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Analysis of the Ecosystem Services of Arrábida's Natural Park terrestrial component

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1. Framework

One of the key supporting arguments for the increase in the adoption of the concept of ecosystem services (ES) by researchers and policy-makers lies in the importance of this concept in relating the value of natural systems with human wellbeing (Cunha et al. 2014). Even more nowadays, in the context of the debates concerning biodiversity conservation and management of natural resources, when aspects of environmental conditions and pressures inflicted upon it by human activities can no longer be out of the discussion and the decision making. There has been great contribution to the dissemination of ES approaches, where different initiatives take place at national and global scales, such as MEA 2005 and TEEB 2010.

Within the global concerns linked with the general use of this concept to bring environmental discussion to the decision making process, there are important perspectives in the process of developing an assessment and managing frameworks that can actually be capable of capturing and integrating ecological, social or economic ES value dimensions (TEEB, 2010). The major goal for this study is to bring together in a structured way, all the major different aspects about the terrestrial components of the Arrábida's Natural Park (ANP) and map its definitive role on the local human wellbeing for, in our best intentions, provide a point of information for future decision makers about the protected area and build a shared recognition about its ES, benefits and value. As a first action, more specific goals of research were defined regarding the evaluation of the ecosystems aspects leading, further, to a choice of methodology in our reach, through data collection and access to recent studies. A better understanding about the process to build the framework based on the *Common International Classification of Ecosystem Services* (CICES, V4.3) took place, making possible to categorize the different aspects of the ANP's ecosystem, including the benefits and overall value, as well as the pressures, for then, developing the classification of those services.

2. Objectives

Our goal is to understand the ecosystem and the interaction between the elements involved in Arrábida's Natural Park, by identifying the current conditions and human pressures. Also, we want to visualize the relation with the economic activities, to have a clear view of the direct and indirect contributions for the human wellbeing and their consequent economic value. For that, we will address the latest studies and raise recent data, to manage the building of a conceptual framework that will help us to draw a detailed picture and assess the valuation of the park's economic values.

3. Methods

The approaches chosen for the conduction of this study were the bibliographic research and data collection, where we could raise material already available on the CICES framework and classification system as well as the latest information about the park's conditions about the aspects required to fill the framework. On a second moment, a work of classification and building of the framework was conducted, for a better understanding about each aspect to be analysed.

At first, we managed to have an overview about the different typologies or ways of classifying ecosystem services available, such as those used in the Millennium Ecosystem Assessment (MA, 2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2010). The decision to go on with the CICES framework was based on its ease of understanding and communicability for the level of data and information that we were able to get access to (CZÚCZ, B., et al., 2018). The CICES conceptual frame brings a cascade model (Potschin and Haines-Young, 2016), with the notion of ecosystem structure and function, with the services, benefits, values and pressures in a sequence. This typology of classification provides a way of envisioning and organization of the different aspects of the ecosystem. Regarding the classification of the services, they are divided into provisioning services, that are the material and energetic outputs from the ecosystems (goods and products); the second division is regulating services category, which includes all the ways in which ecosystems can mediate the environment in which people live or depend on in some way and benefit from. Finally, the cultural services category, which we can identify as the non-material characteristics of ecosystems that contribute to, or are important for people's mental or intellectual wellbeing.

The research and classification

For the collection of data about the current situation of the Arrábida's National Park (ANP), there was the necessity to search through different channels of information, from papers to official sources. The Arrabida's Natural Park (ANP), is a coastal and marine protected area in Portugal, created in 1976 (ICNF, 2021). ANP has numerous biological, geological, floristic and archaeological features of high and unique importance (Cunha et al. 2014). The choice for this specific site is due to the richness of the site in terms of natural values, and also because of the recognition of the challenges placed on nature conservation arising from the intense human presence on the territory (Novais et al. 2004; Cunha et al. 2014).

After the characterization of the area, which made it possible to understand features about the structural functioning and aspects, there was research about the services provided by that ecosystem. In a study of 2016 (Lopes et al.), a participative method to assess the services of the ANP ecosystem has taken place in the local community, in order to understand the perception of the community about the services provided by that ecosystem and the perceived values and benefits around them. This study applied a hybrid of the MA and TEEB classifications in their exercise and served as the main base for this research to list and classificate the ES and made it possible to complement with just a few other services that were not covered and then make the classification according to CICES classification structure. After the Identification and classification of the services, it was time to identify basic benefits and evident value of those ES, for which was made use of the repertoire of the researchers and research about the ecosystem and the perceived aspects of it.

