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Cultural heritage valorization: an application of AHP for the choice of the highest and best use

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Abstract

In the preliminary stages of urban investments, the Public Administration (PA) has often to deal with complex decisional problems characterized by many variables and conflicting objectives. In these phases, the evaluation is a useful tool that, through the application of multi-criteria analysis, can support the PA in the transformation of a problem characterized by high uncertainty and mostly qualitative judgments of value, in a logical-mathematical model to guide the decisions. Defined the objective of the investment, the Analytic Hierarchy Process (AHP) method is particularly useful in the comparison and in the choice of projectual alternatives described through a variety of independent criteria and often in conflict with each other. A series of pairwise comparisons - first between the various criteria and then between the various alternatives on the basis of each criterion - allows to sort the solutions by returning the degree of pursuit of the initial objective. The application of AHP for the identification of the intended use related to the post-seismic recovery of the Rocca Estense in Finale Emilia (Modena) -Italy, highlights the ease of use of AHP, its robustness, confirmed by the consistency analysis, and the transparency of the procedure, that is devoid of "*black boxes*".

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1. Introduction

In recent years in all Europe there has been a growing interest in the valorization of public buildings. The European Framework Program for Research and Innovation (Horizon 2020) highlights the importance of the cultural character of public assets, considered as the "engine of sustainable economic growth", including the conservation and the enhancement of cultural heritage among the priorities of the new programming. The need for a compromise solution between the public enjoyment and the conservation issues of the cultural heritage, in accordance with the constraints established byItalian Code of cultural heritage and landscape (D.L. 42/2004), has given rise to a series of national and international policy measures. In this framework, the valorization of cultural public buildings must be interpreted as a synthesis of the traditional passive protection of these assets - that is proved unfit as well as financially unsustainable for the Public Administration - and their "productive" use, through modalities compatible with their nature and vocation (Calabrò & Della Spina, 2013).

In Italy various legal actions relating to public assets aimed at rationalizing and simplifying the administrative procedures that lead to the definition of new uses of the properties to be enhanced. Some applications in this sense can be cited: the project "Country-Houses Value", managed by the State Property and aimed at the realization of hotels in public buildings located in little-known areas but characterize by high touristic potentialities; the On Line Valorization (VOL), promoted by the Deposits and Loans Fund, aimed at the census and the rationalization of local authorities' assets; the Unitary Redevelopment Programs (PUVAT, D.L. 201/2011), that provides an effective participatory planning tool, combining the propertyvalorizationwith the development of the territory in which the assets are located.

Due to the scarcity of public resources, Public Administrations are increasingly driven to involve new operators, to activateincentive policies and to promote shared and transparent processes involving the communities. Several actors- technical, political, economic, public and private, stakeholders of different goals and often conflicting - participate to the decision-making process. Therefore, there is the need to coordinate and to balance these interests in order to achieve feasible and consistent results (Guarini & Battisti, 2014; Del Giudice, De Paola & Torrieri, 2014a).

The growing demand for public investments, required for reactivating the economy of European Countries, must be combined with the need to carry out works useful to the community and shared at all levels. Stringent and transparent preliminary analyzes, able to externalize in advance the needs of the community and any technical, procedural, economic and managerial obstacles, are essential: the evaluation must be able to work as an integral part of the development process of an investment, a support for the optimization of investment choices and, finally, as a tool for the efficient allocation of public resources.

2. Aims

Historic buildings - often publicly owned, characterized by large size and located in the city center - constitute a catalyst for urban regeneration, due to their symbolic value for the entire community (Del Giudice, De Paola & Torrieri, 2014b). Therefore, it is appropriate to define a transparent and shared process for the identification of the highest and best use and the consequent enhancement strategies. In these complex decisional contexts, characterized by many actors, by different variables and by the use - in the choice process - of verbal and qualitative judgments, the Multi-Criteria Decision Analysis (MCDA) have been widely applied (Roy & Bouyssou, 1993). These decision support tools allow to broadly analyze different projectual alternatives, indicating the best compromise solution (Tajani & Morano, 2014).

