Ecological Engineering 87 (2016) 139–149

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Ecosystem services and bioremediation of polluted areas

Cervelli Elena[a], Pindozzi Stefania[a], Capolupo Alessandra[a], Okello Collins[b], Rigillo Marina[c,*], Boccia Lorenzo[a]

[a] Department of Agricultural Sciences, University of Naples Federico II, Portici (Na), Italy
[b] Department of Biosystems Engineering, Gulu University, P.O. Box 166, Gulu, Uganda
[c] Department of Architecture, University of Naples Federico II, Naples, Italy

ARTICLE INFO

Article history:
Received 27 March 2015
Received in revised form 21 July 2015
Accepted 7 September 2015

Keywords:
LUC scenarios
Multicriteria-Spatial Decision Support Systems
Ecosystem services
Bioremediation

ABSTRACT

Contaminated areas represent a crucial concern in contemporary planning all over the world. The absence of shared value for such areas leads to abandonment and soil sealing specially if such areas have lost their agricultural potential. The European Project LIFE/ENV/IT/275 Ecoremed has implemented a protocol for the bioremediation of contaminated soils in Campania region. The cultivation of no food crops (Poplar and Giant reed) is proposed as buffer crops waiting for the characterization of the areas. This facilitates the uptake of the mineral contaminants and the biodegradation of organic compounds reducing the risk for leaching and the run off of harmful contaminants that would occur on bare soils.

The study discusses a new approach to land use change (LUC) assessment based on environmental and socio-economic factors, evaluated through GIS tool and decision support software (ArcGIS/ILWIS). Literature data have been used to assess the current value of the ecosystem services (ES) provided by such crops (€/ha/year) and the benefits that people obtained from ecosystems. Three scenarios have sorted out and compared through multicriteria analysis. Moving from the deep knowledge of the environmental condition of the territory the study shows the alternative ES values of the land use change starting from no-change scenario to energy crops (Poplar and Giant reed), to abandonment. Results show that is possible to asses an increase of the ES value, both in case of a private and public action, also referring to the opportunities for farmers income in the short and medium-long period.

1. Introduction

Ecosystem services (ES) are crucial for providing condition for human well-being, qualitative livelihoods and efficiency for the human habitat (Costanza et al., 1997, 1998; Millenium Ecosystem Assessment (MEA), 2005; TEEB Foundations, 2010; de Groot et al., 2012; Comino et al., 2014). Changes in ES influence all components of the human well-being (Balmford and Bond, 2005; Farber et al., 2002; Salles, 2011), so that the early assessment of the ES change may effectively support decision makers in planning (Marulli and Mallarach, 2005; Busch et al., 2012) and in programming policies for improving social well-being (Daily et al., 2009; Deutsch et al., 2003).

Further the capacity of evaluating the monetary values of ES (Costanza et al., 1997), although ignores more intangibles services (Viglizzo et al., 2012; von Haaren et al., 2014), makes the ES one of the key elements of the planning processes (Bennett et al., 2009; Frank et al., 2012) and of the decision analysis, leading towards new methodologies in terms of planning alternatives.

The Millennium Ecosystem Assessment (MEA, 2005) definition for ES describes it as the implementation of a set of effective benefits for both natural and urban environment. Thanks to the MEA studies (2003, 2005), ES has become a popular research topic and it acts as conceptual framework for many scientific projects so that various ES classification strategies, mapping methodologies and evaluations proposals have been provided at global, regional and local scales (Daily and Matson, 2008; Fisher and Turner, 2008; de Groot, 2006; Tianhong et al., 2010). Further, the evaluation of ES in economic terms became an increasingly popular approach both to assess alternative scenarios in land use change and to demonstrate the economic value of biodiversity conservation (Bayon and Jenkins, 2010; Chan et al., 2006; Costanza et al., 1997; de Groot et al., 2002; Fisher et al., 2009; Ghazoul, 2007; Ridder, 2008; Wallace, 2007; Schneiders et al., 2012).

Abbreviations: ANP, analytic network process; DEM, digital elevation model; ES, ecosystem services; LUC, land use change; MC-SDSS, Multicriteria-Spatial Decision Support Systems; NIPS, National Interest Priority Sites; PDO, protected designation of origin; SIR, Regional Interest Site; AV, added value.

* Corresponding author.
E-mail address: mrigillo@unina.it (R. Marina).

http://dx.doi.org/10.1016/j.ecoleng.2015.09.045
0925-8574/

In economics, literature recognizes two broad kind of value: "use value" and "no-use value" (de Groot et al., 2010), while the ES value encompasses the state of health of a territorial system and socio-cultural values, such as cultural identity and the degree to which that is related to ES including the importance people give to (Redford and Adams, 2009.). Moreover, EU efforts are also directed towards the implementation of the Green Infrastructure in urban and rural areas of the European Regions (Mazza et al., 2011; Tratalos et al., 2007.) by the aim of arising biodiversity and of improving EU habitats.

Despite the wide acceptance of these concerns, in the scholar's community, the use of ES evaluation in landscape planning is still largely missing. However its consideration could inform regional planning authorities in finding solutions that better respond to competing social needs and demands. According to this, it is necessary to integrate ES evaluation at the early stage of regional planning and decision-making processes (Daily and Matson, 2008; Hein, 2010; Rannow et al., 2010; Koschke et al., 2012).

