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Puzzling Out Ecosystem Services Values: A Participatory Framework to Support Decision-Making

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Abstract

Ecosystems are the support of our lives, with their goods and services backing up human wellbeing. The concept of ecosystem services was advanced as a metaphor to demonstrate the importance of nature and its processes to the existence of our societies. Since the early stages of its adoption, this concept has been seen as a promising way to emphasise the importance of nature conservation. This research field is growing fast, with a strong focus on research-society interfaces. However, as much worldwide attention as the ecosystem services concept has recently received, value reductionism and monistic approaches, still surface in many debates. Looking only into one value dimension brings several associated risks and biases. This calls for adoption of more integrative perspectives where multiple values attached to ecosystem services are considered. Once these multiple values are recognized, the ensuing question is how to promote their articulation in the context of policy and decision-making processes.

Ecosystem services is a value-laden concept that carries in itself potential controversies about the values it translates. On the other hand, it is also seen as a platform to promote participation and to search for new paths of collaborative action. Based on these assumptions this dissertation started from the focal question "how to structure a participatory process for the integration and articulation of multiple values of ecosystem services to inform decision-making?".

A three stage participatory conceptual framework was developed and subsequently tested in the Arrábida Natural Park, a Portuguese coastal and marine protected area. The proposed approach starts with a "set the scene" stage, where a new methodology to implement a collaborative scoping process of ecosystem services was developed. Scoping tasks combine an institutional and stakeholder analysis that allows to identify key stakeholders, their interdependencies and institutional rules governing the study area, with a participatory workshop, where the ecosystem services provided by the area are identified by participants. Such workshop also provides a platform to scope ecosystem services threats, linkages with wellbeing elements, as well as a preliminary assessment of ecosystem services ecological, economic and social importance.

The second stage aims to "deepen understanding" regarding the structure underlying the provision of a sustainable flow of selected ecosystem services. In the case study, this stage was developed through a participatory systems mapping approach. Inter-organisational stakeholder groups collaborated in the conceptualization of feedback processes characterizing ecosystem services during a group modelling workshop, which allowed to share insights on the underlying cause-effect mechanisms and leverage points, supporting the identification of interrelationships among different ecosystem services and the selection of key indicators for management processes.

The framework ultimately envisages to engage stakeholders in the “articulate values” stage. A third participatory workshop is proposed to integrate multiple ecosystem services values in the context of a real world decision-making process. In the Arrábida Natural Park, participants were asked to deliberate on social, biophysical and economic criteria associated to different alternative policies for the protected area, as well as to define decision rules that foster integration of different value dimensions to inform decision-making processes. Using participation as a value articulating institution, stakeholders were engaged in a process to select, discuss and articulate several and distinct ecosystem services value dimensions regarding two decision contexts – a land use conflict and a project evaluation process.

The empirical results and participants’ evaluation support the conclusion that the developed conceptual framework is able to provide a coherent platform to engage stakeholders in ecosystem services scoping, assessment and decision support tasks. Ultimately, the proposed framework offers structured guidelines for puzzling out multiple value dimensions of ecosystem services, which may be further applied to different types of ecosystems and decision processes.

Keywords: ecosystem services; participatory framework; multiple value dimensions; mixed methods; protected areas; stakeholder engagement; collaborative scoping; participatory systems mapping; participatory multi-criteria analysis.

Resumo

Os ecossistemas são o suporte da vida humana, contribuindo para o seu bem-estar através dos bens e serviços que fornecem. O conceito de serviços dos ecossistemas foi criado como forma de demonstrar a importância da natureza e dos seus processos para a existência das nossas sociedades. Desde a fase inicial da sua adoção, este conceito tem sido visto como um caminho promissor para enfatizar a importância da conservação da natureza. Este campo de investigação está por isso a crescer rapidamente, com um forte foco na interface ciência-sociedade, contudo, apesar da recente atenção generalizada que tem sido dada aos serviços dos ecossistemas, as questões relacionadas com abordagens monistas e redutoras ainda surgem em diversos debates. Olhar apenas para uma dimensão de valor acarreta diversos riscos e visões enviesadas, o que leva à necessidade de adotar perspetivas mais integrativas onde as múltiplas dimensões de valor atribuídas aos serviços dos ecossistemas sejam considerados. Uma vez reconhecidos estes valores, surge a questão de como promover a sua articulação no contexto de processos de decisão.

Por um lado, o conceito de serviços de ecossistemas pode originar potenciais controvérsias no que respeita aos diferentes valores que o conceito traduz. Por outro lado, também tem sido apontado como uma plataforma para promover a participação e para procurar novos caminhos de ação colaborativa. Esta dissertação, baseada nestes pressupostos, teve início com a questão focal "como estruturar um processo participado para a integração e articulação dos múltiplos valores dos serviços dos ecossistemas que informe processos de tomada de decisão?".

Como resposta a esta questão, foi desenvolvido um modelo conceptual participado com três fases, testada no Parque Natural da Arrábida, uma área protegida marinha e costeira, em Portugal. A abordagem proposta inicia-se com a fase de definição do âmbito – "*set the scene*" – onde uma nova metodologia para implementar um processo colaborativo de definição de âmbito dos serviços dos ecossistemas foi desenvolvida. Nesta fase é combinada uma análise institucional com uma análise das partes interessadas por forma a identificar atores chave, as suas interdependências, bem como o quadro institucional que rege a área de estudo. Seguindo-se um *workshop* participado, onde os serviços dos ecossistemas fornecidos pela área são identificados pelos participantes, assim como as ameaças e as ligações com os elementos do bem-estar humano. Neste *workshop* é ainda realizada uma análise preliminar da importância, social, económica e ecológica atribuída aos serviços dos ecossistemas.

A segunda fase tem como objetivo aprofundar o conhecimento – “*deepen understanding*” – sobre a estrutura que suporta o fornecimento de um fluxo sustentável dos serviços dos ecossistemas identificados. No caso de estudo, esta fase foi desenvolvida através de um processo de modelação participada em dinâmica de sistemas – *participatory systems mapping*. Diferentes grupos de atores sociais colaboraram na conceptualização dos processos que caracterizam os serviços dos ecossistemas, durante um *workshop* de modelação participada, permitindo a partilha de conhecimento relativamente aos mecanismos causais e aos pontos de intervenção no sistema, permitindo a identificação de inter-relações entre os diferentes serviços dos ecossistemas e a seleção de indicadores chave para processos de gestão.

A última fase do modelo conceptual proposto tem como objetivo o envolvimento das partes interessadas na articulação de valores – “*articulate values*”. Aqui, um terceiro *workshop* participativo é proposto para a integração dos múltiplos valores dos serviços dos ecossistemas no contexto de um processo de decisão concreto. No Parque Natural da Arrábida os participantes discutiram e selecionaram critérios sociais, biofísicos e económicos associados a diferentes politicas alternativas para a área protegida, definindo o sistema de regras a ser seguido na tomada de decisão que integre as diferentes dimensões de valor. Desta forma, os atores sociais são envolvidos num processo em que a participação atua como uma instituição para a articulação de valores, permitindo a seleção, discussão e articulação de diferentes valores atribuídos aos serviços dos ecossistemas relativamente a dois processos de decisão específicos – um conflito de uso de solo e uma avaliação de projetos alternativos.

Os resultados empíricos e a avaliação pelos participantes apoiam a conclusão de que o modelo conceptual desenvolvido fornece uma plataforma que permite o envolvimento das partes interessadas numa sequência de tarefas para definição de âmbito dos serviços dos ecossistemas, avaliação e tomada de decisão. O processo proposto gera um conjunto de diretrizes estruturadas para a obtenção do puzzle completo das diferentes dimensões de valor dos serviços dos ecossistemas, que poderá ser posteriormente aplicado a diferentes tipos de ecossistemas e de processos de decisão.

Palavras chave: serviços dos ecossistemas; modelo conceptual participado; múltiplas dimensões de valor; métodos combinados; áreas protegidas; envolvimento de partes interessadas; definição de âmbito colaborativa; modelação participada; análise multicritério participada.

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Acronyms

ANP – Arrábida Natural Park

AS – Active Sum

CICES – Common International Certification of Ecosystem Services

CLD – Causal Loop Diagram

CO_2 – Carbon Dioxide

EEZ – Exclusive Economic Zone

ENM – Estratégia Nacional para o Mar [National Strategy for the Sea]

ES – Ecosystem Services

ESP – Ecosystem Services Partnership

EU – European Union

Gg – gigagrams

GHG – greenhouse gases

ICNF – Instituto da Conservação da Natureza e FLorestas [National Institute for the Nature Conservation and Forests]

IMP – Integrated Maritime Policy

INAG – Instituto Nacional da Água [Water National Institute]

IPBES – International Panel for Biodiversity and Ecosystem Services

IUCN – International Union for Conservation of Nature

LULUCFs –Land use, land-use change and forestry

MEA – Millennium Ecosystem Assessment

NGO – Non-Governmental Organization

OSPAR – Convention for the Protection of the Marine Environment of the North-East Atlantic

POEM – Plano de Ordenamento do Espaço Marítimo [Marine Spatial Planning]

PS – Passive Sum

PSM – Participatory Systems Mapping

TEEB – The Economics of Ecosystem Biodiversity

TEV – Total Economic Value

UN – United Nations

UNCLOS – United Nations Convention on the Law of the Sea

UNEP – United Nations Environment Programme

WBCSD – World Business Council for Sustainable Development

Chapter 1 | General Introduction

"Biodiversity and the ecosystem services it provides are being depleted at unprecedented rates. Every day, governments and other actors around the world are making decisions which affect the biosphere with profound implications for ecosystem services and human well-being".

— Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

1.1 Relevance of the study

The impacts of humanity on Nature have been growing fast in number and intensity, with some scientists calling the new era that we are living as the Anthropocene, defined as domination of humans upon Earth (*e.g.,* Lewis and Maslin, 2015). This increasing rate of impacts arises from our way of living and aspirations as society. As a result, we are facing the biggest and most complex environmental crises ever experienced: climate change and biodiversity loss at a global level (COM, 2011). As humanity, we need to engage with this reality to find solutions in our way of living. The decisions that are taken by different social actors in distinct areas must accommodate the impacts and the feedback loops that can result from those decisions and engage stakeholders and the general public, which will foster the recognition and integration of different dimensions of complex issues.

Ecosystems are the support of our lives, with their goods and services backing up the humanity, leading to the development of the concept of Ecosystem Services (ES), which has been advanced as a metaphor to demonstrate the importance of nature and its processes to the existence of our societies (Daily, 1997). Since the early stages of adoption, the ES concept has been seen as a promising way to make a difference in Nature conservation. In this sense, this field of research has been growing, with a strong focus on the research-society interface. ES is a value-laden concept that carries in itself a lot of potential controversies about the values it translates, highlighting some, and hiding others. On the other hand, is also seen as a platform to promote participation and to search for new paths of collaborative action (Jax *et al.,* 2013).

There is a recognized growth of recent work on this concept, both in science and policy arenas, with large-scale studies and initiatives pushing forward the development of the field (*e.g.,* MEA, 2005; TEEB; 2010; IPBES, 2012). Concomitantly, some challenges have been underlined regarding the need for integration of multiple values and how this integration can contribute to improve knowledge on natural resource management (de Groot *et al.*, 2002; Gómez-Baggethun *et al.,* 2010).

Within this background, this research brings forward the application of the concept of ES in the development of assessment and valuation processes. The aim of this dissertation is to develop and test a structured and coherent participatory platform to puzzle out the multiple value dimensions of ES to support decision-making processes. The underlying assertion is that through participatory platforms that engage stakeholders in the integration and articulation of ES values, decisions can be better informed contributing to the conservation of ecosystems and consequently reducing the impacts of humanity on Nature.

1.2 Research background

1.2.1 Ecosystem services: a concept and a metaphor

Ecosystems provide goods and services to human life that are vital for the humanity wellbeing. The concept of Ecosystem Services was developed as a metaphor to highlight the importance of ecosystems and their services to societies. One of the first definitions was presented by Daily *et al.* (1997): "*Ecosystem Services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life".* Since this concept was presented several formal definitions have been presented in the literature, which state that ES are:

- *The benefits human populations derive, directly or indirectly, from ecosystem functions* (Costanza *et al.,* 1997);
- *The benefits people obtain from ecosystems* (MEA, 2005);
- *Components of nature, directly enjoyed, consumed, or used to yield human wellbeing* (Boyd and Banzhaf, 2007);
- *The aspects of ecosystems utilized (actively or passively) to produce human wellbeing* (Fisher *et al.*, 2009);
- *The direct and indirect contributions of ecosystems to human wellbeing* (TEEB, 2010).

All these different definitions converge to the importance of promoting a broad societal recognition of the contributions that ecosystems provide to human wellbeing. Not only because these benefits are often overlooked, but particularly since many services are in a declining trend (MEA, 2005; WRI, 2008) and the major drivers of change and degradation of ES are precisely anthropogenic activities (MEA, 2005; UNEP, 2006). To address this contradiction, there have been increasing calls to promote the formal identification of ES and the integration of their multiple values in decision-making processes (MEA, 2005; TEEB, 2010).

Over the last years, different assessment Frameworks were developed concerning ES. The Millennium Ecosystem Assessment (MEA, 2005) was a flagship initiative putting ES in the spotlight and setting out a key Framework for assessing ecosystems goods and services within four main categories (Figure 1.1). According to this study, human well-being is the central focus for the assessment, while recognizing that biodiversity and ecosystems have intrinsic value and that people take decisions concerning ecosystems based on considerations of well-being as well as intrinsic value (MEA, 2005). It assumes that a dynamic interaction exists between humans and other parts of ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems, and with changes in ecosystems causing changes in human well-being. Several national assessments followed the MEA study, including the Portuguese Assessment (Pereira *et al.,* 2009).

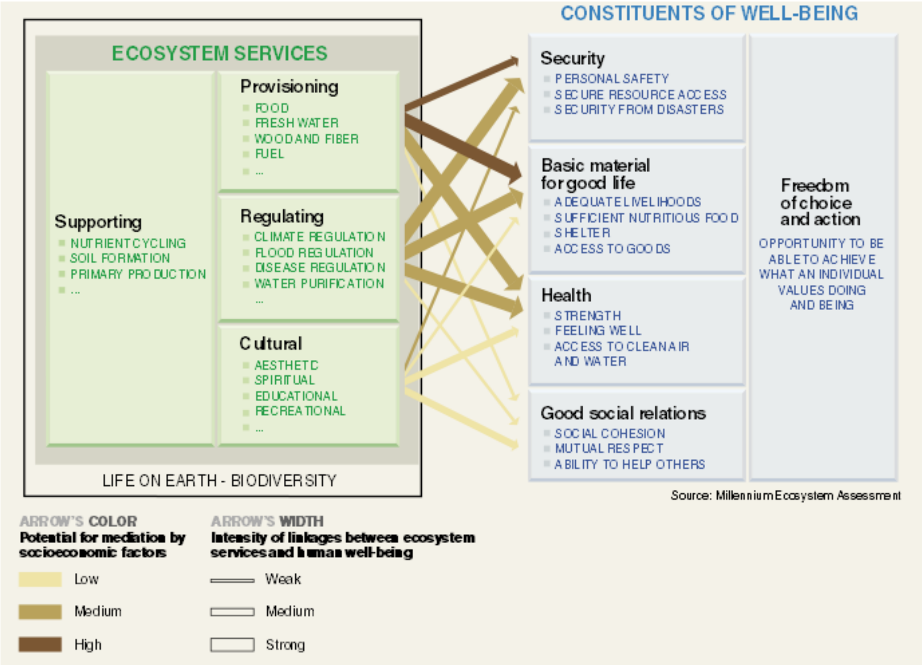

Figure 1.1 - Millennium Ecosystem Assessment Framework: Linkages between Ecosystem Services and Human wellbeing (MEA, 2005)

TEEB, the Economics of Ecosystems and Biodiversity (TEEB, 2010), is another large study on ES and biodiversity economics, providing an assessment of the costs and benefits associated with natural capital (Figure 1.2). This first report prepared the ground for upcoming TEEB reports (*e.g.,* TEEB Climate Issues Update; TEEB Ecological and Economic Foundations; TEEB for National and International Policy Makers; TEEB for Local and Regional Policy Makers; TEEB for Water and Wetlands; TEEB for Oceans). The TEEB assessment Framework is based on three steps: 1) to identify and assess for each decision the full range of ES affected and the implications for different groups in society; 2) to estimate and demonstrate the value of ecosystem services, using appropriate methods, and analyse the linkages over scale and time that affect when and where the costs and benefits of particular uses of biodiversity and ecosystems are realized; 3) to capture the value of ES and seek solutions to overcome their undervaluation, using economically informed policy instruments.

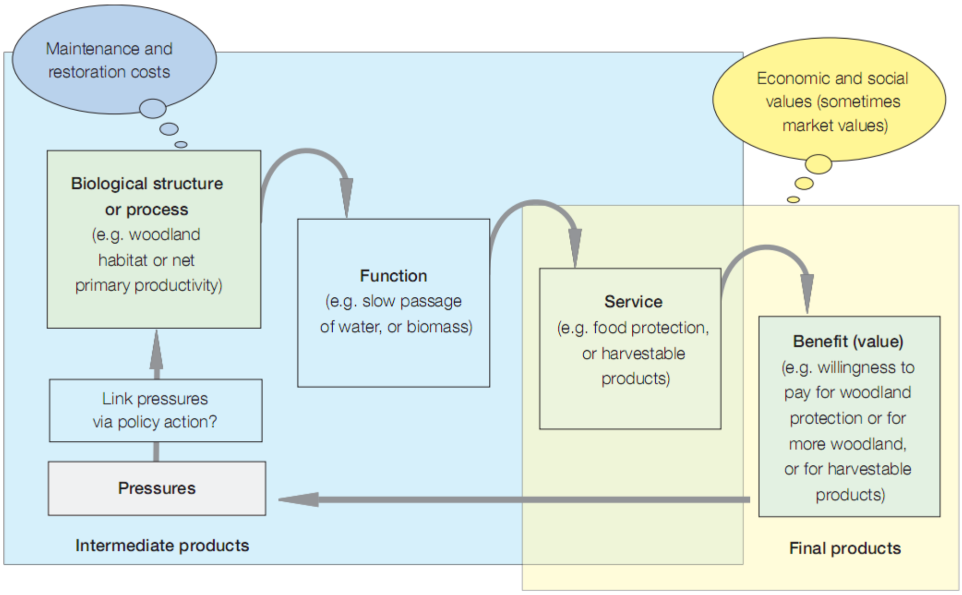

Figure 1.2 - TEEB Framework (TEEB, 2010)

The Intergovernmental Platform on Biodiversity & Ecosystem Services (IPBES), is a platform established by the international community in April 2012, as an independent intergovernmental body open to all member countries of the United Nations. IPBES provides a mechanism recognized by both the scientific and policy communities to synthesize, review, assess and critically evaluate relevant information and knowledge generated worldwide by governments, academia, scientific organizations, non-governmental organizations and indigenous communities (IPBES, 2012; Díaz *et al.,* 2015). This involves a credible group of experts in conducting assessments of such information and knowledge in a transparent way. IPBES is unique in that it aims to strengthen capacity for the effective use of science in decision-making at all levels, aiming to address the needs of Multilateral Environmental Agreements that are related to biodiversity and ES, and build on existing processes ensuring synergy and complementarities in each other's work (IPBES, 2012). The work of IPBES is centred around four complementary core functions:

- Capacity building (increase the capacity of the science policy community to perform and to use assessments and other products of IPBES);
- Knowledge generation catalysis (identify knowledge needs of policymakers, and catalyse efforts to generate new knowledge);
- Assessment (deliver global, regional and thematic assessments of knowledge regarding biodiversity and ecosystem services);
- Policy support (Identify policy relevant tools/methodologies, facilitate their use, and promote and catalyse their further development).

IPBES adopts a pluralistic approach (Figure 1.3) working in order to assess different methods according to different visions, approaches and knowledge systems, recognizing that nature's values can be expressed in diverse ways (IPBES, 2012). The IPBES Framework includes six interlinked elements to link people and nature: nature, nature's benefits to people, anthropogenic assets, institutions and governance systems other indirect drivers of change, direct drivers of change and good quality of life (Díaz *et al.,* 2015).

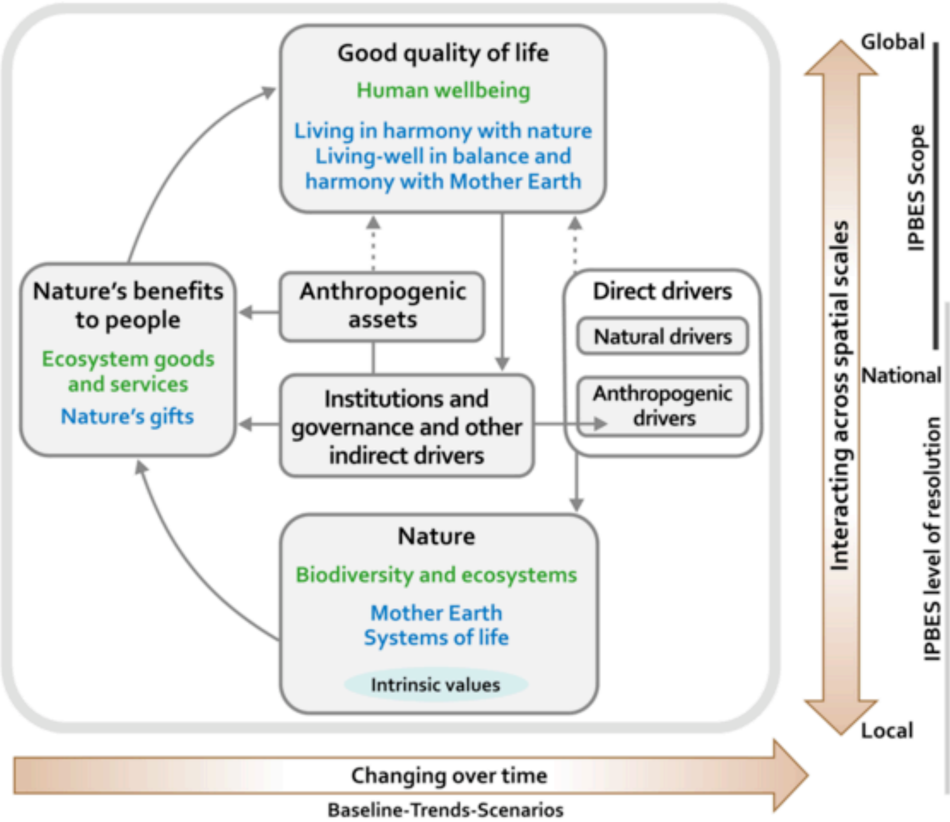

Figure - 1.3 – IPBES Framework (IPBES, 2012)

Along with these international initiatives several other projects have been taking place regarding the understanding of ES metaphor and its practice and applicability: *e.g.,* OpenNESS – Operationalization of Natural Capital and Ecosystem Services (http://www.openness-project.eu), that started in 2012; OPERAs, that helps to put cutting edge ecosystem science into practice (http://operas-project.eu), which started in 2013.

The Ecosystem Services Partnership (ESP) was created as a worldwide network to enhance the science and practical application of ES, with different working groups (thematic, biome and sectorial) (ESP, 2016).

Also with regard to ES classifications, different systems have built on MEA including some modifications, while others emerged in different forms. For example, the Common International

Classification of Ecosystem Services (CICES) was first developed in 2009, and went through diverse evolutionary stages. It did not intend to replace other classifications but to allow the translation between them, being developed as part of the work done in Europe on ecosystem accounting (CICES, 2016), and has been taken up by the European working group on Mapping and Assessment of Ecosystem Services (MAES, 2012). The main distinction of CICES, is the fact that it does not cover supporting services originally defined in the MEA, arguing that it would be best to deal with them in environmental accounts in other ways, since they are indirectly consumed. Another different aspect is the use of five-levels hierarchical structure to define ES, such as: section (*e.g.,* provision), division (*e.g.,* nutrition), group (*e.g.,* terrestrial plants and animals for food), class (*e.g.,* crops) and class type (*e.g.,* wheat) (CICES, 2016).

All these initiatives and advances are symptomatic of the importance of this field of research. However, despite all the efforts and the calls for integration of this concept in policy and how to mainstream its use in order to foster biodiversity and Nature conservation it is still a path to trail. The need for new ways to increase the adoption of ES-based approaches supporting decision-making, as well as, to address the multiple value dimensions and the integration of different knowledge sources, are key gaps to fulfil in ES research (Spangenberg and Settele, 2010).

1.2.2 Valuation and assessment

As presented above, the MEA (2005) and TEEB (2010) are two of the large-scale studies that have looked into the consequences of ecosystem changes for human wellbeing and provided the scientific basis for action needed to enhance the conservation and sustainable use of natural resources. In this context, different methods for valuing ES have been developed.

The first initiatives that have triggered valuation of ES were monist approaches, missing the incommensurability and multiple value dimensions linked to ES. This fact along with the attributed importance to the concept of ES, intensified the debate about how to value ES, which has been a concern for some scholars over the last years (de Groot *et al.*, 2002; Spangerberg and Settele, 2010).

Costanza *et al.* (1997) started a debate on whether to value or not to value ES in monetary terms, pushing the study of valuation and accounting of ES. The advocates of these approaches argued *that* the valuation of ecosystems goods and services is a step to promote conservation, which requires an identification and classification of those benefits. The debate around classification issues increased as a bridge to different valuation approaches. In this context, monetary valuation expanded its dissemination with many different authors supporting its application to

ES (Constanza *et al.,* 1997; Daily *et al.,* 2000; Farber *et al.,* 2002; TEEB, 2010). As highlighted in TEEB (2010) and other studies deploying monetary valuation, only a subset of ES is often expressed in monetary terms. Moreover, despite recent attention given to monetary valuation of ES that do not have a market value, integration of this type of value in the decision making processes has been limited (MEA, 2005). This suggests the importance not only of further exploring valuation methods but also providing policy makers with a supporting deliberative context for decision-making processes.

A criticism of economic valuation is its static nature. According to Spangerberg and Settele (2010) the fact that it refers to a current situation, ignoring future trends is a limitation. They also stressed the risk of the application of economic instruments becoming an end in itself, gaining primacy compared to ES protection. The lack of interconnections when making the valuation process is also referred as one drawback; often when the service is isolated, the entire context is lost.

Valuation, particularly monetary valuation, is sometimes understood to imply that ES must be privatized and commoditized (*i.e.* traded in the market), which is not a necessary corollary, or something that can be countered by demonstrating that public goods and services may better be managed in the public domain (Braat and de Groot, 2012). This argument is sometimes pointed as a limitation of valuation. According to Costanza and Kubiszewski (2012) it is important to clarify some concepts regarding economic valuation. Economics is different from "the market" and valuation is different from privatization, commodification or trading, likewise expressing value in monetary units is different from market values (Costanza and Kubiszewski 2012). Despite these differences, economic valuation still presents some limitations such as the fact that it is not an all-encompassing approach to value elicitation, bringing the need for new methods capable to move beyond and capturing more than what the economic value may contain (Bingham *et al*., 1995; Martinez-Alier *et al.,* 1998; de Groot *et al*., 2002).

The debate on the limitations of this approach allowed the development of alternative ways of valuing, with deliberative methods having an important role to play in this context (Curtis, 2004; Kenter, 2011). Examples of these alternatives are the methodologies based on emergy, the value from a perspective of the work done by the biosphere in generating services and resources (Odum, 1996; Odum, 1998; Ulgiati *et al.,* 2011), or the combination of different concepts, such as ecological simulations and choice experiment (Knowler *et al.,* 2009) or methods like social multi-criteria evaluation which integrates the social choice (Munda, 2004). However, as pointed out by Gómez-Baggethun and de Groot (2010) many of these perspectives have also embodied to some extent a monist view of value.

Looking for the roots of the word value, the Oxford dictionary defines it as "*the regard that something is held to deserve; the importance, worth, or usefulness of something*" and/or "*[...] one's judgment of what is important in life*", which suggests "importance" as the vital word to understand "value". Following this mind-set, it is possible to say that valuation is the understanding of the worth or importance of something and may be defined as *"the act of assessing, appraising or measuring value, as value attribution, or as framing valuation (e.g., how and what to value, who values)"* (Dendoncker *et al.*, 2013).

The attributed importance in a valuation process entails several values, multiple perspectives and the institutional context (O'Neill and Spash, 2000; Spash and Carter, 2001), which indicates that a number of distinct values (*e.g.,* justice, knowledge, equality, beauty, etc.) are incommensurable and not translated into a single value (O'Neill *et al.,* 2008). Valuation of the environment involves dealing with multiple and often conflicting valuation languages, whereby values may be combined to inform decisions, but may not be reduced to a single metric (Martínez-Alier *et al*., 1998). Because of that, the purpose of the valuation context should be defined early in the process to choose the appropriate valuation techniques (Gómez-Baggethun and Barton, 2013). The plurality of values assumes the existence of conflicting values that may be weakly comparable (Martínez-Alier *et al.,* 1998), and often incommensurable (O'Neill 1996; O'Neill and Spash, 2000; Chan *et al.,* 2012).

According to de Groot *et al.* (2002) the value of ES can be divided into ecological (*e.g.,* complexity, rarity), sociocultural (*e.g.,* equity, identity) and economic value (*e.g.,* monetary value). These different dimensions of value can be observed and captured from different perspectives. For example, climate change might have effects on oceans as a source of fish (economic dimension), as a habitat (ecological dimension) and as a source of recreation or aesthetic appreciation (social dimension).

Economic values

The economic values include different types of monetary values that may generally be summed up in order to get the Total Economic Value (TEV), which separates in most of the times, the economic value of ES into use and non-use value categories (Turner *et al.,* 2003; TEEB, 2010).

Use values involve direct use, indirect use, and option values. Provisioning (*e.g.,* agricultural, fishing) and cultural (*e.g.,* recreational activities) services are more associated with direct use values, while regulating (*e.g.,* climate regulation, pollination) and support (*e.g.,* habitat provision) services are more linked with indirect use. Direct use values can be described as the ones that came from the use and enjoyment of ES by the society (individuals and stakeholder groups) and they may be extractive (related with provision services) and / or non-extractive (linked with cultural services). Regulating and support services do not involve the consciousness about the causal relations that are responsible for their provision. Option values translate the potential future direct and indirect uses of Nature (Gómez-Baggethun *et al.,* 2014). Option value represents the uncertainty within TEV, such as the potential medicinal uses of plants that are not currently being explored, which means to consider in what extend any particular organism will demonstrate to be of viable use in the future. Regarding non-use values, they can translate existent values, such as the importance people attribute to the existence of the ecosystem, or the species. And the altruist and bequest values, regarding the importance attributed to the possibility of other people and other generations have the opportunity to enjoy these services (Turner *et al.,* 2003; TEEB, 2010).

This terminology and framing of non-use values has been criticised due to the commodification it represents (Martínez-Alier *et al*., 2002; Gómez-Baggethun and Ruiz-Pérez, 2011; Kallis *et al.,* 2013). The integration of these values could mean to ask questions on whether to maintain or not species and their habitats (Gómez-Baggethun *et al.,* 2014).

Ecological values

Ecologists have often used the word value in its broader understanding as numerical measurement, often used to characterize protected areas in terms of ecological values. However, this broader definition does not explicitly define the importance for whom or for what these values are significant.

In this sense, ecological values entail different definitions, some authors link ecological valuation with biophysical measures (Martínez-Alier, 1987), although the majority of the descriptions associates them to ecosystem functions, processes and components on which the delivery of ES relies on (de Groot *et al*., 2002). The ecological value of an ecosystem, may be defined according to the integrity of the regulation and habitat functions of the ecosystem and by parameters like rarity, complexity, diversity, and stability (de Groot *et al.*, 2003). It might also represent the integrity of "service-providing units", *i.e.* populations, communities, functional groups, and abiotic components such as habitat type, that contribute to ES deliver (Harrington *et al.*, 2010), and consequently may define economic and sociocultural values of ES (García-Llorente *et al.*, 2011; Gómez-Baggethun *et al.,* 2014).

The insurance value has also been linked to ecological values (Gómez-Baggethun and Barton, 2013), and are linked to the resilience of the ecosystems. Insurance value means the role of biodiversity and ecological infrastructure in safeguarding the capacity of the ecosystems in providing ES in the case of a disturbance and/or change. This means that a critical amount of ecological infrastructure and key services-providing unities must be ensured in order to maintain ecosystems functioning (Deutsch *et al*., 2003).

Sociocultural values

Cultural services are defined as *"aesthetic, artistic, educational, spiritual and scientific values of ecosystems"* (Costanza *et al.,* 1997) or as *"non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience"* (MEA, 2005).

People have emotional, affective and symbolic views about nature that influences their values concerning the environment (*e.g.,* material, moral, spiritual aesthetic, therapeutical and other) affecting their attitudes and actions toward ES. All these values, are not sufficiently captured by monetary approaches (Martínez-Alier *et al.*, 1998; Gómez-Baggethun and Ruiz-Pérez, 2011; Chan *et al.*, 2012), since they include intangible things like the value of place that emerge from people's emotional and affective connexions to nature (Williams *et al.*, 1992). Gómez-Baggethun *et al.* (2014) identified authors that have captured different social values, for example spiritual value where the conception of nature is intertwined with sacredness, the heritage value, sense of community, and social cohesion. According to the same authors these values are formed in the mind of the ES beneficiaries, hence the same flow of ecological information may be differently categorized (*e.g.,* inspirational, educational or spiritual) depending on who is the observer, which calls the attention for need of integrating multiple views and multiple "observers".

Cultural values have been receiving less attention when compared to monetary and ecological values (Chan *et al*., 2012; Nieto-Romero *et al.*, 2014). Some could think that once people are not willing to pay for specific ES, they do not value them in cultural terms, which is not true (Gómez-Baggethun *et al.,* 2009). Research evidences show that who are not willing to pay for maintaining ES can be willing to contribute with their time to activities of conservation and restoration (Higuera *et al.,* 2013). Recent research has evolved in a more effective integration of social perspectives and cultural valuation techniques into ES Frameworks, allowing a broader representation of cultural values in ES research and practice (*e.g.,* Chan *et al.*, 2012; ; Gómez-Baggethun *et al.,* 2014; Kenter *et al.*, 2015).

According to Ledoux and Tuner (2002) valuing ES is a crucial way to inform decision-making, however it is yet needed to fully understand how to integrate this information in a decision process. Despite all the evident achievements in defining the multiple value dimensions and to understand how they reflect different views, there is still the need to investigate how to better integrate them. For Wallace (2012) it is essential to develop quantitative and qualitative methods for exploring, documenting and eliciting values, taking into account that effective stakeholder engagement still represents a challenge.

According to Vatn (2009), appraisal methods can be seen as value articulating institutions, where in a practical view institutions assume the nature of rules (*e.g.*, conventions, norms, and legal rules). The author highlights how deliberative methods are value articulating institutions, since they are structures which facilitate articulation of values. This articulation is allowed through a context where deliberative rationality and principles drive the articulation of the involved values (Vatn, 2009).

1.2.3 Stakeholder participation

Participatory approaches have been acknowledged as an important way to deal with complex environmental issues, since they allow the integration of a diversity of knowledge and values (Reed, 2008). A review on the topic developed by Reed (2008) demonstrated the progress of stakeholder participation that has occurred in distinct geographical and disciplinary contexts. This evolution achieved a state where there is a growing awareness on participation and its best practices.

Several and diverse benefits have been assigned to participatory processes, some of them including: potential of increasing public trust in decisions (Richards *et al.*, 2004); improvement of research by providing quality information inputs (Reed *et al*., 2006); recognition of the complexity of human-environmental interactions and the potential of having decisions that are holistic, fair and capable of accounting for a diversity of values and needs (Richards *et al.,* 2004).

The calls for identifying and involving stakeholders in assessment, planning and management processes have been acknowledged by Wallace (2007) in order to have a successful decision-making. For example, Videira *et al.* (2010) developed a participatory modelling approach to support integrated sustainability assessment processes, which allowed the participation of different stakeholders and the integration of different participatory methods and tools. Antunes *et al.* (2009) also proposed deliberative methods as an approach for supporting integrated decision-making processes, concerning river basin management issues. With regard to marine protected areas Abecasis *et al.* (2013) combined quantitative and qualitative methods to explore local and expert views of the marine environment and its conservation and the management of the area. Schmidt *et al* (2014), integrated a set of interviews with stakeholders with a comprehensive survey of a sample of residents regarding their perceptions on Portuguese coastal management and risk, they concluded that there is a strong awareness of coastal risks and possible impacts from climate change, however they identified obstacles to the involvement of local stakeholders in coastal issues.

To participate is to share. Thus, a participatory process involves having different stakeholders engaged in an interaction that promotes knowledge and information exchange and that allows them to express their positions and interests on issues (UNEP, 2010). The core values of relevance, credibility, and legitimacy are best achieved through strategic and effective participation in such processes.

The recognized advantages of participation have been extended to the field of ES valuation, as we can see in MEA (2005), which recommended that the use of deliberative decision-making methods that adopt a pluralistic perspective is important in the context of incorporating information about ES in planning and management decisions. According to Berghofer *et al.* (2008) the concept of ES should integrate humans, which will inevitable imply judgements that can be produced in different platforms. Society should decide, but how to decide is the central question. In the same line of thought Spangenberg *et al.* (2015), highlight that since people are using, being exposed to and/or affected by changes in ES, stakeholders must be involved in the decision process, contributing with their knowledge and expressing their values. According to the same authors, this is the way to motivate them to participate in the future management of ES. The dependency that actors have on ES is evident and should be recognized and accommodated in different arenas. For example, the World Business Council for Sustainable Development (WBCSD) has already produced a set of guidelines for the identification of business risks and opportunities emerging from ecosystem changes (WBCSD, 2011). The proposed tool focuses on the importance and strong dependence of the business sector on ES (*e.g.,* the fishery industry is dependent on oceans' good environmental status to provide food; tourism is dependent on good environmental conditions to attract tourists). The guide defends that valuing the impacts and dependences helps businesses to make better-informed decisions.

Despite this generalized agreement there is still a relatively low number of studies that have indeed included participatory techniques in their approaches. The majority of examples show a tendency to individual interviews and surveys (Martín-López *et al*., 2014) and more recently some workshops conducted supporting the development of geographical maps (Garcia-Nieto *et al.,* 2013; Riper and Kyle, 2014).

The present dissertation was motivated by the premise that participatory methods can play an important role in eliciting and balancing different values of ES (economic, social, ecological), thus supporting decision-making through collaborative platforms combining complementary methods in an integrative way.

To address issues of value articulation, participatory approaches may support a more comprehensive integration of perceptions and stakeholder values. This rationale is supported by the EU biodiversity strategy to 2020 (COM, 2011). Public administration has a key role in regulating many activities that affect ecosystems such as the development of spatial plans which allows or prohibit certain activities. They also represent sovereign states in international negotiations and in the integration of international environmental agreements that directly regulate the way resources are managed (MEA, 2005). Authorities are responsible for taking different decisions and in that way they need to engage in processes aiming to integrate the different values of ES regarding a specific decision. Spangenberg *et al.* (2014), highlight the importance of having the social processes of land management decisions, their impacts on the provided ES, and on the role of social processes in attributing importance to ES translated in the valuation studies. However, this is a complex exercise due to diverging interests, incommensurable world views and the resulting value systems (Görg *et al.,* 2014). Which brings forward the question: How can a participatory process be structured and conducted for integration of multiple ES value dimensions?

There are several participatory methods applied to environmental decision-making (*e.g.,* adaptive environmental assessment and management; advisory committees; deliberative polling; expert panels; focus groups; participatory modelling; surveys; workshops). Videira (2005) described these methods showing the importance and applicability of each one, in the context of river basin management and coastal protected areas decision-making processes, but some cases can be found on the application of these tools to ES. The next section is focused specifically on the methods and tools used in ES studies differentiating the participatory such approaches.

1.2.4 Methods and tools for ES valuation and assessment

As discussed in the previous section, different methods were developed aiming to estimate the value of ES. Figure 1.4 presents different approaches and associated methods based on economic and biophysical perspectives.

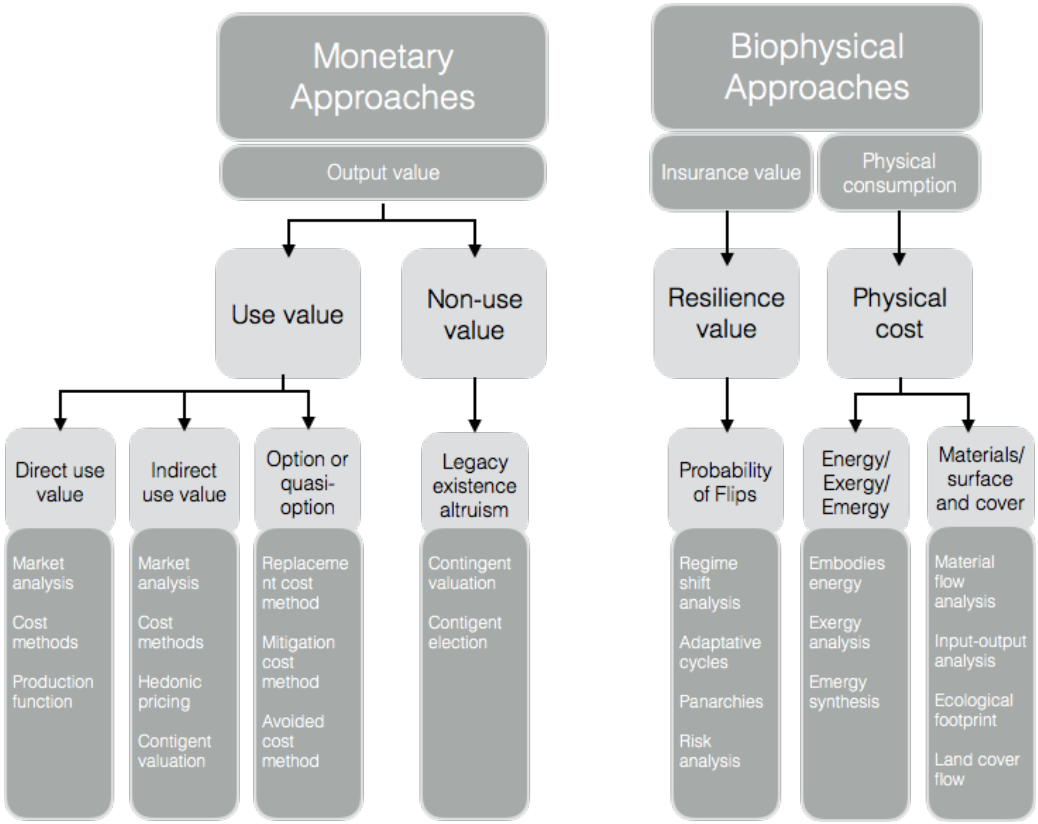

Figure 1.4 – Monetary and biophysical approaches and methods for valuing ES values (adapted from Gómez-Baggethun and de Groot (2010) and TEEB (2010).

The methods presented in Figure 1.4 can be combined and may also include participatory tools to complement them. The most popular participatory tools are surveys and interviews, however deliberative monetary valuation suggests also the use of focus group (Spash, 2008).

Some recent studies have been trying to organize the methods according to their goals, specificities and weaknesses. This have been the case of ValuES project – Integrating Ecosystem Services into Policy, Planning and Practice, identify, describe and analyse different methods to integrate ES into policy, planning and practice (ValuES, 2015).

It is possible to find some examples that have been using participatory approaches to value ES. A different terminology can be associated to valuation approaches that include stakeholder participation such as: social valuation; psycho-cultural valuation; deliberative valuation; socio-cultural valuation (Gómez-Baggethum *et al.*, 2014).

Table 1.1 presents an overview of the applied participatory methods in the context of ES valuation processes.

Table 1.1 – Participatory methods for valuing and assess ecosystem services

Method	Description	Some examples of the use of the method in the context of ES
Surveys	Large group public input techniques, usually consisting of inquiries performed to a sample population in order to gain specific information for statistical validation (Videira, 2005).	A survey was designed to capture respondents' perceptions of the ES supplied by and their demand for ES (Casado-Arzuga *et al*., 2013).
Questionnaires and interviews	Questionnaires aim to elicit statistically significant information on public attitudes, behaviours, the reasons behind these and so on. Interviews may focus less on statistical significance and more on detailed discussions of the issues and how respondents think and behave. In theory any concept of value can be captured via questionnaires and interviews, from general statements of ethical principles through to concrete choices between specific conflicting options (DEFRA, 2006).	A questionnaire used to capture the perceived supply of cultural ES regarding the typical landscapes by tourists. The obtained information feeds the development of geographical maps (Zoderer *et al*., 2016).
Focus groups	Focus groups aim to discover the positions of participants regarding and explore how participants interact when discussing, a pre-defined issue or set of related issues (DEFRA, 2006).	Focus groups were used to validate the obtained results in a questionnaire survey and to get more insights on the impacts of land conversion and their ES provision (Ondiek *et al.,* 2016) Prioritize ES within the local community and discuss the main trade-offs between ES (Kóvacs *et al.,* 2015).
Q-methodology	Q-methodology aims at identifying typical ways in which people think about environmental issues. It is concerned with how individuals understand, think and feel about environmental problems and their possible solutions (DEFRA, 2006).	Q-methodology used to systematically study stakeholder perspectives on coastal ecosystem services and to the identification of natural grouping among stakeholders with shared values (Simpson *et al.,* 2016).
Delphi Surveys	To produce summaries of expert opinion or scientific evidence relating to particular questions, there are, however, very different ways of achieving this. Delphi relies largely on expert opinion, while systematic review attempts to maximise reliance on objective data (they are not methods of valuation but rather means of summarising knowledge (DEFRA, 2006).	The Delphi method is used to solicit expert opinion and address testable predictions and preliminary management recommendations regarding the impact of different management strategies on the ES (Dupras *et al.,* 2016) Delphi method was used to estimate potentials of land cover to provide ES, considering local context (Scolozzi *et al.,* 2012).
Participatory mapping of ES	Participatory mapping does not primarily draw on statistics or research data, but on the practical knowledge of people. Participatory mapping visualizes local knowledge and makes it visible to all. There are several participatory mapping tools available. In an ecosystem service context, the tools can be useful to evaluate how specific ecosystems are perceived and used by local people and who uses them in which way. On this basis it is possible to bring together perspectives and interests of different stakeholders and	A collaborative mapping workshop was conducted aiming to explore differences in the perception of spatial distribution of ES supply and demand between different stakeholders (García-Nieto *et al*., 2015). In a different perspective, a case of a community-managed forest landscape priority ES were mapped using participatory mapping (combined with interviews and

	engage communities to articulate their situation, for example in planning processes. Participatory mapping can also benefit networking and communication, both, among communities and also towards national institutions (ValuES, 2015).	focus group discussions). Priority ES identified in the study included timber, firewood, freshwater, carbon sequestration, water regulation, soil protection, landscape beauty as well as biodiversity (Paudyal *et al*., 2015). Participatory mapping can also be conducted only through surveys. The general public is consulted to identify and map a range of ES that originate in place-based local knowledge and explore the context-dependent nature of subjective well-being (Fagerholm *et al.*, 2016).
Participatory Multi-criteria analysis (MCA)	MCA comprises a plurality of methods. Most MCA rely on similar structure and key steps (a matrix of criteria, alternatives and weights), with the differences relying on the assumptions made regarding commensurability and compensability (coefficient of importance /trade-offs).	The multi-criteria analysis aimed at quantifying the relative importance to these groups of economic, ecological and socio-economic indicators usually considered when managing ecosystem services in a coastal development context. The Analytic Hierarchy Process (AHP) is applied within two nationwide surveys in Australia, and preferences of both the general public and decision-makers for these indicators are elicited and compared (Marre *et al.,* 2016)
Workshops	Meetings that may include presentations, exhibits and interactive working groups. It usually requires experienced and skilled facilitators to undertake a series of activities designed to help participants to progress toward the development objective. Workshops are used to initiate, establish or sustain the collaborations in a participatory process (Videira, 2005).	Workshops were mainly used in the case of participatory mapping (*e.g.,* Garcia-Nieto *et al*., 2015) and also to capture the mental models (Moreno *et al*., 2014).

Table 1.1. describes the most commonly applied methods to conduct participatory assessments and valuations of ES. Some of these methods allow a higher level of participatory engagement, notwithstanding the majority of the cases are based on the consultation of participants (*e.g*., interviews; surveys). Participation can be integrated in the case of multi-criteria analysis where stakeholders are responsible for defining the matrix, such as the criteria, the alternatives and/or the weights (Antunes *et al*., 2011).

The range of participatory methods shows that there are many alternatives to apply and when needed, participatory techniques can be adapted to a concrete situation. Based on the reviewed empirical cases it seems that combining different approaches and methods is the way to improve the obtained outcomes with participatory approaches to ES studies. This methodological integration has been used in some cases as an attempt to capture more than one value dimension and as a bridge to some of the gaps of single approaches. Curtis (2004) developed an innovative method for environmental valuation, based on economic valuation theory and property rights as well as substitute markets, combining a multicriteria analysis with Delphi method, and Kenter (2011) defined a participatory and deliberative approach of choice experiment aimed to define the value attributed to ES in Solomon Islands. They showed how a participatory process could be helpful to find solutions and how important it is to the valuation of a complex good in developed and developing economies. Mascarenhas *et al.* (2016) conducted a participatory approach for the selection of ES in the context of spatial planning. Participatory mapping of ES has been growing in research with different examples (Darvill and Lindo, 2015; Garcia-Nieto *et al.,* 2015). Through more pluralistic approaches, achievement of fair procedures with legitimacy is favoured. In such cases, the deliberative processes helped in formulating values (Robards *et al*., 2011). Despite the empirical evidences on the benefits of participatory approaches in valuation of ES and in the combination of different methods, there is room to investigate how participatory processes can be designed to foster an integrated collection of stakeholders' perceptions, experiences and knowledge to assess and articulate ES values.

1.2.5 Protected areas

1.2.5.1 Ecosystem services and protected areas

Designating protected areas has been the key strategy for conserving ecosystems and maintaining biodiversity. However, biodiversity continues to decline and the changes and challenges seen today are occurring at an unprecedented scale, scope and speed. Biodiversity loss is the most critical global environmental threat alongside climate change (COM, 2011).

The original concept of a protected area is not sufficient to fulfil their original purpose. In a recent paper, out in BioScience (Palomo *et al.,* 2014), the authors propose incorporating a social-ecological approach into the design and management of protected areas in order to conserve unique landscapes, maintain biodiversity, secure the supply of ES, and face the distinct challenges of the Anthropocene. The authors begin by reviewing the historical progression of the protected areas concept and the approaches used in their designation and management. The early designated protected areas were created using what the authors call the *island approach*. Yellowstone, for example, was established in 1872 with the intention of setting it apart to maintain the status quo and protect it from any human impact. This approach takes no consideration of the surrounding landscape or potential stakeholders. Throughout the years since the establishment of Yellowstone, new understanding of the importance of connectedness for species viability and diversity emerged leading to a network approach to protected areas. Strategies like ecological corridors were established. The *landscape approach* then arose in response to the impacts on protected areas stemming from beyond their boundaries. The landscape approach embeds protected areas into the broader ecological and socioeconomic context. The authors thoroughly outline the limitations of these approaches for protected areas and then introduce the social-ecological approach as a model equipped to mitigate many of those limitations.

Martín-López *et al.* (2011) used the ES perspective to quantify trade-offs in ES values associated with different management regimes: conservation inside the Protected Area and development outside the Protected Area. They concluded that conservation of protected areas should not be seen alone but rather integrated in a broader socio-ecological system management policy.

The incorporation of a social-ecological approach into protected areas is crucial in order to: i) conserve unique landscapes, ii) maintain biodiversity, iii) secure the supply of ES, and iv) face the distinct challenges of the Anthropocene. The social-ecological approach to protected areas takes an adaptive perspective to management. Natural and societal changes are a part of the system. Multiple types of knowledge, scientific, technical, and local ecological, are important to manage the intrinsic and instrumental values of a protected area. Taking a social-ecological approach is to recognize that protected areas and the landscapes they are embedded in are multifunctional, meeting a diversity of demands and providing many services. Integrated landscape management is needed to manage the landscape as a whole (Palomo *et al.,* 2014).

There are some challenges for designing and managing protected areas, but protected areas can be more aligned with the needs of people and society by using concepts such as ecosystem services; community-based management embeds the protected area into the social context that is managing, and benefiting from it; and that social-ecological approach incorporates drivers of change and their effects into the long-term planning and management of protected areas. Such complementarities (different methods) point to potential hybrid methods or combinations of several methods along the planning process (Kallis *et al*., 2006; Antunes *et al.,* 2006; Antunes, 2009).

Following the calls to conduct ES assessments in protected areas, the present research uses a protected area as case study.

1.2.5.2 Case study selection

A case study approach is considered a necessary and sufficient method in exploratory research (Flyvbjerg, 2006). Thus, the test of the conceptual Framework developed in this dissertation was developed and tested in the Arrábida Natural Park (ANP), aiming to illustrate the implementation of the methodology and drawing empirical lessons from its application on the ground. The selection of the case study was framed by a set of criteria that allowed to understand which case would better satisfy the goals of the research (Figure 1.5).