Among the MCDA, an important role is assumed by the Analytic Hierarchy Process (AHP), as a technique applied in different fields (Ali, Yadav & Anis, 2015). In the present work, the AHP potentialities are tested to identify the highest and best use of a property in disuse characterized by high cultural and historic values.

The research is organized as follows. In paragraph 3 outlines on multi-criteria analysisand AHP are given. In paragraph 4 the case study is illustrated, relating to the identification of the highest and best use of the Rocca Estense in Finale Emilia, monument currently in disuse as a result of the damage caused by the earthquake of 2012. In paragraph 5 the conclusions of the work are drawn.

3. Outlines on MCDA and AHP

The linear optimization with a single criterion has been for years the classic solution approach to decision-making problems, borrowed from economic-managerial sector. This procedure, however, has often been shown ineffective in decisional contexts characterized by high uncertainty and by the presence of multiple objectives and constraints. In these cases it may be appropriate to use less "rigid" methods, as the MCDA, that combine logical and mathematical algorithms with elements derived from economic, social, psychological and managerial disciplines, and able to sort the possible solutions of the problem (Manganelli, 2015). Widely used in the evaluation of urban (Lotfi & Solaimani, 2009) and territorial (Morano, Locurcio, Tajani, & Guarini, 2014) redevelopment and for the recovery and enhancement choices of individual buildings, the MCDA support the decision-maker in finding a compromise solution capable of balancing the goals (Figueira, Greco& Ehrgott, 2005). In fact, an alternative that prevails over the others in a clear way, i.e. capable of simultaneously maximizing all evaluation criteria, does not generally exist.

Among the MCDA, AHP assumes that the decision-maker, during its choice, implements, more or less consciously, a hierarchy of the different elements involved in the decisional process (Saaty, 1988). The use of hierarchical structures allows to gain a detailed understanding of the complex phenomenon through its division into gradually smaller"units":AHP is based on the motto *divide and conquer*(Ishizaka & Nemery, 2013).Taking in to account these considerations, in 1980Saaty developed the AHP method, whose main phases are: i) development of the objective hierarchy - criteria - alternatives; ii) construction of the matrix of pairwise comparisons among the criteria; iii) determination of the local weights of the criteria; iv) construction of the matrix of pairwise comparisons of the alternatives; v) calculation of the global weights; vi) aggregation of the weights and determination of the best alternative.

4. The case study

4.1. Description ofthe Rocca Estense

The Rocca Estense is located in the municipality of Finale Emilia, which is currently the subject owner. The building was erected in 1213 as defense tower of the city and has been characterized over the centuries by different interventions, which ended with the recovery activities in 2009. In 2012 an earthquake has damaged the fortress, causing the almost complete collapse of the keep, the serious damage to the battlements and the appearance of cracks in many internal parts. These events make urgent the recovery and the enhancement of the cultural building.

For the identification of the highest and best use, AHP has been chosen, taking into account the availability of the Public Administration to define the criteria and to fill the matrices,the immediacy and the transparency of the methodology, the simplicity of the mathematical model, which allows to sort the alternative solutions without resorting to the construction of utility functions.

4.2. Application of AHP

The AHP is implemented through the following steps (Saaty, 1980):

1. *development of the hierarchy:*in this step the hierarchy illustratedin figure 1 is defined:goal of the decision (level 1), evaluation criteria (level 2) and alternative intended uses(level 3). For the level 1, which is at the top of the hierarchy, there is thegoal, i.e. the objective that the decision-maker identifies with the support of the evaluator and that in the present case is the definition of and intended use capable of guaranteeing the “total quality” of the building. The “total quality” takes into account the compatibility of the intended use respect to multiple instances described through the criteria enucleated at level 2.The criteria are derived from the analysis of the building and of the socio-economic context in which it is located, through the support of *expertise*pertaining to different disciplines (technical, economic, legal, social, etc.),andare outlinedin table 1. The lowest level of the hierarchy diagram (level 3) is constituted by 5 possibleintended uses,defined in order to be consistent with the criteria at level 2. The intended uses considered are: a.1 civic and contemporary

exhibitions museum; a.2 civic museum and library; a.3 civic and multimedia museum; a.4 civic museum and restaurant; a.5 civic museum and literary cafe. The structure of the model can be adapted by increasing the number of criteria and of alternatives, by raising the level of detail but contextually increasing the likelihood of inconsistency of the matrices, that may affect the AHP applicability. For this reason, in the present work it is preferred to limit the number of criteria to 8 and the number of alternative intended uses to 5, in order to respect the limit of 10 criteria/alternativesrecommended in the literature and to opt for a less detailed but more manageablemodel (Ishizaka, 2012).

