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Can we infer about ecosystem services from EIA and SEA practice? A framework for analysis and examples from Portugal

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ABSTRACT

Biodiversity, soil, water, air, climate, landscape and other components are typically analyzed in Environmental Impact Assessment (EIA) when looking for the effects of a given project on the biological and ecological components of the environment. Strategic Environmental Assessment (SEA) tends to follow the same general pattern, when looking for the environmental effects of plans and programs. In both cases, ecosystem services are often not explicitly considered. We developed a framework to analyze environmental assessment (EA) practice and infer about ecosystem services based on existing evidence from EIA and SEA reports and supporting information. Our framework addresses the relations between ecosystem services and the environmental factors assessed in EIA and SEA, considering the relevant conceptual frameworks such as the ES cascade model and the DPSIR framework applied to ES provision. We base our proposals on results from a preliminary meta-analysis of recent EIA and SEA reports from several types of plans and projects in Portugal, in which implicit assessments of ES were clearly predominant. We discuss the implications of those results and the opportunities to infer about ecosystem services, and conclude on the need for more dedicated and explicit efforts to ecosystem services assessment in EIA and SEA.

1. Introduction

Ecosystem services (ES), or the benefits generated by ecosystems for human well-being (MA, 2005), are at the core of modern social–ecological research, both as a concept and as an operational tool for environmental and ecological assessment (e.g. Nelson et al., 2009; Slootweg et al., 2010). However, the generalized application of ES typologies in natural resource management and decision-making is still an open challenge (Daily et al., 2009). As part of an on-going research project aimed to evaluate recent and current practice of biodiversity and ecosystem assessment and monitoring in the context of Impact Assessment (IA), this paper reflects on the general question of whether and how have ES been considered in IA practice. More precisely, we addressed the following questions: (1) Have ES been explicitly considered in IA practice? And (2) in the case of implicit ES assessments, do they allow inference about the condition and impacts of projects, plans and programs on ES? With these questions in mind, in the following sections of the paper we: (1) present and discuss the state of the art concerning the consideration of ES in IA practice; (2) present and discuss results from the analysis of recent IA practice in Portugal; and (3) propose a framework for analysis of how ES have been considered in IA practice and discuss perspectives for inference on ES.

2. Ecosystem services and impact assessment

2.1. The rise of ecosystem services as an evaluation tool in environmental sciences

The idea that ecosystems support human activities and well-being dates back to the Greek antiquity, when for instance Plato wrote about the consequences of the deforestation of Attica for soil erosion and the drying of springs (Mooney and Ehrlich, 1997). Throughout the 20th century, awareness on the importance of ecosystem processes in providing direct or indirect benefits to human-beings increased, with the advent of Ecology as a science and the realization of the environmental limits and impacts of economic development and human population growth (e.g. Ehrlich, 1968). The role of biophysical constraints and environmental concerns also emerged as a major component of spatial planning with suitability analysis (McHarg, 1969). Still, the modern concept of ecosystem services (ES) only emerges in the 1970s, first as “environmental services” in the Study

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of Critical Environmental Problems (SCEP, 1970), and then coined as "ecosystem services" by Ehrlich and Ehrlich (1981). More recently, G. Daily's book on Nature's Services (1997) and the economic evaluation of global ecosystem services (Costanza et al., 1997) triggered research on ecosystem services. Finally, the Millennium Ecosystem Assessment (MA, 2005) brought ecosystem services into mainstream scientific and policy thinking.

The conceptual model to assess ES and biodiversity proposed in the Millennium Ecosystem Assessment (MA, 2005) is based on the consideration of ES as a tool to enable the assessment of impacts, allowing ecosystems and biodiversity questions to be addressed in terms of human well-being and poverty (Slootweg et al., 2006). Such assessment, when conducted in relation to land and resource use, spatial organization and integration of sectorial strategies, could also bring benefits to the distribution, quality, and use of a wide range of ES (Geneletti, 2011). The MA states that understanding the factors that cause changes in ecosystems and ES is essential to design interventions, and to enhance positive and minimize negative impacts. Such causal factors of change are usually named drivers of change, and they can be natural or human-induced.

The provision of ES can be modified by many drivers of change operating at different spatial and temporal scales (MA, 2005). Improved frameworks for research and assessment are needed to tackle the challenge of managing multiple ES in complex social–ecological systems (Abson and Termansen, 2010; Carpenter et al., 2009; Daily et al., 2009). From an "ES provider" perspective (Haynes-Young and Potschin, 2010), drivers of environmental and ecological change such as climate, policy or demographic dynamics will tend to produce regional changes in the rate and patterns of ES provision over long time periods, whereas land use or wildfire regimes will represent direct, local pressures on ES provision, sometimes inducing dramatic changes over shorter periods (MA, 2005). Changes in ES levels may also result from fluctuations in societal (i.e. concerning "ES beneficiaries") demand for the benefits generated by ES (Haynes-Young and Potschin, 2010). Robust approaches to ES provision, valuation and management should therefore consider effects of different pressures (internal to the system) and drivers (external to the system and acting on pressures) as well as of societal responses such as adaptation or mitigation, e.g. as proposed by Rounsevell et al. (2010) in their adaptation of the standard DPSIR framework to ES provision.

2.2. Relevance of ecosystem services in impact assessment: why should they be addressed?

As simply defined by the International Association for Impact Assessment (IAIA), impact assessment (IA) is the process of identifying the future consequences of a current or proposed action. Paragraph 1 of Article 14 of the Convention on Biological Diversity (CBD) identifies impact assessment as a key instrument for achieving the conservation, sustainable use and equitable sharing objectives of the Convention. IA is the root expression to refer to different instruments, such as environmental impact assessment (EIA), strategic environmental assessment (SEA) or health impact assessment (HIA), that operate in the context of development processes, with the purpose of scrutinizing decisions that might have significant implications for people and communities, and the systems that comprise the natural environment. According to SCBD and NCEA (2006), the design of an environmental assessment process must be such, that: (i) the full range of factors that cause changes in biodiversity and the environment is considered, including direct and indirect drivers of change; (ii) differentiation is made between those drivers that can be influenced by a decision-maker (endogenous driver), and others which may be beyond the control of a particular decision-maker (exogenous drivers); and (iii) the temporal, spatial and organizational scales at which a driver of change can be addressed, are defined.

