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Ecosystem services in environmental impact assessment

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Abstract

Environmental Impact Assessment (EIA) is an environmental management tool, whose function is to predict and manage possible impacts arising from a given project. With the emergence of new European legislation, there is a need to implement new procedures that make environmental impact assessment more efficient, particularly from an ecological point of view. Incorporation of Ecosystem services (ES) into EIA is an example of this new procedures, since they mirror the functioning of ecosystems and reflect on the socio-economic well-being of populations.

This work is divided into two phases, the first of which consisted in a review of previously carried out environmental impact studies, to assess the use of ES. The second phase will consist on the creation of a methodological guide that allows the integration of ES in EIA, focused on *Quercus* sp. Forests. In this paper the focus will be the first phase of the work.

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Keywords: Ecosystem services; Environmental impact assessment; Oak trees forest

1. Introduction

Environmental Impact Assessment is a preventive instrument in environmental policy, based on studies and consultations, with a focus on public participation and analysis of possible alternatives, whose purpose is the collection of information, identification and forecasting of the environmental effects of certain projects, as well as the identification and proposal of measures that avoid, minimize or compensate these effects, with a view to a decision on the feasibility of such projects and their post-evaluation [1]. The International Association for Impact Assessment (IAIA) defines EIA as the process of identifying, predicting, assessing and mitigating potential impacts before making decisions [2].

The concept of environment in an impact assessment study involves a focus on the biophysical components. It aims to: provide information for decision making, that analyzes the consequences on the biophysical, social, economic and institutional components; promote transparency and public participation in decision-making; identify

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the procedures for a post-project monitoring phase (mitigation and monitoring of negative impacts) in policy, planning and project cycle; contribute to a healthy environment and sustainable development [3].

EIA procedures should be initiated when there is the intention to start a project and they extend to the end of the impacts of that same project. Therefore, this process consists of a set of sequential phases: scope definition; environmental impact study; evaluation phase; and post-evaluation phase.

The Environmental Impact Study phase should include a detailed description of the project, characterization of the reference situation, identification and evaluation of the foreseeable impacts, positive and negative aspects of the project, foreseeable evolution without project realization, mitigation measures and management in order to compensate for negative impacts and a non-technical summary. One of the biggest gaps in the EIA process can be found in this stage, particularly as regards to the assessment of impacts on ecology [4,5].

Existing legislation requires that an assessment of impacts on the natural components (water, soil, atmosphere, weather, minerals, landscape, plants and animals) is always present, however, this evaluation is always carried out in a differentiated way, separating all groups, ignoring all the connections that exist between the biotic and abiotic factors.

However, the European Union, on the 16th April 2014, approved a new directive, directive no. 2014/52/EU, later transposed into Portuguese legislation by Decree-Law no. 152-B/2017, on December 11th, that emphasizes the importance of incorporating, in the evaluation and decision-making process other components such as sustainability in resource use, protection of biodiversity and climate change (*Decreto-Lei n.º 152-B/2017 de 11 de Dezembro de 2017 do Ministério do Ambiente*, [6]). This change has made it even more evident that new methodologies for assessing impacts, namely on the ecological components, are essential, and one of the possibilities is making a correct and detailed analysis of ecosystem services, since from this one can infer about the structure of biodiversity as well as the interactions with the environment [7].

Ecosystem services are the benefits that ecosystems provide to people. These consist of all-natural products and processes that contribute to well-being as well as personal and social enjoyment derived from nature (Fig. 1).

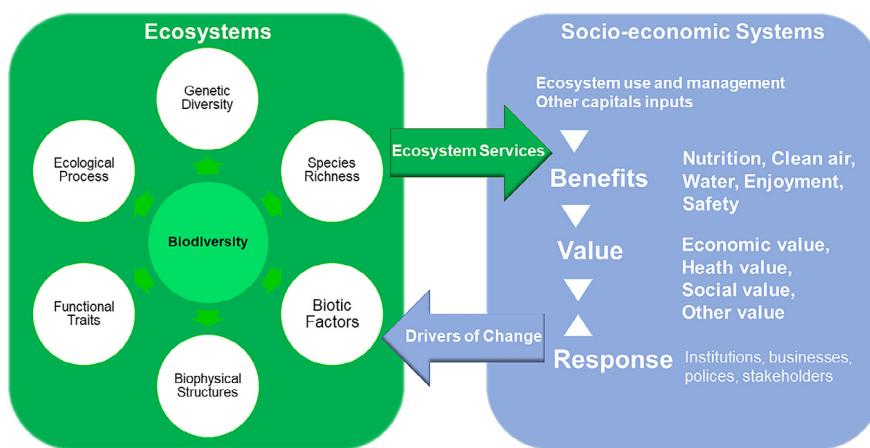


Fig. 1. Connection between ecosystem services and human well-being.
Source: Adapted Maes et al. [8].

