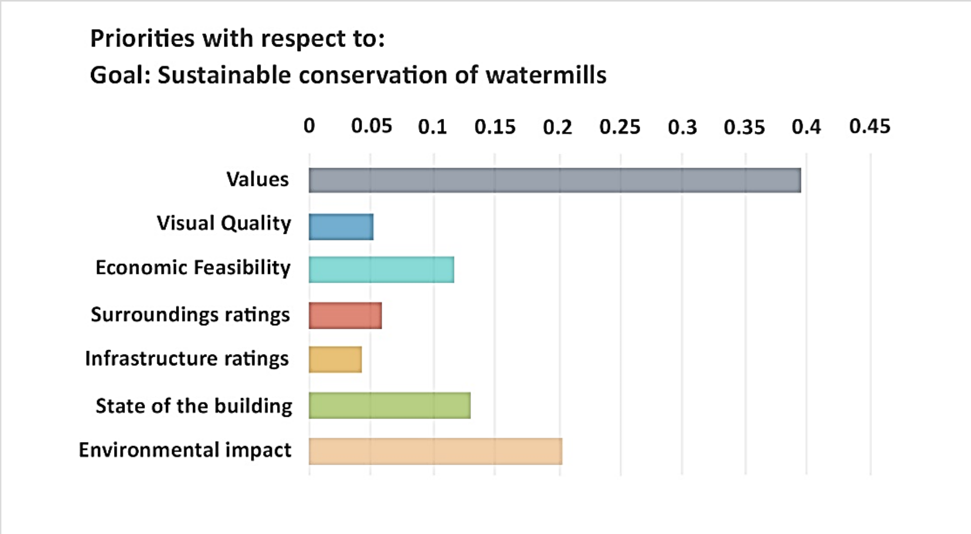

Figure 5: Weightings of the main criteria of the decision matrix

The resultant criterion weightings for pairwise comparisons of sub-factors for each major group are shown in Table 2 and Figure 6. The findings show that the cultural value (20.1%) and the sustainable development opportunities (10.6%) have been listed as the most significant decision-making factors, among all the other sub-factors, by the experts surveyed for the conservation of watermills in Wadi Orjan. Table 2 also indicates the sub-factors that had the highest local weighting in each group, these are: form and design of watermills (group1), investment opportunities of preservation (group2), barrier-free access to watermills (group3), closeness to water supply (group4), maintenance viability of watermills (group5), the sustainable development opportunities of the area (group6), and cultural value and the stories attached to watermills (group7). The Consistency Ratio (CR) for each group was less than 10% for all responses combined.

Table 2: The local and global priorities of main factors and sub-factors

	Criterion	Priorities		Sub-criterion	Local priorities	Global* priorities	Ranking
1	Visual Quality	0.053	1.1	Exterior condition	0.098	0.005	23
			1.2	Interior condition	0.149	0.008	20
			1.3	Covered materials	0.052	0.003	25
			1.4	Aesthetics (form and design)	**0.509**	0.027	12
			1.5	Singular elements	0.192	0.010	19
2	Economic feasibility	0.117	2.1	Increasing the value of lands	0.062	0.007	21
			2.2	Reducing the financial burden	0.054	0.006	22
			2.3	Revive traditional job opportunities	0.277	0.032	9
			2.4	Investment opportunities	**0.407**	0.048	6
			2.5	Encouraging tourism	0.200	0.023	14
3	Surroundings rating	0.057	3.1	Location and settings	0.128	0.007	21
			3.2	Surrounding Landscape	0.131	0.007	21
			3.3	Topography of the plot	0.045	0.003	25
			3.4	Distance to urban core	0.177	0.010	19
			3.5	Views	0.253	0.015	16
			3.6	Barrier-free access	**0.265**	0.015	16

4	Infrastructure rating	0.042	4.1	Closeness to Water supply	**0.490**	0.021	15
			4.2	Plumbing and drainage	0.099	0.004	24
			4.3	Electrical installation	0.177	0.007	21
			4.4	Transport system	0.235	0.010	19
5	State of the building rating	0.130	5.1	Structural conditions	0.199	0.026	13
			5.2	Maintenance viability	**0.361**	0.047	7
			5.3	Geotechnical concerns	0.116	0.015	16
			5.4	Demolition state	0.233	0.030	11
			5.5	Dampness/Cracks	0.091	0.012	18
6	Environmental Impact	0.204	6.1	Minimize environmental pollution	0.313	0.064	5
			6.2	Area Sustainable development	**0.517**	**0.106**	2
			6.3	Use renewable resources	0.170	0.035	8
7	Values	0.395	7.1	Spirit and Feeling	0.177	0.070	4
			7.2	Cultural Value	**0.509**	**0.201**	1
			7.3	Social Value	0.078	0.031	10
			7.4	Historical Value	0.201	0.080	3
			7.5	Technical Value	0.035	0.014	17