At last, there was a deeper understanding about the pressures implied to that ecosystem. There were few studies in the area, mainly regarding the changes through time among the protected areas of Portugal (Rodrigues, Olivença e Rocha, 2021), which made possible the broader understanding about the evolution of human activities and occupation around the area, and also to tackle the key pressures. Other more specific data were collected on specific studies like, for example, information about invasive species (Palma e Almeida, 2020) and economic drivers in the area of study.

4. Results

Structure

As a result of our research on the ES of Arrábida Natural Park, we identified some biophysical structures and processes which are related with the characterization of the study area. This natural park has two components: a terrestrial and a marine area. The terrestrial part is mainly a mountain area that reaches about 500m above the sea level. The rock formations are composed of limestone. On the littoral areas, there are sea cliffs with considerable heights, and some small beaches. There are some small streams, but infiltration largely exceeds runoff. This makes the park poor in surface water resources but rich in subterranean water.

There is a climatic variation along the park, what results in different floristic elements, with 3 main types present: Euro-Atlantic, associated with the more humid and colder climate that exists on the northern part; Mediterranean on the southern part that is drier, hotter and with more sunlight available; Macaronesian in the sea cliffs.

There are in total 42 types and subtypes of habitats, but the main are: sclerophilic weeds, natural and semi-natural herbaceous formations, rocky habitats and caves, and forests. In the Arrábida area, 1450 plant taxa, twelve species of amphibians, seventeen of reptiles, one hundred and ninety-seven of birds and thirty-four of mammals are listed, some of them endangered. The richness of the rupicolous bird communities is noteworthy: the Bonelli's eagle (Hieraaetus fasciatus) has the only known nesting site on a marine cliff in Europe. The peregrine falcon (Falco peregrinus) and the ogea (Falco subbuteo) are other endangered species of prey that nest on these escarpments. Espichel Cape is a part of one of the preferred bird's migration routes (ICNF, 2021).

Considering this, the biophysical structures that can be associated with ES that we identified were some types of habitats that could be related with some ES, specifically: forests, rocky habitats and caves, natural / semi-natural herbaceous formations, Mediterranean arborescent scrubs, sea cliffs, and the faunal communities that live there; as process we identified the food webs.

Function

Functions could be associated with these structures and processes. Water founts can be found on rocky habitats where water infiltrates. Primary production and O2 production that can be associated with all these habitats that contain plants. Nutrients cycle can be related with the trophic food web where the nutrients flow from the producers to the decomposers. The maintenance of genetic diversity that is valid for all the structures containing living beings. Soil formation depends on the rocky habitats that suffer erosion to generate sediments and from the living organisms that compose the biotic component of the soils. Natural habitat provisioning is related to all the habitat types identified. Finally, pollinate function depends on plants to produce pollen and, many times, animals to transport that pollen and fertilize plants.

Services

As a result of these functions, we could list several services that, following the CICES framework, we divided into the 3 groups of provisioning, regulation and cultural. On the provisioning services we identified some which are related with the production of different types of plants or animals for human food/drink needs, medicinal, and in the case of plants also for ornamental uses. These organisms can also provide genetic material. Water font function can provide water for human consumption.

As regulation services many of them are closely related with functions. Nutrients are cycled through the food web. Erosion can be regulated with the presence of vegetation that reduces erosivity by intercepting a part of the rainfall. Animals, like bees, can regulate pollination of plant species. The presence of these different structures can result in habitats for organisms, and the organisms can regulate the size of species' populations (through the food web or even because of competition), preventing pests and diseases. As referred previously, the rocks contribute to form soil (in association with organisms) and to regulate water quality. Climate and air quality regulation can be related to plants.

For the cultural services we identified that in general all the areas can be proper to be a place for recreation activities, ecotourism, sports, distress and nature contemplation, educational and scientific interests. People can also feel connected with the place, appreciate the aesthetic values and maybe get inspiration for art creation, a local symbol of natural history, and it is spiritual and religious since there are various religious monuments present in the park.

Services Classification

Table 1 " Classification of the ES of ANP ” Source: Authors, 2021.