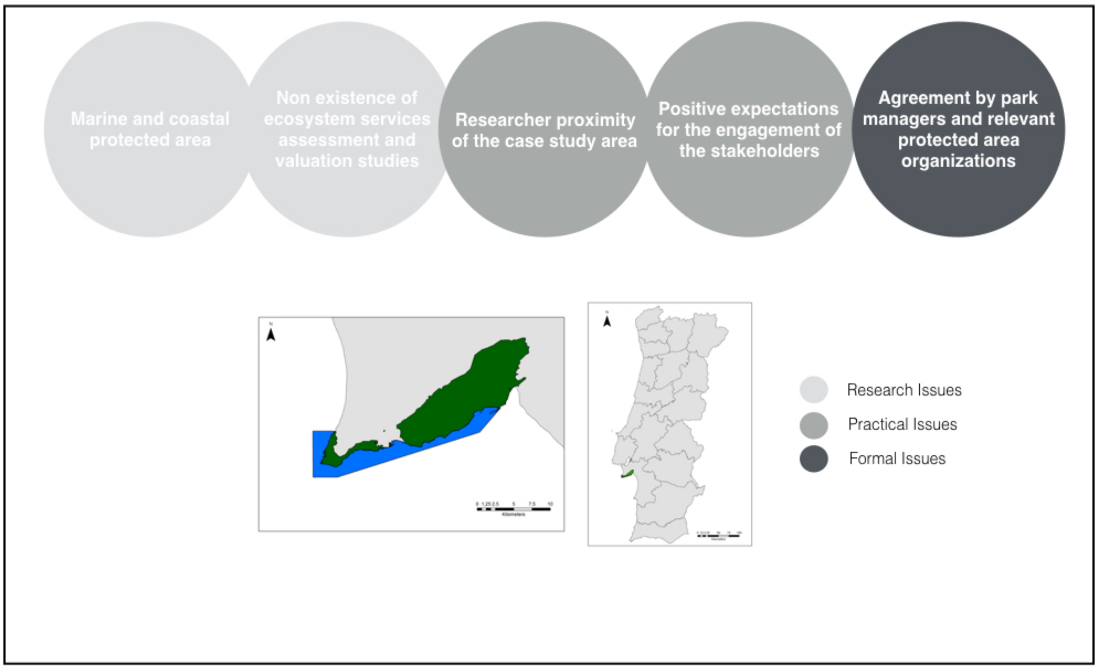

Figure 1.5 – Case study and criteria for its selection.

The criteria that have led to the case study selection guaranteed the development of the different steps of the process and the suitability of the case regarding the Framework. The feasibility of the study had to cover and overcome different issues: constrained financial resources, which includes the logistic (*e.g.,* proximity of the case); the political will and practical agreement by the park managers and the positive expectations for the engagement of local agents (*i.e.,* managers, staff and stakeholders).

Another important aspect considered was the inexistence of similar studies on the area (*i.e.* work in the field of ES), allowing to construct the process without a bias. The knowledge base and expected efforts to identify and value ES at the time of the empirical research design were unbalanced across ecosystem categories. With marine and coastal ecosystems being more critical, since the majority of their goods and services are inaccessible and relatively understudied, posing a particular critical challenge when compared to other ecosystems. Many of the activities that damage coastal ecosystems arise from short sighted and poorly informed decisions that fail to take long-term ecosystems values and the full range of benefits from coastal ES into account (Kushner *et al.*, 2012), bringing forward the goal of developing this research in these type of ecosystems.

Furthermore, the IUCN developed a category system that classifies protected areas according to their management goals. The ANP, is classified as "*V Protected Landscape / Seascape: A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values*" (IUCN, 2016).

The areas within this classification result from biotic, abiotic and human interaction and have some features that makes them unique and also raising some issues to deal with. Some of these issues and unique features were determinant for the development of the process and its aims, highlighting the need for a process of integration of ES values to inform decision-making. According to IUCN (2016), category V protected areas, usually have opportunities for recreation and tourism consistent with life style and economic activities; unique or traditional social organizations, as evidenced in local customs, livelihoods and beliefs; recognition by artists of all kinds and in cultural traditions (now and in the past); potential for ecological and/or landscape restoration. They encompass broader landscapes and multiple values, emphasising values from long-term interactions of people and nature in modified conditions.

1.2.5.3 Setting the background of protected areas engagement with the ES concept

The initial stages of the research process included a background setting step to contextualize the work regarding the application of ES concepts in concrete cases, specifically in the management of protected areas. In this sense, it was conducted a preliminary analysis to feed the design of the empirical process, through the development of an online survey to screen protected areas classified under category V according to IUCN category. This survey was exploratory in nature, aiming to capture insights on how protected areas have been addressing the concept of ES and their inherent characteristics. Although this activity did not provide a representative number of answers, the achieved results allowed to start drawing the backbone elements supporting the construction of the proposed participatory conceptual Framework.

The survey questions were built according to the identified gaps on the literature and regarding the main assumptions of this work. The survey was delivered through Google Forms tool, divided in three different sections, the first regarding the institutional context and stakeholder analysis, the second related with the impacts and ES and the last one regarding value elicitation. An introductory section aimed to characterize the respondents and to assess the degree of familiarity with the concepts. The main observations drawn from the developed survey are detailed below.

Stakeholder involvement in protected areas

According to Mulongoy and Gidda (2008) improving the economic and social benefits of protected areas is driven by an effective integration of stakeholder participation in decision-making and management processes, allowing to incorporate the rights and interests of a broader range of stakeholders. Participatory and equitable conservation, with involvement of local communities, can enhance net benefits for conservation and for people (Borrini-Feyerabend *et al*., 2013).

In that sense the involvement of stakeholders was a key *a priori* issue to explore, since it supported understanding in what extent protected areas managers engage stakeholders. The use of participation in the majority of decisions was acknowledged by most protected areas contacted, while some referred the use participation in some decisions. These outcomes suggest the recognition of the importance in engaging stakeholders in the decision-making processes mainly with respect to: formulating protected area management policies, developing planning efforts, site management policies and their implementation; water management; hunting and fishing, and recreational activities. The next examples of provided answers can illustrate these facts:

- *"some of the decisions made in the protected area involve participation in the formulation management policies, in the development of planning policies and in the site management policies and implementation"* (Respondent 1).
- *"The protected area involve participation in some decisions, more specifically regarding artisanal fisheries (high level) and scuba diving (less involvement)"* (Respondent 6).

Several groups of stakeholders were identified as being typically present in protected areas, such as national government organizations, local government organizations, NGO's, civil society, land managers, multistakeholder consultative councils, industry, trade unions and staff organizations, research, science and education. Despite all these identified stakeholder groups, it was referred by respondents that there are difficulties in engaging the wider community. In regard to the participatory methods used to foster participation in protected areas the outcomes pointed mainly to public hearings, meetings, workshops, internet based methods, citizen's juries, focus groups, regular commissions and surveys.

When trying to understand to which extent do protected areas include assessment studies in their decisions, is was evident that most of the areas typically use environmental impact assessments and sustainability appraisal processes to identify and assess the impacts of a decision in the area.

Looking into the recent reports on protected areas such as the "Protected Planet Report 2016" (UNEP-WCMC and IUCN, 2016) the benefits of engaging stakeholders and local communities in the management of these areas are recognized. These benefits are amplified when allowing the identification and assessment of ES provided by the area and included in the decision-making processes. These results indicate that protected areas managers are amenable to the importance of engaging stakeholders in managing processes and they are already using a large group of methods to do so; however, some efforts should be pursued in involving a wider spectrum of stakeholders and in a consistent way.

Uptake of the Ecosystem Services concept in protected areas

The benefits and values of protected areas need to be recognized and made visible (Mulongoy and Gidda, 2008). UNEP-WCMC and IUCN (2016) highlight the importance of strengthening the communications of the benefits of protected areas across all sectors of society, which will help to demonstrate their economic and social value to the existing and future generations. Protected areas are pivotal to pursue sustainable development namely in the achievement of the Millennium Development Goals. For example, provisioning services of protected areas have direct use and value to rural communities and in fighting climate change, through providing protection against physical impacts such as rising sea levels, rising temperatures and extreme weather events, as well as, by conserving unbroken blocks of intact habitat (Mulongoy and Gidda, 2008). Besides that, the assessment of full range and values of services arising from protected areas strengthens the support to biodiversity financing mechanisms and strategies for protected areas networks (UNEP-WCMC and IUCN, 2016).

These connections between ES values identification and communication and protected areas management, have also been acknowledge by the respondents of the survey, when asked about what are the main challenges in the protected area management, most of the answers revealed that communicating the value of the area is the biggest challenge (*e.g.,* "*for different audiences*", "*to capture political will and to a wider audience to recognize their value*").

Another topic of the survey was meant to capture perceptions regarding the importance of ES concept in different decision contexts. Within this umbrella, the answers showed that "informing planning and management", "building political support" and "addressing conflicts" were classified as the most important decisions where the ES concept could play an important role. On the other hand, less importance was attributed by respondents to "building alliances" and "raising funds". The provided answers indicate that some protected areas have already been identifying ES formally, using the concept in management decisions of the protected area, as illustrated by the following examples:

- *"The concept of ecosystem services is recognized in protected area strategies, management and land-use plans. A formal identification of ecosystem services has been developed for the protected area. This concept is very important in informing planning and management and less but also important to address conflicts and building political support"* (Respondent 1).
- *"The concept of ecosystem services is recognized in protected area strategies, management and land-use-plans. The concept is very important to: build political support; inform management decisions; address conflicts; and build alliances"* (Respondent 6).

Based on these outcomes it was assumed that protected area managers are amenable to the ES concept and recognize the importance of this concept in supporting decision-making and management processes in protected areas.

Different dimensions of values and their articulation in protected areas

While traditionally established to protect our most valuable biodiversity and cultural traditions, protected areas can also generate many other benefits, that can be highlighted through ES assessments. In this sense, and as explored before, the importance of ES concept was recognized in the obtained answers, as well as, in recent reports from IUCN (*e.g.,* Borrini-Feyerabend *et al*., 2013) that highlighted how protected areas play an important role in raising awareness of the values of biodiversity by directly exposing visitors to nature, tourism and recreation are common visitor uses of most protected areas and important contributors to local and national economies.

Making possible that these benefits are better understood and integrated in countries planning can promote broadening support for protected areas from other sectors and highlight their contribution beyond the Aichi Biodiversity Targets to other social and economic objectives, and to the Sustainable Development Goals (UNEP-WCMC and IUCN, 2016).

Regarding the issue on how to value ES and how to articulate the different value dimensions, if they were considered, the survey asked protected areas managers how these studies have been performed. Although, one answer had been negative, revealing that the area in question did not perform studies based on ES approaches, others revealed to have conducted economic, ecological and socio-cultural studies:

- *"No valuation process has been used, the managers are still seeking for an appraisal/valuation process that is understood and of value to a small coastal protected area."* (Respondent 6).
- *"studies of valuation of ES were performed in the protected area including, economic (e.g., economic value of Welsh National Parks), social (e.g., survey to determine special qualities of the Park, factors affecting them and solutions) and ecological ones (e.g., management planning – ES and economy as a subset of ecological transactions); The articulation of the results was determined by the process (using participatory methods), the three studies were integrated in the management plan and in case of conflict, national park purposes have priority, and the Sanford principle gives higher weight to the conservation purpose where there is irreconcilable conflict"* (Respondent 1).

Despite the recognized importance of consider multiple value approaches, only one example had explored how the integration was made. This answer revealed that in that cases preference to the conservation goal is always made.

1.3 Dissertation scope and research questions

This dissertation is a study on how to integrate multiple value dimensions of ES in decision-making processes. Its purpose is to investigate and develop a methodology to assess ES values using participation as the core basis that structures the procedures. The application of the methodology will be illustrated with concrete examples emerging from the test of the approach in the Arrábida Natural Park case study. Thus, the main question that the research aims to answer is:

RQ#1 – *How to foster and structure the participatory integration of different values of ecosystem services in decision-making processes?*

Three more specific questions will contribute to answer the first one:

RQ#2 – *How to conduct a collaborative scoping process of ecosystem services?*

RQ#3 – *How to develop a shared understanding of the underlying structure of ecosystem services?*

RQ#4 – *How to articulate the different values of ecosystem services to support decision-making processes?*

The answers to these questions are expected to contribute to advance the state-of-the art on integrated valuation of ES and articulation of multiple value dimensions.

1.4 Research design and structure of the dissertation

This dissertation is divided in six chapters that organize the different research contributions, as illustrated in Figure 1.6.

Chapter 1 introduces the dissertation, presenting the relevance of the study, the research background, and explaining the scope and the research questions guiding the work. A literature review was conducted on different sets of key concepts: ecosystem services, valuation and assessment, participation and protected areas.

Chapter 2 presents and discusses the proposed participatory conceptual Framework. Its main assumption is that participation is a value articulating institution and ES is a participatory laden concept, which gave place to the scientific publication on Ocean and Coastal Management: *Valuing marine and coastal ecosystem services: An integrated participatory Framework.*

Chapters 3, 4 and 5, present the empirical testing of the developed conceptual Framework. Each chapter answers one of the three specific research questions, and disentangles one of the three stages of the Framework. These chapters illustrate the methods and tools deployed at each stage based on case study application, further discussing the outcomes.

Chapter 3 proposes and discusses an innovative approach for the development of the first stage of the Conceptual Framework – Set the Scene – through a collaborative scoping process of ES. A scientific publication on Environmental Management, emerged from this research, which answers the second research question: *A collaborative approach for scoping ecosystem services with stakeholders: The case of Arrábida Natural Park.*

Chapter 4 addresses the deepen understanding of ES, divided in two parts. The first one presents the methodological process with the focus on one ES and the second part discussing the role of Participatory Systems Mapping in modelling feedback processes underpinning management of ES. Two scientific publications give body to this chapter (one for each part) and both contribute to answer the third research question. The first article was published in the Environmental and Climate Technologies journal, *Conceptualizing stakeholders' perceptions of ecosystem services: A participatory systems mapping approach*. The other article was submitted for publication, *Modelling feedback processes underpinning management of ecosystem services: the role of participatory systems mapping*.

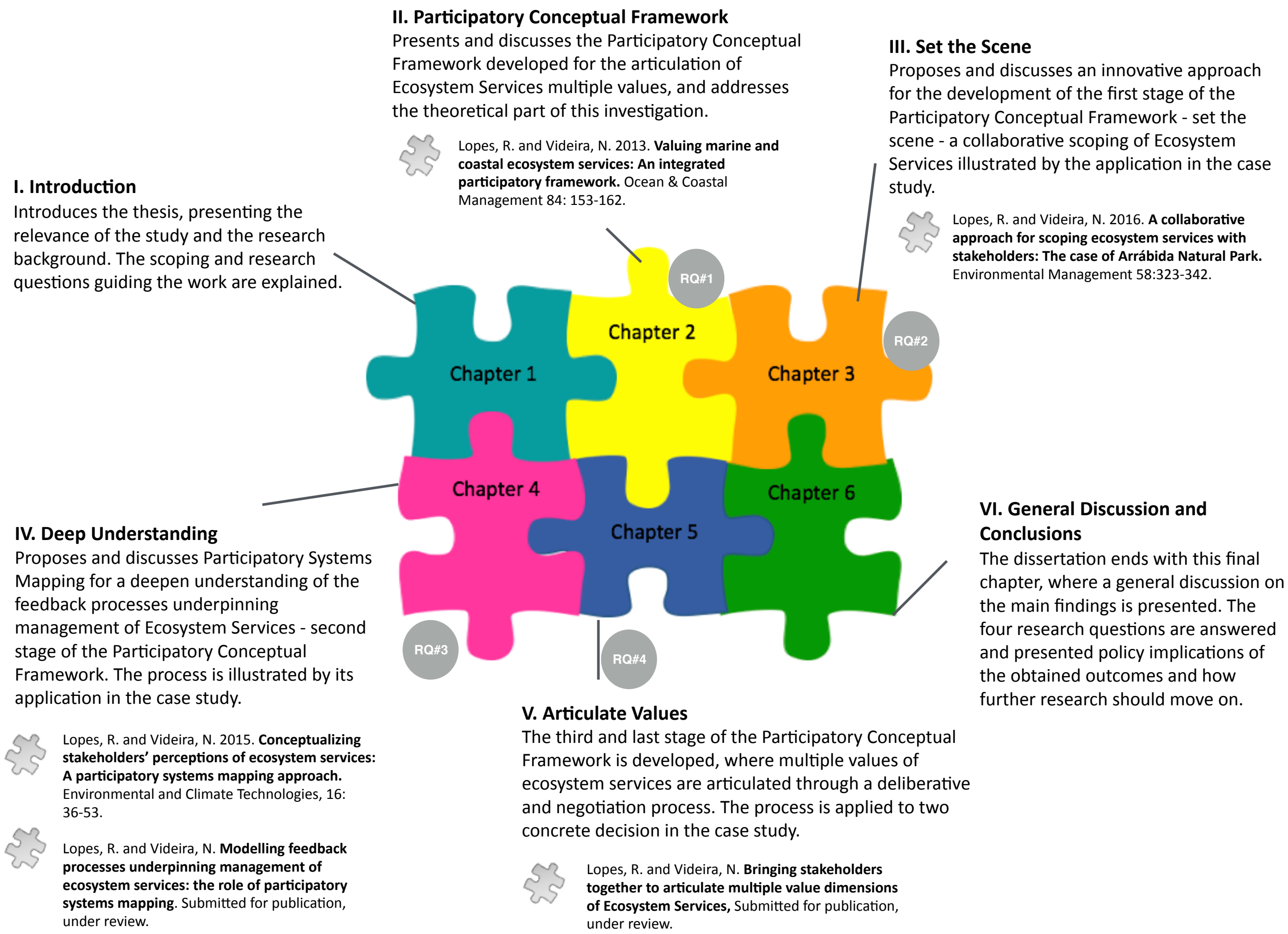

Figure 1.6 – Puzzling out ecosystem services values |Dissertation structure with the chapters' description, the research questions they address and the corresponding scientific publications

Chapter 5 concludes the empirical testing of the theoretical Framework, through the articulation of multiple values of ES, the process is illustrated by its application to the case study, regarding two concrete decisions: a conflict and the selection of alternatives for an ongoing project. The development of this stage answers the fourth and last research question and contributes to closing the outcomes of the empirical part. A scientific publication: *Bringing stakeholders together to articulate multiple value dimensions of Ecosystem Services,* was submitted for publication.

Chapter 6 concludes with the main findings of the dissertation, answering the research questions. It also presents policy implications of the outcomes and how research developments may further address the puzzling out of multiple values of ES.

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Chapter 2 |Participatory Conceptual Framework

"All our knowledge begins with the senses, proceeds then to the understanding, and ends with reason".

— Immanuel Kant

Paper published in Ocean and Coastal Management

Lopes, R. and Videira, N. 2013. Valuing marine and coastal ecosystem services: An integrated participatory Framework. *Ocean and Coastal Management 84: 153-162.*

Valuing marine and coastal ecosystem services: an integrated participatory Framework

ABSTRACT

The complex nature of marine and coastal ecosystems combined with the inaccessibility and invisibility of the majority of their goods and services call for tailored approaches to valuation. Furthermore, a deliberative approach is necessary to support emerging policy initiatives and decision-making processes, and this paper presents a participatory Framework for valuing marine and coastal ecosystem services. The Framework provides a coherent process for the identification and valuation of these services through the active involvement of stakeholder groups. The process begins with "set the scene", a stage in which institutional analysis and procedures for stakeholder involvement are deployed. A value elicitation stage, "deepen understanding", follows to determine the impacts of policy and/or project proposals. This stage involves the identification of the affected ecosystem services, the variations on the flow of services and the associated ecological, social and economic values. The final stage of "articulate values" fosters the integration of knowledge into policy and decision-making processes. The proposed Framework adds communicative and informative features to valuation by advancing an approach that integrates deliberative methods for articulating the multiple values of ecosystem services affected by marine and coastal management decisions.

KEYWORDS

Ecosystem Services; Valuation Framework; Participation; Marine and Coastal Resources

2.1. Introduction

The rate of biodiversity loss has already moved beyond sustainable limits, which has been described by Rockström *et al.,* (2009) as transgressing "the planetary boundaries". This loss is particularly critical in marine and coastal ecosystems because their goods and services are under increasing pressure. These ecosystems are among the most productive in terms of services that are linked to human well-being (MEA, 2005), and thus they require further proactive protection and precautionary actions.

Several initiatives have been emerging at the policy level in different fields of knowledge that highlight the importance of progressing towards the sustainable management of marine and coastal ecosystems. For example, both the European Integrated Maritime Policy and the European Biodiversity Strategy to 2020 (CEC, 2007a; CEC, 2011) call for new methods to identify and quantify the services of these ecosystems to better integrate this information into decision-making processes. From an economic perspective, blue growth has been presented as a long-term strategy to support growth in the maritime sector, which highlights the productive importance of marine and coastal zones (CEC, 2012). The valuation and accounting of ecosystem services is an increasingly studied subject that is gaining more and more attention in the arenas of science and policy. The Millennium Ecosystem Assessment (MEA, 2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2010) are two of the large-scale studies that have examined the consequences of ecosystem change for human wellbeing and provided the scientific basis for actions needed to enhance the conservation and sustainable use of natural resources. However, there is still a scarcity of studies, particularly those related to marine and coastal ecosystems, that follow up on operational guidelines to support more inclusive assessments and decision-making processes that explicitly account for and articulate multiple ecosystem values. According to Ledoux and Turner (2002), valuing ecosystem services is a crucial way to inform decision-making, but it has yet to be determined how to integrate this information into the decision-making process. Therefore, it is important to identify the type of maritime decisions for which valuation can inform the decision-making process and the role of the affected stakeholder groups.

Valuation processes are based on multiple values, perspectives and institutional contexts (Spash and Carter, 2001), which indicates that many distinct values (*e.g.*, justice, knowledge, equality, beauty, etc.) are incommensurable and therefore cannot be translated into a single value (O'Neill *et al.,* 2008). *De Groot et al.,* (2002) define the "value" of ecosystem services as their importance and divide it into ecological (*e.g.*, complexity, rarity), socio-cultural (*e.g.,* equity, identity) and economic (*e.g.,* monetary terms) value.

Several authors have pointed to limitations in economic approaches to the valuation of ecosystem services (De Groot *et al.,* 2002; Kumar and Kumar, 2008; Spangerberg and Settele, 2010; Ulgiati *et al.,* 2011; Ariza *et al.,* 2012) and have called for new methodologies that integrate their economic, ecological and social values. It is therefore important to not limit assessments to monetary units but to include qualitative analyses and physical indicators as well. In this way, valuing ecosystem services requires the integration of ecology, society, sociology and economics into an interdisciplinary Framework. To address the issues of value articulation, a participatory approach may play a valuable role if these multiple, complex and very different values can be effectively addressed in the decision-making process. This rationale is supported by recent maritime policies (*e.g.*, the Green Paper "Towards a future Maritime Policy for the Union" (CEC, 2006), EU Integrated Maritime Policy (CEC, 2007a)) that highlight the importance of active stakeholder participation in policy development and assessment processes.

To address these challenges, this paper advances a conceptual Framework for the valuation of ecosystem services through a participatory and cyclic process that supports the sustainable management of marine and coastal ecosystems. The research aims to promote the identification of the values that different stakeholder groups place on marine and coastal ecosystem services and to determine how these values may be incorporated into decision-making processes.

A discussion of the factors that influence the implementation of the Framework is presented along with a reflection on critical issues, such as the aggregation and/or articulation of different value dimensions. Thus, the proposed Framework addresses factors that are key to the successful implementation of recent maritime policies: facilitating the identification of ecosystem services that could suffer impacts from maritime decisions, analysing the potential trade-offs involved in these decisions, and promoting the involvement of different stakeholder groups in the valuation of their associated services.

The paper is organised as follows: The next section reviews and discusses the main issues concerning policy-making, assessment and participation in marine and coastal decisions. In section three, the proposed conceptual Framework is presented followed by a discussion of issues and limitations surrounding implementation. Finally, the article is concluded with a reflection on the prospects for further development and implementation of the Framework.

2.2. Marine and coastal ecosystem services

2.2.1 Relevance

Three main definitions of ecosystem services are found in the literature: "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life" (Daily, 1997), "the benefits human populations derive, directly or indirectly, from ecosystem functions" (Costanza *et al*., 1997), and "the benefits people obtain from ecosystems" (MEA, 2005).

Ecosystem goods and services are extremely important for human well-being and the pursuit of a vision of sustainable development. However, both political decisions and stakeholder actions negatively influence the supply of goods and services (MEA, 2005).

Seventy-one per cent of the earth's surface is ocean. According to Costanza (1999), because of the vastness of the oceans, these ecosystems have long been unavailable for scientific exploration, but with progress in technology and knowledge, they have become increasingly attractive in recent years. Similarly, coastal ecosystems are responsible for the provision of a large share of ecosystem goods and services (MEA, 2005). The services that these ecosystems provide are essential for the continuity of human life on the planet. The main services linked to marine and costal ecosystems are presented in Table 2.1.

The major drivers of change, degradation, and loss of marine and coastal ecosystems and services are mainly anthropogenic (UNEP, 2006). Reporting recently on the state of the oceans and seas, the European Environmental Agency emphasised the growth of threats such as biodiversity loss, over-exploitation and climate change (EEA, 2010). There are important knowledge gaps regarding the consequences of changes in these ecosystems to human well-being, which underlines the need for policy responses to address uncertainties, such as the benefits and costs of degradation and conservation (UNEP, 2006).

Table 2.1 - Examples of ecosystem services provided by different marine and coastal habitats (adapted from (MEA, 2005 and UNEP, 2006))

Provisioning Services	**Regulating Services**	**Supporting Services**	**Cultural Services**
Food	Biological regulation	Biochemical	Cultural and amenity
Fibre, timber, fuel	Freshwater storage and retention	Nutrient cycling and fertility	Recreational
Medicines, other resources	Hydrological balance		Aesthetics
	Atmospheric and climate regulation		Education and research
	Human disease control		
	Waste processing		
	Flood/storm protection		
	Erosion control		

2.2.2 Policy initiatives

Policy initiatives for marine and coastal ecosystems have been expanding at international, European and national levels. Global concerns regarding protection of marine environments were integrated into the United Nations Convention on Sea Law (UNCLOS) in 1982 (UN, 1982), which defines rights and responsibilities of nations in the use of the world's oceans. UNCLOS establishes guidelines for business activities, environmental protection and management of marine natural resources. The Convention safeguards imperilled marine habitats by strengthening state sovereignty over the enforcement of resource management and environmental regulations in each state's Exclusive Economic Zone (EEZ) up to 200 miles offshore.

In 1992, OSPAR, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR, 1992), emerged as an instrument to guide international cooperation in the protection of the Atlantic Northeast marine environment. OSPAR implements a suite of six thematic strategies: the Biodiversity and Ecosystem Strategy, the Eutrophication Strategy, the Hazardous Substances Strategy, the Offshore Industry Strategy and the Radioactive Substances Strategy along with the Strategy for the Joint Assessment and Monitoring Programme. Climate change is also considered as part of the wider context although is not presented as a separate Strategy.

More recently, the European Commission intensified its efforts to relaunch the debate around marine protection issues through the Integrated Maritime Policy (IMP) (CEC, 2007a). The IMP followed the Green Paper towards a future Maritime Policy for the Union (CEC, 2006) and constitutes an integrated and inter-sectorial approach that was strongly endorsed by several stakeholder groups (CEC, 2007b). Implementing the IMP requires the cooperation and coordination of all sea-related policies at different decision-making levels. The Maritime Strategy Framework Directive (Directive, 2008/56/EC) is the environmental pillar of the IMP and aims to achieve or maintain a favourable environmental status for EU's marine waters by 2020 by protecting the resources upon which marine-related economic activities depend.

Portugal provides an appropriate context for the development and testing of new methodologies that support the sustainable management of marine and coastal ecosystems. In 2006, Portugal pioneered a National Strategy for the Sustainable Development of the Ocean e ENM (EMAM, 2006), which defined the main paths and created a coordinating structure to make progress in several areas of ocean affairs (*e.g.*, economic activities, natural resources conservation). ENM gave rise to maritime spatial planning activities (INAG, 2012), which aim to coordinate present and future uses of the maritime space with coastal zone management. Following the recommendations of the European Union (EU) for good preservation and management of coastal zones, the National Strategy for Integrated Coastal Zone Management was created (INAG, 2009; Calado *et al.,* 2010). All of these initiatives emphasise the importance of an ecosystem-based approach and the participation of interested parties in maritime planning and management.

These policies also demonstrate the need to look for new ways to identify and assess ecosystem goods and services. Bingham et al. (1995) argue that decision makers need good information concerning the value of ecosystem services to better enable the consideration of the advantages and disadvantages of prospective policy actions. Similarly, Ledoux and Turner (2002) point to the important role of valuation in the context of decision-making processes.

2.2.3 Valuation of ecosystems goods and services

The concept of the "value of ecosystem services" has been a subject of scientific debate in recent years (De Groot et al., 2002; Spangerberg and Settele, 2010). Advocates argue that the valuation of ecosystem goods and services is a necessary step to promote conservation, and this requires the identification and classification of those benefits. The intensified discussion around issues of classification (such as distinguishing between services, benefits or uses) serves as a bridge between different approaches to valuation.

Several authors have presented economic valuation approaches to the assessment of goods and services of different ecosystem types (Costanza *et al.,* 1997; Daily *et al*., 2000; Farber *et al*., 2002; TEEB, 2010), including marine and coastal ecosystems. For example, Hawaii's coral reef systems were valued in monetary terms (Cesar and van Beukering, 2004; Foley *et al*., 2010), emphasising their positive influence on the welfare of Hawaii. However, the estimated value did not reflect threats to coral reefs due to climate change, ocean acidification, pollution and/or overfishing.

Despite recent attention given to monetary valuation of ecosystems services that do not have a market value (UK NEA, 2011; Molnar *et al*., 2012), integration of this type of value in decision-making processes has still been limited (MEA, 2005). Other limitation discussed in the literature concerns the risk of monetary valuation becoming an end in itself, which calls for consideration of other perspectives and metrics given the incommensurability of nature's values (*Bingham et al*., 1995; De Groot *et al*., 2002; Martinez-Alier *et al*., 1998; Spangerberg and Settele, 2010).

This debate has encouraged the development of different methodologies based on alternative concepts such as emergy, the value of the work performed by the biosphere to generate services and resources (Odum, 1996, 1998; Ulgiati *et al*., 2011; Grafton *et al*., 2011). Other authors have used ecological simulations and choice experiments (Knowler *et al*., 2009), as well as social multi-criteria evaluation, methods (Munda, 2004). These different approaches illustrate that the importance of the valuation of ecosystem services emerges within a given social and policy-making context. Stakeholder engagement processes are then required in the development of methods for identifying, assessing and articulating values (Wallace, 2012).

2.2.4 Participation

To address the issue of value articulation, this article argues that a participatory approach plays a supporting role by allowing for more comprehensive integration of perceptions and values. Different actors value ecosystem services differently, which is why their participation is potentially useful and appropriate.

Arguments in support of this proposition arise from different sectors of society. For example, the World Business Council for Sustainable Development (WBCSD) produced a set of guidelines for the identification of emerging business risks and opportunities resulting from ecosystem changes (WBCSD, 2011). The proposed tool focuses on the importance of, and strong dependence of the business sector on, ecosystems goods and services (*e.g.*, the fishery industry is dependent on the good condition of the ocean environment to provide food, and the tourism industry is dependent on good environmental conditions to attract tourists). The guide shows that identifying and valuing impacts and dependencies promotes better business decisions.

On the other hand, governments have the primary role in regulating many activities that affect ecosystems (*e.g*., the development of spatial plans that allow or prohibit certain activities). They also represent sovereign states during international negotiations and in the integration of international environmental agreements, which directly influence the way resources are managed (MEA, 2005). Governments, along with their constituents, need to be involved in processes aimed at integrating the different values of ecosystem services underlying those decisions. According to Berghofer *et al*. (2008), the ecosystem concept should integrate humans, which implies making subjective judgements. Society should ultimately make management decisions, but how these decision processes are conducted is the central question.

The choice of methods and tools for the identification and involvement of broad stakeholder groups is determinant for a successful decision-making process (Antunes *et al*., 2009; Wallace, 2007). Curtis (2004) developed an innovative method for environmental valuation, based on economic valuation theory and property rights as well as substitute markets, combining multi-criteria analysis with Delphi methods. Kenter *et al.* (2011) defined a participatory and deliberative approach of choice experiment aimed to determine the value attributed to ecosystem services in the Solomon Islands. These studies show how a participatory process could be helpful to find solutions and how important this is to the valuation of complex goods in developed and developing economies. Ultimately, deliberative processes may help in providing greater legitimacy in the formulation of values (Robards *et al*., 2011). However, several difficulties are expected when accommodating the interests of different stakeholder groups, such as increasing transaction costs, failing to tackle persistent injustices and limiting biases in process facilitation (Robards and Lovecraft, 2010).

Despite the empirical evidences of benefits of participatory approaches in valuation of ecosystems goods and services, its application has been poorly developed. Table 2.2 depicts limited but illustrative review of studies that analyses the level of participation in different types of decisions affecting marine and coastal ecosystem goods and services.

As depicted in Table 2.2, methods of participation in the context of ecosystem services valuation have been largely confined to surveys and interviews. We argue in favour of a more inclusive and deliberative mode of participation to further develop valuation approaches.

According to Maguire *et al.* (2011), the public nature of the marine environment and its multiple uses creates the potential for engaging a broad range of stakeholders. They may vary according to their interests, perceptions of constraints and opportunities, and views about the need for management.

The complex nature of marine and coastal ecosystems, together with recent policy initiatives that promote more inclusive participatory processes (CEC, 2006; CEC, 2007a), supports the objectives of the approach proposed in this paper. The underlying hypothesis is that it is possible to better articulate different values attributed to maritime and coastal ecosystem goods and services through a participatory approach that integrates different tools and methods. Hence, the following section presents a proposal for an integrated participatory Framework to assess and articulate the values of ecosystem services in support of the different stages of marine and coastal decision-making processes.

Table 2.2 – Examples of participatory elements in marine and coastal studies deploying ecosystem services valuation concepts

Study	**Authors/year**	**Type of decision**	**Objectives**	**Valuation methods**	**Participatory methods and tools**	**Outcomes**
The value of recreational fishing in the great barrier reef, Australia: A pooled revealed preference and contingent behaviour model	Prayaga *et al.* 2010	Protecting natural assets in the Great Barrier Reef Marine Park in Australia	To estimate the value of recreational fishing in Capricorn Coast in Queensland centre	Travel cost to estimate the value of recreational fishing. Contingent behaviour models to estimate a change in the value attributed to recreational fishing relating to a variation in initial conditions.	Surveys	The results indicate that there are high values associated with recreational fishing. They concluded that the demand for recreational fishing is inelastic and that attributed values are insensitive to changes in catch rate.
The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning	Rees *et al.* (2010a)	Marine planning	Evaluation of maritime industry of leisure and recreation as argument to the sustainable use of rich marine biodiversity areas.	Surveys applied to four interest groups in monetary and non-monetary terms. Geographical Information Systems to the Analysis of reference spots.	Surveys	The results show that the leisure and recreation industry is dependent on the diversity of sites.
Improving the recreational value of Ireland's coastal resources: A contingent behavioural application	Barry *et al.* (2011)	Improvement of a coastal recreational site	Understanding people's willingness to pay for the introduction of a trail to allow walking along the coast.	Contingent behaviour method. Combining questions of revealed preferences relating the number of travels with questions expressing hypothetical changes in the number of travels if the alteration occurs.	Surveys	The study revealed that willingness to pay for the introduction of the trail increases, which leads to more visitors and this may have positive impact on the local economy. Hypothetical improvements in coastal access have a positive on the number of planned trips by those who take part in water sports activities.

Economic valuation of species loss in the open sea	Ressurreição *et al.* (2011)	Information for marine resources management and conservation (in a broader sense).	Estimate the willingness to pay for avoiding the loss of marine species in Azores archipelago, as well as, analysis of perceptions and people's knowledge and economic preferences related with marine conservation.	Contingent valuation	Surveys	The results suggested a willingness to pay to preserve all the marine taxa as a whole higher than individual conservation. Although results show a significant difference between mammals and fishes when compared with birds, algae and invertebrates the differences are not large as expected.
Assessing prospects for shrimp culture in the Indian Sundarbans: A modelling choice experiment approach (combination of qualitative and quantitative techniques)	Knowler *et al.* (2009)	Evaluate several policy scenarios (four policy scenarios were constructed; analysis is based on a review of the policy context governing shrimp aquaculture in India)	Analysis of the expansion shrimp production in aquaculture	Simulation model for the evaluation of different scenarios. Choice modelling for the identification of stakeholder preferences related with different policies scenarios.	Semi structured interviews, focus group and informal interviews.	The ecological model supports severe restrictions to shrimp production in aquaculture. However local stakeholders prefer a diversified strategy. It was clear that a shrimp production in aquaculture in large scale is less desirable.
Valuing the recovery of over exploited fish stocks in the context of existence and option values	Ojea *et al.* (2010)	Fish stock recovery	Identification of individual preferences relating different levels of recovery overexploited stock fishes.	Contingent valuation applied to a sample of consumers and non-consumers	Individual interviews	The results show that a recovered stocks for hake and Norwegian lobster increase local welfare, and that the median household WTP is about 17.73€ for a recovery programme regulated by the EU.

Decision support in coastal zone management in the Ria Formosa, Portugal	Videira *et al.* (2004)	Information for coastal zone management through mediated modelling process	Provide an useful integrative for stakeholders in Ria Formosa and to test this tool from a research perspective. The model included four different sectors (land use, management, natural system and socio economic activities).	Mediated Modelling workshops: Participatory modelling with stakeholder groups throughout a series of workshops wherein participants collaborated in the construction and simulation of a dynamics model aiming at exploring the relationships between ecological and economic systems in coastal protected area.	Workshops	The concept of total economic value was integrated in the socioeconomic sector of the model. A “benchmark value” for ecosystem services (disturbance regulation, waste treatment, raw material source, habitat, food production and recreation) was derived as an indicator based on the food production and values proposed by Costanza *et al.* (1997).

2.3. Framework for valuing marine and coastal ecosystem services

The conceptual Framework presented in Figure 2.1 is comprised of three major stages that provide a coherent base for the identification and valuation of ecosystem services. The entire Framework is an iterative process in which different cycles contribute by providing information for decision-making and by promoting social learning. Below, the development of each stage and the methods and tools that may be deployed are illustrated (Figure 2.1).

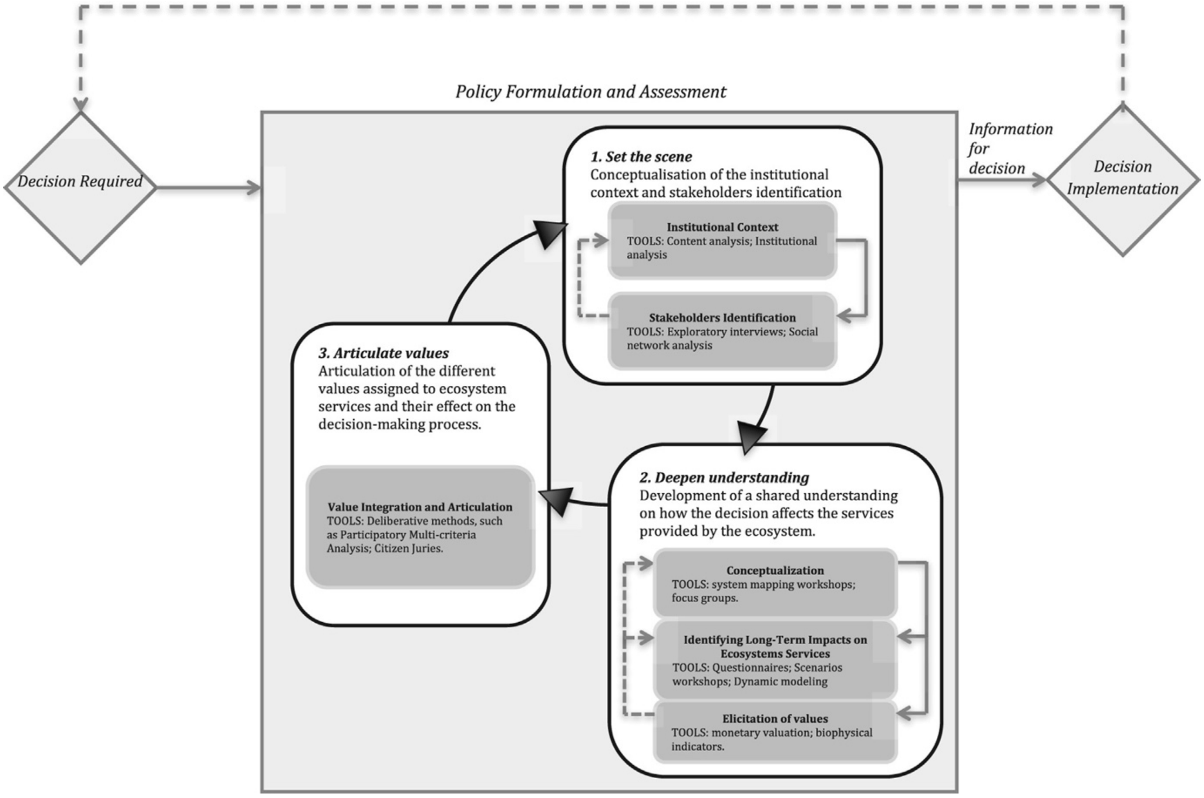

Figure 2.1 – Conceptual Framework for valuing marine and coastal ecosystem services

2.3.1 Set the scene

The process starts with a conceptualisation of the institutional context underlying the decision. The methods to be applied in this phase could include content and institutional analyses. According to Young (2008), institutions can be as much a part of the problem as a part of the solution, so it is important to study institutions that are involved with certain decisions to address maritime issues. Institutions are defined here as the rules governing the decision (Vatn, 2005). The Diagnostic Method (Young, 2008), which is comprised of the analysis of the four Ps (Problems, Politics, Players and Practices), is a useful tool for this phase. Through this approach, it is possible to identify the features and elements of resource and environmental regimes best suited to address specific situations (Young, 2008). This phase will help to understand the key factors that influence a given decision and the role of the underlying institutions. The expected outcome of this first step is a list with all the institutions, or rules for action, that could potentially affect or be affected by the decision.

The identification of stakeholders follows the analysis of the institutional context. There is a need to consider the different groups of agents, such as those considered by the EU Integrated Maritime Policy (*e.g.,* businesses, the public sector and civil society organisations). According to Maguire *et al.* (2012), the level of stakeholder involvement is largely dictated by political and/or legal requirements for participation, but not all stakeholders need to be permanently involved or share the same intensity or type of involvement. To better identify stakeholders who are affected by both policies and their impacts on ecosystem goods and services, we argue that stakeholder selection itself should be a participatory process (Gasparatos, 2010). The suggested methods to be applied at this stage include exploratory interviews with key actors to collect information regarding institutional structure and to identify the stakeholders that should be involved in the process. Videira *et al.* (2012) applied this approach to the Integrated Sustainability Assessment of Maritime Policies, in which exploratory interviews allowed them to become familiar with the main issues and players involved in maritime affairs and to develop a preliminary list of stakeholder groups for the assessment process. A social network analysis, which is a suitable analytical tool for environmental questions (Burgess *et al*., 2000; Syme *et al.,* 2012), is also proposed. This tool allows for the identification of the relationships and networks between different actors and also for understanding centralisation versus decentralisation of social structures (Schneider *et al*., 2013). By the end of the "set the scene" phase, it is expected that there will be a list of stakeholders that should be involved in the deliberative valuation process as well as the network relations established between them (*e.g*., Who is affected by whom? Who is dependent on whom?). A map of connections between institutions and stakeholders also constitutes an important input for the subsequent input steps.

2.3.2 Deepen understanding

The aim of this stage is to develop a shared understanding of the implications for sustainability and how the decision in question affects the services provided by marine and coastal ecosystems. It is important to promote deliberation among stakeholders while identifying the implications of the decision (*e.g*., To whom? Where? Which are the affected policies, stakeholder groups and geographical areas?) and how they are understood by each stakeholder group. Vatn (2009) highlighted the observed differences in preferences that people hold between individual and social settings. Therefore, the Framework for this stage suggests examining the context in which the interested parties operate. This stage is comprised of three different steps: 1) conceptualisation, the identification of ecosystem services and the variations to their flow, 2) the identification of long-term impacts on ecosystem services, 3) value elicitation, the social, ecological and economic values attributed to the different affected services.

For conceptualisation, the methods applied may include the use of focus groups and systems mapping workshops. Qualitative participatory models have been strongly supported and applied in intra- and inter-organisational participatory settings (Vennix, 1996a; Videira *et al*., 2009, 2010). Lane (2008) highlighted that causal loop diagrams work well for conceptualisation processes aimed at promoting the discussion and development of an integrated overview of the problem.

Conceptualisation is followed by the identification of the impacts on ecosystem services that could arise from a given decision. Here, a survey to assess stakeholders' perceptions regarding ecosystem services impacts and their relative importance followed by a scenario workshop is suggested. Long-term impacts on ecosystem services may be analysed using dynamic simulation (van den Belt *et al*., 2006) or spatially explicit models (NCP, 2013).

To determine the respective economic and ecological values, monetary valuation methods (*e.g.,* contingent valuation, benefits transfer, choice modelling) and biophysical indicators of ecosystem services (*e.g.*, ecological footprint, emergy) may be used. Workshops and interviews could be organised to identify socio-cultural values. The mapping exercise can help conceptualise the decision context and the different stakeholder perceptions regarding the value of ecosystem services and how they could be affected by the decision. As shown by Boumans *et al*. (2002) and van den Belt et al. (2006), ecosystem processes and components may also be incorporated into dynamic modelling applications to explore interdependencies and explicitly formalise the implications of their valuation.

This stage conceptualises the ecosystem services affected by the decision and their variation (negative or positive), the elicitation of values that each stakeholder assigns to the goods and services under review and how they might be influenced by their professional and personal backgrounds, and the identification of the long-term impacts of the different policy alternatives.

2.3.3 Articulate values

This phase aims to confront and articulate the different values assigned to ecosystem services and their effect on the decision- making process. According to De Groot *et al.* (2002), the value of ecosystem goods and services should be a combination of economic, ecological and socio-cultural values. Some authors (Farber *et al*., 2002; Howarth and Farber, 2002; Vatn, 2009) have discussed the problem of value aggregation as well as its weighting in decision-making processes.

TEEB (2010) divided the approaches to the estimation of ecosystem values into preference-based approaches (market theory and political science) and biophysical approaches (resilience theory and thermodynamics). Vatn (2009) developed a Framework to choose between various methods, including cost-benefit analysis, multi-criteria analysis and deliberative methods, and differentiated the application of each one in accordance with context and purpose.

Within the proposed Framework, value articulation should also be strongly enhanced through participatory methods. Deliberative methods, such as participatory multi-criteria analysis (Antunes *et al.,* 2011) and social multi-criteria evaluation (Garmendia *et al*., 2010) or citizen juries (James and Blamey, 2005), could play an important role. Framing the discussion around the values of ecosystem services supports learning, awareness and exchanges of perception that lead to a deeper understanding of the issues at hand. According to Vatn (2009), deliberative methods help groups communicate different arguments to achieve a common solution by consensus or commitment. Due to the incommensurability issues (Martinez-Alier *et al*., 1998) between economic, ecological and social values, aggregation into a single value figure is impossible to impose.

The implementation and further development of the proposed Framework is expected to support decision-making processes that affect marine and coastal ecosystems by identifying, informing, discussing, and assessing the values these services provide for human well-being. The development of the three stages promotes the direct inclusion of value measurements of ecosystem services throughout the integrated and adaptive management cycle illustrated by Figure 2.1. The participatory design underpinning the Framework builds on the rationale that the translation and valuation of ecosystem services cannot be restricted to economic terms and that participation may foster the comparison and articulation of differences in perception of values. This approach intends to achieve a high level of stakeholder participation by creating incentives for active engagement. Nevertheless, the choice and design of specific methods and tools will be strongly dependent on the type of decision in each particular context.

The next section discusses, in detail, the critical issues to be considered for the implementation of the proposed Framework.

2.4 Critical issues in the implementation of the proposed Framework

2.4.1 Application in real world decision-making processes

Decision-making involves the selection of a course of action from different possible alternatives to arrive at a solution for a given problem. Here, for purposes of illustration, we present a formalised decision-making process based on the integrated environmental management of marine and coastal environments (Figure 2.2).

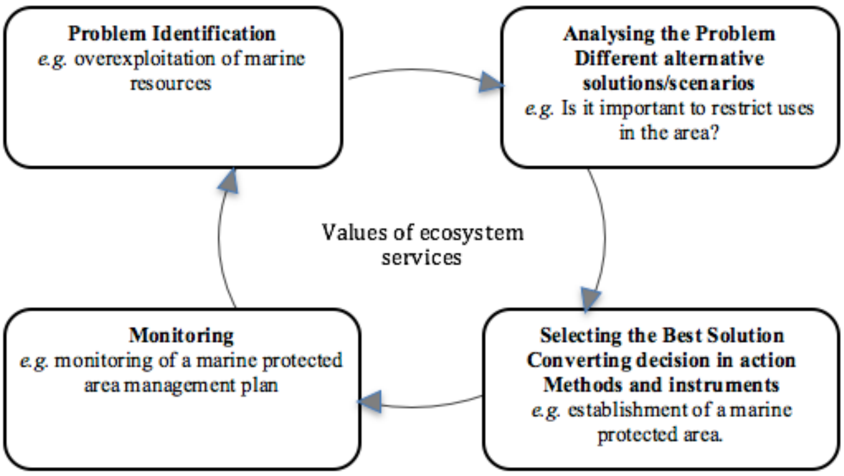

Figure 2.2 – Decision -process in marine and coastal environments (adapted from Antunes and Santos, 1999)

The first phase, problem identification, is where the recognition of a problem occurs. Here, the problem could be the overexploitation of marine resources or the decline of fish stocks. This is followed by problem analysis, which enables a more informed discussion of the different solutions and possible management scenarios. At this stage, it is important to formulate questions such as: "Which are the most suitable areas to develop a given infra-structure?", "Which are the areas of high ecological value?" and "What uses should be permitted?" When all of the alternatives are analysed, it becomes possible to select an alternative and convert the option(s) into actions through different measures and policy instruments, such as through the establishment of a marine protected area. The monitoring phase aims to follow the development of the decisions and to presumably adjust the management strategy if needed.

Decisions over marine and coastal ecosystems and their respective impacts on sustainability are manifold, and choices are implicit at all steps of the decision-making cycle represented in Figure 2.2. Several practical examples may be found in relation to the construction of offshore pipelines (Wilday *et al*., 2011; Koornneef *et al.,* 2012), aquaculture production (Merino et al., 2010), the location of maritime ports (Hommes *et al*., 2009), conflict over use in marine and coastal areas (Bess and Rallapudi, 2007; Douvere, 2008) and the establishment of marine protected areas (Angulo-Valdés and Hatcher, 2010; Rees *et al*., 2010b). Other examples of infrastructure-related decisions may be cited, such as tourist ventures affecting Network 2000 sites and other overlapping environmental conservation interests, which demonstrate an intersection of the different planning instruments (Santos *et al*., 2012). Such decisions could lead to a detrimental change to, or loss of, some services provided by these ecosystems.

However, how are these negative and positive impacts considered when making a decision that ultimately affects the provision of ecosystem goods and services? Are these values integrated into the decision-making process? And how do decision and policy-makers promote the articulation of the different values attributed by stakeholder groups? These questions are the basis for identifying the methodological needs for the valuation processes in support of decision-making.

One of the potential areas of application of the proposed approach concerns the spatial planning processes required to regulate activities that use marine and coastal resources. This is the case with the Portuguese Marine Spatial Plan (POEM) (INAG, 2012). This spatial planning process entails the identification of all existing and potential activities (*e.g.,* fisheries, aquaculture, transport, energy infrastructure development) and their location in suitable areas, so that the sustainable use, conservation and restoration of natural resources are promoted. The proposed Framework may be used in such a context at different stages of the planning process: developing the plan and defining alternative uses, promoting a strategic environmental assessment of the plan, supporting decisions over the licencing of activities, assessing environmental impacts at the project level and monitoring the outcomes of plans, programmes and projects.

The scope of the application of the suggested approach is also expected to contribute to the management of protected areas by providing input to nature conservation decisions (Lewis, 2007). Mapping of the ecosystem services provided by these areas and the alignment of perceptions of different stakeholder groups may help park managers to establish priorities for conservation and development, ameliorate potential conflicts, and communicate the values of the protected areas to users.

We argue that the proposed Framework is conducive to different decision-making strategies, both top-down and bottom-up (Cairns, 2003), which may be combined and adapted to local contexts and governance structures. For example, for decisions involving maritime spatial planning, the maintenance of a sustainable flow of ecosystem services will require balancing both top-down (*e.g.*, plan development and implementation by governmental agencies) and bottom up (*e.g.*, proposals for economic activities from the business sector, such as aquaculture and nautical recreation) initiatives. Hence, it is important to account for the different power structures and levels of governance established at different jurisdictional, spatial and administrative scales (Suskevics, 2012).

Marine and coastal ecosystem services involve wider regimes through international agreements, local resource management rules, and specific governance Frameworks. When creating a formal platform to integrate ecosystem services values into decision-making processes, the “set the scene” stage of our Framework highlights the importance of paying attention to the institutional context. The process should then be based on the institutional background to understand which actors should be involved (from private, governmental and voluntary sectors) at local, regional, and international scales.

2.4.2 Designing the participatory processes

Stakeholder participation plays a fundamental role in the implementation of the proposed Framework. However, according to Webler and Tuler (2001), there is no single definition of what constitutes a good participatory process. The authors identified five guiding criteria, namely that the process should: a) be legitimate, b) promote a search for common values, c) realise democratic principles of fairness and equality, d) promote equal power among all participants and viewpoints, e) foster responsible leadership. Accounting for these features is recommended in the design and evaluation of the participatory activities promoted at each stage of the deliberative valuation Framework.

A critical factor for success is early engagement and support from top managers and decision-makers. Fraser et al. (2006) analysed three different cases where such participation helped in the selection of indicators to monitor environmental issues. They concluded that although the establishment of a clear Framework to facilitate the process and the interaction of different stakeholders is important, it does not guarantee changes to environmental management outcomes. When implementing a valuation process, we have to note that the resulting choices require plurality and diversity, which inevitably lead to a range of alternative decision outputs. The causes of resource depletion can sometimes be traced to the marginalisation of important stakeholders who feel excluded and therefore withhold their support from the implementation of decisions and undermine the management of complex ecosystems (Brown *et al*., 2001).

Policy-makers usually need tools to bring together the input from the local community and expert advice (Fraser et al., 2006), something that the conceptual Framework could provide. The Framework allows for the co-production, organisation and communication of information about different management options and their impacts. We believe that, to successfully implement the Framework, the relevant interest groups and their socioeconomic activities must be clearly identified. The inclusion of stakeholder views and values within this Framework can provide rich information for decision-makers and lead to more sustainable natural resources management.

The choice of which participatory methods and tools to deploy at each stage of the Framework is also a critical task, and several emergent approaches are suggested. In the first stage, both content analysis and institutional analysis are extremely important for defining the institutional context at this instrumental level. The interviews and actor network analysis will help to select the stakeholders to involve and delineate the actors' network. This activity is especially important for the anticipation of potential conflicts and interdependencies. Rauschmayer and Wittmer (2006) highlighted that the way participants are selected will determine the extent of representation of the different perspectives on the issues.

