[Article] Strategic Management Plan Evaluation of a River Basin District

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Strategic Management Plan Evaluation of a River Basin District

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Abstract

Purpose: In strategic planning and management of environmental resources, traditional multicriteria analysis are usually adopted for evaluating alternative development scenarios against a set of criteria. However, the modeling of the problem is often inadequate to represent the complexity which characterized the decision. For overcoming this problem, this paper suggests the application of an advanced version of the Analytic Hierarchy Process: the Analytic Network Process (ANP).

Methodology: The ANP is the first mathematical approach that makes possible to systematically deal with all kinds of dependencies and feedback among elements. It requires the identification of a network of clusters and nodes, as well as pair-wise comparison to establish relations within the network elements. The number of comparisons is dependent upon the number of interrelations among the elements.

Findings: The method is applied to the Strategic Management Plan of River Po Basin, in Italy. The result obtained is a surprising ranking which places major weight to the cultural heritage and landscape rather than to traditional environmental categories, such as land and water. This result reflects the recent River Po Basin Authority strategy to institute an integrated and coordinated policy action in the field.

Originality/value. The proposed approach has improved the integration of the strategic evaluation in the decision making process within the management of territorial development policies, thanks to a better representation of the interrelations among issues within the decision model.

Keywords analytic network process, strategic planning evaluation, water management

Paper type research paper

1 Introduction

Strategic planning and management of environmental resources is a complex activity which usually requires the application of multi-criteria analysis (MCA) for evaluating alternative development scenarios against a set of decisional criteria. In particular, planning and management of water and river basins usually deals with multiple and conflicting issues which are concerned with territorial, economic, environmental, social components. The list of issues mentioned by the EU Directive on Strategic Environmental Assessment, SEA (SEA Directive 2001/42/EC) includes, alongside 'traditional' issues such biodiversity, flora and fauna, population, health, water, soil, landscape, aspects related to mobility, energy efficiency, climatic change which are more closely linked to human activities and their impacts on the eco-system. These issues are often interrelated and dependencies can be recognized among the aspects involved.

More specifically, in river basin district planning and management, the selection of environmental objectives is influenced by the complex reciprocal interactions between the river basin district conditions and the human (social, economic and cultural) activities. Unfortunately, traditional multicriteria decision-aid techniques are generally based on linear or hierarchical analytical schemes which seem inadequate to represent the complexity which characterized the decision in the field.

The paper suggests the application an innovative promising approach, named Analytic Network Process (ANP), an advanced version of the Analytic Hierarchy Process developed by Thomas Saaty in Pennsylvania. The ANP is the first mathematical theory that makes possible to systematically deal with all kinds of dependencies and feedback among decision elements (Saaty, 2001; 2005). This model seems more appropriate for representing and supporting decision making in this area because it provides an identification of all the clusters of elements involved in the decision. In addition, it allows pair-wise comparison between the aspects. This method has been successful applied to a real case study: the Strategic Management of River Po Basin District, in Italy

The paper is structured as follows. Section two discusses the problems related to the strategic evaluation of river basins and water resources according to the SEA, highlighting the need for more appropriate evaluation methodologies; sections three presents the case study and the ANP application; finally, section four discusses the results and provides some conclusions.

2 The Strategic Evaluation of River Basin Management Plans

In 2000 the European Parliament and the European Council passed the Water Framework Directive (WFD) to be implemented in the Member States, among these Italy. The consequence of the directive is that the authorities shall prepare River Basin Management Plans (RBMPs), which according to European and Italian legislation are subject to a Strategic Environmental Assessment (SEA) (Larsen and Kørnøv, 2008).

The purpose of the SEA-Directive (2001/42/EC) is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and before their adoption. In particular, the SEA Directive requires that a preliminary environmental assessment be carried out in order to ensure that environmental issues are taken into consideration at the early stages of discussing and preparing plans and programs, and to guarantee that the changes in an area are correlated with the achievement of an acceptable level of sustainability. Specifically, the Directive states that environmental assessment must be integrated into the preparation of plans and programs, before their adoption or submission to the legislative procedure.