Environmental impact assessment (EIA), as the most widespread form of IA, is well established in the world as evidenced by its generalized use in statutory development control and other environmental law processes, and by its presence in international law and lending institutions standards. EIA has been frequently used to assess the impacts of major development projects that can potentially impact on ES provision in multiple ways. The impressive case of the massive hydropower dam on the Yangtze River in central China (Hvistendahl, 2008) is one outstanding example, where environmental impacts include contamination of freshwater, disappearance of endemic species, changes in the regulation of water timing and flows, among others. Tellería (2009) pointed out the impacts of wind farms, especially related to habitat destruction and/or fragmentation (i.e. impacts on biodiversity) and to visual impact on the landscape (i.e. cultural services). The transformation of natural landscapes into urbanized landscapes is also an important force behind the erosion of biological diversity worldwide that modifies ecosystem services such as water purification, soil production, carbon sequestration, and climate regulation, namely by shifting the diversity of species with key ecological roles in ecosystems (O'Shea and Olander, 2011; Sanford et al., 2008).

Strategic environmental assessment (SEA) expanded as an EIA version for plans, programs and policies. It is however, increasingly recognized as a different and essential instrument for strategically facilitating sustainability processes, by creating conditions for development through the integration of environment and sustainability concerns in decision-making (CSIR, 1996; Partidário, 2000). When considered at early decisional stages, with a flexible and adaptive approach, SEA can play a decision support role providing a framework for strategic assessment. The Ecosystem Services Approach, adopted by the United Nations Environment Programme (UNEP) and the Convention on Biological Diversity (CBD), expands the focus on how development strategies affect ecosystems (WRI, 2008). The incorporation of ecological systems and valuation of ES may be explored in a wide range of policy options, as for example (WRI, 2008): (i) national and sub-national policies and plans (including investments in ES in government budgeting); (ii) economic and fiscal incentives (establishing trading systems for use of ES); (iii) sectorial policies and plans (include ecosystem services in strategic environmental assessments); and (iv) governance (strengthening local community rights to manage ES).

Safeguarding and valuating natural and cultural heritage and biodiversity, by integrating biodiversity and ES in the development of strategies, allows the protection and reinforcement of ES benefits (UNEP, 2009). Human activities can impact ES, because of the cyclical interaction between human actions, ecosystem goods and services. When talking about spatial planning or strategy development, decisions that can have significant positive or negative impacts on ES, and on human well-being, will need to be analyzed considering a complex intertwine of values and relationships. Recognizing ES in governance at all levels of decision-making may help to identify spatial and temporal trade-offs between humans and ecosystems (Braimon et al., 2009).

An integrated approach for addressing ES in policy options was recently proposed by Partidário and Gomes (2011) to highlight the relationship between governance and ES. Recognizing the link between human well-being and ecosystems is accepting the argument that it is necessary to consider and integrate ES in territorial development strategies (Partidário and Gomes, this issue). Different stakeholders will set different preferences and trade-offs with respect to the use and contribution of ES to their well-being. The integration of ES in all policy decision-making will highlight the inequities between stakeholders, enabling the identification of winners and losers (Braimon et al., 2009).

2.3. Ecosystem services in EIA and SEA: what is the current state of practice?

Many components of the biophysical and social–ecological environments are typically analyzed in IA practice when looking for the

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effects of a given project (EIA) or of plans and programs (SEA). In both cases, evidence shows that ecosystem services are often not explicitly considered. Mainstreaming ES in EIA and SEA would harness the potential to integrate information of ES impact assessment process, enhancing its quality, and the quality of the development strategies and projects (Geneletti, 2011; OECD DAC, 2010; Slootweg et al., 2010; van Beukering and Slootweg, 2008). EIA practitioners are still not engaged to apply the concept of ecosystem services, mostly due to a lack of guidance on how to address ES, and what is its added value to traditional impact assessment practices. Recent efforts to provide technical guidance to address ecosystem services in impact assessment include the review by Landsberg et al. (2011) or the more sector-oriented for oil and gas developments, by IPIECA/OGP (2011). Moreover, business companies, and the consultants that analyze and report on impact assessment, limit their effort to what is required in the legislation, which does not explicitly consider ES. Thus, the implementation of the ES concept and typology in EIA practice is still quite immature.

Concerning SEA, methodological guidelines to assess and integrate ES in strategic decision-making have been multiplying in recent years, including those published by the World Resources Institute (2008), the OECD-DAC (2010), Slootweg et al. (2006) and the WBCSD (2011). According to van Beukering and Slootweg (2008), the integration of ES in SEA allows to: (i) increase the transparency and commitment on decision making; (ii) provide knowledge related to equity and poverty issues; (iii) identify winners and losers as a consequence of development options; (iv) favor the sustainability in its three dimensions; (v) improve the planning process, through the integration of biodiversity; (vi) valuate ES, recognizing their value and putting biodiversity on decision agenda; and (vii) safeguarding the providing of ES for future generations. A step by step process to include ES on the planning process was advanced by Geneletti (2011), linking SEA activities to four stages of the planning process and relating to ES in each of those stages (Table 1).

Another relevant framework based on an ecosystem approach was presented by the OECD DAC (2010), with linkages between SEA processes and ecosystem functions and benefit flows. It is organized in two categories: the resource or supply side, and the demand or regulatory side (with the latter based on the application of the precautionary principle).

In Portugal, the research group on Strategic Approaches to Environment and Sustainability (SENSU) of the Instituto Superior Técnico (IST) has been adopting, since 2008, a SEA inclusive ecosystem approach. Based on the work developed by Slootweg et al. (2006), van Beukering and Slootweg (2008), OECD-DAC (2010), and WRI (2008) and also on the Critical Decision Factors (CDF) framework developed by Partidário (2007), a methodology was adopted to address ES within SEA (Partidário and Gomes, 2011). The general methodological steps and further details on the methodology are described in Partidário and Gomes (this issue).

