Giving space to multicriteria analysis for complex cultural heritage systems: The case of the castles in Valle D'Aosta Region, Italy

Alessandra Oppio [a,*], Marta Bottero [b], Valentina Ferretti [b], Ugo Fratesi [c], Davide Ponzini [a], Valeria Pracchi [c]

[a] *Department of Architecture and Urban Studies (DAStU), Politecnico of Milano, via Bonardi 3, 20133 Milan, Italy*
[b] *Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico of Torino, viale Mattioli 39, 10125 Tourin, Italy*
[c] *Department of Architecture, Built environment and Construction engineering (ABC), Politecnico of Milano, via Bonardi 9, 20133 Milan, Italy*

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1. Research aims

The paper aims at exploring how multicriteria-spatial decision support systems (MC-SDSS) can support the definition of enhancement strategies for cultural built heritage. Differently from the traditional analysis, the use of such an integrated approach allows decision maker to consider the spatial features of each development option and to evaluate simultaneously their multi-dimensional impacts.

In this study MC-SDSS has been applied to the system of castles owned by the Region Valle d'Aosta in the North of Italy. The focus of the research is not the definition of strategies, quite the process of structuring the decisional problem in order to point out opportunities and the risks, before the definition of future actions. Two main challenges has been faced: on one hand the construction of an integrated knowledge of the territory at a regional scale; on the other, the spatial analysis of both tangible (accessibility, supply of services, land use) and intangible aspects (local identity, social and cultural vitality, economic resources).

2. Introduction

Enhancing cultural heritage in mountain regions is a crosscutting topic: environmental and landscape protection, social and cultural promotion and economic development have the same relevance and require to find a durable balance among them. Alpine areas bear geographic and permanent disadvantages [1]. These include physical factors, such as morphology, climate, hydro-geologic risk, and human geography weaknesses, such as the low density, which prevents agglomeration economies, the isolation of local communities and the limited accessibility. Moreover, a large number of traditional economic activities of mountain areas can be performed only in certain seasons during the year.

* Corresponding author. Department of Architecture and Urban Studies (DAStU), Politecnico di Milano, via Bonardi 3, 20133 Milan, Italy. Tel.: +39 3927 502520.
E-mail addresses: alessandra.oppio@polimi.it (A. Oppio), marta.bottero@polito.it (M. Bottero), valentina.ferretti@polito.it (V. Ferretti), ugo.fratesi@polimi.it (U. Fratesi), valeria.pracchi@polimi.it (V. Pracchi).

The opportunities for strengthen the territorial development by enhancing cultural heritage are not always consensual. Conflicts between preservation of tangible and intangible cultural values for local communities and the heritage marketing according to consumers' needs often arise.

In this context, the paper explores the potentials of a MC-SDSS in one of the most advanced of Alpine regions. Given the general institutional framework and heritage characteristics of Italy, Valle d'Aosta can be seen as a peculiar laboratory for experimenting new decision making solutions. At the same time, the analysis and the re-framing of the management policies for preserving and promoting a set of castles in the Autonomous Region of Valle d'Aosta seems relevant for the international debate. The density of heritage castles here is generally high due to the presence of borders between Italian and French states and the local political history. In addition, the set of Valle d'Aosta castles is articulated at the regional scale and entails significant relationships with a mountain landscape and economy. These aspects can be found in other areas around the frontiers in Europe and constitute a relevant case for comparative purposes.

From a methodological perspective, the value-focused thinking approach [2] highlights the potentials of the constructive and explorative use of evaluation, which enables decision makers to catch opportunities instead of simply analyzing/selecting existing options.

3. Cultural heritage and local development processes

In the recent regional development theory cultural capital can be thought as one of the components of what can be labelled as territorial capital. This definition, coming from an OECD study [3], encompasses all those assets, which are embedded in the territory and act as determinants of territorial growth and well-being.

Following this conception, cultural heritage can hence also be thought as one important asset of territorial development and, rather than being just a service for people to enjoy, it has been recognized an important input of economic growth [4]. One traditional channel for this to happen lies in the fact that, by investing in cul-tural heritage, local bodies can improve the attractiveness of their assets to tourists, and in this way increment the influx of people who spend time (and money) to visit the area [5]. Cultural her-itage has been more and more interpreted as a central matter for urban regeneration and revitalization [6]. However, cultural goods can also be integrated into normal products, through a process of "culturalization", which improves their symbolic sign-value [7].

More recently, summing up concepts coming from a large number of different but interconnected strands of literature, the elements of territorial capital have been conceptualized and classified according to two main dimensions, namely the materiality and the rivalry [8]. Materiality refers to the tangibility of goods, with goods ranging from the most hard and tangible ones to the intangible and softest ones. Rivalry refers to the well-known economic taxonomization of economic goods, which can be private (i.e. rival and excludable) on an extreme and public on the other.

All the factors of territorial development can be classified within this categorization, for example the endowment of human capital, which is currently recognized as one of the most important ones is a private and intangible good, while institutions and social capital are intangible and public, infrastructure are hard and public and, finally, private capital is private and hard.

Other territorial assets, however, are intermediate in terms of rivalry and materiality. In the classification by Camagni [9] cultural heritage is mostly a tangible good and an impure public good. In fact, although cultural heritage, in its many aspects, is often freely available or publicly owned, opportunistic behaviours, unsustainable uses and congestion can make its fruition not completely unrival.

4. Methodological framework

4.1. Spatial multicriteria analysis

In the context of decision-making processes and sustainability assessments, a fundamental support is played by spatial multicrite-ria analysis [10], which combines geographic information systems and multicriteria decision aiding [11]. In particular, spatial multi-criteria analysis transforms and integrates geographic data (map criteria) and stakeholders' preferences and uncertainties (value judgments) in order to obtain information for decision-making and an overall assessment of the decision alternatives. In recent years, there has been a growing interest towards the development and application of spatial multicriteria analysis across many scientific fields for solving different decision problem typologies [12,13]. The ability of this integrated approach to both generate alternatives during the strategic planning phase and to compare them during the evaluation phase makes this tool suitable to deal with complex territorial problems, as the one illustrated in the present paper.