The introduction of this Directive, preceded in Italy by Legislative Decree 11th May 1999, No. 152 (DLG 152/99), which foreshadowed some of its basic concepts, completed the regulatory framework governing the use and protection of water resources, making several substantial changes. In addition to safeguarding aquatic ecosystems and wetlands depending directly on them and promoting sustainable use of water resources (and hence reducing water pollution), the general goals set out by the Directive include protecting water resources and mitigating the effects of extreme events such as floods and droughts.

The specific environmental objectives indicated by the Directive differ according to the water system and its context. Thus, the Directive identifies three types of system: surface water, ground water and protected areas. Management programs and initiatives for protecting water resources focus on individual river basins or on river basin districts in cases where the intent of the Directive can be more effectively served by considering the higher-level water system.

The main tool contemplated by the Directive is the River Basin Management Plan (RBMP), which plans and schedules the action and requirements for the conservation and stewardship of the soil and the correct use of water resources on the basis of the physical and environmental characteristics of the geographical area concerned. Its specific content and aims reflect the range and complexity of the issues to be dealt with, as well as the plan's innovative scope. The river basin is seen as the basic ecosystem unit for all aspects of water governance (Larsen and Kørnøv, 2008). Responsibility for drawing up the plan lies with the River Basin Authority.

The Community Directive states that environmental assessment must be integrated into the preparation of plans and programs, before their adoption or submission to the legislative procedure. As part of a planning process of this kind, environmental assessment must in turn interact closely with the dynamics of the changes and the measures implemented in and for the areas concerned. This means that it must also be seen as an on-going process, keeping pace with the construction of environmental sustainability scenarios that are consistent with the economic and social conditions that prevail in these areas (Forsyth, 2003; Therivel, 2004).

In river basin planning and management, the SEA procedure is designed to adapt to the processes of change in the territorial and planning systems, and thus has the flexibility needed to support the process as it moves forward (Hirji and Davis, 2009). Consequently, the SEA can be defined as a "systematic process for evaluating the environmental consequences of proposed policy, plan or program initiatives, in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision making on par with economic and social considerations" (Sadler and Verheem, 1996), it must be capable of furthering the progress of the planning process. In this sense, the SEA complies in full with the first four articles of the Directive, as specified in the Common Implementation Strategy (CIS) for the Water Framework Directive (CIS, 2003; 2006), and gains additional value when interpreted as an integration strategy which encourages political decision-makers to bear environmental considerations in mind when formulating a policy, plan or program.

Since the SEA is a flexible process rather than a specific method, there is not a precise analytical methodology. This process usually varies from sector to sector and from case to case (Sheate et al., 2006). Methodologies have to be selected in each application to cover each of the different stages of the process. These include scenario exercises, systems analysis, risk assessments, life-cycle assessments, economic appraisal tools, surveys (expert judgements), stakeholders engagement, environmental impact matrices and multi-criteria analysis (Ehrhardt and Nilsson, 2006; Deakin et al., 2007). The latter is particularly used for selecting and ranking preferred choices alternatives in river basin districts plans.

Unfortunately, the large number of MCA methods currently available and the lack of specific hints on the 'best' or preferred method to be used for a specific planning or management problem, do create difficulties in practice (Deakin et al., 2002; Figueria et al., 2005; Muller and Patassini, 2005; Kazmierczak et al., 2007). An additional complication in the adoption of MCA methods in planning and management is the rigid hierarchical structure underlying most of these methods which does not sufficiently reflect the interdependences among aspects recognized in decision making problems related to water planning and management (Brandon and Lombardi, 2005; Bottero et al., 2008).

This paper does not specifically deal with the problem of selecting the appropriate method for the right problem (see Lombardi, 1997), but it suggested the application of a new promising MCA method, named Analytic Network Process – ANP, an advanced version of the Analytic Hierarchy Process – AHP, which seems able to better tackle and reflect the complexity of a decision making problem in the field of water management without reducing it to a hierarchy structure (Saaty and Vargas, 2006). See also Table 1 for a synthetic description of the main differences between MCA, AHP and ANP. More specifically, this study shows an application of the ANP to the evaluation of strategic environmental resources for the River Po Basin District Management Plan by using a more coherent and consistent network representation of the decision elements. In the next section, the case study and the ANP application are described.