According to the CICES (Common International Classification of Ecosystem Services) approach, ecosystem services can be classified into three categories: Provisioning services; Regulatory services; Cultural services [9]. There is a strong link between ecosystem services and the biological community that constitutes a given ecosystem, as well as a link between ecosystem services and socio-economic well-being, thus linking the three pillars of sustainability (economic, social and environmental) [10].

Nowadays, according to the last national forest inventory (IFN6), prepared by the ICNF based on data from 2010, the forest territory in mainland Portugal is represented by an area of about 3155.10^3 ha, being the terrestrial ecosystem that occupies the largest area, as well as an ecosystem that is responsible for providing numerous ecosystem services. The most abundant species are *Pinus pinaster* (714,000 ha); *Eucalyptus globulus* (812,000 ha); and *Quercus suber* (736,000 ha), corresponding respectively to about 23, 26 and 23% of the area of continental

Portugal [11]. The introduction of non-native species such as *Fagus sylvatica*, *Pinus spp.*, *Eucalyptus spp.* and *Acacia spp.* and the increasing human pressure had a huge impact on autochthonous communities, leading to the disappearance and reduction of many other types of forests [11]. As an example, the oak forest, that once dominated the landscapes of the country, is a type of Portuguese autochthonous forest with high economic and patrimonial value.

The composition of the forest in Europe and Portugal has undergone numerous modifications over the years, mainly in response to the numerous fluctuations in the climate, mostly due to climate change. Nevertheless, in more recent time scales, changes in the forest composition have also been verified, not only due to climatic factors, but also due to anthropic factors [12].

Portugal is a country that, since its earliest days, has been linked to maritime activities, namely the discovery of new lands and fishing activities, since it has a large stretch of coast. The need to obtain raw material for these activities makes it very close to the existing forest, since it is from this that the necessary raw materials are obtained. This straight link, together with exponential population growth and demographic expansion that emerged in the following centuries, further increased the pressure on the forest, leading to profound changes in the country's forest composition [13].

Before the sea expansion and the time of Portuguese discoveries, the forests of *Quercus spp.* dominated the landscape of mainland Portugal. *Quercus pyrenaica* and *Quercus robur* were dominant in the north of the Tagus River, while the southern perennial species *Quercus suber* and *Quercus rotundifolia* dominated to the south of the Tagus River, as well as extensive areas of *Pinus pinea* [14,15].

Today, oak forest ecosystems provide countless ecosystem services to mankind. The oak forests are a type of native forest that provides a large amount of ecosystem services, including climate regulation, water cycle regulation, wood, energy, air purification, erosion control and others [16].

This split on oak forests can be explained by biogeographic influences, since Portugal is inserted in the Mediterranean region, with only a small strip of the territory in the Atlantic zone [17]. The region that finds itself with Atlantic influence is characterized by having a temperate and rainy climate without a clear dry season. The most representative formations here are the forests of thin, flat, large, deciduous winter tree trees such as oak trees (*Quercus robur*, *Quercus pyrenaica*), [17]. The Mediterranean Region is characterized by a climate in which rain is scarce in summer, but there may be excess water in other seasons. [17].

The *Quercus robur* forests are characterized by having large deciduous trees, which achieve a high longevity (more than 1000 years in some cases) and reach dimensions over 40 m in height and 3 m in diameter. This species, from ancient times, has a fundamental role in providing raw material for mankind, notwithstanding that, for certain ethnic groups, it was also considered a mystical tree of great religious and cultural value [18]. Numerous ecosystem services are currently being allocated to these forests, among which are regulation services such as CO₂ sequestration, climate regulation, prevention of natural disasters, water cycle regulation, retention and soil formation, regulation of the nutrient cycle, disposal-recycling of waste, biodiversity refuge; provisioning services: food production, production of wood; cultural services: aesthetic information; recreation, artistic and cultural information, spiritual and cultural information and education and science [19].