Van Beukering and Slootweg (2008) conducted a case-evidence study where through international real case experience evidence is provided on ES recognition, quantification and valuation, as well as how this has contributed to strategic decision-making. The authors found that it was very difficult to find practical examples of the application of ES in an SEA context. However, based on ten cases, they could elaborate on key recommendations about the recognition of ES and how it helps the identification of relevant stakeholders, the distribution of ES benefits, highlighting poverty and equity issues, and the valuation of ES in terms of financial, social and environmental aspects.

The lack of practical examples is a severe limitation to improve knowledge on how ES can improve development strategic decision-making through impact assessment. Söderman et al. (2012) presented a set of ES criteria to improve strategic decisions, by providing decision with the "substance to ecological sustainability of an urban region in the context of ecosystem services". The authors provide several recommendations to practitioners and researchers based on their findings on the development and test of the ES criteria in Finland, highlighting the need of specific tools for ecological sustainability to enhance decision-making through impact assessment. The recommendations include: the definition of ES benefits instead of ecological facts; using understandable and simple indicators to prevent complexity; engaging, from the beginning of the planning processes, stakeholders, planners and decision-makers for a parallel use of the chosen indicators, and to reduce the complexity of the communication processes between them; and using spatial data instead of statistics and numbers for a better comprehension by planners and stakeholders.

Results of a Portuguese Environmental Agency (APA, 2010) study on the practice of SEA in Portugal showed that, based on the quality review of SEA reports, about 60% of the 30 SEA cases reviewed included indicators to assess or monitor biodiversity, but none considered ES, their benefits and valuation. Research also conducted by Eira (2009) revealed that there are gaps concerning the assessment and consideration of biodiversity and ES in the decision-making processes.

3. Analysis of ecosystem services in EIA and SEA in Portugal

In this section, we present results of a preliminary analysis of how ES have been considered in previous EIA and SEA processes in Portugal. We analyzed whether ES have been explicitly or implicitly considered, and whether the relevant impact quantifications (EIA) and connections to stakeholders (SEA) have been included. Outcomes of this analysis will

Table 1
Linkages between planning stages and SEA activities, with actions to include information on ES (Geneletti, 2011).

Planning stages	SEA activities	Actions to include information on ES
Defining the scope and the objectives of the plan	• Describe environment baseline • Identify environmental and sustainability objectives relevant to the territory being planned • Identify other relevant plans and policies and test for consistency	• Identify what ES the plan's objectives depend upon or affect • Map areas of production and fruition of key ES (including analysis of beneficiaries and stakeholders) • Collect data on spatial and temporal trends • Analyze issues of scale and spatial relationships
Identify actions to achieve the objectives	• Propose and compare alternative actions, possibly in different scenario conditions • Predict and assess environmental effects • Support the selection of the preferred options • Test for consistency among plan's actions	• Track the direct and indirect drivers of changes in ES, by paying particular attention to the foreseen land-use changes • Test the effects of different options on ES, by quantifying changes whenever possible and evaluating them in biophysical and/or monetary terms
Drafting the plan, revision and final approval	• Suggest mitigations • Assess overall impact of the plan and suggest mitigations • Write SEA report	• Make trade-offs and synergies among ES explicit, considering both the production of services (where is it likely to increase/decrease?) and their use by different groups of beneficiaries (who wins and who loses?)
Implementation	Monitoring and follow-up	• Suggest solutions to reduce the impact of the plan on critical ES • Assess cumulative effects on the ES, under different future scenarios • Verify if patterns of use and production of ES are evolving as expected and suggest adaptive management strategies

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support an analytical framework to infer about ES based on existing environmental assessments (Section 3).

3.1. Ecosystem services in EIA

The Portuguese legislation for project EIAs (DL 197/2005), as much as the legislation for the Environmental Assessment of Plans and Programmes (DL 232/2007), encompasses most of the general principles of the European Directives. It sets requirements for the assessment of environmental factors potentially related to ES concepts. Several of the legislated sections of EA reports could provide valuable information on the state and expected project impacts on several ES categories. Examples of such sections are those related with localization and characterization of the project, description of expected impacts, land planning and restrictions, landscape and geomorphology, geology, water resources, natural values (fauna and flora), soil, effluents, residues, and emissions to the water, soil and atmosphere.

Twelve EIA processes (all post 2000 and located in the north of Portugal) related to power production were selected from a larger set of EIAs for a preliminary analysis of ES in EIA practice. We chose projects related to power production, located either inside (n = 6) or outside (n = 6) protected areas (National Network of Protected Areas or EU Natura 2000 Network), and dated before (n = 7) or after (n = 5) the year of publication of the Millennium Ecosystem Assessment (2005). The set included six processes related to wind farms and six processes related to hydroelectric projects. We chose energy production projects because: (i) the common final objective of these projects (energy production); (ii) the high number of projects related to energy production in the region; and (iii) the complementarity between wind farms and hydroelectric dams in terms of their physical location and potential impacts (types, magnitude and spatial expression).

For each EIA process, we revised documentation related to site characterization and evaluation of project impacts. A preliminary relationship between the adopted ES typology and the structure of EIAs was established a priori (Table 2), based on the definitions of ES of MA provided by Landsberg et al. (2011). Based on such relationship, all four categories of ecosystem services (provisioning, regulating, cultural, and supporting; MA, 2003, 2005) were evaluated on whether: (i) they have been explicitly vs. implicitly considered in impact assessment; (ii) specific services within general ES categories have been considered; (iii) the assessments in the reports might allow ES estimation; (iv) the assessments were spatially explicit and the maps had adequate information and detail as to allow an indirect ES assessment and thereby enable technical decision; and (v) the data and results provided in the reports allowed the quantification of any ES. In the analysis of EIA reports, we considered as "explicit ES assessment" the stated use of the ES typology as an impact assessment tool, using explicit expressions such as "ecosystem services", "landscape services", or "environmental services of ecosystems". By "implicit ES assessment" we meant the use of concepts and measures relatable to ES, i.e. information potentially allowing the estimation of project impacts on any type of ES (examples are given in Table 3).

