Ecohydrology & Hydrobiology 15 (2015) 13–25

Contents lists available at ScienceDirect

Ecohydrology & Hydrobiology

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

Original Research Article

Provision of ecosystem services in the lagoon of Venice (Italy): an initial spatial assessment

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ARTICLE INFO

Article history:
Received 4 December 2013
Accepted 12 December 2014
Available online 24 December 2014

Keywords:
Mapping ecosystem services
Erosion regulation
Water Framework Directive
Coastal ecosystems
GIS

ABSTRACT

The lagoon of Venice is a complex human–environmental system where several environmental, economic and social issues call for new integrated management perspectives. The ecosystem services approach can provide a new framework for the management of this area, and one of the first steps towards its application is ecosystem services mapping. In this work, the spatial distribution of ecosystem services in the lagoon of Venice was assessed in a qualitative way. Seven ecosystem services were chosen for the assessment: four provisioning services (*aquaculture*, *fish and seafood*, *wild food* and *crops*), two cultural services (*recreation and tourism* and *knowledge systems*) and one regulating service (*erosion regulation*). The services were mapped by integrating biophysical and socio-economic information, resulting in an easily understandable representation of the services provided. The ecosystem services maps were used to perform a zonal analysis, referred to the water bodies adopted in compliance with the Water Framework Directive, which allowed to identify the patterns of ecosystem services provision that characterize each water body.

1. Introduction

The lagoon of Venice (LV) is a large and shallow coastal lagoon located in the north-eastern Italy (Fig. 1). It has a surface area of ca. 550 km^2 and it extends for about 50 km along the north-western Adriatic coast, to which it is connected by three inlets (from north to south, Lido, Malamocco and Chioggia). The LV presents a heterogeneous morphology, characterized by a complex pattern of major (navigable) and minor channels, salt marshes, tidal flats and islands.

Several human interventions, such as the diversion of the main water courses outside the lagoon, have been carried on in the LV since the time of the Venice Republic (Ravera, 2000), and have been crucial for the morphological evolution of the lagoon: by maintaining the dynamic equilibrium between land and water they allowed the survival of Venice and its lagoon throughout centuries. However, the further modifications occurred in the 20th century, such as the construction of jetties at the inlets and the dredging of the Malamocco–Marghera channel ("Oil Channel"), shifted the lagoon towards a prevalent erosion,

Abbreviations: ESS, ecosystem services; LV, lagoon of Venice; WFD, Water Framework Directive; MAV, Magistrato alle Acque di Venezia (Venice Water Authority).

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http://dx.doi.org/10.1016/j.ecohyd.2014.12.001
1642-3593/