In the second phase of the Framework, we suggest the use of participatory modelling methods using system dynamics and systems thinking tools to conceptualise the interrelationships between ecosystem services. Participatory modelling fosters social learning through the coproduction of knowledge (Vennix, 1996b) and promotes the shared definition of problems and the mapping of a diversity of values.

For the last stage of the Framework, social multi-criteria analysis can be an important method since it simultaneously avoids two pitfalls common in decision processes e excluding both non-economic values and important stakeholders from the process of valuation e which reduce the legitimacy of decisions and challenge their successful implementation. Multi-criteria analysis, due to its flexibility in handling complex information, can be applied when there is a need for trade-off analysis to be sensitive to the construction of values during priority-setting. According to Brown *et al*. (2001), stakeholders can then explore the possible outcomes and impacts of decisions made according to different priorities.

Financial costs, time and effort, involved in the implementation of the conceptual Framework will depend on the nature of each process. Namely, they will depend on social complexity, the problem/decision at hand, the type of conflict, and the current state of ecosystem services, among other features. However, participatory methods are generally costly and time consuming, although this depends on the targeted level of participation intensity. For example, according to Rauschmayer and Wittmer (2006), expert inputs are usually more cost intensive than simpler procedures involving fewer participants from the lay public. Roggero (2013) divides participation costs into two categories: the decision-making costs, as those efforts dedicated to bridging the diversity of positions among participants, and the implementation costs, a function of the alignment between participants at the end of the process and the social context. From this perspective, involving a large number of participants will increase the decision-making costs, but the implementation costs would be less.

2.5. Concluding remarks

According to Brown *et al.* (2001), the complex nature of coastal and marine resources in terms of ecology, patterns of utilisation and types of users, demands holistic management solutions. The conceptual Framework proposed here supports a comprehensive analysis of marine and coastal ecosystem values to be integrated into planning and management processes. With this proposal, we intend to advance a formal platform to produce information on the values of ecosystem services based on the different visions and perspectives of multiple stakeholder groups. Participants in future case study applications will also play a key role in evaluating and validating the proposed Framework.

Due to recent policy initiatives and increasing economic exploration, marine and coastal ecosystems are becoming highly exposed to anthropogenic pressures. The complexity of marine and coastal ecosystems and the inaccessibility of their goods and services become obstacles to creating awareness and recognition of the suite of benefits they provide. One dimensional approaches to valuation of ecosystem services have several limitations that are amplified when applied to marine and coastal ecosystems. To this end, the proposed Framework is expected to add communicative and informative features to decision-making processes by advancing a methodological proposal that combines different participatory tools, while creating space for the discussion, integration and articulation of the multiple value dimensions of ecosystem services. Despite the discussed potential limitations (*e.g.,* high costs, inability to involve all relevant stakeholders), the Framework emphasises the need for explicitly articulating different value dimensions (social, ecological, economic) so that different perceptions are integrated within the context of adaptive management.

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Chapter 3| Set the Scene

"Alone we can do so little; together we can do so much"

— Helen Keller

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A collaborative approach for scoping ecosystem services with stakeholders: The case of Arrábida Natural Park

ABSTRACT

This paper presents an innovative approach for conducting collaborative scoping processes aiming to elicit multiple values of ecosystem services. The proposed methodology rests on three steps combining different participatory tools that promote a comprehensive examination of the perceptions hold by relevant stakeholder groups. The first step consists of an institutional and stakeholder analysis developed in the study area. The second includes a participatory workshop, where a sequence of scoping exercises is conducted with the active collaboration of the invited stakeholders. The final step aims to validate scoping results and develop dependency networks between organizations and the identified ecosystem services. The approach was tested in the Arrábida Natural Park, a marine and coastal protected area in Portugal. Invited participants were able to identify an extensive list of ecosystem services in the natural area, establish linkages between those services and human wellbeing, identify drivers of change and perform a preliminary screening of the associated ecological, social and economic values. The case study evaluation provided positive feedback on the usefulness of the approach, which advances the existing set of methods for participatory identification of ecosystem services and sets the scene for involvement of stakeholder groups in assessment and management processes.

KEYWORDS

collaborative scoping, identification of ecosystem services, stakeholder participation, management of protected areas

3.1 Introduction

The concept of ecosystem services (ES) has been increasingly adopted by researchers and policy-makers in debates concerning biodiversity conservation and management of natural resources (Gómez-Baggethun *et al.*, 2010). One of the key supporting arguments lies in the importance of this concept in relating the value of natural systems with human wellbeing. Under this premise, several initiatives have taken place at global (*e.g.,* MEA 2005; TEEB 2010) and national scales (*e.g.,* UK-NEA, 2014), greatly contributing to the dissemination of ES approaches. Notwithstanding, some concerns have been associated with the use of this concept (Martínez-Alier, 2002; Spash, 2008), namely pointing out to the risks of ignoring multivalue dimensions of ES (de Groot *et al.*, 2002) and differences in values attached by natural resources managers, affected local communities and broad stakeholder groups (Zagarola *et al.*, 2014). Hence, the development of assessment and management Frameworks capable of capturing and integrating different ES value dimensions (*e.g.,* ecological, social or economic) are needed to provide a wider information base to support decisions affecting natural and social systems (Lopes and Videira, 2013; Martín-López *et al.*, 2014).

Despite the increasing attention given to development of ES assessment methods and tools (Bremer *et al.*, 2015), participatory approaches for eliciting relevant ES at a scoping stage are still less examined. Since adaptive and integrated management processes usually start with a scoping process, where a preliminary problem definition is developed, such stage is important to broaden problem views and contextualize the issues at stake. Scoping often entails tasks such as stakeholder analyses and integrated system analyses (Weaver and Rotmans, 2006), bringing together different perspectives and sustainability dimensions in a given social-ecological system (Jäger *et al.*, 2008). At a scoping phase, the identification of goods and services provided by ecosystems is thus a first critical step where it is important to understand not only the purpose of the assessment and the type of values to be elicited (Kallis *et al.*, 2013), but also to create a shared understanding of the relevant ES in a given study area. Furthermore, if ES are defined in broad terms as the benefits people obtain from ecosystems (Costanza *et al.*, 1997; de Groot *et al.*, 2002; MEA, 2005), it seems all the more important to deploy a participatory approach to integrate the perspectives of those parties that affect or are affected by changes in ES provision, from the early stages of a decision-making process (Lopes and Videira, 2013; Kenter *et al.*, 2015; Zagarola *et al.*, 2014).

Notwithstanding the generalized agreement on the importance of conducting participatory ES assessments, a literature review on this topic reveals that there is still an incipient inclusion of stakeholders in these processes, particularly at a scoping stage (Menzel and Teng 2010; Seppelt *et al*., 2011; Iniesta-Arandia *et al*., 2014). Most scoping studies thus far engage social actors in the identification of ES through survey-based (*e.g.,* Casado-Arzuga *et al*., 2013) and individual semi-structured interview approaches (*e.g.,* Quinn *et al*., 2015). In the deployment of these methods, individual respondents are often presented with a list of services, for a given study area, which is prepared in advance by experts (Garcia-Nieto *et al*., 2013; Carcamo *et al*., 2014). In a case developed in Canada, Darvill and Lindo (2015) conducted individual interviews to identify ES hotspots for provisioning and cultural services using GIS methods. Examples of participatory approaches for ES identification where stakeholder groups are jointly engaged in scoping tasks are still scarce, with exceptions found in a few ES spatial mapping applications. For example, in the study reported by García-Nieto *et al.* (2015) collaborative workshops were conducted to collect stakeholders' perceptions regarding spatial distribution of a set of ES in a protected area in Spain. Moreno *et al.* (2014) have also conducted participatory workshops to create mental model maps facilitating a collective analysis of relationships between ecosystems and society. Their study was focused on exploring two specific ES selected by the research team. These cases show that in most participatory ES assessment studies, stakeholder involvement has been focusing on the use of spatial mapping techniques and individual interviews.

Within this context, and drawing on the participatory Framework developed by Lopes and Videira (2013), this paper aims to present a collaborative scoping methodology to be applied at inception stages of ES assessment and management processes. Such approach recognizes that using stakeholders' perceptions to capture social values (*e.g.,* Howarth and Wilson, 2006; Kumar and Kumar, 2008; Kenter *et al*., 2011) is an important way to foster multidimensional assessments of ES, sharing knowledge and creating awareness on the importance of ES from the very beginning of a decision-making process. Particularly since intangible values of ES are sometimes ignored (Chan *et al*., 2012), a multi-method approach is presented to promote triangulation of results and provide different opportunities to integrate and articulate perceptions of multiple stakeholder groups.

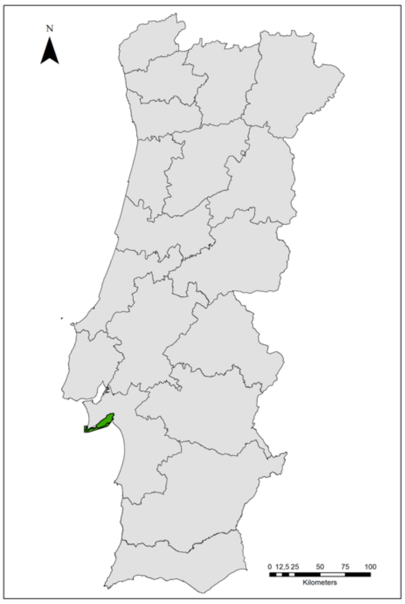
The proposed methodological approach was implemented in a natural park as an illustration of how "bottom-up" ES identification processes may be promoted by natural resource managers with engagement of broad stakeholder groups. According to Potts *et al.* (2014) identifying and valuing ES in protected areas is a promising approach to foster attention to the services provided by the area. A shared recognition of the existence of ES may inform the discussion on their links to human wellbeing (Potts *et al.,* 2014), facilitate dialogues between nature conservation managers and stakeholders, and consequently gather support for management actions. This argument seems particularly promising in protected areas such as natural parks and protected landscapes, where the interaction of people and nature over time plays a vital role and gives rise to distinctive spaces with significant ecological, biological, scenic and cultural values (Dudley 2008; Riper and Kyle, 2014). As argued also by Palomo *et al.* (2014), the current "socio-ecological perspective" advocated for management of protected areas, requires an interdisciplinary approach connecting biophysical processes with human activities at different scales, thus showing the importance of capturing and integrating stakeholders' perspectives to support management of protected areas. We aim to demonstrate how such stakeholder involvement may be initiated through a process of collaborative scoping of ES, which prepares and informs subsequent stages of participatory assessment and management processes (Lopes and Videira, 2013).

The paper will proceed as follows. The next section describes the case study area selected for the implementation of the proposed approach, as well as the methods deployed at each stage of the ES collaborative scoping process. The third section presents and discusses the results achieved with the empirical application of the Framework, while the final section highlights the main lessons learned and avenues for future research.

3.2 Collaborative scoping approach and methods

3.2.1 Study area

The site selected for testing the ES collaborative scoping approach was the Arrábida Natural Park (ANP), a coastal and marine protected area in Portugal, created in 1976 (Figure 3.1). ANP is also a Natura 2000 site that has numerous biological, geological, floristic and archaeologies features of high and unique importance (Batista *et al*., 2011; Cunha *et al*., 2014). The coastal protected area was enlarged with a contiguous marine protected zone (Marine Park *Professor Luíz Saldanha*), designated in 1998, which harbours more than 1000 species of marine fauna and flora and is considered a hotspot for European marine biodiversity (Cunha *et al*., 2014).



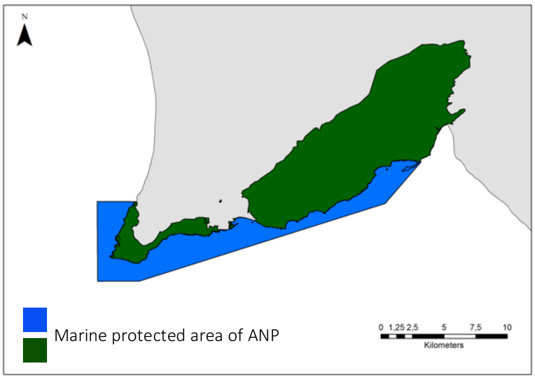


Figure 3.1 - Arrábida Natural Park map (Portugal). Source: adapted from ICNF (2015)

The case study area was selected for the implementation of the collaborative ES scoping Framework due to the richness of the site in terms of natural values (Novais *et al*., 2004; Cunha *et al*., 2014), and also because of the challenges placed on nature conservation arising from the intense human presence on the territory. Overlapping the limits of the ANP there are three main urban centres – Setúbal, Palmela and Sesimbra – with a population of about 235 000 residents (INE, 2011). Long-term conflicts have been observed in the area, such as the controversy arising from the existence of a limestone quarry inside the limits of this protected site (Clemente *et al*., 2004). However, despite several pressures, there is still a significant wild marine and terrestrial area, which is actively managed by nature conservation authorities (ICN, 2003).

3.2.2 Collaborative scoping approach[1]

The proposed approach for conducting a collaborative scoping of ES emerges from a broader Framework to assess and value ES through a structured participatory process (Lopes and Videira, 2013). This Framework is based on three stages, 1) set the scene; 2) deepen understanding; 3) articulate values. Thus, on this paper we focus on the first stage, where "setting the scene" is achieved through a collaborative scoping process. Figure 3.2 illustrates the Framework, detailing the tasks performed at the scoping stage. We envisioned a level of

[1] Support material used in the first stage – set the scene – can be found in Annex I.

participatory impact usually designated as “active involvement” (Videira *et al*., 2006), which means that stakeholders’ own understandings and mental models regarding ES will be explicitly accounted for throughout the different steps of the scoping process.

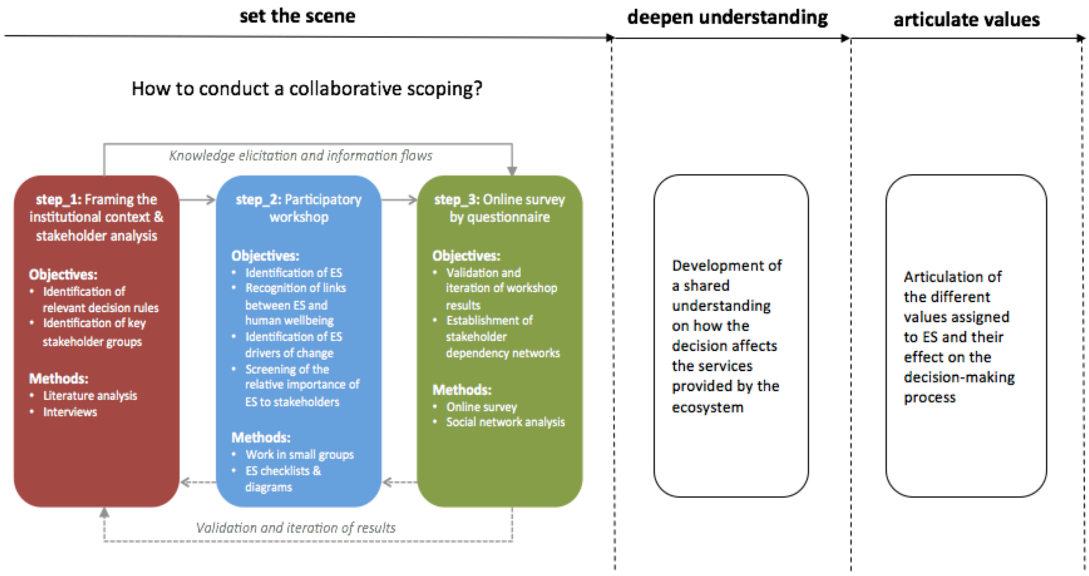


Figure 3.2 Ecosystem services collaborative scoping approach (based on the Framework developed by Lopes and Videira 2013)

3.2.2.1 Step 1 – Framing the institutional context and stakeholder analysis

The institutional context plays an important role in decision-making processes. Institutions are hereby understood as the rules governing a decision (Vatn, 2005). Hence, during a two-month inception state, we identified institutions in ANP by collecting and reviewing relevant documents at national and regional levels (*e.g.,* conventions, laws, management instruments). This process was developed in collaboration with managers of the protected area, throughout interviews and several meetings. The aim was to elaborate an interpretative list with the most important institutions that have some influence on the protected area, and at the same time, understand to which extent the ES concept was reflected in the management instruments of the park. Stakeholders’ identification was also developed in collaboration with ANP managers, combined with a snowballing procedure where invited stakeholders could provide suggestions of other participants to be invited.

3.2.2.2 Step 2 – Participatory ES scoping workshop

After the identification of the main institutions and the key stakeholders to invite to the scoping process, we conducted a workshop in Setúbal, where the headquarters of the ANP are located. The workshop aimed to address four broad scoping objectives: i) identifying ES provided by the protected area, ii) eliciting the linkages between ES and human well-being, iii) identifying ES drivers of change, and iv) assessing the importance attached by stakeholders to different ES values. These scoping objectives were defined to reflect the core elements of the conceptual Frameworks advanced by the MEA - Millennium Ecosystem Assessment (MEA, 2005) and TEEB – The Economics of Ecosystems and Biodiversity (TEEB, 2010). According to these Frameworks, adopting an ES approach entails the identification and classification of ES according to different categories of services (*e.g.,* provisioning, regulating, cultural and supporting), linking ES with constituents of well-being, identifying direct and indirect drivers of change and eliciting values (*e.g.,* economic, socio-cultural, biophysical) to support governance and decision-making.

Hence, in the implementation of the scoping approach to the ANP case study, a sequence of small group exercises was organized to deliberate on the following questions: *Which are the ecosystem services that ANP provides? Which are the links between those ecosystem services and human wellbeing? Which are the main threats to ecosystem services in ANP? Which services are perceived as having a higher ecological, economic and social importance?* A script was developed to support the activities conducted during the workshop, including a detailed description of the different tasks and expected outcomes (Table 3.1).

Table 3.1 - Script for the ecosystem services scoping workshop at the Arrábida Natural Park

Task 1 - Background presentations **(60 min)**	*Purpose:* Familiarize participants with the concept of ES, the management objectives and main features of the protected area and the participatory process to be conducted. *Role of research team:* researchers provide an overview of methods and the workshop process; ANP park managers provide an overview of the main features and objectives of the protected area.
Task 2 - **Organization of working groups** **(15 min)**	*Purpose:* Organize four working groups, each of them dealing with a category of ES (*i.e.*, provisioning, regulation, support and cultural). *Role of research team:* Assist participants in the configuration of the groups. With 4 to 6 participants expected per group, several post-it cards with the name of each category of ES are distributed on a wall for participants to select. In each small group, the inclusion of participants with different backgrounds is incentivized. *Role of participants:* Participants select, on a first-come first-served basis, the thematic working group that they would like to join.
Task 3 - **Work in small groups: Identification of ES** **(70 min)**	*Purpose:* Answer the question: which are the ES provided by ANP? *Role of research team:* Team members support each group's rapporteur in moderating the discussions and clarifying any questions regarding the filling of the worksheets. *Role of participants:* Identifying ES in the study area, giving specific examples.
Subtask 3.1	*Purpose:* Development of a list of ES provided by the study area.

Providing examples of each ES category **(45 min)**	*Role of research team:* A paper worksheet (size A1) is delivered and placed at the centre of each small group's working table. Each sheet includes a generic list of ecosystem services for each main category, defined according to MEA (2005) and TEEB (2010): Provisioning services: "food", "water", "raw materials", "genetic resources", "medicinal resources" and "ornamental resources"; Regulation services: "air quality regulation", climate regulation", "water regulation", "erosion regulation", "pollination", "human disease and pest regulation"; Support services; "primary production", "O_2 production", "soil formation", "nutrient cycling" and also "habitat formation" and "maintenance of genetic diversity"; Cultural services: "aesthetic values", "recreation and ecotourism", "cultural diversity", "spiritual and religious values", "knowledge and educational systems" and "sense of place". *Role of participants:* Participants of each small group mark up the checklist, with the types of ES that are present in the ANP, and add concrete examples of ES in the ANP.
Subtask 3.2 **Participants exchange groups Group change (5 min)** **Validation** **(20 min)**	*Purpose:* Extend and validate the list of ES identified in each small group. *Role of research team:* Prompts participants of each small group to exchange seats with colleagues except for the four rapporteurs who stay in the original groups (*e.g.*, participants from the *provisioning group* exchanged with participants from the *support group*, and the *cultural group* members switched with the r*egulation* ones). *Role of participants:* Rapporteur stays in the original group and explains key results from the first round of discussions (Videira *et al.*, 2012). Participants deliberate and suggest changes to the initial list of examples, using a different colour pen to mark the changes made.
Task 4 - **Work in small groups: identifying links between ES and human wellbeing** **(30 min)**	*Purpose:* Answer the question: which are the links between ES and human wellbeing? *Role of research team:* Adding a new sheet, guide participants through the identification of links between different components of human wellbeing and the previously identified ES. The Millennium Ecosystem Assessment (MEA, 2005) defines five components of human wellbeing, which include security (*e.g.*, personal safety, secure resource access); basic material for good life (*e.g.*, shelter, access to goods); health (*e.g.*, feeling well, access to clean water and air); good social relations (*e.g.*, social cohesion, mutual respect) and freedom of choice and action (opportunity to be able to achieve what an individual values doing and being). These components help participants to think in terms of wellbeing provided by ES allowing the recognition of these linkages. *Role of participants:* Participants identify the links between human wellbeing and the ES identified in task 3.
Task 5 - **Work in small groups: identifying threats to ES** **(30 min)**	*Purpose:* Answer the question: *Which are the main threats to ES?* *Role of research team:* Adding a new worksheet on each table, guide participants in each small group through the process of identification of threats to the provision of ES identified in task 3. *Role of participants:* Develop a list of threats, that should be organized according to different drivers of change (demographic; economic; socio-political; cultural and religious; scientific and technological; climate variability and change; nutrient application to agricultural systems; land conversion; biological invasions and diseases (following the classification proposed by MEA (2005) and Nelson *et al.* (2006)).
Task 6 - **Work in small groups: Screening the importance of ES**	*Purpose:* Answer the question: *Which are the most important services at ecological, economic and social level?* *Role of research team:* Distribution of nine dots to each participant (3 red dots for economic importance, 3 blue dots for social importance and 3 green dots for ecological importance), and prompting participants to screen the ES that they perceive as more important in the ANP.

(20 min)	*Role of participants:* Participants are able to circulate around all the tables for voting (*i.e.*, placing dots) in different categories of services. Participants vote for the services perceived as more important for ecological, social and economic reasons.
Task 7 - **Workshop evaluation by participants** **(5 min)**	*Purpose:* Collect feedback regarding the workshop and collaborative scoping approach, to evaluate outcomes of the process at different levels: Organization Participants Discussions Results *Role of research team:* Distribution of the evaluation survey. *Role of participants:* Answer an evaluation survey about the workshop.

3.2.2.3 Step 3 – Online survey by questionnaire

The workshop outcomes were validated and enhanced by an ex-post online survey by questionnaire. This survey, which was prepared using the Google Forms tool, was distributed to all stakeholders through e-mail. The questionnaire was composed by three sets of questions. The first set aimed to consolidate the list of ES identified during the workshop, the second was meant to validate results regarding the screening of ES importance and the third, to capture the dependencies between stakeholder organizations and the identified ES.

Social network analysis methods (Scott and Carrington, 2011) are based on a conceptual network representation of social interactions and are relevant for ES scoping activities since they facilitate the understanding of complex social relationships (Fliervoet *et al*., 2016; Scott and Carrington, 2011) and provide useful information for subsequent stages of participatory assessments. This was shown by Cárcamo *et al.* (2014) who developed a network graph to observe dependency relationships and possible trade-offs among different ES, biodiversity features and uses. Kreakie *et al*. (2016) also recognized the usefulness of these methods for conservation professionals. In our study, we propose adapting the social network analysis approach to build stakeholder dependency networks from the ES identified during the collaborative scoping process. The networks for each category of ES were developed using the Cytoscape tool (Shannon *et al*., 2003).

3.3. Results and discussion

3.3.1 Institutional and stakeholder analysis

The institutional analysis revealed the most relevant rules for action in the ANP. Due to its classification as a "Natural Park" a combination of different socioeconomic activities and a strong human presence on the territory is allowed. Thus, several formal institutions are important for the management of the area, such as ANP's management plan, Natura 2000 rules and several development and conservation programs. A review of these formal instruments showed that despite the reference to examples of services provided by ANP's ecosystems, the concept of ES is not yet explicitly recognized.

The stakeholder analysis performed with the collaboration of ANP's managers, allowed to identify 67 representatives in 38 organizations, classified according to four categories of stakeholder groups (Table 3.2).

Table 3.2 Invited and participating stakeholder groups in the collaborative ecosystem services scoping process

	Stakeholder analysis		**Workshop participants**		**Online survey participants**	
Organization Category (based on Marega and Urataric, 2011)	Number of organizations	Number of participants	Number of organizations	Number of participants	Number of Organizations	Number of participants
Government / Authorities (GA)	16	35	7	12	6	11
Research Institutions (RI)	3	5	1	1	3	4
Civil Society (CS)	12	16	3	5	3	5
Business (B)	7	11	3	3	6	6
Total	**38**	**67**	**14**	**21**	**18**	**26**

Table 3.2 shows that a mix of representatives from the four stakeholder categories was achieved both in the workshop and online survey. Governmental organizations included representatives from local authorities (*i.e*. municipalities), public agencies and protected area managers. Research institutions were represented by universities and research centres. Civil society organizations included local community associations and interest groups. National associations, as well as regional and local organizations, represented business stakeholders.

In the evaluation questionnaire distributed at the end of the workshop, participants were asked to comment on the composition of the stakeholder group. They agreed that a diverse group of relevant interested parties were involved in the scoping process (most frequent answer: 5 - meaning strongly agree), although some stakeholders have been absent from the workshop, mostly business representatives (*e.g*., from tourism, agriculture, fisheries and forest sectors). Notwithstanding the agreement that they functioned well as a group, the majority of participants commented that time available for developing the exercises in the workshop was limited. In further applications of the approach, the extension of the length of the participatory workshop could be tested. Nevertheless, this raises the question on the possible trade-off between the duration of events and the attendance rate in such type of voluntary participatory processes (Videira *et al*., 2012). The fact that an ex-post online survey was deployed provided an additional opportunity and expanded the time available for participants' engagement. This seemed to have worked well in the ANP case, where 39% of invited participants responded to the online survey, while an attendance rate of 31% was achieved in the ES scoping workshop.

3.3.2 Identification of ecosystem services in the Arrábida natural park

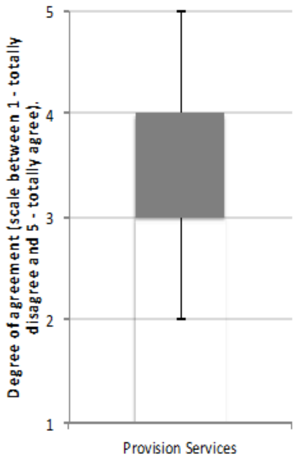
In this key task we aimed to engage stakeholders in the elaboration of a comprehensive list of specific ES provided by the protected area. Table 3.3 shows that workshop participants were able to deliberate, from the ground up, on the ES provided by the protected area, achieving a list with a total of 53 specific examples of ES across all of the four main categories.

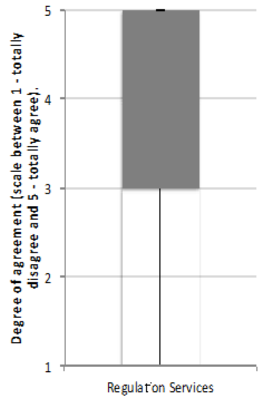
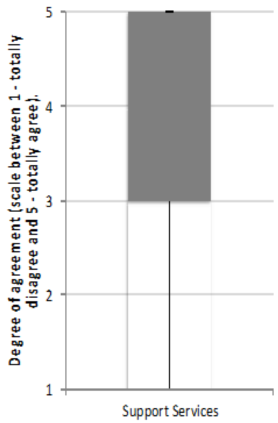
Participants' first recognized the presence of all 'generic services' identified in a preliminary checklist distributed at the beginning of the workshop. Subsequently, we asked them to debate on concrete examples for the case study area. This promoted a more in-depth discussion, translating general perceptions on ES types into specific examples that participants could more easily relate with for providing suggestions based on their empirical knowledge. On the other hand, the results we had obtained in the institutional analysis step showed that the concept of ES, as well as some types of ES (*e.g.,* ES.2.5, ES.2.6, ES.3.3, ES.3.4), were not reflected in current institutions for the protected area (*e.g.,* such as those established in the ANP management plan). The rules approved by ANP's nature conservation regulations do not fully adopt an ES approach yet. This was evident from the analysis of legal instruments establishing the institutional context for management of the protected area, wherein the concept of ES was not explicitly mentioned in any of the reviewed documents.

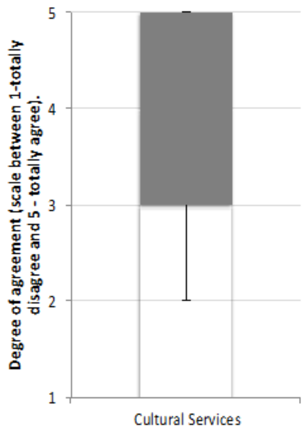
Table 3.3 also indicates that examples elicited for provisioning and cultural services were more extensive than those collected for regulation and support services. This confirms the tendency referred by several authors who have pointed that the latter ES are usually less ‘visible’ to people (Iniesta-Arandia *et al*., 2014). Nonetheless, the scoping approach deployed in the workshop gave positive indications that a deliberative process of ES identification is able to address this limitation by broadening individual perceptions. This happened not only during the debates taking place in the original small groups (subtask 3.1, Table 3.1), but also by allowing participants to sit in different groups and add suggestions to extend the scope of ES identified by fellow participants in the first round of discussions (subtask 3.2, Table 3.1).

The degree of familiarity of workshop participants with the ES concept was relatively high. 60% of participants declared that they knew well the ES concept, 33% knew it to some extent, while only 7% declared that they knew the concept but did not fully understand it at the beginning of the workshop. To verify whether the ES list identified by workshop participants was comprehensive, the ex-post questionnaire made available online after the workshop to all stakeholders, was used to validate results. We asked participants to classify their degree of agreement with the set of ES identified in the workshop, using a Likert scale, from 1 – “totally disagree” to 5 – “totally agree”. The results are presented in the box-plots included in Table 3.2 With most answers concentrated between “3” and “5” in all four major categories, it may be concluded that a mid to very high level of agreement with workshop results was achieved. In the online survey a few additional comments were collected – as showed in the last column of Table 3.3 – mostly related with examples that did not illustrate ES in the ANP (ES 1.1.5, ES 2.6.1, ES 4.5.3), ES examples missing from the original list (ES 1.1, ES 1.4, ES 3.5, ES 4.6), and suggestions for management of some of the identified services (ES 1.6.1, ES 2.1.1, ES 4.2.2). A revised list of services obtained at the end of the collaborative scoping process may then be subsequently used to inform future ES assessments in the ANP.

Table 3.3 - Ecosystem services identified by stakeholders in the Arrábida Natural

Main ES category		STEP 1 – Institutional Analysis	STEP 2 – Participatory Workshop		STEP 3 – Ex-post online survey	
	Generic examples of ecosystem services in each main category (adapted from MEA, 2005; TEEB, 2010)	*Are generic examples of ecosystem services referred to in the protected area management plan?*	*Were generic ecosystem services recognized by workshop participants (Task 3 – see Table 3.1)?*	*Specific examples of ecosystem services in the protected area, identified by workshop participants (Task 3 – see Table 3.1)*	*Degree of agreement of survey respondents with the list of ecosystem services identified by workshop participants (scale ranges between 1: totally disagree, and 5: totally agree*	*Comments added by survey respondents and suggested changes to the list of specific examples of ES elicited in the workshop*
ES.1. Provisioning Services	**ES.1.1. Food**	✔	✔	ES.1.1.1. Fish ES.1.1.2. Dairy products ES.1.1.3. Wine ES.1.1.4. Herbs ES.1.1.4. Vegetables ES.1.1.5. Other endemic varieties		• "Specific examples of "food" is missing" – build up examples on ES.1.1. • "There is no endemic species that could be considered food" – delete ES.1.1.5. • "Honey should be an example of food" – add honey to ES.1.1 • "For me water is relevant" – maintain ES.1.2.1. • "More examples of biodiversity in genetic resources" – build up examples in ES.1.4. • "I disagree with fossils (…) they should not be explored" – suggestion for management of ES.1.6.1.
	ES.1.2. Water	✔	✔	ES.1.2.1. Water provisioning ("although this service is not very relevant in the area")		
	ES.1.3. Raw materials	✔	✔	ES.1.3.1. Limestone		
	ES.1.4. Genetic resources	✔	✔	ES.1.4.1. Algae ES.1.4.2. Endemic orchid		
	ES.1.5. Medicinal resources	✔	✔	ES.1.5.1. Medicinal herbs ES.1.5.2. Carob		
	ES.1.6. Ornamental resources	✔	✔	ES.1.6.1. Handicraft (scales, shells, fossils)		

ES. 2.Regulation Services	**ES.2.1. Air quality regulation**	X	✔	ES.2.1.1. Pollution from quarries controlled by vegetation		• "The vegetation is not enough to control the pollution from the quarry industry" – suggestion for management of ES.2.1.1. • "Humidity increase is more correct than rain increase" – rename ES.2.2.1. • "Coastal zone is also protected by dunes and beaches" – complete description of ES.2.4.1. • "The hospital is not an ecosystem service" – delete example ES.2.6.1.
	ES.2.2. Climate regulation	X	✔	ES.2.2.1. Rain increase ES.2.2.2. Carbon sequestration with potential increase of biomass close to the soil		
	ES.2.3. Water regulation	✔	✔	ES.2.3.1. Karst aquifer recharge		
	ES.2.4. Erosion regulation	✔	✔	ES.2.4.1. Coastal zone protection by vegetation		
	ES.2.5. Pollination	X	✔	ES.2.5.1. Growth of agriculture and biodiversity compared to areas outside the limits of the ANP		
	ES.2.6. Human disease and pest regulation	X	✔	ES.2.6.1. Outão Hospital		
ES.3. Support Services	**ES.3.1. Primary production**	✔	✔	ES.3.1.1. Primary production ("The ANP presents all the features needed for primary production")		• "I do not agree that the ANP presents all the features needed for primary production" – rewrite description of ES.3.1.1. • "It is important to mention the shredders habitat, which is the refugee for migratory birds" – add this specific example to ES.3.5. • "Instead of Park Luís Saldanha it should be mentioned marine natural park" – rename ES.3.5.1.
	ES.3.2. O_2 production	✔	✔	ES.3.2.1. O_2 production by forests, prairies, and pastures		
	ES.3.3. Soil formation	X	✔	ES.3.3.1. Pockets of land in karst areas that allow attachment of vegetation in mountain areas and water retention		
	ES.3.4. Nutrient cycling	X	✔	ES.3.4.1. Nitrogen cycle - existence of pulses that enable the fixation of atmospheric nitrogen that enters in the cycle. ES.3.4.2. Cycles of other nutrients (*e.g.*, P, K, Mg) fixed in organic matter and vegetation		
	ES.3.5. Habitat provision	✔	✔	ES.3.5.1. Park Luíz Saldanha's habitats are important for species fixation		

				ES.3.5.2. Natural forest as habitat for birds		
	ES.3.6. Maintenance of genetic diversity	✔	✔	ES.3.6.1. Different varieties of oak ES.3.6.2. Several types of orchids ES.3.6.3. Atlantic marine biodiversity		
ES.4. Cultural Services	**ES.4.1. Aesthetic values**	✔	✔	ES.4.1.1. Landscape ES.4.1.2. Area with low population density ES.4.1.3. Artistic inspiration ES.4.1.4. Mountain-sea contrast		• “Education for citizenship; the environment has ethnical and scientific content in the context of sport and leisure.” – add ethnical and scientific content to ES.4.5. • “The migration was more important to the canning, salt and oysters’ industry” – specify in ES.4.3.3. • “Fishing is also a cultural service”– add this example to ES.4.2. and ES.4.6. • “Add several national and international classifications as an example of cultural services” – specify in ES.4.1.1. • “Application for world heritage” – eliminate ES.4.5.3. • “It is missing the recognition of the place by humans and the integration of ecology in culture” – to include in ES.4.6. and in ES.4.5. • “The sense of place in ANP and surrounding area leads to a natural predisposition to nature conservation” – add nature conservation to ES.4.6.
	ES.4.2. Recreation and eco-tourism	✔	✔	ES.4.2.1. Beaches ES.4.2.2. Nature sports ES.4.2.3. Gastronomy ES.4.2.4. Closeness to river and sea		
	ES.4.3. Cultural diversity	✔	✔	ES.4.3.1. Several people (“There was always human presence in the territory”) ES.4.3.2. Invasion territory ES.4.3.3. Migration processes from Lisbon		
	ES.4.4. Spiritual and religious values	✔	✔	ES.4.4.1. Mysticism ES.4.4.2. Isolated areas ES.4.4.3. Arrábida convent ES.4.4.4. Finisterra territory ES.4.4.5. Cape Espichel ES.4.4.6. Tapers ES.4.4.7. Arrábida legends		
	ES.4.5. Knowledge systems and educational values	✔	✔	ES.4.5.1. Biophysical and geological features ES.4.5.2. Limited access to the local ES.4.5.3. Arrábida’s candidacy for UN World Heritage site		
	ES.4.6. Sense of place	✔	✔	ES.4.6.1. Mountain-sea connection ES.4.6.2. Remote place to discover ES.4.6.3. Closeness to marine environment		

3.3.3 Linking ecosystem services and human wellbeing

Recognizing the linkages between the services provided by ecosystems and human wellbeing is part and parcel of an ES approach (MEA, 2005; Willemen *et al.*, 2013). Notwithstanding, it is often unclear whether stakeholders realize those linkages and the mechanisms through which they are established. For example, in a study focusing on the role of marine protected areas in delivering flows of ES to support human welfare, Potts *et al.* (2014) argued that capturing these links was essential to inform debates on how to manage those ecosystems. The MEA (2005) defends that wellbeing components are related with all ES categories, although there are differences in the intensity and in the potential for mediation by socioeconomic factors. In the Ecosystem Services and Poverty Alleviation Framework, Fisher *et al.* (2014) highlighted the possibility of establishing how a specific ES contributes for wellbeing, thus supporting understanding of stakeholder priorities.

For this workshop exercise (see Task 4, Table 3.1) we aimed to raise awareness on the linkages between ES and human well-being and assess how stakeholders perceived these interrelationships. Firstly, participants were asked to identify the contribution of ES to the wellbeing components advanced by the MEA (2005), by checking the ES categories that they perceived as relevant to each benefit (wellbeing component) (Table 3.4).

Table 3.4 - Summary of the linkages between wellbeing components and the main categories of ecosystem services recognized by workshop participants

Wellbeing components (MEA, 2005)	**Main ecosystem services categories**			
	ES.1.Provisioning	**ES.2. Regulation**	**ES.3. Support**	**ES.4. Cultural**
Security	X	✔	✔	✔
Basic material for good life	✔	✔	✔	✔
Health	✔	✔	✔	✔
Good social relations	✔	X	✔	✔
Freedom of choice and action	✔	X	✔	✔

Interestingly, a few wellbeing components were considered independent of some ES categories. For example, regarding “good social relations” and “freedom of choice”, the small group working on regulation services argued that these two benefits do not result from ES.2. In the study developed by Fisher *et al.* (2014), these two components appear linked with all the ES categories, although they are more strongly related with cultural services (ES.4.). During the workshop, participants have also identified direct linkages between support services and all wellbeing components, which again showed the importance that the group attached to this ES category. On the other hand, the wellbeing component “security” was not linked to provisioning services (ES.1.). According to Fisher *et al.* (2014) this wellbeing component is more dependent from the regulation services (ES.2.), which seems to be aligned with workshop results.

Subsequently, we asked each group of participants to detail which components of wellbeing were affected by the specific ES examples they had identified for the ANP. Table 3.5 provides an example of results achieved by the group working on the cultural ES category.

Table 3.5 - Perceptions of workshop participants regarding the links between human wellbeing components and cultural ecosystem services

ES.4. Cultural Services	**Human wellbeing components**				
	Security	**Basic material for good life**	**Health**	**Good social relations**	**Freedom of choice and action**
ES.4.1. Aesthetic values	X	✔	✔	✔	✔
ES.4.2. Recreation and eco-tourism	✔	✔	✔	✔	✔
ES.4.3. Cultural diversity	✔	X	✔	✔	✔
ES.4.4. Spiritual and religious values	✔	X	X	✔	✔
ES.4.5. Knowledge systems and educational values	X	✔	✔	✔	✔
ES.4.6. Sense of Place	✔	✔	✔	X	✔

Table 3.5 shows that workshop participants considered that all cultural services (ES.4.) are associated with “freedom of choice and action”, which underlines the importance of these services, many times considered “invisible” to people and associated with “intangible values”. The wellbeing components less linked with the cultural services (ES.4.) were “security” and “basic material for good life”, which is also aligned with the results from Fisher *et al*. (2014). The results emphasize how cultural services are important in the ANP context. According to Karrasch *et al*. (2014) stakeholders typically express their perceptions and needs in collective rather than individual terms, which is very similar to what happened in the discussion of this scoping objective in the ANP. Identifying these slight differences could help to understand different contributions of ES to wellbeing components in the context of a specific protected area.

3.3.4 Identifying drivers of change of ecosystem services

Anthropogenic drivers of ecosystems change are described as any human-induced factor that directly or indirectly causes a change in ecosystems (MEA 2005). In Task 5 (see Table 3.1), workshop participants deliberated on the main drivers affecting each of the ES identified in the previous tasks. The examples provided by participants were subsequently assigned to the categories of drivers defined by the MEA (2005) and Nelson *et al*. (2006). Table 3.6 presents the results from this task, showing the number of drivers of change identified by participants across the different categories of ES. It should be noted that this procedure did not aim to measure the degree of change induced by each driver on each ecosystem service. It rather meant to collect participants' perceptions regarding the diversity of drivers affecting ES in the ANP and scope the range of interconnected effects observed across the different categories of ES.

Indirect drivers of change were the ones most identified, especially demographic and economic drivers with link to thirteen and twelve ES, respectively. According to the MEA (2005) the distribution of population and living arrangements affects consumption patterns and consequently impacts on ecosystems. The economic, socio-political and cultural drivers affect in terms of availability of resources, and how individuals choose to allocate them. Science and technology drivers are the ones allowing transformation of raw materials provided by ecosystems into services of value to humans. We allocated "over-exploitation" threats within the demographic and economic drivers of change category, based on the MEA (2005). According to workshop participants, by addressing over-exploitation, it will be possible to reduce a significant source of impacts on different ES. In the context of a protected area it is understandable that drivers of change such as "cultural and religious" or "science and technology" are less perceived as having impacts on ES. However, it can be pointed as an unexpected result the fact that "nutrient application to agricultural systems" was not mentioned, although agriculture is present in ANP. Additionally, there were few links with "land conversion", despite that according to Rodríguez-Loinaz *et al.* (2015) this is one of the main drivers of change of ES provision.

Considering each ecosystem service individually, "food" (ES.1.1) is the one showing a higher number of different threats (four in total), followed by "ES.1.2. Water", "ES.1.3.Raw materials", "ES.1.4.Genetic resources", "ES.1.5.Medicinal resources", "ES.2.1.Air quality regulation", "ES.2.3.Water regulation" and "ES.4.3.Cultural diversity", all with three different drivers of change. Four ES did not have any driver of change linked to them (ES.1.6; ES.4.4; ES.4.5; ES.4.6).

In terms of categories of ES, provision services were the ones where more drivers of change have been identified, followed by regulation, support and cultural services. According to participants' perceptions the majority of the threats to provisioning services are demographic, economic and socio-political drivers, whereas regarding regulation services land conversion was the driver most linked with this category (ES.2.2; ES.2.4; ES.2.5).

Table 3.6 - Drivers of change of ecosystem services in the Arrábida Natural Park

	ES.1. Provision Services						ES.2. Regulation Services						ES.3. Support Services						ES.4. Cultural Services						*Total per driver of change*				
	ES.1.1.	ES.1.2.	ES.1.3.	ES.1.4.	ES.1.5.	ES. 1.6.	ES.2.1.	ES.2.2.	ES.2.3.	ES.2.4.	ES.2.5.	ES.2.6.	ES.3.1.	ES.3.2.	ES.3.3.	ES.3.4.	ES.3.5.	ES.3.6.	ES.4.1.	ES.4.2.	ES.4.3.	ES.4.4.	ES.4.5.	ES.4.6.	ES.1.	ES.2.	ES.3.	ES.4.	
Drivers of change	Food	Water	Raw materials	Genetic resources	Medicinal resources	Ornamental resources	Air quality regulation	Climate regulation	Water regulation	Erosion regulation	Pollination	Human disease and pest regulation	Primary production	O2 production	Soil formation	Nutrient cycling	Habitat provision	Maintenance of genetic diversity	Aesthetic values	Recreation and eco-tourism	Cultural diversity	Spiritual and religious values	Knowledge systems and educational values	Sense of place	Provision Services	Regulation Services	Support Services	Cultural Services	Four categories of ES
Demographic																									5	2	3	3	13
Economic																									5	2	2	3	12
Sociopolitical																									4	2	1	0	7
Cultural and religious																									0	0	0	1	1
Science and technology																									0	0	0	0	0
Climate variability and change																									1	1	0	0	2
Nutrient application to agricultural systems																									0	0	0	0	0
Land conversion																									0	3	2	0	5
Biological invasion and diseases																									1	2	3	0	6
Total per service	4	3	3	3	3	0	3	1	3	1	2	2	2	1	2	2	1	2	2	2	3	0	0	0					

3.3.5 Screening the relative importance of ecosystem services to stakeholders

The final workshop exercise (Task 6, Table 3.1) aimed to develop a preliminary assessment of the relative importance of ES to stakeholders. Each participant had sticky dots for voting on ANP's ES they perceived as more important from an ecological, economic and social perspective. As highlighted by several authors (de Groot *et al*., 2002; Lopes and Videira, 2013; Martín-López *et al*., 2014), one of the main challenges in ES research is to implement approaches capable of integrating biophysical, socio-cultural and monetary value domains to inform decision-making processes. Martín-López *et al.* (2014) found that depending on the value-domain according to which ES are valued, different outcomes and trade-offs emerge, which underscores the importance of integrating different value dimensions from the onset of assessment and valuation processes. Hence, this scoping exercise intended to test the process of articulating multiple values at a scoping stage, by promoting the screening of the ES importance on different value dimensions (Figure 3.3).

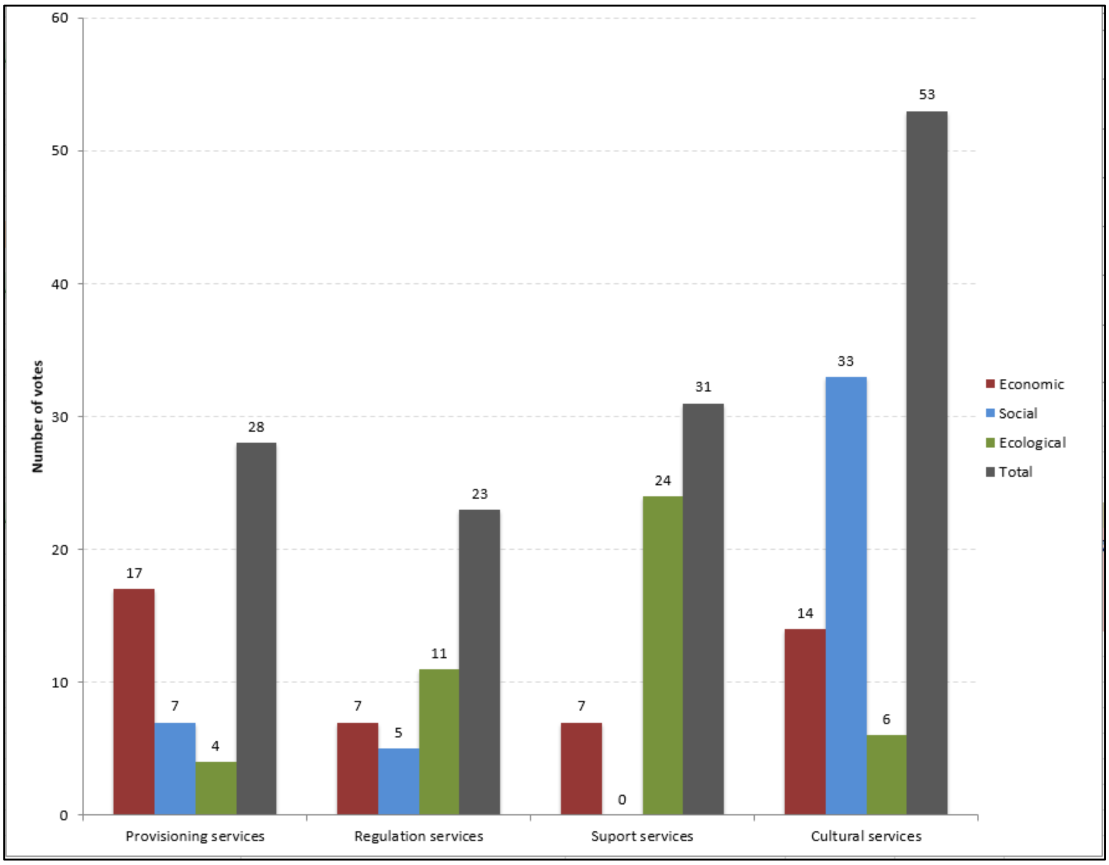


Figure 3.3 - Sum of votes per ecosystem service category, by type of value (economic, social, ecological and total)

Cultural services gathered the overall higher number of votes per ES category, mainly driven by the social importance attached to these services. On the other hand, provisioning ES received the higher votes in terms of economic importance, but in total this category had fewer votes than supporting services. This was a somewhat unexpected result since the literature points to the fact that usually provisioning services are the most understandable and easily identified category by stakeholders (Iniesta-Arandia *et al*., 2014). It is interesting to note that this result is largely justified by the highest ecological importance that participants attached to supporting services.

From Figure 3.3 it is also evident that stakeholders assigned economic, ecological and social importance to all categories of ES, with the exception of supporting services, which did not receive any vote in terms of social importance. This does not mean that participants did not recognize a social value resulting from support services, particularly since they were able to provide specific examples and establish links between this category of ES and human wellbeing in previous workshop exercises. It rather points out that when asked to screen among a relatively large list of ES, participants directed the available three "social importance" votes to other categories, mostly cultural ES.

Looking at the results for each ES type, the service that gathered more votes was "ES.4.2. Recreation and ecotourism", included in the cultural ES category (Figure 3.4). This may be justified by the fact that the ANP is a well-known touristic area comprising wild beaches surrounded by vegetation, and is recognized as a national and international tourist destination (ICN, 2003).

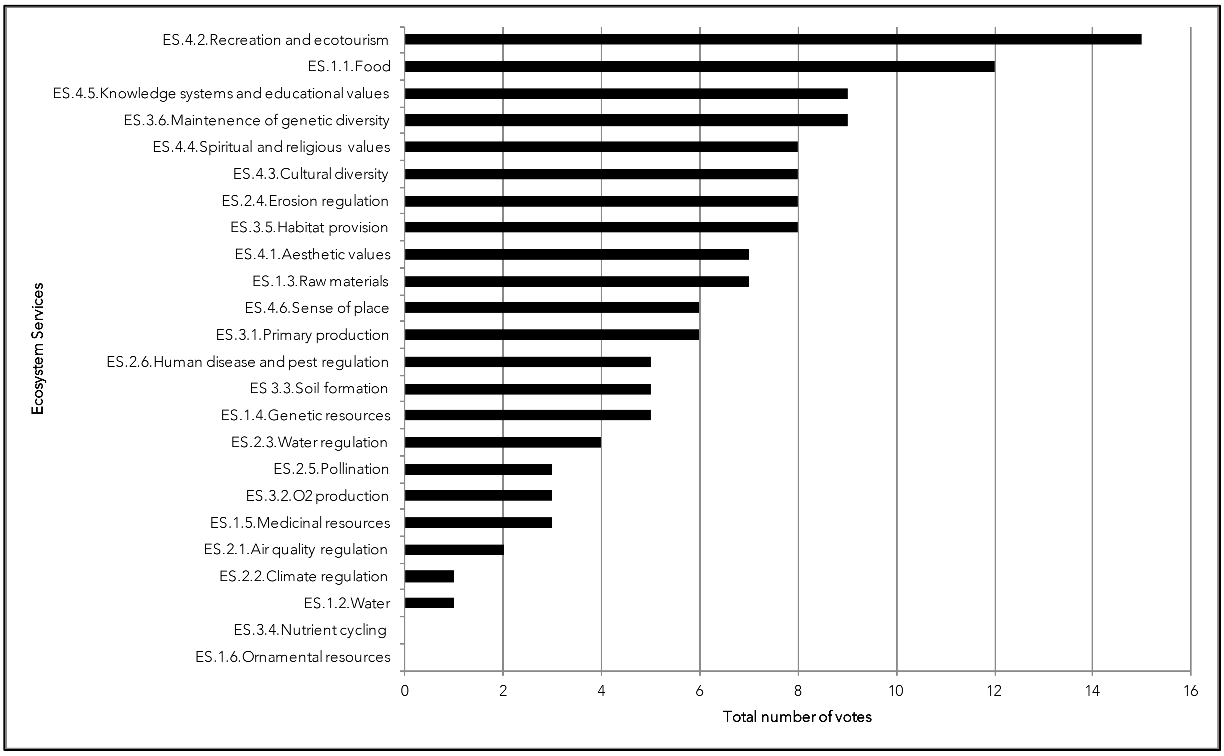


Figure 3.4 - Ranking of importance attached by participants to the Arrábida Natural Park's ecosystem services

"ES.1.1.Food" appears as the second most voted service. This was a surprising result for the ANP management team, which did not expect such level of importance attributed to food ES. However, this result was considered relevant to use in future public communications on the benefits provided by the protected area. The third most voted services included "ES.4.5.Knowledge systems and educational values" and "ES.3.6. Maintenance of genetic diversity", both with nine votes. It is interesting to note the importance attributed to the maintenance of genetic diversity, revealing an alignment with the biodiversity and nature conservation classification of the area. Finally, it may be observed in Figure 3.4 that two services, "ES.3.4. Nutrient cycling" and "ES.1.6. Ornamental resources" did not gather any vote, which may be justified by the lower awareness or relative importance attributed to these services by participants who concentrated their choices on more prominent ES.