3 The Po Basin District Plan Case-Study

3.1 Description of the case study

The Po basin district extends through Liguria, Piedmont, Valle d'Aosta, Lombardy, Trentino, Veneto, Emilia-Romagna and Tuscany, and also penetrates into parts of France and Switzerland (see Figure 1). Consequently, there are municipalities whose territory lies entirely in the Po basin and, along the basin's edges, municipalities with a certain proportion of territory lying within it.

For several years, the Po River Basin Authority has been working to achieve safer conditions for the Po valley's inhabitants, protect the riparian corridors, improve the ecological network and preserve the quality and quantity of water resources, while at the same time promoting river tourism and public access to environmental, historical and cultural resources. All of the objectives set by the River Basin Authority are outlined in the Po River Valley Special Strategic Project, or SSP (Autorità di Bacino del Po, 2008), in which the Authority has attempted to institute an integrated policy of action for protecting the soil, safeguarding water and environmental resources and valorising the area which goes beyond a disjointed, piecemeal approach, to centre on the coordinated, synergistic use of the various available tools.

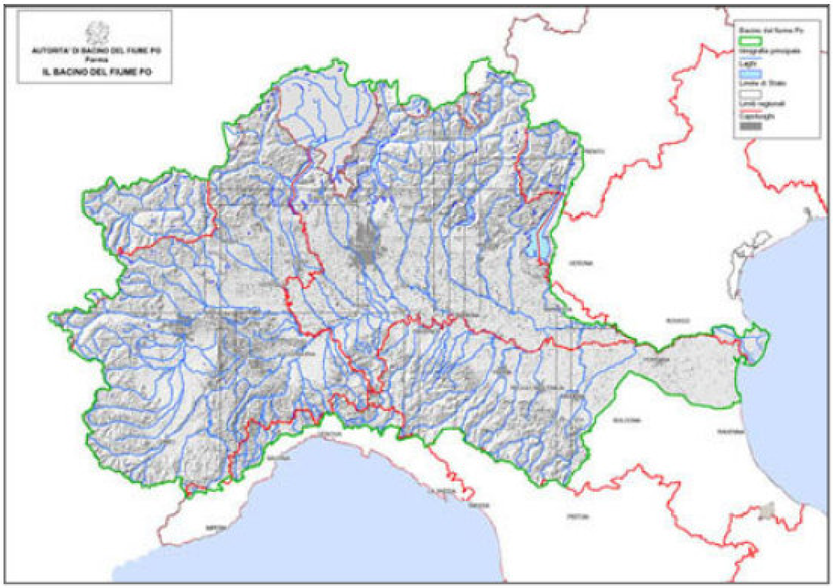

Figure 1: The River Po District

The SEA process is one facet of the SSP development process, in which preliminary studies of its sustainability and compliance with strategies fielded by Community, national and regional policies have already been carried out. It is also part of the River Basin Authority's efforts to ensure that planning activities continue to reflect the latest European Directives. This Project, in fact, aims to establish methods and procedures capable of guaranteeing the effective implementation of Directive 2001/42/EC on the assessment of the effects of certain plans and programs on the environment. More specifically, the SSP project calls for four areas of action:

Area 1. Watercourse restoration, increases in riparian corridor buffer capacity and flood bed reshaping;

Area 2: Conserving the ecological integrity of the riparian corridor and the Po's water resources;

Area 3: System of utilization and of cultural and recreational services;

Area 4: System of governance and of intangible networks for knowledge, education and participation.