With specific reference to the planning and decision-making process, the steps needed for the development of a spatial multicriteria analysis model are summarized in Fig. 1 [14].

4.2. MC-SDSS and cultural heritage: state of the art

As it has emerged from the previous general overview, MC-SDSS find a wide range of applications to decision and evaluation problems. Cultural heritage enhancement and conservation can be considered as a field where problems are not well structured, because of the wide range of interests and values to be considered. Choices about what and how to conserve for representing us and our past to future generations reveal that many different – and sometimes divergent – are the values (economic, aesthetic, cultural, educational, political) subject of discussion [15]. Under the cultural economic perspective there is a clear difference among goal values, that stress the importance of preserving cultural heritage, and instrumental values, namely the means for its sustenance [16]. Since the notion of total economic value encompasses both intrin-sic and instrumental values, decisions about the future of cultural heritage and the allocation of resources should be based on use and non-use criteria. In addition to the duality of cultural significance

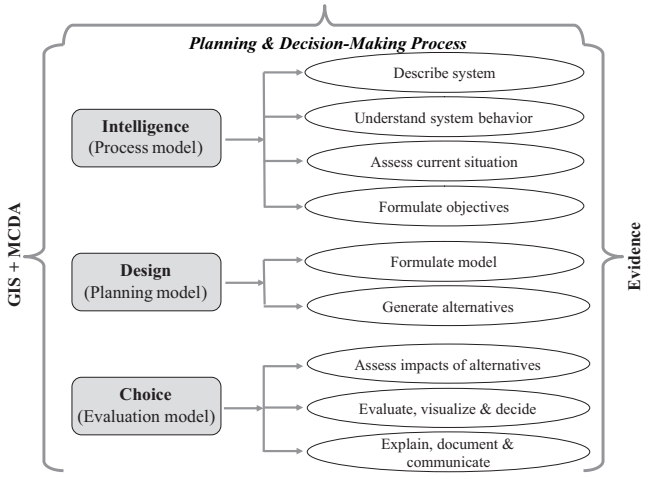

Fig. 1. Framework for planning and decision-making process. *Adapted from Sharifi and Retsios, 2004.*

Table 1
Main works available in the literature concerning MC-SDSS applications in cultural heritage.

Authors	Decision problems	Objective of the evaluation	Types of MCA	Preference structure	Journal
Ercolano et al. [27]	Policies definition/implementation	To define policies for supporting regeneration processes of historic centers	Multiobjective	Individual	*Studies in fuzziness and soft computing*
Harmon and Viles [28]	Plan/scenario evaluation	To plan a geotourism network of heritage sites	Multiattribute	Group	*Environment Systems and Decisions*
Tarragüel et al. [29]	Impact assessment	To evaluate the impact of landslides and avalanches on cultural heritage	Multiattribute	Group	*Journal of Cultural Heritage*
Fusco et al. [30]	Strategies definition	To elaborate a master plan of an historic center	Multiattribute	Group	*Central European Journal of Operations Research*
De Noronha Vaz et al. [31]	Scenario evaluation	To predict urban heritage endangerment	Multiattribute	Individual	*Habitat International*
Hamadouche et a.l [32]	Ranking alternatives	To evaluate the priorities of conserving the biodiversity in protected areas	Multiattribute	Individual	*Arab Journal of Geoscience*
Cerreta et al. [33]	Plan/scenario evaluation	To evaluate the effects of urban transformations of an historic center on the real estate market	Multiattribute	Individual	*Lectures Notes on Computer Science (LNCS)*
Cerreta et al. [24]	Knowledge production	To analyze soft and hard values	Multiattribute	Group	*Lectures Notes on Computer Science (LNCS)*

and economic issues, it is largely acknowledged that cultural capital assets may be tangibles or intangibles. According to the classifica-tion of cultural capital given by Bourdieu [17] and its development, Throsby points out:

- the cultural relevance of buildings, sites, locations and the flow of services they generate;
- the ideas, practices, beliefs and traditions which tie groups of people [18].

The semantic evolution of the concept of cultural heritage shown by Vecco highlights progressive changes and enrichment towards the inclusion of universal as well as more subjective values [19]. Starting from the Burra Charter, international charters and resolutions on cultural heritage suggest to understand the place and its cultural significance, including the plurality and diversity of meanings to people, before making decisions about its future and to involve the communities, along with specialists and administra-tors [20,21]. The introduction of present and future generations into decisions, as well as the call for careful choices based on a systemic approach make the principles of cultural heritage preservation very close to the notion of sustainable development (WCED, 1987) [22].

The explicit recognition of the existence of multiple interdependent values within the policy making and the achievement of a good balance among them is one of the most difficult challenges in making conservation decisions that satisfy the needs of stakeholders directly or indirectly participating in the heritage conservation processes [23,24].

From this perspective, the role of multicriteria analysis in providing an analytical framework to address policies includ-ing distributional issues reflected in the weight vector is widely acknowledged in the scientific literature [25,26]. Although the great number of application of multicriteria analysis in the field of cul-tural heritage, MC-SDSS are not so commonly used (Table 1).

5. Case study characterization

5.1. Presentation of the case study and description of the context

Valle d'Aosta is the smallest Italian region, located in the northwestern part of the country and occupying a remarkable mountain area. Despite of its size, the region is characterized by an extremely rich history, represented by the tangible and intangible cultural heritage spread over the region. A significant part of it is made up of castles and fortifications, mostly scattered along the region's cen-tral valley, whose impact and visibility is very high although some of them are disused. They have changed their function through the centuries according to different instances: from the need to protect and control territory and communication infrastructures to places of residence. Nowadays the priority is to enhance their role as focal poles of contemporary cultural and long-term socio-economic development of the territory by new uses.

Within the territorial capital classification the Valle d'Aosta castles are certainly one type of territorial capital available for the region and its inhabitants to achieve further growth and well-being.

