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The Ria de Aveiro Lagoon

Current knowledge base and
knowledge gaps



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CO Confidential, only for members of the consortium (including the Commission Services)

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List of abbreviations

ARHCentro	Administração da Região Hidrográfica do Centro I.P.
DA	Food, beverages and tobacco industries
DB	Textiles industry
DC	Manufacture of leather and leather products
DD	Manufacture of wood and cork
DE	Manufacture of pulp, paper and paperboard and paper products; publishing and printing
DF	Manufacture of coke, refined petroleum products and nuclear fuel
DG	Manufacture of chemical products and synthetic or artificial fibers
DH	Manufacture of rubber and plastic products
DI	Manufacture of other non-metallic mineral products
DJ	Metallurgical industry and metal products
DK	Manufacture of machinery and equipment, n.e.
DL	Manufacture of electrical and optical equipment
DM	Manufacture of transports equipment
DN	Manufacturing industries, n.e.
EU	European Union
FARAV	Feira de Artesanato de Aveiro
ICNB	Portuguese Institute for Nature Conservation and Biodiversity
INE	National Institute of Statistics (Portugal)
IPCC	Intergovernmental Panel on Climate Change
LGM	Last Glacial Maximum
MAMAOT	Ministério da Agricultura, Mar, Ambiente e Ordenamento do Território
MSD	Marine Strategy Directive
SCI	Sites of Community Importance
SNIRH	Sistema Nacional de Informação de Recursos Hídricos
SPA	Special Protection Area
UNEP	United Nations Environment Programme
WFD	Water Framework Directive

Summary

The Ria de Aveiro is a shallow coastal lagoon located on the north-west coast of Portugal (40°38'N, 08°45'W). The lagoon covers an area of approximately 83 km² and 66 km² of wetland at high and low water respectively, integrated in the Vouga River catchment area. The geographical location of the Ria and its natural resources contributes largely to its recognised value at national and international levels. The Ria is part of the Natura 2000 network, has the designation of Special Protection Area (SPA – with the PTZPE0004 code), and includes several areas classified as Sites of Community Importance (SCI). The Ria de Aveiro has a complex history, both geologically and related to human activity. Since the 19th century, the settled population has shaped the ecosystem by creating salt pans and drainage marshes, opening small channels for navigation, and by creating farmlands such as the smallholdings named “bocage”, thus contributing to the increase of habitat diversity and associated biodiversity. According to the 2011 Census, the Ria has a population of 353 688 inhabitants in the watershed area, with main activities in the secondary and tertiary sector. Nevertheless, farming and fishing activities are still important for the local population, both in a socio-cultural and economic aspect. The Ria’s natural capital is an important factor for the development of the municipalities situated in the lagoon area. The Ria de Aveiro’s unique environmental, cultural and socio-economic features not only support high added value economic activities, but are also intertwined with a rich socio-cultural heritage which faces increasing pressures and inappropriate changes, putting its ecological balance and heritage at risk. Therefore, more participative and sustainable management policies are needed. The Ria de Aveiro is managed within a complex policy and legislative context, with a wide variety of institutions and actors engaged in the use and management of the lagoon. Consequently, the temporal, spatial and managerial dimensions of this coastal area should be taken into account. It will allow a better understanding of the interactions between the activities, functions and uses of the lagoon, and also support the development of management guidelines.

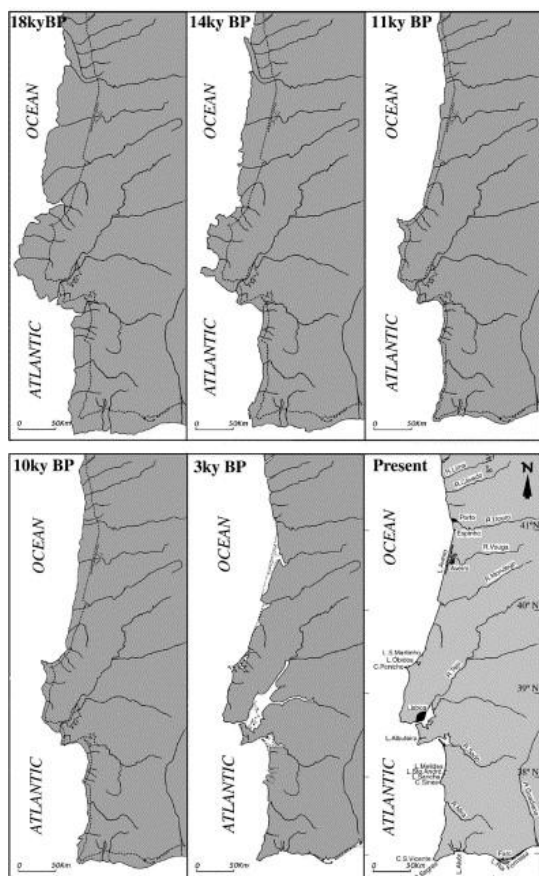
1 Introduction

The Ria de Aveiro is located on the Portuguese Atlantic coast. It covers an area of approximately 83 km² and 66 km² of wetland at high and low water respectively, with recognised national and international value (<http://www.bioria.com>).

The main objective of this report is to systematize the knowledge base regarding this coastal lagoon, and to present a critical analysis in order to identify knowledge gaps. Chapter one starts with a brief review about the history of the lagoon regarding its geologic formation and dynamics, and the related human activities. A short overview of the ecosystem services provided throughout the history of the Ria de Aveiro is also given. The reader will also get an overview of the policies and practices underpinning spatial planning in Portugal since January 1986, when Portugal became a member of the European Union. Since the lagoon is integrated in the Vouga river catchment area, Chapter one finalizes with an introduction to the land uses in the drainage basin. Chapter two focuses on the physiogeographical story of the system. This chapter includes the physical condition of the lagoon and of the catchment area, the climate and the natural resources and land use in the lagoon watershed area. This characterization is followed by an identification of the main ecological and environmental problems in the lagoon. Finally, related knowledge gaps are highlighted. Chapter three emphasizes the socio-economic, livelihood and political aspects of the lagoon. Readers will find a description of the main activities developed in the watershed area including agriculture, fishing, aquaculture, salt production, industries and tourism. This chapter also considers high level legislative frameworks and detailed regulatory provisions, the relevant institutions, key stakeholder groups and entities identified so far. The reports finalizes with the identification of prevalent conflicts or tensions regarding the use and management of the lagoon.

1.1 History of the Ria de Aveiro

The Ria de Aveiro has a complex history, both geologically and related to human activity. Its geological formation follows the shoreline evolution along the Portuguese coasts since the Last Glacial Maximum (LGM) (Figure 1.1, *for a more detailed information please see Dias et al., 2000*). From the analysis of maps dating back to the 13th, 16th and 19th centuries AD, Duck and Silva (2012) suggest that the Ria de Aveiro has developed from an embayment



approximately 70 km in length and 20 km in width at the mouth of the River Vouga. At that time, the system was separated from the ocean only in the north by an embryonic sand spit. According to the same authors, in the 16th century, Aveiro was a prosperous port that had free access to the Atlantic Ocean. However, by the end of the 16th century, the natural inlet from the ocean became progressively smaller in width, and followed the continued southward growth of the spit. Furthermore, by the beginning of the 19th century, the Aveiro lagoon was almost completely isolated from the Atlantic Ocean. Thus, the connection with the Atlantic was only possible for very small boats, while the system became naturally fluvially dominant (Duck and Silva, 2012).

