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Supporting land use change assessment through Ecosystem Services and Wildlife Indexes

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ABSTRACT

Biodiversity and landscape management are recognized as crucial pillars of EU policies and strategies in order to ensure the integration of environmental issues with socio-economic needs at the base of human-made changes, in structural and functional terms. Midterm EU's Biodiversity Strategy (Feb 2th 2016) highlights the importance of biodiversity protection in Europe, not only in terms of ethical behavior but also due to its intrinsic value of the biodiversity loss, estimated in EUR 50 billion a year. The study is framed into the LIFE/ENV/IT/275 Ecoremed Project, aimed to development of eco-compatible remediation protocols for polluted soils in the area of Litorale Domitio Flegreo – Agro Aversano (declared Regional Interest Priority Site).

The paper is aimed at defining potential land use change scenarios, by which positive biodiversity impacts could be provided. It entails 2 steps: definition of three LUC scenarios, through a multi-criteria approach; LUC scenarios assessment, through Ecosystem Services and through wildlife impact assessment. The study works on a physical-mathematical model, by which the multi-criteria evaluation for scenarios construction and the quantitative assessments have been integrated. The procedure allowed to identify the most LUC suitable areas and, then, the potential conflict areas between LUC scenarios and target species presence areas, with the specific identification of wildlife species more impacted, in order to calibrate mitigation interventions and strategies, through specific forms/interventions. Our evidence demonstrates an excellent land response to the LUC-LIFE protocols in terms of Ecosystem Services, while highlights the need to consider more targeted strategies with respect to wildlife impacts.

1. Introduction

1.1. Background

Land Use Change (LUC) is broadly recognized as crucial in investigating impacts on landscape alteration, and in deepening the loss of natural environment produced by human activities. LUC analysis allows to critically highlight the driving forces leading territory decline, deepening the specific condition (mostly unexpected) by which emerging new neglected landscapes, such as those generated by land abandonment and by pollution. In these cases, LUC analysis supports the assessment of the site condition for understanding the territorial potentials and for deeming planning opportunities toward more sustainable uses. Indeed, LUC analysis allows to point out selected factors by which generating a set of alternative scenarios in order to effectively compare the future changes and their impacts (Wu and Hobbs, 2002; Dormann et al., 2007; Pelorosso et al., 2009; Riccioli, 2011; Raven, 2011; Pindozzi et al., 2013, 2016; De Montis et al., 2017).

As a consequence of human development, the balance among natural resources is not always guarantee leading to a downgrade in landscape system which is often extremely simplified. It is often very difficult to predict the specific policy measures consequences on biodiversity. The awareness of LUC scenarios assessment is now achieved, in respect of international, European and national indications, directives and regulations.

Abbreviations: ES, Ecosystem Services; LUC, land use change; S-MCDA, Spatial-MultiCriteria Decision Analysis; GIS, Geographic Information Systems; NIPS, National Interest Priority Sites; SI, Sensitivity Index; HI, Habitat Index; CI, Conservation Index; PI, permeability index; RI, rarities index; SI%, Percentage Sensitivity Index

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1.2. Current approaches analysis

According to the need of producing more innovative knowledge of the territorial dynamics, studies on LUC involves vary research fields, (going from soil modeling to the taxonomy of spatial patterns, up to the historic land uses and of historic data set collection), by the aim of understanding causes and impacts of the future changes (Irwin and Geogheganm, 2001).

The studies in the field of Geography have demonstrated the opportunity of using more complex approaches by which stating the integration of socio-economic dynamics into the LUC territorial dynamics (Verburg et al., 2004; Rotmans et al., 2000; Verburg et al., 2008; Baker, 1989; Cialdea and Maccarone, 2012), stressing data set for generating scenarios alternatives as specific prediction support approach, where the term "scenario" is here assumed as *"a means to sketch what could happen, assuming changes in preconditions that differ in nature, course, rate, duration or place"* (Verburg et al., 2008 p.59). In this perspective, scenarios alternatives represent an effective support to deepen knowledge-oriented visions of the LUC potentials, orienting decision makers toward a more aware approach to LUC and planning.

In the framework of the LUC scenarios building, MultiCriteria Decision Analysis (MCDA) techniques have been increasingly applied. Because of their capacity at integrating mathematical models study with GIS spatial references, MCDA is a prime decision support system, guaranteeing transparency in the decision-making process. Moreover, Spatial – MultiCriteria Decision Analysis (S-MCDA) is conceptually dynamic and it allows to integrate both knowledge and contributions from different expertise within the decision framework, cross-cutting policy makers decisions and stakeholders interests (Janssen, 2001; Zhang et al., 2012; Colantoni et al., 2016; Rigillo and Cervelli, 2014; Ferretti et al., 2014; Cervelli et al., 2016a). The S-MCDA supports the construction of a set of alternative scenarios (Malczewski, 2006; Geneletti and van Duren, 2008; Lami et al., 2011; Gbanie et al., 2013; Staals et al., 2013), aimed at exploring the consequences of LUC assumed as preconditions on the observed system (Rashed et al., 2007; Verburg et al., 2008), stressing those territorial topics established as preferred by the decision makers panel (politicians, stakeholders, professionals, scientists, ecc.).

