



Review

Management international estuarine systems: The case of the Guadiana river (Spain-Portugal)

C. Pallero^{a,b,*}, J.M. Barragán^a, M. Scherer^b

^a Research Group on Integrated Management of Coastal Areas (PGIAL), University of Cádiz (UCA), Spain

^b Research Group of Integrated Management of Coastal Zone (LAGECI), Federal University of Santa Catarina (UFSC), Brazil

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ABSTRACT

For an integrated management of estuarine socio-ecological systems it is necessary to adopt an ecosystem approach and to elaborate proposals adapted to the social, administrative and ecological characteristics.

An appropriate spatial scale approach should include interrelated and mutually interfering elements. Managing uses and occupation in a sustainable way involves managing natural resources and ecosystems, establishing proposals consistent with the concept of sustainability and that can be successful in a long-term projection. Thus, the transversal concept of ecosystem services and ecosystem-based management (EBM) responds to this need, especially when applied to an international and cross-border estuary such as the Guadiana River.

The present research delimits and diagnoses the socio-ecological elements and the relations among economic and social sectors, environment and administrative and political components. It aims to justify the priority and strategic elements needed for manage the system in the European Union Framework. Protected areas and their management were also analyzed as articulators of the resources and territory management. The results of the analysis demonstrated the need to delimit the management area. For the Guadiana estuary, it goes up to 1644 km² on land and 4 kilometers seawards.

The main instruments and opportunities presented in the case of the Guadiana river estuary, such as land-use management plan and especially the protected areas management plan, suggest a well-defined scenario and an integrated and ecosystem-based approach to its management. The main sectors considered (tourism, farming, navigation, fishing and aquaculture), their relationship with the environment, as well as the European Union framework, strengthen the proposal of an integrated management of the estuarine socio-ecological system based on existing opportunities and considering socio-environmental characteristics and initiatives and interests present in the system.

1. Introduction

The management of transboundary estuaries in an approach where uses and activities are included in a balanced context between society and the system requires an integrative diagnosis prior to the development of measures and actions (Pallero et al., 2017a). This premise, which could be obvious for the management of any territory and/or resources, acquires significant relevance in a transition system such as estuarine, shared by different administrative levels and between two countries. This is the case of the Guadiana river estuary, southwest of the Iberian Peninsula, shared by five municipalities and one region on the Spanish margin, and four municipalities and two regions on the Portuguese margin. In addition, delegations and sectors involved in the administration (e.g.: ports, Public Maritime Domain, Public Hydraulic

Domain, fishing) are present in the estuarine system.

According to Olsen et al. (2006) and Barragán and de Andrés (2015) a significant proportion of the world population is concentrated around transition systems such as estuaries, as one of the strategic sites. In addition, some of the highest values of ecosystem services are observed, both *stricto sensu* estuary and associated environmental units (e.g. MEA, 2005; TEEB, 2010; de Groot et al., 2012; Barbier, 2011; Savage et al., 2012; Costanza et al., 1997; Daily, 1997). However, the state and evolution of the estuarine systems management seems to indicate that they are not fully with the integrative vision (Pallero et al., 2017a).

To consider all the elements involved in a socio-ecosystem such as estuarine, Ecosystem-Based Management (EBM) demonstrates to be the most complete and ecosystemic approach (Sousa et al., 2016; Lubchenco, 1998; Altman et al., 2011; Kelble et al., 2013; CE, 2017;

* Corresponding author.

E-mail address: cristinapalleroflores@gmail.com (C. Pallero).

among others). As described in the Marine Strategy Framework Directive (DMEM 2008/56/CE) and assumed in this work, the ecosystem approach is based on the application of scientific methods that encompass the essential processes, functions and interactions between organisms and their environment, considering the human being including cultural diversity, as an additional component of ecosystems. The socio-ecological system is understood according to the concept defended by Ostrom (2009) and defined by Martín-Lopez et al. (2012) as bio-geo-physical units that are associated with one or more social systems delimited by stakeholders and institutions (Glaser et al., 2008). Formal and non-formal institutions regulate relationships within the social system and between the social and natural system.

This approach can be used to achieve a balance between conservation and sustainable use of natural resources, constituting a tool to accomplish balance between pressure applied by human activities and the conservation of the environment. Hence, to incorporate the effect of multiple pressures on ecosystem and its services, a holistic analysis of the risk must be done. This would determine the pressures that cause the greatest loss of ecosystem services and those services subject to increased stress due to the cumulative effect of all pressures (Altman et al., 2011).

However, it is complex task due to the frequent asymmetry of the effects of managerial decisions on ecosystem services. The responses are often direct and localized, while the benefits of ecosystem services are more diffuse and indirect (Cook and Heinen, 2005). Strategically addressing these challenges and complexities implies that natural resource management needs to plan and act at broader spatial scales, considering the long-term response, explaining the interconnectedness of related problems, and including the interests and perspectives of multiple stakeholders (Cabot et al., 2016). Taking into account the perceptions and preferences of stakeholders on the different ecosystem services is essential for the implementation of integrated management plans as differences in perceptions and uses help determine behavior and suggest future conflicts (de Juan et al., 2017; Gelcich et al., 2009; Hicks and Cinner, 2014).