Figure 3.5 highlights the number of votes received by the different type of ES according to each value dimension. Social importance was mainly attributed to cultural ES, and ecological importance was more recognized in relation to support and regulating services. The distribution of the economic importance votes shows a more scattered distribution along the four main categories of ES.

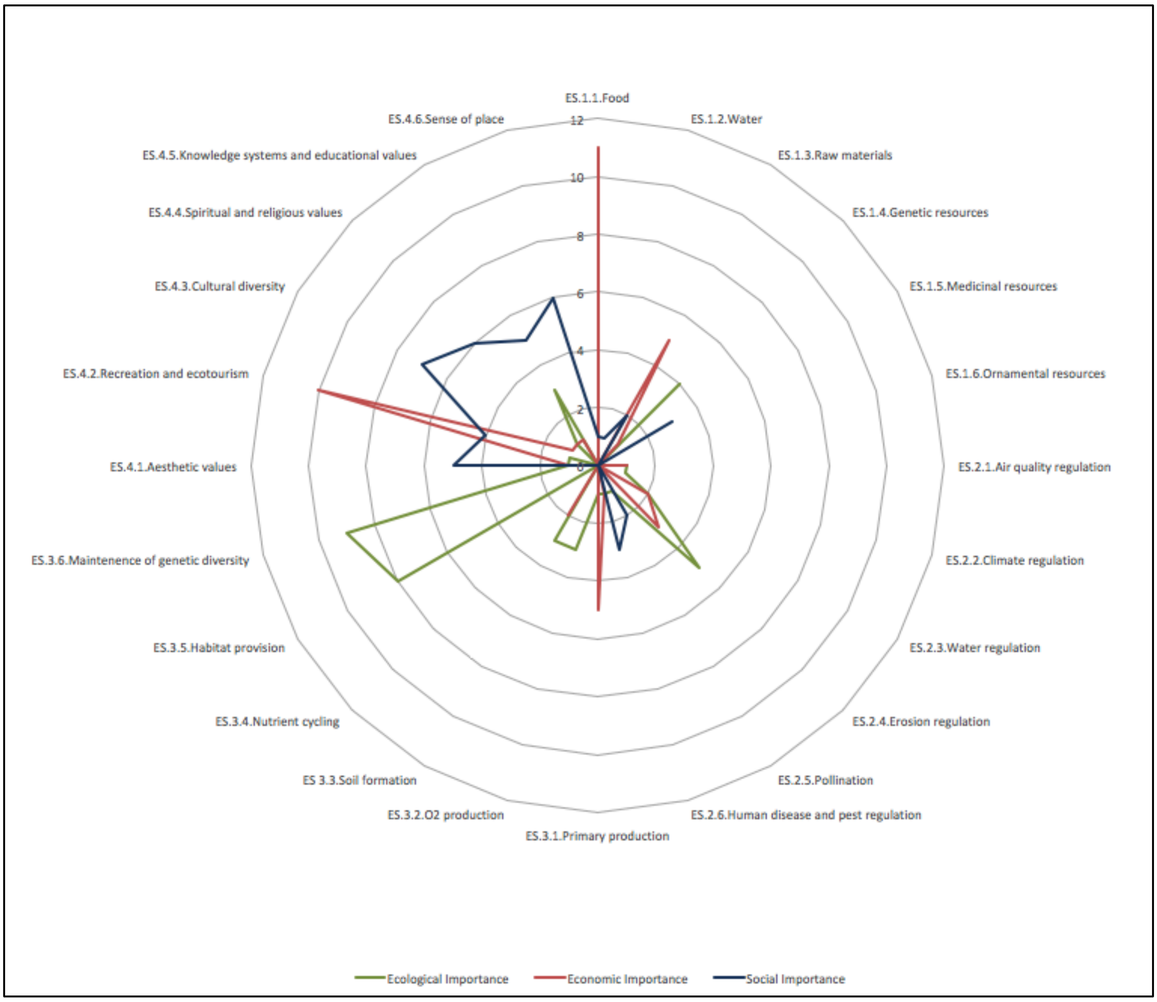


Figure 3.5 - Number of votes in each type of ecosystem services according to the three value dimensions

The three most voted ES in each dimension were "ES.1.1.Food" for economic importance, "ES.3.6. Maintenance of genetic diversity" for ecological importance and "ES.4.3. Cultural diversity" for social importance. Interestingly, none of these services received votes in more than one value dimension. This result shows that is critical to consider different values-domains when performing participatory ES assessments, since there is a risk to ignore important ES when single dimensional analyses are performed. As value articulating institutions, and consequently not neutral, assessment and valuation methods need to account for the plurality of values possibly assigned to ES (Vatn, 2005; Gasparatos, 2010; Gómez-Baggethun and Ruiz-Perez, 2011; Martin-López *et al*., 2014; Hattam *et al*., 2015). While it is argued that the concept of ES implicitly embodies the ecological importance of ES, the explicit consideration of the three dimensions in this screening exercise allowed to create awareness among workshop participants regarding the multidimensional values of ES in the protected area.

Respondents of the ex-post online survey were also asked to reveal their degree of agreement with the outcomes of the voting procedure conducted in the workshop. Using a Likert scale ranging from 1 ("totally disagree") to 5 ("totally agree"), 4 ("agree") was the most frequent answer obtained from the 26 responses, which denotes an alignment of respondents' perceptions with those of workshop participants. In cases where the level of agreement was low, we asked for additional comments. These justifications largely fell into two different groups of arguments:

a) Incomparability of ES values and interdependencies among ES (*e.g.*, *"I do not agree (…) to vote on ES that are complementary and dependent on each other; there can be no one more important than the other"; I think that without the functions of regulation and support it is not possible to have provision and cultural services*");
b) Invisibility of some categories of ES (*e.g., "I believe that it has only been taken into account the direct benefits of tourist activity. However, without proper preservation and conservation of support, regulation and provision services, cultural services will not have much future (…) the importance of these services is very high, however just because it is not properly accounted for, it was not taken into account".*

These comments emphasized the need for considering interdependencies between ES and promoting an integrated analysis of the different value-dimensions.

3.3.6 Combining stakeholder perceptions of ecosystem services importance and threats

We investigated the connection of outcomes from the previous workshop exercise with the results obtained in the drivers of change task. It was observed that the most important category of services (*i.e.*, cultural services) is also the one with less number of identified drivers of change, mainly demographic and economic. It should be underlined that the identification of the type and diversity of threats is not a measure of their intensity. Notwithstanding, according to the UK National Ecosystem Assessment (2014), a high number of drivers of change acting on ES supply could increase the threats posed by drivers of change, since the combined impact of multiple drivers on an ecosystem service increases the unpredictability of changes in ES. Figure 3.6 displays the most important ES for workshop participants against the number of different drivers of change associated with each service.

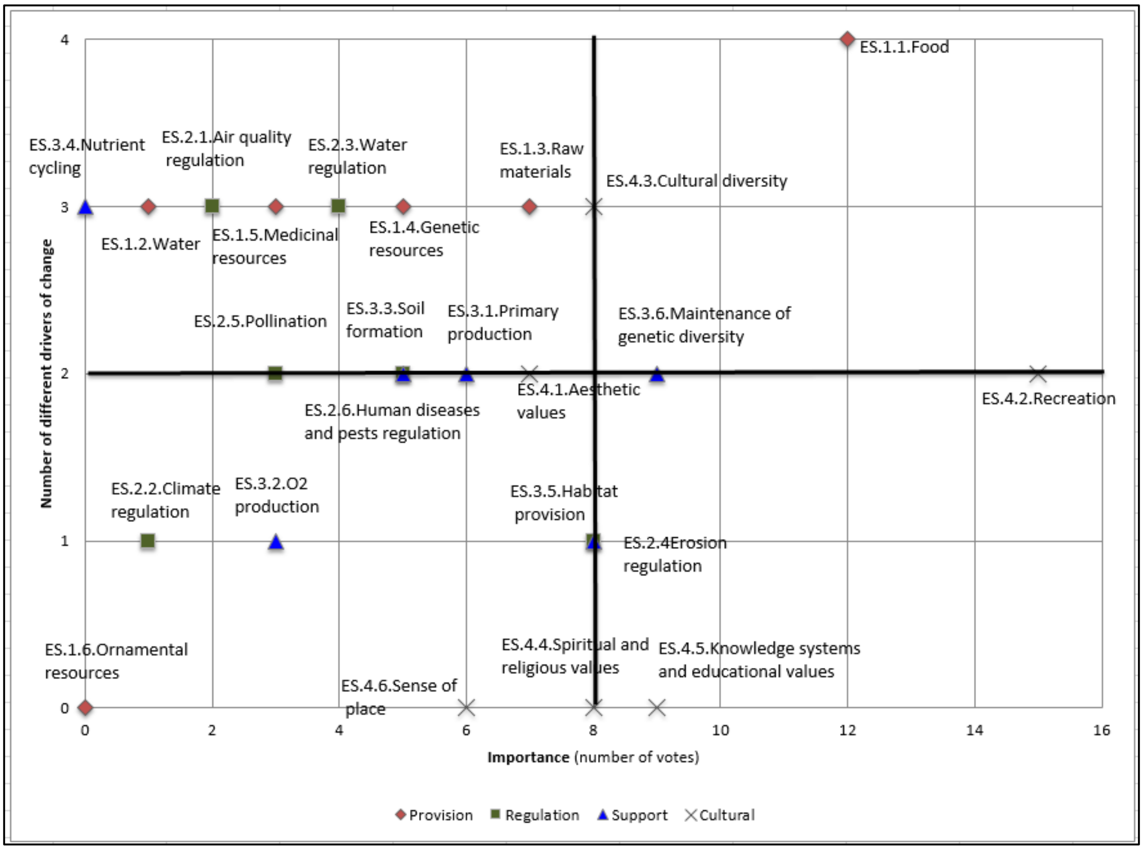


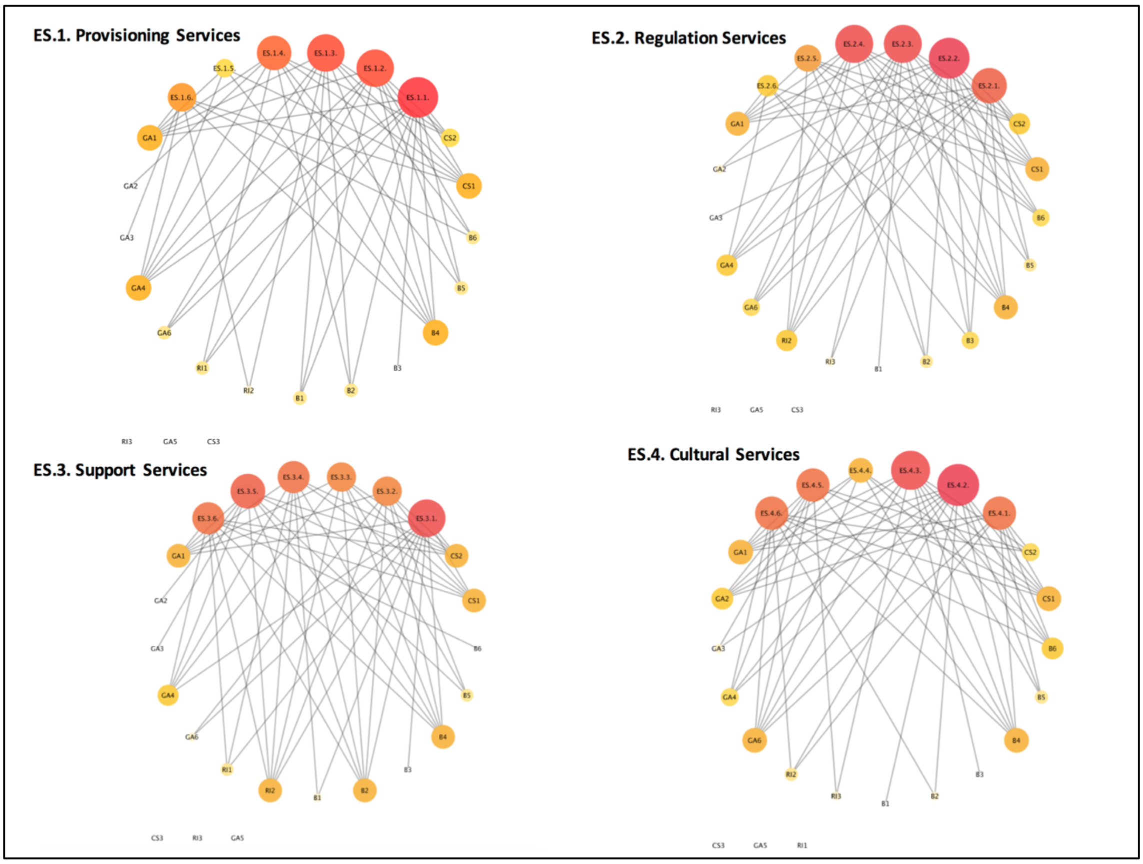
Figure 3.6 - ES in the ANP according to the importance and number of different drivers of change recognized by workshop participants

The majority of ES are positioned in the upper left quadrant, which corresponds to the "less important" and the "more threatened" cluster (assuming that a higher number of different threats is potentially more threatening). In the upper right quadrant, combining the "more important" ES with the ones that have "more drivers of change", "ES.1.1. Food" stands out.

This type of analysis may have an important role to play when developing ES management policies in the protected area. Combined with information of the supply of ES, decision-makers may establish priorities and direct measures to most important and threatened ES. However, as discussed by Martín-López *et al.* (2014), it is also critical that managers look into the most threatened and less important ES (upper left quadrant), otherwise these services may be at risk.

3.3.7 Establishing stakeholder dependency networks and following-up of scoping activities

To conclude the testing of the collaborative ES scoping approach to the ANP, a social network analysis was performed to elicit the dependency relationships established between stakeholder groups and the ES identified during the workshop. Considering each category of ES (ES.1; ES.2; ES.3; ES.4), we asked respondents of the ex-post online survey to select the ES from which their organization depended. Participants were also able to specify the degree of dependence, *i.e.* the type of dependency and/or to which extent the dependency exists. Figure 3.7 depicts the obtained network graphs representing stakeholders' dependencies from the different types of ES.



Note: Networks developed in Cytoscape software (Shannon *et al.,* 2003). The larger nodes and darker colours represent a higher value for indegree (*i.e.* the number of arcs that end on a node, here representing the expression of ES causing more dependencies) higher values of outdegree (*i.e.*, the number of arcs that starts from one node, here representing the expression of dependence on ES by respondents). Ecosystem services use the terminology presented in Table 3.1 and Stakeholders groups use the terminology presented in Table 3.2: GA – Government Authorities, RI – Research Institutions, CS – Civil Society and B – Business.

Figure 3.7 - Conceptual networks representing dependency relationships between stakeholders and ES according to the four ES categories

The two ES that generated more dependencies (*i.e.* a higher indegree value of 13 and 12 respectively) were "ES.2.2. Climate regulation" and "ES.4.2. Recreation and eco-tourism". The subsequent group of ES with more associated dependencies include "ES.2.3. Water regulation", "ES.3.3.Primary production", "ES.2.4.Erosion regulation", "ES.1.1.Food" and "ES.4.3. Cultural diversity". It should be noted that while "ES.4.2. Recreation and eco-tourism" was also pointed as one of the most important services for workshop participants (Figure 3.4), "ES.2.2. Climate regulation" was not perceived as important. As observed in Figure 3.7, stakeholders expressed a higher degree of dependency to regulation ES than the voting procedure suggested during the workshop. This is an interesting result, which demonstrates the value of combining different participatory exercises to validate perceptions of stakeholders regarding the multiple value dimensions of ES.

Additionally, this tool also allows to analyse the stakeholder groups with more recognized dependencies. For example, in Figure 3.7 stakeholder group RI (Research Institutions) is the one with lower intensity of dependencies on provision (ES.1.) and cultural services (ES.4), with both participants in this group revealing no more than three links with these ES categories. Stakeholder group GA (Government Authorities) showed a similar outdegree value for all ES categories. With respect to the six business stakeholders represented (Group B, Business), results indicate a diversity of recognized dependencies, with at least one respondent showing the highest outdegree value for all ES categories. Finally, the two stakeholders in the Civil Society group (CS) recognized dependencies with at least four examples of ES in all the four main categories.

As illustrated in this example, the social network analysis is a useful complementary tool in the participatory scoping process. These dependency webs offer a network map that may support managers in the definition of follow-up activities, namely by creating awareness of dependencies of different stakeholder groups on specific ES. This information may be used to target involvement of stakeholder groups in management decisions and engaging them in the assessment of the demand side of ES.

As a first step within an integrated participatory process for valuing ES, managers may obtain a rich scoping picture on relevant ES provided in the area and how this is interpreted by local stakeholders. As such, new information may be used to communicate the importance of natural areas, while integrating multiple stakeholder views in management decisions as a means to articulate different values. The ES concept discloses links between humans and nature allowing the recognition of crucial ES in protected areas, particularly in those with a strong human presence in the territory, such as the case of ANP. On the other hand, the integration of a collaborative ES scoping approach in management structures may face some challenges, namely with respect to the institutionalization of the concept. This requires time to allow ES approaches to be adopted and formally recognized in the rules for action, thus implying a change in worldviews and how problems are defined.

As presented in Figure 3.1 the proposed collaborative scoping approach tested in the ANP sets the scene for further ES assessment and management processes. Natural resource managers, such as those involved in the ANP, may implement the collaborative scoping methodology to support several decisions, for example, in development and assessment of land use plans, selection of alternative conservation projects, sourcing of conservation funding or designing new monitoring programs.

By opening up ES assessment to interest parties since the very early stages, the proposed scoping approach may subsequently be combined with other methods and tools to provide a deeper understanding and articulation of ES values. Hence, scoping results may provide useful input to support follow-up activities, such as, spatial mapping of ES (*e.g.,* García-Nieto *et al.,* 2013), development of ES value matrices (*e.g.,* Kandziora *et al*., 2013; Burkhard *et al.,* 2014), quantification of ES indicators (*e.g.,* Villamagna *et al*., 2014) or application of ES valuation techniques (*e.g.,* TEEB, 2010).

3.4 Conclusions

With increasing calls for active involvement of stakeholders in assessment and valuation of ES, this paper advanced a scoping approach to engage diverse social actors in the collaborative identification of ES. Such participatory processes are expected to capture, from the bottom-up, stakeholders' perceptions on ES and foster the incorporation of different types of knowledge in decision-making processes. The presented approach is anchored on a participatory workshop wherein stakeholders deliberate on a set of scoping tasks, namely the identification of ES, their drivers of change, the linkages between ES and human wellbeing, and the screening of the relative importance of different ES values. Complementing these group activities, the approach also takes into account preparatory tasks regarding the institutional and stakeholder analysis and follow-up activities involving validation of workshop results and the establishment of stakeholder dependency networks affecting ES.

The testing of such collaborative scoping Framework to the Arrábida Natural Park case study provided positive indications towards the usefulness of the approach. Throughout the process we were able to engage distinct stakeholder groups ensuring the integration of plural perspectives. By having more than one participatory procedure the process provided multiple opportunities for participation, thus reducing the risk of excluding stakeholders who may not be present in a one-off event. Invited participants have developed a comprehensive list of ES in the protected area. Throughout the series of interactive exercises developed a preliminary shared understanding on the underlying values and management implications. The majority of participants agreed that the used methods allowed to structure the discussion on ES values in the ANP and led to integration of ES knowledge. The sequence of steps was also effective in disclosing information related with multiple value dimensions.

We conclude that this proposal supports the practical implementation of the ES concept by opening up ES assessment and management processes to interest parties since the very early stages, raising stakeholders' awareness and fostering integration of knowledge. This is especially relevant for achieving a comprehensive identification of ES beyond the generic categories considered in reference ES Frameworks. On the other hand, since this is but the first stage in the adoption of an ES approach (Lopes and Videira, 2013) we suggest to follow-up on scoping results to strengthen the integration of ES in decision-making processes. By considering the "stakeholder-driven" (Menzel and Teng, 2010) nature of the ES concept and stakeholder participation as a value articulating institution, the proposed scoping methodology is expected to facilitate debates and set-the-scene for involvement of stakeholder groups in broader ES assessment processes.

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Chapter 4 |Deepen Understanding

"Look deep into nature, and then you will understand everything better"

— Albert Einstein

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4.1 Conceptualizing stakeholders' perceptions of ecosystem services: a participatory systems mapping approach

ABSTRACT

A participatory system dynamics modelling approach is advanced to support conceptualization of feedback processes underlying ecosystem services and to foster a shared understanding of leverage intervention points. The process includes a systems mapping workshop and follow-up tasks aiming at the collaborative construction of causal loop diagrams. A case study developed in a natural area in Portugal illustrates how a stakeholder group was actively engaged in the development of a conceptual model depicting policies for sustaining the climate regulation ecosystem service.

KEYWORDS

Participatory Systems Mapping; Ecosystem services/Climate regulation; Stakeholders' perceptions; Causal loop diagrams

4.1.1 Introduction

Ecosystem services are the benefits people obtain from nature (MEA, 2005). This concept has been increasingly used in research and policy agendas over the last decade, fostered by major studies and initiatives such as the Millennium Ecosystem Assessment (MEA, 2005), The Economics of Ecosystems and Biodiversity (TEEB, 2008) and, more recently, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Several authors have been debating the use of this concept (Gómez-Baggethun *et al*., 2010), how it should be integrated in decision-making processes (Gómez-Baggethun *et al*., 2014) and how to foster articulation of multiple values of ecosystem services (Lopes and Videira, 2013; Martín-López *et al*., 2014).

Understanding the concept of ecosystem services and its applicability in different contexts can be defined as an "unstructured problem" (Hisschemoller and Hoppe, 2001). Such designation refers to complex and less studied subjects, with uncertainties in the available scientific knowledge and disagreements on norms and values at stake. These problems typically call for a "policy as learning" approach and a high level of stakeholder participation. This is the case with complex environmental and sustainability problems, often characterized by high scientific uncertainties, multiple interrelationships, non-linear dynamics, large-scale consequences and irreversible damages (Funtowicz and Ravetz, 1993).

Participatory Systems Mapping (PSM) emerges in this context as a promising approach to address complex and unstructured problems through a participatory system dynamics modelling process (Antunes *et al*., 2015; Videira *et al*., 2009). PSM can be defined as the preparation and development of group model building activities, engaging stakeholder groups in the construction of causal loop diagrams (CLDs) to deliver insights regarding a specific issue and foster knowledge exchange (Sedlacko *et al*., 2014). Some authors have recently been applying this approach to different environmental and sustainability issues. Videira *et al*. (2012) mapped maritime problems with maritime stakeholders, Sedlacko *et al*. (2014) used a PSM approach for sustainable consumption and Videira *et al*. (2014) conducted an exploratory study aiming to improve understanding on degrowth pathways through collaborative causal models. These examples were used to promote involvement of broad participant groups in environmental and sustainability debates, using system dynamics conceptualization tools, namely causal loop diagrams.

CLDs were developed since the 1960's and have been used for communication of feedback processes in complex systems using the system dynamics modelling language (Forrester, 1971;

Lane, 2008; Sterman, 2000). The development of CLDs has the goal of defining a dynamic hypothesis regarding what can happen if a certain change within a system takes place. The conceptual nature of a CLD allows drawing a causal chain of effects sketched along a string of variables describing a dynamic issue, thus showing the relevant feedback structure of the problem being studied. The production of CLDs in participatory contexts generates an open learning platform, structuring the deliberative process and fostering the co-production of knowledge (Sedlacko *et al*., 2014; Videira *et al*., 2012).

Within this background, this paper presents an innovative approach for conceptualizing stakeholders' perceptions on the complex feedback structure underlying the provision of ecosystem services. We combine a PSM workshop informed by preparatory problem scoping activities with a comprehensive diagram postproduction process. The expected contribution is twofold: i) an approach to understand feedback processes underlying management of ecosystem services, and how the preservation of a specific service is linked with others; and ii) a procedure to identify options describing key management mechanisms for a specific area in order to allow for a sustainable flow of ecosystem services.

The proposed methodology was tested in Arrábida Natural Park, a Portuguese natural area with protected coastal and marine ecosystems. We invited stakeholder groups to collaborate in the development of CLDs addressing different ecosystem services identified in the park. Here, we will illustrate the methodology with results achieved for the "climate regulation" ecosystem service. This service underpins one of the main issues addressed in international climate negotiations (Polasky *et al*., 2011), and was essentially translated into carbon vegetation sequestration and storage. CO_2 emissions through deforestation, biomass burning, wetlands drainage, soil tillage and sealing of natural ecosystems are very significant and constitute about 20% of the worldwide anthropogenic emissions (Lal, 2004). Land use change also leads to service loss, impacting the future carbon sequestration and storage service by terrestrial ecosystems. With the collaboration of local participants, we aimed to identify such drivers of change, and the interplay between management policies able to provide a sustainable flow of the service in this area.

The paper is organized in five sections. Section 2 details the methodological approach, while in Section 3 we present and discuss the results of the participatory systems mapping process. The evaluation of the process by participants is presented in Section 4. Finally, Section 5 concludes with a synthesis of the main findings and lessons learned.

4.1.2 Methods and participatory systems mapping script[2]

The proposed participatory modelling process leading to the conceptualization of stakeholders' perceptions of ecosystem services takes place in two distinct steps: a PSM workshop and a postproduction stage aiming to integrate different knowledge sources. Two complementary steps bookend these activities, namely problem scoping tasks gathering information to set the scene for the mapping workshop, and follow up procedures to prepare outcomes for subsequent ecosystem services assessment and valuation studies (Figure 4.1).

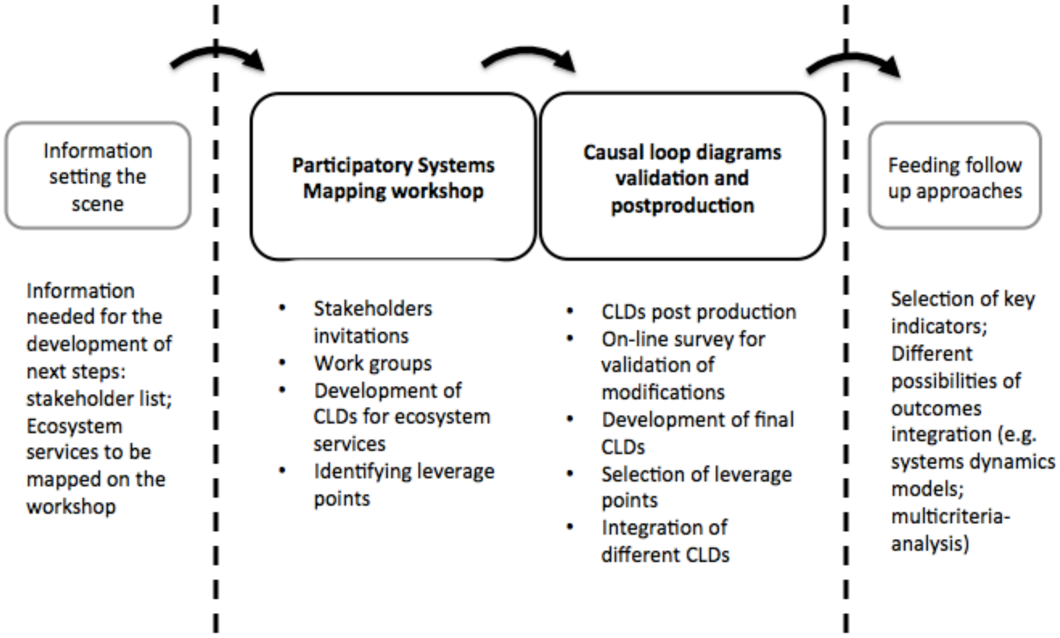

Figure 4.1 – Methodology for participatory systems mapping of ecosystem services

To set the scene for the PSM workshop, a collaborative scoping process of ecosystem services is suggested (Lopes and Videira, 2013; 2016). At this stage, information is collected on the relevant institutional setting and stakeholder groups acting in the study area, who may then be invited to identify a relevant set of ecosystem services, drivers of change, and linkages with human wellbeing. Results from this preparatory stage support the PSM workshop by providing a list of relevant ecosystem services to be mapped, along with potential variables associated with each service.

The participatory systems mapping workshop involves the collaborative construction of CLDs representing the structure underlying the provision of specific ecosystem services. The

[2] Support material used in the second stage – deepen understanding – can be found in Annex II.

innovative features of this approach lie on the elicitation of stakeholders' perceptions of ecosystem services dynamics, using this concept to structure the discussion and to understand interactions in socio-ecological systems. This is expected to promote a better understanding on the management options for the delivery of a sustainable flow of ecosystem services.

Diagramming tools such as CLDs allow capturing participants' perceptions and mental models (Lane, 2008). CLDs facilitate the representation of the feedback mechanisms underlying the unstructured issue by using elements such as variable names and arrows representing causal links between two variables. Causal links can be positive (a "+" sign is used) if the variables change in the same direction, or negative (a "-" sign is used) if the variables change in opposite direction. The set of links can form feedback loops, which in turn can be designated as reinforcing or balancing loops (Lane, 2008).

For the construction of CLDs in groups we propose following the methodology presented by Vennix (1996), according to which participants identify a problem variable, add causes and consequences and then identify feedback loops linking consequences and causes. Here, the structural mapping process is also guided by a leading question that fosters alignment of participants' perceptions with a common goal and draws a comparable baseline for mapping different ecosystem services. Table 4.1 presents the script developed for conducting a PSM workshop for the conceptualization of ecosystem services.

Table 4.1 – Script of a participatory systems mapping workshop addressing ecosystem services (Template source: adapted from Hovmand *et al.,* 2013).

Description	**Script for conducting a participatory systems mapping process for ecosystem services.**
Script Status	Promising practice.
Context	This script is meant to be used in the context of a participatory systems mapping workshop aiming to build conceptual models depicting dynamics of ecosystem services. Construction of CLDs is envisaged with engagement of participants from broad stakeholder groups.
Purpose	Framing the problem and initiating systems mapping Eliciting variables Eliciting feedback loops
Primary nature of group task	Convergent (activity designed to clustering and categorizing ideas and interpretations)
Time	Preparation time: approximately 2 months Time required to complete steps in script: approximately 4 hours (extendable) Follow up time: approximately 1 month (extendable)

Materials needed to complete script	Markers, flip charts, cards or *post-its*, computer, overhead projector.
Inputs from other scripts	Initiating and elaborating a causal loop diagram (Vennix, 1996).
Outputs from this script	Causal loop diagrams representing different ecosystem services (exact number depends on specific goals and size of participant group).
Team roles required and expertise needed	Facilitator and modellers with experience in system dynamics and causal loop diagramming.
Who is in the room?	Research/modelling team, including a facilitator who helps in construction of CLDs and one or more modellers and recorders who translate CLDs on system dynamics software to show to all participants at the end of the workshop; Participants representing broad stakeholder groups.
Key steps	Step 1 – Briefing presentation (20-30 min) *Purpose:* Familiarize participants with ecosystem services concepts, including the information collected at preparatory stage regarding the ecosystem services to be mapped at the workshop. Give explanations on the method to be used, presenting concrete examples on the development of the CLDs. *Role of modelling team:* provide an overview of diagramming methods and the workshop process, giving room for participants' questions and emphasizing the leading question which guides the model building process. Step 2 – Work in small groups: development of CLDs (70-90 min) *Purpose:* Organize working groups, each of them dealing with a specific ecosystem service and develop the underlying dynamics. Example of leading question: "*How to ensure a sustainable flow of ecosystem service X over the next 20 years"?* *Role of research team:* Assist participants in the configuration of small groups comprising participants from different stakeholder organizations, and in the designation of a rapporteur in each small group. A paper worksheet (size A1) is delivered and placed at the center of each small group's working table. Cards/*post-its and* A4 sheets with information on systems mapping methods and examples of variables are distributed. *Role of participants:* Participants select the thematic working group that they would like to join. Rapporteurs are responsible for moderating small group discussions and presenting results to the whole group in plenary discussions. Small group participants identify the possible causes and consequences of "the problem" (*i.e.* underlying the leading question) and mark the polarity of causal relationships established. After identifying the feedback loops, participants select the key leverage intervention points in the CLD to address the main question. Step 3 – Plenary discussion and debriefing (30-60 min) *Purpose:* Presentation of the CLDs developed in small groups to all participants. Identification of interrelationships between CLDs. Debriefing of main results and lessons learned. *Role of research team:* Translate CLDs to system dynamics software, identify interrelationships between CLDs and conduct debriefing of results. *Role of participants:* Rapporteur from each group presents the final CLD to all the audience and the selected leverage points. All participants are invited to plenary discussion of results and lessons learned.

Evaluation criteria	The modelling team distributes an evaluation questionnaire to collect participants' opinions regarding the workshop and the PSM approach. Evaluation allows to determine effects of the process according to different criteria and levels of impact: individual (*e.g.*, reaction and learning), group (*e.g.*, communication); organizational (*e.g.*, impact on decision rules) and methodological (*e.g.*, usefulness of results and methods).
Authors	Lopes and Videira (2015)
History & basis for script	Framework for the participatory articulation of ecosystem services values (Lopes and Videira, 2013) – Phase 2: developing a deeper understanding of the dynamics and feedback processes underlying sustainable flows of ecosystem services.
Revisions	Not yet revised.
References	Vennix (1996); Videira *et al*. (2012)

The postproduction stage follows the PSM workshop and aims to iterate and improve the quality of CLDs developed in the group model building session. While respecting the structure developed by participants, this task fosters the production of revised CLDs addressing, for example, inconsistencies, duplicities and under-developed structures observed in the diagrams from PSM sessions (Sedlacko *et al*., 2014). The modelling team conducts such tasks "behind-the-scenes" and then returns the CLDs back to stakeholders for validation.

We advocate that two distinct editing tasks may be needed. First, a *format* editing, which includes the digitalization of the CLDs (*e.g.,* using Vensim^{TM} software) made by the modelling team. For example, incorporating small changes in variable names or in the identified causal relationships. We propose a set of rules (Table 4.2) according to the good practices for drawing a CLD developed by Sterman (2000). This formatting edits allow to improve formal issues in the diagrams and to use a common layout for all CLDs developed by different working groups.

Table 4.2 - Rules for postproduction of CLDs (Adapted from Sterman, 2000)

Type of adjustment	Rules for modification
Variables	Variables should be described through names and without prefixes (change as necessary).
	Identification of intermediate variables (include as necessary).
	Level of aggregation (aggregation and split of variables).
	Standardization of variable names repeated in several CLDs (change as necessary).
Causal links	Identification of relationships between variables that were missing in the original CLD.
	Identification of the polarity of relationships (when missing).
	Identification of feedback loops.

A revised version of the diagram may then be sent back to participants through an online survey (*e.g.*, using Google forms). The goal is to validate the changes made in the CLD and to give participants the opportunity to reflect upon the dynamic hypothesis and to introduce potential modifications that they did not think of during the workshop. This survey may also allow to validate the identified leverage points.

Format editing may be complemented by some degree of *content* editing in order to integrate knowledge based on expert consultation or literature review. Similarly, this may be reported back to participants for validation or for comparing results from the stakeholders' system map with documented knowledge on key variables and causal relationships. Moreover, when different CLDs are produced in separate working groups, it is useful to build an integrated systems map depicting the potential interrelationships established between several ecosystem services. This also supports the analysis of how a specific intervention in one part of the system may affect more than one ecosystem service, as well as performance evaluation of alternative management strategies.

Finally, results from the PSM process may be used to deepen understanding on the dynamics of ecosystem services and support policy-making processes. Follow-up options may include defining and measuring ecosystem service indicators, building simulation models for policy analysis and/or evaluating alternatives with multicriteria analysis methods.

4.1.3 Results and discussion

4.1.3.1 Arrábida natural park

The proposed methodology was applied in Arrábida Natural Park, a coastal and marine protected area in Portugal created in 1976. The area is characterized by Mediterranean climate with two distinct seasons, one hot and dry and the other cold and rainy (Fumega, 2014). The nature of the protected area allows for an intense human presence that contributes with several management issues, as the Natural Park presents different land uses across the territory. According to Fumega (2014), based on data from EEA (2006), Arrábida Natural Park presents discontinuous urban fabric, industrial and commercial units, mineral extraction sites, non-irrigated arable land, permanently irrigated land, vineyards, olive groves, complex cultivation patterns, land principally occupied by agriculture, with significant areas of natural vegetation, agro-forestry areas, broad-leaved forest, coniferous forest, mixed forest, Sclerophyllous vegetation, transitional woodland-shrub and bare rocks. Inside the Natural Park area, a cement industry is the major individual source of emissions in the area, with an annual average of 1200

Gg CO_2 emissions between 2010-2014 (EC, 2015). The variety of land uses, the strong human presence, the touristic component and the pollutant activities all compound to make this natural area suitable for the implementation of the proposed methodology, while looking for different narratives and management options on how a sustainable flow of ecosystem services could be made possible.

At a preliminary stage, we have conducted a scoping exercise in the Arrábida Natural Park (Lopes and Videira, 2016), which framed the application of the methodology for conceptualization of ecosystem services presented in this paper. The preparatory tasks allowed for outlining the key four ecosystem services to be mapped in the PSM workshop: food production, biodiversity conservation recreation and eco-tourism, and climate regulation. For illustrative purposes, in this paper we selected the climate regulation ecosystem service as an applied example of the proposed PSM approach described in the next sections. This service belongs to the category of "regulation services", responsible for regulating ecosystems (*e.g.,* water regulation, air quality regulation, erosion regulation, pollination, human disease and pest regulation). In particular, according to local stakeholders, the climate regulation service in the Arrábida Natural Park is translated into control of rain/humidity and carbon sequestration, which influences biomass close to the soil. According to stakeholders consulted at the scoping stage, the main driver of change for this service is perceived to be land conversion, for example as a consequence of forest fires.

4.1.3.2 Climate regulation reference mode

Climate regulation is the service provided by ecosystems through controlling the flux of greenhouse gases – GHG (mainly carbon dioxide), contributing to carbon sequestration and storage through several mechanisms (UK-NEA, 2014). Carbon circulates permanently, in various chemical states, between the atmosphere, the biosphere, the lithosphere and the hydrosphere. Gaseous exchanges are thus made in the interface of various natural ecosystem types (*e.g*., forests, grasslands, oceans, wetlands.). Carbon dioxide (CO_2) is a gas mixed in the atmosphere, and the global climate regulation service benefits all humans, regardless of where the beneficiaries are located. The loss of this service is a function of direct habitat destruction, and depends on the types of ecosystems affected.

Increased emissions of GHGs may result from certain land use changes, such as the cultivation of previously undisturbed soils, peat extraction or the production of methane by ruminant livestock, amongst others. Management of ecosystem uses may also reduce emissions through removals, for example, via forest planting (UK-NEA, 2014). Hence, the main drivers of change within the land use change category are expansion, conversion or abandonment of productive area, urbanization and artificial sealed surfaces (UK-NEA, 2014). Some authors have been modelling the climate regulation service globally, looking for the possibility to map its economic value and relative changes under different scenarios of ecosystems and land use change (TEEB, 2010).

Based on the literature, we defined the reference mode for this ecosystem service (Figure 4.2) for Portugal including two key variables: a) total GHG emissions and b) total GHG removals from the land use, land use change and forests sector (LULUCFs). We characterized the historical trend taking into account the national emissions and removals reported to date (APA, 2015).

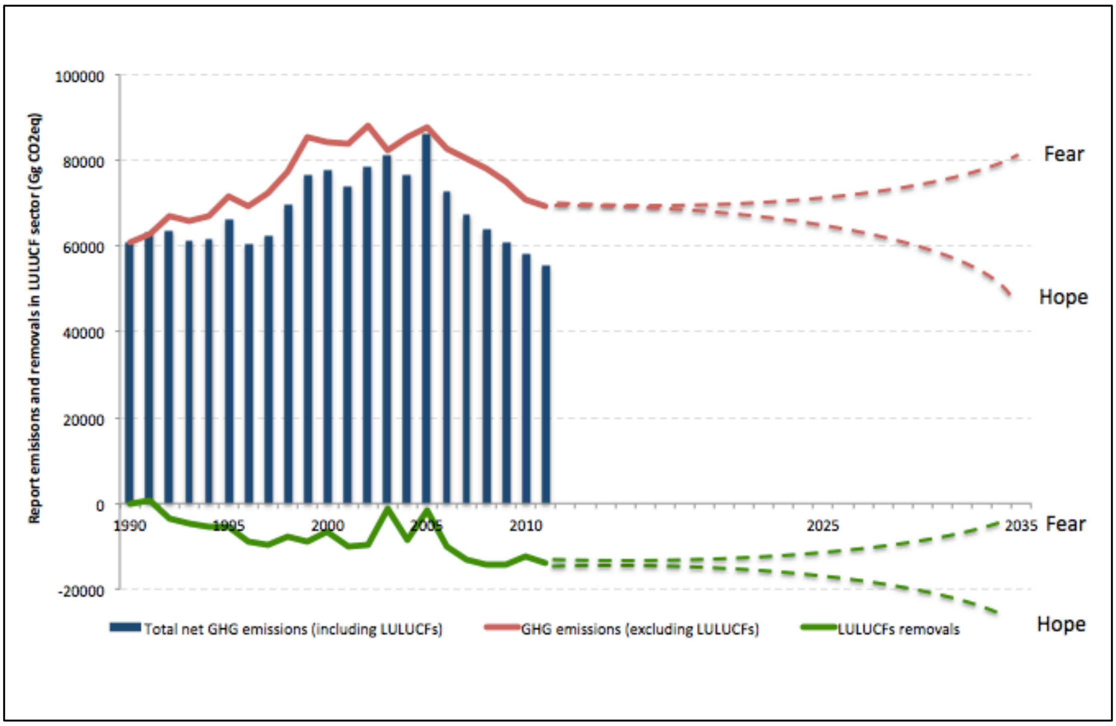

Figure 4.2 – Climate regulation reference mode (Data from APA, 2015; “Hopes and fears” pathways adapted from the approach proposed by Otto and Struben, 2003)

Total emissions (excluding LULUCF’s) include several sectors, such as energy production, industrial processes, solvents and use of other products, agriculture and waste. The emissions are represented in CO_2eq and include carbon dioxide, methane, nitrous oxide and fluorinated gases.

The reference mode presented in Figure 4.2 captures the evolution at the national context of the net GHG emissions (blue bars), with and without the LULUCFs removals (red and green lines, respectively). Following Otto and Struben (2003) we hypothesized a “Hopes and Fears” exercise, adding two possible broad pathways for GHG emissions and for LULUCFs removals until 2035.

4.1.3.3 Participatory systems mapping workshop

The PSM workshop took place in the district of Setúbal, Portugal, where the Arrábida Natural Park is located. Twenty participants from different stakeholder groups (*e.g.*, government/administration, research institutions, civil society, business) were gathered during an afternoon. These participants were divided in four groups (see step 2 in Table 4.1) each one developing collaboratively a CLD for a specific ecosystem service.

The mapping exercises in each small working group were guided by the question: "How to guarantee a sustainable flow of provision of the ecosystem service X in the next 20 years?". The group responsible for the climate regulation service produced the CLD illustrated in Figure 4.3.

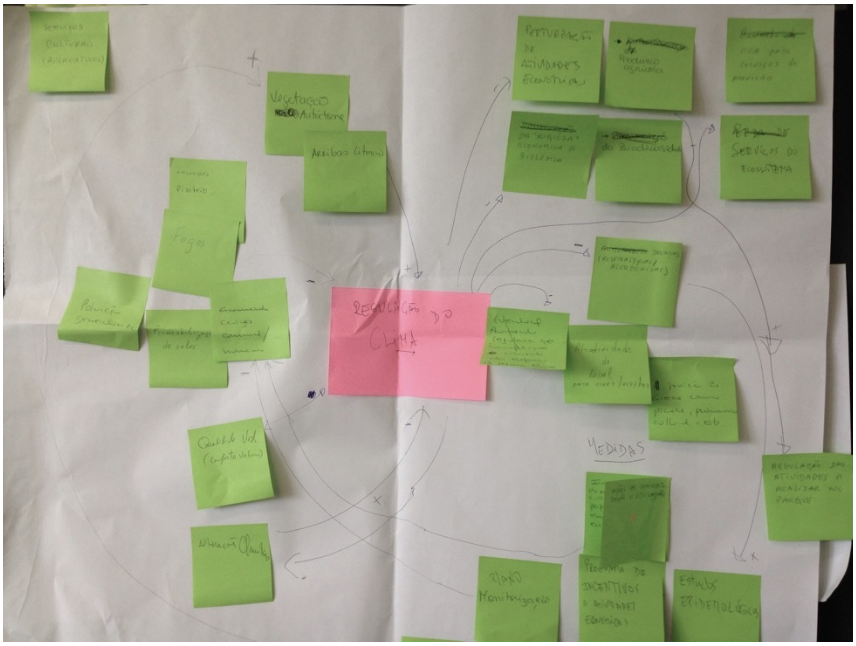

Figure 4.3 – Picture of the causal loop diagram developed by workshop participants for the climate regulation ecosystem service

The placement of *post it* cards show how participants discussed and perceived the management of this ecosystem service in the protected area, following the steps proposed by Vennix (1996). A key variable was placed at the centre of the diagram (pink card) representing the ecosystem service; (green) variable cards to the left hand side were added by participants as drivers of change in ecosystem service supply, and the consequences of those changes were subsequently added to the right hand side. Stakeholder drew the causal links connecting these variables and identified the polarity of the relationships. Finally, they established feedback loops and found intervention points to balance the consequences of negative changes in ecosystem service flows. Participants provided a short description of the meaning of each variable on the respective card. The variables depicted in Figure 4.3 for the climate regulation CLD are presented in detail in Table 4.3.

Table 4.3 – Variables included in the climate regulation CLD produced during the PSM workshop

Causes	*Consequences*	*Intervention points*
• Trampling	• Economic activities disorder	• Habitat conservation program*
• Coastal cliffs	• Economic and biological richness	• Regulatory activities in the protected area
• Native vegetation	• Biodiversity	• Awareness and educational actions*
• Generalized pollution	• Agricultural output	• Monitoring plan
• Fires	• Allergenic and respiratory diseases	
• Soil waterproof	• Free use of space	
• Animal and human load	• Local attractiveness • Climate change	

* Intervention points with more leverage, as voted by participants

As discussed by Vennix (1996) in messy and complex situations, people hold very different and mostly open loop views on what the problems are. With the deployed script (Table 4.1) we enabled the discussion and the convergence on the perceptions about a complex and global issue that needs local awareness and management. The following sections describe the iteration of the CLD constructed during the workshop and the lessons learned from the process.

4.1.3.4 Postproduction and validation results

The CLDs obtained were submitted to a postproduction process in order to promote a comprehensive analysis of the outcomes. The postproduction step was developed in two different steps with distinct goals: i) an online survey that returned the CLDs to participants, which aimed to obtain a validation on changes made on variables and links (format edits) and ii) a further improvement of the CLD based on information collected through a literature review (content edits).

We asked participants to validate the changes made after the workshop and to add some variables or links they considered to be missing. More specifically, the group of participants that worked on the climate regulation CLD agreed on the modifications and did not contribute with additional variables or links. This outcome may indicate that a high degree of consensus among participants of this small working group was achieved during the workshop exercise.

The reviewed ecosystem services literature (*e.g.,* MEA, 2005; UK-NEA, 2014) supported the small content edits produced in the CLD (*e.g.,* aggregation of variables, formalization of causal links and feedback loops, specifying variable names), which allowed for improvements in this system map while retaining the fundamental structure agreed upon by participants (Table 4.4).

Table 4.4 – Examples of adjustments made to the original CLD during the postproduction process

Problem causes		**Problem consequences**		**Intervention points**	
Original variable	**Adjustments made**	**Original variable**	**Adjustments made**	**Original variable**	**Adjustments made**
Trampling	Habitat trampling intensity	Economic activities disorder	Economic costs	Habitat conservation program*	Habitat conservation measures
Coastal Cliffs	Vegetation on coastal cliffs	Economic and biological richness	*Variable was deleted*	Regulatory activities in the protected area	Regulatory activities in the protected area
Native vegetation	Native vegetation	Biodiversity	Biodiversity	Awareness and educational actions*	Monitoring, awareness and educational measures
Generalized pollution	Total CO_2 in the atmosphere	Agricultural output	Agriculture output	Monitoring plan	
Fires	Forest fires	Allergenic and respiratory diseases	Allergenic and respiratory diseases		Technological measures (added variable)
Soil waterproof	*Variable was deleted*	Free use of space	*Variable was deleted*		
Animal and human load	Human and animal GHG emissions	Local attractiveness	Area attractiveness and quality of life		
		Climate change	Climate change		

The CLD presented in Figure 4.4 shows the final result, including the combination of outcomes from the PSM workshop and the postproduction activities, revealing the relationships underlying the supply of the climate regulation ecosystem service.

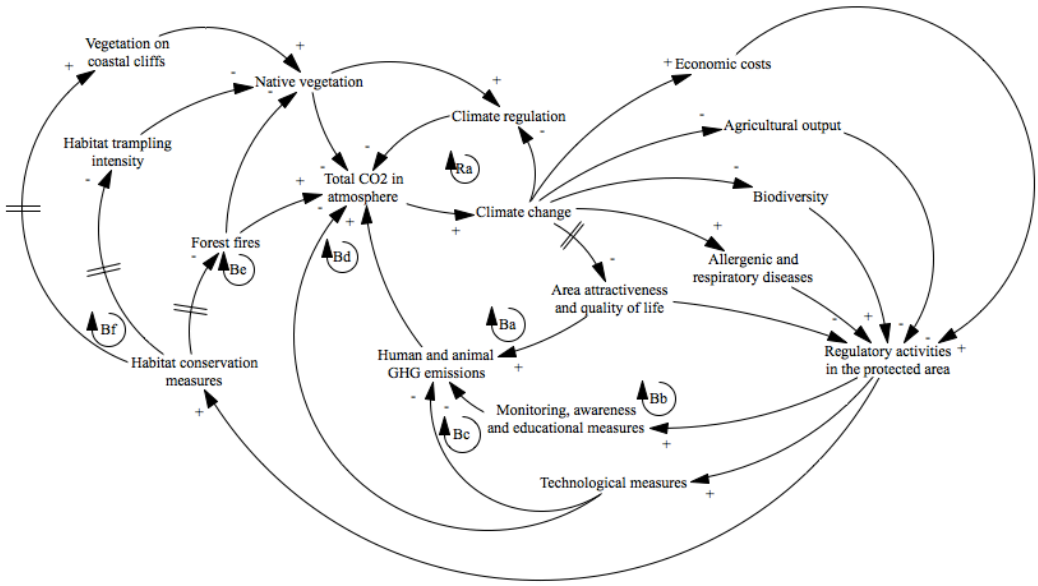

Figure 4.4– Climate regulation causal loop diagram

From the CLD, we can observe how stakeholders perceived the management of the "climate regulation" service in order to guarantee the supply of the service over the next 20 years. We can also infer how the protected area influences or is influenced by this ecosystem service. The diagram has several feedback loops described below, as well as links established between this service and other categories of ecosystem services (*e.g.,* provision, cultural, support and regulation).

According to participants' perceptions, climate change is deeply connected with climate regulation, forming a reinforcing (Ra). The decrease of climate regulation service leads to an increase of total CO_2 in atmosphere, which will increase climate change. In this context the variable "climate change" was perceived as an aggregated measure of a number of extreme events and changes in temperature and precipitation. Positive feedback loops indicate reinforcing dynamics, that underlies continued growth or decline patterns. In this case, an increase in climate change, all other things equal, will cause a decrease in climate regulation, *i.e.* as a consequence of climate variability that will affect existing carbon stores, evapotranspiration and GHG emissions (UK-NEA, 2014). Schröter *et al.* (2005) also point to this reinforcing loop, revealing that climate change feeds back to climate regulation services, while Maani (2013) showed how a climate that induces global warming also forms a reinforcing loop.

Balancing loops represent negative feedback showing a resistance or a response to change, aiming for stability and depicting rules, regulations and policy mechanisms, which can provide control or stability in a system. The diagram represented in Figure 4.4 has a dominance of balancing loops (*e.g.*, labelled as sets of loops Ba, Bb, Bc, Bd, Be and Bf) demonstrating a typical structure of a CLD depicting a management process. These loops show different management options to maintain the capacity of ecosystems to provide climate regulation services over the next 20 years, for example through the carbon storage in the context of the protected area. This causal narrative revolves around two distinct management strategies, one without any intervention by the natural park managers (set of loops Ba) and the other with measures aiming for active conservation actions that enable the climate regulation service (set of loops Bb, Bc, Bd, Be, and Bf).

What are the consequences arising from a decrease of the climate regulation service? More total CO_2 in the atmosphere, which leads an increase of climate change. All things held equal, with an increase of climate change effects, in the long term and with no intervention, the area will lose attractiveness and quality of life, which will induce a decrease of human and animal GHG emissions (and consequently of the total CO_2 in the atmosphere), thus decreasing climate change (set of loops Ba). These negative feedback loops highlight how the system can find its balance in the long term, showing how a self-response to the problem may be triggered, albeit an undesired one from a managers and human well-being point of view. An entry point for these loops could be, for instance, a reduction in the levels of GHG emissions that in some way pacify authorities and cause them not to intervene further, leading to increased levels of carbon emissions. Subsequently, an increase in climate change effects (through the reduction of the climate regulation service) will have different impacts (*e.g.*, economic costs, agricultural outputs decrease, biodiversity loss) that motivate distinct actions and intervention measures.

Economic, social, human health and ecological impacts observed with an increase of climate change lead to an increase of “regulatory activities in the protected area” fostering three key types of answers. One of the actions proposed by participants to endorse a sustainable flow of climate regulation was “monitoring, awareness and educational measures” (Bb), which will induce a decrease of “human and animal GHG emissions” and thus, possibly, the decrease of total CO_2 in atmosphere, decreasing climate change and allowing for an intensification of “climate regulation”. This set of cycles includes five loops that are similar to each other differing only on the impact that motivated it (*i.e*. economic costs, agricultural output, biodiversity, allergenic and respiratory diseases or area attractiveness and quality of life).