The *Quercus pyrenaica* forests are characterized by medium sized trees, usually growing between 20 and 25 m in height. Although it is a deciduous leaf tree, the leaf of this species only falls in the spring.:The root system is strong, equipped with numerous shallow secondary roots, including a deep “taproot”, which allows the trees to reach the water content in the soil. These two features constitute an adaptation to climates of warmer characteristics [18,20]. Due to its great capacity for regeneration, this species has always been used in silvo-pastoral regime, for firewood and charcoal production. Currently the wood of this species continues to be exploited, however, due to its enormous importance from a landscape point of view, forming forests rich in biodiversity, this species is protected by European legislation [21]. Numerous ecosystem services are currently being allocated to the forest of this species, among which are regulation services: CO₂ sequestration, climate regulation, prevention of catastrophic phenomena, water cycle regulation, retention and soil formation, regulation of the nutrient cycle, disposal-recycling of waste, biodiversity refuge; provisioning services: food production, production of wood; cultural services: aesthetic information; the recreation, artistic and cultural information, spiritual and cultural information and education and Science [19].

The *Quercus rotundifolia* forests, often known as holm oak, are characterized by a broadleaf or shrub tree, which can grow up to 25 m high and about 2 m in diameter, and can reach a longevity of 1000 years [22]. In the Iberian

peninsula, this species is often exploited in the form of a “montado”, an agro-silvo-pastoral system, where the holm oaks are distant from each other's and where the cattle feeds [23]. The holm oak is a species that is quite tolerant with respect to soil, climate and altitude types, supporting soils that can range from arid to humid; from areas that do not have high levels of precipitation and high temperatures to areas of high altitude associated with low temperatures. Numerous ecosystem services are currently being allocated to forests of this species, among which are regulation services CO₂ sequestration, water cycle regulation, retention and soil formation, regulation of the nutrient cycle, biodiversity refuge; provisioning services: food production; cultural services: aesthetic information, spiritual and historical information and education and Science [19].

The *Quercus suber* forests, commonly known as Cork Ocher is native to the Mediterranean region. This species can grow up to 20 m in height, 1.5 m in diameter and have a longevity of about 200 years [22]. One of the most representative characteristics of the species is its bark, called cork, which is harvested periodically, and used as raw material. However, the bark is an adaptation to hot and dry climates since it allows the tree to survive fires [18]. It is often associated with agro-silvo-pastoral ecosystems, called “montado”, where mature and dispersed trees coexist with a sub-forest stratum composed of pastures and cereal crops. Numerous ecosystem services are currently being allocated to the forest of this species, among which are regulation services CO₂ sequestration, water cycle regulation, retention and soil formation, regulation of the nutrient cycle, biodiversity refuge; provisioning services: cork production; cultural services: aesthetic information, spiritual and historical information and education and Science [19].

The general trend is that pressure on ecosystems, include oak forests, will globally increase in the coming decades, unless human attitudes and actions change [24]. The need to change the current paradigm for using natural resources, leads to the need to change the context in which economic, political and social decisions are made, in order to implement methodologies that allow the integration of ecosystem services into decision making [25].

2. Material and methods

In a first phase of this work, all the environmental impact studies available on the site of the Portuguese Agency of the Environment were downloaded on October 29, 2018 and reviewed in order to evaluate the use of ecosystem services in their making process. In the analysis was done a systematization, grouping the several kinds of project according to their typology, taking into account the different phases of the project (construction, development and deactivation phases).

In this process, impacts and the mitigation and monitoring measures were analyzed (Fig. 2).

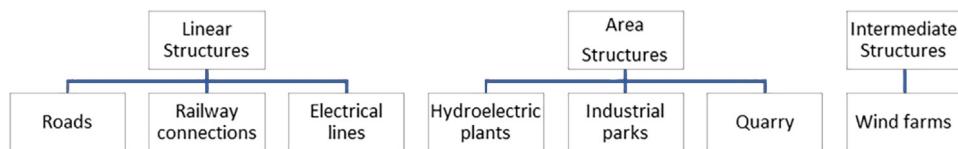


Fig. 2. Structures types used in the systematization of EIA in Portugal.

The second part of this work, which is still underway, is the preparation of a practical guide, which will contain methodological instructions on the integration of Ecosystem Services in the environmental impact assessment process, for projects that are carried out where there are forests patches of *Quercus* sp.