This project is the first of its kind in Italy, as a strategic environmental assessment of the SSP is to be conducted to ensure full compliance with sustainability criteria, including those embodied in the recent corrections and additions introduced by Legislative Decree 152/2006 (DLG, 2006), the so-called Environmental Code. As part of a planning process of this kind, environmental assessment must in turn interact closely with the dynamics of the changes and the measures implemented in and for the areas concerned. This means that it has to be seen as an on-going process, keeping pace with the construction of environmental sustainability scenarios that are consistent with the economic and social conditions that prevail in these areas. Consequently, it must be capable of furthering the progress of the planning process. As used in river basin planning and management, then, the SEA process is to be designed to adapt to the processes of change in the territorial and planning systems, and thus it requires the flexibility needed to support the process as it moves forward.

In this context, a ANP evaluation has been conducted with the aim to prioritize both the environmental strategic actions (i.e. the actions included in the above mentioned 1, 2 and 3 areas of the SSP) and the environmental categories included in the Po River SSP by using a coherent and consistent network representation of the decision elements.

As better illustrated in the next section, the evaluation was conducted inside a focus group, composed by the supervisors of the River Basin Authority Pilot Project and the members of the work group in charge for the evaluation of the project, at the Po River Basin Authority in Parma on May 21, 2008.

3.2 The ANP methodology

Inside the large 'family" of MCA (Figueira et al., 2005), the Analytic Network Process (ANP) is the only decision support method which makes possible to deal systematically with all kinds of dependencies and feedback. The model consists of clusters (i.e. groups of homogeneous elements of a decision problem), elements (i.e. nodes of the network), interrelationship between clusters, and interrelationship between elements. It allows interactions and feedback within and between clusters and provides a process to derive ratio scales priorities from the elements.

Synthetically, the methodology involves the following steps (Saaty, 2001; 2005).

i. Structuring the decision-making model. This activity involves an identification of both the elements constituting the decision problem and their relationships. The network model is constituted by various clusters of elements, and alternatives or options from which to chose. Each element can have influence and inter-dependence relations: it can be a "source", that is an origin of a path of influence, or a "sink", that is a destination of paths of influence. There are two possible modelling approaches to ANP: the BOCR (Benefits, Costs, Opportunities, Risks) approach, suggested by Saaty (Saaty and Vargas, 2006), which allows to simplify the problem structuring by classifying issues into traditional categories of cost and benefit; and a free-modelling approach, which may better reflect the complexity of a problem. The latter was adopted in this case study.

ii. Developing pairwise comparison of both elements and clusters to establish relations within the structure. In this step, a series of pairwise comparisons are made by participants to the decision making process (usually experts, managers and citizens representatives) to establish the relative importance of decision elements with respect to each component of the network. In pairwise comparisons, a ratio scale of 1-9 number is used (named, fundamental scale or Saaty' scale). The numerical judgments established at each level of the network form pair matrixes which are used to derive weighted priority vectors of elements (Saaty, 2001).

iii. Achievement of the final priorities. To obtain the global priority vector of the elements, including the alternatives, the mathematical approach encompass the use of "supermatrices" (portioned matrices composed by sub-matrices consisting of priority weight vectors of the elements which have been evaluated). A final supermatrix is obtained at the end of the process, containing the global priority vector of the elements.

In the following, the above steps are described with reference to the case study:

3.3 The problem structuring

The decision problem to be addressed corresponds to the objective: "The Po as a territorialized and integrated system". This objective is broken down into a number of decision elements which were then grouped together into four clusters (see Figure 2).

The first cluster consists of the elements to be evaluated, viz., the environmental categories (evaluation topics), which will be verified and ordered according to priority. These include:

1) Water resources;

2) Soil;

3) Flora, fauna, biodiversity;

4) Landscape, environmental and cultural assets, rural spaces;

5) Hydro-geological risk.

The additional three clusters are represented by the areas of actions included in the SSP, broken down into the individual actions, i.e., the nodes or elements in the cluster. More specifically, these are:

Area 1 - *Watercourse restoration, increases in riparian corridor buffer capacity and flood bed reshaping:* a. Rebalancing the river's sediment transport and morphological dynamics; b. Increasing floodplain areas;c. Improving the riverbank system.

Area 2 - *Conserving the ecological integrity of the riparian corridor and the Po's water resources:* d. Increasing biodiversity and creating an riparian ecological network.; e. Increasing knowledge which will be instrumental in controlling the pollutant loads carried by the river in different hydrological conditions (low and high water): f. Increasing the amount of water available for environmental purposes; g. Limiting saltwater intrusion into the delta branches.

