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Integration of stakeholder choices and multi-criteria analysis to support land use planning in semiarid areas

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ABSTRACT

The ecosystem services concept is increasingly considered as a policy tool to achieve the sustainable use of natural resources. However, it is still not sufficiently integrated into land use planning. We assessed five land use types (*Tetraclinis articulata* woodlands, *Pinus halepensis* plantations, Shrublands, Cereal-almond crops and Cactus groves) in a semiarid area of northern Morocco using empirical data on 17 ecosystem services whose weights were established by 67 stakeholders. The analysis included MCA and direct ranking of the five land uses. Three groups of stakeholders (scientists and managers, collaborators, and direct users of natural resources) were particularly concerned by water supply, protection against erosion and floods, soil fertility and food provision. Multi-criteria analysis showed that the three groups concurred in that *Tetraclinis* woodlands, crops and cactus fields were the most suitable land uses for the area, regarding ecosystem service provision. Direct ranking confirmed this tendency but showed some divergence between the three groups, as collaborators and users were more inclined towards crops and cactus. The integration of the ecosystem services concept in land use planning is needed to be more practical and easily perceived as a logical response to environmental exigencies and social aspirations.

1. Introduction

Ecosystems provide a variety of benefits, known as ecosystem services, which are vital for sustaining economic growth and human wellbeing, and alleviating poverty (MEA, 2005; Turner and Daily, 2008). The ecosystem services concept has gained growing interest as a key tool in environmental policies (Fisher et al., 2009; Braat and de Groot, 2012; Müller and Burkhard, 2012). In land use planning, the application of this concept provides decision makers with arguments regarding the choice of suitable options to achieve environmental and social goals (McKenzie et al., 2014). However, land use decisions often focus on achieving one or a few ecosystem services (Tallis et al., 2008; Fu et al., 2015). For instance, in forestry and agricultural interventions, many services such as those related to water and carbon cycles, aesthetics and biodiversity are often omitted (Cortina et al., 2011). There is still a need for land use strategies that address the full spectrum of services provided by ecosystems including both market goods and non-market services (Bateman et al., 2013).

Studies focused on operational implementation of the ecosystem services approach highlight the critical requirement for integrating a wide range of stakeholders (Ruckelshaus et al., 2015; Van Wensem et al., 2017). The term "stakeholder" refers to those people who will be affected or may have some influence on a decision (Freeman, 1984; Wilcox, 2003). Stakeholders may equally include local natural resource users, political and administrative decision makers, members of non-government organizations, and expertise providers (Spangenberg et al., 2015). These groups may have various and sometimes conflictive social needs and demands regarding ecosystems (Hein et al., 2006; Menzel and Teng, 2009; Seppelt et al., 2011). The explicit consideration of potential agreements and disagreements between stakeholders is likely to improve the likelihood of successful project implementation (Primmer et al., 2015).

Multi-criteria analysis (MCA) is a suitable tool for participative planning that enhances environmental decision making processes (Mendoza and Martins, 2006). MCA has desirable characteristics that make it appropriate for land use planning based on ecosystem services: it offers the possibility to consider both marketable and

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no marketable goods and services, it can incorporate a mixture of quantitative and qualitative information, and it allows the visualization of the opinion of different groups of stakeholders (Qureshi et al., 1999; Mendoza and Prabhu, 2000). Through a MCA, it is a possible to obtain a classification of a set of land uses according to their contribution to the provision of vital ecosystem services (Koschke et al., 2012; Fontana et al., 2013). However, like other models, MCA represents a simplification and an abstraction from the real system (Munda, 2004), and operational validity is needed to check for the agreement between MCA outputs and the real system (Dodgson et al., 2001). Many studies dealing with participative MCA used the opinion of scientists and practitioners as a basis for validation (Qureshi et al., 1999; Paracchini et al., 2009), but few studies have crossed MCA output with direct stakeholder choices. In land use planning, stakeholder validation may allow checking if the highly scored land use options resulting from MCA indeed correspond to those favored by stakeholder groups.

Collective validation of MCA results through constructive dialogue can be useful for promoting reciprocal learning, and represents a valuable contribution to deliberative democracy (Munda, 2004; Zhang et al., 2012). However, practical cases of collective validation are scarce, especially in developing countries in which stakeholders, mostly local ones, are considered as sources of information and passive recipients of top-down decisions, rather than influential actors.

In response to these concerns, our study provides a structured tool for decision-makers to make choices on land use options, bridging scientific data and comprehensive social aspirations. The main objectives of this study are: (i) to assess vital ecosystem services provided by different land use types in a semiarid area of northern Morocco, (ii) to determine the most suitable land use options for human well-being using a participative MCA, and (iii) to propose a framework for land use planning considering MCA results and stakeholder choices.