Section	Division	Group	Class	Code	Services provided
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	1.1.1.1	Herbs, Vegetables, Other endemic varieties
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing	1.1.1.2	Grapes for wine, medicinal herbs, ornamental herbs and genetic material
Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy	Animals reared to provide nutrition	1.1.3.1	Dairy products
Provisioning (Biotic)	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from plants, algae or fungi	Higher and lower plants (whole organisms) used to breed new strains or varieties	1.2.1.2	Endemic orchid
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for drinking	4.2.2.1	Water for drinking
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water (and subsurface) used as a material (non-drinking purposes)	4.2.2.2	Water for production
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Bio-remediation by microorganisms, algae, plants, and animals	2.1.1.1	Nutrient cycling
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Control of erosion rates	2.2.1.1	Erosion regulation
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context)	2.2.2.1	Natural pollination services

Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats (Including gene pool protection)	2.2.2.3	Habitat provision
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control	Disease control	2.2.3.2	Human disease and pest regulation
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality	Weathering processes and their effect on soil quality	2.2.4.1	Soil formation
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Water conditions	Regulation of the chemical condition of freshwaters by living processes	2.2.5.1	Water quality regulation
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of chemical composition of atmosphere and oceans	2.2.6.1	Climate regulation
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of temperature and humidity, including ventilation and transpiration	2.2.6.2	Air quality regulation
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1	Place for recreation, ecotourism and sports practice
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2	Place for destress and nature contemplation
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1	Place for scientific research

Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	3.1.2.2	Place for educational purpose
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3	Sense of place
Cultural (Biotic)	**Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting**	**Intellectual and representative interactions with natural environment**	**Characteristics of living systems that enable aesthetic experiences**	3.1.2.4	Aesthetic values
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have symbolic meaning	3.2.1.1	Local emblem
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have sacred or religious meaning	3.2.1.2	Spiritual and religious value

Benefits and Values

Based on the services identified we tried to point out some generic benefits and values that can be generated. The services related with production of plants for food needs enable us to obtain harvest crops, to have a healthy diet (spending less money on health), and livelihoods. This type of provisioning services make more resources available to support more economical activities. Regulation services like regulation of water quality result in the benefit of local communities having water security. Habitats can result in interesting landscapes. The cultural services allow people to participate in activities, to have relevant personal experiences and to learn more. It also can increase the income for tourism and recreation, and employment. Finally, when people benefit from all this, they may be willing to pay for the protection of these ecosystems.

Pressures

A driver is any natural or human-induced factor that directly or indirectly causes a change in the ecosystem. Driving forces are almost always multiple and interactive, so that a one-to-one linkage between particular driving forces and particular changes in ecosystems rarely exists.

Demographic changes are an important driver affecting both demand and supply of ecosystem services. According to the data published by the INE, the municipalities on which the park is located have all experienced an increase in population density levels, going overall from 400 inhabitants/km2 in 1960 to almost 1000 inhabitants/ km2 in 2021. High population density puts high pressure on ecosystems and produces great demand, when low density as in rural depopulation withdrawals demand and increases farmland abandonment.

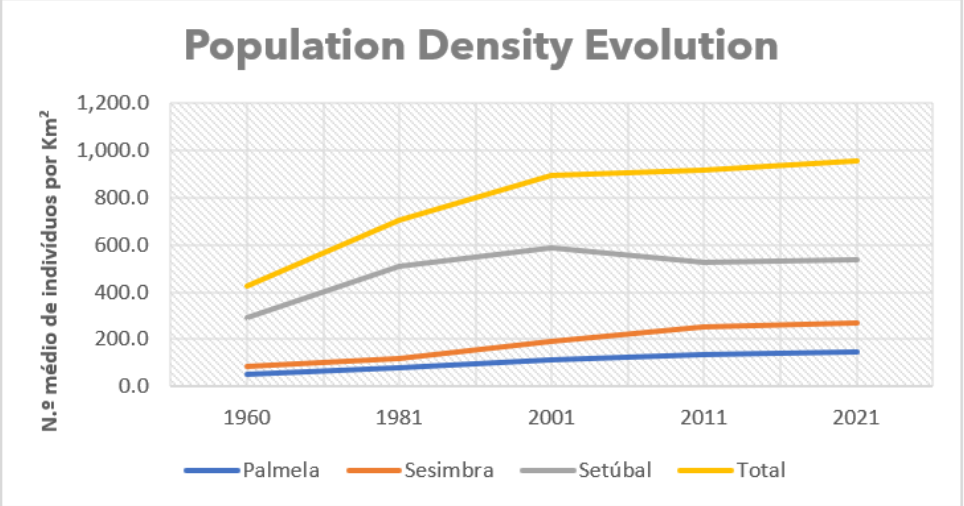

Figure 1 "Population Density Evolution"
Data Sources: INE - X, XII, XIV, XV and XVI General Population Censuses

Socio-political drivers encompass the forces influencing decision-making and include the quantity of public participation in decision-making, the groups participating in public decision-making and levels of education and knowledge among others. According to INE's data, most of the adult population is well educated and has reached at least the level "Basico 3° ciclo". People with a higher degree of education in the area are more than 25 thousand.