Since 1980s, scenarios evaluation and their possible effects on environment, is carried out with Ecosystem Services (ES) approach (Costanza and Ruth, 1998; MEA, 2003, 2005). The issue is particularly relevant: according to the EU Biodiversity Strategy to 2020 – Action 5 (EU, 2016), all Member States, in their territory, should evaluate and map the state of ecosystems and their services. The ES are related to land use and, therefore, are affected by its change (Foley et al., 2005; de Groot et al., 2010; Lautenbach et al., 2011; Rozas-Vásquez et al., 2016). Many of these changes have effects on landscape composition and structure (Büntgen et al., 2011; Syrbe and Walz, 2012). Different ES classifications, mapping and assessments have been developed and proposed, on global, regional, and local levels. The most widely used approach is the ES monetary value, not only to evaluate alternative strategies for land use but also to demonstrate and justify the need for biodiversity conservation (de Groot et al., 2002; Fisher et al., 2009; Cervelli et al., 2016b). Several applications have been developed, for ES modeling and evaluation such as Ecometrix, Invest, ARIES, MIMES, etc. Among others, INVEST is generally recognized as the most sensitive to assess even minor changes in ES productivity, and it is the most relevant tool to establish environmental policies and compensation/remuneration ES mechanisms (Schirpke et al., 2015).

The wildlife impact assessment is an additional element to support the decision-maker, in order to compare foreseeable effects as a result of different policies and different scenarios of LUC (de Lima et al., 2012). Midterm EU's biodiversity strategy (Feb 2th 2016) posits the importance of biodiversity protection in Europe, not only in ethical terms, but also for the intrinsic value of biodiversity loss, estimated as almost 50 billion euro a year. The wildlife impact assessment is, consequently, an additional element to support the decision-maker, in order to compare foreseeable effects as a result of different policies and different scenarios of LUC. The possible impacts can be studied through deductive or inductive models. In deductive models, the knowledge is employed to identify the most suitable regions for a given species.

1.3. Aim of the study

Starting by this, the study assumes that intense human activities (namely those concerning the development of peri-urban areas) are often not consistent with the preservation of natural resources, nor in terms of efficiency of uses, nor in terms of services provided for the territory. Especially, as consequences of such kind of LUC, extremely simplified landscapes have replaced the original and more complex habitats, producing the loss of ecosystem services and of biodiversity (Ales et al., 1992; Macdonald, 2000). Further, the study consider the LUC planning approach as key opportunity for turning negative impacts into positive ones, even in case of severely damaged areas, such as polluted areas, especially focusing on the biodiversity potential coming from the application of both LUC analysis and S-MCDA techniques.

In order to this, the study proposes the application of such prediction in the study area of SIR Agro-Aversano, located in the peri-urban context, in between the territories of the Metropolitan City of Naples and the Caserta Province. The study area is formally recognized as polluted by the inscription into the National Interest Priority Sites (NIPS) list, built by the Italian National Authority (Ministry of the Environment) in attendance of the Italian Law n. 152/06 for waste management and soils pollution. Such area – currently downgraded into Sites of Regional Interest (SIR) – has been under pressure for the assumed presence of diffuse pollution into the soils and for the practice of burning waste illegally disposed. Driven by an intensive media campaign, the supposed contamination – not fully confirmed by the soil sampling campaign – has created a crushing correlation between land degradation and the land hazard potential, especially concerning the safety of the food chain thus causing severe damages to the local economy mostly based on agriculture (Capolupo et al., 2015). Since 2012, the study area is under the attention of the EU project LIFE11/ENV/IT/275 – ECOREMED aimed at assessing the comprehensive environmental conditions of the area and at applying specific soil remediation protocols.

According to this description, the study area is very representative of the cultural assumption posit by the study, because of it maintains a number of territorial assets (i.e. agricultural landscape, cultural heritage) that encourage the approach to LUC as an opportunity for sustainable development and for reinforcing the natural assets, in contrast with the images of abandonment, marginalization, inappropriate land use, and pollution (real or perceived).

Therefore, the specific aim of the study is to build a set of LUC scenarios through the application of the MCDA methods, making them comparable in terms of the provision of ecosystem services and of biodiversity enhancement. Such objective is also aimed at understanding the re-development potential of the case study area according to different LUC alternatives. The cultural framework of the study is consistent with the EU Biodiversity Strategy to 2020. Along with this aim the LUC assessment made through ES provision together with wildlife impact evaluation can provide new insights, being of help for regional planners as well as decision makers.

Despite the study has been conceived as cross-cutting research, in which different steps dialogue together in every phase of the research, the paper has been organized as follow:

- the S-MCDA is used to analyze the complex and heterogeneous framework to create LUC scenarios;
- special attention has been given to Ecosystem Services, through two approaches: (1) monetary valuation and (2) Invest Habitat Quality module;