2. Methods

2.1. Study area

The study area corresponds to Béni Boufrah catchment (34°58′–35°10′N; 4°14′–4°25′W). It is located in the Central Rif Mountains, 55 km W of Al Hoceima (northern Morocco, Fig. 1). The catchment is 21 km long, from Jbel Izoural (1700 m) to the Mediterranean coast, and covers an area of 16,300 ha. Climate is semiarid Mediterranean with irregular and often stormy rainfall. Socio-demographic conditions are disadvantageous, showing high demographic density and serious problems of poverty, illiteracy and rural exodus (Moroccan General Census, 2014; Forest Administration of NE Morocco, 2012).

The main productive activity is agriculture dominated by rainfed cereals, mainly barley and wheat, and fruit trees, mostly almond and olive. Agricultural yields are low as a consequence of land fragmentation, rough terrain, high soil stoniness, and lack of irrigation and mechanization (Al Karkouri, 2003; Forest Administration of NE Morocco, 2012). An emerging agricultural activity is linked to a cactus cultivar (*Opuntia ficus-indica* (L.) Mill. var. *Dellahia*) which has gained an increasing economic and cultural value. Animal husbandry, based on sheep and goats, has decreased in the last decades as a result of droughts, rural exodus and abandonment of traditional agro-pastoral systems. The area hosts other economic activities such as sea fishing, harvesting of aromatic and medicinal plants, beekeeping and eco-tourism. These activities are seasonal, and produce low monetary incomes.

Natural forests in Béni Boufrah are mostly dominated by Barbary Red Cedar (*Tetraclinis articulata* Vahl Masters) and Holm oak (*Quercus ilex, subsp. ballota*; Fig. 1). These forests have faced high human pressure for a long time, mainly illegal cutting and expansion of agricultural land (Pascon and Wusten, 1983). Forest decline, combined with harsh biophysical conditions, led to serious problems of land degradation, including large scale soil erosion, flooding and depletion of soil fertility (Aboulabbes et al., 2005). To combat land degradation, the Moroccan Administration implemented several forest and agricultural actions. The most significant ones were undertaken within the framework of the DERRO project (Economic and Rural Development of the Western Rif, 1961–1972), whose main objective was to shift the Rif's population away from traditional agriculture and grazing, towards more productive and sedentary modes of living (Perry, 2014). Implemented actions mainly included afforestation with *Pinus halepensis*, fruit-tree plantations on terraces and various measures to control soil erosion (Pascon and Wusten, 1983). Despite these efforts, the provision of natural resources is still declining, and land degradation is of major political and social concern (Al Karkouri, 2003).

2.2. Stakeholder selection

In MCA, there are no strict rules on whom stakeholder to include (Banville et al., 1998), but it is crucial that all actors who can affect or can be affected by the decision are included (Macharis et al., 2012). In our case, we established a multi-stakeholder platform enclosing people involved in land use management decision in Béni Boufrah. A total of 67 individuals were involved (Appendix A). They comprise a wide and representative sample of age, gender, education level, socio-professional profile, proximity to the area and dependence on natural resources. We distinguished between three groups of stakeholders: (i) *scientists and managers*, (ii) *collaborators* and (iii) *direct users* (Derak et al., 2016; Table 1). The two latter were considered as local stakeholders. *Scientists and managers* have advanced educational degrees and a relatively high income level. They commonly live outside the area and have large experience in environmental activities such as ecological restoration. They have a significant influence on the decision making process linked to land use planning. *Collaborators* hold secondary and higher educational degrees, and half of them enjoy relatively high income levels. They live in the area and are familiar with environmental activities. They play a relevant role as facilitators for the implementation of socio-development projects. *Direct users* have low to very low education level, and most of them have low incomes. The all live in the area, and few of them have previous experience with environmental activities. They strongly rely on the use of local natural resources.

Our study focuses on the divergence of opinions and interests between and within the three groups of stakeholders. Thus, for each group, we distinguished a number of sub-groups, separated on the basis of socio-demographic profile, professional activity and role in the decision making process. Equilibrated number of individuals per sub-group was also taken into consideration. Accordingly, for *scientists and managers*, we distinguished two sub-groups: *scientists* and *managers*. For *collaborators*, we differentiated between *authorities and representatives*, *NGOs members*, and *facilitators*. Finally, for *direct users* we distinguished between *farmers*, *members of agricultural cooperatives*, *other users*, and *inhabitants* (Table 1).

2.3. Multi-criteria analysis

2.3.1. Problem structuring and data gathering

The MCA structure included three levels. The first level (criteria) corresponded to five categories of ecosystem services: supporting, regulating, provisioning, cultural services, and biodiversity, as described in MEA (2005), in addition to economical benefits. Hereafter, we consider all six criteria as being categories of ecosystem