The set of feedback loops Bc and Bd describe technological management mechanisms, and both contain five similar loops. Technological measures can act on emissions directly promoting their reduction (Bc); examples of technologies arising as a solution for CO_2 mitigation in Portugal are the introduction of renewable energies such as solar photovoltaic rooftops or the biogas from agricultural and animal waste (Seixas *et al*., 2012), and the use of Carbon Capture and Storage

(CCS) technologies in cement industries (Gouveia *et al*., 2013; Seixas *et al*., 2015). Regarding technological measures acting in the direct reduction of total CO_2 in the atmosphere (Bd), some authors have been describing the addition of biochar (organic material thermally decomposed under limited supply of oxygen) to soils as a means of CO_2 sequestration, increasing soil productivity (Lehmann *et al*., 2009).

Finally, "habitat conservation measures" are the third type of options emerging from the increase of "regulatory activities in the protected area". These measures are depicted through two different sets of causal loops (Be and Bf). Local stakeholders' perceptions regarding the drivers of change of climate regulation are mainly focused on land changes, which is aligned with recent literature on ecosystem services assessment (UK-NEA, 2014). Higher habitat conservation measures will induce less forest fires (Be), which will reduce the CO_2 in the atmosphere by increasing the native vegetation that is responsible for CO_2 sequestration and by avoiding the amount of CO_2 that is emitted to the atmosphere with the burning of biomass. In the Arrábida Natural Park, these measures should counteract abandonment of rural areas, active forest management (*e.g.*, cutting and cleaning), and the introduction of extensive grazing practices in order to decrease the probability that fires ignite inside the Park (ICN, 2003).

The increase of habitat conservation measures will be responsible, after some delay, for the expansion of vegetation areas on coastal cliffs and for the reduction of habitat trampling intensity, both leading to an increase of natural vegetation. This will reduce the total CO_2 in the atmosphere and the increase of climate regulation service (Bf).

Hence, the described CLD clearly shows different management options to deal with the climate regulation service. Compared against the reference mode (Figure 4.2), it is clear that the set of feedback loops Bb, Bc and Bd are related with trends depicted by the red line (GHG emissions, excluding LULUCFs). Intervening on "monitoring, awareness and educational measures" and on "technological measures" promotes the corresponding *hopes* pathway. Conversely, the set of feedback loops Be and Bf are linked with the green line (LULUCFs removals), which represents the lion share of the climate regulation service flow, thus allowing the reduction of the net GHG emissions. Another interesting lesson from the developed CLD is highlighted in Figure 4.5, concerning the identification of inter-linkages between climate regulation and other ecosystem services.

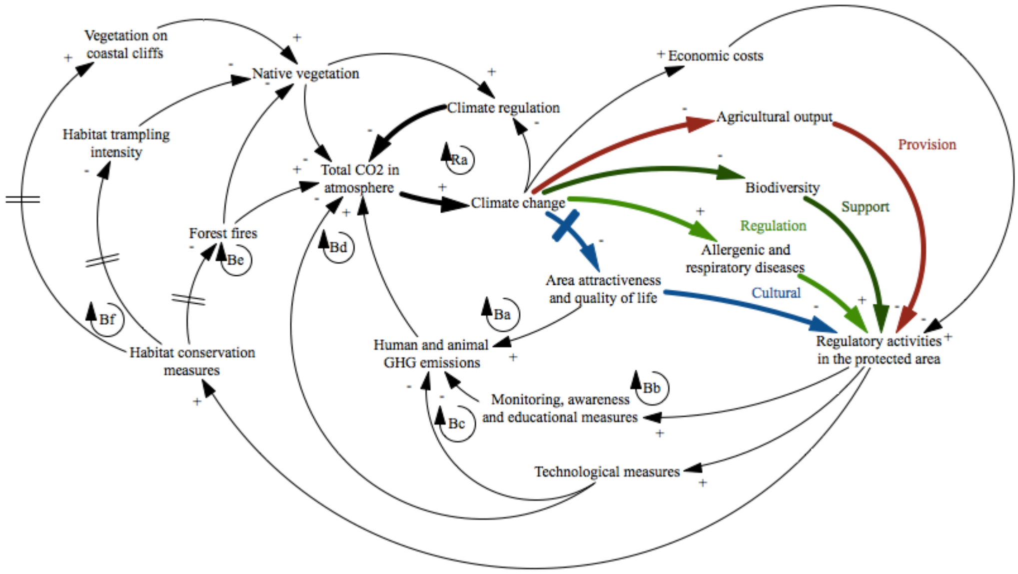

Figure 4.5 – Causal loop diagram highlighting the links among different categories of ecosystem services

By explicitly formalising these interrelationships, managers are more likely to understand how the preservation of climate regulation services affects preservation and management of other ecosystem services. The red causal link portrays the representation of provision services, here exemplified by food production (agricultural output). According to participants, the increase in climate change will lead to a decrease of agricultural output. The dark green arrow represents support services – increasing effects of climate change will increase the threats to biodiversity. Climate regulation also interacts with services from the same category since, through a decrease in climate change which leads to a reduction of allergenic and respiratory diseases (depicted by the light green arrow). Cultural services are represented in Figure 4.5 through the variable "area attractiveness and quality of life" (and causal links portrayed in blue), which shows a delayed response in the opposite direction as the climate change increases.

This integrated analysis brings forward the argument that the preservation of climate regulation will foster the delivery of other categories of services, which means that the measures identified will also contribute for the sustainable flow of more ecosystem services. Furthermore, the CLD obtained throughout the PSM process reflects participants' understanding of the regulation mechanism underlying this ecosystem service and that they are able to frame it within the local protected area context.

4.1.3.5 Follow up: developing indicators for ecosystem services assessment

As depicted in Figure 4.1, results from the proposed PSM approach may be subsequently used in ecosystem services assessment studies. Conceptualizing stakeholders' perceptions on ecosystem services supports an increased shared understanding of the underlying supply and demand side mechanisms. Hence, one of the follow-up options includes the definition of ecosystem services indicators, which may be quantified over time and space and deepen the analysis on the system.

Defining indicators for ecosystem services has been argued as an important research topic since the MEA study (2005). However, some categories of services are more suitable for a process of indicator selection than others. According to Layke (2009), regulating and cultural services indicators are much more broadly defined than provisioning indicators, and indicator sets vary significantly in their inclusiveness. Thus, to address this knowledge gap, different authors have been working on ways to improve ecosystem services indicators. For example, Hernández-Morcillo *et al.* (2013) presented an empirical review of cultural ecosystem services indicators, while Villamagna *et al.* (2014) developed a multi-indicator Framework for mapping cultural ecosystem services. According to the TEEB study (2010), indicators are variables communicating something of interest or relevance to policy or decision makers with logical connection to the object or the process being measured. When looking for indicators for ecosystem services one of the important criteria is the fitness to the purpose (TEEB, 2010), which means setting clear goals (*e.g.*, in the process described above this may translate into having a clear question guiding the development of a CLD) and an understanding of the target audience and their needs (*e.g.*, the stakeholder group invited for the collaborative systems mapping process). Interestingly, some authors have also recently described the use of system dynamics modelling processes to support the definition of ecosystem indicators. That is the case of Vugteveen *et al*. (2015) who developed socio-ecological system indicators using group model building for dealing with mussel fisheries and tourism development in The Netherlands.

In the proposed PSM methodology, we were able to define indicators from the collaborative CLD in order to illustrate follow-up activities. Examples of indicators include the "standing stock of carbon (metric tons/hectare)" and the "value of carbon storage sequestration (million euros)" (MEA, 2005; Layke, 2009). These two indicators act on carbon storage and sequestration, leading to a lower concentration of CO_2 in the atmosphere. Carbon exchange in the vegetation-soil-atmosphere could also contribute for this process. To address measures of habitat conservation, relevant indicators could include the "change in extent of ecosystems coverage (percent)". In synthesis, formalising ways to translate the leverage points into indicators is important when extracting lessons from a PSM process concerned with the different management options for ecosystem services.

4.1.4 Evaluation of the participatory systems mapping process

At the end of the workshop, we requested participants to answer a questionnaire aiming to evaluate results of the ecosystem services PSM approach. The questionnaire was developed based on the structure developed by van den Belt (2000; 2004) and Videira *et al.* (2012). The questionnaire aimed at evaluating the outcomes at different levels: individual, group, organization and method. The majority of the questions had a closed answer format with statements according to which participants expressed their level of agreement, through a Likert scale ranging from 1 (totally disagree) to 5 (totally agree).

The majority of participants considered that the workshop gathered a diverse group of agents with interest in the area (average score: 4,4). Participants suggested that more residents in the Park and representatives of nature sports activities should be present. The questionnaire revealed that stakeholders agreed that participants functioned as a group during the workshop, thus oriented towards a common goal (average score: 4,8), with open and frontal discussions (average score: 4,8). When asked about the consensus and the discussions to achieve it, participants from the climate regulation group revealed: "good interaction allowing us to achieve a consensus", "interaction close to the ideal", "consensus on the need to guarantee the flow of the service", however "several distinct ideas on how to do it".

Regarding the methodology of CLD construction, 94% of the participants agreed on the importance and usefulness of the methodology in structuring the discussion and the analysis of ecosystem services provided in the natural park, creating opportunities for everyone to participate in the process. Concerning the systems language used in this methodology, the majority of the answers indicated an agreement that the common language helped them to analyse in an integrated form the relevant problems associated with ecosystem services. All participants of the climate regulation working group "agreed" or "totally agreed" on the usefulness of the exchange of ideas to map the relationships underlying this ecosystem service. The discussions during the workshop were constructive and allowed participants to improve knowledge about the ecosystem services of the area (average score: 4,5).

Figure 4.6 illustrates the results regarding the evaluation of the methodology and individual participant contribution for the outcomes. The results show an average higher than 4 (agreement) in all the presented statements.

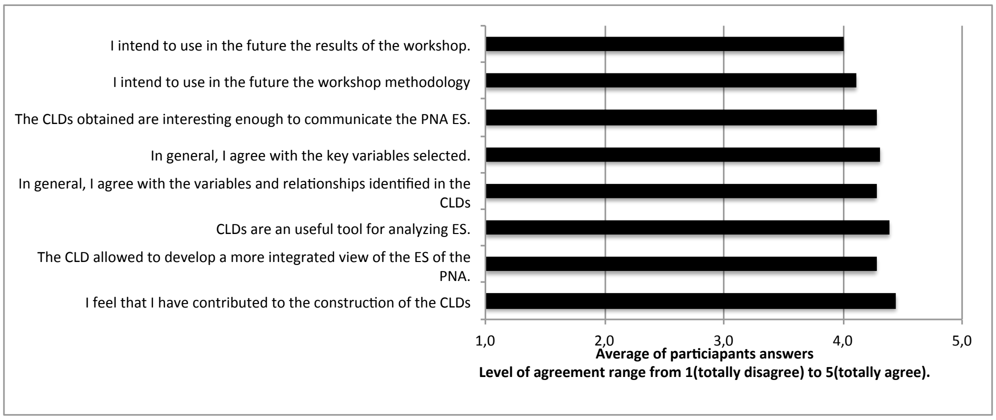

Figure 4.6 – Evaluation of outcomes from the participatory systems mapping process (average of selected evaluation statements)

The majority of participants (87,5%) stated that the workshop was worth the time spent and only 12,5% answered "in some way", while none of the participants replied negatively to this question. Regarding the positive and negative aspects of the workshop, the comments collected can be organized into broader categories. The identified negative aspects were mainly related with to time available (*"little time for final discussion"; "difficulty to manage the time available"; "too much information to discuss during the time"; "need to understand the methodology"*). These comments point out the importance of research teams striking a balance between the time available to implement the proposed methodology and the time requested from stakeholders participating on a voluntary basis. Furthermore, only one participant from the climate regulation working group argued that the services were insufficiently adapted to the area. Despite the criticism of this comment, the analysis presented in the previous section shows how management of this ecosystem service could indeed be addressed locally.

The majority of positive comments were related with "sharing" and interaction between participants *("sharing between all the parts"; "sharing of ideas"; "interaction between participants"; "consensus")*. Some respondents referred to the "*open and active participation of all"* the *"diversity of people and consequently diversity of options"* and the *"PSM methodology"* that enabled us *"to capture the vision of other sectors understanding the measures of unifying the sectors"*. One participant also referred to the importance of "*contributing to the sustainability of the Natural Park*" and another one to the "*opportunity to deepen the knowledge about ecosystem services*".

4.1.5 Conclusions

This paper presents a structured methodology, based on participatory systems mapping, for the conceptualization of stakeholders' perceptions of ecosystem services. With the increasing calls for using this concept in decision-making processes, the proposed approach advances a platform to involve social actors in the identification of the underlying structure behind the sustainability of ecosystem services flows. The proposed PSM process unfolds in two main steps, namely, a participatory systems mapping workshop followed by postproduction and validation tasks.

The testing of the proposed approach in a case study aimed at eliciting knowledge to support management of a natural area in Portugal, taking the concept of ecosystem services as a basis for the identification and discussion of alternative policies. The PSM workshop had as a guiding question: *how to guarantee a sustainable flow of ecosystem services in the protected area over the next 20 years?*

The results showed that participants were able to co-produce knowledge, share mental models and bridge perspectives in order to produce a joint CLD. Regarding the climate regulation service, the outcome was very positive, since it was possible to capture stakeholder perceptions of the variables and links explaining the flow of this service in the case of Arrábida Natural Park. Six sets of balancing feedback loops were identified, representing different options for the management of the service. Climate regulation by ecosystems is (partly) provided through the control of CO_2 in the atmosphere. Higher levels of carbon emissions can trigger and promote actions by protected area managers to reinforce measures such as habitat conservation programs, technological innovations, monitoring, awareness and educational activities that, over time, are expected to mitigate carbon emissions and contribute to the capacity of the ecosystem to provide climate regulation services. Our approach demonstrated how broad stakeholder groups may be engaged in participatory modelling processes to address such complex issues, collaboratively eliciting perceptions on the feedback structures underlying changes in the provision of ecosystem services, formalizing interrelationships among different categories of services, and exploring solutions to guarantee a sustainable flow of benefits provided by nature to human well-being.

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4.2 Modelling feedback processes underpinning management of ecosystem services: the role of participatory systems mapping

ABSTRACT

Ecosystem services are dynamically interdependent. When conducting studies on ecosystem services valuation and assessment, the interdependencies and feedback structures underpinning ecosystem functioning should be identified and explicitly considered in management processes, especially when the goal is to pursue a plural and integrative approach that accounts for multiple values. This paper explores the role of a participatory system dynamics modelling approach – participatory systems mapping – as a tool to articulate different value dimensions of ecosystem services. The application of the tool is illustrated with a case study conducted in a protected area in Portugal, wherein inter-organisational stakeholder groups collaborated in the conceptualization of feedback processes characterizing ecosystem services during a group modelling workshop. Food production, recreation and ecotourism, biodiversity conservation and climate regulation were the four ecosystem services explored in this event. Results show that by accommodating the co-creation of causal system maps with stakeholders, the proposed approach fosters sharing of insights on the underlying cause-effect mechanisms and leverage points, supporting the identification of interrelationships between different ecosystem services and the selection of key indicators for management processes.

KEYWORDS

Ecosystem Services; Participatory Systems Mapping; Collaborative Causal Models; Cross Impact Matrices; Ecosystem Services Indicators

4.2.1 Introduction

The concept of Ecosystem Services (ES) brings forward the benefits people obtain from nature (MEA, 2005). The dissemination of ES approaches is notorious in both research (Costanza and Kubiszewski, 2012) and policy arenas (*e.g.*, MEA, 2005; TEEB, 2010; IPBES, 2012). This has led to an intensification of the debate around the conceptual and practical implications of approaches to capture the importance of ES (Costanza *et al*., 1997; Martínez-Alier, 2002; Spash, 2008). Moreover, the recognition of different types of value associated with ES (de Groot, *et al*., 2002; Farber *et al*., 2002; TEEB, 2010), calls for new platforms capable of integrating multiple value dimensions (Chan *et al*., 2016; Lopes and Videira, 2013; Martín-López *et al*., 2014; Lopes and Videira, 2016). For example, Van den Belt and Blake (2014) reviewed fifty-eight articles in the agro-ecosystem literature and concluded that there is a need to bring forward social and cultural aspects, link the supply and demand for ES and develop an integrated understanding of the institutions using ES approaches to inform better decisions.

Within this context, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) has recently highlighted the role that modelling methods and tools may provide to support decision makers in the conservation of ES (IPBES, 2016). This assertion has also been defended by several authors that have recently deployed modelling approaches in the context of ES valuation and assessment processes (Burkhard *et al*., 2013; Bagstad *et al*., 2013; Boumans *et al*., 2015). That is the case of Guimarães *et al*. (2013) who tested conceptual modelling tools to integrate science and policy for natural resource management. Pascual *et al*. (2016) also showed that gathering information into mind-maps allows the creation of a unified knowledge base, while Costanza *et al*. (2014) focused on the role of simulation games for research and learning about ES (Costanza *et al*, 2014). As argued by Boumans *et al.* (2002) and de Groot (2002), the feedbacks characterizing ecological functions and associated ES can be translated into dynamic models, which could then highlight important interdependences. This is also defended by Videira *et al*. (2011) while recognizing the benefits of integrating system dynamics modelling approaches where stakeholders are involved in the construction of models fostering knowledge co-creation. Following this rationale, different integrated models have been developed using participatory system dynamics approaches to support management of natural resources, with varying degrees of stakeholder engagement in the model building processes (Antunes *et al*., 2015; Videira *et al*., 2011).

The calls for integrating modelling approaches and participation in ES studies (*e.g.,* TEEB, 2010; Lopes and Videira, 2013; IPBES, 2016) pave the way for testing new platforms capable of addressing the complexity of ES. In this article we argue that Participatory Systems Mapping (PSM) can provide a sound collaborative modelling option within this scope. PSM is a participatory system dynamics modelling approach that includes the preparation and development of group model building activities, engaging inter-organizational stakeholder groups in the construction of qualitative models - Causal Loop Diagrams (CLDs) – to foster knowledge exchange and sharing of insights on dynamic issues (Sedlacko *et al*., 2014). This approach has already been applied to different topics by some authors aiming to promote involvement of different group of participants in debates on environmental and sustainability issues (Videira *et al*, 2012; Sedlacko *et al*., 2014; Videira *et al*., 2014). In early PSM applications, CLDs were used as a conceptualization tool to support and organize the discussions and to allow the elicitation of different individual mental models of participants. PSM represents an approach capable of conducting a shared understanding of systems, qualified for accommodating different perspectives from distinct stakeholders and also to provide a structured platform for sharing worldviews. All these features are potentially well suited for addressing the complexity of ES.

Hence, this paper aims to shed new light on the role of PSM in the context of promoting a deeper understanding of ES to support management processes. Through a collaborative process of mapping stakeholders' perceptions of specific ES it is possible to define interrelations and feedback models that explain the dynamics of ES and highlight the relations between people and nature, enabling also to emphasise relational values (Chan *et al*., 2016). We further reflect on the translation of PSM causal diagrams into a comprehensive set of socially constructed indicators. The proposed methodology is illustrated with a case study, where stakeholder groups were invited to co-create causal diagrams for key ES provided in the Arrábida Natural Park (ANP), a Portuguese natural area with protected coastal and marine ecosystems.

The expected contribution of this work is threefold: i) develop an approach to articulate different values on the same modelling platform, providing room to discuss intrinsic, instrumental and relational values through the understanding of feedback processes underlying management of ES; ii) bring an holistic perspective on the interrelationships among different ES identified in a study area; iii) test a structured methodology to define key indicators for the supply and demand of ES supporting decision-making processes.

The paper proceeds as follows. The next section describes the methodology to conduct a collaborative mapping of ES using PSM. Section three presents the results from the application of the methodology to the ANP case study, including the CLDs developed in the workshop, the integration of the causal maps for each ES into a holistic model, and the analysis of CLDs through a cross impact matrix to identify key variables and indicators. Section 4 discusses the role of PSM in mapping feedback processes, identifying leverage points and defining ES indicators. Section five concludes with main lessons and future developments.

4.2.2 Methods and PSM process[3]

The proposed methods emerged from a broader participatory Framework for valuing and assessing ES (Lopes and Videira, 2013). The Framework facilitates the study of ES through a participatory process that integrates a mixed set of tools, leading to the articulation of multiple value dimensions (Figure 4.7). It comprises three major interconnected stages, the first one is called *set the scene*, where a collaborative scoping workshop is promoted following an institutional context and stakeholder analysis. This initial stage envisages the identification of ES, their threats and linkages with human wellbeing, their relative social, economic and ecological importance and the development of stakeholder networks depicting ES dependencies (Lopes and Videira, 2016). The second stage, which is addressed in this paper is called *deepen understanding*. As highlighted in Figure 4.7, such co-learning process may be achieved through a PSM process for modelling with stakeholders the feedbacks and interrelationships identified in the first stage. The third and last stage aims to *articulate values* in the context of a specific decision, which should be informed by the results achieved at the previous stages.

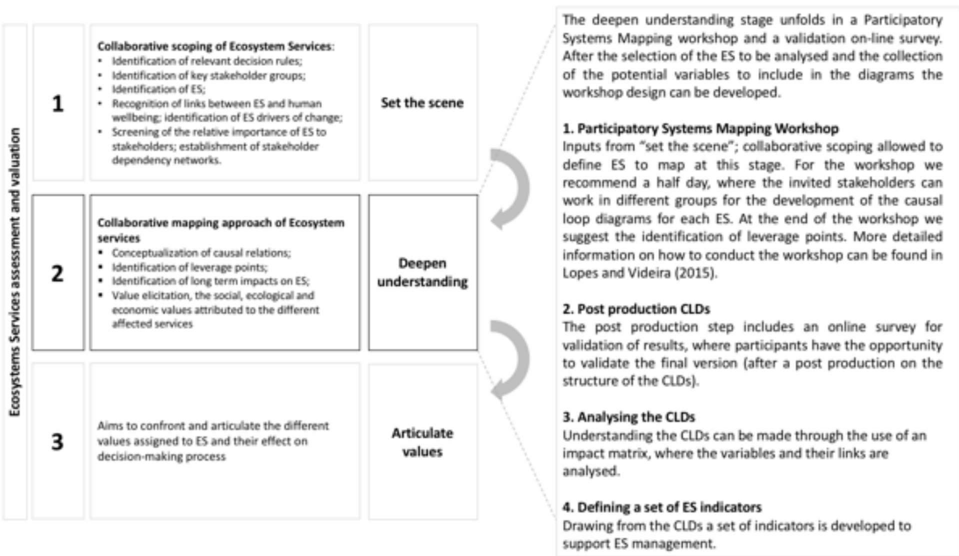


Figure 4.7 - Conceptual Participatory Framework for Articulating ES (adapted from Lopes and Videira, 2013)

[3] Support material used in the second stage – deepen understanding – can be found in Annex II.

The methods for the proposed “deepen understanding” stage are centred on a PSM process. PSM materializes providing a modelling platform where different stakeholders can collaboratively draw a Causal Loop Diagram (CLD) including the variables and causal links describing a given ecosystem service.

CLDs, also called “system maps”, are a particular type of model representation used in the system dynamics approach (Forrester, 1971; Lane, 2008; Sterman, 2000). These diagrams are built through the identification of system variables that are linked to each other through arrows depicting cause-effect relationships. If variable “A” is connected to variable ‘B’ through a positive link a “+”sign is drawn to indicate that the variable change in the same direction, *i.e*. if “A” increases, all else equal, “B” increases. On the other hand, two variables connected through a negative “-“ sign, means that they change in opposite directions. Feedback loops are drawn when two or more variables are connected in a closed cycle. Feedback loops are classified as Reinforcing (R) if they propagate an initial change in one of the loop variables, or Balancing (B), if the loop counteracts the initial change. Based on a CLD, modellers may develop a dynamic hypothesis about the causal chain of effects that may happen if a certain change occurs within a system. Assumptions of the method consider that any cause-effect relationship depicted between two variables must be read *ceteris paribus* (Lane, 2008).

Using the CLD language in a PSM workshop means that stakeholders are invited to collaboratively construct themselves a causal structure of the problem under study, with the support of group facilitators. This creates an open learning platform, structuring the deliberative process and fostering the co-production of knowledge (Sedlacko *et al*. 2014; Videira *et al*. 2012).

To conduct a PSM process for exploring the causal relationships underpinning ES, a sequence of tasks was designed to lead a participant group in the development of CLDs during a half a day event (Figure 4.7). Such a script (Lopes and Videira, 2015) involves group modelling such as, workshop preparation, where the produced information in the first stage – s*et the scene* – is retrieved. This includes the selection of ES to map, based on the obtained information regarding the most important and/or the most threatened ES. A list of potential variables to integrate in the causal maps is a starting point for the group modelling tasks. Thus, the participatory workshop integrates all the relevant information previously produced, gathering participants in different working groups for constructing the system maps describing the different ES. After the workshop, a postproduction step should be promoted in order to improve the draft CLDs (Figure 4.7). Stakeholders are invited to provide comments and suggest changes to the CLDs through an online survey. Refinements are subsequently performed by the modelling team, both in terms of format and context, following a set of rules concerned with clarity of presentation, avoiding overlap of variables and closing of feedback loops drawn in the workshop (Lopes and Videira, 2015).

In this paper, CLDs for each of the ES addressed in the case study are presented, followed by a discussion based on the use of cross impact matrices (Beck *et al*., 2012; Videira *et al*., 2014). Through this analysis one may understand the mutual sensitivity among variables within a CLD in order to determine the most critical pieces of structure. Cross impact matrices are useful to better understand key leverage points in the system (Meadows, 1999) and identify relevant variables supporting the definition of ES indicators.

From the individual analysis of each CLD we developed a cross impact matrix aiming to build a deeper understanding of the diagram. Value “0” indicates that a given variable has no effect on the other, while value “1” indicates that a given variable has an influence on the other (Beck *et al*., 2012; Videira *et al*., 2014). Active sum (AS) represents the variables with more influence in the system, since this measures the number of all direct causal links that one variable has with others, which means, that higher AS values (sum of the values in rows) correspond to variables with a high effect on the system. These variables have a potential to be translated into indicators of management points in the system. On the other hand, passive sum (PS), measures how strongly a variable is affected by others (sum of the values in columns) providing information on the variables that can be translated into indicators of system changes. Percentages of AS and PS are calculated by dividing each sum of a row and column by the largest AS and PS, respectively (Beck, *et al*., 2012; Videira *et al*., 2014).

This analysis is a valuable complement to the interpretation of the CLDs, since all the identified variables result from a coherent analysis on the observed causal links. After this process suitable indicators for the assessment of ES are defined based on the group modelling process and the cross impact analysis.

4.2.3 Results

4.2.3.1 Case Study: Arrábida Natural Park, Portugal

Arrábida Natural Park (ANP) is a Portuguese protected area where the test of the proposed PSM process took place. This natural area comprises coastal and marine protected zones. It is also a Natura 2000 site and its regulations allow the presence of human activities, which brings several challenges to nature conservation. Within the limits of the park there are intersections with three main urban centres (Setúbal, Palmela e Sesimbra) with a population of about 235 000 residents (INE, 2011). The complexity arising from several human pressures observed in the area, and the diversity of services provided by its marine and coastal ecosystems underscore its suitability for testing this approach.

We conducted a PSM workshop that gathered twenty participants from sixteen different organizations corresponding to distinct stakeholder groups - public administration, research, civil society, business. During half a day, four groups developed four CLDs each dealing with a specific ES. Since this workshop was part of the application of the multi-stage conceptual Framework presented in Figure 4.7, the outcomes of the *set the scene* stage allowed to identify which were the most important, threatened, and critical ES according to the protected area stakeholders. In combination, these results informed the decision of mapping in the PSM workshop three ES which ranked high in those criteria: *food production*, *recreation and eco-tourism* and *biodiversity conservation*. A fourth group was allowed to select the service they wanted to map, having chosen the *climate regulation* service. The common question that guided the participatory systems mapping activities in each small group was "*How can we guarantee a sustainable flow of the service X in the next twenty years*?".

4.2.3.2 Causal loop diagrams for selected ecosystem services and cross impact analysis

4.2.3.2.1 Food production

Food production is one of the most easily recognizable services by people (Iniesta-Arandia *et al*., 2014). As a provision service, different factors are involved when studying food supply, such as the amount of land, the yield (amount of food that is produced per unit of land) and also food quality or nutritional value (UK-NEA, 2014). In ANP, participants were very interested in this service, recognizing its importance in the context of the natural park, particularly in economic terms. Specific examples of food provision services identified in the Arrábida area include: fish, dairy products, wine, herbs, vegetables and other endemic varieties. To start drawing this CLD, workshop participants decided to represent the service level at an aggregated scale, designating the central variable in the system map as "food production".

Subsequently, we prompted participants to think of "what causes food production to increase or decrease?". Threats to food production were added to the map, informed by the list of pressures identified at the scoping stage. Afterwards, variables representing policies for increasing food production and sustaining the service were elicited from participants. The final CLD, following the post production step, is presented in Figure 4.8, where several feedback loops are represented, as well as the leverage points perceived by stakeholders depicted in bold.

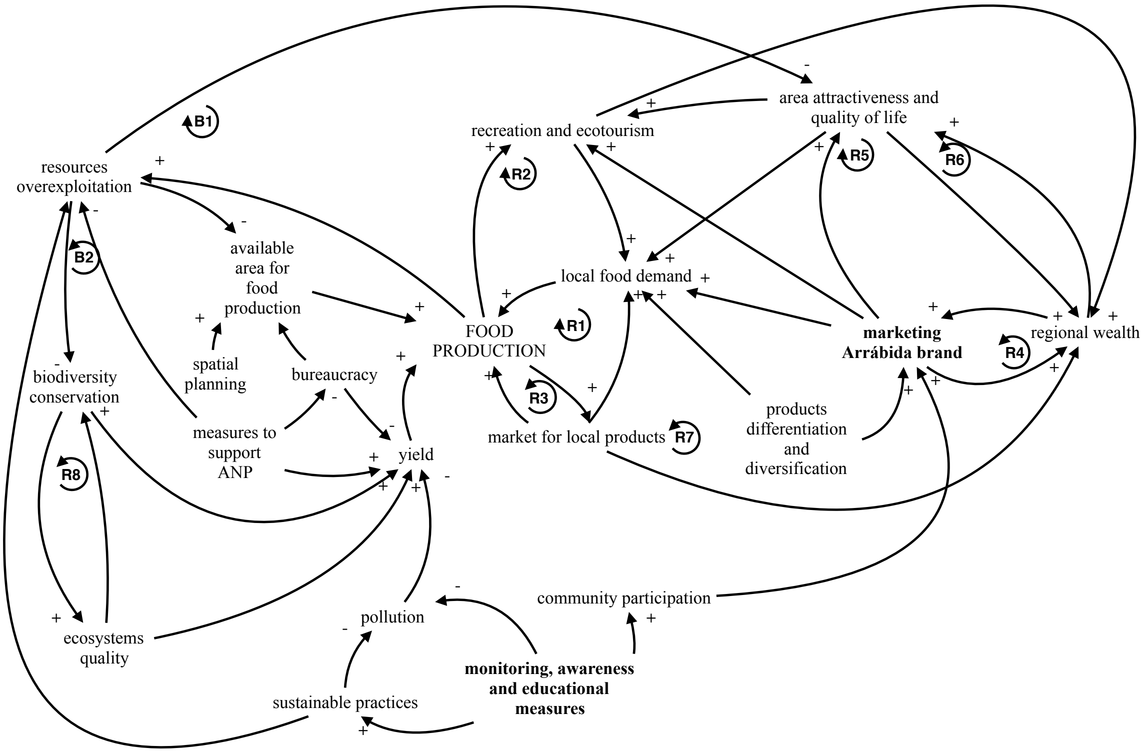


Figure 4.8 – Causal Loop Diagram for the food production ecosystem service in the Arrábida Natural Park.

B1 is a balancing loop that illustrates how the increase of food production leads to an increase of resources overexploitation, which in turn decreases the area attractiveness and quality of life, decreasing local food demand, and consequently food production. The increase of resources overexploitation is also responsible for a decrease in biodiversity conservation, which will affect the yield and food production, which subsequently closes the balancing loop B2 by decreasing resources overexploitation.

Increasing markets for local products was one of the highlighted measures that will increase local food demand, which leads to the increase of food production (Reinforcing Loop R1).

R2 is a reinforcing loop that shows the relation between food production and other services such as recreation and ecotourism. In other words, by increasing food production, an increase in the recreation and ecotourism service levels may occur, leading to an increase in local food demand, and consequently, more food production. This feedback loop was discussed in the workshop mainly in relation to food and drinks – based tourism (*e.g.,* wine). Ultimately, participants considered that such local products could drive other forms of tourism too. This effect was translated by the reinforcing loop R3: the increase of food production will promote the development of market for local products and vice versa. As a consequence, participants reckoned that increasing the market for local products leads to an increase in regional wealth, driving up area's attractiveness, which increases the demand for food (R7).

Another discussed policy was the marketing of Arrábida brand. Increasing Arrábida's branding efforts will lead to an increase in regional wealth (and the reverse is also true R4), which ultimately causes an increase of local food demand. More marketing of Arrábida brand will also increase the area attractiveness and quality of life, which will increase the regional wealth (R6) and again Arrábida's brand value (R5). All these feedback loops show how food production can be potentiated in the area by acting on the demand side. By contrast, R8 shows how biodiversity and ecosystems quality are responsible for increasing the service from the supply side: support for nature conservation measures in the ANP form a basis of delivery of this service and how it should be preserved.

This CLD makes evident that participants perceived that a mix of policies is needed to guarantee the sustainable flow of food production. They found that there is a need to act on different points in the system to increase service levels, however in the context of this protected area, the preservation of biodiversity and natural resources is crucial for balancing provisioning of different services.

A deeper analysis of the CLD was conducted through the construction of a cross impact matrix (Figure 4.9), which reveals more detailed information on how to monitor the flow of food production. The variables with more influence on the system - active sum (AS) - can give information on where to act, which may originate important indicators to monitor management actions. The variables more influenced by the system - passive sum(PS) - translate potential variables to look for changes in the flow of the service. Variables with percentages of AS and/or PS above 50% are selected as critical variables.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	AS	%
1	food production		1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	75%
2	market for local products	1		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	50%
3	local food demand	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	25%
4	recreation and ecotourism	0	0	1		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	50%
5	area attractiveness and quality of life	0	0	1	1		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	75%
6	regional wealth	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	50%
7	marketing Arrábida brand	0	0	1	1	1	1		0	0	0	0	0	0	0	0	0	0	0	0	0	4	100%
8	products differentiation and diversification	0	0	1	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	2	50%
9	community participation	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	25%
10	monitoring, awareness and educational measures	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	3	75%
11	sustainable practices	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	0	0	0	0	2	50%
12	pollution	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	1	25%
13	yield	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	1	25%
14	ecosystems quality	0	0	0	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	2	50%
15	biodiversity conservation	0	0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	0	0	0	2	50%
16	resources overexploitation	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1		0	0	1	0	3	75%
17	spatial planning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1	0	1	25%
18	measures to support ANP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0		0	1	3	75%
19	available area for food production	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1	25%
20	bureaucracy	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1		2	50%
	PS	4	1	4	3	3	4	3	0	1	0	1	2	5	1	2	3	0	0	3	1		
	%	80%	20%	80%	60%	60%	80%	60%	0%	20%	0%	20%	40%	100%	20%	40%	60%	0%	0%	60%	20%		

Figure 4.9 – Cross impact matrix of the CLD for the "Food Production" ecosystem service

The variable with higher active sum is “marketing Arrábida brand” (100%), which means that it has a strong impact in the system, affecting four other variables. Other important variables are “food production”, here understood as the result of the available area and the yield; “area attractiveness and quality of life”; “monitoring, awareness and educational measures”; “sustainable practices”; “ecosystems quality”; “biodiversity conservation”; “resources overexploitation”; “measures to support ANP” and “bureaucracy”. Comparing these results with the leverage points identified by workshop participants, we can see overlaps regarding only two variables. This reveals that the two approaches are complementary in the search for critical intervention points.

On the other hand, by analysing the passive sum, we identified variables affected by multiple changes in the system, thus representing good options for indicators aiming to monitor changes in the flow of the service. In the case of food production, these variables are: “yield”; “regional wealth”; “local food demand”; “food production”; “available area for food production”; “recreation and ecotourism”; “area attractiveness and quality of life”; “marketing Arrábida brand” and “resources overexploitation”.

4.2.3.2.2 Recreation and ecotourism

Cultural services are “*the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, recreation and aesthetic experiences*” (MEA, 2005 p.29). These context specific services include recreation and ecotourism, which can be defined as the use of natural and cultivated landscapes for pleasure activities (UK-NEA, 2014). This has been one of the most studied cultural ES in recent ecosystem assessments (UK-NEA, 2014).

Arrábida Natural Park stakeholders have identified the following concrete examples of recreation and ecotourism features in the case study area: beaches, closeness to river and sea, gastronomy, and nature sports. To map out the interrelationships underpinning the sustainability of this ES, participants have drawn the CLD represented in Figure 4.10 This diagram has four reinforcing feedback loops and two balancing loops, with several variables linked with the demand and supply side of this service.

Participants started by emphasizing the importance of support infrastructures for the increase of the number of visitors, which lead to an increase of recreation and ecotourism and after a certain time, this will call for an increase of support infrastructures (R1). With investment in support infrastructures there is also an increase of the number of visitors and vice versa (R2).

Investing in the marketing of the Arrábida brand was selected as a variable affecting the number of visitors, which by its turn will increase incentives to traditional practices and activities. As a consequence, this will drive protection of cultural heritage and lead to further reinforcing marketing activities, thus closing the feedback loop (R3). Spatial planning is another important variable in this CLD. All other things held equal, with an increase of spatial planning, conflicts of uses and activities will be ameliorated, which diminishes the override that tourism often creates locally in the presence of conflicts (R4). With more spatial planning efforts, accessibility is expected to improve, and consequently the number of visitors. While mapping the negative impacts that may occur due to the increase of this service, participants identified two controlling mechanisms that form the balancing feedback loops identified in Figure 4.10 In one hand, as the number of visitors goes up, environmental and social pressures are also heightened, leading to a decrease of biodiversity, which in time will induce a reduction in number of visitors (B1). B2 also depicts the concomitant effect of growing pollution with an increase in the visitation rate. Important leverage points to control demand side impacts of this service are depicted in bold in Figure 4.10 Such controlling variables selected by participants include monitoring, awareness and educational measures, as well as surveillance and spatial planning.

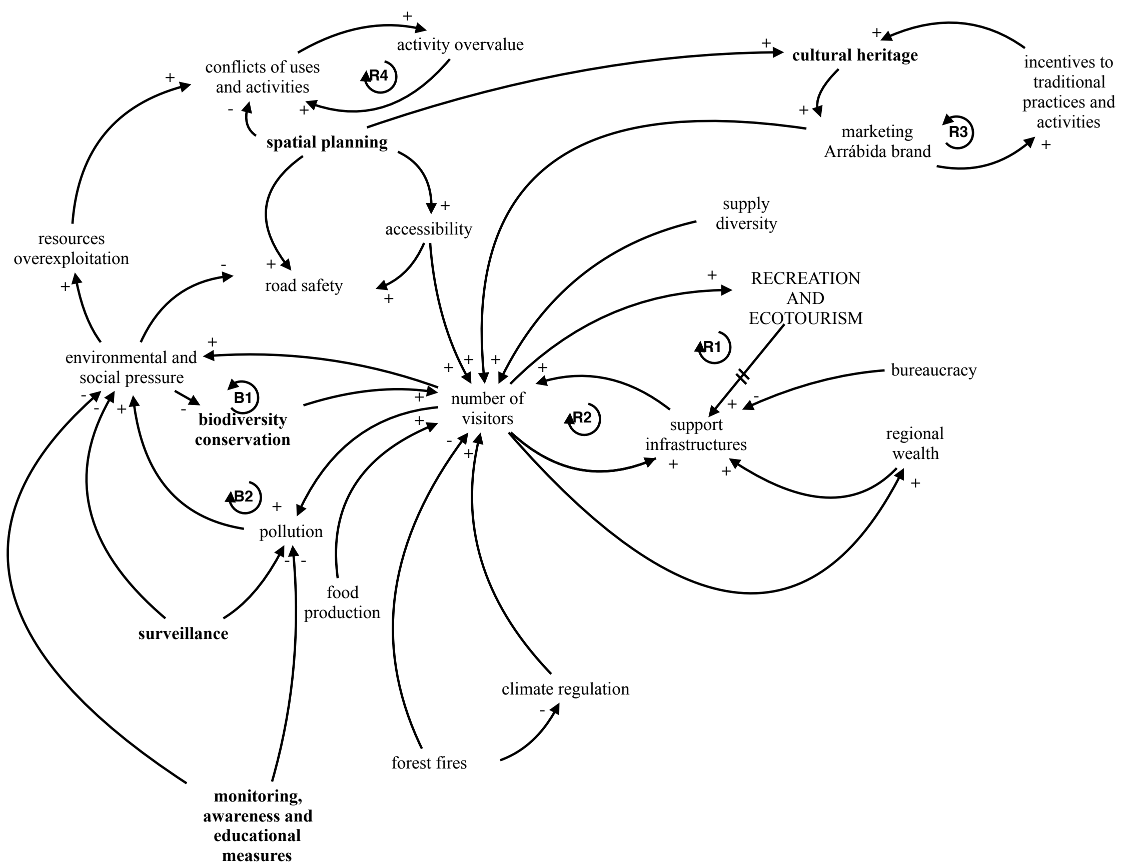


Figure 4.10 - Causal Loop Diagram for “recreation and ecotourism” ecosystem service in the Arrábida Natural Park

Again, as in the case of “food production”, recreation and ecotourism should be managed in tight integration with biodiversity and nature conservation policies. All the measures to potentiate the delivery of this service could lead to an increase of ecological impacts, which will feed back affecting negatively the flow of this service. Figure 4.10 also shows that there are possible linkages between recreation and ecotourism and other ES (*e.g.,* through food production, biodiversity and climate regulation variables).

The cross impact matrix built for this CLD (Figure 4.11) shows that “number of visitors” is the variable with the higher AS (100%), causing changes in five different variables. This is followed by “spatial planning” (80%) and “environmental and social pressure” (60%). With regard to the PS results, the variable “number of visitors” is again the variable with higher percentage (100%), followed by “support infrastructures” and “environmental social pressure”.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AS	%
1	recreation and ecotourism		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
2	regional wealth	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
3	support infrastructures	0	0		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
4	bureaucracy	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
5	supply diversity	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
6	number of visitors	1	1	1	0	0		0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	5	100%
7	accessibility	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	40%
8	road safety	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
9	spatial planning	0	0	0	0	0	0	1	1		1	0	0	0	0	0	0	0	0	0	0	1	0	0	4	80%
10	conflicts of uses and activities	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0	1	20%
11	activity overvalue	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1	20%
12	resources overexploitation	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	20%
13	environmental and social pressure	0	0	0	0	0	0	0	1	0	0	0	1		1	0	0	0	0	0	0	0	0	0	3	60%
14	biodiversity	0	0	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	20%
15	pollution	0	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	1	20%
16	surveillance	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1		0	0	0	0	0	0	0	2	40%
17	monitoring, awareness and educational measures	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0		0	0	0	0	0	0	2	40%
18	forest fires	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		0	1	0	0	0	2	40%
19	food production	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	20%
20	climate regulation	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	1	20%
21	cultural heritage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0	1	20%
22	marketing Arrábida brand	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	2	40%
23	incentives to traditional practices and activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1	20%
	PS	1	1	4	0	0	8	1	3	0	3	1	1	4	1	3	0	0	0	0	1	2	1	1		
	%	13%	13%	50%	0%	0%	100%	13%	38%	0%	38%	13%	13%	50%	13%	38%	0%	0%	0%	0%	13%	25%	13%	13%		

Figure 4.11 – Cross impact matrix of the CLD for the “recreation and eco-tourism” ecosystem service

An interesting result is that the cross impact matrix revealed different important variables apart from the ones identified as leverage points by participants. Furthermore, merely from the cross impact analysis “biodiversity conservation” and “monitoring, awareness and educational measures” would not be regarded as important variables.

4.2.3.2.3 Biodiversity conservation

Biodiversity can be defined as the diversity within species, between species and of ecosystems within ecosystems (MEA, 2005). TEEB (2010) states that biodiversity reflects the hierarchy of increasing levels of organization and complexity in ecological systems at level of genes, individuals, populations, species, communities, ecosystems and biomes. According to a comparison made by TEEB (2010), biodiversity is considered differently in what concerns ecosystem services studies. In ANP case study biodiversity conservation (and/or maintenance) has been considered as a support service from the outset of the participatory process.

The CLD depicted in Figure 4.12, reflects the idea that there are several entry points to promote biodiversity conservation in the Arrábida protected area, which is translated by a set of reinforcing feedback loops. Nevertheless, a balancing feedback loop (B1) also shows how this service can be negatively affected by an increase in the number of visitors, which leads to an increase of resources exploitation and consequently the decrease of biodiversity conservation.

To assure the maintenance of biodiversity, it is important to foster the equilibrium of the Arrábida ecosystems, and vice versa (R1). Participants identified as a leverage point the "monitoring, awareness and educational measures" variable, which affects several feedback loops. Increasing monitoring, awareness and education may promote biodiversity conservation directly (R3), and indirectly through the increase of ecosystem equilibrium (R2). It will also improve the status of habitat and species conservation (R5), increase spatial planning measures (R6), including three more links and counteract the negative effects from the introduction of exotic species (R7). Participants also identified mechanisms for controlling invasive species and spatial planning measures as leverage points.

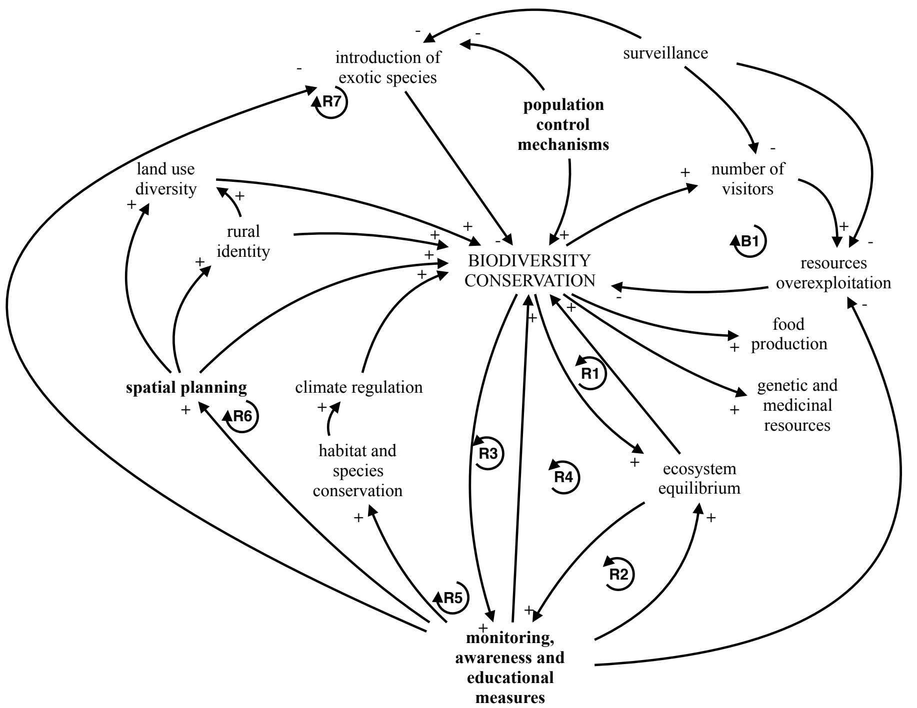


Figure 4.12- Causal Loop Diagram for "biodiversity conservation" ecosystem service in the Arrábida Natural Park

The corresponding cross impact matrix (Figure 4.13) reveals the existence of four critical variables, with the highest AS and PS in this CLD, namely, “monitoring, awareness and educational measures”, “biodiversity conservation” itself, “surveillance” and “spatial planning”.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	AS	%
1	biodiversity conservation		0	0	1	0	0	1	1	1	1	0	0	0	0	0	5	83%
2	population control mechanisms	1		1	0	0	0	0	0	0	0	0	0	0	0	0	2	33%
3	introduction of exotic species	1	0		0	0	0	0	0	0	0	0	0	0	0	0	1	17%
4	number of visitors	0	0	0		0	1	0	0	0	0	0	0	0	0	0	1	17%
5	surveillance	0	0	1	1		1	0	0	0	0	0	0	0	0	0	3	50%
6	resources overexploitation	1	0	0	0	0		0	0	0	0	0	0	0	0	0	1	17%
7	food production	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0%
8	genetic and medicinal resources	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0%
9	ecosystem equilibrium	1	0	0	0	0	0	0	0		1	0	0	0	0	0	2	33%
10	monitoring, awareness and educational measures	1	0	1	0	0	1	0	0	1		1	0	1	0	0	6	100%
11	habitat and species conservation	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	17%
12	climate regulation	1	0	0	0	0	0	0	0	0	0	0		0	0	0	1	17%
13	spatial planning	1	0	0	0	0	0	0	0	0	0	0	0		1	1	3	50%
14	rural identiy	1	0	0	0	0	0	0	0	0	0	0	0	0		1	2	33%
15	land use diversity	1	0	0	0	0	0	0	0	0	0	0	0	0	0		1	17%
	PS	9	0	3	2	0	3	1	1	2	2	1	1	1	1	2		
	%	100%	0%	33%	22%	0%	33%	11%	11%	22%	22%	11%	11%	11%	11%	22%		

Figure 4.13 – Cross impact matrix of the CLD for the “Biodiversity Conservation” ecosystem service

It may be observed that “biodiversity conservation” itself is the variable that influences and its influence by most others in this causal structure. “Monitoring, awareness and educational measures” is an active variable in the sense that influences many other points in the system, thus playing a key role for the maintenance of the service according to participants.

4.2.3.2.4 Climate regulation

Stakeholders from a fourth small working group had the chance to choose the ES they would like to model, having agreed to explore the climate regulation service. Climate regulation is responsible for controlling the flux of greenhouse gases (GHG) through carbon sequestration and storage mechanisms. Based on the diagrams built by participants, the CLD depicting the maintenance of this service in the Arrábida area is presented in Figure 4.14.

R1 shows how the decrease of climate regulation service increases total CO_2 in atmosphere leading to the increase of climate change with impacts in different dimensions, such as economic costs, less agricultural outputs, less biodiversity, more allergenic and respiratory diseases and a decreasing area attractiveness and quality of life. All these impacts will culminate on the need for regulatory activities in the protected area, which will lead to two types of measures: monitoring, awareness and educational measures (set of loops including in B2) and technological measures that can control directly the emissions (set of loops representing by B3 and B4) or through habitat conservation measures (set of loops including in B5 and B6). If no management activities are conducted, all things held equal, the system will find in the long term a self-response by auto regulating itself through B1.

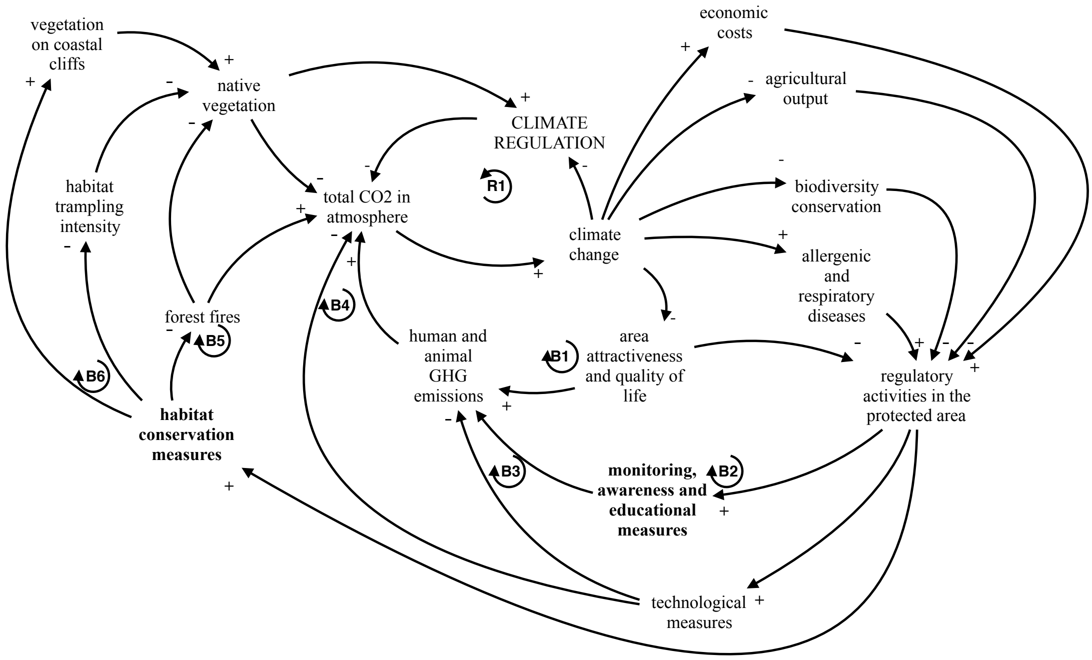


Figure 4.14 - Causal Loop Diagram for “climate regulation” ecosystem service in the Arrábida Natural Park (adapted from Lopes and Videira, 2015)

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	AS	%
1	climate regulation		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17%
2	climate change	1		0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	6	100%
3	total CO2 in atmosphere	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17%
4	native vegetation	1	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	2	33%
5	forest fires	0	0	1	1		0	0	0	0	0	0	0	0	0	0	0	0	2	33%
6	habitat conservation measures	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	0	3	50%
7	habitat trampling	0	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	1	17%
8	vegetation on coastal cliffs	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	1	17%
9	human and animal GHG emissions	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	1	17%
10	area attractiveness and quality of life	0	0	0	0	0	0	0	0	1		0	0	1	0	0	0	0	2	33%
11	monitoring, awareness and educational measures	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	1	17%
12	technological measures	0	0	1	0	0	0	0	0	1	0	0		0	0	0	0	0	2	33%
13	regulatory activities in the protected area	0	0	0	0	0	1	0	0	0	0	1	1		0	0	0	0	3	50%
14	economic costs	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	1	17%
15	agricultural output	0	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	1	17%
16	biodiversity	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	1	17%
17	allergenic and respiratory diseases	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		1	17%
	Passive sum	2	1	5	3	1	1	1	1	3	1	1	1	5	1	1	1	1		
	%	40%	20%	100%	60%	20%	20%	20%	20%	60%	20%	20%	20%	100%	20%	20%	20%	20%		

Figure 4.15 – Cross impact matrix of the CLD for the “Climate Regulation” ecosystem service

The climate regulation cross impact matrix (Figure 4.15) shows the importance of acting in “climate change”, “habitat conservation” and “regulatory activities in the protected area”. The variables “total CO_2 in atmosphere”, “native vegetation”, “human and animal GHG emissions” and the “regulatory activities in the protected area” have percentages above 50%, which makes these important points to monitor in the system the flow of the climate regulation service.