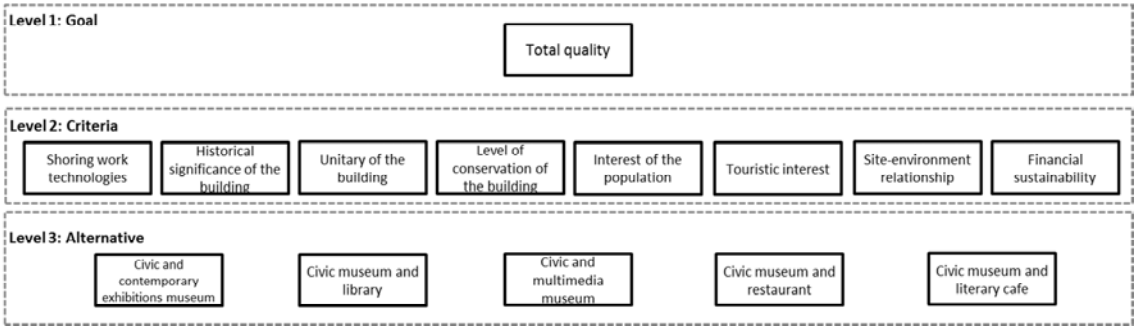

Fig. 1. Hierarchy of decision levels.

Table 1. Description of the criteria (level 2)of the hierarchy tree.

N	Criterion	Description
c.1	Shoring work technologies	Compatibility of the investment with the provisional structures that must ensure the safety of workers
c.2	Historical significance of the building	Attention to the compatibility of the new use with the historical characteristics of the building
c.3	Unitary of the building	Preservation of the unitary character of the building, limiting its fragmentation into many functions
c.4	Level of conservation of the building	Protection of historical building characters, avoiding invasive works such as new openings, traces for installations, etc.
c.5	Interest of the population	Involvement of local communities in the definition of the new use
c.6	Touristic interest	Opportunities of the new use to attract tourists
c.7	Site-environment relationship	Attitude of the new use to fit harmoniously in the neighborhood
c.8	Financial sustainability	Capacity of the new use to generate incomes that allow to financially self-sustain in the absence of public funds

2. *definition of the matrix of the criteria:*in this step, that is preparatory to the determination of the weights of the criteria (step 3),the decision-maker,with the support of the evaluator, works out the pairwise comparisons among the criteria and, according to theSaaty's semantic scale,fills the matrix in table 2. In order to ensure the consistency in the assignment of the scores in the pairwise comparisons,the Consistency Ratio (CR) must be less than 10%:higher values indicate the lack of respect of the transitivity property of the matrix and impose to revise the attribution of scores. In the present case, CR is equal to 6.28% for the matrix of the criteria, which identifies a good consistency in the assignment of the scores;

3. *determination of the relative weights:* in this step the vector*w* of the relative weights expressed in percentage terms is determined,both through the approximate method (AM) and the calculation of the eigenvector associated to the matrix (EVN):

$w = (w_1, \dots, w_i, \dots, w_8)$ with$i = 1 \div 8$ (1)

The vector*w*representsthe weight of each criterion for achievingthe objective of the evaluation. The examination of table 2, in which the comparison among the weights of the criteria determined through the AM and EVN methods is reported,highlights that the absolute difference among the weights determined through the two methods ($\Delta = w(AM) - w(EWN)$) variesbetween the minimum equal to 0.16% and the maximum equal to 3.04%.Sincethe consistency is respected, the order(r) obtained through the two methods does not change;