In particular, the analysis presented in this paper refers to a set of 13 castles that are owned and managed by the Regional government of Valle d'Aosta (Fig. 2). In the current phase, the Regional government forecasted a reduction in the resources available for cultural policy and in particular needed to have further knowledge and orientation in the preservation and promotion policy choices to be made with reference to the castles. The driving idea was to avoid programming for individual castles and properties, and on the contrary reasoning about potential clustering strategies in order to strengthen the social use and the economic side effects of the castles and therefore avoid the (politically uncomfortable) risk of selling or leasing the castles to the private sector.

These castles show peculiar characteristics that are briefly summarized in Table 2, which highlights their strengths and weaknesses.

6. Model development

6.1. Structuring of the decision problem

The first step of the analysis consists in structuring the decision problem under examination. In the present case, in order to take into account the complexity of the decision problem under investigation, the Valle D'Aosta castles system was subdivided according to different groups of elements. In particular, the framework proposed by Nijkamp et al. [34] was followed and the main aspects of the problem were organized in several "wares", namely hardware

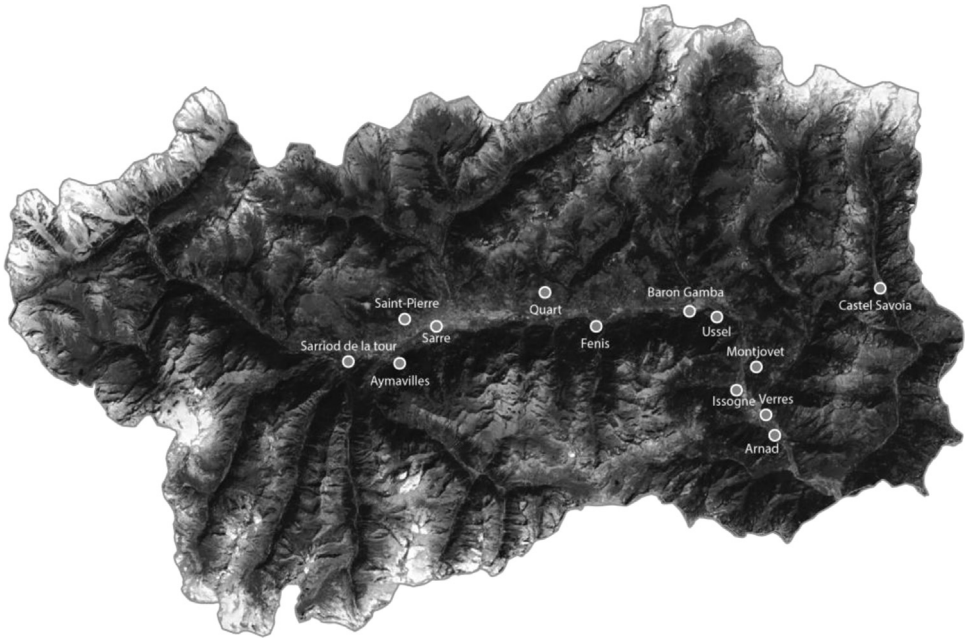

Fig. 2. The system of the 13 castles owned by the Valle D'Aosta Region.

(physical infrastructures), eco-ware (environmental impacts), soft-ware (logistics and informalities), fin-ware (financial arrangements and funding), org-ware (institutional and organizational setting), civic-ware (social capital).

In order to support the decision-making process under analysis, the analytic network process method [35] has been used. The elements of the problem have been grouped into clusters (represented by the wares) that have been organized according to the categories of opportunities (factors having a positive influence on the problem) and risks (factors having a negative influence on the problem). The reasons for using an ANP based decision approach in the present analysis include:

- the assessment of opportunities and risks for a territorial transformation process is a multicriteria decision-making process;
- there are dependencies among groups of criteria and between these and the alternatives to be analyzed;
- the detailed analysis of the inter-relationships between criteria forces the decision makers (DMs) to reflect carefully on their project priority approach and on the decision-making problem itself.

This helps DMs to gain a better understanding of the problem and to make a more reliable final decision. The structure of the decision problem under investigation is represented by Table 3 while Fig. 3 illustrates the example of the opportunities subnetwork in order to clarify the interdependencies considered among the criteria.

Another very important step in the application of the ANP method consists in the identification of the relationships among the different elements of the network. In fact, in ANP evaluation models all the elements of the network can be related in different ways since the network can incorporate feedbacks and complex inter-relationships within and between clusters, thus providing a more accurate modelling of complex settings. In the present application, both for the opportunities and for the risks sub-networks, it was decided to connect all the elements to the goal; moreover, further relationships were identified among the elements. These influences characterize the natural dynamics of the socio-economic and territorial system under investigation, where link and interaction pathways exist between individual elements, which can, positively or negatively, affect each other. In particular, Table 4 represents the influence matrix [36] for the opportunities sub-network. The presence of the X in a cell means that the element represented in the column has an influence on the element represented in the raw. As an example, we can observe the influence played by the element highway entrances/exits on the element revenues from tickets; this influence is due to the assumption that high accessibility leads the castle to have a high number of visitors and thus high revenues. Following a very similar procedure, the influence matrix for the risks subnetwork was also created.

6.2. Mapping

In the next phase, the elements have been represented by raster maps where each pixel has a suitability value. The criterion map represents the spatial distribution of the criterion performance in reaching the objective. These maps were derived from basic raster GIS operations (map overlay, buffering, distance mapping, spatial queries, etc.).

After criteria identification and mapping, standardization was required to make factors comparable and was performed by using a value function, i.e. a curve that expresses the corresponding value score with reference to the level of objective achievement [37]. This operation converts the source map factor scores into a given value ranging between zero (minimum suitability) and one (maximum suitability). A linear approach has been applied by the use of value functions defined by a team of experts.

Once all the maps have been standardized in the 0–1 range, the next step of the decision process consisted in weighing all the factors according to the pair-wise comparison in order to establish the relative importance of the different elements, with respect to a certain component of the network.

The comparison and evaluation phase is divided into two distinct levels: the cluster level, which is more strategic, and the node level, which is more specific and detailed.