4.2.3.3 Integrated system map for the selected ecosystem services in the Arrábida Natural Park

Having analysed and explored the individual CLDs, their integration into a comprehensive systems map represents one of the advantages of the proposed approach. The combination of the final versions of the CLDs allows to get a holistic perspective on the causal interrelations established between ES through the causal feedback loops that emerge from the different services connections, and also to identify the common variables within the system. Figure 4.16 presents the integration of food production, climate regulation, recreation and ecotourism and biodiversity conservation causal maps (represented by the grey boxes). Variables in bold outside the boxes are the ones shared by two or more of the individual CLDs. Based on the approach of Fiddaman (2002) we developed a diagram that incorporates the main loops among the CLDs showing the most important feedbacks of the integrated system's picture.

The goal of this representation is to highlight the main links among the four ES and how they interact with each other, but also to understand how the common variables emerge on a single CLD. Different colours, density and dashed arrows represent different loops.

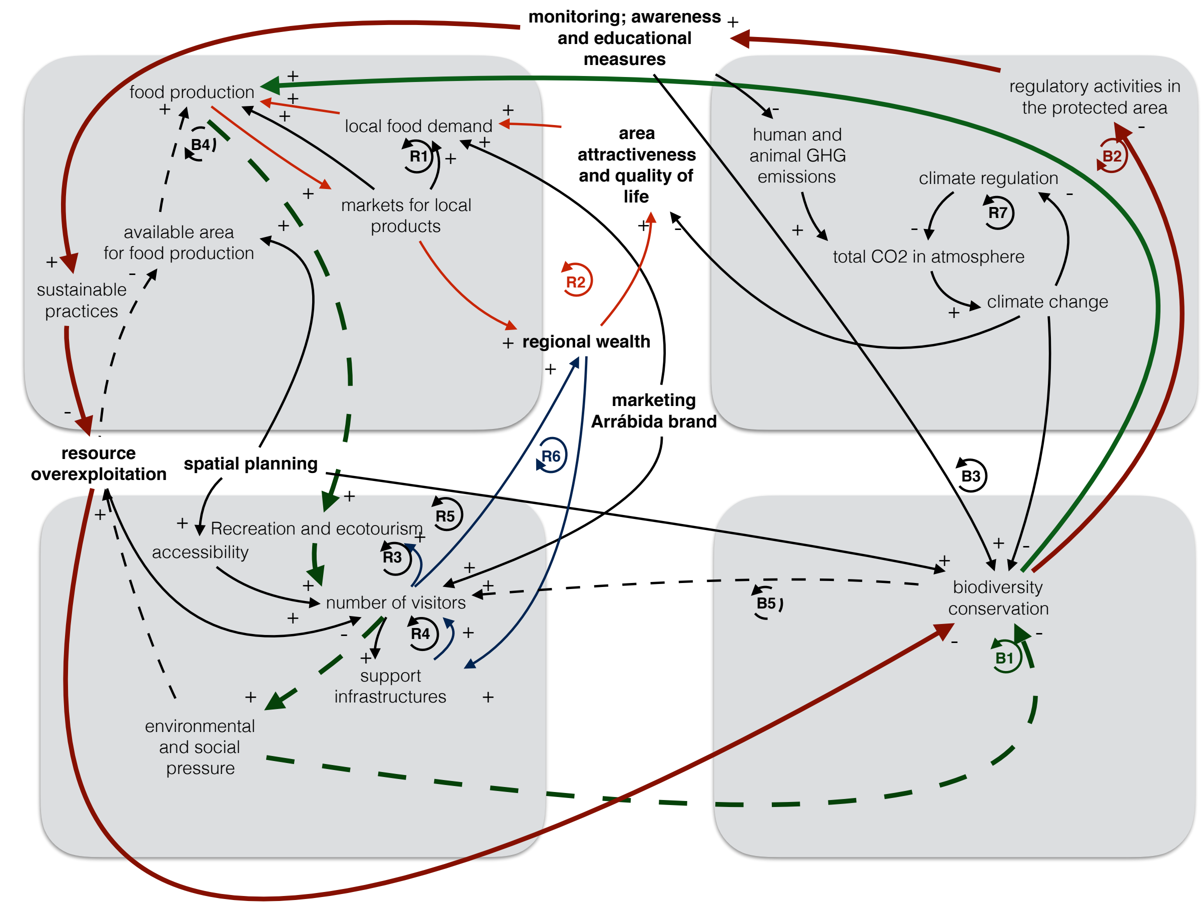
Several reinforcing feedback loops translate the supply flows of each ecosystem service (*e.g.,* R1; R3; R4; R7), while balancing feedback loops are mostly linked with the larger cycles involving multiple services (*e.g.*, B1; B2; B3; B4).

The following key lessons can be drawn from the final integrated CLD translating participants' perceptions:

Biodiversity conservation is a keystone service

By analysing these four interlinked ES, one obvious outcome is the fact that "biodiversity conservation" is closely linked with the other three services, which means that by interfering in "food production", "climate regulation" or "recreation and ecotourism", biodiversity suffers changes and the reverse is also true.

B1 shows how biodiversity conservation underpins the development of human activities in the area, which are dependent on the natural values. The decrease of biodiversity conservation leads to a decrease of food production, which will consequently decrease the recreation and ecotourism (at least the part that is connected with this ES, as for example, the tourism linked with gastronomy and wine taste and vineyards). The decrease of the ES will decrease the number of visitors, and because of that, environmental and social pressures decrease, but only because human activities dependent on biodiversity conservation are less intensive.



B1 (biodiversity conservation - food production - recreation and ecotourism - number of visitors - environmental and social pressure)
B2 (biodiversity conservation - regulatory activities in the protected area - monitoring, awareness and educational measures - sustainable practices - resource overexploitation)
B3 (biodiversity conservation - regulatory activities in the protected area - monitoring, awareness and educational mesures)
B4 (food production - recreation and ecotourism - number of visitors - environmental and social pressure - resource overexploitation - available area for food production)
B5 (biodiversity conservation - number of visitors - environmental and social pressure)
R2 (food production - markets for local products - regional wealth - area attractiveness and quality of life - local food demand)
R6 (number of visitors - regional wealth - support infrastructures)

Figure 4.16 – Integration of the four ES CLDs with the main feedback loops and common variables

Pressures on biodiversity conservation will lead to an increase of regulatory activities in the protected are and thus an increase in monitoring, awareness and knowledge, promoting more sustainable practices and thus less resources are explored leading to more biodiversity conservation (B2). B3 represents the same idea, however shortcutting the causal pathway and increasing biodiversity conservation directly from the increase of monitoring, awareness and knowledge. The relation between biodiversity and recreation and ecotourism is represented by the balancing loop (B5).

One may verify that Biodiversity conservation is highly linked with the large loops around the four individual maps, potentiating the delivery of other ES. The pivotal role of biodiversity in the system map is aligned with the fact that this is a designated protected area with natural values of high conservation interest.

Food provision and recreation & ecotourism services are closely linked

R2 and R6 are reinforcing loops representing the effects on regional wealth concerning “food production” and “recreation and ecotourism”. The increase of local food demand will increase food production, thus increasing markets for local products, which will promote the rise of regional wealth, which with other things held equal, will increase area attractiveness and quality of life (R2). On the other hand, an increase in the number of visitors will increase regional wealth and consequently support infrastructures that will foster the increase of number of visitors (R6).

The link between food production and recreation and ecotourism is represented by B4, where the increase of food production leads to the increase of recreation and ecotourism and consequently the increase of number of visitors that might increase environmental and social pressure, increasing resource overexploitation, which lowers available area for food production and consequently leads to less food production.

The connection between the ES food production and recreation and ecotourism become evident to ANP stakeholders with this integrated systems map.

Integrated management of ES is needed - policies impact on several ES

Figure 4.16 shows a set of variables which are common to two or more of the individual CLDs. Most of these translate into policies for managing ES. Thus, a change in these variables will have an impact on the flow of several services. This result underscores the importance of an integrated management of ES. Developing management actions and policies that include these variables would push forward an integrated approach to ES management. The system map allows to articulate these relationships in one single diagram.

Human well-being is affected by multiple ES

Another lesson that comes forward with the analysis of this integrated diagram is how it exposes the links between ES and human-wellbeing. This is illustrated by variables such as “regional wealth” and “area attractiveness and quality of life”, which crosscut several CLDs and may be understand as constituents of well-being affected by ES.

4.2.3.4 Towards defining ecosystem services indicators

Several methods and approaches have been proposed to identify indicators for ES (Kandziora *et al.*, 2013; Maes *et al.*, 2016; Muller and Burkhard, 2012), including the deployment of participatory processes (Baró *et al.*, 2016; Marques *et al.*, 2013). A relevant example is shown by Vugteveen *et al.* (2015) who used participatory modelling workshops to select potential socioecological system indicators wherein participants have identified ES indicators associated with CLDs built in group modelling exercises.

According to Meadows (1998), not only indicators arise from value systems but they also create values, which means that they should measure what is important and not only what is measurable. The same author underlines that the process of indicator development for social systems is as important as the indicators selected, hence the importance of integrating participation. Thus, in this section we illustrate how the PSM results described above may be translated into a set of indicators that take into account stakeholders' perceptions and their mental models reflected in the causal maps built for ANP's ES.

More specifically, potential ES indicators may arise from three sources: i) the variables identified by participants as leverage points during the PSM workshop, which represent instant perceptions on where is the leverage to act in the system; ii) the information generated with the cross impact matrices provides a second layer of relevant information; and iii) variables that are common to several CLDs highlighted in the integrated systems map. Thus, these sources combine stakeholders' perceptions on ES, the study of the system underpinning ES flows, as well as its causal relations and feedback processes.

Next tables (4.5, 4.6, 4.7 and 4.8) give some examples of possible indicators and measurement units, for the four categories of ES, that may be defined based on the identified variables across the three layers of information. This is an important outcome of the PSM workshop and the "deepen understanding" stage of the followed Framework. This preliminary list of indicators may be subsequently discussed and iterated by stakeholders, supporting monitoring and articulation of ES in decision-making processes.

Table 4.5 – Indicator set for "food production" ES derived from the PSM workshop and cross impact analysis.

	Source / Criteria for selection			***Potential Indicators to measure the selected variables***	
Food Production Variables	*Perceived Leverage Points*	*Cross Impact Matrix (AS & PS)*	*Integrated diagram*	*Description*	*Units*
Available area for food production		x		Available area for food production / Total area	Percentage (%)
Bureaucracy		x		Number of procedures to get a license / time need to have the answer regarding the authorization of the activity	Absolute number / number of days
Ecosystems quality		x		Air, soil and water pollution levels	Qualitative (low-high)

Food production		x		Food production index covering food crops	Number (against 100) /
Local food demand		x		Food consumption, which may be measured in kg of food produced in the area that are consumed per capita.	kg/per capita
Measures to support ANP		x		Number of programs and measures to support the ANP (or total of funds / investment)	Absolute number (or euros)
Recreation and ecotourism		x		Number of beaches; number of dive schools; number of beds	Absolute number
Sustainable practices		x		Sustainable practices taking place in the area	Qualitative (low-high)
Yield		x		Yield of a crop per unit of area of land cultivation	kg / ha
Area attractiveness and quality of life		x	x	User satisfaction rating; facilities and accessibility; quality of recreational activities; jobs opportunities	Qualitative (low-high)
Biodiversity conservation		x		Number of species; ecological quality status; total abundance	Absolute number
Marketing Arrábida brand	x	x	x	Investment on marketing campaigns (*e.g.*, TV; flyers; local communication)	euros
Monitoring, awareness and educational measures	x	x	x	Number of monitoring campaigns; registered actions on education and awareness; Interpretative centres; family programs	Absolute number / qualitative (low - high)
Regional wealth		x	x	Regional GVA (Gross Value Added) is a productivity metric that measures the difference between output and intermediate consumption. GVA provides a euro value for the amount of good and services that have been produced, less the cost of all inputs and raw material that are directly attributable to that production.	euros
Resources overexploitation		x	x	Level of natural resources exploration	Qualitative (low-high)

Note: grey cells highlight indicators that are relevant to two or more ES, corresponding to variables depicted in the integrated systems map.

Table 4.6 – Indicator set for "recreation and ecotourism" ES derived from the PSM workshop and cross impact analysis.

	Source / Criteria for selection			***Potential Indicators to measure the selected variables***	
Recreation and ecotourism Variables	*Perceived Leverage Points*	*Cross Impact Matrix (AS & PS)*	*Integrated diagram*	*Description*	*Units*
Cultural heritage	x			Classified heritage (*e.g.*, international classifications)	Qualitative (low-high)
Environmental and social pressure		x		Total of population in high seasons; number of species in red book	Total of population / number of species
Number of visitors		x		Number of registered visitors per year	Persons/year
Support infrastructures		x		New support infrastructures built per year	Number/year
Biodiversity conservation	x			Number of species; ecological quality status; total abundance	Absolute number
Monitoring, awareness and educational measures	x		x	Number of monitoring campaigns; registered actions on education and awareness; Interpretative centres; family programs	Absolute number / qualitative (low - high)
Spatial planning	x	x	x	Spatial planning strategies, plans and programmes	Qualitative (low-high)

Note: grey cells highlight indicators that are relevant to two or more ES, corresponding to variables depicted in the integrated systems map.

Table 4.7 – Indicator set for “biodiversity conservation” ES derived from the PSM workshop and cross impact analysis.

	Source / Criteria for selection			***Potential Indicators to measure the selected variables***	
Biodiversity Conservation Variables	*Perceived Leverage Points*	*Cross Impact Matrix (AS & PS)*	*Integrated diagram*	*Description*	*Units*
Introduction of exotic species		x		Ratio of exotic species by endemic species	Percentage (%)
Population control mechanisms	x			Number of identified individuals	Absolute number
Surveillance		x		Number of protocols aiming to support surveillance in the area; Number of actions taking place in year regarding surveillance	Absolute number
Biodiversity conservation		x		Number of species; ecological quality status; total abundance	Absolute number
Monitoring, awareness and educational measures	x	x	x	Number of monitoring campaigns; registered actions on education and awareness; Interpretative centres; family programs	Absolute number / qualitative (low - high)
Resources overexploitation		x	x	Level of natural resources exploration	Qualitative (low-high)
Spatial planning	x	x	x	Spatial planning strategies, plans and programs	Qualitative (low-high)

Note: grey cells highlight indicators that are relevant to two or more ES, corresponding to variables depicted in the integrated systems map.

Table *4.8* – Indicator set for “climate regulation” ES derived from the PSM workshop and cross impact analysis.

	Source / Criteria for selection			***Potential Indicators to measure the selected variables***	
Climate Regulation Variables	*Perceived Leverage Points*	*Cross Impact Matrix (AS & PS)*	*Integrated diagram*	*Description*	*Units*
Climate change		x		Number of extreme climate events	Absolute number
Habitat conservation measures	x	x		Ecological quality status;	Absolute number

Human and animal GHG emissions		x		Total of GHG emissions from sources in the area	Mt on CO_2 eq.
Native vegetation		x		Number of native species; contribution of land use change and forestry	Absolute number
Regulatory activities in the protected area		x		Number of regulatory activities in the protected area	Absolute number
Total CO_2 in atmosphere		x		CO_2 concentration in atmosphere	ppm CO_2
Monitoring, awareness and educational measures	x		x	Number of monitoring campaigns; registered actions on education and awareness; Interpretative centres; family programs	Absolute number / qualitative (low - high)

Note: grey cells highlight indicators that are relevant to two or more ES, corresponding to variables depicted in the integrated systems map.

4.2.4 Discussion

This paper proposes an approach for deepening understanding on ES and explore the role of PSM in this process. We have started with the premise that ES is a "participatory-driven" concept and participation is a value articulating-institution. This means that the presented proposal builds on the notion that through a deliberative process where stakeholders are invited to deepen their understanding on the structure underlying ES, recognizing their variables, relations and feedback loops, the management of ES may be better informed and consequently improved.

CLDs are built in a common platform where knowledge and experiences are shared in order to delve into the system responsible for providing ES. Key variables, drivers of change and impacts, as well as, management actions are identified and linked through cause-effect relationships. Participants in the ANP case study were asked to identify leverage Points in each CLD, which translates their instantaneous perceptions on where to act in the system in order to foster a sustainable flow of a given service. These entry points are very important to inform management decisions, since they represent stakeholders' mental models and knowledge on the system and avoid management segmentation. Leverage points thus become socially accepted points to intervene in the system.

The analysis of the CLDs through cross impact matrices represented a second level of analysis to inform the selection of important variables to monitor the system. Critical variables are selected as those with high influence and/or very influenced by other parts of the system. With this information, it is possible to select indicators capable of monitoring changes in the flow of the ES, as well as, key points to potentiate the delivery of the service.

Putting all CLDs together allows to build an integrated systems map, which brings forward an often neglected holistic view of the interrelationships between different ES. When we showed an integrated diagram to participants working in four separate groups at the end of the PSM workshop, many revealed enthusiasm for seeing interconnections among ES CLDs. These unexpected insights were driven by the synthesis effect produced when piecemeal views were brought together in one single diagram, which not only connected the four individual CLDs but also put forth the linkages between ES and human wellbeing.

The articulation of information based on three layers of analysis allows to capture the critical variables that may be translated into indicators supporting assessment and management of ES. Each layer provides a particular angle and perspective which is relevant for indicator selection. Thus, the role of PSM is thought to deepen understanding of ES by accommodating complexity and uncertainty in a participatory setting. Multiple values dimensions are considered in the same modelling platform and the variables with high importance in the system may afterwards originate different qualitative and quantitative indicators to support assessment and policy-making processes. PSM outcomes may be subsequently used to explore the dynamic behaviour of the system with the construction of simulation models, support ES spatial mapping processes or multi-criteria analyses.

4.2.5 Conclusion

In this article we present a structured methodology to conduct a collaborative process of deepen understanding of ES with a PSM approach. Through stakeholders' engagement it was possible to developed a collaborative construction of CLDs understanding feedback processes underlying management of ES. With this approach information collected previously on ES with stakeholders' perceptions was combined. The process fosters sharing of experiences allowing co-production of knowledge and providing information to articulate ES values.

The causal maps provide a holistic perspective on the interrelations among ES allowing to identify entry points to act in the system. Stakeholders revealed their instantaneous perceptions on key variables, by selecting leverage points. Cross impact matrices also work well to support the selection of key indicators for the supply and demand of ES. Integrated system maps combining CLDs depicting individual ES confers to this approach the possibility to look into common variables to more than one service.

With this collaborative process structural components of ES are identified and selected indicators are socially accepted, revealing what is important to measure for affected stakeholders. ES is a concept that aims to highlight the importance of nature to human wellbeing, using this concept in a participatory platform fosters the discussion around these benefits recognizing the relational values as the intrinsic and instrumental ones and how participants perceived them in a causal relational context. Although the process already fosters values articulation, based on these outcomes, the information can be gathered and quantified in order to inform concrete decision-making process where ES values need to be articulated.

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Chapter 5 | Articulate Values

"biodiversity, species richness, integrity, fragility, health, (...) tones of colour, such as the contrasting browns and reds of autumn, the subtle shifts in shades of green in spring, the dappled sunlight in woodlands; the forms and shapes of nature such as the ruggedness of mountains, the gentleness of hills, the landscapes shaped by stone wall and terrace; the sounds such as birdsong and river over rocks; and textures such as the roughness of gritstone and the sharp and smooth of limestone (...) the violent wildness of a storm, the serene lakeside, the force of a waterfall. We use then a rich vocabulary to appraise the environments we live in, from and with. The idea that this could be reduced to a single value looks implausible".

– John O'Neill *et al.*[4]

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[4] John O'Neill, Alan Holland & Andrew Light

Bringing stakeholders together to articulate multiple value dimensions of ecosystem services

ABSTRACT

Ecosystem services embed multiple values. Capturing and integrating plural perspectives when conducting ecosystem services studies is a recognized need and yet a challenge. This paper proposes a participatory approach that fosters articulation of values allowing the integration of different value dimensions to inform decision-making processes, an important challenge that has been gaining traction in the field of ecosystem services research. Using participation as a value articulating institution, stakeholder groups of the Portuguese Arrábida Natural Park were engaged in a workshop to articulate value dimensions expressed by ecological, economic and social criteria in two different contexts: a conflict related with allocation of vineyard areas and the assessment of project alternatives for regulating access to beaches and recreational activities. Results demonstrate that the proposed deliberative process fostered changes in participants' initial mental models and created new insights, namely by generating additional alternatives, expanding perceptions on affected ES, and supporting the formalization of multiple evaluation criteria and decision rules.

KEYWORDS

Ecosystem Services; Articulation of Values; Participatory Processes; Multi-criteria approaches

5.1 Introduction

As much worldwide attention as the ecosystem services (ES) concept has recently received, value reductionism and monistic approaches, still surface in many debates. Looking into one dimension of value brings several associated risks and bias (O'Neill 1996; de Groot et al. 2002; Spash, 2008; Martínez-Alier, 2002). Hence, different authors have been following a more integrative perspective, calling attention to the importance of considering a broader range of ecological, social and economic ES values (Chan et al., 2016; de Groot et al., 2002; Spangenberg and Settele 2016).

However, practical questions on how to articulate multiple ES values still remain. Once different ES values are recognized, the way they are integrated is determinant to support decision-making processes, as highlighted by recent studies on ES value pluralism (Martín-López et al., 2014) and articulation (Lopes and Videira, 2013). Following such integrative perspectives will expand the scope of traditional ES valuation by openly supporting a more comprehensive approach.

In this article, participation and deliberative ES-based evaluation processes are assumed as value articulating institutions, following Vatn's definition of the concept as meaningful rule structures facilitating value articulation (Vatn, 2005; Vatn, 2009). These rules represent contexts where discussions take place based on different rationalities and distinct principles on how these values should be articulated. Antunes et al (2009) explored this argument recognizing the need to develop new multi-dimensional, inclusive and plural approaches to natural resource management. Koschke et al. (2014) conducted a study to identify benefits and challenges of combining ES concept with participation, which showed that using the ES concept in participatory contexts can support more informed decisions, facilitating integrated solutions and promoting a comprehensive view in impact assessments. Participatory ES-based approaches were recognized to foster awareness-raising, consensus and commitment. These arguments are also defended by Mascarenhas et al. (2016), who explored the participatory selection of ES in a spatial planning context revealing the importance of the approach in planning and strategic environmental assessments. Furthermore, according to Hauck et al. (2013), the concept of ES enables a comprehensive evaluation of policy impacts, which is dependent on the incorporation of the diversity of stakeholders' perceptions, knowledge and preferences.

Within this context, we developed a collaborative platform for the articulation of ES values following a participatory conceptual Framework for ES valuation and assessment (Lopes and Videira, 2013). A structured methodology is proposed and tested in a coastal and marine protected area in Portugal, which revealed the advantages and limitations of an integrated and participatory process to articulate ES values. The approach was tested in two different decision-making settings: 1) A land use conflict involving allocation of vineyard areas in the natural park (provisioning service) and 2) An assessment process comparing alternative projects to regulate access and visitation to recreation sites (cultural service).

The paper proceeds with a review of different approaches to articulate values and range of decision contexts where ES values may possibly be used and articulated. The third section presents the methods, deliberative process and an overview of the main features of the selected case study. Section four describes the obtained results while section five discusses the main lessons drawn from the empirical application. The main conclusions of our study are presented in the final section.

5.2 Different approaches for articulating ecosystem services values in environmental decision-making

The Oxford dictionary defines articulation as the act of being "*related to something so that together the two parts form a whole*". How this relationship is expressed, and the whole is formed, depends on the aims of the process, and consequently, on the methods and tools used. This may lead to a broad spectrum of articulation mechanisms. When it comes to ES, this procedure should connect multiple value dimensions in some way, supporting holistic decision-making processes.

In Table 5.1 we summarize key features from a set of nine ES studies where different sorts of value articulation processes were promoted, illustrating the diversity of approaches presented thus far in the literature.

The majority of the analysed studies were aimed at developing maps depicting spatial distribution of ES (Esse et al., 2014; Nahuelhual et al., 2013; Hayha et al., 2015; Buckard et al., 2012). In a few studies, authors stated that the process was destined to support management processes (Riper and Kyle, 2014; Bredin et al., 2015) or conducting cross-scale analysis (Dick et al., 2014). Martín-López et al. (2014) specifically aimed to analyse trade-offs across multiple value domains, while Hattam et al. (2015) focused on mixed methods for ES valuation and the challenges that go with multidimensional assessments.

In order to address these objectives, the reviewed studies used distinct methods and tools promoting to some extent articulation of ES values. We conclude that the use of GIS was a common tool to capture and to articulate at least two value dimensions. Maps have been also combined with indicators (Hayha et al., 2015), matrices (Buckhard et al., 2012), and participatory methods (Riper and Kyle et al., 2014). Although some cases consider two value dimensions, others such as Hattam et al. (2015) recognize three value dimensions – ecological, social and economic values. These authors aimed at capturing ES values through standalone methods while Martín-López et al. (2014) combined different values using plots revealing different information and trade-offs across value dimensions.

The use of multi-criteria analysis techniques was proposed in the study from Esse et al. (2014). Due to its capacity to assess trade-offs and accommodate value pluralism, multi-criteria analysis has showed promising results as a method for integrated valuation of ES (Langemeyer et al., 2016). Several other examples may be found in the literature where multi-criteria analysis has been used in ES assessments (Seidl and Lexer, 2013; Fontana et al., 2013; Nordstrom et al., 2011; Grazhdani, 2014). Langemeyer et al. (2016) analysed multi-criteria processes involving ES observing that many studies differentiate the alternatives spatially. However, lack of information on context-specific ES data was a challenge highlighted when conducting multi-criteria analysis on ES (Langemeyer et al., 2016). Other contested issues that may arise during the implementation of these methods include the choice of aggregation rules, trading-off incommensurable values, or increasing the risk of under representation of minority goals (Langemeyer et al., 2016). One way to overcome some of these issues is combining participation with multicriteria analysis. Typically, when conducting multi-criteria analysis in participatory contexts stakeholders are asked to discuss and explore different criteria, alternatives and weights (*e.g.,* Antunes et al., 2011). For example, Acosta and Corral (2015) conducted a participatory multi-criteria assessment of forest planning policies with regard to conflicting situations and Salgado et al. (2009) combined multi-criteria with social research techniques for the evaluation of urban water supply alternatives. Carnoye and Lopes (2015) compared cases applying four different valuation methods revealing the achieved gains when combining participatory techniques in multi-criteria analysis with regard to cognitive (*e.g.,* invisibility) and normative problems (*e.g.,* incommensurability), since these processes allow to make problem structuring more explicit by providing time for sharing perceptions without forcing trade-offs across value domains.

Table 5.1 – Overview of selected ecosystem services studies promoting articulation of multiple values and/or stakeholder participation

Publication title	**Trade-offs across value-domains in ES assessment**	**A multi-criteria model for mapping ecosystem services in forested watersheds, southern Chile**	**Mapping recreation and ecotourism as a cultural ecosystem service; An application at the local level in Southern Chile**	**Capturing multiple values of ecosystem services shaped by environmental worldviews: A spatial analysis**	**Mapping ecosystem service supply, demand and budgets**	**Mapping value plurality towards ecosystem services in the case of Norwegian wildlife management: A Q analysis**	**Cross-scale analysis of ecosystem services identified and assessed at local and European level**	**Assessing, valuing, and mapping ecosystem services in Alpine forests**	**Integrating methods for ecosystem service assessment and valuation: Mixed methods or mixed messages?**
Authors and date	Martín-López *et.al* 2014	Esse *et al.*, 2014	Nahuelhual *et al.*, 2013	Riper and Kyle, 2014	Buckhard et al., 2012	Bredin *et al.*, 2015	Dick *et al.*, 2014	Hayha *et al.*, 2015	*Hattam et al.*, 2015
Aim of the study	Scoping of ecosystem services	Mapping ecosystem services	Mapping recreation and ecotourism at the municipality level	Supporting environmental management decision-making in the context of protected areas	Mapping ecosystem services to link supply and demand across different spatial and temporal scales.	Analyse the perceived and actual trade-offs related to Norwegian wildlife management following the ecosystem services Framework	Investigating the relation between ecosystem services analysis carried out at different spatial scales	To assess, map and value forest ecosystem services through biophysical measures, spatial distribution, and economic value	Assess and value ecosystem services derived from the Dogger Bank, in southern North Sea
Methods and tools	• Biophysical indicators • Socio-cultural preferences • Monetary values • Amoeba plots articulate information on different indicators	• Multi-criteria analysis based on GIS tools and homogeneous environmental units	• Combination of GIS and participatory methods (Delphi and Analytic Hierarchy Process)	• Maps depicting spatial relationships between environmental worldviews and assigned values across land	• Ecosystems integrity • Demand and supply • Use of CORINE land cover • Ecosystem services matrix and maps	• Intrinsic vs cultural vs utilitarian values • Venn diagram and Q analysis	• Ecosystem services indicators	• Biophysical indicators • Economic values • Spatial distribution of ecosystem services using maps	• Indicators and future scenarios • Discrete choice experiment • Citizen's jury

Participatory elements of the study	• Face to face surveys by questionnaire (for the socio-cultural values)	• Relevant actors involved in the identificatio n of ecosystem services making use of the maps	• Validation of results (attributes) were performed with two groups of experts using the Delphi method	• Public participation GIS methods to collect survey data • Application to spatially analyse a range of ecosystem values	• Experts consultation	• Q statement • Different narratives (intrinsic, cultural utilitarian)	• Meetings with land managers	• No participation	• Citizen's jury
Outputs	• Quantification of ecosystem services indicators and trade-offs	• Maps with spatial distribution of three ecosystem services	• Identification of recreation areas to inform local decision making regarding land use planning	• Preferences for the provision of biological diversity, recreation, and scientific-based values of ES varied across a spatial gradient	• A matrix linking spatially explicit biophysical landscape units to ecological integrity • ES supply and demand	• Trade-offs regarding pro-sheep grazing (cultural values), pro-carnivore conservation (intrinsic values) and recreational hunting (utilitarian values).	• Total ecosystem service index • Indicators for different services (provision, regulation and cultural)	• Maps with biophysical and economic values of recreation and ecotourism, hydrogeologic al protection and carbon sequestration	• Indicators for ecosystem services provision, according to two scenarios • Willingness to pay for improvements in ecosystem services • Deliberation on the uses, conflicts and dilemmas

Participation played an important role in the majority of the studies reviewed in Table 5.1, with the exception of Hayha *et al.* (2015). However, involvement of interested parties was seemingly promoted for a specific task and not as an integrative feature of the value articulation process. Questionnaires (*e.g.,* Martín-López *et al*., 2014) and participatory maps (Esse *et al*., 2014; Riper and Kyle, 2014) were the tools most frequently used to integrate stakeholders in the process. The involvement of experts was promoted in two cases (Nahuelhual *et al*., 2013 and Buckhard *et al*., 2012) and a citizen's jury was conducted by Hattam *et al.* (2015) as a complementary element of the study to identify conflicts regarding ES uses.

The final products of the different studies were diversified, including, maps to support planning and management activities (*e.g.,* Esse *et al*., 2014; Nahuelhual *et al*., 2013), matrices with ES supply and demand (Buckhard *et al*., 2012), preferences across a spatial gradient (Riper and Kyle, 2014) and narratives characterizing stakeholders' perceptions on the importance of arguments about biodiversity and ES (Bredin *et al*., 2015). From the study of Dick et al. (2014) emerged a total ecosystem service index and different ES indicators. Two studies (Martín-López *et al*., 2014 and Hattam *et al*., 2015) concluded that the assessment of different value domains reveals different degrees of importance assigned to a given ecosystem service. Similar conclusions were achieved by Lopes and Videira (2016) when conducting an exercise where stakeholders were asked to select ES according to different value domains.

Despite the evidences and calls for articulation of multiple ES values (Lopes and Videira, 2013; Martín-Lopez, 2014) Table 5.1 shows that few studies are considering the active involvement of stakeholder groups in the articulation of two or more value dimensions. The importance in identifying and capturing multiple ES values does find resonance, however the question of how to operationalize such articulation in participatory decision-making processes still remains open.

To tackle this challenge, the identification of the range of decisions that may be informed by multiple values is also useful to understand under which circumstances value integration should be promoted. We therefore present in Table 5.2 a categorization of decisions according to a set of ES assessment purposes, adapted from Berghofer *et al.* (2015). The decisions were grouped in seven categories which are related to different assessment goals and questions guiding the application of the ES concept.

Table 5.2 – Categorization of decision-making processes to which ecosystem services may contribute (Adapted from Berghofer *et al*., 2015).

Decision-making process	Description	Questions guiding the application of ES concept
Scoping of ecosystem services	Identification of ES provided by a given site and selection of relevant ES for further characterization and assessment.	What are the ES that the area in study provides? What are the links between ES and human wellbeing? What are the main threats? Which ES are important from the ecological, social and economic points of view?
Conveying environmental messages, arguments and evidence & Enhancing environmental awareness and education	Understand and use the information on ES provision and impacts to communicate the importance of a specific decision/ context.	How can information on ES be used to inform the public and stakeholders creating awareness on the links between ecosystems and human wellbeing?
Comparing alternative policies, programs and projects	A comparison of different alternatives (policies, programs or/and projects) may be performed based on the supply and demand of ES and how they can be affected by the different options at stake.	Which are the ES directly/indirectly affected positively/ negatively by each alternative?
Calculating environmental damages, losses and compensation requirements & Designing environmental policy instruments, including incentives, regulations	Represents a type of process where quantification of damages and compensation requirements to victims is required. Environmental policy instruments may be defined based on ES information, such as in the case of payment for ecosystem services (PES) schemes.	Which are the losses and damages of human activities on ES? Which information about ES allows to design more efficient, effective and equitable policy instruments?
Supporting livelihoods, development and investment opportunities & Sourcing new conservation funding	Identifying the relation of ES with livelihoods and development programs.	How do alternatives differ in terms of the ES gains and losses they give rise to? What new or improved economic opportunities can be developed based on the conservation and sustainable use of ES?
Advancing monitoring and evaluation	Monitoring the state of ES.	How have implemented policies been helping in the conservation of ES flows?
Tackling environmental conflicts	The use of ES information (identification, impacts, causal relations among different ES) may be used to promote deliberation on multiple perspectives, create shared understanding and ameliorate conflicts.	How may information on ecosystem services be used to inform debates and provide a vehicle for managing conflicts?

Table 5.2 shows the importance of identifying the type of decision-making process, since different decisions will require different information on ES. In this sense, when conducting a process of articulation of ES values, information may need to be presented in different formats, analysed and integrated with different methods and tools, and the concomitant stakeholder involvement adapted to the different contexts. For example, if the purpose is to create

environmental awareness or conveying environmental messages or arguments, using disaggregated, broad and flexible information is important as highlighted by Berghofer *et al.* (2015). On the other hand, when comparing alternative plans, programmes or projects, the focus on ES should allow to consider environmental changes in terms of impacts. In the case of conflict management processes, it is important to collect the information on ES with a high level of participation and collection of the dissenting perspectives (Berghofer *et al*., 2015). The categorization presented in Table 5.2 is thus a supporting step for designing the participatory process underpinning articulation of ES values. In this paper we illustrate the proposed methodological approach with examples from two decision-making processes: "tackling environmental conflicts" and "comparing alternative policies, programmes and projects".

5.3 Proposed methodology for articulating values of ecosystem services [5]

Articulating ES values means to relate different values assigned to ES and assess their implications for a decision-making process. Based on the results from the review outlined in the previous section, and the conceptual Framework developed by Lopes and Videira (2013), we developed an approach to engage stakeholders in a process of ES value articulation. The cornerstone of the process is a participatory workshop where different ES value dimensions are discussed and articulated based on multi-criteria principles (Munda, 2004; Gamper and Turcanu, 2015).

Figure 5.1 summarizes the key tasks and methods envisaged in the proposed methodology, depicting the connections between activities of the "value articulation" stage and the information that supports them collected in preparatory stages.

As observed in Figure 5.1, the value articulation process starts with the framing of the decision problem. This is supported by two stages designated as 'set the scene' and 'deepen understanding'. Once the decision problem is framed and alternatives are defined, participants are asked to identify which ES are affected by those alternatives (Task 2). This task may be supported by a collaborative scoping approach, where concrete ES in the study area are identified and selected according to stakeholders' perceptions (Lopes and Videira, 2016). Task 1 then leads to the construction of a matrix where effects of each alternative are assessed in relation to each ES identified by participants (matrix 1).

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[5] Support material used in the third stage – Articulate – can be found in Annex III.

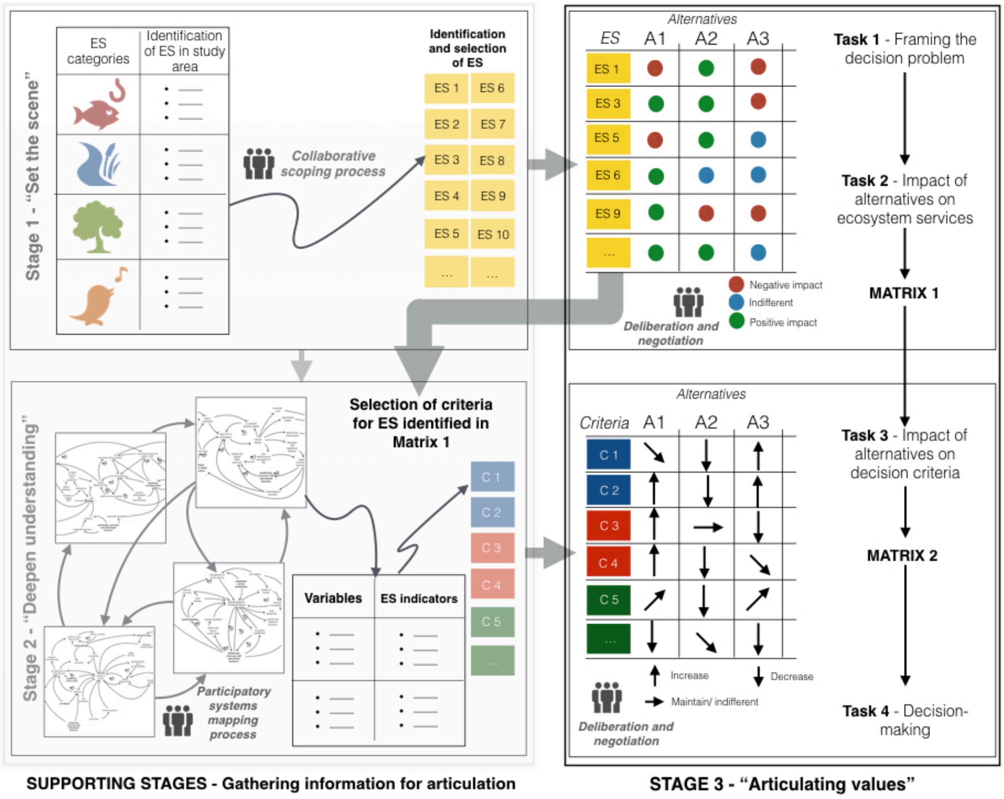


Figure 5.1 – Process of value articulation

Task 2 aims to support the analysis of effects of each alternative on multiple evaluation criteria. The identification of these criteria is support by information produced in the "deepen understanding" stage, wherein participants may be asked to collaborate in mapping, modelling and other analytical processes that produce detailed information on selected ES. For example, we have previously tested a participatory systems mapping approach that captured the interdependencies and feedback structures underpinning ecosystem functioning (Lopes and Videira, 2015). These causal models included variables which were translated into ES indicators that support the definition of ecological, economic and social evaluation criteria to consider in Task 3. A second matrix is then constructed, where participants choose criteria (*e.g.,* using coloured cards for economic, social and ecological criteria) against which each alternative is scored, quantitatively or qualitatively, for example, with respect to direction of change induced by alternatives on each criteria (*e.g.,* increase, decrease, maintain or indifferent, and higher and lower decrease or increase).

At the end of this process, decision-making may be better informed by an integrated process where different values of ES were articulated for the decision context, supported by previous stages of information collection. Engagement of relevant stakeholders may continue during follow-up and monitoring stages, after the decision (*e.g.,* selected alternative(s)) is implemented.

The value articulation tasks proposed in Figure 5.1 may be conducted in a participatory workshop, to which interested parties affecting or affected by the decision at stake are invited. Table 3 provides a detailed script supporting the activities to be conducted in such value articulation workshop, including the role of participants and research team, as well as the methods and materials needed for each task.

Table 5.3 – Script for a participatory workshop supporting articulation of ecosystem services values

Task 1 - Framing the Environmentally Complex Decision Problem (30 min)	
Task 1.1 - Participants reception and individual survey	***Purpose**:* Capture participant's individual mental models regarding ES affected by the decision process and the important criteria to consider.
	Role of participants: Participants select a group they would like to join, and answer an individual survey regarding the decision-making process to be discussed, particularly focusing on ES and criteria to integrate the decision. The question guiding this survey is how would each participant decide in that context.
	Role of research team: Distribute the survey to participants.
	Materials: Printed individual questionnaire sheets.
Task 1.2 - Briefing presentation	***Purpose:*** Establish decision context.
	Role of research team: Provide an overview of previous stages of collecting information for articulation, and frame the decision context, emphasizing the goal of the participatory workshop and how the process will unfold.
	Materials: Workbook containing information previously collected which is relevant for the decision at hand (*e.g.*, identified links within ES; information on the decision context; explanation of alternatives to explore during the process). It is expected that the workbook supports the discussions and the exercises during the workshop.
Task 2 - Group exercises I – Impact of alternatives on ecosystem services (90 min)	
Task 2.1 - Alternatives selection	***Purpose:*** Select the alternatives to be analysed.
	Role of participants: Each group should select a spokesperson, responsible for filling in a control sheet guiding the discussion. Participants should discuss, adjust and select the alternatives to assess during the exercise.
	Role of research team: Provide a set of preliminary alternatives, that are defined according to the collected information for articulation. Research team should also facilitate the discussion among participants (*e.g.,* one member of the team takes notes, while the other facilitates the group discussion).
	Materials: Paper worksheet (size A1) to develop the exercise. Alternatives disposed in different cards or paper sheets in order to allow participants to see, pick and move them around the matrix template provided in the worksheet.
	***Purpose**:* Identify the ES that may be affected by the decision at hand.

Task 2.2 – Identification of ecosystem services affected by the decision	***Role of participants:*** Deliberate on which ES could be affected by the alternatives adding and removing cards according to their perceptions on the subject. Participants can also introduce new cards with different ES or remove others (approach developed based on Simo's card method (Antunes *et al*., 2012)).
	Role of research team: Deliver the cards with ES, that should be selected according to the collected information for articulation. Research team should also facilitate the discussion among participants and clarify any questions regarding the concept and definition of ES (*e.g.*, one member of the team takes notes, while the other facilitates the group discussion).
	Materials: Cards with ES names and blank cards; a list of ES identified in the study area is distributed. This information is collected in the 'set the scene' stage of the adopted Framework.
Task 2.3 - Scoring the impact of alternatives on ecosystem services	***Purpose****:* Classification of the effects of the alternatives on ecosystem services.
	Role of participants: Classify the degree of impact of each alternative in the identified ES by drawing of sticking different dots according to the attributed impact *(e.g.,* red for negative; green for positive and blue for indifferent). During this sub-task, participants have the option to attribute a "red flag" to any ecosystem service they considered to be critical. This means, that in case of a negative impact in the service with the red flag, the alternative should not be considered (based on the approach proposed by Antunes *et al*., 2012).
	Role of research team: Provide the cards with ES, that should be selected according to the collected information for articulation. Research team should also facilitate the discussion among participants and clarify any questions regarding the concept and definition of ES (*e.g.*, one member of the team takes notes, while the other facilitates the process).
	Materials: Colour markers or coloured sticky dots.

Task 3 - Group exercises II – Impact of alternatives according to selected criteria (60 min)	
Task 3.1 - Criteria selection	***Purpose****:* Comparison of the alternatives against the evaluation criteria.
	Role of participants: Deliberate on which specific ecological, economic and social criteria to use in the evaluation of alternatives. Participants may add and remove cards while deliberating, or introduce new cards with new criteria (approach is based on Simo's card method proposed by Antunes *et al*., 2012).
	Role of research team: Provide the cards with possible evaluation criteria, selected according to the collected information for articulation. Research team should also facilitate the discussion among participants and clarify any questions regarding the concept and definition of criteria (*e.g.*, one member of the team takes notes, while the other facilitates the discussion).
	Materials: Cards with criteria names (*e.g.*, blue cards for social criteria, red cards for economic criteria, and green cards for ecological criteria), as well as blank cards; Previously developed causal models for the relevant ES and critical variables. This information is collected in the "deepen understanding" stage of the adopted Framework; Colour markers or coloured sticky dots.
Task 3.2 - Scoring alternatives against criteria	***Purpose****:* Classify the alternatives according to the perceived effects on different criteria.

	Role of participants: Classification of the level of impact of each alternative in the identified criteria, for example, by drawing different arrows according to the specific level of impact (*e.g.*, increase, decrease, or no effect)). During this sub-task, participants have the option to attribute a “red flag” if they consider that a given criterion is critical, i.e., an undesired effect on a red flagged criteria indicates that the alternative should not be considered (Antunes *et al*., 2012).
	Role of research team: Research team should facilitate the discussion among participants and clarify any question regarding criteria and classification process (*e.g.*, one member of the team takes notes, while the other facilitates the discussion).
	Materials: Markers for filling in the impact matrix.
Task 4 - Group exercises III - Decision-Making	
Task 4.1 - Decision-making simulation	***Purpose**:* Simulate the decision-making process
	Role of participants: The group is asked to deliberate based on the obtained outcomes and come up with (a simulation of) a decision using the developed matrices.
	Materials: document with indications to guide the discussion during the simulation exercise (*e.g.* how the group considered the different criteria?; which matrix was used? or both?; which rationale and decision rule was followed?).
Task 4.2 - Plenary presentation	***Purpose**:* Presentation of the outcomes of the group exercises to all participants
	Role of participants: The groups spokesperson presents to all participants their final decision and the process that was followed to achieve that outcome.

5.4 Results

5.4.1 Case-study

The proposed methodology was tested in Arrábida Natural Park (ANP), a Portuguese protected area, that comprehends a marine and a coastal area. This protected site was already used previously for testing a participatory scoping and systems mapping process of ES (Lopes and Videira, 2015; 2016). The nature conservation status confers several challenges to this area, due to tensions between high human presence on the territory and preservation of natural ecosystems.

From those previous experiences, it was found that stakeholders give high importance to provisioning and cultural services. A set of meetings with the Park management team was organized in order to select the decision-making processes to apply the proposed approach. Two prominent decisions surfaced regarding a pressing environmental conflict – the expansion of vineyards land use category in the park – and, the comparison of project alternatives for regulating access to protected beaches and recreational activities. These meetings also allowed to capture park managers' perceptions on the relevant alternatives to assess during the process.

A participatory workshop took place in April 2016 at Casa da Baía, Setúbal gathering fourteen participants from different backgrounds and representing different stakeholder groups: public administration (nine participants), research institutions (one participant) and local businesses (four participants). Through a sequence of exercises participants were engaged in a deliberative process that fostered value articulation regarding the selected decision-making contexts. Figure 5.2 illustrates the case study area and the two decision processes analysed in the value articulation workshop.

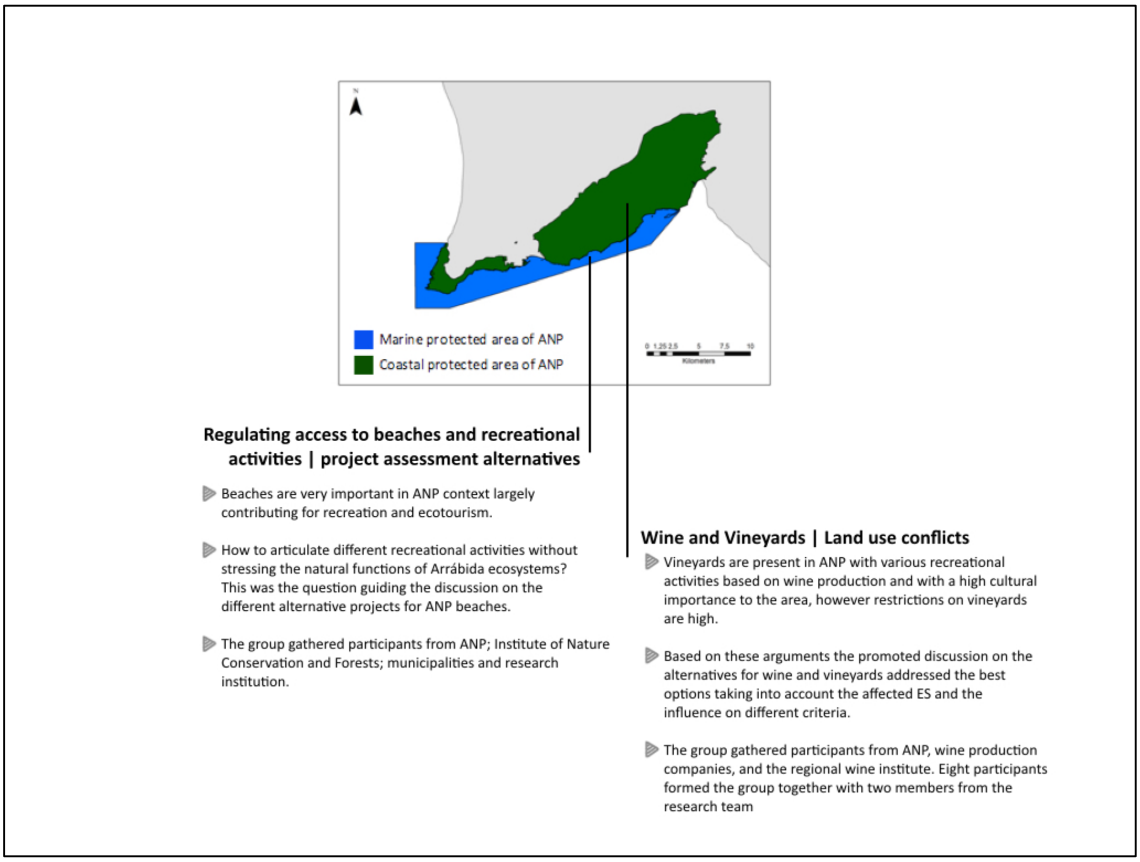


Figure 5.2 – Case study | Decision processes explored for the ES value articulation process

Vineyards are present in ANP with various recreational activities based on wine production and with a high cultural value attached to the area. On the other hand, ANP restrictions on vineyards land uses are in place leading to conflicts among wine producers and nature conservation managers. Different authors have pointed to the importance of managing these areas in order to improve related ES and to handle associated trade-offs. According to Orre-Gordon et al. (2013), the way a wine region is managed influences tourism attractiveness, and may positively influence local biodiversity when focusing on native species (Fiedler et al., 2008; Jedlicka et al., 2011). If vineyards are monocultures they will reduce the natural abundance of species, which can increase the vulnerability of vineyards to pests (Viers et al., 2013). According to Williams et al. (2011), a mosaic with wines and native natural land cover may help to increase carbon stocks in the soil. Based on these arguments the promoted discussion on the alternatives for wine and vineyards addressed the best management options taking into account the affected ES and the influence on different criteria.

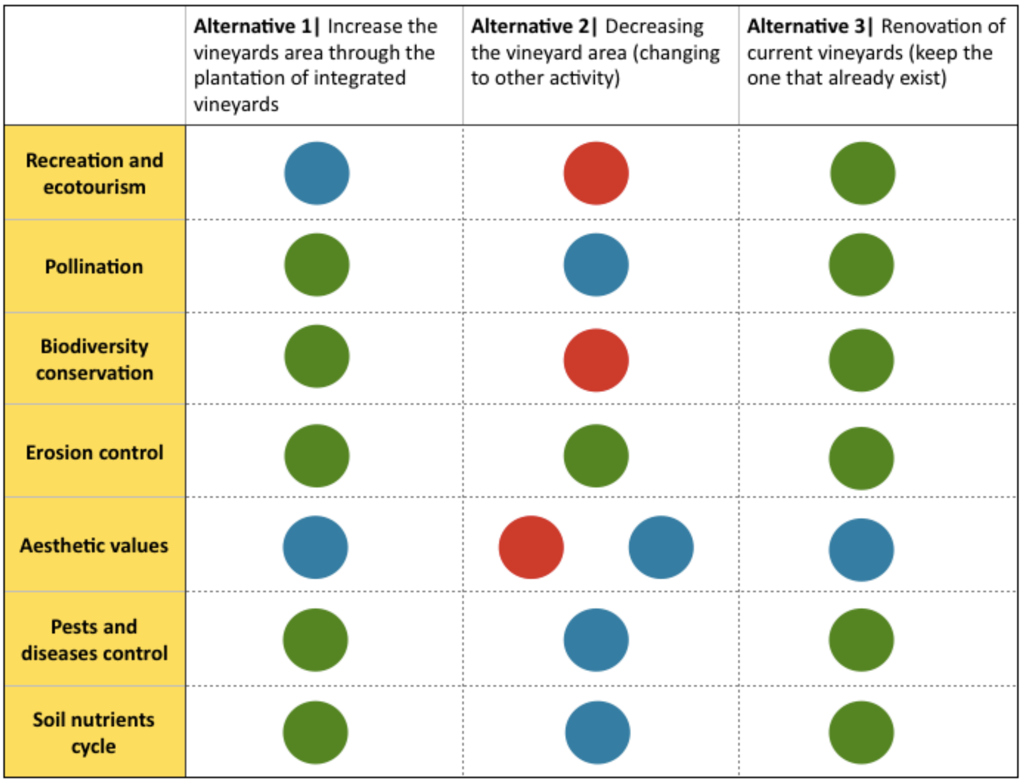
Beaches are also very important sites in ANP context, largely contributing for recreation and ecotourism activities in the area. Beaches are natural systems that need space to response to natural and anthropogenic pressures (Marshall et al., 2014). They are responsible for natural delivering of diverse ES like recreation and aesthetic values. The natural beauty of ANP beaches attracts a high number of visitants each year. These visitants ask for more and better support infrastructures, however this could mean an increase in pressures to other ES (*e.g.*, habitat provision; biodiversity conservation, or aesthetic values). Beaches are valued for the opportunities they offer, their habitats, and benefits for tourism (Johns et al., 2001). Oversizing beaches beyond their carrying capacity results in a substantial loss of natural functions and biodiversity (Marshall et al., 2014). How to regulate access to different recreational activities without stressing the natural functions of Arrábida ecosystems? This was the question guiding the discussion on the different alternative projects for ANP beaches.