Figure 1.1 | Shoreline evolution along the Portuguese coasts since the LGM. Source: data and figure from Dias *et al.*, 2000, based on [Rodrigues and Dias, 1990], [Rodrigues *et al.*, 1991] and [Dias *et al.*, 1997]

When the connection between the Ria and the sea ceased to exist, stagnant water (<http://www.bioria.com>) caused disaster and poverty for the region's inhabitants. From the XIV to the XVII century, Aveiro was an important national and international trade centre, exporting local and regional goods, namely corn, wheat, beans, fruits, wine, salt, olive oil, timber and firewood, ceramics and copper (Amorim, 2000). Locally, salt production, agriculture and fisheries were the main activities of the population. By the end of the 18th century, the lagoon became isolated from the maritime trade routes and, consequently, Aveiro

was no longer regarded as a port city (Amorim, 2000). In addition, due to the reduction in marine influence and water exchange with the sea, the landscape also changed. These changes affected the local population activities, resources and health. The accumulated freshwater flooded the adjacent agricultural fields and salt pans, reducing the resources and goods produced. Moreover, Aveiro's city center was also flooded, which affected the social environment and public health (Amorim, 2000). These changes negatively affected all social strata, and there was an increase in diseases and mortality (APA, S.A., 2008 based on Neves 1956). This scenario changed in 1808 when an artificial connection to the sea was established by opening a canal in the coastal strand (Figure 1.2).



Figure 1.2 | Map of Ria de Aveiro before 1808 showing the narrow natural connection with the ocean in the southern end of the lagoon and the planned artificial connection in the central area, by the Engineer Luis Gomes de Carvalho. Source: image from <http://oitograus.blogspot.pt/2011/01/aveiro-no-sec-xix.html>.

From the 19th century on, the geographical location of the Ria and the established connection to the sea permitted Aveiro to recover its function as a seaport, while its natural resources such as fisheries resources and fertile farmland for crops and cattle, provided goods and services for the populations that settled in the watershed area. These changes largely contributed to the current characteristics of the lagoon. In fact, the settled population continued to shape the ecosystem by creating salt pans and drainage marshes, opening small channels for navigation, and by creating farmlands and smallholdings named “*bocage*”, which contributed to an increase in habitat diversity and associated biodiversity (<http://www.bioria.com>). Regarding ecosystem services, in Ria de Aveiro, we can easily identify the four categories in which they were organized by the Millenium Assement working group (<http://www.millenniumassessment.org/>); specifically the supporting services including biodiversity, and the regulating, cultural and provisioning services. The natural capital of this coastal lagoon is recognized internationally, namely by its classification as

Special Protection Area (SPA), and by having several areas classified as Sites of Community Importance (SCI). This recognition highlights the need to enhance, maintain and promote the ecosystem services, including biodiversity, provided by the Ria de Aveiro coastal lagoon in a sustainable way.

Since Portugal became an EU member in 1986, the national legal and administrative system has undergone profound changes, assuming a clear need to increase the role of regional and local authorities in the management and planning of land and natural resources, including cultural heritage (Martins, 1997; Fidélis da Silva, 2000; Alves, 2006).

1.2 Characterization of the Vouga river drainage basin

The Vouga river drainage basin covers 31 counties, with a total population of 961316 inhabitants (2011 census). The drainage basin is mostly occupied by forest and farmlands. According to the Agricultural Census 2009 (RGA 2009), farmlands correspond to 76 700 ha (about 12.4%), from which 21 261 ha correspond to irrigated areas. In addition to vineyards, orchards and olive groves, the main crops are maize and rice (Figure 1.4).

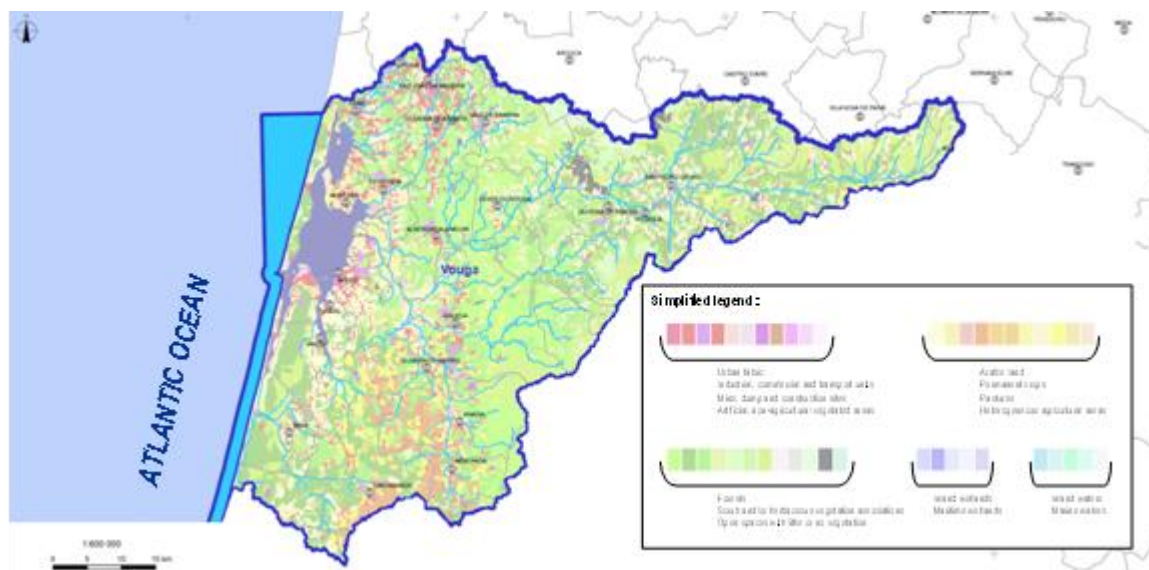


Figure 1.4 | Land cover of the Vouga river drainage basin. Source: adapted from MAMAOT/ARHCentro, 2012. Simplified legend: pink and reddish colours – urban areas; green and greenish colours – forest and semi natural areas; Orange and yellowish colours – agricultural areas; lilac – wetlands; greenish blue – water bodies.