At the cluster level, the evaluation of the importance of the criteria and subcriteria refers to a political sphere and it does not reflect a strict objective and technical knowledge. For this reason, in the application the numerical judgments used to fill the

Table 2
SWOT analysis of the castles under investigations.

Castles	Strenghts	Weaknesses	Opportunities	Threats
Arnad	Frescos pictorial cycle	Currently under partial restoration	The vineyards in the park represent a good opportunity for the castle's valorization	No future use defined
		Need of expensive and extensive restoration works	The annual event Sagra del lardo that involves local economic activities	
		Not so good accessibility		
Aymaville	Good state of preservation with interesting interior spaces	Currently not open for visits	Wine producing fields all around the castle and an amazing landscape	
	Seasonally events as wine demonstrations	Expensive and time-consuming restoration works	Good transportation system (public and private)	No common vision or ideas for the new identity of the castle
			Good supply of services	
			Wide and beautiful park	
			Pride of the local population	
Baron Gamba	Head of the new regional Museum of Modern Art	The use of park is not related to the museum activities and it is mainly used for musical event once in a year	Beautiful park surrounding the castle	Possible lack of interest in the castle by both local people and foreigners in the near future
	Strong characterization		There is a catering school in a great proximity to the castle's area	
Fenis	The structure of the castle is fairytale-like and it is well conserved	The castle is only used as a museum of the castle itself	Possible collaboration with MAV (Museo dell'Artigiano Valdostano), which is a museum of great relevance, located just in front of the castle	Industrial and commercial areas in the surroundings
	Excellent accessibility because of the closely located railway station and highway	The linkage to the territory, local actors and natural environment around is limited	High accessibility	
	High visibility from the highway	Any kind of connections to other castles is completely absent	A cycling path along the Dora River will be open close to the castle, improving accessibility	
	The castle has an illumination plan, illustrative panels and 3D models			
	Accessibility for disable people			
	Adoption of economic measures for attracting visitors			
Issogne	The fountain in the castle's courtyard and the many famous frescos' cycles	Long queues of people in front of the castle's entrance		
	The castle is equipped with many technological tools (video, virtual book and projectors) which improve the tourists' experience	The entrance path is covered by gravel which strongly reduces the accessibility for disabled people		
		The technological equipment is not exploited to its full potential		
		The fountain is out of order		
		Visits cannot last more than 25 minutes, because the castles' roof is quite unstable		
Quart	The presence of antique frescos	It is not accessible for disabled people and the accessibility is difficult in general	Presence of cycling paths in its surroundings	
		It is not open to the public and it's currently under restoration (no finish date settled)	The presence of Francigena historical path	
			The presence of the mining village	
			The linkage to the cheese fair	
Montjovet	Panoramic view	No accessibility for disabled people: the only way to get to the castle is first by car and then by foot	There is a strong relationship between orography and architecture, which increases the attractiveness of the castle	
	Path in the nature	The castle is in ruins: there are limited opportunities for giving it a function	Saint-Germain is located on the "castle highway" (A5: that is the highway passing by Ussel, Cly, Issogne, Arnad), and it is clearly visible	
		Currently the access to the castle is forbidden for safety reasons		
		There are no events related to the castle		
		Its visibility is very limited		
		The castle is highly isolated: the people going to see it should be specifically interested in the castle		
		Many parts of the castle are missing		

Table 2 (*Continued*)

Castles	Strenghts	Weaknesses	Opportunities	Threats
Saint Pierre	The castle has a beautiful fairytale-like appearance It is used for the Natural Museum exhibitions There is an antique church beside the castle Good accessibility	It is not accessible for disabled people	It is situated very close to the Sarriod de la tour castle	
Sarre	Good state of preservation Pieces of the original furniture of the royal family of Savoy Magnificent hall abundantly decorated with horns collected during the hunting seasons by the royals		Vast green terrain all around the castle which could be fully used for agricultural purposes	
Sarriod de la Tour	Good state of preservation	Far from regional highway system Weak function (museum of rocks) Too close to the garden of some of the houses in the surroundings	High quality of the landscape in the immediate surroundings Local agricultural activities in the surroundings Local events during summertime (also Chateaux en Musique)	
Savoia	Good state of preservation Guided tours are available	Far from regional highway system (one hour trip) Severe weather conditions during winter Public transportation accessibility is only through bus rides (no railway station in the surrounding areas)	High quality of the landscape in the surroundings Strong relation to queen Margaret of Savoy Closeness to winter sports facilities (ski-resorts) The castle is located within the "Walser" region, the only German speaking area in Aosta Valley (titsch) Local events during summertime Chateaux en Musique Quite an adequate number of hotels and B&B in the municipality	
Ussel	The castle is open to the public and is well maintained It is used for exhibition purposes and has big open spaces One of its main characteristic features is the accessible rooftop, from where with a beautiful view can be admired	It is open for visits only from the 1st of April until the 31st of October, because it has no heating system and thus it is closed during the winter months The castle is not accessible for the disabled and hard to get to, since one has to climb the steep, on which it is located, hill by foot There is a leisure space in front of the castle There is a parking lot and a bar-restaurant just under the hill where the castle is located	It is located on a high hill and is visible from the road	The environment around the castle is strongly affected by anthropic activities
Verres	The castle is located on a hill with a beautiful view The path that leads to the castle is located in a natural environment The castle is open and the security level is high	The castle is not accessible for disabled people, since it is possible to get there only by foot Very few events takes place there during the entire year Some rooms in the castle are empty and the story of the castle is not valorized	There are important events related to castle, such as the Verres carnival It is located close to a protected natural area There are some forest paths that pass by near the castle	

pairwise comparison matrices were derived by a specific focus group. The technique of the focus group is a qualitative research method, which allows taking into account the social preferences in a group decision aiding process. The key feature of a focus group consists of the creation of a flow of information on the structure, the beliefs and the values of social groups within a specific problem [38–41]. In the case under investigation the focus group was made up of decision makers and projects coordinators from the local public authorities. In details, six participants attended the focus group, 3 from the Regional Authority for the protection of Cultural Heritage and 3 from the Regional Department of Land and Environment. It has to be noticed that in some cases the participants maintained different opinions and a consensus was not reached. In those cases, the principle of the "majority" was adopted for weights aggregation [42]. In particular, we gave preference to the node which had the highest number of votes and has been calculated the arithmetic average of these votes in order to obtain a unique value. The questions that were solved by the focus group were of the type:

With reference to the enhancement of the Valle d'Aosta castles, which of the two aspects do you think is more beneficial? And to what extent?