Area 3 - *System of utilization and of cultural and recreational services*: h. Valorizing the river area's natural and cultural heritage; i. Improving the usability of the river and surrounding area by offering integrated services and other means; l. Increasing the river system's image and appeal to tourists.

The expected end result of this application is a ranking in terms of importance of all the decision elements included in the network, and the prioritized environmental categories in particular.

After identifying the nodes of the problem, the relationships of influence in the network were structured. This involved identifying the links between the various elements in the network, or, in other words, the relationships and the directions of influence between the decision elements. The relational model is shown schematically in Figure 2. One of the first relationship of influence that can be identified is that exerted by the criteria belonging to the areas of action on the alternatives. As it was assumed that the alternatives are influenced by the elements making up the clusters, an arrow goes from each "area of action" cluster towards the "environmental categories" cluster. It was also assumed that the environmental categories can influence the nodes of the three SSP areas-of-actions clusters; accordingly, a second arrow was placed in the direction of each area-of-actions cluster. In addition, links were found between nodes belonging to different clusters. In the diagram, these links are again represented by arrows. Finally, the third type of relationship consists of the links between nodes in the same cluster ("loop"), which are represented by a curved starting from the cluster and returning to it, which denotes the effect of feedback. The links between activities (nodes) in the different areas (clusters) are also shown in Table 1.