While the methods and tasks developed on the workshop have been described in the script provided in Table 3, the following sections detail the results achieved in each of the two participant groups addressing the two decision contexts outlined above.

5.4.2 Wine and vineyards – land use conflicts

5.4.2.1 Impact of alternatives on ecosystem services

This group gathered participants from the ANP, wine production companies, organizations, and the regional wine institute. The group was formed by eight participants and two members of the research team. Participants started by introducing themselves and by discussing the initial alternatives proposed by the research team following the preliminary meetings with ANP managers. During the first exercise (see Table 3, task 2) participants decided that the initial four alternatives should be reformulated, which included: i) increase the vineyard area through new traditional plantations, ii) increase the vineyard area through the plantation of biological vineyards, iii) decrease the total vineyard area in the ANP, iv) maintain the current vineyard areas, only allowing restoration of old crops. The first alternative (i) was ruled out by the group, with one participant arguing that "*in a natural park, the conventional plantation of vineyards is not recommended*". One the other hand, in the second alternative (ii), the designation of 'biological vineyards' was adjusted to 'integrated vineyards plantation methods', since according to the group, biological vineyards are considered less sustainable than integrated production. Integrated production was defined as a set of guidelines specifying good agricultural practices related to grape production. They can be related to different activities (*e.g.*, farm, winery and bottling), separately or in combination, contributing positively to biodiversity, soil and water conservation, enhancing ecosystem regulation, natural resource preservation, among other benefits. Regarding the third alternative (iii), the group decided to elaborate on its specification, namely by adding that a decrease in the total vineyard area would imply substitution by another economic activity (*e.g.,* cattle production). After the definition of the decision alternatives the group based on the provided yellow cards representing ES and on the information from the "set the scene" stage discussed and deliberated on the ES that may suffer impact from the alternatives. Figure 5.3 shows the matrix obtained in this first group exercise.



Colours key: negative impact | positive impact | indifferent

Figure 5.3 – Matrix results from task 2 (impacts of alternatives on ES) for the group "wine and vineyards conflicts"

From the analysis of Figure 3 we conclude that the group was able to reach a consensus regarding the identification of ES affected by each alternative. The exception was the impact on "aesthetic values" in alternative 2 where some disagreement was observed. While some participants reckoned that a decrease in vineyard areas would lead to negative impacts on this service, others considered that the alternative would not affect it, neither positively nor negatively.

Overall, alternatives 1 and 3 are expected to generate more positive impacts on the protected area's ES than alternative 2. Regarding the latter option, participants considered that decreasing the vineyard area would negatively affect "recreation and ecotourism" due to the losses in number of visitors driven by wine-related activities. In the case of "biodiversity conservation", a negative impact was also expected since vineyards attract protected species, which would suffer with the reduction of its habitat.

Increasing the area of vineyards in the Park (alternative 1) and restoration of old crops in the current vineyards (alternative 3) yield similar results according to participant's perceptions, with positive impacts expected for the majority of the possibly affected ES.

5.4.2.2 Impact of alternatives according to selected criteria

The second group exercise (see Table 5.3, task 3) aimed to select the multi-dimensional evaluation criteria to compare alternatives. To kick-start discussions, we provided examples of potential economic, social and ecological criteria to include in the analysis. The selection of the final criteria by participants was supported by the information collected in stage 2 ("deepen understanding") of the proposed conceptual Framework. We provided examples of ES social, economic and ecological indicators defined from the causal loop diagrams elaborated at that stage and these informed the selection of criteria. For example, in the case of biodiversity conservation, participants selected protecting habitats and species as criteria, and left out other indicators translating ecological criteria, such as ecological quality status or total species abundance, which had also been provided as preliminary options. For the case of aesthetic values, maintenance of landscapes was selected as criterion, based on the associated indicators defined in the previous workshop.

Figure 5.4 shows the final matrix result with the selected criteria and the attributed arrows translating the effect of the alternatives on a given criterion. As described in the workshop script (Table 5.3) participants had the opportunity to add a "red flag" to a criterion that they considered to be critical.

			Alternative 1| Increase the vineyards area through the plantation of integrated vineyards	Alternative 2| Decreasing the vineyard area (changing to other activity)	Alternative 3| Renovation of current vineyards (keep the one that already exist)
Revenues			↑	↓	↑
Gross added value			↑	↓	↑
Supply diversification			→	↓	→
Protected Species	x		↑	↓	↑
	y		↓	↑	↓
Protected habitats			→	→	→
Soil erosion			→	→	→
number of jobs			↑	→	↑
Compatibility of uses and activities			↑	→	→
Cultural heritage			→	↓	→
Landscape			→	→	→
Winetourism			↑	↓	↑

Arrows key: ↓ Decrease | ↑ Increase | → Maintain or indifferent

Figure 5.4 – Matrix of results from task 3 (impacts of alternatives on selected criteria) for the group “wine and vineyards conflicts”

A differentiation was made by the group in the criterion “protected species”, since some protected species benefit from vineyards (*e.g.*, such as the common starling, *Sturnus vulgaris*) represented by “x”, while other species present in wild nature could be negatively affected by the increase of these areas, represented by “y”.

Overall, alternatives 1 and 3 scored better (i.e. expected impacts change in the preferred direction of selected criteria). However, since participants allocated red flags to the “protected species” criterion, when choosing alternative 1 or 3 it should be guaranteed that species “y” would not be affected by the alternative, otherwise it should be rejected.

This second exercise, started with a lively debate between wine producers and park managers, the former arguing that the park should license more vineyard areas and the latter saying how vineyards within the park boundaries have negative impacts. As the exercise progressed, with the need to assess each alternative across the criteria for the different value dimensions they started to realize that they shared an understanding on the impact of alternatives, despite their initial opposite mind sets. In the end, they all have agreed that alternative 2 would not perform well regarding both economic (*e.g.*, decreasing revenues or supply diversification) and ecological criteria. This is due to expected impacts on protected species and to the fact that decreasing vineyards in the park would imply an increase of other economic activities, which could be worse from an ecological perspective.

We observed that the exercises structured well the discussion with the use of different criteria translating multidimensional ES values. The need to classify the effects of alternatives (*e.g.*, choice of arrows), allowed participants to find a common language that was not yet determined by quantitative values attached to each indicator substantiating the evaluation criteria. While this qualitative judgment worked well to overcome possible bias that the numeric values of indicators might bring, this does not mean that further developments and iterations could not be pursued, based on the quantification of the indicators and the changes induced by each alternative.

5.4.2.3 Decision-Making

At the end of the workshop, participants were put in a simulation context where they were asked to decide on the preferred alternative, if they were to use the information and matrices produced in the event.

The wine group agreed that the second alternative should be eliminated, however to decide between the first and the third they proposed to count the arrows representing a change in the desirable direction of criteria. They concluded that the first alternative was the best since it would improve most of the selected indicators, however a guarantee should be given regarding the "protected species, y". When they were asked to express which criteria should always be considered when deciding on vineyards allocation in protected areas, participants said that all of them were important, however protecting species and habitats, increasing revenues and maintaining landscapes should always be taken into account. This shows that ecological, social and economic criteria were simultaneously considered, underscoring the importance of integration of different value dimensions. Through this approach, participants stated their perceptions on the value dimensions that should be considered when making a decision and how they should be integrated.

5.4.3. Assessing alternatives for regulating access to beaches and recreational activities

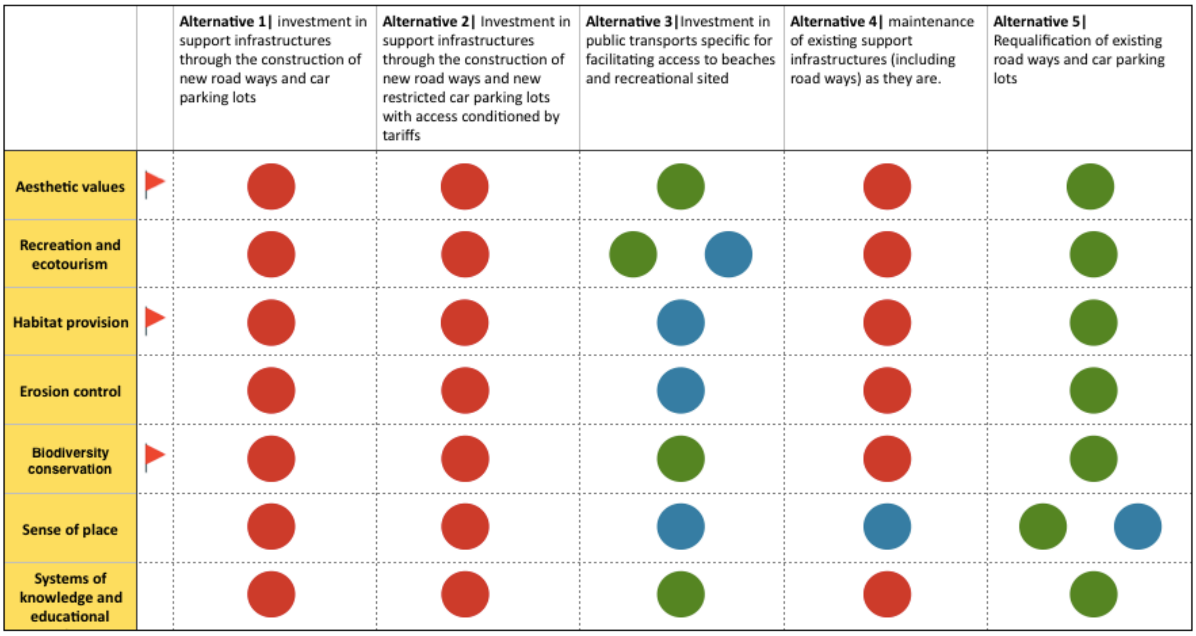
5.4.3.1. Impact of alternatives on ecosystem services

The second group dealt with another type of decision, namely, the assessment of project alternatives for regulating access to beaches and recreational activities. It gathered a total of six participants including representatives from ANP, the Institute of Nature Conservation and Forests, municipalities and research institutions. This group was perceived as more homogeneous, in the sense that mind sets were more aligned from the onset and there was no previous knowledge on pre-existing conflicts among participants.

The group activity started with definition of the alternatives to be discussed. The preliminary alternatives presented by workshop organizers included: 1) investment in support infrastructures through the construction of new road ways and car parking lots; 2) Investment in support infrastructures through the construction of new road ways and new restricted car parking lots with access conditioned by tariffs; 3) Investment in public transports specific for facilitating access to beaches and recreational sites, and 4) maintenance of existing support infrastructures (including road ways) as they are. After initial deliberation, participants added a fifth alternative, defined as 5) Requalification of existing road ways and car parking lots.

Figure 5 presents the obtained results from the first exercise. Based on their knowledge and on the provided information (*e.g.*, list of ES from the first stage – "set the scene") the selected ES to be considered when deciding on projects for regulating access to beach and recreation sites were: aesthetic values; recreation and ecotourism; habitat provision; erosion control; biodiversity conservation; sense of place and systems of knowledge and educational values. Analysing the impacts of the different alternatives on these different ES, it is evident that according to participants' perceptions the third and fifth alternatives are the ones with the most positive impacts. It was also evident that investments on additional support infrastructures represent the worst alternatives in terms of ES impacts, since both options (alternatives 1 and 2) only negative effects.

This group also decided to assign "red flags", namely to signal a critical result when alternatives affected negatively the following ES: "aesthetic values", "habitat provision" and "biodiversity conservation", which was the case for options 1, 2 and 4.



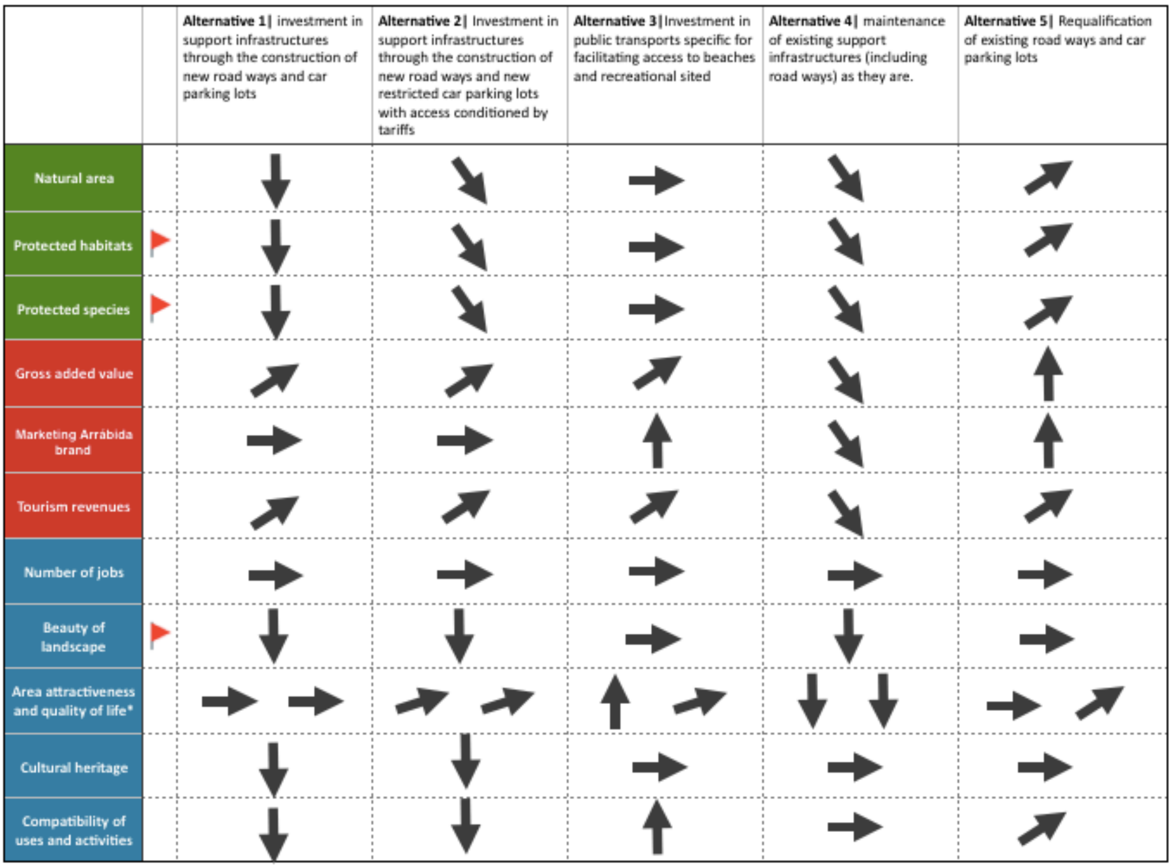
Colours key: negative impact | positive impact | indifferent

Figure 5.5 - Matrix results from task 2 (impacts of alternatives on ES) for the group “Projects to access to beach and recreational activities”

5.4.3.2. Impact of alternatives according to selected criteria

When developing the second exercise this group proposed to differentiate the degree of intensity of the arrows classifying the effect induced by alternatives on each criterion, considering that an increasing/decreasing effect could be lower or higher, which was translated by using different arrow slopes.

From the analysis of the resulting impact matrix (Figure 5.6) we can see that alternative 5 is the one that performs better, since it has the highest number of increasing arrows (with different intensity levels), which means that this alternative leads to desired direction of changes in the majority of selected criteria. On the contrary, alternative 4 performs worse, with negative impacts expected on the majority of criteria, with the exception of ”number of jobs”; “cultural heritage” and “compatibility of uses and activities”, which was expected to remain the same. This means that the option of doing nothing – i.e., maintaining access to recreation sites as they are presently – is also not desirable. Alternatives 1 and 2 also perform worse with respect to most ecological and social criteria, while alternative 3 was evaluated with positive effects on social and economic ES criteria.



Arrows key: ↓ Higher decrease | ↑ Higher increase | → indifferent | ↗ Lower increase | ↘ Lower decrease

*The group of participants felt the need to score separately area attractiveness and quality of life.

Figure 5.6 - Matrix of results from task 3 (impacts of alternatives on selected criteria) for the group "Projects to access to beach and recreational activities"

If the analysis would only be based on economic criteria, only the fourth alternative would be ruled out. However, when including ecological and social criteria in the decision space we see that alternatives 1 and 3 bring negative effects. The group chose to attribute three red flags, which means that alternatives affecting negatively "protected habitats", "protected species" and "beauty of landscape" would be critical and should not be selected, which was the case for alternative 1, 2 and 4.

5.4.3.3. Decision-Making

When this group was asked to simulate a decision based on the produced matrices, they developed a rationale according to which, for each alternative, the number of arrows translating a positive effect is summed, and then the number of arrows with a negative effect is subtracted. This decision rule implicitly assumes some compensation of impacts amongst value dimensions. The higher net result was thus achieved for alternative 5, followed by alternative 3.

5.5 Discussion

As previously mentioned, ES valuation methods may be seen as value articulating institutions and consequently not neutral (Jacob, 1997; Vatn, 2005). We support the claim that participation is in itself a value articulating institution and when promoted within a comprehensive and integrated assessment platform it is able to foster articulation of ES values. Based on this premise, the questions guiding the concept of "value articulation institution", as formulated by Vatn (2005), were adapted to structure the discussion of results of the proposed approach.

Who should participate?

Different stakeholder groups were invited to the participatory process. The stakeholder analysis developed at the "set the scene" stage (Lopes and Videira, 2016) led to the identification of a broad list of relevant stakeholders that were invited to all stages of the adopted conceptual Framework. Stakeholders participated assuming the perspective of the represented organization, allowing to capture complementary perceptions from authorities and government, civil society, research institutions and businesses. Representativeness of the invited stakeholder list was validated according to participants' perspectives, who had the opportunity to recommend and suggest others. While not all stakeholder groups have been equally represented throughout the process, plural perspectives have been included. In the described value articulation workshop, a diversity of participants affected or affecting the selected decision processes was present.

How did stakeholders participate?

Stakeholder engagement started in the supporting stages where information for articulation was collected and two previous workshops took place. This involvement was promoted through additional platforms including, face-to-face interviews and online surveys. All engaged actors had the opportunity to provide inputs to the process, both orally and written form, working in groups and individually. A core group of twelve participants involved in the ANP case study have been present in two or more events, which allowed to maintain a coherence without alienating other participants.

What counts as data? How is information conveyed to participants? and How is data produced?

The information for value articulation refers to the importance attributed to ES in the different dimensions (ecological, economic and social). In this sense, a process of this nature needs a prior identification of ES provided by the study area, as well as, a set of associated indicators that allow to express the effect of the alternatives on the identified ES. This information may be produced and distributed in different formats (*e.g.*, tables, graphs, maps, causal diagrams, indicators) at the beginning of the workshop to support deliberation, collected from different sources (*e.g.*, valuation studies, official statistics, tacit knowledge of participants).

In the ANP process, a list of ES provided by the area was obtained at the first stage of the adopted conceptual Framework (Lopes and Videira, 2016) and a set of indicators was defined at the deepen understanding stage (Lopes and Videira, 2015). Although there was not sufficient information to quantify all indicators at the date of the workshop, they supported the establishment of the evaluation criteria. The sequence of stages performed brought consistency to the analysis of alternatives, selection of evaluation criteria and assessment of ES impacts, as well as creation of a shared understanding amongst the participating stakeholder groups. Even for the case of stakeholders who have not participated in the supporting stages, it was still possible to accommodate their perspectives in the value articulation workshop. For example, in the conflict resolution case described in section 4.2, participants who did not attend previous workshops were struggling with the first group exercise, dealing with the identification of affected ES. After the research team members facilitating this group explained again the concepts and showed examples of ES identified at the scoping stage, these participants were able to express their views and engage in the workshop tasks.

How are conclusions reached?

The value articulation workshop allowed participants to discuss and deliberate on different value dimensions of ES in the Arrábida area. The articulation of information was translated by the matrices showing the impacts of alternatives on ES and on evaluation criteria. Participants were asked to propose themselves a decision rule to reach closure. One possible way was a consensus-based solution reached upon argumentation and matrices' results. However, as stated before, this approach, is also prone to limitations. For example, a linear sum of effects generated by a given alternative may imply accepting compensation among criteria associated with different value dimensions. We therefore gave the possibility for participants to decide whether they would like to incorporate other decision rules reflecting non-compensatory viewpoints in the appraisal exercise, such as the assignment of "red flags" to ES and evaluation criteria.

With the proposed participatory tasks tested in the ANP case study, we tried to address some constraints of ES value articulation approaches described in Table 5.1. Firstly, the co-produced and shared knowledge from the supporting stages allowed to include different perspectives and to integrate a plurality of values. Secondly, bringing participants' perceived relevant criteria to the discussion allows incommensurable values to be considered. Decoupling the selection of criteria from actual measurement of associated indicators allowed to tackle potential biases regarding the choice and classification of evaluation criteria. This means that during the workshop participants were actually first asked to deliberate on relevant criteria for the assessment. Alternatives may be subsequently scored using quantitative information on the changes induced by a given alternative in each criterion indicator, which may be a follow-up iteration recommended for the ANP case.

How does stakeholder deliberation affect the articulation of values as opposed to individual mental models?

As indicated in the workshop script (Table 5.3), before starting the group activities participants were asked to fill in an individual questionnaire. They were surveyed on the same questions to be addressed during the group activities (*e.g.*, definition of alternatives, affected ES, evaluation criteria, decision making rule), which provided an instrument for measuring effects of the deliberative process (Table 5.4).

It is possible to observe in Table 5.4 that deliberations in both groups expanded individuals' mental models on which are the ES affected by the decisions, as well as the criteria/indicators for evaluation. Grey cells also denote that despite new ES and evaluation criteria have been identified as a result of group deliberations, there are, as expected, common results to the "before" and "after" workshop results. By means of group discussions, individual perceptions were then broadened and participants created a more comprehensive set of criteria and ES affected by decisions.

The individual answers to the last question also support the notion that frequently people have preconceived ideas on the "best" option, often without formalizing an explicit decision rule upon which that decision is made. Many participants indicated before workshop activities which was the best alternative without expressing the underlying criteria or thinking about affected ES. Bringing into the discussion criteria translating economic, social and ecological values of ES, shed new light into the benefits and the disadvantages of each alternative. Although the deliberative process unfolded differently in the two groups, both cases showed integration of ecological, economic and social value dimensions. With this respect, the proposed sequence of tasks to be conducted in a value articulation workshop worked well in challenging participant's preconceived ideas on 'what is the best alternative' through the deliberative tasks that structured the examination of alternatives.

Table 5.4 – Comparison of results from the individual questionnaires (at the beginning of the workshop) and the group exercises (at the end of the workshop)

	Decision process I: Wine and vineyards land use conflicts	Individual	Group	*Decision process II: Regulating access to beaches and recreational activities*	Individual	Group
Survey (1st Question): Which are the ecosystem services affected by the decision? **Workshop (Task 2.1):** Selection of affected ecosystem services	Biodiversity conservation	2	✔	Habitat provision	4	✔
	Erosion control	1	✔	Aesthetic values	2	✔
	Nutrients cycle	1	✔	Recreation and ecotourism	2	✔
	Recreation and ecotourism	2	✔	Biodiversity conservation	2	✔
	Aesthetic values	1	✔	Sense of place	0	✔
	Pests and diseases control	0	✔	Knowledge and education	0	✔
	Pollination	0	✔	Coastal protection	2	x
	Soil nutrients cycle	0	✔			
	Habitat provision	3	x			
	Soil formation	1	x			
	Climate regulation	1	x			
Survey (2nd Question): Which decision critera / indicators would you choose? **Workshop (Task 3.1):** Criteria / indicators selection	Protected species	1	✔	Natural area	1	✔
	Protected habitats	1	✔	Protected habitats	2	✔
	Revenues	0	✔	Protected species	0	✔
	Gross added-value (GAV)	0	✔	Gross added-value (GAV)	0	✔
	Supply diversification	0	✔	Marketing Arrábida brand	0	✔
	Soil erosion	0	✔	Tourism revenues	0	✔
	Number of jobs	0	✔	Number of jobs	0	✔
	Conflicts of uses and activities	0	✔	Beauty of landscape	0	✔
	Cultural heritage	0	✔	Area attractiveness and quality of life	0	✔
	Landscape	0	✔	Cultural heritage	0	✔
	Wine tourism	0	✔	Compatibility of uses and activities	0	✔
	Economic (generic)	1	x	Landscape integration	1	x
	Business point of view (generic)	1	x	Coastal protection	1	x
	Vineyard area	1	x	Nature cinservation (generic)	1	x
	Available area for plantations	1	x	Users' safety	1	x
	Soil slope	1	x	Spatial planning	1	x
	Environmental impact (generic)	1	x	Coastal sustainability (generic)	1	x
				Habitat provision	1	x
				Recreation and ecotoruism	1	x
				Costs (generic)	1	x
				Feasibility of alternatives	1	x
				Investments	1	x
Survey (3rd Question): How would you decide? Which alternative would be chosen? **Workshop (Task 4.1):** Deliberation on decision-making rules	Selecting the alternative with higher number of positive impacts and taking red flags into account (Alternative 1)	0	✔	Selecting the alternative with higher net positive impacts on criteria and taking red flags into account (Alternative 5)	0	✔
	Identify intervention zones, define an increase in the allowed areas and monitoring habitats (Alternative 1)	1	x	Selecting alternative 2	1	x
	Selecting an option which reduces the area for other land uses	1	x	Selecting after evaluating alternatives according to safety versus conservation criteria	1	x
	Selection after reflecting upon selected criteria	1	x	Selecting alternative 3	2	x
	Selecting the lowest environmental impact option and performing economic valuation of wine production	1	x	Selecting after environmental impact and risk assessments of alternatives	1	x

Despite these positive outcomes, some limitations can be pointed to the process, such as the fact that discussions took place in a research context, as the process was not mandated by the decision-makers in the public agencies who have jurisdiction on the decisions addressed in this experiment. Nevertheless, by selecting two concrete decision-making processes that were relevant pressing challenges for the ANP allowed to offer a realistic setting for testing the proposed approach. Another aspect that is suggested for further development is the extension of the multi-criteria analysis process considering also a quantitative appraisal of the changes promoted by each of the assessed alternatives, which requires a quantitative assessment of the selected set of economic, social and ecological indicators associated to each criterion.

How did participants evaluate the process?

At the end of the workshop, participants were asked to answer an evaluation questionnaire aiming to capture their individual impressions on the workshop, the methodological approach that was followed and the achieved outcomes. Despite some differences observed between the two groups the overall results were very positive. Figure 5.7 shows the most frequent answer per group. Each participant could answer according to a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

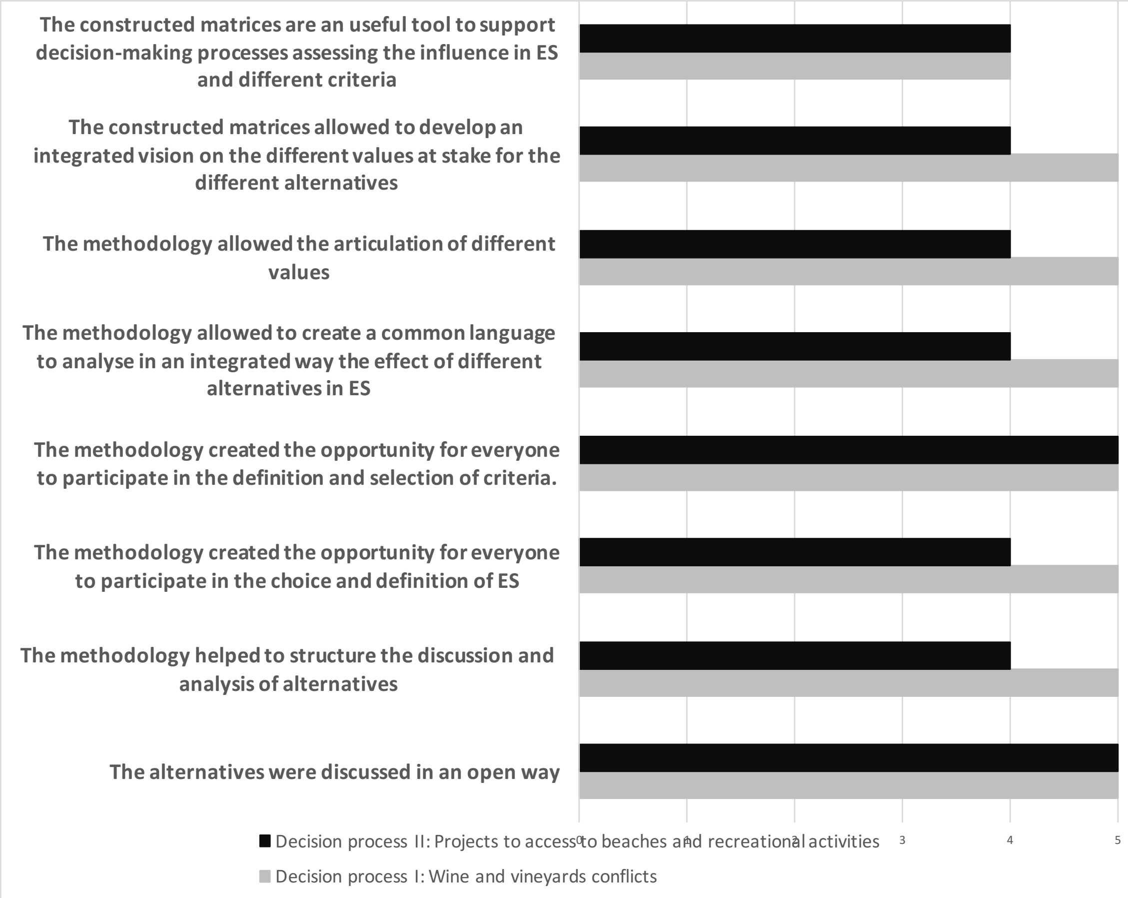


Figure 5.7– Workshop evaluation survey results (most frequent answers per group)

We can see that the most frequent answers to all the questions were 4 (agree) and 5 (strongly agree), which shows how the methodology was judged positively by participants. The constructed matrices were considered an advantageous tool to support decision-making processes and to capture an integrated vision on the different values at stake for the different alternatives. As reported by participants the approach allowed the articulation of different values, creating a common communication platform that gave a chance for everyone to participate.

5.6 Conclusion

This paper advances a participatory approach to relate and integrate ES values informing decision-making processes. Drawing from the concept of value articulating institution, stakeholder participation is adopted as a frame to promote deliberation on multiple value dimensions through the collaborative construction of impact matrices depicting participants' perceptions on the effects of different decision alternatives on ES and associated evaluation criteria/indicators.

The empirical testing of the methodology in the Arrábida Natural Park case study revealed positive outcomes regarding the role of involving inter-organisational stakeholder groups in deliberative ES assessment processes. Results from both workshop observations and questionnaires showed that new insights are created and a shared understanding is possible when participants are brought together to appraise decision alternatives based on scientific information and tacit knowledge on functioning of the underlying socio-ecological systems. Group deliberations led to changes in participants' initial mental models, allowed to generate new alternatives, expanded perceptions on affected ES, and supported formalization of evaluation criteria and decision rules.

The presented research-oriented process offered useful lessons to the debate on the operationalization of multi-criteria stakeholder-based ES assessments in the context of two pressing challenges for local protected area managers in the case study area. The dissemination and replication of the proposed approach in other type of decision contexts is recommended to collect further insights on best practices and integrated assessment methods to engage stakeholders in non-reductionist ES value articulation processes.

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Chapter 6 | General Discussion and Conclusions

"The answers you get depend on the questions you ask."

— Thomas S. Kuhn

6.1 General discussion

ES is a concept which evolved quickly from the research arena to the policy field. This brings forward the pressing need to create strategies informing decision-making processes and guaranteeing that ES values are not overlooked. The first attempts to capture the importance of these services to highlight their crucial role in our lives were mostly aligned with an economic valuation perspective. To promote a plural value approach different research lines started to investigate procedures capable of capturing multiple perspectives / world views translated into ES values.

An ES approach calls for participation, which should encourage the engagement of all interested parties in sharing and in co-producing knowledge. ES values may then assume different metrics and be translated in several quantitative and/or qualitative forms, which need to be articulated.

This research aimed to develop a comprehensive approach capable of articulating multiple value dimensions attached to ES. Through the construction of a conceptual Framework, the goal was to understand if and how participation, with a structured and coherent sequence of tasks, could act as a value articulating institution, fostering the integration of multiple values of ES into decision-making processes. Three interconnected stages – set the scene, deepen understanding and articulate values - were proposed to unfold sharing of experiences and knowledge regarding ES. Testing the Framework in Arrábida Natural Park (Portugal) allowed to draw insights and elicit the practical implications towards an effective implementation of such methodological approach.

The following sections present a general discussion of the pros and cons of the Framework and case study process with analytical focus on the participatory elements, its overall evaluation and the enabling factors for replication in other contexts. The chapter concludes with insights for policy and suggestions for future research developments.

6.1.1 Evaluation of participatory process

In this section the participatory process is discussed and analysed regarding the main achievements and the identified limitations. The fact that the empirical testing of the conceptual Framework was framed in an exploratory research context, as opposed to a formal participation process convened by local authorities in the context of an ongoing decision-making process, created some uncertainty regarding the willingness of stakeholders to participate in research activities. Additionally, the novelty of the process and the possible unfamiliarity of stakeholders with the ES concept could have led to low levels of engagement. Hence, the successful testing of the developed Framework depended *a priori* on the voluntary participation of different stakeholders and their commitment and predisposition to participate in workshops and other interactive tasks where they would learn and share knowledge.

Figure 6.1 illustrates the participatory process in terms of the number of participants (by stakeholder groups) in the different steps of the Framework testing ground, highlighting the scope of each participatory stage, which have implications on the participation rate.

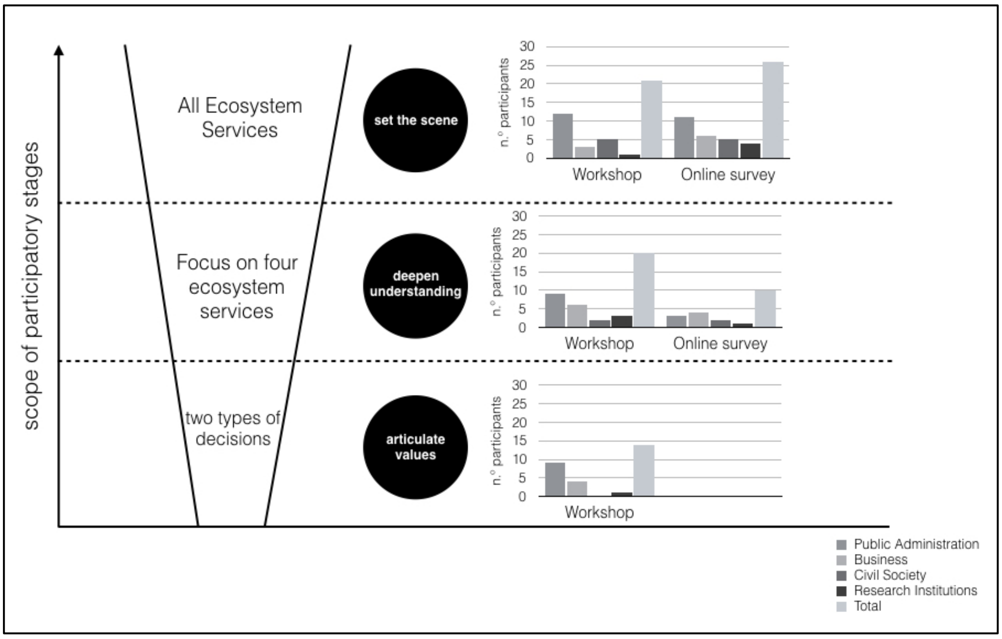

Figure 6.1 – Participatory process and participation rate in each stage

Despite the uncertainties referred above, the outcomes of the process demonstrate as a first immediate result that it is was possible to engage a group of protected area stakeholders in a sequence of three stages such as the one advanced in the proposed Framework. The positive engagement of interest parties is revealed mainly through the number of participants and their diversity. Stakeholders were organized according to four different stakeholder groups: “Public Administration”, “Business”, “Civil Society” and “Research Institutions”. All the groups were represented in the different stages, with exception for civil society in the last workshop. “Public Administration” was always more represented, however this group includes different categories (*e.g*. central administration, local administration, park management institutions). Contrary to a “neo-liberal” participatory mode (Renn and Schweizer, 2009), where representation is decided in proportion of the share of preferences in the affected population, we rather aimed at gathering as much diversity of worldviews as possible combining elements of “deliberative”, “post-modern” and “functionalist” modes of participation (Renn and Schweizer, 2009), in order to have the different perspectives reflected in the discussions (Vennix, 1996). In that sense, it is possible to say that the process achieved this goal, with a similar distribution of stakeholders and participation rate at the different stages.

As depicted in Figure 6.1 the scope of ES analysis started very broadly and narrowed down as the process evolved, which means that the number of participants were expected to be higher in the first workshop than the following stages. This was in fact observed, however it is not possible to affirm that other aspects have not contributed to that fact (such as, for example, participants' agenda constraints for attending a given workshop, or lack of motivation to sustain participation in a research-oriented experiment).

It may be concluded that the participatory process was able to engage stakeholders, with a core group of participants highly committed during the different states. The process provided multiple opportunities for people to participate, and in different formats (*e.g.*, interactive workshops versus individual surveys).

As pointed out by Webler and Tuler (2001), there is no single definition for what a good participatory process is, however, there are some guiding criteria that this process tried to pursue: a) be legitimate, given the research nature of the empirical process; b) promote a search for meaningful values, fostered during all the process; c) realise democratic principles of fairness and equity, which was the base for the participatory process design; d) promote equal power among all participants and viewpoints, since every participant had opportunity to participate and contribute to the results; e) foster responsible leadership, by having park managers engaged during all the stages.

Participants have also evaluated the process in its different steps, through evaluation surveys allowing them to provide feedback on the approach, methods and tools, results and the quality of the interaction. Chapters 3, 4 and 5 explored participants' evaluation regarding each stage of the process – set the scene, deepen understanding and articulate values – with a positive result. Table 6.1. presents an overview of their evaluation regarding the whole process and in terms of individual and group levels, obtained through the combination of the different surveys' answers.

Table 6.1 – Evaluation of the process according the individual and group level (source: participants' evaluation surveys).

Individual Level **Workshop development**	**Group Level** **Workshop development**
• The process allowed to get a better understanding of the ES provided by the case study area; • The process promoted learning; • Time spent was worthy; • The process allowed for a sense of contribution to the overall results of the different participatory stages.	• The workshops allowed to structure the discussion on the different issues; • The workshops created the opportunity for everyone to participate in the discussion; • The workshops provided a common language to analyse ES in an integrated way; • There were productive discussions during the three workshops; • Participants worked as a group oriented towards the same goal; • The problems were discussed in an open and frontal way; • It was created a space for an interesting debate in the different participatory workshops.
Individual Level Workshop outcomes	Group Level Workshop outcomes
• The majority of participants throughout the workshops revealed interest in using the results in the future; • The majority of participants throughout the workshops revealed interest in using the methodology in the future; • The majority of the participants agreed on the main outcomes of the workshop (*e.g.*, identified ES; identified threats; variables and causal links; impact indicators; multi-criteria matrices).	• Recognition of ES provided by the area; • Social learning; • Co-production of knowledge; • Identification of causal interrelations among ES; • Identification of indicators to assess different ES; • Articulation of different values attached to ES.

The evaluation results according to participants' perspectives shows a positive outcome, since it demonstrates that the process achieved the expectations regarding the conduction of the sequence of tasks and the obtained outcomes. All the stages gave space and triggered co-production of knowledge, sharing of perceptions and experiences and values articulation. Outputs from one stage provided the inputs required for the subsequent one, thus conferring a sense of coherence to the overall approach.

6.1.2 Enabling factors for further applications of the Framework

Through the development and implementation of the proposed Framework, it was possible to identify which are the enabling factors for the replication of this Framework in future applications and dissemination to other contexts. The effective conduction and implementation of a process like the one developed in this dissertation will depend on different aspects and how they are combined. Table 6.2 summarizes these factors, cross-referencing the dissertation chapters where such analysis is described in detail.

Table 6.2- Enabling factors for the dissemination and transfer of the proposed Framework to other contexts

Enabling factors for replication	**Description**
Scope and Purpose	The scope and purpose for the application of the Participatory Conceptual Framework may be any process of assessment and valuation of ES to support decision-making processes (see Chapter 2). The implementation of the Framework should be supported by a real world decision or / and process, driving the political will to be involved in the process and use the outcomes of the process to inform the decision (Chapter 3, and section 6.1.1 Chapter 6).
Steering team	The steering team should be aware of the existence of multiple values and the integration of qualitative and quantitative approaches, which means that when implementing this Framework, it is expected to have the articulation of multiple value dimensions (see Chapters 3,4 and 5); The steering team should collect background information on the decision-making process under study, since such preparation empowers facilitation of the different participatory tasks. It is also suggested that facilitators have domain on the methods applied at each stage (*e.g.*, causal loop diagrams (Chapter 4); participatory multi-criteria (Chapter 5)) in order to improve effectiveness in the implementation of the procedures.
Study area	The study area where the Framework is to be implemented should be studied in order to accommodate the contextual factors connecting to ES assessments. This is particularly important when developing the institutional analysis and stakeholder dependency networks (see Chapter 3) and in the stage of articulating values (see Chapter 5). A concrete decision and alternative solutions regarding which the values will be articulated is a necessary premise in order to implement the last stage of the Framework (see Chapter 5).
Participation	For the success of the process participants should represent multiple views and stakeholder groups, preferably engaged from the very beginning of the process, as happened with the protected area managers in the Arrábida case study (see Chapters 3,4, 5 and section 6.1.1 from Chapter 6). To guarantee a better deployment of the participatory process the concept of ES should be

	communicated and explained in detail to participants at early stages (see Chapter 3).
Qualitative and quantitative data	In a process of this nature where qualitative and quantitative data are integrated, it is recommended to have robust information for use in developing the "deepen understanding" stage, such as in the construction of causal loop diagrams (see Chapter 4), as well as, on the ES evaluation criteria / indicators to integrate in the "value articulation" stage, for example through the use of multi-criteria analysis (see Chapter 5).
Sequence of tasks	The application of the suggested sequence of participatory stages is expected to lead to a useful outcome, since it progressively builds the information base for articulating values, as well as, social capital. The "deepen understanding" is dependent on the information generated on "set the scene" and "articulate values" stage depends on the inputs from "deepen understanding" stage. This information can already exist or it can be produced in complementary studies, through different methods, thus building the ES puzzle in a different form. However, information formats and contents should be consistent to allow the conduction of the different process stages (see section 5, Chapter 5). The combination of more than one participatory methods (*e.g.*, workshops; online surveys) and establishing a short period of time between the different stages are expected to enhance engagement and keep participants' motivated throughout the process.

When taking into consideration the enabling factors described on Table 6.2, it is possible to acknowledge that the implementation of the Framework, allows the accomplishment of the expected outputs from each stage.

In "set the scene" the expected achievements are the identification of the ES provided in the area, their main threats and the links with human wellbeing; a screening of importance (ecological, economic and social) of ES and the dependence network analysis. In the "deepen understanding" the outputs are the mapping of interrelations and feedbacks underlying ES, with the identification of critical variables and indicators. And in the "articulate values" stage the results should be the production of a holistic view integrating the different criteria and ES, and a multi-criteria analysis process translating how they are affected by different alternatives regarding the decision at hand.

6.2 Answering research questions

This section summarizes the answers to research questions, addressed in the different chapters of the dissertation. The first research question underpinned the whole investigation process and triggered development and testing of the methodology. The process of building the proposed approach started with the gaps found in the literature and the concerns highlighted therein regarding ES valuation and assessments. The answers to the subsidiary research questions were supported by the implementation of the participatory conceptual Framework to the selected case study.

RQ#1 - How to foster and structure the participatory integration of different values of ecosystem services in decision-making processes?

The need to integrate ecological, social and economic ES values (de Groot *et al*., 2002) has been acknowledged by different authors (Chan *et al*., 2012; Dendoncker *et al*., 2013; Gómez-Baggethun and Barton, 2013; Jax *et al*., 2013; Martín-López *et al*., 2014) tackling diverse criticisms of monist approaches such as the monetary ones (Spash, 2008). If ES are defined in broad terms as the benefits people obtain from ecosystems (Costanza *et al*., 1997; de Groot *et al*., 2002; MEA, 2005), it is evident the importance of deploying a participatory approach to integrate the perspectives of those parties that affect or are affected by changes in ES provision, from the early stages of a decision-making process (Kenter *et al*., 2015; Zagarola *et al*., 2014; Spangenberg and Settele, 2016).

As an attempt to address the identified needs, different authors have been working on approaches to deal with multiple value dimensions of ES. Examples include the development of specific plots with three value dimensions (*e.g*., biophysical indicators, socio-cultural preferences and economic trade-offs) (Martinez-López *et al*., 2014), participatory mapping of ES in different contexts to inform decision-making (*e.g*., Buckhard *et al*., 2012; Riper and Kyle, 2014; Hayha *et al*., 2015) and the combination of parallel studies to assess under different perspectives ecosystems and their services (Hattam *et al*., 2015).

This dissertation advanced further insights elaborating a structured approach to puzzle out the different value dimensions of ES, which was translated in the development of a participatory conceptual Framework. The main goal was to be capable of fostering and structuring by design the integration of multiple value dimension of ES to inform decision-making. In that sense, the research was formulated based on the assumptions that participation could improve such articulation, as long as it is organized and structured through a common platform that allows the integration of multiple tools and methods capturing the plurality of world-views. The key lessons from the proposed integrated three stage process – "set the scene", "deepen understanding" and "value articulation" – are disentangled in the answers to the next research questions, showing how to conduct each piece of a participatory ES assessment. Participation is the main engine that keeps the process moving and allows to puzzle out the ES values in the context of a specific decision.

RQ#2 - How to conduct a collaborative scoping process of ecosystem services?

The second research question was addressed in detailed in Chapter 3, where the first empirical piece of the puzzle is explored.

Adaptive and integrated management processes commonly start with a scoping phase due its importance in defining the problem, broadening up the views on the issue and contextualizing the issues at stake. Scoping often entails tasks such as stakeholder analyses and integrated system analyses (Weaver and Rotmans, 2006). Despite the generalized agreement on the importance of conducting participatory ES assessments, this research revealed that there is still an incipient inclusion of stakeholders in ES assessment processes, particularly at a scoping stage (Menzel and Teng 2010; Seppelt *et al*., 2011; Iniesta-Arandia *et al*., 2014).

The majority of the studies usually engage social actors in the identification of ES through survey-based (*e.g*., Casado-Arzuaga *et al*., 2013) and individual semi-structured interview approaches (*e.g*., Quinn *et al*. 2015). Individual respondents are frequently presented with a list of services, for a given study area, usually prepared by experts (García-Nieto *et al*., 2013; Cárcamo *et al*., 2014; Darvill and Lindo, 2015). Few examples where stakeholder groups are jointly engaged in scoping tasks are found in ES spatial mapping applications (García-Nieto *et al*., 2015; Moreno *et al*., 2014).

This research adds to the state of the art by proposing an approach where it is possible to conduct a scoping process from the ground up, broadening the scope of ES identification. An institutional and stakeholder analysis is recommended based on secondary information as well as meetings with local managers to inform and prepare the participatory workshop. The workshop should gather participants from different stakeholder groups, that together will explore and answer the following questions: which are the ES that the area provides? Which are the links between those ES and human wellbeing? Which are the main threats to ES in the area? Which services are perceived as having a higher social, ecological and economic importance? A following online survey allows the validation of the obtained outcomes and the development of dependency network analysis between stakeholder groups and ES.

The proposed approach on the conduction of a collaborative scoping of ES values, revealed an accomplishment of the predefined tasks (*i.e*. institutional and stakeholder analysis; scoping workshop and validation online survey). Having different points of operationalization within this stage allowed a more complete collection and production of information, increasing the credibility of the results. The collaborative scoping of ES sets the background and baseline as a way to inform decisions affecting ES. It creates the foundations of the participatory assessment phases.

RQ#3 - How to develop a shared understanding of the underlying structure of ecosystem services?

It was argued in this dissertation that the development of a shared understanding of the underlying structure of ES is required to support ES studies (Chapter 4). Given the complexity of ES, modelling methods and tools have been defended for such purposes by several authors (Burkhard *et al*., 2013; Bagstad *et al*., 2013; Boumans *et al*., 2015; IPBES, 2016,). For example, modelling approaches have been tested as tools for the integration of science and policy in natural resource management (Guimarães *et al*., 2013), the creation of mind-maps offering a unified knowledge base (Pascual *et al*., 2016), and the development of simulation games (Costanza *et al*., 2014). Previous ES studies have also tried to promote a rich characterization of ES, using for example using geographical maps (*e.g*., García-Nieto *et al*., 2013; Cárcamo *et al*., 2014) or matrices (*e.g*., Buckhard *et al*., 2012). However, these approaches do not necessarily focus on the study of interrelations and feedback processes within the system where ES operate.

Hence, the second stage of the developed Framework explored ways to address this challenge the state of the art by proposing a methodology that uses a Participatory Systems Mapping approach (Videira *et al*., 2009; Antunes *et al*., 2015) for conducting a deep understanding of ES. Participatory Systems Mapping may play an important role by allowing to develop a collaborative understanding of the structure underlying ES, integrated in a single diagram. By eliciting the causal relations and feedbacks between ES through the use of system dynamics conceptual models, more specifically causal loop diagrams, this approach allows to identify critical leverage points to intervene in the conservation of ES. Furthermore, it facilitates the identification of interrelationships between different ecosystem services and the selection of critical variables that could be used to define key indicators for management processes. These indicators may be formulated according to different units allowing a process where multiple value dimensions are integrated. This methodology represents a qualitative approach that paves the way towards the detailed understanding of the system allowing a selection of a set of key indicators for the supply and demand of ES. These indicators are selected based on their feedback leverage and perceived importance for stakeholders, rather than only based on the information that is readily available. The shared understanding leads to the identification of common variables which can support integrated management decisions.

RQ#4 - How to articulate the different values of ecosystem services to support decision-making processes?

The last research question is addressed in Chapter 5. Within ES debates, significant attention has been given to the importance of considering ecological, social and economic values (De Groot *et al*., 2002) to expand the scope of traditional ES valuation by openly supporting the view of value pluralism as a core foundation. However, and despite recent contributions, how is value articulation promoted in practice in the context of decision-making processes? This question is addressed with the last empirical piece of the puzzle.

Already existing approaches either considering only one value dimension in ES assessments or those do consider more than one dimension, are often conducted without tight value articulation concerns (*e.g*., Martín-López *et al*., 2014; Buckard *et al*., 2012; Dick *et al*., 2014; Hattam *et al*., 2015).

This research proposes an approach for the participatory articulation of ES values in the context of a real world decision process that is socially meaningful and relevant for the preservation of ES in a study area.

Through this process, different values are articulated within the same platform, providing space to equally consider intrinsic, instrumental and relational values. The co-production of knowledge mediated by the ES concept upstream this stage supports the value articulation tasks. Deliberations help to define criteria and allow incommensurable values to be considered in the discussions. Results showed that new insights are created and a shared understanding is possible when participants are brought together to appraise decision alternatives based on scientific information and tacit knowledge on functioning of the underlying socio-ecological systems. Group deliberations led to changes in participants' initial mental models, allowed to generate new alternatives, expanded perceptions on affected ES, and supported formalization of evaluation criteria and decision rules.

At this point the choice and classification of criteria was not determined by previous quantification of impacts, and provided useful lessons to the debate on the operationalization of multi-criteria stakeholder-based ES assessments in the context of two pressing challenges for local protected area managers in the case study area.

6.3. Conclusions and future research

The concept of ES was developed as an attempt to inform policy making and societies in general about the crucial importance of ecosystems, showing how they contribute with goods and services to human wellbeing. In this sense, the research conducted in this field is essential to give insights on how policy may assimilate and apply this concept allowing to understand its benefits in this context. This research showed the importance of integrated ES in the management of protected areas and on how to inform decisions that emerge from this management.

The integration and articulation of multiple values attached to ES in the context of a protected area was acknowledged by this work, being highlighted the risk of monist approaches to support decision-making (Chapter 3), where different types of importance were attributed to distinct ES underscoring the problem of having only one value dimension captured in the assessment procedures.

This research work aimed to provide a structured participatory process where different value dimensions of ES could be articulated in order to support decision-making processes. A conceptual Framework was developed combining different methods and tools in a coherent platform that supports a multidimensional approach to ES valuation. This approach expands the scope of traditional ES assessment by explicitly endorsing the principles of value pluralism, integrating the diversity of knowledge expressed in distinct formats.

The selected case study – Arrábida Natural Park – allowed to test the Framework, providing insights on its applicability and enabling factors for replication in similar contexts. A natural park, with high human presence in the territory was important to motivate stakeholders to engage in the process. The implementation of this methodological approach in the protected area illustrated how to conduct a bottom up process of ES identification and value articulation.

Although this work tested the Conceptual Participatory Framework in a specific situation of a Natural Park, this proposed process can be adapted for policy-makers regarding its application in different contexts of protected areas management. Understanding the importance of this Framework for policy means to recognize the benefits of stakeholder engagement, the role of co-learning and co-production of knowledge and the importance of the ES concept to a more informed management of protected areas. Having said that, stakeholder participation should be institutionalized and also recognizing the local and the scientific knowledge in the process. This engagement should be accounted as early as possible and throughout the process and guided by a philosophy of empowerment, equity, trust and learning.