Ecoware	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Civicware

The results of the collaborative procedure for weighing all clusters are summarised in Table 5. Considering the results of Table 5, it is possible to state that, according to the judgments expressed

Table 3
Structure of the decision problem.

Cluster	Description	Elements	O/R
Civicware	Civic-ware deals with the social capital, it pertains to intra- and inter-generational equity, stakeholders and community involvement and local quality of life	Initiative in/about the castle	O
		Initiative for kids and schools	O
		Vitality	O
		Pride of population	O
		Demographic dynamics	R
		Permutation rate	R
		Poor appeal for events	R
		Tourist/local relationships	R
Software	Soft-ware is the layer concerning events and cultural opportunities	Distribution of events (based on summer/winter database)	O
		Lack of distribution of events through the year	R
Ecoware	Eco-ware deals with landscape, natural resources and natural environment in general	Mountain dew ponds	O
		Pathways	O
		Protected sites	O
		High quality of agricultural areas	O
		Vineyards and groves	O
		Hydrogeological risk	R
Hardware	Hard-ware describes the physical territorial characteristics of the region, concerning accessibility, mobility and the presence of services	Highways entrances and exits, train stations	O
		Public transportation	O
		Availability of services (hotel, restaurants, post offices, shopping centers, banks, sports facilities)	O
		Historical pathways	O
		Historical centers	O
		Anthropic pressures	R
Org-ware	Org-ware aims at analysing the intangible parts of the system related to the organization, management and network of relationships	Events promoted by municipality departments	O
		Network density	O
		Events promoted by external actors	O
		Hierarchy of relationships among actors	R
		Number of permanent actors	R
Fin-ware	Fin-ware describes financial arrangements and funding	Revenues from tickets	O
		Income/events ratio	R

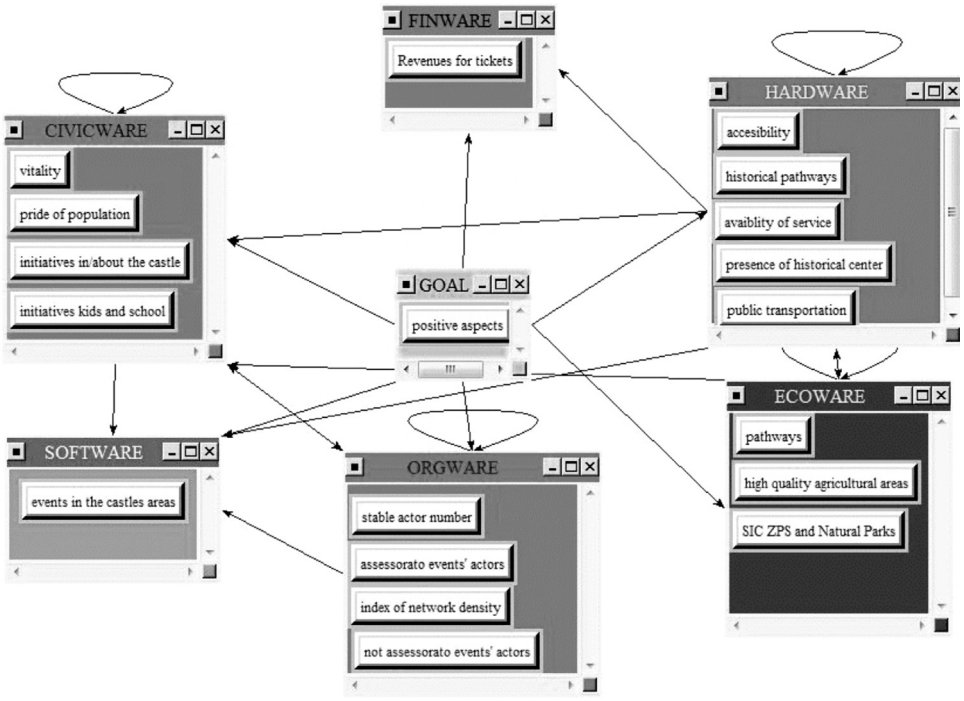

Fig. 3. ANP model. Opportunities subnetwork.

by the focus group, the most important benefits related to the enhancement of the castles systems concern the civicware aspects (36% of importance in the priorities of Table 5), followed by hardware aspects (22% of importance). Following the same reasoning it is possible to affirm that, according to the opinion of the member of the focus group, the most important risks affecting the system are related to the orgware aspects (39% of importance), followed by the finware aspects (25% of importance).

Once the clusters comparison had been conducted, it was necessary to study the problem in depth through the analysis of the elements by technical experts in the field of environmental assessment, history of architecture, social analysis, urban planning

Table 4
Influence matrix for the Opportunities subnetwork.

		CIVICWARE				ECOWARE			FW	G	HARDWARE					ORGWARE				SW
		IC	IK	PP	VI	HA	PT	PR	RV	PA	HE	AE	HP	HC	TR	ME	ND	EE	PE	CE
CIVIC-WARE	Initiatives in/about the castle (IC)			X		X				X	X									
	Initiatives kids and school (IK)									X										
	Pride of population (PP)									X	X							X		
	Vitality (VI)					X				X										
ECO-WARE	High quality agricultural area (HA)									X										
	Pathways (PT)									X			X							
	Protected sites (PR)						X			X										
FIN-WARE	Revenues for tickets (RV)									X	X			X						
GOAL	Positive aspects (PA)																			
HARD-WARE	Highways entrances/exits (HE)						X			X										
	Availability of services (AE)									X	X									
	Historical pathways (HP)									X										
	Historical centres (HC)									X										
	Public transportation (TR)									X										
ORG-WARE	Municipality events (ME)									X										
	Network density (ND)									X										
	External events (EE)			X						X										
	Permanent actors (PE)									X							X			
SOFT-WARE	Cconcentration of events (CE)			X						X	X	X				X				

Table 5
Priorities of the clusters according to the judgments expressed by the focus group.