3. Results

In total, 339 studies were analyzed in a first phase and, of these, approximately 54% percent already had implicit references to ecosystem services, namely in relation to provisioning services, but only 1% explicitly used Ecosystem Services. Even these only refer briefly their importance, usually on the characterization phase. The implicit references found mention mostly the importance of the study area as feeding, breeding, nursing spots, for numerous species, which correspond to the service life cycle maintenance, habitat and gene pool protection. Less frequently there are some references to air purification, soil retention, water cycle, temperature regulation and creation of better edaphic conditions. Frequently a connection is found between the production services and some ecosystems like agricultural and forest, like the production of wood, and other nutrition products. The cultural

services are even more rare, and usually connect to a scientific and landscape value or tourism and education. These results evidence that the ecosystem services are rarely consider in environmental impact studies, carried out in Portugal.

The systematization allowed to infer that, in some cases, the impacts caused by the different kinds of projects could be very diverse, such as the mitigation and monitoring measures that were proposed. Nevertheless, in most of the cases, there is a consensus in this strand and the measures are very similar.

One of the most common errors encountered at this stage was that, in many cases, the mitigation measures suggested are mandatory by law, which means that these are not mitigation measures but rather legal obligations

In the second phase, still in development, a guide will be created, with indications of how to evaluate environmental impacts in ecosystem services. For this, indicators of ecosystem services are used, such as global climate regulation by reduction of greenhouse gas concentrations, or climatic parameters on regulation services; raw material production by amount, type and use; and data on by visits/use, plants and animals diversity, ecosystem type importance for cultural services [26]. The evaluation in the provision of services will be done on a scale of 1 to 5, where 1 means that a given ecosystem service is no longer being provided, and that the project has had a major impact on that service and 5 means that the service continues to be provided without any kind of impact. In addition to this methodology, mitigation measures and ecological monitoring plans directly linked to ecosystem services will be suggested in order to minimize the impacts on these ecosystem services.

4. Conclusion

The increase of anthropic pressure on ecosystems, especially on oak forests, has been increasing the need to establish new methodologies that allow inferring about the impacts caused on ecosystems. The guide that is being developed in the course of this work will focus on the evaluation of impacts applied to ecosystem services, through the evaluation of ecosystem service indicators. With this, the guide seeks to improve the mechanism of environmental impact assessment, thereby ensuring the sustainability of these ecosystems for future generations.

References

- [1] Agência Portuguesa do Ambiente, 2019. APA - Instrumentos ; Avaliação do Impacte Ambiental [WWW Document]. URL <https://www.apambiente.pt/index.php?ref=17&subref=146> (accessed 01.14.19).
- [2] IAIA, IAIA The leading global network on impact assessment [WWW Document]. URL <https://www.iaia.org/index.php> (accessed 1.31.19), 2019.
- [3] IAIA, What Is Impact Assessment? [WWW Document]. URL https://www.iaia.org/uploads/pdf/What_is_IA_web.pdf (accessed 02.01.19), 2009.
- [4] S. Briggs, M.D. Hudson, Determination of significance in ecological impact assessment: Past change current practice and future improvements, *Environ Impact Assess Rev* 38 (2013) 16–25, <http://dx.doi.org/10.1016/j.eiar.2012.04.003>.
- [5] D. Geneletti, *Ecological evaluation for environmental impact assessment*, *Ned Geogr Stud* (2002) 1–217.
- [6] Decreto-Lei n.º 152-B/2017 de 11 de Dezembro de 2017 do Ministério do Ambiente, 2017. Lisboa, Portugal.
- [7] E. Nelson, G. Mendoza, J. Regetz, S. Polasky, H. Tallis, Dr. Cameron, K.M. Chan, G.C. Daily, J. Goldstein, P.M. Kareiva, E. Lonsdorf, R. Naidoo, T.H. Ricketts, Mr. Shaw, Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales, *Front Ecol Environ* 7 (2009) 4–11, <http://dx.doi.org/10.1890/080023>.
- [8] J. Maes, A. Teller, M. Erhard, C. Liquete, L. Braat, P. Berry, B. Ego, P. Puydarrioux, C. Fiorina, F. Santos-Martín, M.L. Paracchini, H. Keune, H. Wittmer, J. Hauck, I. Fiala, P.H. Verburg, S. Condé, J.P. Schägner, J.San. Miguel, C. Estreguil, O. Ostermann, J.I. Barredo, H.M. Pereira, A. Stott, V. Laporte, A. Meiner, B. Olah, E.R. Gelabert, R. Spyropoulou, J.-E. Petersen, C. Maguire, N. Zal, E. Achilleos, A. Rubin, L. Ledoux, P. Murphy, M. Fritz, C. Brown, C. Raes, S. Jacobs, P. Raquez, M. Vandewalle, D. Connor, G. Bidoglio, Mapping and assessment of ecosystems and their services-An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020: discussion paper – final, 2013. <http://dx.doi.org/10.2779/12398>, 2013.
- [9] CICES, 2019. CICES: Towards a common classification of ecosystem services [WWW Document]. URL <https://cices.eu/> (accessed 02.01.19).
- [10] F. Landsberg, J. Treweek, M.M. Stickler, N. Henninger, O. Venn, Weaving ecosystem services into impact assessment. A step-By-Step Method (Version 1.0), 2013.
- [11] ICNF, 6º Inventário Florestal Nacional. Áreas dos usos do solo e das espécies florestais de Portugal continental. Resultados preliminares, 2013.
- [12] J. San-Miguel-Ayan, D. de Rigo, G. Caudullo, T. Houston Durrant, A. Mauri, *European atlas of forest tree species*, Publication Office of the European Union, Luxembourg, 2016.
- [13] B.S. Pinto, C. Aguar, M. Partidário, Brief historical ecology of northern Portugal during the holocene, *Environ Hist Camb* 16 (2010) 3–42, <http://dx.doi.org/10.3197/096734010X485283>.