2 The Physiogeographical Story

2.1 Physical conditions of the lagoon and the drainage basin

The Ria de Aveiro (40°38'N, 08°45'W) is a shallow coastal lagoon connected to the Atlantic Ocean through a single inlet (1.3 km long, 350 m wide and 20 m deep) (Dias & Lopes, 2006), and is located in the central coastal zone of Portugal integrating the Vouga river catchment area (<http://www.arhcentro.pt/>) (Figure 2.1). The Vouga river originates in the mountains of Lapa at an altitude of about 930 m. The catchment area has approximately 3362 km², and the river crosses about 141 km before flowing into the Ria de Aveiro coastal lagoon (Van der Weijden *et al.*, 2006, <http://www.arhcentro.pt/>). The main tributaries of the Vouga river are the rivers Sul, Caima, Antuã and Águeda (Figure 2.1). The Antuã river forms a sub-basin reaching the Vouga river in the lagoon area (<http://www.arhcentro.pt/>). The lagoon is approximately 45 km long (NNE-SSW), 10 km wide and, during spring tide, covers an area of approximately 83 and 66 km² of wetland at high and low water, respectively (Dias *et al.*, 2000). The bathymetry of the Ria de Aveiro consists of four main channels with several branches forming islands, inner basins and mudflats (Dias *et al.*, 2000). The Mira and Ílhavo channels are narrow and shallow; the S. Jacinto - Ovar channel is wider and deeper in its southern part, forming secondary narrow and shallow channels and basins northwards. The Espinheiro channel is characterised by secondary channels, islands, marshes and basins (Figure 2.2). Other smaller rivers also discharge into the lagoon, namely the river Boco in the Ílhavo channel; the Cáster river in the Ovar channel, and the Mira river in the Mira channel. The catchment areas of these smaller rivers are, respectively, 104 km², 105 km² and 302 km² (Figueiredo da Silva, 1994). The Vouga river is the most important, accounting for 2/3 of the total freshwater input (Moreira *et al.*, 1993). The total fluvial discharge into the lagoon during a tidal cycle is about 1.8×10⁶ m³, while the tidal prism is 137×10⁶ m³ for maximum spring tide, and 35×10⁶ m³ for minimum neap tide (Dias *et al.*, 2000). The circulation in the Ria de Aveiro is therefore essentially dominated by tidal forcing. The tidal phase lag, relative to the mouth, is in the order of 6 h in the upper reaches of the channels. Due to the combined effects of freshwater discharge and tidal penetration, the Ria de Aveiro exhibits a longitudinal salinity gradient from about 0 in the upper reaches of the channels to about 36 at the sea boundary (Vaz & Dias, 2008). The average depth of the lagoon relative to the chart datum is about 1 m, except in navigation channels where dredging operations are frequently carried out. The lagoon is mesotidal with an average tidal range of 2 m (tidal amplitude at the inlet ranges from 0.6 m in neap tides to 3.2 m in spring tides) (Dias *et al.*,

2000). Due to the low depth and tidal amplitude, the lagoon is characterised by large areas of intertidal flats exposed during low tide.

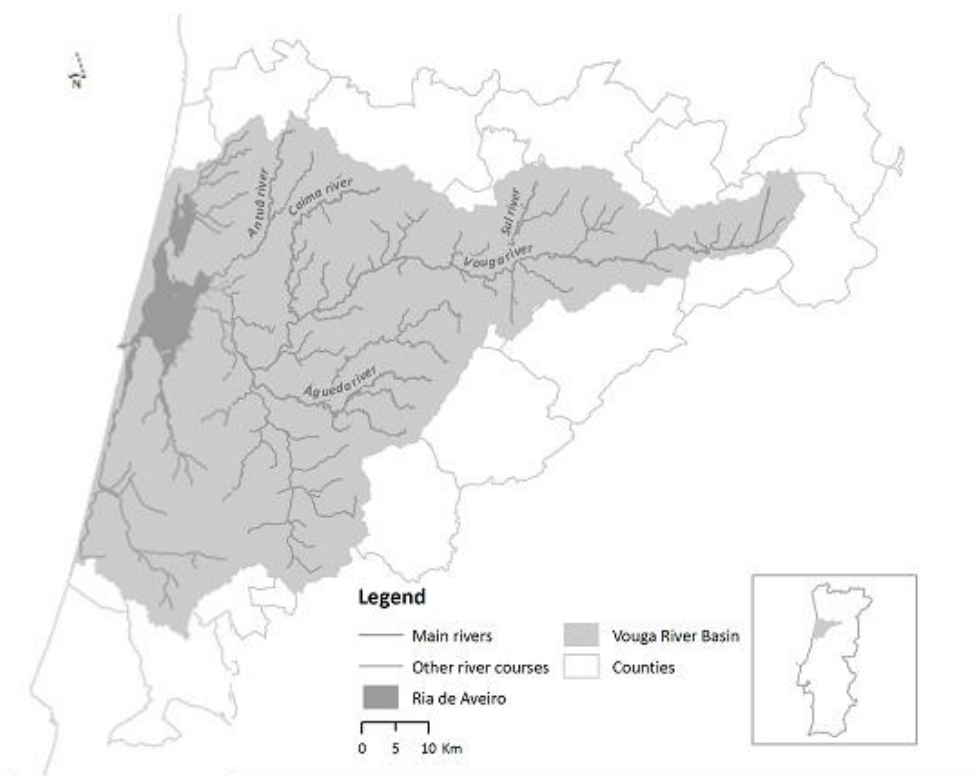


Figure 2.1 | Location of the Ria de Aveiro coastal lagoon and the Vouga River drainage basin

The river Vouga is characterized by episodic flood events that inundate the low-lying adjacent lands, mostly due to adverse weather conditions during winter such as heavy rainfalls. Concerning the available data (1857 - 2011, see annexes, Tables 2.1 and 2.2), these flooding events occurred mainly between November and February, and Ovar seems to be the county that is most affected. Other adverse weather conditions, like low-pressure north/northwest of Portugal and high-pressure south/southwest, as well as strong southerly winds cause surges along the Portuguese coast. High tides also impact the level of flooding, as well as the mean sea level evolution. In addition, the morphodynamics of the inlet channel depend on the mean sea level and on the northeast Atlantic wave climate regime. These factors and the sediment supply greatly impact the coastal erosion of the Ria de Aveiro Littoral (IHRH, 2003; www.euroasion.org/reports-online/reports.html). The surrounding littoral stretches of Esmoriz-Furadouro, Barra–Costa Nova and Vagueira-Mira have coastal erosion problems with a high risk of sand spit rupture (EEA 2006; http://www.eea.europa.eu/publications/eea_report_2006_6).