*Global priority of sub-factor = priority of factor X local priority of sub-factor

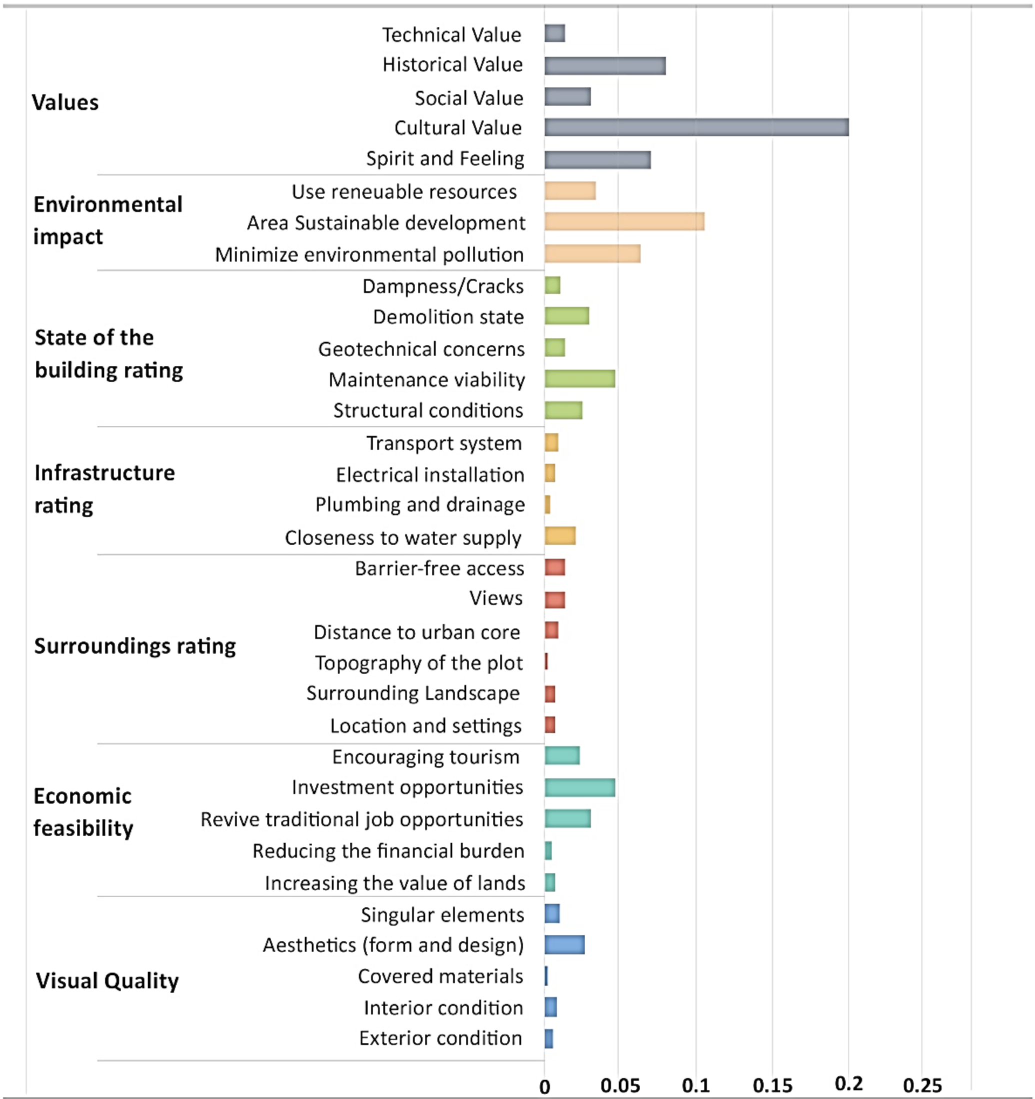

Figure 6: Global weightings of the sub-criteria of the decision matrix

3.2. *Implementation of the proposed methodology*

After determining the weightings for each evaluation criteria and sub criteria, the decision-makers can evaluate the watermills in Wadi Orjan and rate them on the basis of priority values for preservation. The priority index is obtained from the scores assigned to each watermill with regard to the decision criteria and sub-criteria. Generally, the most favorable proposal is the one with the highest preference/priority index. There are a variety of alternatives for preserving the industrial heritage ranging from minimal (least) intervention to restoration or adaptive reuse and modifications in the building use or building demolition. So we can rely on the priority index to decide the most suitable method of preservation for Orjan's watermills (as shown in Figure 7).

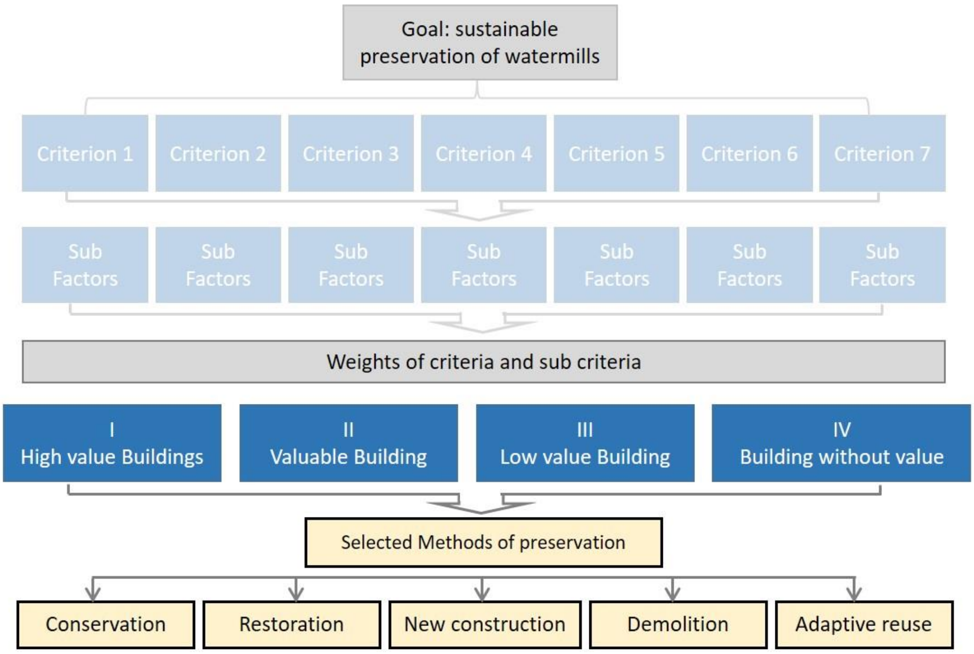

Figure 7: Priority index and preservation alternatives

4. DISCUSSION AND CONCLUSION

Preserving the industrial heritage is not an easy task, as there are a range of problems that need to be addressed in order to propose a viable method of conservation; for instance, the economic costs produced by maintaining the heritage. Due to its multi-faceted nature, the preservation of industrial heritage often poses many challenges in the decision-making process. This paper provides a proposal on the multi-criteria decision-making (AHP) approach to deal with the complex problems of watermill preservation decision-making. The AHP was used for deciding the weightings for each defined criteria with regard to the overall project goal to obtain more accurate and unbiased results. This approach also improves the satisfaction of stakeholders by improving the ranking process transparency and increasing their participation and awareness in the process. This study comes at a particularly appropriate time in Jordan, as the government has launched a number of initiatives to preserve historic buildings. When evaluating proposals, attention should be given to the significance of buildings and how they can provide the decision-makers with indicators to preservation. Decision-makers need to consider complex criteria, such as place values, economic viability, visual qualities, infrastructure ratings, surrounding ratings, state of the building, and environmental impacts. These criteria clash with each other in most cases. Which makes the decision-making process challenging, particularly as it requires a wide number of parameters.

Under this context, it is important to apply the AHP model developed in this analysis to determine the factors that affect the preservation act. More studies are advised to investigate how to use this set of factors weightings to evaluate the watermills and pick the most appropriate watermill preservation proposals. The definitions and principles could be quickly applied to other applications related to preservation activities.

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