None of the analyzed EIA processes included any explicit ES consideration in their assessments. However, implicit considerations of ES were found in several chapters of EIA reports (Table 3). Implicit references to provisioning services (P) were found in assessments of "Landscape, Land use and Geomorphology" (namely for food, biological raw materials, and freshwater), supporting services (S) were implicitly referred in "Flora/fauna/habitats" assessments (namely for the "habitat" ES subcategory), and implicit evaluations of cultural services (C) were found in assessments of "Land planning/restrictions" (namely for "Recreation and ecotourism" and "Ethical and spiritual values"). The most commonly addressed regulating services (R) were "Regulation of water timing and flows" and "Erosion control", which are often implicitly considered in assessments of water resources.

A large number of ES subcategories mentioned in the MA were not considered in any of the analyzed EIA reports, not even implicitly (they are thus not listed in Table 3). These include: "Biomass/fuel (P)", "Biochemicals, natural medicines, and pharmaceuticals (P)", "Regulation of diseases (R)", "Regulation of soil quality" (R), "Biological control" (R), "Pollination" (R), "Regulation of natural hazards" (R), "Educational and inspirational values" (C), "Nutrient cycling" (S), and "Primary production" (S). The most frequently considered ES (always implicitly) were by far the provisioning services, followed by the cultural services. However, the most frequent ES subcategory was in fact "Habitat", related to supporting services. Despite the non-explicit reference to ES in all the analyzed cases, the information found in some reports was considered sufficiently detailed to allow the quantification and/or spatialization of some ES (Fig. 1). This was particularly possible for the ES subcategories "Food", "Biological raw materials", "Habitat", and "Recreation and ecotourism".

Finally, no relation was apparent between the location of the project (inside or outside protected areas) (National Network of Protected Areas or EU Natura 2000 Network) and the number of implicit ES references in the assessment reports. Likewise, the MA (2005) conceptual framework is not explicitly present in EIA practice, and no difference was found between the EIA reports dated before and after 2005. In fact, the differences observed among the analyzed EIA reports seemed to be more related to the intrinsic approach, scope and detail of reports

Table 2
Equivalences between the structure of EIA reports and ES categories: (0) no conceptual relationship expected; (+) significant relationship expected; (++) very significant relationship expected. Examples of key ES are presented below each ES type.

Structure of EIA reports (environmental factors)	Provisioning services (P)	Regulating services (S)	Cultural services (C)	Supporting services (S)
	Food (crops, wild game and food, capture fisheries) Biological raw materials and freshwater	Climate regulation Air quality regulation Prevention of soil erosion Water flow regulation	Recreation and tourism Aesthetical fulfillment derived from landscape	Habitats and biological corridors for biodiversity Nutrient and water cycling
Air quality	0	+	0	+
Climate	+	+	0	+
Noise	0	0	+	0
Landscape, land use and geomorphology	++	+	++	+
Geology	0	+	+	+
Soil	+	+	0	+
Water resources	+	+	++	+
Fauna/flora/habitats	+	+	++	++
Land planning/restrictions	+	++	+	+
Cultural heritage	0	0	++	0
Structuring systems	0	+	0	+
Socio-economics	++	+	++	+
Demography	+	+	+	+

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Table 3
Summary of results and examples of assessments or references related to ES found in twelve processes of EIA reports (Provisioning services (P); Regulating services (R); Cultural services (C); Supporting services (S) (only subcategories with data figure in the table)).

ES categories and subcategories		Processes												Examples of assessments or references to ES
		1	2	3	4	5	6	7	8	9	10	11	12	
P	Food provisioning (references only to “crops”, “livestock”, “capture fisheries”, “wild foods”)	x	x	x	x	x				x		x	x	Calculation/cartography of impacted areas (ex: agriculture, vineyards, and pastures); quantification of negative impact on “hunting areas”; considerations on the negative impact on areas included in “National Agricultural Reserve” or in inland waters with fishing activities; considerations on the positive impact of new accesses for cultivation/forest areas.
	Biological raw materials (references only to “timber and other wood products”)	x	x	x	x	x				x	x	x		Calculation/cartography of impacted areas (ex: production forest and natural forest suitable for wood production); quantification of negative impact; considerations on the negative impact in areas suitable for forest occupation.
	Freshwater provisioning	x	x	x	x	x	x		x	x	x			Previsions/quantifications of water availability for human use with the modification of fluvial ecosystems.
	Genetic resources				x		x							References to the loss or the impact on populations of some species which are rare or/and have restricted distribution (e.g. Iberian Peninsula endemic fish).
R	Regulation of air quality						x	x						Identification of the most susceptible zones for air pollution relating air quality parameters and protection of vegetation.
	Regulation of climate									x		x		Qualitative previsions on the micro- or meso-climatic changes of temperature and humidity due to the change of fluvial ecosystem.
	Regulation of water timing and flows	x	x	x	x			x		x	x			Calculation/cartography of impacted areas (ex: water drainage/infiltration zones); quantification of impact on local runoff after dam construction; considerations on the impacts on the water flow; quantifications of minimum ecological flow.
	Erosion control	x	x	x						x	x			Calculation/cartography of impacted areas (ex: high risk erosion or high gradient zones); quantification of impact on soil exposure and bank stability by vegetation removal or construction.
	Water purification and waste treatment													Calculation and models of water quality in the fluvial system (models including biotic components).
C	Recreation and ecotourism	x	x	x		x		x	x	x	x			Cartography and quantification of landscape units with different values for “quality–fragility–sensitivity” indexes; quantification of areas where the construction/structures sites are visible; considerations on the camping and access improvements.
	Ethical and spiritual values	x	x	x		x		x	x	x	x			Cartography and quantification of landscape units with different values for “quality–fragility–sensitivity” indexes, quantification/cartography of units of high esthetic value.
S	Habitat provisioning	x	x	x	x	x	x	x	x	x	x			Calculation/cartography of the habitat of several species of flora and fauna; creation of indexes valuing the habitats in their degree of rarity, resilience or association with species important for conservation; quantification of ecological flow needed; cartography of habitats highly sensitive to impact or “support/protection habitats”.
	Water cycling			x										General cartography on the underground infiltration zones; considerations on the relation between vegetation damage and water flow.

than to any other factor. Future analyses over a higher number of reports could eventually reveal other aspects. Nonetheless, from the analyzed reports two conclusions could be extracted: (1) none of the EIAs included explicit references to ES as a concept or to any of the ES categories, nor were ES used as an operational assessment tool; and (2) even if a large part (75%) of the analyzed EIA processes would allow mapped and quantified inference on some ES, this would only apply to less than 20% of the implicit references to ES found in those processes (Fig. 2).