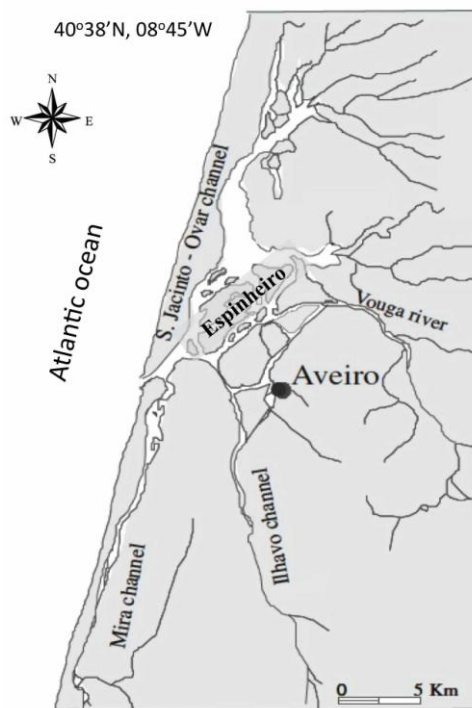
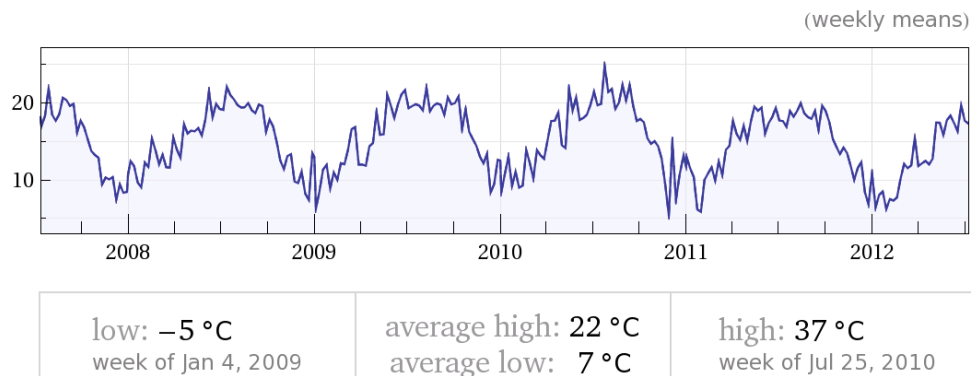


Figure 2.2 | The main channels in the Ria de Aveiro coastal lagoon

2.2 Climate, natural resources and land-use

2.2.1 Climate

The Aveiro region is under the influence of a temperate maritime climate with a warm period between July and September and a cold period between December and February. Rainfall occurs mainly between October and May, with higher precipitation periods in December and January (AMBIECO, 2011). The annual range of the monthly average temperature is around 10°C in the countryside and 8.5°C to 9.5°C on the coast (AMRia/CPU, 2006). Figures 2.3 and 2.4 show the history of temperature and the amount of precipitation in the Aveiro region from 2008-2012. (Wolfram Alpha, 2012; SNIRH, 2012).



Computed by Wolfram|Alpha

Figure 2.3 | Temperature; Source: <http://www.wolframalpha.com>.

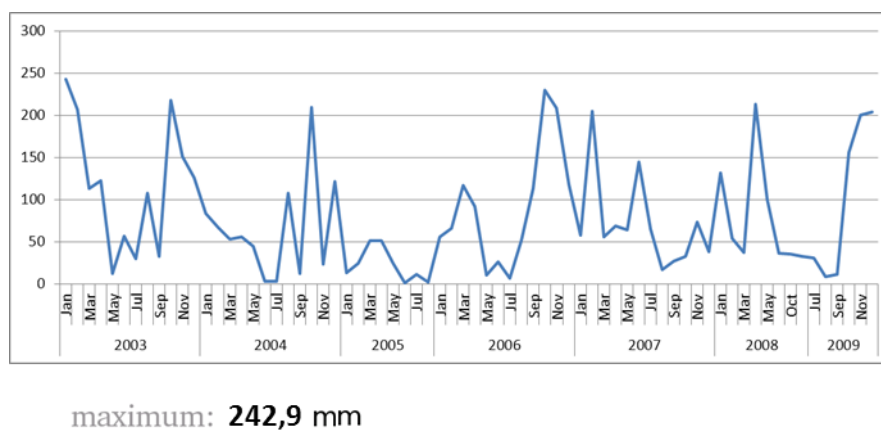


Figure 2.4 | Amount of precipitation; Source: <http://snirh.pt>.

2.2.2 Natural resources

The natural resources include ecosystem services and natural capital such as the sea, the lagoon, the watershed and the associated biota, as well as all activities that can be practiced enjoying the provided goods and services. These activities can be included in the cultural services provided by the Ria. Relevant examples are: harvesting of reeds for traditional activities and products (e.g. handcraft), local festivals including gastronomic festivals related to fisheries (e.g. cod fish festival and eel festival), salt production (international salt festival), traditional confectionery ("*ovos moles*" festival), farmers (AGROVOUGA livestock festival) and handcraft (FARAV festival), religious celebrations, recreation and ecotourism (e.g. traditional "*moliceiro*" boat trips, sports (sailing, wind-surfing, kayaking), walking, cycling, fishing, birdwatching), and aesthetic and educational values. In this context, the Ria de Aveiro coastal lagoon is a wetland of great ecological importance. The Ria provides a wide

variety of biotopes with high biological diversity including open water, beaches, seagrasses, saltmarshes, sand and mudflats, riparian forests, dunes and farmlands (Figure 2.5).

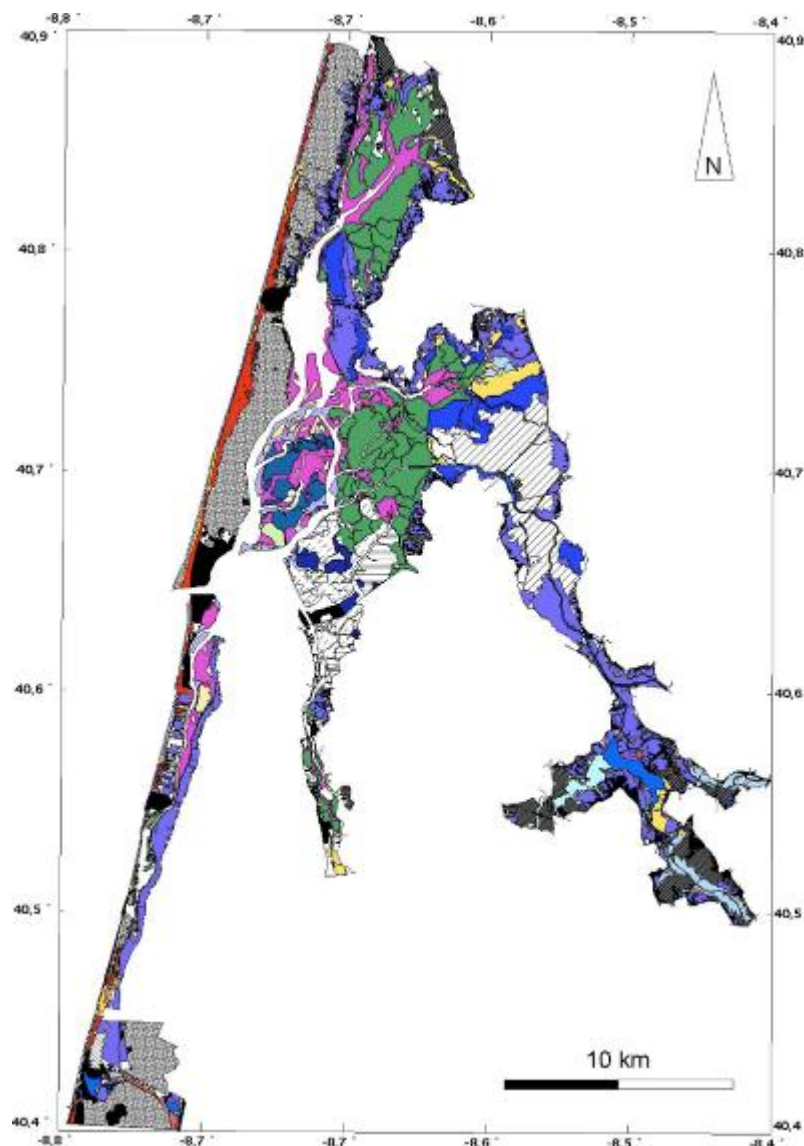


Figure 2.5 | Spatial distribution of the Ria de Aveiro biotopes. Source: data and figure from AMBIECO report for Polis Littoral Ria de Aveiro, 2011). Simplified legend: red – littoral dunes; green and greenish blue – saltmarshes; pink – mudflats; light yellow close to pink areas – seagrass beds; lilac – sand flats; yellow - sea rush (*Juncus maritimus*); blue - common reed (*Phragmites australis*); grey dashed - “bocage” landscape