Clusters	Opportunities subnetwork	Risks subnetwork
Orgware	0.13	0.39
Civicware	0.36	0.12
Ecoware	0.10	0.05
Finware	0.10	0.25
Hardware	0.22	0.12
Software	0.10	0.07

and economic feasibility. Each expert received a detailed questionnaire containing only questions about his own field of expertise with reference to the specific issue of the decision-making process. In a different way with respect to the focus group, which is based on the deep debate among the participants, interviews envisage interaction only between the interviewer and the interviewed. For example, a question submitted to a technical expert in the transport field was of the type:

With reference to the enhancement of the Valle d'Aosta castles, from the benefits point of view, which of the two aspects belonging to the cluster hardware is more important? And to what extent?

Accessibility 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 Level of services

Finally, according to the ANP methodology, it was possible to combine the numerical values coming from the evaluation at the cluster level with the results of the evaluation at the element levels in order to have the final priorities of the model (Fig. 4).

As it is possible to see from Fig. 4, according both to the judgments expressed by the Valle d'Aosta stakeholders included in the focus group and to the opinions of the different experts involved in the evaluation by mean of a questionnaire, the most beneficial element for the enhancement of the Valle d'Aosta castles' system is the pride of the population, belonging to the civicware cluster (20.1% of preferences in the priority list). This result is related to the strong attachment of the Valle d'Aosta population to its tradition and territory and can be read as a great interest in enhancing the castles especially for local inhabitants. The second most important beneficial element resulting from the evaluation concerns the accessibility, considering presence of trains, highways, etc. (10.9% of the preference in the priority list). It is interesting to notice that the element related to the events organized by the local authorities was considered not very important for the valorisation of the castles network (0.6% of the preference in the priority list).

With reference to the importance of the risks elements (Fig. 4, bottom), it is interesting to highlight that most risky element is related to the hierarchical structure of the relationships among the stakeholders (39% of importance in the priority list), followed by the element related to the financial performance of the system (25.5% of importance).

6.3. Results: aggregation and construction of the final maps

Following the MC-SDSS methodology, once the maps were obtained for each element and the factor weights were established, it was necessary to combine all the information in order to achieve the overall suitability map. In this case, a weighted linear

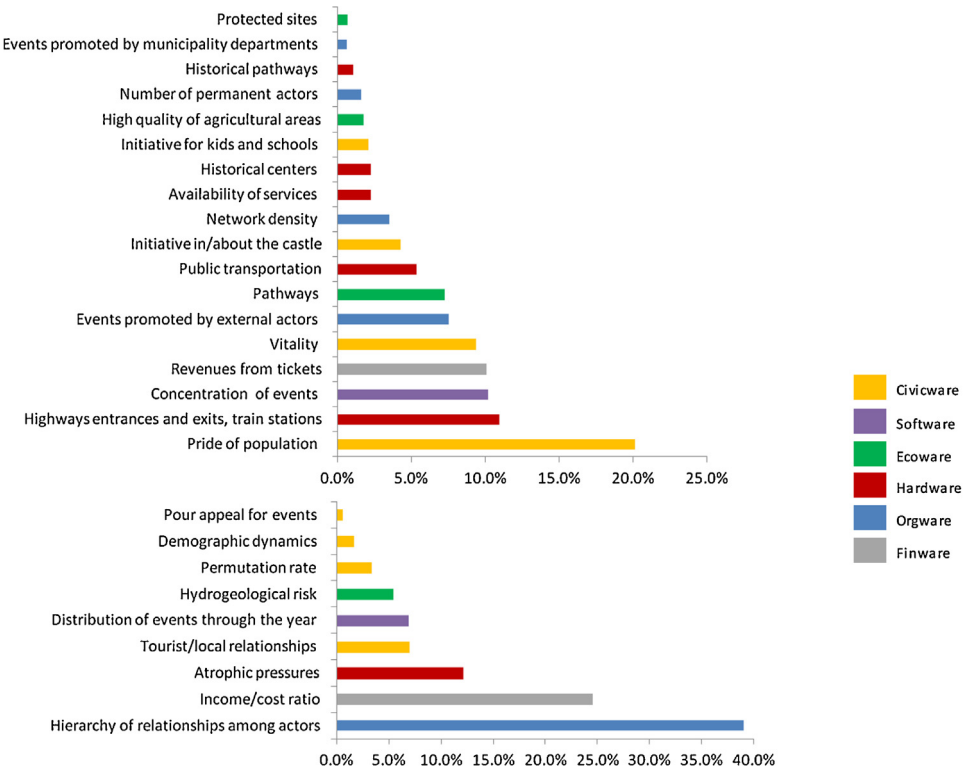

Fig. 4. Final priorities of the evaluation model (on the top priorities of the opportunities elements and on the bottom priorities of the risks element).

combination was used, combining the element maps according to the following formula:

$$S_j = \sum W_i X_i$$

where Sj represents the suitability for pixel j, Wi represents the weight of element i, and Xi represents the standardized criterion score of element i. The elements were combined by applying a weight to each, followed by a summation of the results in order to obtain a suitability map.

The results of the proposed study are represented by two maps highlighting the spatial distribution of opportunities and risks within the area under examination. These maps represent a first synthesis of negative and positive aspects for each ware obtained through the weighted overlay of all the elements that belong to that specific ware.

The analysis of the overall maps displays the existence of a spontaneous organization of clusters of three or four castles, which helps to create positive synergies because each castle can benefit from virtuous elements of other castles. In particular, the strongest cluster seems to be the western one, including the castles of Aymaville, Sarre, Saint Pierre and Sarriod de la Tour which is able to share in a good proportion all the existing positive aspects. On the other hand, the negative impacts due to the strong urban pressure given by Aosta city and its surroundings (i.e. highway, quarries, landfills) make the western clusters weaker than the others.