Some operational issues arise at a policy implementation level such as the need of resources and capacity for the conduction of a process of this nature, which requires data, time, money and skills. It is important to acknowledge the possibility of a weak recognition of the usefulness of this concept in some policy contexts, nevertheless the proposed process can contribute to create awareness with such regard. It is important to understand the role of the application of this concept in management of protected areas. Despite the fragmented work across levels of governance and the typically narrow focus of appraisals in protected areas, it is important to understand the role of adopting processes such as the one advanced in this dissertation. The identified key enabling factors for the integration of ES concept in future policy developments may help to improve the tailored implementation of this Framework.

This research lifts the veil on further important research to be develop in this topic. It is recommended to extend the application of this Framework to other areas besides protected sites, understanding what changes might occur in the process regarding the design and the outcomes of a participatory value articulation process due to a change of context. Here, it seems relevant to explore possible differences regarding the outputs when studying ES importance and the articulation of values to support ES management (*e.g.,* biodiversity conservation) in a non-protected area.

Another line of research suggested to pursue in the future is a comparative study on the Framework application to all types of decisions presented in chapter 5. Analysing which are the potential differences and critical factors.

This research tested a continuum and cyclical process, however, as the name indicates and as it was discussed in some parts of this dissertation, the puzzle out process that the Framework presents may be tested using other methods and tools at each stage and explore the differences that might emerge (Chapter 2).

Another perspective for future research concerns the extension of use of the proposed modelling tools. This means to advance research by exploring the construction of simulation models based on the conceptual systems maps to support scenario and policy analysis at the deepen understanding and value articulation stages. A decision support tool, integrating the achieved outputs at different stages might be a future possibility for research, to facilitate access and dissemination of results to interested parties.

In conclusion, to foster and structure the integration of different values of ES in decision-making processes this dissertation argued that one needs to join different pieces of a participatory ES assessment by combining a variety of tools and methods to capture the multiple value dimensions. The developed puzzling elements of this approach are the integration of a collaborative scoping of ES aiming to set the scene (Chapter 3), a deepen understanding stage, (Chapter 4) and a final stage of value articulation concluding the puzzle (Chapter 5).

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Annexes

Annexes Contents

During the development of this research different support tools were developed in order to support the conduction of the implementation of the Framework. This chapter presents the more important documents used in different stages. Since the case study was a Portuguese protected area, which gathered Portuguese participants, the annexes are present in Portuguese.

The content of the annexes will be slightly described in English, once the main outcomes are already present in the different chapters of the thesis. The annexes of this thesis are the following:

Annex I – Set the scene stage support materials

- First workshop workbook;
- First workshop evaluation survey;
- First online surveys;
- Photos from the event;
- List of workshop participants.

Annex II – Deepen understanding stage support materials

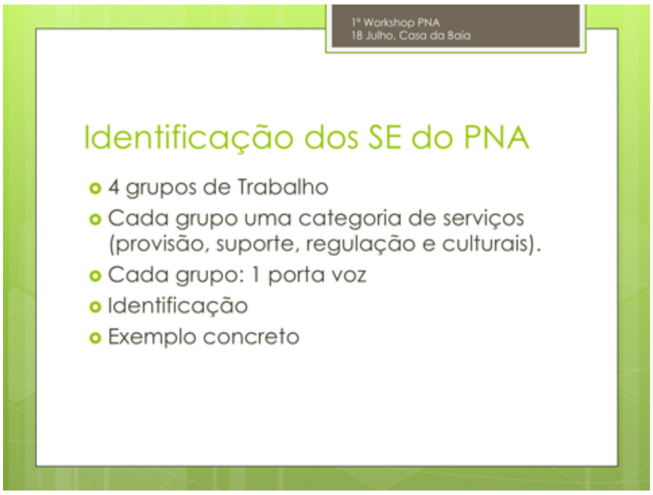
- Second workshop workbook;
- Second workshop evaluation survey;
- Second online survey;
- Photos from the event;
- List of workshop participants.

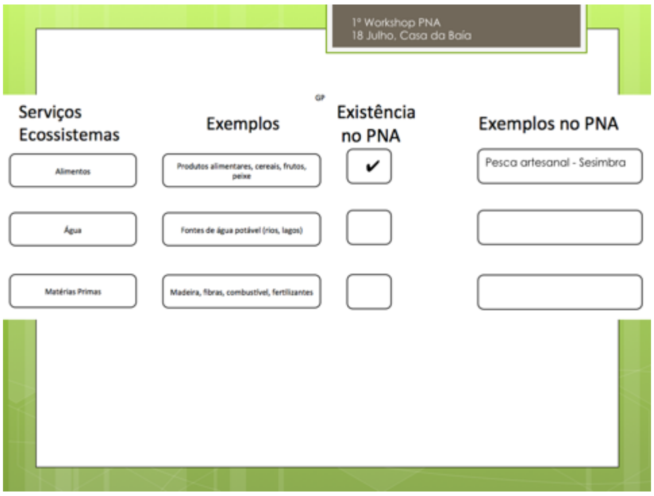
Annex III – Articulate stage support materials

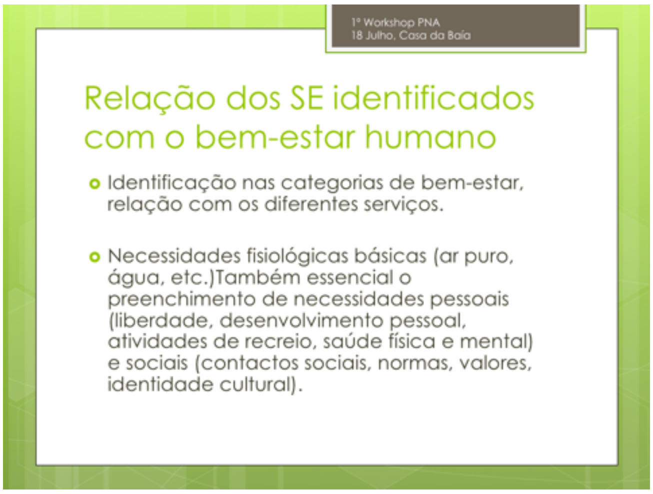
- Third workshop workbook;
- Third workshop evaluation survey;
- Photos from the event;
- list of workshop participants.

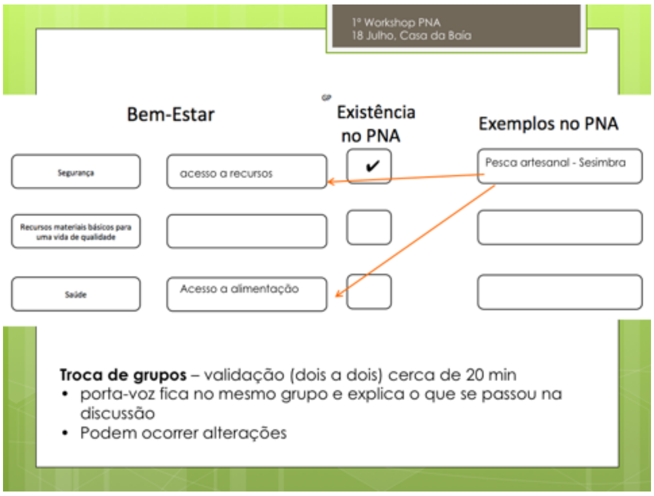
Annex I – Set the scene stage support materials

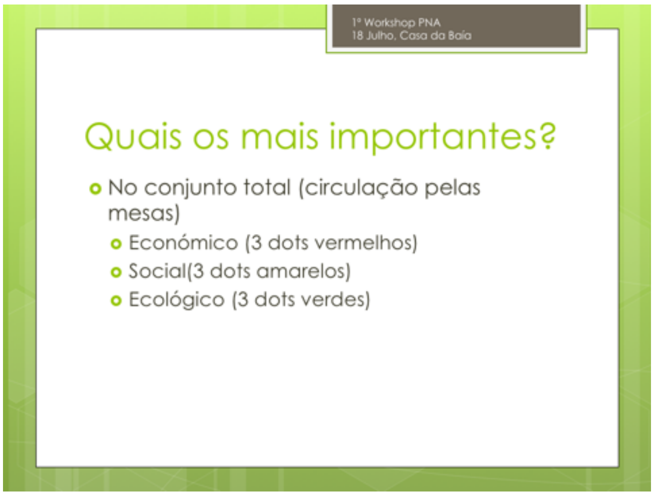
First workshop workbook

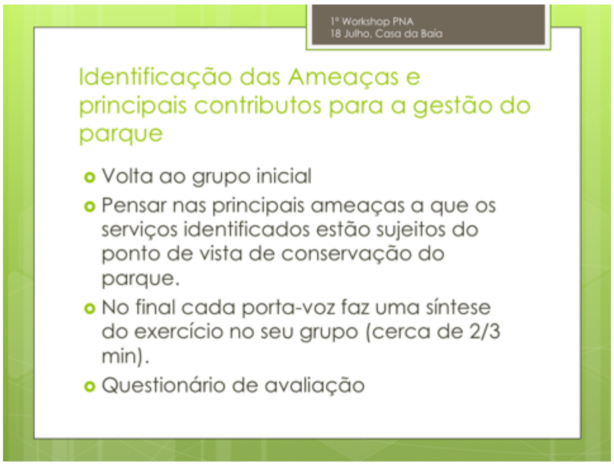











1º Workshop PNA
18 Julho, Casa da Baía
Identificação das Ameaças e principais contributos para a gestão do parque
Volta ao grupo inicial
Pensar nas principais ameaças a que os serviços identificados estão sujeitos do ponto de vista de conservação do parque.
No final cada porta-voz faz uma síntese do exercício no seu grupo (cerca de 2/3 min).
Questionário de avaliação

First workshop evaluation survey

1º Workshop de Avaliação Participada dos Serviços dos Ecossistemas do Parque Natural da Arrábida (PNA)
18 de Julho, 2014 Casa da Baía, Setúbal

Nome ____

Instituição ____

Algumas questões são colocadas sob a forma de afirmações, pretendendo-se que assinale com uma cruz "X" apenas uma das opções, de acordo com uma escala entre 1- discordo totalmente e 5 – concordo totalmente.

1. O workshop reuniu um grupo diversificado de agentes com interesses no PNA.
2. Que grupos de *stakeholders* poderiam também ter estado presentes? _______
3. Os participantes do workshop funcionaram como um grupo.
4. Já tinha conhecimento do conceito de serviços dos ecossistemas?
5. A troca de ideias foi uma forma útil de identificar os serviços dos ecossistemas presentes no parque.
6. As discussões durante o workshop foram construtivas, tendo permitido obter um maior conhecimento sobre os serviços dos ecossistemas.
7. Como acha que decorreu a interação e a comunicação entre os participantes durante o workshop? ______________
8. Considera que houve um consenso sobre os serviços dos ecossistemas fornecidos pelo PNA?____________________________________
9. A discussão em grupo permitiu-me reconhecer serviços dos ecossistemas que não identificava anteriormente.
10. O exercício prático permitiu estruturar a discussão sobre os valores económicos, sociais e ecológicos dos serviços dos ecossistemas do PNA.
11. Como avalia a organização do workshop?
12. O workshop valeu o tempo que despendeu?
13. Na sua opinião quais foram os aspetos mais negativos do workshop? ________
14. Pretende manter-se informado relativamente aos trabalhos a desenvolver neste estudo? __________

First online surveys

Inquérito sobre os Serviços dos Ecossistemas do Parque Natural da Arrábida (enviado por e-mail através de *Google forms*).

No passado dia 18 de julho de 2014, foi realizado um workshop no Parque Natural da Arrábida (PNA) na Casa da Baía, em Setúbal, com o tema "Avaliação Participada dos Serviços dos Ecossistemas do PNA". Este inquérito surge no seguimento desta sessão de trabalhos, como forma de complementar e validar os resultados obtidos bem como fornecer informação para o passo seguinte do processo.

Agradecemos desde já a sua colaboração.

1. Instituição ____________
2. Nome ________________
3. Esteve presente no workshop de 18 de julho, na Casa da Baía? (sim / não)

Identificação dos Serviços dos Ecossistemas do PNA

Durante o workshop os participantes identificaram um conjunto de serviços dos ecossistemas que consideram ser fornecidos pela área de estudo, fornecendo exemplos concretos, descritos nos seguintes quadros:

Serviços de Provisão

Serviços de Provisão	**Exemplos no PNA**
Alimentos	Peixe, lacticínios, vinhos, ervas aromáticas, hortícolas, variedades endémicas.
Água	Existe, mas pouco relevantes
Matérias Primas	Pedra calcário (marga)
Recursos Genéticos	Algas, Orquídeas endémicas (potencialidade ainda não desfrutada)
Recursos Medicinais	Ervas medicinais, alfarroba; hospital do outão
Recursos Ornamentais	Artesanato (escamas, conchas, fósseis)

4. Indique o grau de concordância com os elementos fornecidos para os serviços de provisão. (Escala entre 1 - discordo totalmente e 5 - concordo totalmente).
5. Por favor justifique. Gostaria de acrescentar ou retirar algum serviço? Porquê? ____

Serviços de Regulação

Serviços de Regulação	**Exemplos no PNA**
Regulação da qualidade do ar	Vegetação controla poluição proveniente das pedreiras

Regulação do clima	"possível aumento de chuva"; sequestro de carbono com possível aumento da biomassa em pé e no solo.
Regulação da água	Recarga do aquífero cársico
Controlo da erosão	Crescimento ZC – prevenção ZC coberto vegetal
Polinização	Crescimento da agricultura e biodiversidade face a áreas externas ao PNA
Regulação de doenças humanas e pragas	Senatório de Outão

6. Indique o grau de concordância com os elementos fornecidos para os serviços de provisão. (Escala entre 1 - discordo totalmente e 5 - concordo totalmente).
7. Por favor justifique. Gostaria de acrescentar ou retirar algum serviço? Porquê? ____

Serviços de Suporte

Serviços de Suporte	Exemplos no PNA
Produção Primária	O PNA apresenta todas as características necessárias para a produção primária.
Produção de O2	Produção florestal, pradarias mourinhas, pastagens
Formação de solo	Bolsas de terra nas zonas cársicas que permitem a fixação da vegetação nas zonas de montanha e a retenção da água.
Ciclo de nutrientes	Existência de leguminosas que permitem a fixação de azoto atmosférico e que entram no ciclo. Ciclos dos outros nutrientes (P,K,Mg...). São fixados na matéria orgânica e na vegetação
Provisão de habitat	Parque Luiz Saldanha, importante para a fixação de espécies; floresta natural para as aves
Conservação da biodiversidade	Variedades de carvalho, vários tipos de orquídeas, biodiversidade marinha.

8. Indique o grau de concordância com os elementos fornecidos para os serviços de provisão. (Escala entre 1 - discordo totalmente e 5 - concordo totalmente).
9. Por favor justifique. Gostaria de acrescentar ou retirar algum serviço? Porquê? ____

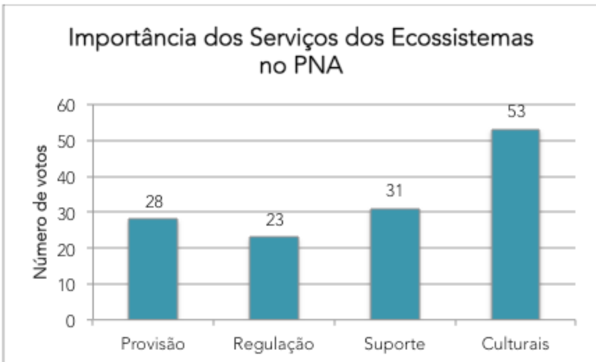
Serviços Culturais

Serviços Culturais	Exemplos no PNA
Valores estéticos	Paisagem, baixa densidade populacional, atmosfera, inspiração artística; serra e mar.
Recreio e ecoturismo	Gastronomia; praias; desporto natureza; proximidade ao rio e ao mar.
Diversidade cultural	presença humana no território desde sempre; vários povos; território de invasões; processo de migração de Lisboa.
Valores religiosos e espirituais	Misticismo; isolamento; convento da Arrábida; território finisterra; espichel; círios; lendas da Arrábida.
Sistemas de conhecimento e educacionais	Características biofísicas e geológicas do lugar; reserva no acesso ao local; candidatura da Arrábida a património mundial.

10. Indique o grau de concordância com os elementos fornecidos para os serviços de provisão. (Escala entre 1 - discordo totalmente e 5 - concordo totalmente).
11. Por favor justifique. Gostaria de acrescentar ou retirar algum serviço? Porquê? ____

Importância dos Serviços dos Ecossistemas

Foi pedido aos participantes que votassem nos serviços mais importantes (a nível social, económico e ecológico). Os resultados totais apresentam-se no gráfico seguinte:



12. Qual o seu grau de concordância com os resultados apresentados no gráfico? (Escala entre 1 - discordo totalmente e 5 - concordo totalmente).
13. Por favor justifique. ____
14. Na sua opinião quais são as categorias de serviços com maior importância económica? Provisão / Regulação / Suporte / Culturais / Nenhuma
15. Na sua opinião quais são as categorias de serviços com maior importância ecológica? Provisão / Regulação / Suporte / Culturais / Nenhuma
16. Na sua opinião quais são as categorias de serviços com maior importância social? Provisão / Regulação / Suporte / Culturais / Nenhuma

Dependência dos Serviços dos Ecossistemas

Pretende-se neste grupo analisar a dependência da sua organização face aos serviços dos ecossistemas.

17. De que serviços de provisão depende a sua organização?

alimentos / água / matérias primas / recursos genéticos / recursos medicinais / recursos ornamentais / nenhum

18. Por favor especifique para cada item selecionado o grau de dependência existente. ____

19. De que serviços de regulação depende a sua organização?

regulação da qualidade do ar / regulação do clima / regulação da água / prevenção da erosão / polinização / regulação de doenças humanas e pragas / nenhum

20. Por favor especifique para cada item selecionado o grau de dependência existente. ____

21. De que serviços de suporte depende a sua organização?

produção primária / produção de CO^2 / formação de solo / ciclo de nutrientes / provisão de habitat / conservação da biodiversidade / nenhum

22. Por favor especifique para cada item selecionado o grau de dependência existente. ____

23. De que serviços culturais depende a sua organização?

valores estéticos / recreio e ecoturismo / diversidade cultural / valores religiosos e espirituais / sistemas de conhecimento e educacionais / sensação de lugar / nenhum

24. Por favor especifique para cada item selecionado o grau de dependência existente. ____

Análise de Stakeholders

A seguinte tabela apresenta o conjunto de stakeholders identificados. Pretende-se que responda às seguintes questões baseando-se nesta lista.

25. A sua organização depende de alguma das organizações presentes na lista de stakeholders identificados? (sim/não).
26. Se sim quais? ____
27. A sua organização apresenta algum tipo de conflito com alguma das organizações presentes na lista de stakeholders identificados face à preservação dos serviços dos ecossistemas? (sim /não)
28. Se sim, especifique em que medida esses conflitos podem surgir. __________________

Stakeholders Identificados
Ministérios do Ambiente, do ordenamento do Território e Energia
Ministério da Aricultura e do Mar
Câmara Municipal de Setúbal
Câmara Municipal de Sesimbra
Câmara Municipal de Palmela
Administração do Porto de Setúbal
Administração do Porto de Sesimbra
Direcção-geral de Política do Mar
Direcção-geral de Recursos Naturais, Segurança e Serviços Marinhos
Instituto Português do Mar e da Atmosfera
Instituto de Conservação da Natureza e das Florestas
Agência Portuguesa do Ambiente
Autoridade Marítima Nacional - Capitania do Porto de Setúbal
Turismo de Portugal
LPN - Liga de Protecção da Natureza
Quercus
GEOTA
Sciaena
Associação para o Desenvolvimento Regional da Península de Setúbal
AERSET - Associação Empresarial da Região de Setúbal
APECATE - Associação Portuguesa das Empresas de Congressos, Animação Turística e Eventos
APISET - Associação de Apicultores da Península de Setúbal
Associação Regional dos criadores de ovinos leireiros da Serra da Arrábida
Associação cultural Sebastião Gama
Associação de Agricultores do Distrito de Setúbal
Associação de Armadores de Pesca Artesanal
Associação de Produtores do Queijo de Azeitão
Associação de Viticultores do Concelho de Palmela
Associação de Municipios da Região de Setúbal
Comissão Vitivinícula Regional da Península de Setúbal
Diocese de Setúbal
Direcção Regional de Agricultura e Pescas LVT
Federação Portuguesa de Espeologia
Fundação Oriente
Instituto Politécnico de Setúbal
Núcleo de Espeologia da Costa Azul
Museu de Arqueologia e Etnografia do Distrito de Setúbal
Liga de Amigos de Setúbal e Azeitão
Turismo Região de Lisboa
Escola de mergulho - Best dive
Escola de mergulho - Cipreia

Obrigada pela sua participação. Caso tenha alguma sugestão de contactos a quem este questionário deva ser enviado, pode deixar a informação abaixo que procederemos ao envio.

____

Photos from the 1st event

The photos displayed above are regarding the different tasks developed during the first participatory event, where different groups work on different exercises towards a collaborative scoping of ecosystem services provided by the Arrábida Natural Park.

List of 1st workshop participants

Institution	Participant name
ADREPES - Associação de Desenvolvimento Regional da Península de Setúbal	Cláudia Bandeiras
AMRS - Associação dos Municípios da Região de Setúbal	João Afonso Luz
APECATE - Associação Portuguesa das Empresas de Congressos, Animação Turística e Eventos	José Pedro Calheiros
APSS - Administração do Porto de Setúbal	Graça Viegas
Câmara Municipal de Setúbal	Cristina Coelho
Câmara Municipal de Setúbal	Filipa Fernandes
Câmara Municipal de Setúbal	Elsa Morais Lopes
DGPM - Direção Geral de Política do Mar	Carla Frias
DRAP LVT - Direção Regional de Agricultura e Pescas de Lisboa e Vale do Tejo	Paulo Martins
ERTRL - Entidade Regional de Turismo da Região de Lisboa	Jorge Humberto
FCT - UNL - Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa	João Joanaz de Melo
GEOTA - Grupo de Estudos de Ordenamento do Território e Ambiente	António Galvão
GEOTA - Grupo de Estudos de Ordenamento do Território e Ambiente	Maria João Flôxo
ICNF - Instituto de Conservação da Natureza e Florestas	Lúcio do Rosário
LASA - Liga de Amigos de Setúbal e Azeitão	Joaquim Rocha
LPN - Liga Proteção da Natureza	Eugénio Sequeira
LPN - Liga Proteção da Natureza	Carlo Bifulco
PNA - Parque Natural da Arrábida	Eduardo Carqueijeiro
PNA - Parque Natural da Arrábida	João Martins
PNA - Parque Natural da Arrábida	Miguel Henriques
PNA - Parque Natural da Arrábida	Rui Costa

Annex II – Deepen understanding stage support materials

Second workshop workbook

2º WORKSHOP GRUPOS DE TRABALHO

Metodologia

Workshop . Objectivo

Desenvolver, de forma participada, um diagrama causal integrado, representando as principais inter-relações entre as variáveis que caracterizam o fluxo sustentável dos serviços dos ecossistemas no PNA.

Os **diagramas causais** constituem uma ferramenta de conceptualização, permitindo:

- ★ Captar de forma expedita a hipótese relativa à dinâmica de problemas;
- ★ Revelar os modelos mentais de indivíduos ou equipas;
- ★ Comunicar os mecanismos de retroação mais importantes responsáveis pelo comportamento de problemas complexos.

Mapeamento Participado de Sistemas

- Identificação de interações entre diferentes partes de sistemas complexos – visão holística
- Partilha e construção colaborativa de conhecimento com grupos de *stakeholders*
- Abordagem metodológica da dinâmica de sistemas participada testada como ferramenta de apoio à decisão em diferentes contextos
  - e.g. diálogo entre decisores e investigadores (e.g. Projeto RESPONDER)
  - e.g. Apoio a processos de planeamento e gestão de recursos naturais (e.g. Projetos ADVISOR e MODELAR)

Diagrama Causal . Exemplo

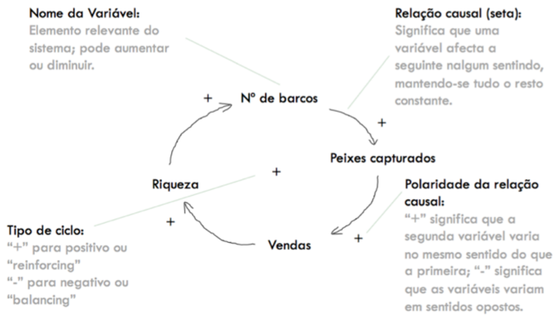
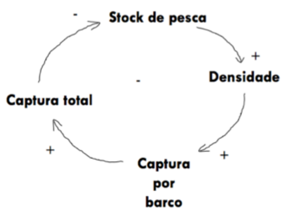


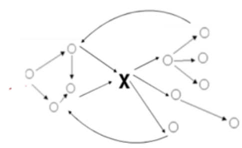
Diagrama causal . exemplo

Ciclo de retroação negativo – "*balancing*"



Construção dos Diagramas Causais

- Variável problema
- Adicionar as causas
- Adicionar os efeitos
- Identificar ciclos de retroação
- Identificar pontos de intervenção

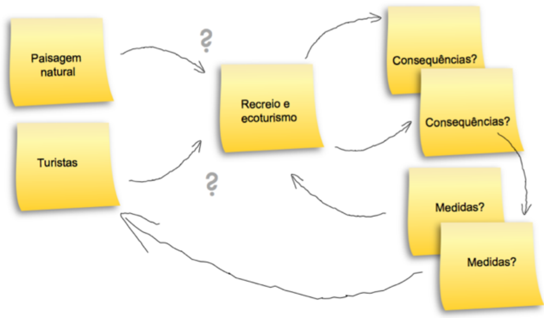


Grupos de Trabalho

- Como assegurar um fluxo sustentável dos serviços de ecossistemas do PNA nos próximos 20 anos?

- Recreio e Ecoturismo
- Alimentos
- Manutenção da Diversidade Genética (Biodiversidade)
- ? Em aberto (e.g. Ciclo dos nutrientes; Regulação da qualidade da água...)

Diagramas Causais . Processo



Questões para a construção dos DC

- Q1 - Quais as causas da alteração do fornecimento sustentável do fluxo do SE em análise?

- Q2 - Quais as consequências da alteração do fluxo do SE?

- Q3 - Quais as medidas para assegurar um fluxo sustentável do SE nos próximos 20 anos?

- Q4 - Qual a ligação que este SE tem com outros SE?

Seleção de Variáveis-chave

- Suponha que é responsável pela manutenção de um fluxo sustentável dos serviços de ecossistemas nos próximos 20 anos.

- Quais as variáveis do diagrama que escolheria para avaliar e monitorizar:
  - Pressões
  - Estado
  - Respostas

Second workshop evaluation survey

2º Workshop Serviços de Ecossistemas do Parque Natural da Arrábida
16 de Abril, 2015, Casa da Baía, Setúbal

Nome ____

Instituição ____

Algumas questões são colocadas sob a forma de afirmações, pretendendo-se que assinale com uma cruz "X" apenas uma das opções, de acordo com uma escala entre 1- discordo totalmente e 5 – concordo totalmente.

1. O workshop reuniu um grupo diversificado de agentes com interesses no PNA.
2. Que grupos de *stakeholders* poderiam também ter estado presentes?

   ____

3. Os participantes do workshop funcionaram como um grupo, isto é, estiveram orientados para um objetivo comum.
4. A troca de ideias foi uma forma útil de mapear as inter-relações dos serviços de ecossistemas presentes no PNA.
5. As discussões durante o workshop foram construtivas, tendo permitido obter um maior conhecimento sobre os serviços de ecossistemas do PNA.
6. Os problemas foram discutidos de modo frontal e aberto.
7. As discussões durante o workshop foram construtivas, tendo permitido obter um maior conhecimento sobre estes serviços.
8. Como acha que decorreu a interação e a comunicação entre os participantes durante o workshop? Considera que houve consenso entre os participantes sobre como assegurar um fluxo sustentável dos serviços dos ecossistemas nos próximos 20 anos no PNA? _____________
9. O processo de modelação participada ajudou a estruturar a discussão e a análise dos problemas.
10. O processo de modelação participada criou oportunidade para que todos participassem na construção dos diagramas causais.
11. O processo de modelação participada ajudou a criar uma linguagem comum para analisar de forma integrada os problemas atuais dos serviços de ecossistemas do PNA.
12. Como avalia a organização do workshop?

    ____

13. O workshop valeu o tempo que despendeu?

    ____

14. Na sua opinião quais foram os aspetos mais positivos e os mais negativos do workshop? _______
15. Recomendaria a modelação participada a outras pessoas?

    ____

16. Sinto que contribui para a construção dos diagramas causais.
17. Os diagramas causais permitiram desenvolver uma visão mais integrada dos serviços de ecossistemas do PNA.
18. Os diagramas causais constituem uma ferramenta útil para analisar os serviços de ecossistemas.
19. De um modo geral, concordo com as variáveis e relações identificadas nos diagramas causais.
20. se discordou, indique qual(ais) o(s) diagrama(s) que sugere modificar

    ____

21. De um modo geral, concordo com as variáveis-chave selecionadas.
22. Os diagramas causais obtidos têm interesse suficiente para comunicar sobre os serviços de ecossistemas do PNA.
23. Tenho intenção de utilizar no futuro a metodologia do workshop.
24. Tenho intenção de utilizar no futuro os resultados do workshop.

Second online survey (example from Biodiversity group)

Diagrama causal Conservação da Biodiversidade

Na sequência do workshop realizado no passado dia 16 de Abril foi produzido um diagrama causal relativo ao serviço “conservação da biodiversidade”.

Neste inquérito solicitamos que responda a um conjunto de questões que permitirão validar e completar a construção deste diagrama. Para tal estão disponíveis três imagens diferentes: A fotografia do diagrama causal construído pelo grupo de trabalho, o diagrama causal em formato digital e o diagrama causal resultante de uma pós-produção.

Nome: ______________________

Glossário – Linguagem Diagramas Causais

Mantendo tudo o resto constante, se X aumenta (diminui), então Y aumenta (diminui)

Variáveis variam no mesmo sentido

Mantendo tudo o resto constante, se A aumenta (diminui), então B diminui (aumenta)

Variáveis variam em sentidos opostos

Fotografia Diagrama Causal “Conservação da Biodiversidade”

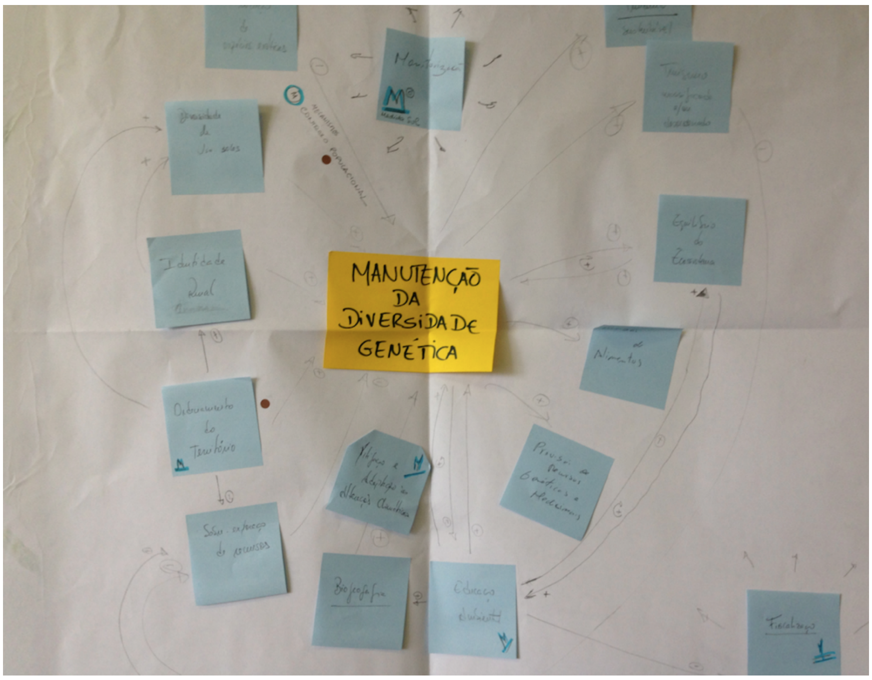


Diagrama Causal “Conservação da Biodiversidade”

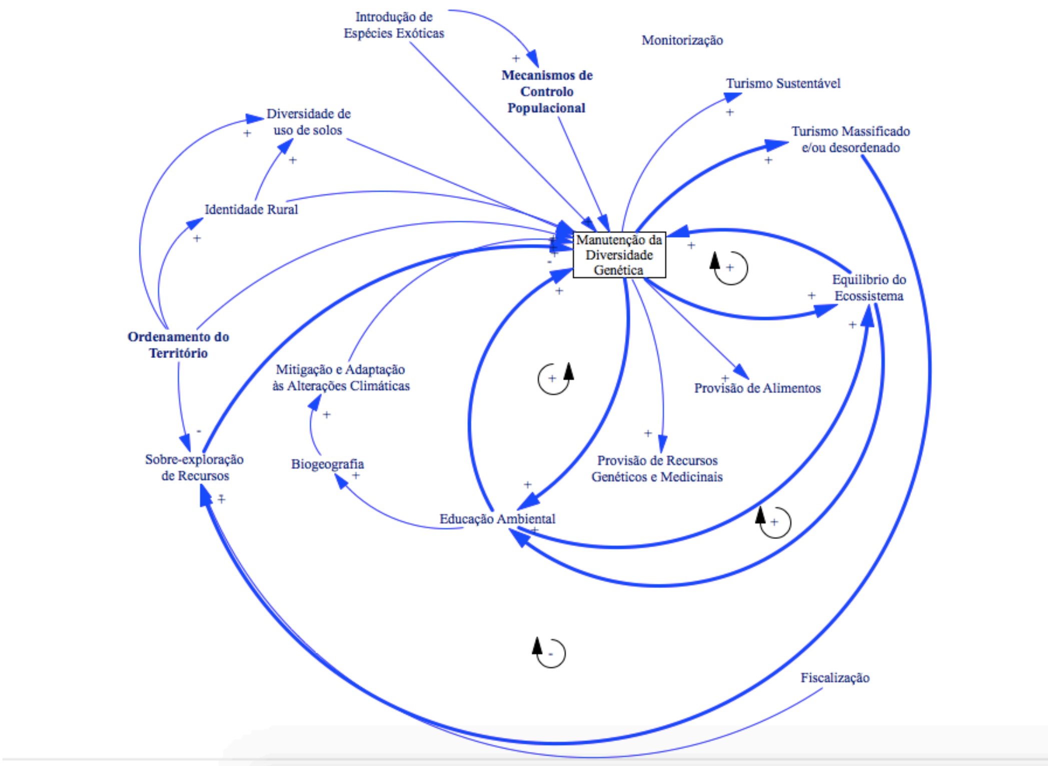
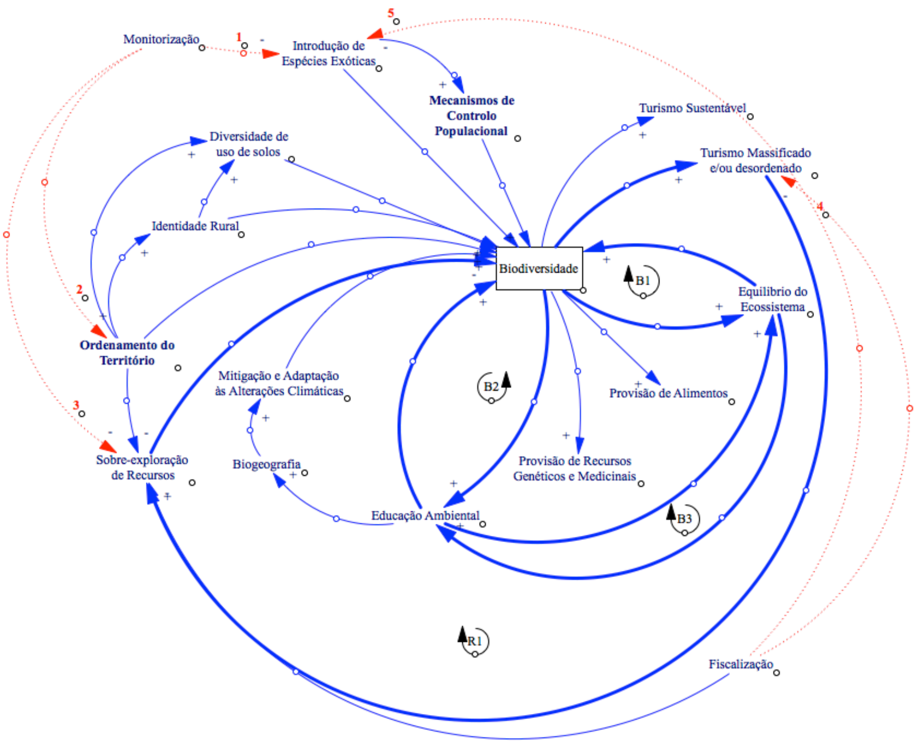


Diagrama Causal “Conservação da Biodiversidade”: Pós-produção (alterações a vermelho).



1. Concorda com as alterações efetuadas ao Diagrama Causal?

relação negativa 1 / relação positiva 2 / relação negativa 3 / relação negativa 4 / relação negativa 5 (concordo ou discordo).

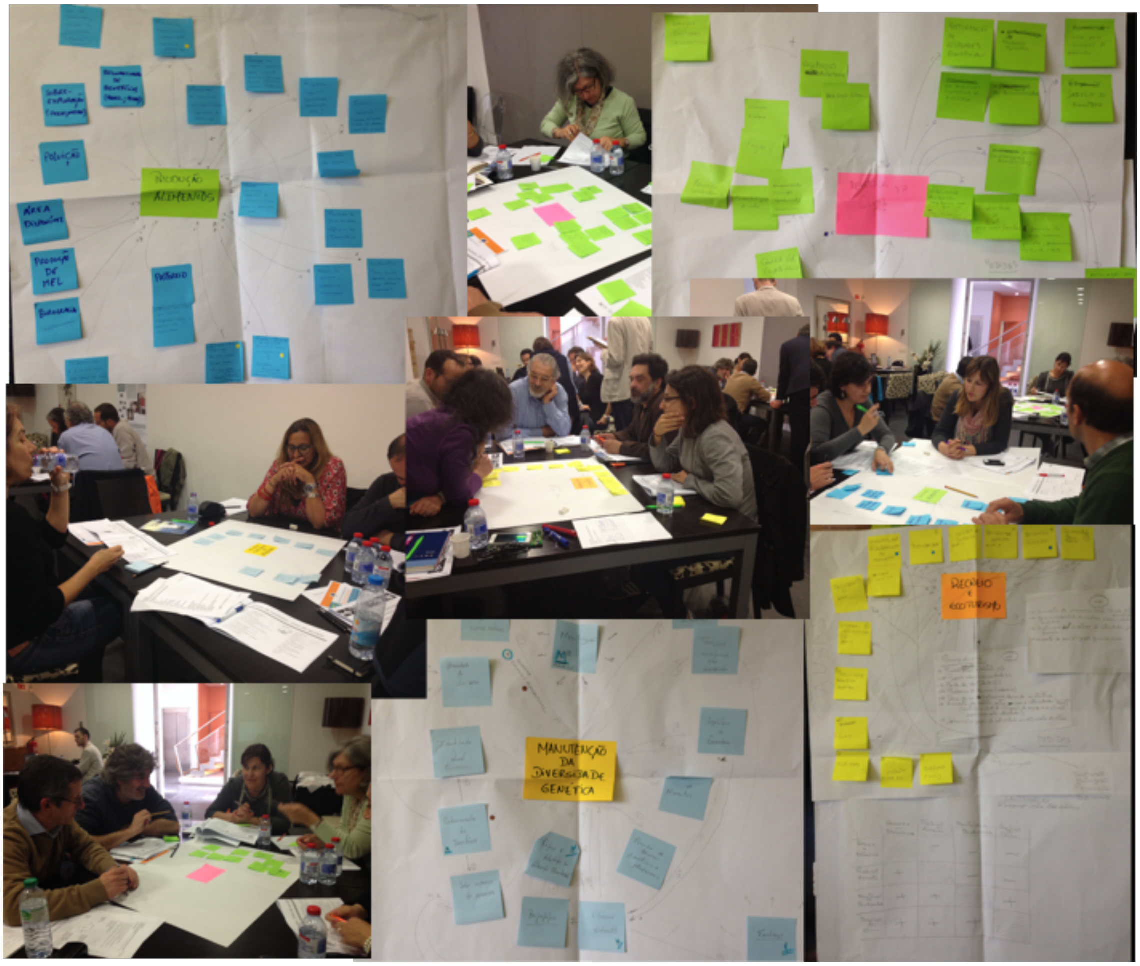
2. Pretende acrescentar alguma(s) variável(eis) ao diagrama? Se sim, qual(ais)? E com que variáveis se relaciona?

____

3. Pretende acrescentar alguma(s) ligação(ões) ao diagrama? Se sim qual(ais)?

____

Photos from the 2nd event



The photos displayed above are regarding the different tasks developed during the second participatory event, where different groups work on different exercises towards a deepen understanding of four ecosystem services provided by the Arrábida Natural Park.

List of 2nd workshop participants

Institution	Participant name
AAPES - Associação de Armadores de Pesca Artesanal	Carina Reis
ADREPES - Associação de Desenvolvimento Regional da Península de Setúbal	Cláudia Bandeiras
ARGOLA - Associação Regional dos Criadores de Ovinos Leiteiros da Serra da Arrábida	Francisco Macheta
AVIPE - Associação de Viticultores do Concelho de Palmela	Miguel Cachão
Câmara Municipal de Sesimbra	Marta Franco
Câmara Municipal de Sesimbra	Anabela Gato
Câmara Municipal de Setúbal	Cristina Coelho
Câmara Municipal de Setúbal	Filipa Fernandes
DGPM - Direcção Geral de Política do Mar	Carla Frias
DRAP LVT - Direcção Regional de Agricultura e Pescas de Lisboa e Vale do Tejo	Paulo Martins
ERTRL - Entidade Regional de Turismo da Região de Lisboa	Fátima Santos
FCSH-UNL - Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa	Carlos Pereira da Silva
FCSH-UNL - Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa	Ricardo Mendes
IPMA - Instituto Português do Mar e da Atmosfera	Yorgos Stratoudakis
LASA - Liga de Amigos de Setúbal e Azeitão	Joaquim Rocha
PNA - Parque Natural da Arrábida	João Martins
PNA - Parque Natural da Arrábida	Miguel Henriques
PNA - Parque Natural da Arrábida	Rui Costa
SCIAENA	Henrique Folhas
Westur, Lda	Sofia de Spínola

Annex III – Articulate values stage support materials

Third workshop workbook

LIVRO DE TRABALHO

Produção de Alimentos | Vinho e Vinha

ALTERNATIVAS A CONSIDERAR NOS EXERCÍCIOS

Alternativa I

Aumento da área de vinha através de novas plantações de vinha.

Alternativa II

Aumento da área de vinha através da plantação de vinha biológica.

Alternativa III

Diminuição da área de vinha.

Alternativa IV

Renovação da vinha atual (manter a que existe atualmente).

Descrição do Dilema 3º workshop

A produção de vinho em Portugal é reconhecida mundialmente pela sua qualidade. A região de Setúbal é uma das regiões vitivínicolas de Portugal com vinhos reconhecidos, tendo conquistando vários prémios (e.g. Óscares do vinho 2015).

A produção de vinho é um serviço fornecido pelo ecossistema - produção de alimentos - identificado com elevada importância económica, no entanto, este serviço depende da existência de outros serviços prestados pelos ecossistemas (e.g. polinização; provisão de habitat; regulação do clima; regulação da qualidade da água, entre outros). A presença de vinhas também contribui para o fornecimento de alguns serviços dos ecossistemas.

Por outro lado, existem pressões associadas à plantação de vinhas, como por exemplo, no caso de monoculturas, a redução do habitat natural e redução de biodiversidade. Ou no caso de interferência de outras atividades, reduzindo área disponível para outros usos.

Como decidir de forma harmoniosa favorecendo o fornecimento de vários serviços dos ecossistemas?

As vinhas e os serviços dos ecossistemas

A biodiversidade nas vinhas tem efeitos positivos na resiliência de todo o ecossistema tanto no controlo de pestes e doenças como na produção de bens comerciais (*Kross et al., 2012; Tompkins, 2010*).

Existem riscos associados às monoculturas, como a redução de habitat natural com decréscimo de biodiversidade aumentando a vulnerabilidade das vinhas a pestes (*Viers et al.,*

Imagem @ visitesetubal.com.pt

1

2013). A aplicação de pesticidas pode ter consequências no controlo de pestes, polinização e ciclo de nutrientes no solo (*Nash et al., 2010*).

A gestão de vinhas pode influenciar positivamente a biodiversidade local optimizando a produção de vinho (*Gaigher and Samways, 2010*).

O uso de espécies nativas para o controlo de pestes pode potenciar atividades recreativas para visitantes na medida em que em que na maioria das vezes fornecem um serviço estético (*Tompkins, 2010*).

As vinhas armazenam menos carbono quando comparadas com outras espécies. Contudo a mistura de cobertura de solo entre vinhas e espécies nativas pode aumentar a captura e armazenamento de carbono no solo (*Williams et al., 2011*).

Os consumidores estão cada vez mais interessados em vinhos "sustentáveis" (*Tompkins, 2010*). Os consumidores estão dispostos a pagar mais por um vinho que é produzido de forma sustentável e que saiba igualmente bem ou melhor (*Forbes et al., 2009*).

A diversificação de espécies das pastagens aumenta polinização com potencial impacte positivo na produtividade das culturas (*Orford et al., 2016*).

Alguns dados na Arrábida

Estimativa de área de vinha dentro do PNA: Entre **400ha e 500ha** (Fonte: Declarações de colheita e Produção da Campanha 2015/2016 dados fornecidos por IVV e CVRS).

Estimativa de produção dentro do PNA:Aproximadamente **40.000 hectolitros** em 2015/2016, superior à media da região (Fonte: Declarações de colheita e Produção da Campanha 2015/2016 dados fornecidos por IVV e CVRS).

A produção de vinho na zona da Arrábida está fortemente ligada ao turismo: existência de uma **rota de vinhos**: "Por terras da Arrábida".

A rota dos vinhos da Península de Setúbal desenvolveu no ano de 2015 67 atividades enoturísticas, envolvendo 4341 participantes.

O plano Estratégico para o Turismo na Região de Lisboa 2015/2019, define a **Arrábida como uma das 5 centralidades** da região e a Rota de Vinhos da Península de Setúbal como recurso para o desenvolvimento do **produto enoturismo.**

LIVRO DE TRABALHO

Recreio e eco-turismo | Praias

ALTERNATIVAS A CONSIDERAR NOS EXERCÍCIOS

Alternativa I

Investimento em infraestruturas de apoio através da construção de novos acessos e novos parques de estacionamento.

Alternativa II

Investimento em infraestruturas de apoio através da construção de novos acessos e novos parques de estacionamento com restrições de acesso, como seja o aumento de tarifas de parqueamento.

Alternativa III

Investimento em transportes públicos, específicos para acesso às praias.

Alternativa IV

Manter as infraestruturas de apoio (incluindo acessos), como estão atualmente.

Descrição do Dilema 3º workshop

As praias são ecossistemas naturais que fornecem diversos serviços, como o recreio, mas também valores estéticos. A beleza natural das praias da Arrábida atrai um grande número de visitantes que usufruem de diversos serviços culturais, que em parte só são possíveis devido a outros serviços.

A contribuição das praias da Arrábida para o turismo é grande, no entanto uma aposta grande em infraestruturas de apoio pode significar um aumento das pressões em outros serviços (e.g. provisão de habitat; conservação da biodiversidade; valores estéticos).

Como conjugar as diferentes atividades turísticas sem por em causa o funcionamento natural dos ecossistemas?

Como decidir de forma harmoniosa favorecendo o fornecimento de vários serviços dos ecossistemas?

Imagem @ visitesetubal.com.pt

As praias e os serviços dos ecossistemas

As praias são sistemas dinâmicos caracterizados por acumulação de material não consolidado (*Castaño-Isaza et al., 2014).*

Os benefícios fornecidos pelas praias dependem de diversos factores qualitativos e quantitativos como: a largura da praia; morfologia; tipo de areia; a presença de estruturas de engenharia; número de visitantes (*Landry et al., 2003*).

As praias são valorizadas pelos habitats que fornecem; oportunidades de recreio (passivo e ativo); protecção de tempestades; benefícios para o turismo; controlo de erosão (*Johns et al., 2001*).

A alteração das praias por atividades humanas resulta numa perda substancial do funcionamento natural do habitat e redução da diversidade biológica (*Marshall et al., 2014*).

As praias são ecossistemas dinâmicos que necessitam de espaço para responder às pressões naturais e antropogénicas (Marshall et al., 2014).

Alguma das principais ameaças às praias incluem: erosão; reposição artificial de areia; veículos fora de estrada; limpeza de praias; poluição; pescas; remoção de areia; alterações climáticas; introdução de espécies (*Jones et al., 2009*).

Quando os ecossistemas (praias) são deixados intactos conseguem suportar os processos ecológicos em harmonia com usos humanos sustentáveis. No entanto, a alteração das praias através do recreio, e outras atividades humanas podem resultar numa perda de diversidade biológica, alterando o funcionamento natural do habitat (*Marshall et al., 2014*).

Alguns dados na Arrábida

Existem atualmente 46 empresas turísticas licenciadas para aturar no PNA (Fonte: ICNF)

As praias da Arrábida são na sua maioria utilizadas por famílias e/ou grupos de amigos da área metropolitana de Lisboa.

A deslocação é maioritariamente feita por viatura própria. Transporte público é residual e não existe para todas as praias.

Os visitantes atribuem uma elevada importância às áreas protegidas.

Os visitantes consideram positivas as condições, serviços e ofertas das praias destacando a beleza natural da região. Os aspetos negativos relacionam-se com o estacionamento e acessos.

Os valores de utilização são muitas vezes superiores aos definidos pelo POOC para a capacidade de carga.

Os visitantes consideram ter existido uma melhoria nos últimos cinco anos (melhores condições de acesso, circulação, estacionamento).

Grande parte dos utilizadores desconhece a importância e as mais valias ambientais, sociais e económicas do PMPLS.

Fontes:

- Pereira da Silva et al.,(2016) Beach carrying capacity and protected areas: management issues in Arrábida Natural Park, Portugal. ICS2016, Sidney.
- Implementação do Parque Marinho Professor Luiz Saldanha (Parque Natural da Arrábida): Ponto de situação realizado no âmbito do Projeto de conservação e gestão BIOMARES. ISBN: 978-989-97260-6-2

Third workshop evaluation survey

3º Workshop Avaliação dos Serviços dos Ecossistemas do PNA
19 de Abril, 2016, casa da Baía, Setúbal

Nome:____

Instituição: _______________________________________

Algumas questões são colocadas sob a forma de afirmações, pretendendo-se que assinale com uma cruz "X" apenas uma das opções, de acordo com uma escala entre 1- discordo totalmente e 5 – concordo totalmente.

1. workshop reuniu um grupo diversificado de agentes com interesse no PNA.
2. As alternativas foram discutidas de um modo frontal e aberto.
3. A metodologia utilizada ajudou a estruturar a discussão e análise das alternativas.
4. A metodologia utilizada criou oportunidade para que todos participassem na definição e escolha dos serviços dos ecossistemas afetados pelas alternativas.
5. De um modo geral concordo com os serviços dos ecossistemas definidos.
6. A metodologia utilizada criou oportunidade para que todos participassem na definição e escolha dos critérios.
7. De um modo geral concordo com os critérios definidos.
8. Os exercícios de grupo permitiram reconhecer serviços dos ecossistemas que anteriormente não associava às alternativas discutidas.
9. Os exercícios de grupo permitiram reconhecer critérios que anteriormente não associava às alternativas discutidas.
10. A metodologia utilizada permitiu criar uma linguagem comum para analisar de forma integrada o efeito das diferentes alternativas nos serviços dos ecossistemas.
11. A metodologia utilizada permitiu a articulação de diferentes critérios a considerar na avaliação das alternativas discutidas.
12. As matrizes construídas permitiram desenvolver uma visão integrada dos diferentes valores em causa para as alternativas discutidas.
13. As matrizes construídas são uma ferramenta útil para apoiar os processos de decisão avaliando a influência nos serviços dos ecossistemas e de diferentes critérios.
14. Depois da discussão promovida alteraria a resposta ao questionário inicial? Se sim porquê?____
15. Como acha que decorreu a interação e comunicação entre os participantes durante o workshop?____

16. Qual foi o racional seguido pelo grupo para a tomada de decisão?____
17. Na sua opinião quais foram os aspetos mais positivos e os mais negativos do workshop?____
18. O workshop valeu o tempo que despendeu? _____________________________
19. Recomendaria a metodologia utilizada a outras pessoas?___________________
20. Tem intenção de utilizar no futuro a metodologia do workshop?______________
21. Tem intenção de utilizar no futuro os resultados do workshop? ______________
22. Sente que contribuiu para definição dos critérios?___________________________
23. Como avalia a organização do workshop?_________________________________

Photos from the 3rd event

The photos displayed above are regarding the different tasks developed during the third participatory event, where different groups work on different exercises towards the articulation of multiple value dimensions of ecosystem services provided by the Arrábida Natural Park.

List of 3rd workshop participants

Institution	Participant name
AMRS - Associação dos Municípios da Região de Setúbal	Wieslaw Bodziony
AVIPE - Associação de Viticultores do Concelho de Palmela	Miguel Cachão
Câmara Municipal de Sesimbra	Marta Franco
Câmara Municipal de Setúbal	Cristina Coelho
CVRSetúbal - Comissão Vitívinicola Regional da Península de Setúbal	Alexandre Andrade
FCSH-UNL - Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa	Ricardo Mendes
ICNF - Instituto de Conservação da Natureza e Florestas	Luís Leitão
ICNF - Instituto de Conservação da Natureza e Florestas	Maria Céu Santos
José Maria da Fonseca	Paulo Horta
PNA - Parque Natural da Arrábida	Ana Sofia Palma
PNA - Parque Natural da Arrábida	Eduardo Carqueijeiro
PNA - Parque Natural da Arrábida	Miguel Henriques
PNA - Parque Natural da Arrábida	Rui Costa
Quinta de Alcube	João Serra