As shown in figure 2.5, the lagoon comprises large areas of seagrass and salt marshes (AMBIECO, 2011; <http://www.biorede.pt/>), whilst upstream areas are characterized by freshwater marshes, forest and the “bocage” landscape. Seagrasses and salt marshes belong to the most productive ecosystems in the world with recognized associated ecosystem services (Barbier *et al.*, 2011). Specifically, but depending on vegetation type, density and habitat

characteristics, seagrasses and salt marshes provide raw materials, coastal protection (attenuating and/or dissipating waves), erosion control (providing sediment stabilization and retention in vegetation rhizosediment), water purification (buffering potential for excess nutrients and pollutants), maintenance of fisheries (providing food resources, shelter and nursery grounds), carbon sequestration, tourism, recreation, education, and research activities (Barbier *et al.*, 2011). Furthermore, seagrass and seaweed mixtures named “*moliço*” were traditionally harvested by the local populations, transported in traditional boats (“*moliceiro*”) and used as natural fertilizers in agriculture. The “*moliço*” harvesting was a unique and traditional activity in the Ria until the 19th century, but declined sharply after 1960, probably due to changes in agricultural practices rather than the absence of seagrass (Silva *et al.*, 2004). This activity employed up to 1400 “*moliceiro*” boats at the end of the 19th century and, according to Silva *et al.*, (2004), more than 2×10^5 t were collected per year at this time. The number decreased to 4×10^3 t per year between the mid 80s and 1990. However, seagrass was still abundant at that time. By the end of the 20th century, specifically in 1998, the activity ceased completely due to the sharp decrease in the sub-tidal populations (Silva *et al.*, 2004). Nowadays, the traditional boats are mainly used for tourist trips in the Aveiro city canals and inside the lagoon (Figure 2.6).



Figure 2.6 | Left photo: A traditional “*moliceiro*” boat in the lagoon close to the seagrass beds during low tide; Right photo: Traditional “*moliceiro*” boats in the central canal in the city of Aveiro (© A.I. Lillebø).

Many European salt marshes have been traditionally cut for hay and grazed by cattle (Andresen *et al.*, 1990). In the Ria de Aveiro, sea rush (*Juncus maritimus*) and common reed (*Phragmites australis*) were also traditionally harvested for hay by the local population. Sea rush was used as bed for livestock, as raw material for mats, and for protecting the salt

mounds in the salt pans from wind and rain. However, grazing pressure in the Ria's marshes is not comparable to other European systems. There is only an indigenous cattle species, the certified Marinhoa breed, which is raised in the Baixo Vouga Lagunar marsh area.

The area where the Vouga reaches the lagoon, the Baixo Vouga Lagunar, includes three homogeneous landscape units: open fields, wetlands and the “*bocage*” smallholdings. This area is characterized by a diversity and specificity resulting from human interaction with the environment; namely, the local population's shaping of the ecosystem by creating drainage marshes, farmlands and opening small channels for navigation. The agricultural area is separated from the lagoon's water body by extensive marshland areas. Following the salinity gradient, downstream areas are mainly populated by sea rush (*Juncus maritimus*), while the upstream area is dominated by reed beds (*Phragmites*). The Baixo Vouga Lagunar comprises a recent agroecosystem characterized by fertile soils managed for purposes of livestock and agricultural production. However, this area is under the permanent threat of flooding and of surface saline intrusion (http://www2.apambiente.pt/IPAMB_DPP/docs/RNT792.pdf). The farmland is characterized by irrigated fields (rice) or dry fields (maize and wheat). The traditional smallholdings, named “*bocage*”, measure about 7-8 ha and are bounded by hedges of willows, alders and ditches, which fragment the landscape and define the property boundaries (Figure 2.7).



Figure 2.7 | Left photo: Aerial view of the “*bocage*” landscape (© H. Queiroga); Right photo: Detail of a smallholding cultivated with maize (© A.I. Lillebø).

As part of the living hedges we can also find *Salix*, *Quercus robur* or *Laurus nobilis*. In addition to livestock and agricultural practices, the Baixo Vouga Lagunar is an environmentally sensitive habitat important for birds such as the fish-hawk (*Pandion haliaetus*), the purple heron (*Ardea purpurea*), the black kite (*Milvus migrans*), the mallard

duck (*Anas platyrhynchos*), and the white stork (*Ciconia ciconia*), among others. It is also an important habitat for mammals like the least weasel (*Mustela nivalis*), the hedgehog (*Erinaceus europaeus*), and the European otter (*Lutra lutra*), for amphibians like the common toad (*Bufo bufo*), the tree frog (*Hyla arborea*), the fire salamander (*Salamandra salamandra*), the marbled newt (*Triturus marmoratus*) and the Iberian Painted Frog (*Discoglossus galganoi*), for reptiles, namely the Iberian emerald lizard (*Lacerta schreiberi*) and the viperine water snake (*Natrix maura*), and for several fish species including the eel (*Petromyzon marinus*) and the lamprey (*Lampetra planeri*) (Leão, 2003; Leão, 2011a; Leão, 2011b) (For more detailed information about Baixo Vouga Lagunar please see FACTS project <http://www.factsproject.eu/>). According to AMRia/CPU (2006), many of these species are classified as "strictly protected" or as "protected" by the Bern Convention. As an example the otter, which occurs in many channels of the Ria, is classified as "strictly protected" and the hedgehog as "protected". Many birds are also protected by the same convention. In accordance with Annex III of the Bern Convention all species of amphibians and reptiles are considered protected (AMRia/CPU, 2006). The pisces class (ichthyofauna) is represented by 64 species, which can be divided into four ecological categories: i) marine species occasionally entering the lagoon with the tides (e.g. *Sardina pilchardus*, *Gobius niger*, *Symphodus bairdii*, *Sparus aurata*, *Trigla lucerna*, *Callionymus lyra*, *Scophthalmus rhombus*, *Ammodytes tobianus*); ii) marine species dependent on the lagoon environment for food resources, shelter and nursery grounds (e.g. *Lisa aurata*, *Dicentrarchus labrax*, *Platichthys flesus*); iii) resident species, well adapted to the lagoon (e.g. *Atherina presbyter*, *A. boyeri*); iv) migratory species (e.g. *Anguilla anguilla*, *Alosa alosa*, *Lampetra planeri*) (AMRia/CPU, 2006).