Table 2. Matrix of pairwise comparisons among the criteria (left) and comparison of the criteria weights through AM and EVN methods (right).

	c.1	c.2	c.3	c.4	c.5	c.6	c.7	c.8
c.1	1	1/2	1/3	1/6	1/6	1/7	1/4	1/8
c.2	2	1	1/2	1/5	1/3	1/3	1/2	1/7
c.3	3	2	1	1/2	1/5	1/4	1/7	1/6
c.4	6	5	2	1	1/2	1/3	1/3	1/4
c.5	6	3	5	2	1	1/2	1/2	1/2
c.6	7	3	4	3	2	1	1/2	1/2
c.7	4	2	7	3	2	2	1	1/2
c.8	8	7	6	4	2	2	2	1
CR = 6.3%						consistent		

➔

n	w (AM)	w (EVN)	Δ	r
c.1	2.2%	2.4%	-0.3%	8
c.2	4.1%	4.4%	-0.3%	7
c.3	5.9%	4.6%	1.2%	6
c.4	12.5%	9.5%	3.0%	5
c.5	15.0%	13.5%	1.5%	4
c.6	17.0%	16.9%	0.2%	3
c.7	17.4%	20.3%	-2.8%	2
c.8	25.9%	28.5%	-2.6%	1

4. *construction of the matrices of the priorities:*the pairwise comparison among the 5 alternatives intended uses is performed for each criterion, in order to determine the measure of the satisfaction of the criterion for each intended use. In the case consideredthe8matricesof the priorities are consistent (table 3),characterized by CR that ranges between 1.4% and 9.5%;

5. *analysis of the priorities:* this is thestep in which the priority relative to each intended use for each criterion is obtained through the elaboration of data in table 3, as it has been already implemented in the step 3 for the matrix of the criteria through the AM and EVN methods. The 8 priority vectors are summarized intable 4:
$p_{k=1\div8} = (p_{k,1}, \dots, p_{k,j}, \dots, p_{k,5})$with$j = 1 \div 5$ (2)

6. *aggregation and determination of the total priority*: the priorities listed in table 4 are aggregated with the weights identified in table 2and relatedto the EVN method, in order to obtain the total priority of the alternative intended uses considered as a function of the objective. For the aggregation, the additive approach of AHP has been implemented, according to which the total priority P_k relative to the*k*-thintended use is equal to the sum of the products between the weights $w_i$relating to the criteria (table 2) and the priorities $p_{k,i}$ (table 4):
$P_k = \sum_{i=1}^{8} w_i \cdot p_{k,i}$ (3)

The total priorities are shown in table 5 and graphed in figure 2, in which the contributions that each criterion provides for the determination of the total priorities, representative of the capacityof each intended useto satisfy the goal "total quality", are highlighted.
As can be seen from the results summarized in table 5 and figure 2, the intended use "civic museum and literary cafe" is the dominant one. This intended use, in particular, maximizes the criterion "financial sustainability" (figure 3), characterized by the greatest importance for the pursuit of the goal (matrix on the right in table 2).

Table 3. Matrix of pairwise comparisons among the alternative intended uses with respect to each criterion.

c.1	Shoring work technologies				
	a.1	a.2	a.3	a.4	a.5
a.1	1	1/3	1/8	1/6	1/9
a.2	3	1	1/5	1/3	1/7
a.3	8	5	1	5	1/2
a.4	6	3	1/5	1	1/6
a.5	9	7	2	6	1
CR =	7.1%			consistent	

c.2	Historical significance of the building				
	a.1	a.2	a.3	a.4	a.5
a.1	1	1/2	1/6	1/2	1/4
a.2	2	1	1/4	3	2
a.3	6	4	1	5	3
a.4	2	1/3	1/5	1	2
a.5	4	1/2	1/3	1/2	1
CR =	9.5%			consistent	

c.3	Unitary of the building				
	a.1	a.2	a.3	a.4	a.5
a.1	1	1	3	5	6
a.2	1	1	3	5	6
a.3	1/3	1/3	1	2	4
a.4	1/5	1/5	1/2	1	2
a.5	1/6	1/6	1/4	1/2	1
CR =	1.4%			consistent	