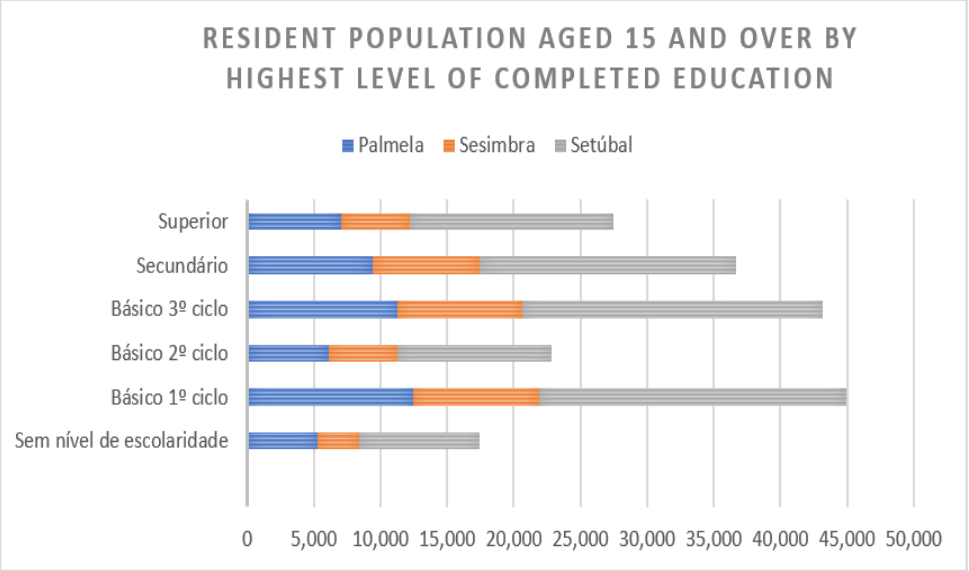

Figure 2 "Resident population aged 15 and over according to the Census: total and by highest level of completed education".
Data Sources: INE - X, XII, XIV and XV General Population Censuses, last update 2015

The number of people actively participating in elections, thus to the public affairs, remained constant from 1975 to 2019. On the other hand, the number of abstainers has risen up along the same time span (SGMAI, 2019). Taking into account the growth in population experienced in those areas, this information indicates that the amount of people being interested and taking part in the public decision-making process is decreasing. This can indirectly exert a negative influence on the ES.

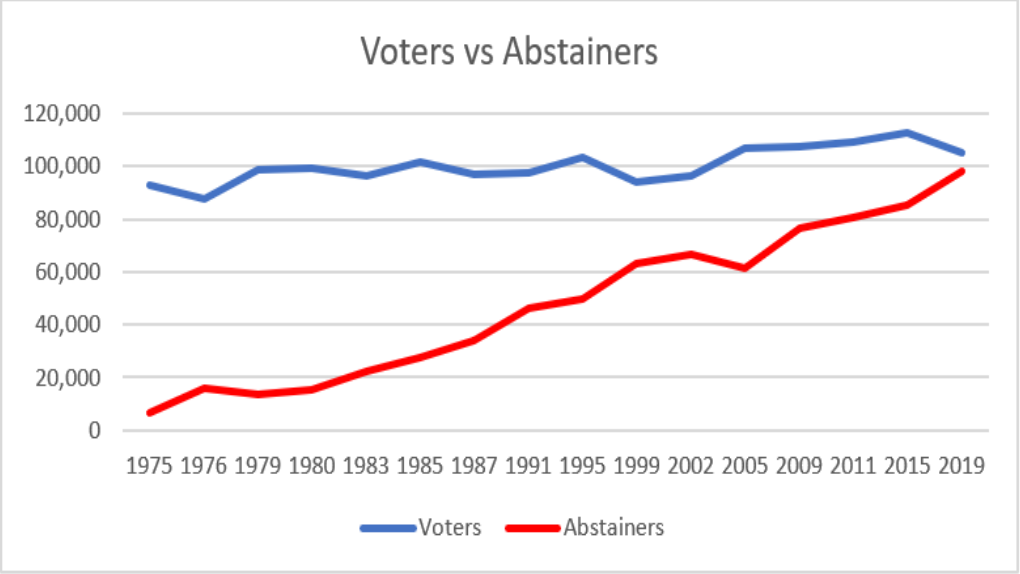

Figure 3 "Voters in the elections for the National Assembly: voters and abstention"
Data Sources: SGMAI - Voter Registration Database (Voters) | Provisional scrutiny (voting)

As a proxy of the economic drivers, the current study proposes the number of companies founded in the three municipalities from 2009 until 2019 in INE's registers. Overall, the total number of companies has increased over time.