- [14] J. Pais, Paleoetnobotânica (finais séc. XI a séc. XIII–XIV) do Sul de Portugal—Setúbal, Mértola e Silves. Arqueol Mediev. Mértola, 277–282, 1996.
- [15] J. Pais, Evolução do coberto florestal em Portugal no Neogénico e no Quaternário, Comum Serv Geol Port (1989) 67–72.
- [16] M. Ecosystem Assessment, Ecosystems and human well-being: Synthesis, ecosystems, Island Press, Washington, DC, 2005.
- [17] J.C. Costa, C. Aguiar, J.H. Capelo, M. Lousã, C. Neto, Biogeografia de Portugal continental, Quercetea (1998) 5–56.
- [18] J. San-Miguel-Ayanz, D. de Rigo, G. Caudullo, T. Houston Durrant, A. Mauri, W. Tinner, D. Ballian, P. Beck, H. Birks, E. Eaton, C. Enescu, S. Pasta, I. Popescu, C. Ravazzi, E. Welk, R. Abad Viñas, J. Azevedo, A. Barbati, J. Barredo, B. Zecchin, European Atlas of Forest Tree Species, 2016.
- [19] ICNF, Plano Setorial RN2000 Habitats 1 a 9 — ICNF, 2008.
- [20] A. Lopez Lillo, A. López Santalla, C. Madrid, Obra Social, Arboles madrileños: Guía para reconocimiento de arboles y arbustos arboriformes de la ciudad de Madrid. Obra Social Caja Madrid, Madrid, 2007.
- [21] P. Velasco-Aguirre, Comprehensive study of *Quercus pyrenaica* willd. forests at Iberian Peninsula: indicator species, bioclimatic, and syntaxonomical characteristic 159. <https://doi.org/ISBN:978-84-693-1123-3>, 2014.
- [22] A. Praciak, C.A.B. International, The CABI encyclopedia of forest trees, 2013.
- [23] D. de Rigo, G. Caudullo, *Quercus ilex* in Europe: distribution, habitat, usage and threats, 2016.
- [24] H.M. Pereira, P.W. Leadley, V. Proença, R. Alkemade, J.P.W. Scharlemann, J.F. Fernandez-Manjarrés, M.B. Araújo, P. Balvanera, R. Biggs, W.W.L. Cheung, L. Chini, H.D. Cooper, E.L. Gilman, S. Guénette, G.C. Hurt, H.P. Huntington, G.M. Mace, T. Oberdorff, C. Revenga, P. Rodrigues, R.J. Scholes, U.R. Sumaila, M. Walpole, Scenarios for global biodiversity in the 21st century, Science (80-.) 330 (2010) 1496–1501, <http://dx.doi.org/10.1126/science.1196624>.
- [25] K.M.A. Chan, T. Satterfield, J. Goldstein, Rethinking ecosystem services to better address and navigate cultural values, Ecol Econ 74 (2012) 8–18, <http://dx.doi.org/10.1016/j.ecolecon.2011.11.011>.
- [26] F. Müller, B. Burkhard, Y. Hou, M. Kruse, L. Ma, P. Wangai, Indicators for ecosystem services. 157–169, 2016.