c.4	Level of conservation of the building				
	a.1	a.2	a.3	a.4	a.5
a.1	1	2	7	8	9
a.2	1/2	1	6	7	8
a.3	1/7	1/6	1	2	3
a.4	1/8	1/7	1/2	1	4
a.5	1/9	1/8	1/3	1/4	1
CR =	6.5%			consistent	

c.5	Interest of the population				
	a.1	a.2	a.3	a.4	a.5
a.1	1	1/3	1/2	1/4	1/7
a.2	3	1	2	2	1/3
a.3	2	1/2	1	1/2	1/6
a.4	4	1/2	2	1	1/3
a.5	7	3	6	3	1
CR =	2.4%			consistent	

c.6	Touristic interest				
	a.1	a.2	a.3	a.4	a.5
a.1	1	3	1/5	1/4	1/8
a.2	1/3	1	1/7	1/7	1/9
a.3	5	7	1	1/3	1/3
a.4	4	7	3	1	1/3
a.5	8	9	3	3	1
CR =	7.3%			consistent	

c.7	Site-environment relationship				
	a.1	a.2	a.3	a.4	a.5
a.1	1	3	1/6	1/4	1/5
a.2	1/3	1	1/7	1/5	1/7
a.3	6	7	1	2	1/3
a.4	4	5	1/2	1	1/3
a.5	5	7	3	3	1
CR =	6.5%			consistent	

c.8	Financial sustainability				
	a.1	a.2	a.3	a.4	a.5
a.1	1	3	1/3	1/5	1/6
a.2	1/3	1	1/6	1/8	1/9
a.3	3	6	1	1/2	1/4
a.4	5	8	2	1	1/5
a.5	6	9	4	5	1
CR =	7.3%			consistent	

Table 4. Matrix of priorities for the alternative intended uses.

		Priorities							
		$p_{1,i}$	$p_{2,i}$	$p_{3,i}$	$p_{4,i}$	$p_{5,i}$	$p_{6,i}$	$p_{7,i}$	$p_{8,i}$
Alternatives	a.1	3%	6%	36%	48%	5%	6%	7%	6%
	a.2	6%	20%	36%	34%	20%	3%	4%	3%
	a.3	32%	49%	15%	8%	9%	17%	27%	14%
	a.4	12%	12%	8%	7%	16%	26%	17%	22%
	a.5	47%	13%	5%	3%	49%	47%	45%	54%
	TOT	100%	100%	100%	100%	100%	100%	100%	100%

Table 5. Synthesis of AHP output values.

		Criteria								
		c.1	c.2	c.3	c.4	c.5	c.6	c.7	c.8	TOT
Alternatives	a.1	0.07%	0.27%	1.69%	4.56%	0.73%	0.98%	1.37%	1.81%	11.49%
	a.2	0.15%	0.86%	1.69%	3.20%	2.73%	0.52%	0.76%	0.87%	10.79%
	a.3	0.78%	2.14%	0.68%	0.78%	1.22%	2.94%	5.49%	4.09%	18.12%
	a.4	0.29%	0.54%	0.36%	0.62%	2.18%	4.41%	3.51%	6.31%	18.21%
	a.5	1.15%	0.57%	0.22%	0.31%	6.62%	8.00%	9.12%	15.40%	41.40%