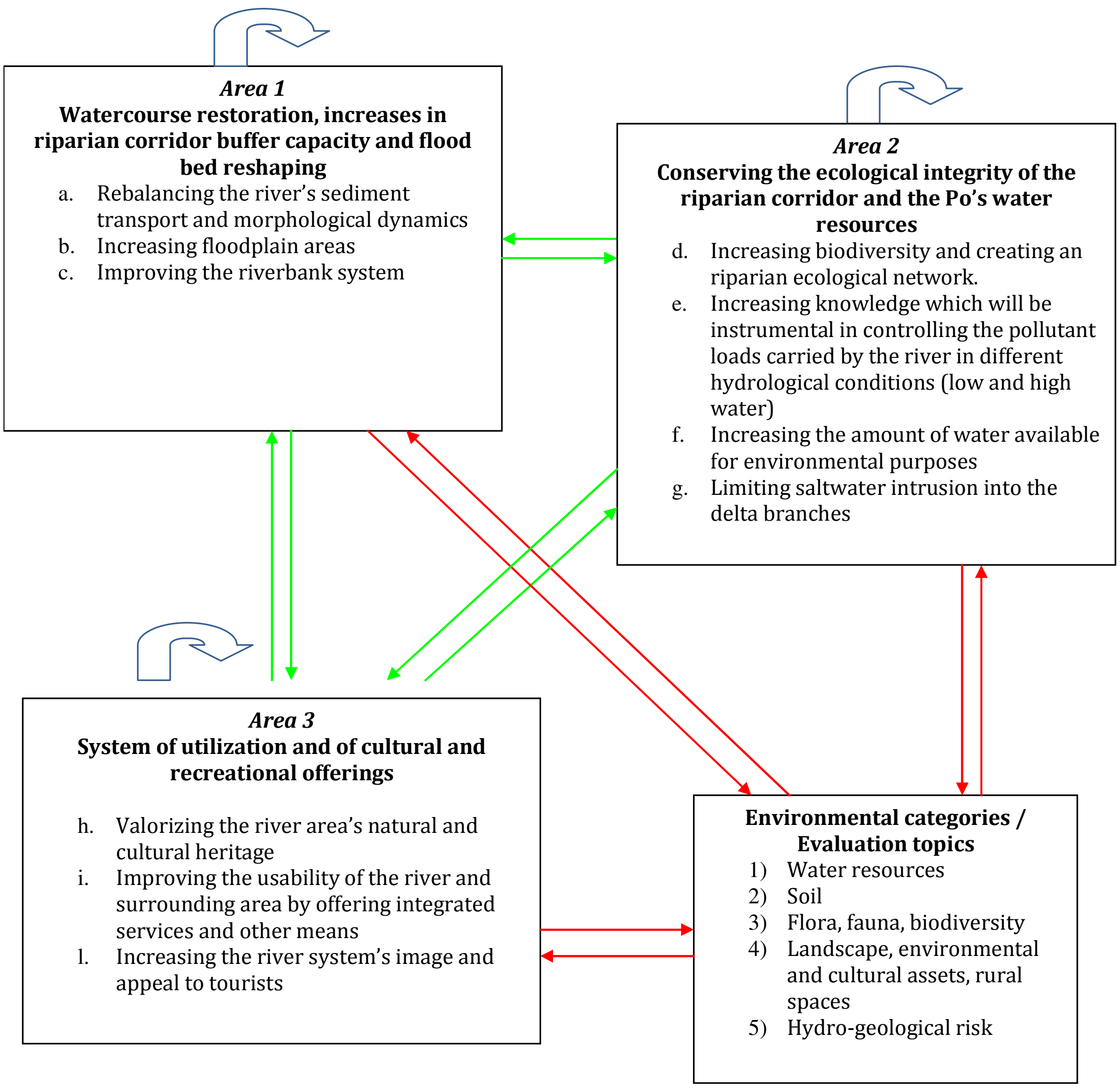

Figure 2: The network model.

Table 1: Interrelations between the nodes in the three SSP areas of actions

AREAS/ACTIONS		AREA 1			AREA 2				AREA 3		
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**l**
AREA 1	**a**		X		X			X	X		X
	b	X		X	X			X	X		
	c		X								
AREA 2	**d**	X	X			X	X	X	X		X
	e				X			X		X	X
	f				X			X			
	g		X		X	X	X		X	X	X
AREA 3	**h**	X	X	X	X	X	X	X		X	X
	i								X		X
	l								X	X	

3.4 Pairwise comparison and weight estimation

The application of a ANP requires pairwise comparison and relative weight estimation, as in the standard AHP. The determination of relative weights is based on the pairwise comparison (Saaty, 2001). These give to the decision makers a basis to reveal their preference by comparing two elements.

Pairwise comparisons of the elements at each level are conducted with respect to their relative importance towards control criterions (nodes) or clusters. In this case study, each node of the clusters has been assessed with regard to the node placed at the top of the model. For instance, at the level of alternatives, it has been asked: “what environmental category is more important between water and soil with regard to the criterion (a): "rebalancing the river sediment's transport etc. and how much?”.

The experts involved in this evaluation process had the option of expressing preferences between the two as equally preferred, weakly preferred, strongly preferred, or absolutely preferred, which have been translated into pairwise weights of 1, 3, 5, 7 and 9, respectively, with 2, 4, 6 and 8 as intermediate values.

This assessment process has been developed for all the elements in the clusters and, subsequently, a “supermatrix” of paired comparisons and its normalisation by cluster, has been developed in accordance to the ANP procedure (Saaty, 2001). The application has been developed using the specific software available on: http://www.superdecisions.com/.

3.5 Final ranking and discussion of the results

The first result obtained is the final ranking of the SSP actions included in the decision making model as network nodes. This ranking is illustrated in Figure 3. The length of the bars in this figure shows that the most important criterion is belonging to the Area 3, related to the issues of cultural and recreational system, named “valorising the river area’s natural and cultural heritage” (h), with a weight equal to 0.551. Next important elements are related to the areas 1 and 2, focusing on protection, restoration and conservation, as follows: the node “increasing floodplain areas” (b), belonging to Area 1 (watercourse restoration, increases in riparian corridor buffer capacity and flood bed reshaping) has achieved a weight equal to 0.475; the node “rebalancing the river’s sediment transport and morphological dynamics” (a), belonging to the same Area 1 has been weighted equal to 0.445, and the node “increasing the amount of water available for environmental purposes” (g), belonging to Area 2 (conserving the ecological integrity of the riparian corridor and the Po’s water resources), with a weight equal to 0.434. These results reflect the River Po Basin Authority attempt to institute an integrated and coordinated policy of actions in both the fields of protection and valorisation of the environmental resources.