The Ria is considered a high priority coastal wetland for wildlife, particularly for migratory birds (Reis, 1993), and is therefore designated as a Special Protection Area (SPA – with the PTZPE0004 code). The Ria de Aveiro has a rich fauna, with most of the species protected by international conventions such as the EC Birds Directive (Council Directive 2009/147/EC on the conservation of wild birds (the codified version of Council Directive 79/409/EEC as amended)) and the EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora). It is also part of the Natura 2000 network.

In terms of natural resources, it is essential to mention the “Reserva Natural das Dunas de S. Jacinto” (Natural Reserve of S. Jacinto Dunes) and the fishery resources. The Reserva Natural das Dunas de S. Jacinto covers an area of approximately 960 ha with 210 ha

corresponding to the maritime area, and has a vast diversity of habitats and species. The Decree-Law No. 47/79 of 6th March established the “Nature Reserve” status in order to create the necessary conditions for the preservation of the coastal dunes (ICNB webpage, <http://portal.icnb.pt/>).

The Ria de Aveiro includes several zones of different types of hunting (hunting areas and municipal associations). This region cannot be compared with other regions of the country since hunting in Aveiro is mainly duck-related. In 2003, the Aveiro district had 13,132 resident hunters (<http://www.clubecpav.com/artigos.html>). To preserve the sustainability of this wetland and wildlife that it supports it is necessary to manage the hunting resources and their habitats (especially for the aquatic species).

Regarding fisheries, freshwater species have relatively little overall importance to the local economy, meaning that the fishing activity is mainly focused on marine catches (EU, 2010). In Aveiro, the registered fishing fleet comprises of 18 offshore fishing vessels, 38 vessels for coastal fisheries and 851 small-scale fishing boats. Small pelagics are the predominantly landed species with horse mackerel (*Trachurus trachurus*) and sardine (*Sardina pilchardus*) representing the largest volumes in terms of weight (EU, 2010). The sardine stock has recently been certified by the Marine Stewardship Council, which indicates that it is being managed in a sustainable fashion. The abundance of horse mackerel has fluctuated over time, yet, it is still high and able to sustain the fishery (EU, 2010). Official data regarding the total captures of seabass (*Dicentrarchus labrax*) and seabream (*Diplodus sargus*) are greatly underestimated since they only reflect the reported fisheries. It is recognized that these two species belong to a large group of unreported catches, i.e., "*Both species are highly valuable and sellable directly to restaurants.*" (EU, 2010).

Shellfish harvesting (e.g. clams, shrimps and crabs) constitutes a natural value of the Ria de Aveiro with a high socio-economic role. Figure 2.8 shows the main areas for clam harvesting within the Ria. The yellow and orange areas represent intertidal flats, whilst the brown areas represent subtidal areas.

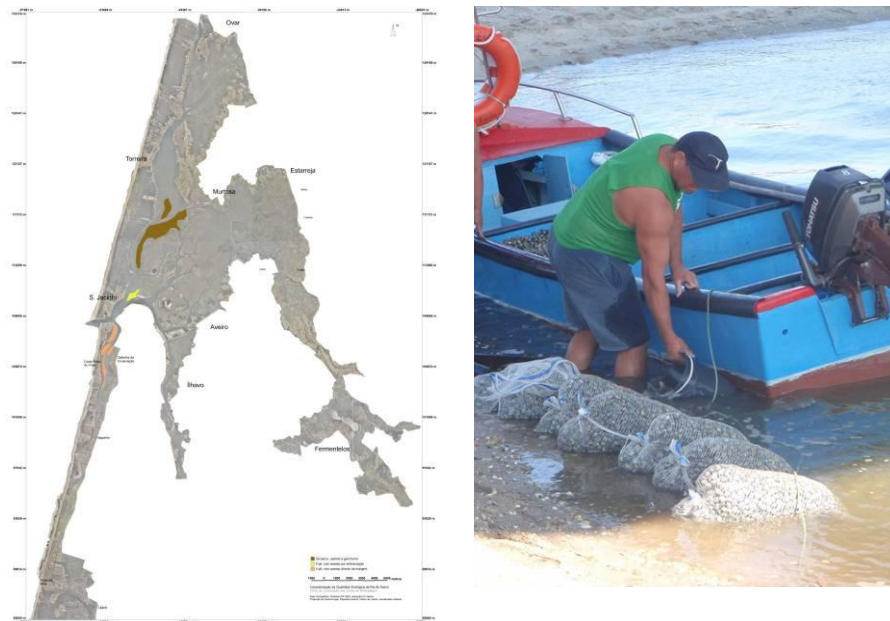


Figure 2.8 | Left photo: Areas of shellfish harvesting in the Ria de Aveiro. Source: data and figure from AMBIECO 2011, report for Polis Littoral Ria de Aveiro); Right photo: Clam harvest in the Ria (© NJ de Voogd).

Bait digging of worms for recreational and commercial fishing is widely practiced (Figure 2.9) and economically significant in the Ria (Cunha *et al.*, 2005). One of the captured species is *Diopatra neapolitana*, the solitary tube worm, which is used as fresh bait to catch several important demersal fishes for human consumption such as sea bass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), and white seabream (*Diplodus sargus*) (Cunha *et al.*, 2005). Other relevant examples of marine worms (polychaetes) collected and used as bait are ragworm (*Hediste diversicolor*) and catworm (*Nephtys hombergii*) (Cunha *et al.*, 2005).



Figure 2.9 | Bait digging in the Canal de Mira (© R.Calado)

The Japanese oyster (*Crassostrea gigas*) has been produced for nearly two decades in the intertidal zone of the Canal de Mira using the trestle method (Figure 2.10) (Neto, 2011). This species has a high commercial interest and is consumed throughout the world, particularly in southern Europe. Oyster producers import the seeds from France and sell 98% of their production to the French market (Neto, 2011).

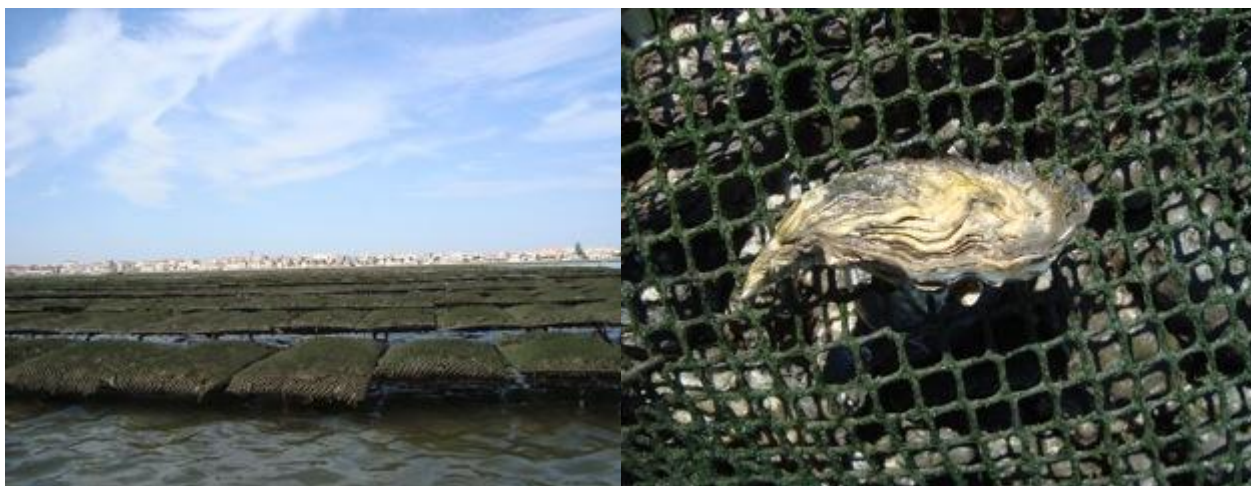


Figure 2.10 | Left photo: Oyster production in the Canal de Mira (©A.I. Lillebø); Right photo: Oyster in detail (©A.I. Lillebø)