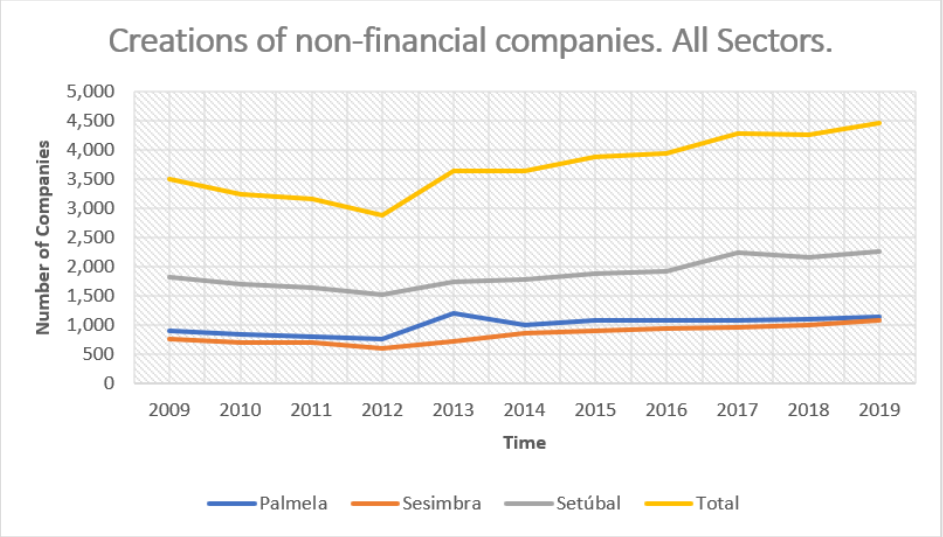

Figure 4 " Creations of non-financial companies. All sectors."

Source: INE -Demographics of the Companies

The number of companies in the agriculture and fisheries field created skyrocketed in 2013 in the municipality of Palmela and then it slowly decreased. In general, the number of companies in such key sectors for the ES evolved on a positive trend and from 2018 on, it is consistently decreasing and remaining low. On the other hand, the number of firms involved in the industry, construction and energy increased exponentially and this process represents a huge threat against the maintenance of the ES in the area of study.

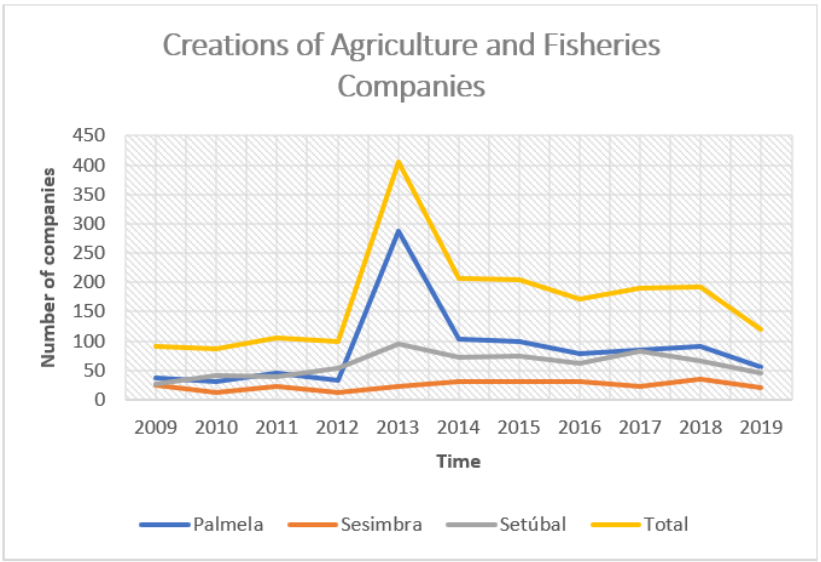

Figure 5"Creations of agriculture and fisheries companies"