6.4. Sensitivity analysis

In order to test the robustness of the obtained results and to provide proper recommendations for the definition of new strategies for the castles' systems based on a clear understanding of the uncertainties involved in the modeling procedure (i.e. weighting phase), we developed a sensitivity analysis for the final maps. In particular, we simulated different points of view and thus created different scenarios by giving each time more weigh to one of the different aspects involved in the analysis and keeping the others less important and equally weighted, as shown in Table 6.

Table 6
Weights for the sensitivity analysis.

Scenario/ware	Eco-ware	Org-ware	Soft-ware	Civic-ware	Hard-ware
Balanced All the wares have the same importance	0.20	0.20	0.20	0.20	0.20
Social The most important role is assigned to the wares that are related to social aspects and to the involvement of people in castles vitality, i.e. civic-ware and soft-ware	0.1	0.1	0.35	0.35	0.1
Environmental Eco-ware related aspects are the more relevant in this scenario	0.40	0.15	0.15	0.15	0.15
Anthropic The most important element is Hard-ware privileging historical centers, accessibility and services	0.15	0.15	0.15	0.15	0.40

7. Conclusions

Although MS-SDSS find few applications in decision processes regarding cultural heritage, this paper suggests that interventions involving this kind of goods as leverage of local development should be addressed by a wide and integrated knowledge about territory. Because of their multifunctional nature, cultural goods call for systemic approaches. Moreover, strategies related to a network of historical assets located in mountainous areas require to be grounded on the examination of opportunities and risks at a large scale. Thus, they couldn't be good-based but they should pay a special attention to their impacts on environmental, cultural, social, and economic dimensions of the surrounding territory. From this perspective, MC-SDSS provide a multidimensional framework of analysis, evaluation and definition of future actions according to both tangible and intangible aspects.

The integration of multicriteria analysis techniques and geographic information system is crucial for developing a scenario for balanced enhancement policies for cultural heritage, especially in alpine regions due to their geographic constraints.

The methodology described in the present paper can be seen as an innovative approach in the field of decision making processes regarding cultural built heritage, since it considers the cultural and environmental resources as a system and it uses the evaluation as a cyclic activity aimed at finding out new development strategies. On one hand, the partial and the final evaluation maps represent an effort for clarifying the complexity of the reality in order to provide a rational basis for understanding complex information, on the other hand, they can play the role of a common knowledge platform. To this purpose, one must underline that the collection and interpretation of a huge amount of data and information from several sources within the intelligence step of MC-SDSS process might be considered as a starting point since it has produced a new layer of knowledge for decision makers, stakeholders and evaluators and has brought to a shared formulation of the decision problem.

The decision-makers engagement in the analytical phase is very helpful since the maps should be considered as dynamic picture to be updated according to the monitoring of territorial systems' change. Although the widely acknowledged advantages of developing a spatial decision support, some remarks are necessary. Giving space to intrinsic values is often a difficult task, since the system of collective meanings and relations behind the concept of cultural value is mostly qualitative and imprecise. As a consequence, the robustness of results of such an evaluation process depend on the involvement of a multiplicity of point of views into the analytical phase and on the way they interact within the different multicriteria analysis techniques. Increasing the transparency of the process, by putting in evidence subjectivity and incomplete information about intangible issues, is consistent to the notion of constructive evaluation process, though we know the policy-making process can be complex and uncertain.

The ANP method revealed to be suitable in representing the complexity of the decision problem under examination and allowed to perform trade-offs among the evaluation criteria, while taking into account the DM's preferences. The main drawback in the practical application of the ANP is a consequence of the complexity of the decision-making problem that has to be analyzed. To this end, the ANP prescribes a high number of comparisons that occasionally become too complex to understand for DMs who are not familiar with the method. Hence, a great deal of attention should be devoted to the elaboration of the questionnaires and the comparison process must be helped by a facilitator. With specific reference to the focus group, this proved to support the evaluation process in an efficient way. However, it has to be stated that the focus group can be characterized by possible biases, which affect in a negative way the final results. The most important problem arising from the method is related to the social influence, as every actor has not the ability to answer the question autonomously. On the contrary, it is possible to mention that without discussion an actor may not be sufficiently informed about the fact at stake and could therefore answer the questions in an inappropriate manner.

Finally, future developments of the present work will investigate the possibility of studying the problem under analysis according to the benefits, opportunities, costs and risks structure once more detailed data will be available for the different wares under investigation.

Given the complexity of the decision making environment as well the latent material and immaterial interests at stake in such policy a further research development should focus on a revision of such analytical and interpretative methods.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version.

References

[1] G. Gorla, Le determinanti economiche degli svantaggi relative della montagna, in: G. Cannata, G.G. Folloni, G. Gorla (Eds.), Lavorare e vivere in montagna, svantaggi strutturali e costi aggiuntivi, Bononia University Press, Bologna, 2007, pp. 5–26.

[2] R.L. Keeney, Value-focused thinking. A path to creative decision making, Harvard University Press, Cambridge, MA, 1992.

[3] OECD, OECD Territorial Outlook, OECD, Paris, 2001.

[4] E. Bowitz, K. Ibenholt, Economic impacts of cultural heritage. Research and perspectives, J. Cult. Herit. 10 (1) (2009) 1–8.

[5] M. Giaoutzi, P. Nijkamp, Tourism and regional development: new pathways, Ashgate, London, 2006.

[6] A. Rodríguez-Pose, M. Vilalta-Bufi, Education, migration, and job satisfaction: the regional returns of human capital in the EU, J. Econ. Geogr. 5 (5) (2005) 545–566.

[7] F. Leriche, S. Daviet, Cultural economy: an opportunity to boost employment and regional development? Reg. Stud. 44 (7) (2010) 807–811.

[8] S. Roodhouse, Cultural quarters: principles and practice, Intellect, Bristol, 2007.

[9] R. Camagni, Territorial capital and regional development, in: R. Capello, P. Nijkamp (Eds.), Handbook of regional growth and development theories, Edward Elgar, Cheltenham, 2009, pp. 118–132.

[10] J. Malczewski, GIS and multicriteria decision analysis, John Wiley and Sons, New York, 1999.