3.2. Ecosystem services in SEA

To infer about ES in the Portuguese SEA practice, a sample of 60 SEA cases was selected for a first scan on whether ES have been considered explicitly or implicitly. The criteria used to distinguish the 60 cases were: (1) the explicit assessment of ES, and (2) whether ES were explicitly mentioned, as a critical decision factor (CDF), or the core theme, as assessment criteria within a given CDF (see Partidário and Gomes in this same special issue for a clarification on this methodology), or explored as a critical subject in the plan. From the 60 cases reviewed, only eight mentioned ES in an explicit way. For further analysis, only these eight cases where ES were explicitly considered and mentioned were selected. Where ES were addressed implicitly, examples of assessment indicators, and identification of opportunities and risks that somehow relate to ES were collected and are summarized in Table 4.

In order to support our analysis of cases, criteria were identified from the literature and used as relevant aspects for explicit analysis (Fig. 3). These are the most used criteria in the revised SEA reports when explicitly referring to ES.

Identifying the ecosystems related to specific development initiatives may express important ES for different stakeholders. Drivers of change that affect ecosystems, directly or indirectly, the recognition of benefits that people will obtain from them, and the ES valuation for promoting discussion among the different stakeholders, were considered the most important topics for explicit analysis. Ecosystems, in an ecosystem approach, are normally identified by the importance they represent to different stakeholders. In the reviewed cases, only two cases identify stakeholders and translate their recognitions in the ES values. These cases explore the “*natural or human induced factor that causes changes in an ecosystem*” (MA, 2005).

The results obtained from the analysis of these eight cases are compiled in Table 5. Of these, only one case did not value ecosystem services in any way (social, economic and environmental). These results show a lack of consideration and information regarding the human–environment interactions, as well as the identification of the most important issues for the specific planning context. This also provides information about the low attention given to stakeholders, as well as participation practices in SEA processes. It should be noted that both theory and good practice point out that in order to rightfully address ES the identification of beneficiaries and stakeholders is required (Slootweg et al., 2006; van Beukering and Slootweg, 2008).

ES represent values for the society. At high levels of decision-making, strategy development and implementation may result in changes to those values, for better (taken as opportunities) or for worse (taken as risks). In this study, we noticed that ES are not properly addressed in strategic approaches, and as a consequence, it is difficult to clearly understand how the consideration of ES may improve future strategic development. In the implicit cases, ES are normally associated

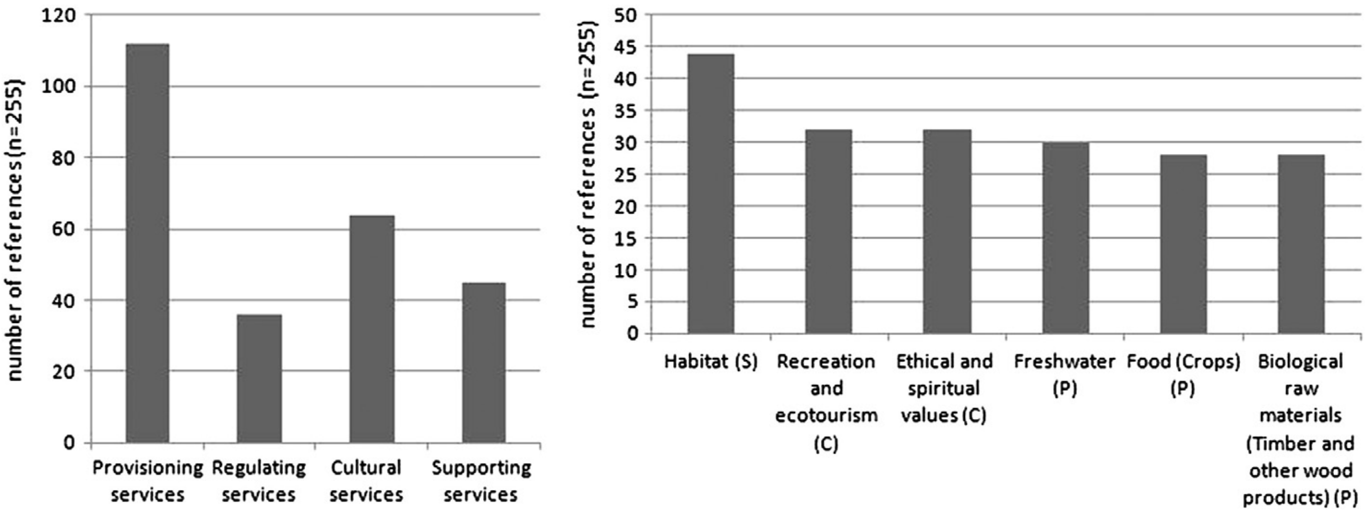

Fig. 1. Number of references of ES categories (left), or ES sub-categories (right) found in twelve EIA Portuguese processes (ES always assessed implicitly).

to their ecological values, and there is not a specific analysis related to ES benefits, values and links to human well-being.

The way ES was considered in the explicit cases varies, and the approaches differ from one case to another, which makes it hard for a comparative analysis of the results. Even when the same general criteria are considered and integrated in the SEA process, different levels of assessment are found: the understanding of linkages between ecosystems and strategies development, the future development and risks or opportunities on ES, the ES incorporation into the decision, the accountable and iterative consideration of ES in all SEA process. Table 5 results show two cases – Tomar municipality and Pico's Island – where ES are addressed in a strategic and systematic way, contributing to the strategy formulation and implementation, improving future strategies and projects developments.

4. A framework for inferring about ES based on EIA and SEA practice

The analysis of previous practice in considering the assessment of ES in EIA and SEA would encourage the proposal of: (i) a framework for analysis of EA practice to assess possible inference on ES; but also of (ii) a standard framework (which we hereby name "ESEA — Ecosystem Services in Environmental Assessment") that may allow a more systematic consideration of ES (both explicit and implicit) towards better practice in EIA and SEA. Here we focus on the development of the former, as a contribution for gathering experience towards the establishment of the later. In this section, we describe the general approach of such a framework for analysis of EA practice and instantiate it in its application to EIA and SEA.