Source: INE -Demographics of the Companies

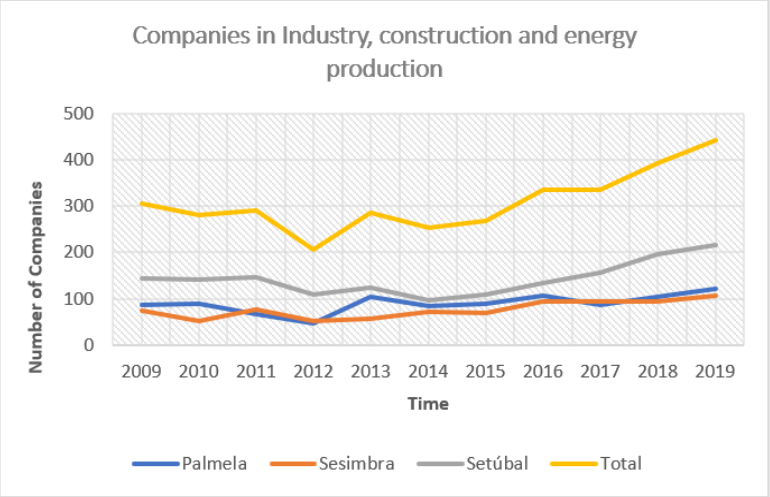

Figure 6"Companies in industry, construction and energy production".
Source: INE -Demographics of the Companies

Tourism accounts for a huge portion of the local economy as well as it exerts a huge pressure on the local Ecosystem. The following plot shows the evolution of the number of guests in tourist accommodations per 100 inhabitants from 2001 to 2020 in the study area according to the INE's information available. Overall, the number of tourists has almost doubled from 2001 until 2019 (pre pandemic era). It is possible to appreciate a big drop from 2019 to 2020 due to the negative impact of the covid19 to the tourism sector of all European countries.

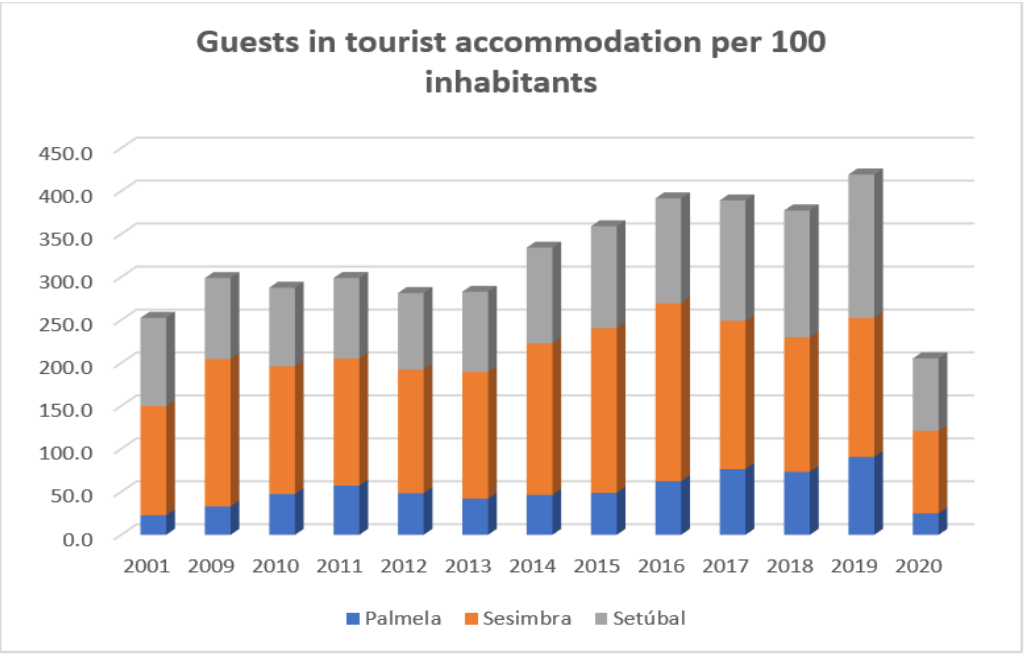

Figure 7"Guests in tourist accommodations per 100 inhabitants"
Data Sources: INE - Annual Resident Population Estimates

Land-use change is one of the most important drivers of ecosystem and ecosystem service supply change. Agricultural abandonment is evident and accounts for 27.48% of all dynamics between 1995 and 2015 in the area. The transfers between the different types of crops have been important in the period, 537.61 ha representing the 35.52% of the total dynamics. In general, they are replacing temporary crops for permanent ones. It is also detected an increase in natural vegetation between spaces cultivated.