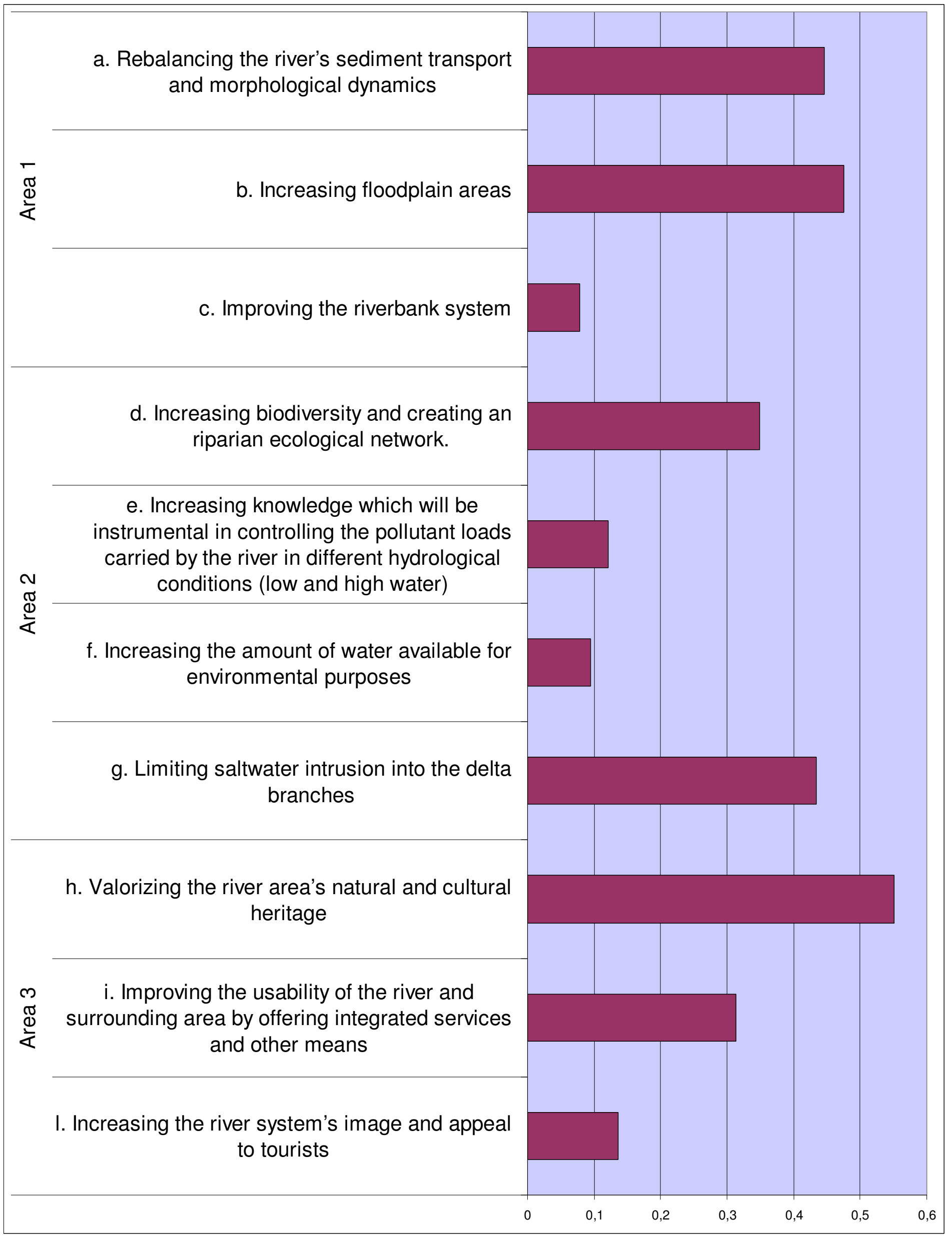

Figure 3: Weights of evaluation criteria

The second main result of this analysis is the final ranking of the environmental categories included in the alternatives cluster. This is illustrated in Figure 4. The highest position is occupied by the landscape and cultural heritage (43%), followed by water (27%). The theme of flora, fauna and biodiversity is as much important as the hydro-geological risk (13%) while the soil (3%) is the last one in the list.