The proposal of an operational framework to assess or infer on ES from EA practice is based on the assumption that most environmental assessments explicitly or implicitly include information that is of value for evaluating ES, as well as for supporting the assessment, monitoring and mitigation of impacts on ES provision. Considering the little accumulated experience of considering ES in impact assessment, a framework for analysis of EA practice (the "ESEA analysis framework") was first developed based on a set of questions addressing assessment issues (Tables 6 and 7) that are of the highest relevance for inference on ES based on previous EA practice. In EIA these questions can be addressed for impact assessment, monitoring and mitigation (Table 6), whereas in SEA they will focus on issues related to the strategic consideration of ES in the planning process (Table 7). We have learned that in both cases the framework can be applied focusing on a specific ES, or for several types of ES recognized in the standard typologies. Based on this analysis, we will move, in this research project, to develop and propose a standard ESEA framework for considering ES in EA.

When used to infer about ES from previous EIA practice, the ESEA analysis framework addresses the (total or partial) use of the ES typology as an evaluation tool, the explicit vs. implicit nature of the

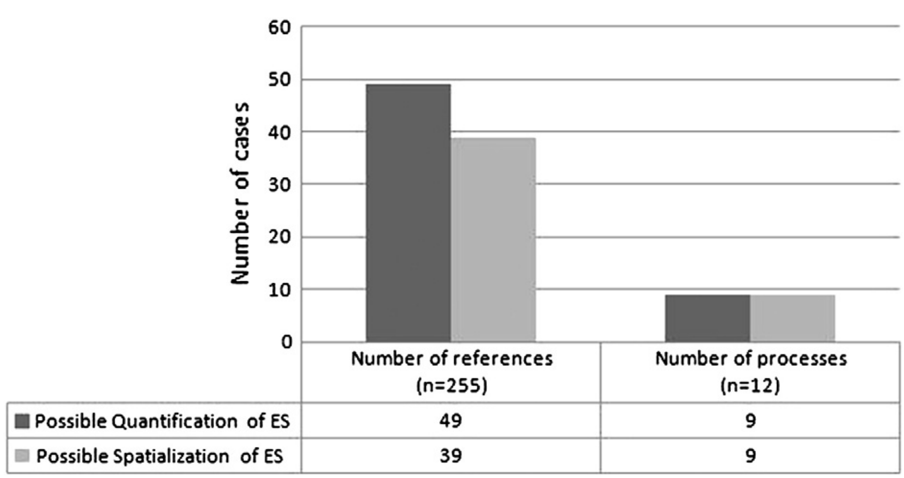

Fig. 2. Number of cases with (implicit) references to ES sub-categories. Cases are distinguished depending on the possibility of quantification and spatialization/mapping of impacts on ES.

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Table 4
Examples of assessment indicators, opportunities and risks related to ES identified in SEA cases in Portugal.

Assessment indicators as proxy for ES	Provisioning services (P)	Regulating services (S)	Cultural services (C)	Supporting services (S)
Intervention area within the national agricultural reserve	+	+	+	+
Quality of superficial and subterranean water	+	+	0	+
Coverage rate of resident population with water supply	+	0	0	0
Demand of ecotourism	+	0	+	0
Weight of biological production in agriculture	+	0	0	+
Capacity of carbon sink	0	+	0	0
Ecosystem fragmentation	0	+	+	0
Level of pond eutrophication	0	+	0	0
Number of peoples and goods vulnerable to natural hazard	0	+	0	0
Variation of use of waterlines for irrigation	+	0	0	0
Investment rate in integrated management of water	+	+	0	+
Fauna and flora resilience to disturbances in the support biotope	0	+	0	+
Active population in fish sector	+	0	+	0
Number of actions to promote the agricultural potential	+	0	0	+
Opportunities that express benefits for ES				
Recovery and vitalization of old mineral water concessions	+	0	0	0
Demand qualification of green areas to recreation and leisure	0	0	+	0
Multifunctionality of forest areas	+	+	+	+
Potential use of endogenic tourism	+	0	+	0
Landscape valuation	0	0	+	0
Stimulation of ecotourism	+	0	+	0
Risks that express losses for ES				
Explore intensification of natural resources	+	+	+	+
Food crisis due to decrease of agricultural and fishery production	+	+	+	+
Expansion of invader species	+	0	+	+
Soil waterproofing due to economic activities	+	+	0	+

evaluations, and the quantitative and spatially explicit nature of data presented in instances of implicit references to ES (Table 6). The assessment of previous EIA practice reported above for Portugal confirms that these are the crucial factors constraining inference on ES.

The application of the ESEA analysis framework in a SEA context would reflect the strategic approach to impact assessment that characterizes SEA practice and distinguishes it from EIA practice. In this regard, the approach developed by Partidário and Gomes (this issue), as well as the results presented above, may help us to analyze how ES are addressed in SEA processes. This is also based on the assessment of five questions concerning issues that are relevant throughout the several stages of SEA practice (Table 7).

Tables 6 and 7 reveal that the ESEA analysis framework is focused on three key components of assessment that permit inference on the importance of the ES typology throughout each EA process: (1) Integration: the possible use of the ES typology for integration of ES issues across areas of assessment; (2) Evaluation: the possible use of the ES typology for evaluation of ES in at least some areas of assessment; and (3) Quantification: the possibility of inference on ES based on explicit mapping and valuation, even under implicit ES evaluations (Table 8).

Assessments based on these three components should consider: (i) the dynamic relation between the biophysical (i.e. ecological) infrastructures supporting ES provision and the societal demand of each service (e.g. Haynes-Young and Potschin, 2010), and (ii) the direct effects of multiple pressures and societal responses on ES provision as well as their dependence on a set of external drivers (e.g. Rounsevell et al., 2010).