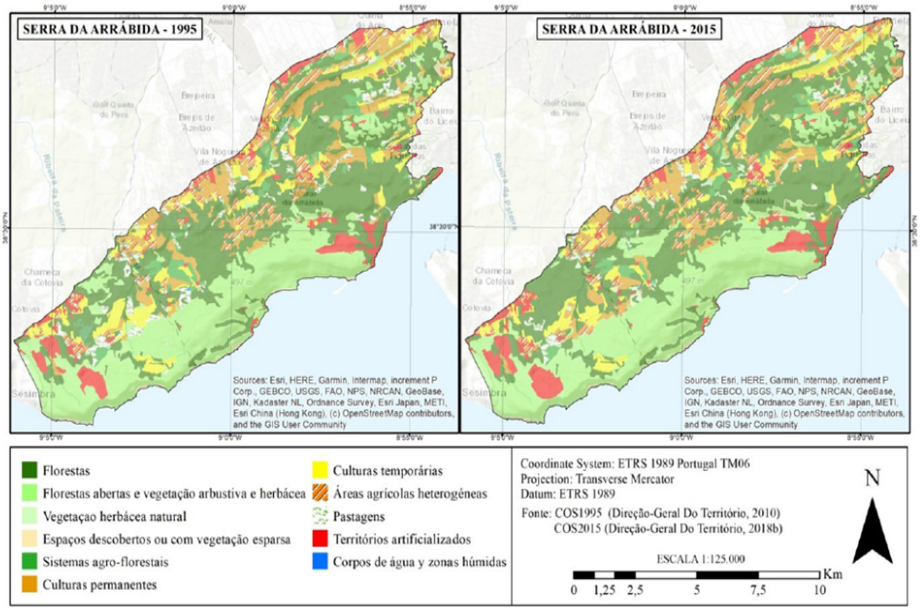

Figure 8 " Maps of uses and coverage for the years 1995 and 2015. Own elaboration based on Directorate-General for the Territory (2010, 2018b)"

Forest areas have increased in area thanks to the densification of forest formations open and revegetation of cultivated areas and pastures. The increase in artificial areas, despite its scarce representation in the total volume of dynamics (less than 10% of the dynamics), is one of the most drastic change processes identified in the scenery. In relation to the agricultural area and according to the census information for the years 1989, 1999 and 2009, in the three municipalities it increased by more than 2,823 hectares (9.07%) (PORCEL-RODRÍGUEZ et al. 2021).

Introduction of alien species spread and changed ecosystems and habitats, thus impacting a wide range of ES. There are three ornamental plants mostly coming from South Africa that are invasive species present in the area of study (PALMA E ALMEIDA, 2020):