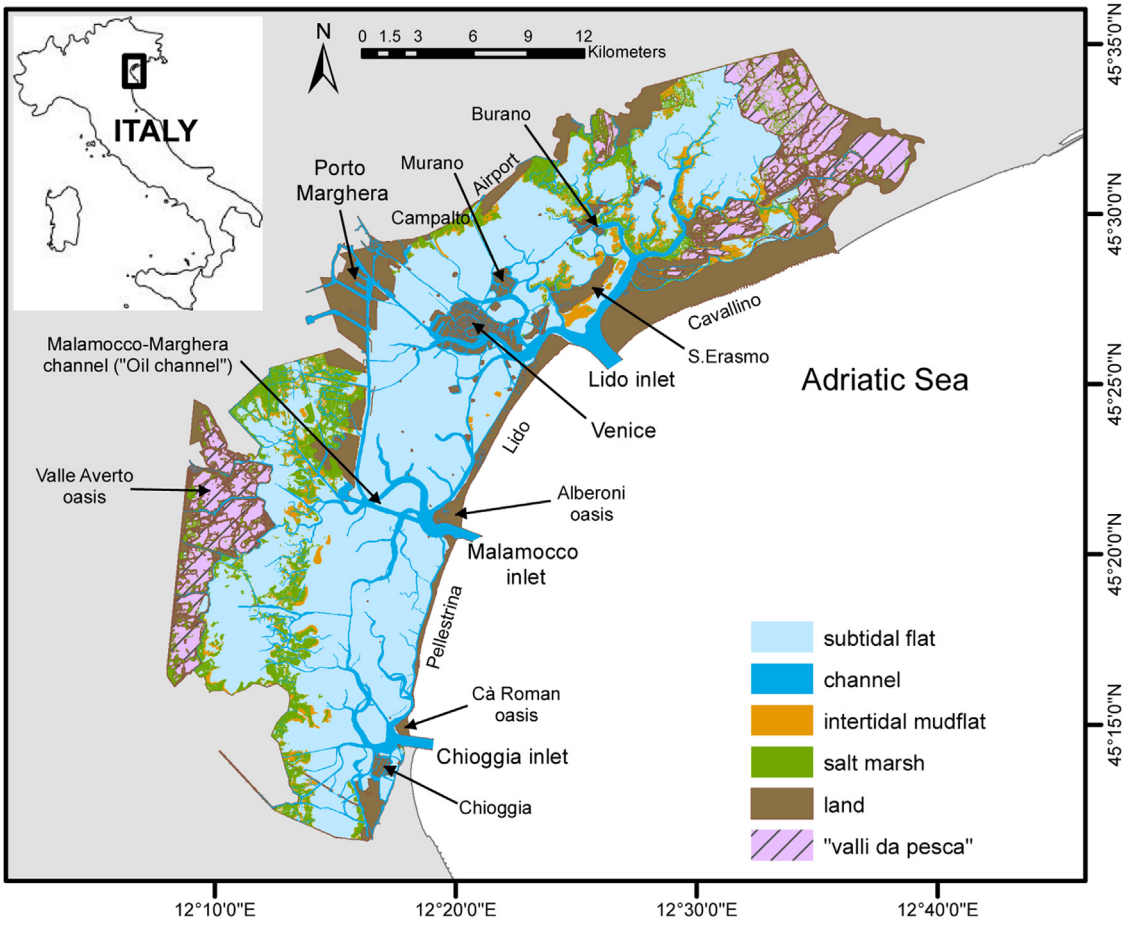

Fig. 1. Study area: the lagoon of Venice.

which lead to a negative sedimentary budget (Sarretta et al., 2010). This, added to natural and anthropogenic subsidence (12 cm) and sea level rise (11 cm) (Brambati et al., 2003), resulted in significant changes of the lagoon morphology, such as the reduction of the area occupied by salt marshes, the increased bathymetry of tidal flats and the siltation of channels, leading to a general flattening of beds and loss of spatial heterogeneity (D'Alpaos, 2010; Sarretta et al., 2010).

The complexity of the LV is further increased by the various economic activities which take place in it nowadays, acting as drivers of change with different degrees of (un)sustainability. The most important among them are tourism, fishing, aquaculture, industrial activities, maritime shipping and port, development of urban areas and related activities, and agriculture. The combination of past interventions, physical forcing functions and present activities is responsible for several issues which threaten the lagoon ecosystem, such as the above mentioned morphological modifications, nutrient and pollutant loads (and consequent eutrophication events), loss of biodiversity, relative sea level rise and increased frequency and severity of "high water" events (for a review see Ravera, 2000; Solidoro et al., 2010). These issues call for new perspectives for the integrated management of the LV and its resources.

Ecosystem services (ESS), which are defined as the contributions of ecosystem structure and function – in combination with other inputs – to human well-being (Burkhard et al., 2012), provide a valuable framework to analyze human–environmental systems, focusing on the linkages between natural and human systems (Burkhard et al., 2010). In order to represent these linkages Haines-Young and Potschin (2010) have introduced the "service cascade" conceptual model, which links ecological structures on the one hand, and elements of human well-being on the other, proposing a series of intermediate stages between them (in order: "biophysical structure or process", "function", "service" and "benefit (value)") (Potschin and Haines-Young, 2011). Furthermore, the ESS cascade can be embedded in the DPSIR (Drivers-Pressures-State-Impact-Response) adaptive management cycle, the well-known framework adopted by the European Environmental Agency (EEA, 1999). In this comprehension, suggested by Müller and Burkhard (2012), the cascade stages of "biophysical structures and processes", and the linked ecosystem "functions", can be placed in the *state* step, whereas the changes of ESS provision, with their