On the other hand, the analysis of ecosystem services, although quantifiable and integrated, is not static and the interpretation and the spatial and temporal relationship of services, beneficiaries and impacts are not always clear (Sousa et al., 2016). Nevertheless, this is a very useful approach to management and should not be encapsulated within physical boundaries because errors would be inherited from the inconsistency between natural functional boundaries and administrative boundaries. For this reason, the delimitation of the area of management requires considering institutional frameworks and analysis of the relations' power. It means it requires an approach from the political ecology point of view (Robbins, 2012; Norman et al., 2012).

Taking into account protected areas is also an important approach for delimiting the management area. They are considered one of the most effective instruments for promoting nature protection and at the same time promoting and supporting sustainable development (Maretti, 2012). The creation of these areas can be considered an important territorial control strategy, once the limits and dynamics of specific use and occupation are established (Medeiros, 2006).

The present research justifies and demonstrates the need to determine limits of management through the ecosystem services approach, allowing their conservation, taking into account the components and ecological processes, from a socio-ecosystemic point of view. The elements developed in this work present a realistic scenario for Guadiana river estuary integrated management. This transboundary estuary, between Spain and Portugal, displays a high human presence and anthropic alteration, showing the need for an adapted and integrated approach

2. Methodology

Guadiana estuary system delimitation and zoning was carried out

according to Pallero et al. (2017b).

To delimit the fluvial-coastal transitional system this methodology proposes to take into account ecosystem criteria, direct and indirect drivers of change and major conflicts. Besides identifying the areas with the highest concentration of conflicts, legally defined zones must also be represented. These include: floodplain or hydrographical public domain; terrestrial and maritime public domain or equivalent; protected areas; municipal boundaries and other administrative divisions (e.g. boundaries between states, regions, etc.).

To conduct the zoning Pallero et al. (2017b) propose three zones: Critical Zones (CRZ), including upper, lower and lateral limits, and transitional waters; Dynamic Zones (DZ) covering sporadic flooding areas, connected fresh water, direct dependent ecosystems not included at the CRZ, groundwater that is part of the river basin water cycle; and Influence Zones (IZ), taking in consideration indirectly related marine and land ecosystems, and regions between areas already defined as CRZ and/or DZ,

Based on the information collected, the cartography was elaborated using a Mapping Tool (QSIG). The elements described represented cartographically demonstrates the management limits of the estuary. This allows identified the main uses and activities present at the Guadiana River estuary system.

The main economic sectors and the activities that are developed in the system were identified, as well as the analysis of their level of systemic dependence. In order to establish the level of dependence each activity was analyzed regarding its location, type of ecosystem service and benefits associated. The benefits, goods and/or products derived from the activity are based on the types identified in MEA (2005) and data from the Guadiana estuarine system such as GIT-AAA (2011), National Institute of Statistics – Spain; National Institute of Statistics – Portugal; sectorial reports of the Andalusian Government; among other sources. This dependency was established in qualitative terms according to:

- Relation of the activity with the location and ecosystem services for its development (high: exclusive dependence of the place and services; medium: depends on certain minimum factors of the system that can be partially supplied artificially; low: it does not depend on the location or the services of the system).
- Diversity of goods and products of the activity in relation to the goods and products identified of the Guadiana estuary system (11 different types) (high: 8–11; medium: 5–7; low: 1–4).

Main conflicts and problems, specific to the case of the Guadiana estuary, were identified (GIT-AAA, 2011; MAGRAMA-IEO, 2012; Costa and Fraidiás, 1997). It was done based on the classification and relationship proposed by Pallero et al. (2017a) (types of problems, main causes and relation with ecosystem services). This allowed a qualitative identification of the state of the ecosystem services (loss, maintenance and/or improvement) based on changes and evolution obtained from bibliographic resources (GIT-AAA, 2011; Dias et al., 2003; Sanchez-Moyano et al., 2003 among others). Through a relationship diagram, taking into account the main activities and beneficiaries, connections between conflicts and or problems related with social, political-administrative components and drivers of change were established.

Subsequently instruments integrating land management and resources were analyzed. Firstly, protected areas were identified, considering the international protection figures (Natura 2000 Network and RAMSAR) and the figures established in the corresponding national laws of Spain (Law 42/2007 of December 13, Natural Heritage and Biodiversity) and Portugal (Decree-Law no. 142/2008, of 24 July, on the conservation of nature and biodiversity). In the case of Spain, regional regulations due to the Autonomous Communities's jurisdiction in environmental matters (Law 2/1989 on Protected Natural Areas of Andalusia) were also considered. Main management instruments (management and use) of natural resources in Spain and Portugal, as

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