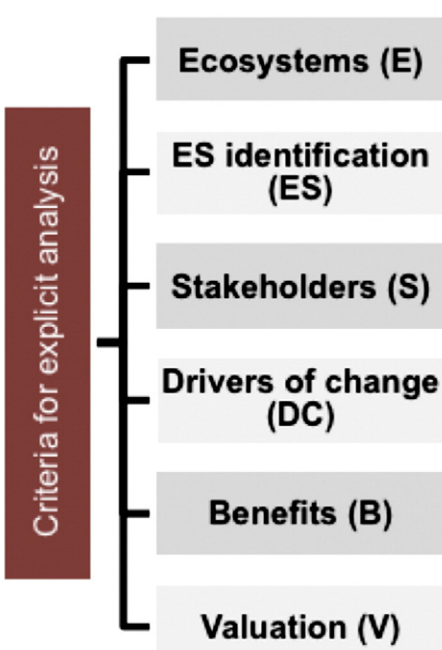

Fig. 3. Criteria for explicit analysis for consideration of ecosystem services in SEA.

5. Conclusions and future perspectives

5.1. Preliminary conclusions from EA practice in Portugal

In this paper, we performed a review of recent practice in environmental assessment (both EIA and SEA), using examples from existing environmental assessments in Portugal to illustrate that there is a general under-representation of ecosystem services in environmental assessments. From a preliminary analysis of EIA and SEA reports, we concluded that explicit assessments of ecosystem services in environmental assessments are scarce, even when considering specific environmental factors. No examples of EIA practice were found in which an ecosystem services typology has been used as an integrative framework for assessment, and ecosystem services were considered in eight SEA of plans but generally in a very broad way. Implicit references to ecosystem services were recognized in both EIA and SEA practice in Portugal, which is not uncommon since any of these EA will consider the biological and ecological components of the environment. However, in most cases there was not a quantified assessment or mapping of proxies allowing inference across a range of ES.

Table 5
General approaches to ecosystem services in SEA cases.

Study	Plan typology	Consideration of ES in the assessment	E	ES	S	DC	B	V	Examples of indicators and guidelines
Tomar Municipality	MP	Critical factor in the plan	X	X	X	X	X	X	Assessment indicator: maintenance of agricultural and forest systems with particular interest to ES Monitoring guideline: installation of agricultural and forest companies with sustainable ways of production and contributions to ES optimization
Sado e Mira Hydrographical Region	RBMP	Assessment criteria or indicator	X	X	–	–	–	X	Assessment objective: safeguard proper provisions of goods and ES
Ribeiras do Algarve Hydrographical Region	RBMP	Assessment criteria or indicator	X	X	–	–	–	X	Assessment objective: safeguard proper provisions of goods and ES
Peneda Gêres National Park	SP	Critical factor in the plan	X	X	–	–	X	–	Monitoring guideline: implement monitoring plans to identify the conservation status of habitats and species, their relation to humans use and respective management practices
Pico's Island	CSP	Critical factor in the plan	X	X	X	X	X	X	Planning guidelines: increase the areas with esthetic value
Portuguese Maritime Space	MSP	Assessment criteria	X	X	–	–	X	X	Assessment indicator: the level of acceptable change of ES and their effectiveness Monitoring indicator: investments in recovery actions of marine ecosystems and respective ES
National Integrated Coastal Zone Management	ICZM	Ecosystem approach as an assessment criteria	X	X	–	–	–	X	Planning guideline: valuation of costal ecosystems, with the systemic relation earth/sea
Lisbon Metropolitan Area	RP	Assessment criteria	X	X	–	–	X	–	Planning guideline: promote the social and economic valuation of carbon fixation services for the forest areas

Legend: MP — Master Plan; RBMP — River Basin Management Plan; SP — Special Plan; CSP — Coastal Spatial Plan; MSP — Maritime Spatial Plan; ICZM — Integrated Coastal Zone Management; RP — Regional Plan. E — ecosystems; ES — ES identification; S — stakeholders; DC — drivers of change; B — benefits; V — valuation.

In EIA practice, explicitly considering ES as a tool for assessment would promote more coherent and integrative evaluations of impacts and cost–benefit analyses. In a SEA context, ecosystem services that are not explicitly identified may be overlooked, and even overridden by the strategy development, leading to negative consequences on other services, as well as on human well-being. Explicitly addressing ES provides an opportunity to identify conflicts and synergies between human actions and ecosystems, to establish dialogs and negotiation processes, to enhance gains for beneficiaries and avoid losers, as well as for exploring long term benefits for which the strategic level of discussion is appropriate. In addition, the analysis of ES can be highly relevant to the debate on cumulative effects associated to natural resources management.

Our analysis shows that implicit consideration of ES can be quite useful as a proxy analysis. In fact in some of the cases reviewed the assessment indicators, as well as the consideration of risks and opportunities opens up a good case for consideration of ES. The problem with implicit assessments is the way information is presented and understood by those who will use and explore it. Evident and explicit mention of problems enables quicker understanding, and unless the preoccupation is also explicit, there are great chances that the implicit issue will pass unnoticed. The analysis also revealed that the benefits

Table 6
The ESEA analysis framework to infer about ecosystem services in EIA practice.

Stage	Question	Rationale
1. The ES typology as an integrative evaluation tool	Have ES been explicitly used as a central evaluation tool across the IA process?	ES typologies provide a suitable framework on which to base the integrated assessment of impacts, conflicts and trade-offs, thereby supporting decision on project viability and on impact mitigation options. This first stage of the framework intends to distinguish those cases in which an ES typology has been explicitly used as an evaluation tool across the EIA process.
2. The ES typology as a thematic/sectorial evaluation tool	Have ES been explicitly evaluated in any of the thematic IA evaluations?	Even if an ES typology has not been used as an integrative evaluation tool, ES may have been explicitly considered and evaluated in one or more specific assessments (e.g. land uses and water resources). Those explicit ES assessments may have yielded more consistent evaluations of the potential impacts of the project being assessed. They may also have supported ES-based monitoring and mitigation.
3. Implicit thematic/sectorial ES assessments	Have ES been implicitly evaluated in any of the thematic IA evaluations?	In previous EIA practice, ES may have not been explicitly assessed, not even in evaluations of specific environmental factors. However, implicit assessments may be more common and still allow inference on ES. Such assessments may have supported decision and recommendations that considered the ES dimension of o ne or more components of (social–) ecological systems.
4. Quantified thematic/sectorial ES assessments	Do data and results from thematic/sectorial assessments allow a quantified evaluation of ES?	Regardless of being explicit or implicit, ES assessments will be particularly useful if they have been based on standard quantitative evaluation frameworks. Results from such quantitative evaluations may have been provided on monetary units or not, but still they allow conflict and trade-off analyses based on quantitative estimates of impacts on ES provision, further supporting integrative analyses of project viability.
5. Spatially-explicit thematic/sectorial ES assessments	Do data and results from thematic/sectorial assessments allow a spatially-explicit evaluation of ES?	Spatially-explicit ES evaluations identify areas that are more important for the provision of each ES or ES category. They allow explicit comparisons with areas of potential project impacts. They also allow spatial integration of ES value maps with zonations related to other areas of assessment. Finally, they can also support the spatial–explicit design or monitoring programs and mitigation measures.