- *Senecio angulatus (senecio)*
- *Ipomoea indica*
- *Carpobrotus edulis*

Framework

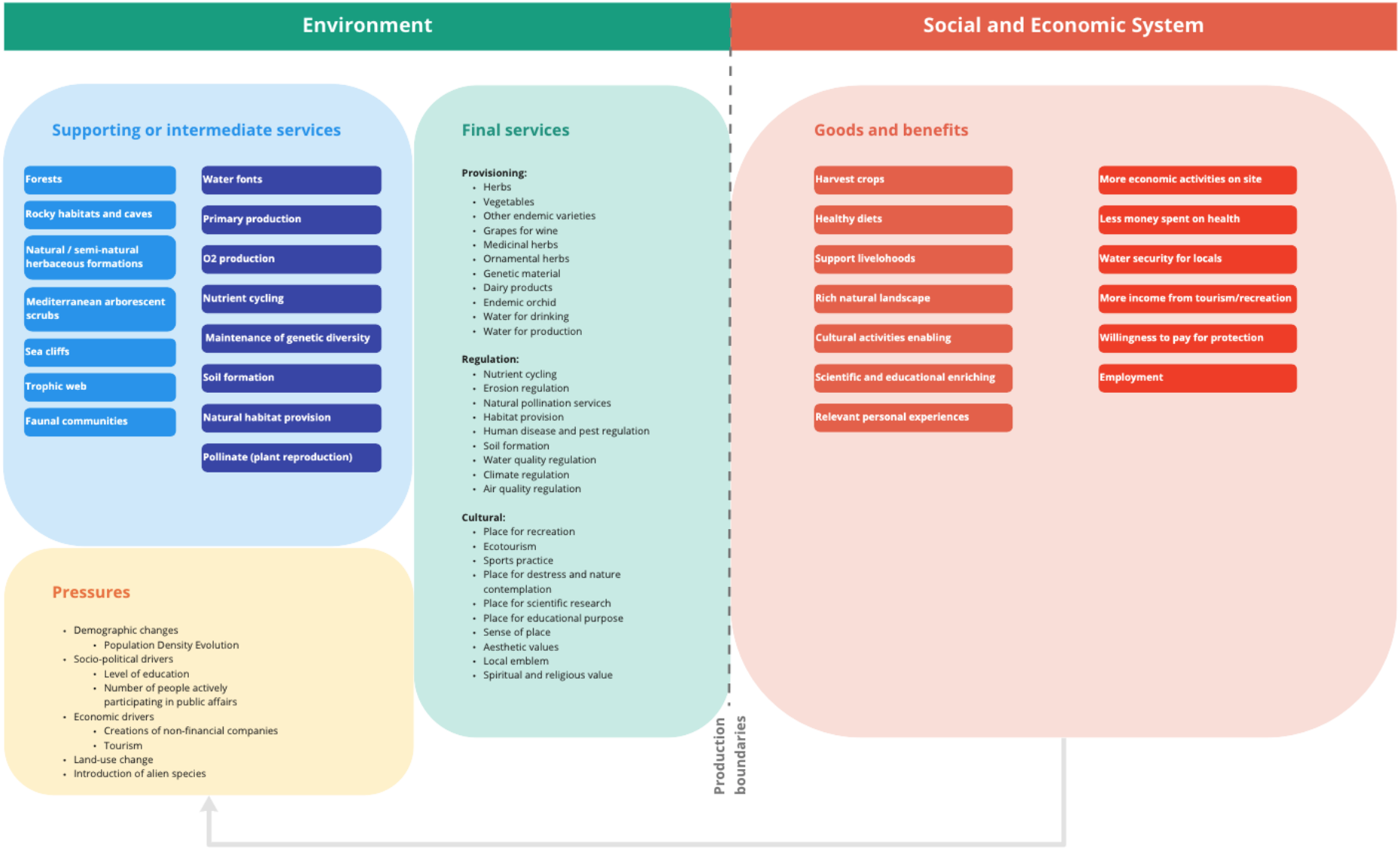

Figure 9 " CICES framework ANP " Source: Authors, 2021.

5. Discussion

An important clarification has to be done at this stage: the data analysed, and on which the discussion has been developed, refers to all the municipalities including areas that are not within the Arrabida Natural Park's perimeter, so the results might be a bit biased. Protected areas are perceived as a shield not only for the conservation of biodiversity but also from wild economic growth and constructive pressure. However, many of these areas are located in socioeconomically disadvantaged regions, being extraordinarily sensitive and generally averse to public decisions dealing with economic affairs.

For this reason, land usage is a key factor to discuss as well as the effects it has on the whole functioning of the ecosystem. It is strongly linked to most of the intermediate services mentioned above in the report and in fact even the "small" increase of both artificial and agricultural areas could have direct effects on soil formation, and because of this it is perceived by the researchers as "drastic" (PORCEL-RODRÍGUEZ et al. 2021**)**. It is also worth mentioning that not only has there been an increase in the population density, but also the growing touristic sector could exert a huge pressure on the ecosystem.

An important aspect of the land usage has to do with the infrastructures such as roads, railways, airports etc. With respect to its strategic position it is important to mention that the Arrábida Natural Park is located only 40 kilometers from the Portuguese capital. For this reason, transformations in the study area are in direct relation with the pressures exerted from Lisbon which increase the level of vulnerability in terms of forest fires, agricultural abandonment, construction and tourist activities.

The more economic activities are present in those municipalities, the more people living there. That said, this process can have a negative impact on the equilibrium of the Arrabida natural park ecosystem due to an increasing the demand over some of the park's resources, like more people consuming more food products, or bringing ornamental plants or alien animal species from abroad, that can be dangerous for the functioning of the whole Ecosystem.

The comparison with previous works that had the theme of the park as a focal point, made it possible to understand the novelty of this research, although we understand that other points of discussion are necessary to enrich the assessment (for reasons of time and access). As an example of comparison with the results of another work, specifically Lopes & Videira (2016), the services identified are quite similar as this article was one important source for our identification, but we used a different methodology (CICES) and tried to focus more detail on human pressures. In carrying out this work, we were able to be sure of the value and importance of building a mapping that brings not only relevant and accurate data about the ANP, but also that the visual and relational organization of these aspects together

with the classification can bring essential communication elements to place the environment as a powerful lens, with the potential to bring in the eyes and thoughts of political and economic decision-makers at the local and national levels. A good idea for a more efficient and effective management of the area would be to develop a dashboard, that constantly monitorize data about the main pressures and its evolution over time.

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