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Exploring the environmental value of ecosystem services for a river basin through a spatial multicriteria analysis

Elena Comino [a,*], Marta Bottero [b], Silvia Pomarico [b], Maurizio Rosso [a]

[a] Department of Environment, Land and Infrastructure Engineering (DIATI), Politecnino di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy
[b] Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico di Torino, Viale Mattioli 39, 10125 Torino, Italy

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ABSTRACT

Environmental quality preservation and nature conservation are complex land use planning problems, involving not only environmental aspects but also socio-economic and operational factors and represent ecosystem services of fundamental importance to human well-being, for health, livelihoods and survival. The present paper proposes a Multicriteria Spatial Decision Support System (MC-SDSS) development for the assessment of the environmental quality of the river basin of the Pellice river in the Province of Turin (Italy) with the objective of increasing awareness of environmental issues in the territorial planning phase. In order to fulfill this goal, the environmental quality issues were divided into two main aspects, "naturalness" and pressures", which represent the strengths and the weaknesses of the territory. Different criteria were considered for each theme and were integrated into composite maps by a weighted linear combination of factors resulting from a focus group with several experts in different fields. The results of this approach generated a final suitability map of the study area. The map identifies some critical zones that need mitigation measures and highlights areas with high environmental quality which require future specific monitoring procedures and valorization actions. The application was performed by means of the IDRISI software. This paper is based on an integrated approach which facilitates the comprehension of complex phenomena and aims at exploring innovative MCDA models in the field of the environmental quality preservation assessment of territorial transformation.

Introduction

Ecosystems provide a range of services, many of which are of fundamental importance to human well-being, for health, livelihoods, and survival (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005; TEEB Fundations, 2010; De Groot et al., 2012). Ecosystem degradation and the loss of biodiversity undermine ecosystem functioning and resilience and thus threaten the ability of ecosystems to continuously supply the flow of ecosystem services for present and future generations (De Groot et al., 2012). Consequently, the ecosystem services concern has gained a great and steadily rising attractiveness for environmental scientists, land managers and decision makers (Müller and Burkhard, 2012).

Although the importance of ecosystems to human society, the economic and ecological assessment of ecosystem services is rarely recognized or included in development and land use policies. Expressing ecosystem service values in monetary units also facilitate the integration of environmental concerns into economic decisions in particular with reference to plans and projects of land transformation in order to orient the choices toward a sustainable development.

Sustainable development is widely accepted as a strategy in the planning decision making (IUCN, 1994). However, ecological sustainability is not yet well integrated in the landscape planning and the explicit inclusion of ecological issues in this field represents a recent development (Ahern, 2002). There is a lack of quantitative methods capable of assessing ecological value that can effectively support the process of planning and strategic environmental assessment of plans and projects (Marulli and Marallach, 2005). New planning tools are necessary to preserve and increase the ecological value of natural fragmented landscape (Bruel and Baudry, 1999) and estimate the economic value of ecosystem services in order to achieve integrated planning of the territory that pursues the principles of sustainable development (Bennett, 1991).

In this context, this paper presents a Multicriteria Spatial Decision Support System (MC-SDSS, Malczewski, 1999) in order to provide an assessment of the ecosystem services ecological and economic value. In particular, the object of this paper is to explore

* Corresponding author. Tel.: +39 0110907647; fax: +39 011 5647699.
E-mail addresses: elena.comino@polito.it (E. Comino), marta.bottero@polito.it (M. Bottero), silvia.pomarico@polito.it (S. Pomarico), maurizio.rosso@polito.it (M. Rosso).

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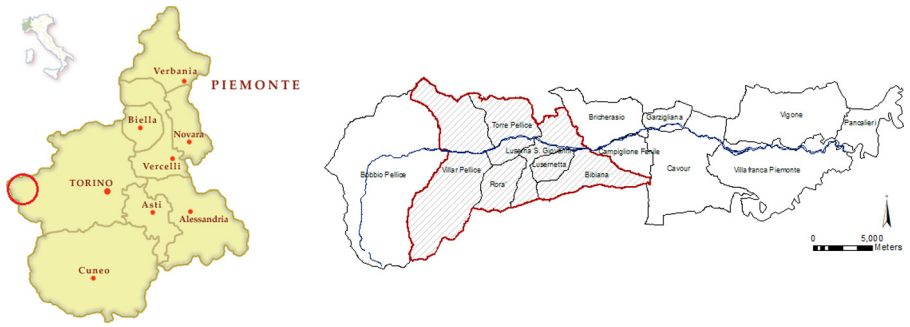