The clam species *Ruditapes decussates* is also cultivated in the Canal de Mira. The seeds, usually obtained from France, are cultivated directly in the sediment between the oyster trestles (Neto, 2011). This clam is especially popular in the coastal areas of southern Europe including southern Portugal, Spain, France, Italy and Tunisia, where the natural resources of this species are not sufficient to meet the market's requirements (Neto, 2011). Approximately 70% of the national production is exported to Spain, while the remaining 30% are reserved for the Portuguese market (Neto, 2011).

The extraction of sea salt was a traditional and important activity in the lagoon firstly recorded in the 10th century (Bastos, 2009). Throughout the history of the region, the importance and intensity of this activity varied due to environmental (e.g. climate and geomorphology of the lagoon) and anthropogenic factors (demography, wars and trade) (Bastos, 2009). As an example, through centuries this activity has been closely related to food preservation as well as to cod fishing and preservation (the so called “bacalhau”). Nowadays, freezing is the most common way to preserve food, taking away part of the historical and economical importance of this activity, and contributing to the abandonment of the salt pans (Bastos, 2009). Presently, there are still eight operational salt pans, corresponding to 15 km²

(Silva, 2010), one of them being classified as an ecomuseum (Figure 2.11). Most of the other salt pans have been abandoned or converted into open semi-intensive fish farms.



Figure 2.11 | Left photo: Overview of the Troncalhada salt pan ecomuseum (© A.I. Lillebø); Right photo: pile of salt in detail (© A.I. Lillebø).

2.2.3 Land Use

Figure 2.12 shows the percentage of the lagoon watershed area occupied by different land uses according to the first hierarchical level of the CORINE Land Cover (CLC), for the years 1990, 2000 and 2006, respectively (Silva, 2011).

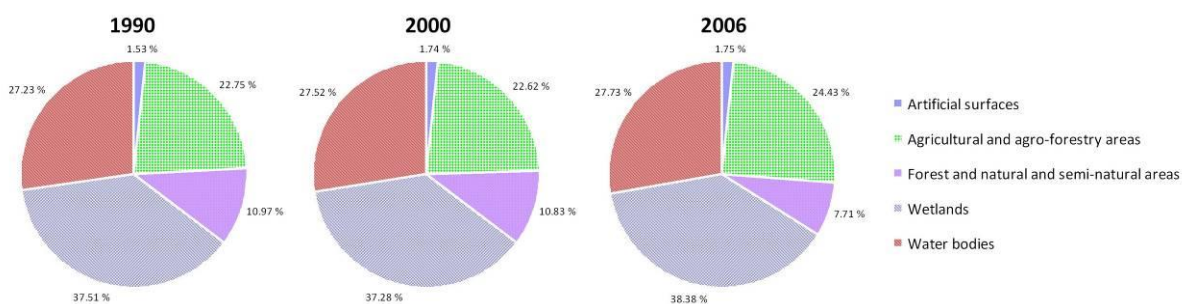


Figure 2.12 | Distribution of land use classes for the years 1990, 2000 and 2006. Source: adapted from Silva, 2011

Using the CORINE Land Cover nomenclature, the data analysis shows a slight continuous growth of artificial surfaces (urban fabric; industrial, commercial and transport units; mine, dump and construction sites; artificial, non-agricultural vegetated areas), agricultural (arable land; permanent crops; pastures; heterogeneous agricultural areas) and agro-forestry areas (forests; scrub and/or herbaceous vegetation associations; open spaces with little or no

vegetation), water bodies (inland and marine waters) and wetlands (inland and maritime wetlands). On the other hand, there is a decrease of forest, natural and semi-natural areas (Figure 2.13).

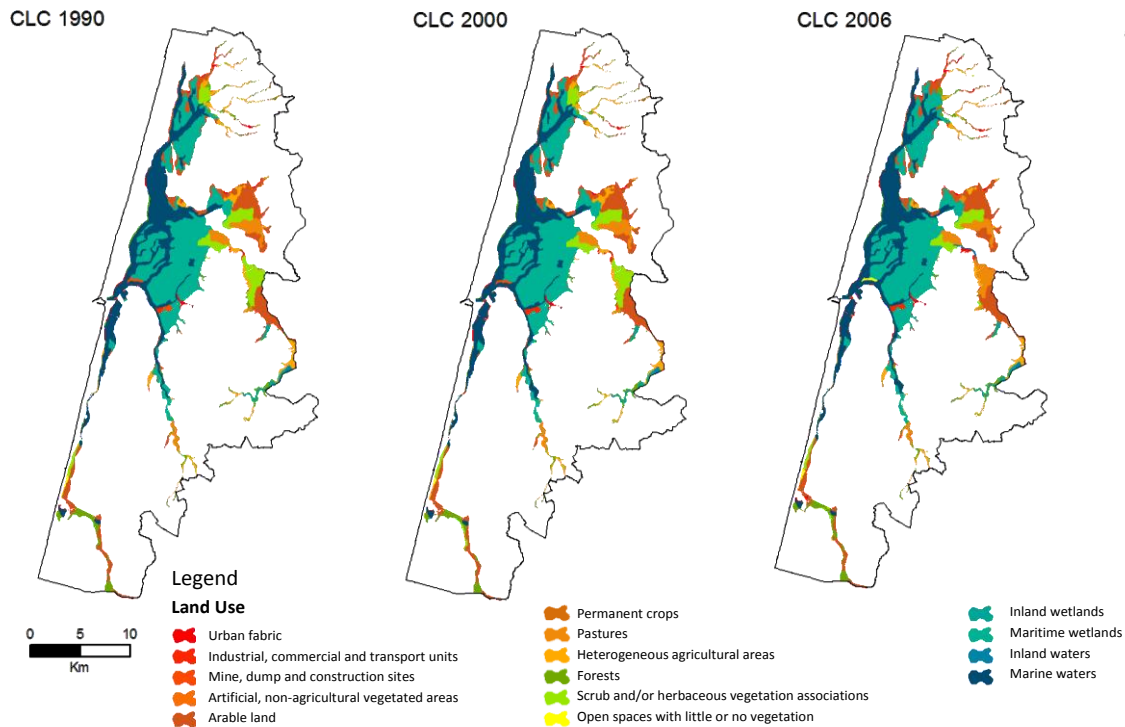


Figure 2.13 | Distribution of land use classes for the years 1990, 2000 and 2006. Source: adapted from Silva, 2011