These findings, specifically the highest priority attributed to cultural heritage and landscape, are quite unpredictable since the River Basin Authority primary deals with traditional environmental categories of water and soil. From a logical viewpoint, however, the result reflects the higher weight assigned to the criterion (h) on valorisation in Area 3 rather then conservation (Area 2).

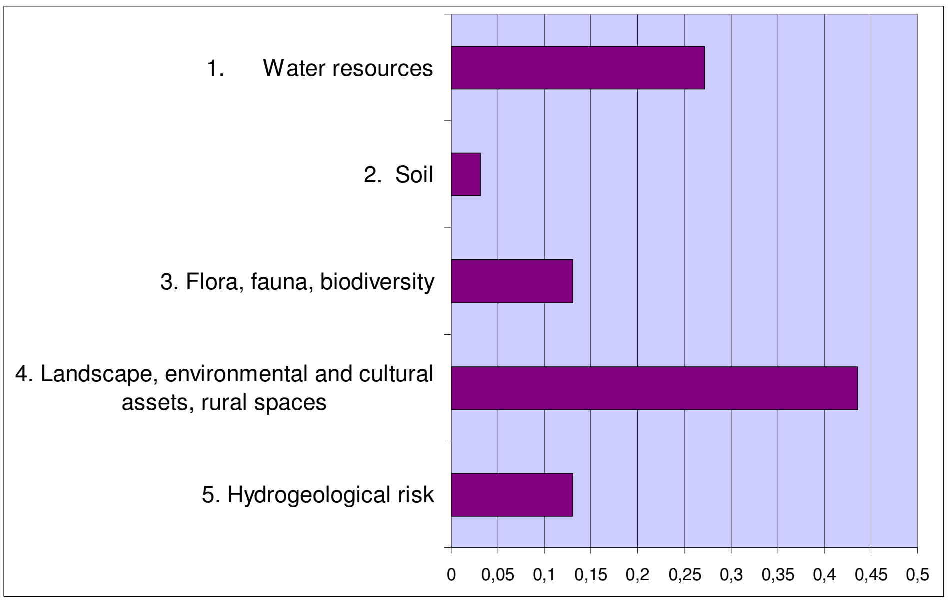

Figure 4: Final ranking of the environmental categories

4 Conclusive remarks

This paper has illustrated an application of the ANP to the SEA of the Italian Strategic River Po Basin Plan. As far as the author of this paper concerns, this represents the first case study in the filed water management strategic assessment at international level.

Traditionally, the evaluation of water planning and management issues is conducted by adopting conventional impact assessment techniques and MCA which are based on bi-dimensional (matrices) and hierarchical schemes. These do not allow an interrelated and holistic assessment of all the components, including those within the same cluster which may led to rank reversal result findings. The evaluation approach for the alternative environmental strategic objectives carried out in this case study, on the contrary, has been based on an innovative methodology, the ANP model, which makes possible interactions and feedback among decision elements. This has allowed a more realistic representation and weights estimation of the complex reciprocal interactions between the water district conditions and the human (social, economic and cultural) activities. Therefore, it has been able to better reflects the spirit and recommendations included in the recent norms and regulations related to SEA and RBMPs.

The results obtained have shown a strengthened integration of the strategic environmental issues within the management of sustainable regional development policies, pinpointing the need for a deeper valorisation of landscape and cultural heritage. These findings support the strategies underlying the recent policy actions delivered by the Po Basin Authority, providing an additional aid toward the achievement of integrated policies for the long-term sustainability and resilience of the Po District.

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Biography-note of Patrizia Lombardi

Associate Professor/Doctor Patrizia Lombardi is a leading expert in the use of environmental assessment methods and an established figure in the field of evaluating sustainable development for over 20 years, publishing widely in the subject area and coordinating, or serving as lead partner, in several Pan-European Projects.