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Table 7
The ESEA analysis framework to infer about ecosystem services in SEA practice.

Stage	Question	Rationale
1. Prioritization of ES	Have ES been identified in their relevance to the strategic decision context?	Identifying services that the success of the strategy depends on and whether services may be affected by the strategy
2. Stakeholders identification and involvement	Have stakeholders been adequately identified and engaged?	ES are the benefits for people. Ignoring people, as direct or indirect stakeholders, is cutting the main rationale for ES
3. ES inclusive SEA	Are ES on the SEA agenda in terms of critical decision factors, assessment criteria or indicators, and included in trend analysis?	Doing SEA must include ES. SEA can enable that strategy development will benefit with the identification and valuation of ES. Possibly, decision-makers will see an added-value if and when the economic valuation will be included as well.
4. ES as part of problem and stakeholders mapping	Have ES and stakeholders been related in relation to priorities, sensitivities and benefits?	If ES are the benefits for people, mapping people's benefits and ES will enable relating to each other, and this relationship be analyzed and considered in the SEA
5. ES valuation	Can ES be valued in a pragmatic and operational way?	Policy and planning decisions are taken on the basis of public and private interest, expressed in social and economic values. Attention to ES will improve when these will be expressed in monetary values.

of ES are being overlooked in both EIA and SEA. There is a lack of quantitative assessment of ES losses, although these are sometimes recognized. However, it is striking how EIA and SEA miss the opportunity of exploring how ES can improve local well-being.

5.2. Recommendations for future EA practice

From the above conclusions, and considering the integrative and operational nature of ES typologies, it seems clear that efforts must be made to improve the assessment of ecosystem services in EA practice. We think that significant improvements could be achieved by using an ESEA type of framework in at least three main lines of action:

(1) *Promoting and evaluating the use of ES typologies as integrative tools in environmental assessments*, taking advantage of the integrative and overarching character of ES classifications (Landsberg et al., 2011; MA, 2005), and thereby supporting coherent evaluations based on a common set of comparable indicators. These would in turn allow the identification of conflicts and the development of the cost–benefit and trade-off analyses that are usual components of environmental assessments. If based on robust conceptual frameworks relating ES provision to structural and functional features of ecosystems and landscapes (e.g. Haynes-Young and Potschin, 2010) and to the effects of multiple drivers, pressures and societal responses (e.g. Rounsevell et al., 2010), those assessments will support more robust and operational approaches to impact mitigation, offset and monitoring.

(2) *Promoting and evaluating the explicit assessment of ecosystem services for the most relevant environmental factors*, even when the use of ES typologies as an integrative and overarching assessment tool is not an option. Methodologies for identification, quantification and mapping of multiple ES are available and have been used to assess the effects of planning and management options (Egoh et al., 2008; Nelson et al., 2009). Depending on the type of projects, plan or program under evaluation, explicit assessments of the key supporting, regulating, provisioning and cultural services would allow more complete assessments of specific impacts (both positive and negative), thereby influencing integrative assessments as well as priorities for impact mitigation and monitoring.

(3) *Considering ecosystem services in the definition of priorities for impact mitigation and monitoring*, selecting indicators that help decision-makers and planners to recognize the importance of ES and the benefits in a societal context. In EIA, explicit ES assessments would provide the reference framework and condition for adequate impact mitigation and cost-efficient monitoring of impacts on indicators expressing ES of higher societal relevance. In a SEA context, monitoring will enable increasing knowledge on how strategies in policies, plans and programs relate to the enhancement of ecosystem services. Sometimes there will not be a direct pathway to demonstrate this, so a strategic view is necessary to find relationships where they are not obvious at first glance. Drivers of change, benefits and values can be considered as assessment indicators, opportunities and risks may point out to monitoring guidelines. At strategic levels, indirect drivers are the most important to be considered and precise cause–effect relationships are often very hard to establish (Partidário and Gomes, this issue).

The lessons learned from the analysis of a limited set of environmental reports suggest that these general conclusions may encourage a more explicit inclusion of ES in environmental assessments, both in EIA and SEA, thereby improving assessment while providing a framework for conflict and trade-off analysis. Monetized assessment of impacts on ES would further improve political and technical decision on projects, plans and programs. Furthermore, in the context of EIA mitigation, an ES-based assessment framework would improve the prioritization of resource allocation between impact minimization and compensation, through a more direct link between resource management and societal needs in the several geographic contexts. The analysis of a larger number of reports, across a wide range of (social–) ecological situations, plans and projects, will likely advocate the relevance of a standard ES-based framework for environmental assessment. Our ESEA proposal could provide such an ES-based framework to be tested and implemented in future EIA and SEA practice.

Table 8
Components of the ESEA framework and their instantiation in EIA and SEA contexts.

Component of the ESEA framework	EIA	SEA
(1) Integration The ES typology as a core evaluation and integration tool in EA practice (should include ES evaluation and quantification)	1. The ES typology as an integrative evaluation tool	1. Prioritization of ES 2. Stakeholders identification and involvement
(2) Evaluation The ES typology as an evaluation tool in some areas of assessment	2. The ES typology as a thematic/sectorial evaluation tool 3. Implicit thematic/sectorial ES assessments	3. ES inclusive SEA 4. ES as part of problem and stakeholders mapping
(3) Quantification Mapping and valuation for some areas of assessment	4. Quantified thematic/sectorial ES assessments 5. Spatially-explicit thematic/sectorial ES assessments	5. ES valuation

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