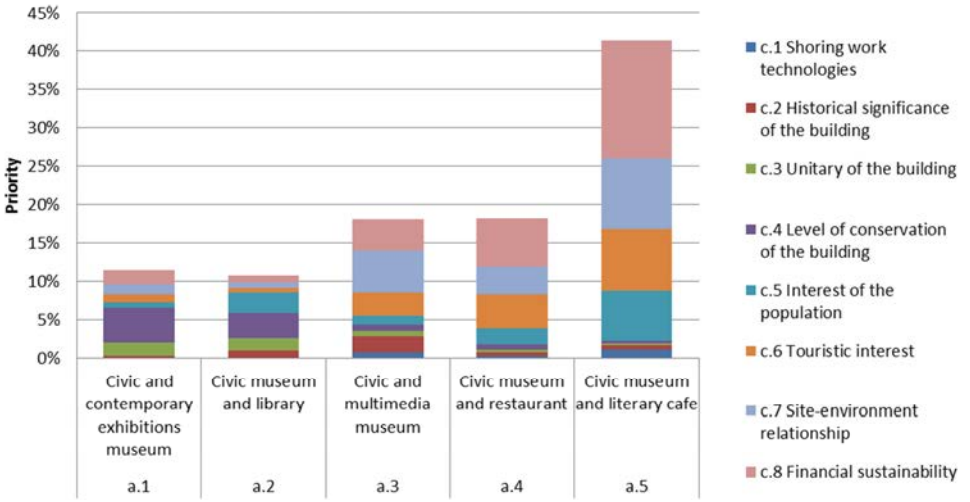

Fig. 2. Bar graph with the synthesis of AHP results.

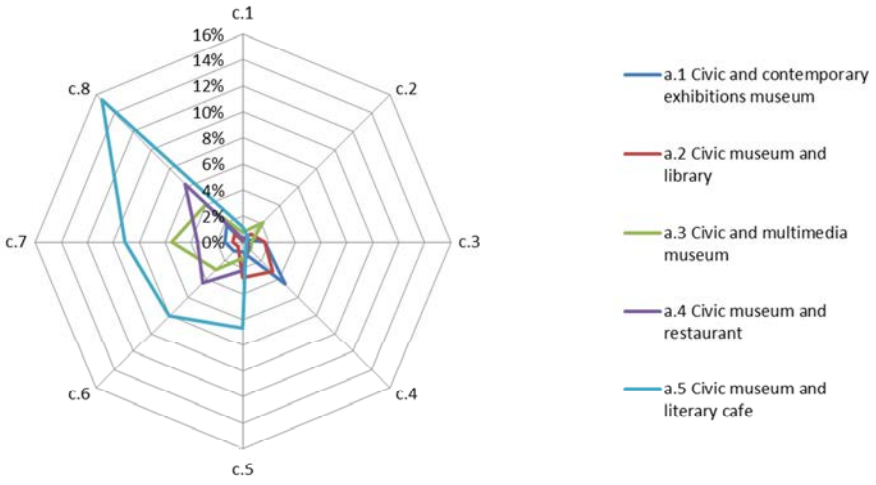

Fig. 3. Radar graph with the synthesis of AHP results.

5. Conclusions

The MCDA are widely applied forsolving decisional problems related to all fields of knowledge. Specifically, AHP has many applications, implemented by Public Administrations and private operators, in different sectors and referred to complex issues, e. g. the optimal allocation of resources from the Department of Defense of the United States, the study of post seismic recovery of the city of Adapazariin Turkey, the resolution of conflicts related to the intellectual property of software between the USA and China, the detection of customer satisfaction by the Ford Motor Company (Saaty, 2008), the modeling aimed at sustainable waste management (Morrissey & Browne, 2004).

The multi-criteria methodologies are shown particularly useful in urban valorization process and redevelopment of property assets, as tools of mediation among multiple and often divergent interests and able to create a shared platform among decision-makers, stakeholders and people directly affected by the final solutions. The use of different techniques of MCDA in the preliminary phases can support the Public Administration to obtain participated choices, through the negotiation among the various stakeholders in the rehabilitation of historic buildings, and weighted solutions, clarifyingthe timelines and the bureaucratic procedures for the urban permissions.

The high transparency of the AHP phases and the simplicity of representation of the different steps constitute the etiology of the widespread application of this multi-criteria technique and of its intrinsic effectiveness in the identification of shared choices (Triantaphyllou & Mann, 1995). The use of the hierarchy diagram, the matrix of criteria and the matrices of the alternatives, in input phase, and the construction of the bar graph and the radar graph, in the output phase, connote the multi-criteria technique of operational simplicity and clarity of the logical-mathematical process for all the subjects involved. The availability of open source software (http://makeitrational.com/) and the ability to reproduce the model through electronic spreadsheets - procedure adopted in the present work - makes the application of this tool particularly easy even by less experts users.

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