Fig. 1. Territorial context of area under examination and Pellice Torrent river basin. The area under analysis is part of the Pellice Valley which belong to the Piedmont Region in Northern Italy. The area of interest in the river basin of Pellice Torrent has a surface of 138 km^2 and includes the municipalities of Villar Pellice, Torre Pellice, Rorà, Luserna San Giovanni, Lusernetta and Bibiana.

the use of this tool for the analysis of the environmental quality of the river basin with particular reference to the issue of nature conservation and anthropic and natural pressures, and to support both the planning and management processes. The MC-SDSS model was applied to the river basin of the Pellice River[1], which is located in the Province of Turin (Italy) and the application was performed by means of the IDRISI software.

Case study and research objective

The area studied in this research is a part of the Pellice Valley, which belongs to the Piedmont Region in Northern Italy. The valley lies within the Northern Hautes Alpes territory (France) and converges to the Monviso mountain in the Province of Turin.

The alpine valley coincides with the catchment of the Pellice River, which is the first tributary of the Po River. It flows over a total length of 60 km. In the case study, the area is a specific zone of the hydrographic catchment area which covers a surface of 138 km^2 (Fig. 1).

This area is characterized by an important vegetation coverage which makes the Pellice valley one of the most wooded Italian valleys. The presence of a rich forest landscape and of two Sites of Community Importance (SCI) (European Commission, 2001) gives the territory a particular natural and environmental value. Furthermore, presence of the river gives the area a great ecological value, because it represents an ecological corridor characterized by linearity and organized into complex networks, that need to be protected (European Commission, 2001).

From the spatial planning point of view, the urban areas are mostly concentrated in the Western portion of the basin; this is due to the high degree of urbanization along the plain zone of the Pellice River. In addition to the main settlements, the area presents a widespread distribution of small urban areas.

The final outcome of the analysis will be a suitability map of the area under examination that is able to highlight the most important zones for environmental quality preservation due to their naturalness value. This will support the decision-making process concerning river basin planning and management, highlighting the areas to be conserved and restored and those to be valorized. The methodology generates thematic maps to be used as decision variables during the planning phase, in order to assess the environmental impacts of territorial transformation.

In order to reach the final outcome expected from the methodology, the environmental quality assets were divided into two main aspects, "naturalness" and "pressures", which represent the strengths and weaknesses of the territory under analysis. These two aspects were then compared to identify the most conflicting sites where conservation strategies are needed and the most degraded areas where valorization and transformation actions would be possible.

Methodology

Theoretical background

Multicriteria-Spatial Decision Support Systems (MC-SDSS, Malczewski, 1999) combine Geographic Information Systems (GIS) and Multicriteria Decision Aiding (MCDA) in order to provide a collection of methods and tools for transforming and integrating geographic data (map criteria) and Decision Maker's preferences and uncertainties (value judgments) to obtain information for decision-making and an overall assessment of the decision alternatives.

Coupling MCDA and GIS represents an important improvement to the conventional method since tools that incorporate information from different research areas can greatly assist the policy development of today's complex and interconnected issues. This method helps in dealing with weak and unstructured problems thereby supporting users in alternative scenario exploration (Carver, 1991; Engelen et al., 1997; Malczewski, 1999). It presents the advantage of being able to store and manipulate complex spatial data structures, conduct analyses within the domain of spatial analysis, and provide spatially-explicit output (i.e. maps) and other reporting tools. This provides a robust framework for exploring resource management issues by highlighting potential limits to resource use and the consequences of different allocation schemes (Rutledge et al., 2008).

From the methodological point of view, a spatial decision support tool can be defined as an interactive computer system designed to assist the user, or group of users, to achieve high levels of effectiveness in the decision-making process, while solving the challenge represented by semi-structured spatial decision problems (Malczewski, 1999). Sharifi and Rodriguez (2002), according to the model proposed by Simon (1960, 1991) and considering the work of Steinitz (1993), have developed a framework for planning and decision-making processes, which describes the MC-SDSS model (Fig. 2). In this model, there is a flow of activities from Intelligence to Design to Choice phase as well as steps in each phase (Sharifi, 2007). The framework highlights how each phase of the decision-making process involves the methodological contribution of both GIS and multicriteria evaluation methods. In particular, data acquisition, processing and examining are done in the intelligence phase; formal modeling/GIS interaction is the design phase, in which a solution set of spatial decision alternatives are developed;

[1] The study is part of the "Pellidrac" project which belongs to the Alcotra project Italy-France 2007-2013 (Coordinator: Prof. Elena Comino).