In this perspective a special heed is given to the global demand for energy crops that has increased all over the world, due to shared awareness of the global impacts of using of the fossil fuels, including costs (Ajanovic, 2011). In the framework of the Kyoto Protocol, Renewable Energy Directive (RED) is now addressing political strategies to foster no-food production (ATLASS Consortium, 2010; European Parliament, 2009) together with the other sustainable energy sources. Thanks to the RED recommendation and the economic and political investment done by the UE, many European Regions are going to address their land use planning towards no food production by the aim of providing more opportunities for the agriculture sector and for realizing better condition for peri-urban environment. Indeed no food crops represent a key strategy for reducing soil loss and land abandonment, for increasing soil pollution remediation and for developing, locally, new potential of economic growth. The land use change of the agricultural crops in to no-food production is a key opportunity for the local economy and for increasing the natural processes of soil formation and erosion (Recanatesi et al., 2013), but also a potential threat for rural landscape and biodiversity. Because of this, the assessment of the land use change (LUC) of the agricultural crops could use the methodologies for ES values comparison in land use change as an effective indicator of the impacts related to the LUC itself.

The Campania Region is one of the most important Italian Region due to its huge tradition in food production (one of the leading areas for PDO certificated food), for the added value (AV) of the agricultural production and because of agricultural uses shaped an outstanding traditional agrarian landscape (Pindozzi et al., 2015). Campania is now under pressure for implementing no-food production thanks to a number of driving forces such as economic incentives, the rising prices of biomass, the implementation of biomass chain, the re-organization of the supply chain, etc. (Pindozzi et al., 2013). The implementation of no food production is also pushed by the social context due to the land abandonment and of the illegal waste disposal in some rural and peri-urban areas.

Besides, Campania Region is under the media pressure due to the illegal disposal of pollutants and waste in a very wide area, almost of 110 thousand ha, named by press "Terra dei Fuochi" (Land of Fires). The media interest has damaged the perception of food safety in the area and has caused a big loss in terms of national and international products demand. The value of the agricultural crops decreased and there is a local pressure for transform the agricultural plots in new built areas.

The described condition is in some ways common to other places in the world, such as Poland, Bangladesh, China, US, and some Countries of the Central Africa (Ailshire and Crimmins, 2014; Bednarska and Stachowicz, 2013; Li et al., 2014; Seraj et al., 2014; Wang et al., 2010) where a widespread pollution are taking agricultural soils away.

Life Project Ecoremed (LIFE11/ENV/IT/275) is now under development to support Campania Region in facing soil pollution emergency. The project is funded by the EU Life Programme and it is aimed at demonstrating the potential of no-food change both in reducing environmental risk (in terms of reducing pollutant mobilization, implementing living-machine process, implementing phytoextraction) and in providing new economic incomes for farmers. The cultivation of no food crops is aimed at creating a stand by zone in which operate while the characterization of each fields will be done. No food use is here strategically merged with the specific aim of soil remediation that is the uptake of the mineral contaminants and the biodegradation of organic compounds, reducing risk for leaching and run-off of the harmful contaminants that would occur on bare soils. Bioremediation represents an effective technology for reducing the concentration of organic pollutants (EPA, 2005), aiming at reaching a target of 40% less of contaminated soils (LIFE11/ENV/IT/275 – ECOREMED, 2014). The plants species/varieties selected by LIFE Project (*Populus nigra* and *Arundo donax*), should reduce contaminant dispersion, exposure to contaminants and their transfer into the food chain (Henry et al., 2013).

The paper discusses the ES evaluation approach for assessing opportunities and constraints of no-food crops in land use change by the aim of supporting the decision process. More in deep, the study looks at the land use change of the whole SIR area, specially focusing on the polluted areas that are potentially suitable for bioremediation and on some other areas that lay in abandonment and that could be easily interested by pollution or illegal uses. Starting from this, the study is aimed at:

- implementing methodologies for selecting the most LUC suitable areas and assessing their ES values
- outlining a set of scenarios of LUC for the selected areas
- comparing scenarios by means of their monetary ES values

2. Materials and methods

2.1. The study area

The selection of the study area comes from the list of the National Interest Priority Sites (NIPS) produced by the Italian Ministry of the Environment in attendance of the Law n. 426/1998 that transpose the EU Directive (Decree of the Ministry 31/01/2006) about the waste management and soils pollution. According to this, the study area does not correspond to unique administrative boundary but respond to the definition of "part of the national territory bordered according to the site characterization, to the presence of pollutants (quantity and quality), to the environmental impacts on the adjacent areas." (Musmeci et al., 2008).

The regulatory matter is now under the control of the Campania Region that classified the study area as SIR (Regional Interest Site) in attendance to the following national laws: Decree of the Ministry of Environment n. 7 del 11/01/2013, Decree Law n.136 10/12/2013, Law n. 6 06/02/2014.

The study area (Fig. 1) is extended for 157 000 ha and covers 77 Municipalities and hosts almost 1.4 millions of inhabitants, showing a positive trend of population growth thank the migration flows. In terms of natural assets, twenty-nine Nature 2000 sites have been registered and the rural landscape is featured by the merging of traditional and modern cultivation techniques. The study area is supported by territorial infrastructures such as railways, motorways, commercial and industrial areas and it is featured by urban