[11] J.R. Figueira, S. Greco, M. Ehrgott, Multiple criteria decision analysis: state of the art surveys, Springer, Berlin, 2005.

[12] J. Malczewski, GIS-based multicriteria decision analysis: a survey of the literature, Int. J. Geogr. Inf. Sci. 20 (2006) 703–726.

[13] V. Ferretti, Le Analisi Multicriteri spaziali a supporto delle procedure di pianificazione e valutazione: Analisi e classificazione della letteratura scientifica, Geoingegneria Ambientale e Mineraria 139 (2) (2013) 53–66.

[14] M.A. Sharifi, V. Retsios, Site selection for waste disposal through spatial multiple criteria decision analysis, J. Telecommun. Inf. Technol. 3 (2004) 28–38.

[15] E. Avrami, M.R. Mason, M. de la Torre, Values and heritage conservation: research report, The Getty Conservation Institute, Los Angeles, 2000.

[16] A. Klamer, The values of cultural heritage, in: I. Rizzo, A. Mignosa (Eds.), Handbook on the economics of cultural heritage, Edward Elgar, Cheltenham, 2013.

[17] P. Bourdieau, Forms of capital, in: J.G. Richardson (Ed.), Handbook of theory and research for the sociology of education, Greenwood, New York, 1986.

[18] D. Throsby, Cultural capital, J. Cult. Econ. 23 (1999) 3–12.

[19] M. Vecco, A definition of cultural heritage: from the tangible to the intangible, J. Cult. Herit. 11 (3) (2010) 321–324.

[20] The Burra Charter 1979, downloaded from http://austarlia.icomos.org website, January 2015.

[21] Krakow Charter 2000, downloaded from http://www.fcpcrv.com/website, 2014.

[22] D. Throsby, Economics and culture, Cambridge University Press, Cambridge, 2001.

[23] R. Mason, Economics and Heritage Conservation: Concepts, Values, and Agendas for Research, in: Economics and heritage conservation, The Getty Conservation Institute, Los Angeles, 1999, pp. 2–18.

[24] M. Cerreta, R. Mele, A landscape complex values map: integration among soft values and hard values in a spatial decision support system, in: B. Murgante, et al. (Eds.), ICCSA 2012, Part II, Springer, Berlin, 2012, pp. 54–70.

[25] V. Ferretti, M. Bottero, G. Mondini, Decision making and cultural heritage: an application of the multi-attribute value theory for the reuse of historical buildings, J. Cult. Herit. (2014), http://dx.doi.org/10.1016/j.culher.2013.12.007.

[26] V. Ferretti, M. Bottero, G. Mondini, An integrated approach for exploring opportunities and vulnerability of a complex territorial system, in: B. Murgante, et al. (Eds.), ICCSA 2014, Part III, LNCS 8581, 2014, pp. 667–681.
[27] S. Ercolano, F. Monacciani, P. Rostirolla, Assessing plans and programs for historic centers regeneration: an interactive multicriteria approach, in: A.G.S. Ventre, A. Maturo, Š. Hošková-Mayerová, J. Kacprzyk (Eds.), Multicriteria and multiagent decision making with applications to economics and social sciences, Springer, Berlin, 2013, pp. 151–162.
[28] B. Harmon, H. Viles, Beyond geomorphosites: trade-offs, optimization, and networking in heritage landscapes, Environ. Syst. Decis. 33 (2) (2013) 272–285.
[29] A. Tarragu-el, B. Krol, C. van Westen, Analysing the possible impact of landslides and avalanches on cultural heritage in Upper Svaneti, Georgia, J. Cult. Herit. 13 (2012) 453–461.
[30] L. Fusco Girard, P. De Toro, Integrated spatial assessment: a multicriteria approach to sustainable development of cultural and environmental heritagein San Marco dei Cavoti, Italy, CEJOR 15 (2007) 281–299.
[31] E. De Noronha Vaz, P. Cabral, M.M. Caetano, P. Nijkamp, M. Painho, Urban heritage endangerment at the interface of future cities and past heritage: a spatial vulnerability assessment, Habitat Int. 36 (2) (2012) 287–294.
[32] M.A. Hamadouche, K. Mederbal, L. Kouri, Z. Regagba, Y. Fekir, D. Anteur, GIS-based multicriteria analysis: an approach to select priority areas for preser-vation in the Ahaggar National Park, Algeria, Arab J. Geosci. 2 (2014) 1–16.
[33] M. Cerreta, S. Panaro, D. Cannatella, Multidimensional spatial decision-making process: local shared values in action, in: B. Murgante, et al. (Eds.), ICCSA 2012, Part II, Springer, Berlin, 2012, pp. 54–70.
[34] P. Nijkamp, P. Rietveld, H. Voogd, Multicriteria analysis in physical planning, North-Holland Publ. Co., Amsterdam, 1989.
[35] T.L. Saaty, Theory and applications of the analytic network process, RWS Publications, Pittsburgh, 2005.
[36] A. Ishizaka, P. Nemery, Multi-criteria decision analysis: methods and software, Wiley, Chichester, 2013.
[37] E. Beinat, Value functions for environmental management, Kluwer Academic Publishers, Dordrecht, 1997.
[38] D.L. Morgan, Focus group as qualitative research. University series on qualitative research methods, Vol. 1, Beverly Hills, Sage, 1998.
[39] D.L. Morgan, R.A. Krueger, When to use focus groups and why, in: D.L. Morgan (Ed.), Successful focus group: advancing the state of the art, Newbury Park, Sage, 1993.
[40] D.W. Stewart, P. Shamdasani, Focus group theory and practice, Newbury Park, Sage, 1990.
[41] A. Ishizaka, A. Labib, Selection of new production facilities with the group analytic hierarchy process ordering method, Expert Syst. Appl. 38 (6) (2011) 7317–7325.
[42] I.M. Lami, F. Abastante, M.M. Bottero, E.E. Masala, S. Pensa, A MCDA and data visualization framework as a problem structuring method (PSM) to address transport projects, Euro J. Decis. Processes 2 (2014) 281–312.