2.3 Main ecological and environmental problems

The Ria de Aveiro coastal lagoon is highly productive, providing a number of essential services of ecological and economic importance, where human pressure has increased during the past decades. Although the Ria de Aveiro is quite urbanized and industrialized in some areas, it has recently been classified to be in a reasonably good state of environmental preservation. The study leading to this conclusion was done in the scope of the Polis Litoral Ria de Aveiro programme (<http://www.polisriadeaveiro.pt/>) reported by AMBIECO (2011). Other studies have shown that the Ria de Aveiro has a moderate degree of eutrophication and low overall human influence in comparison to other estuarine systems (Ferreira *et al.*, 2003, Lopes *et al.*, 2007). The productivity of the Ria de Aveiro is sustained by large quantities of dissolved inorganic nutrients, mainly from freshwater inputs (e.g. runoff and drainage from agricultural fields); less than 10% are coming from point sources such as urban and industrial effluents (Ferreira *et al.*, 2003). However, despite some human interventions like the construction of a submarine outfall that reduced nutrient loads, water quality inside the

lagoon can vary spatially (Figure 2.14). Vulnerable areas should be considered for specific monitoring programmes and management measures, particularly with regard to areas upstream that receive higher concentrations of dissolved inorganic nutrients, namely nitrogen (Figure 2.14) (Lopes *et al.*, 2007).

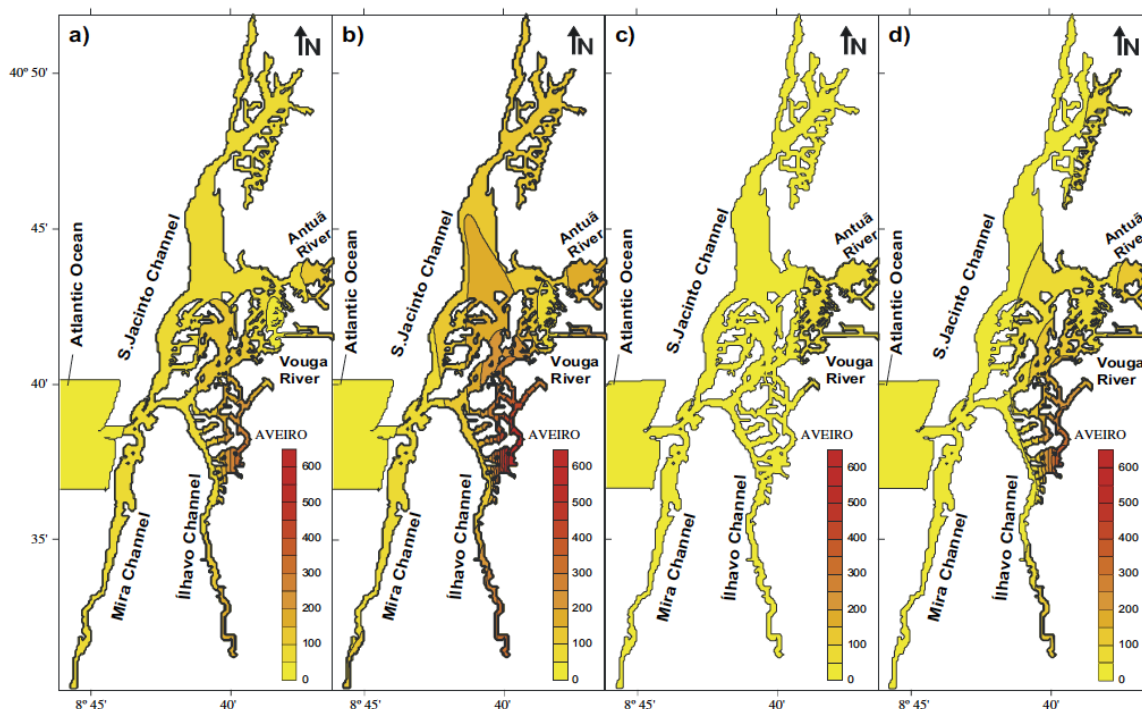


Figure 2.14 | Spatial distribution of DIN concentrations ($\mu\text{mol L}^{-1}$, mean values at low tide and high tide) at surface water during the sampling program: a) late autumn, b) winter, c) late spring and d) late summer. Source: data and figure from Lopes *et al.*, 2007.

The implementation of EU environmental policies has furthermore aided in reducing anthropogenic sources of potentially toxic elements (e.g. Pereira *et al.*, 2009). However, there is substantial contamination in bottom sediments as a result of historical contamination. In fact, the most impacted areas are a comparatively small basin in the northern part of the estuary (Coroa basin) (Castro *et al.*, 2006), and the Laranjo basin, a shallow area measuring 2 km², that is historically contaminated with mercury (Pereira *et al.*, 2009). From the 1950s until 1994, the Laranjo basin received a highly contaminated effluent that was discharged from a mercury cell chlor-alkali plant located in the Estarreja industrial complex (Pereira *et al.*, 2009). The sediment pool of mercury is still a cause of concern since it may constitute a potential source to biota (Pereira *et al.*, 2009). Outside the Laranjo basin, Hg levels are much lower and below the European threshold concentration for fish and seafood consumption (0.5 mg kg⁻¹ for seafood and 1 mg kg⁻¹ for certain fish, EC No. 466/2001) (Pereira *et al.*, 2009). Another study (Sousa *et al.*, 2007) denoted a decrease in TBT pollution in the Ria over the

last years. Changes became particularly clear after 2003 and might be associated to the EU ban of TBT.

Regarding species richness and biodiversity, the lagoon is composed of a wide range of biotopes used as nursery areas for many valuable species. However, the system is experiencing the presence of exotic species like the Manila clam (*Ruditapes Philippinarum*). In addition, changes in the system's hydrodynamics have altered the tidal prism and increased the water velocity (Picado *et al.*, 2010), resulting in the loss of saltmarshes (Silva *et al.*, 2004) and seagrasses in some areas of the Ria. Seagrass meadows have decreased dramatically in subtidal areas since the 1990s due to an increase in tidal water velocity and turbidity (Silva *et al.*, 2004). Previously, seagrass community composition included the species *Potamogeton pectinatus*, *Ruppia cirrhosa* and *Zostera noltii*, but now only the dwarf eelgrass (*Zostera noltii*) can be found (Silva *et al.*, 2004, Cunha *et al.*, 2011). These days, the dwarf eelgrass is mostly restricted to intertidal areas. In the Baixo Vouga Lagunar, the area of sea rush (*Juncus maritimus*) marshes has also decreased due to prolonged periods of saltwater inundation. In addition, the Baixo Vouga Lagunar farmlands, including the living hedges, are under threat due to saltwater intrusion (Figure 2.18). Changes of the hydrodynamics in the lagoon area and the abandonment of salt production, have led to the collapse of the salt pan walls. Consequently, valuable habitats for waders have been lost (Figure 2.15).



Figure 2.15 | Left photo: Salinization of the Baixo Vouga fields and death of the living hedges (© A.I. Lillebø); Right photo: Collapse and loss of salt pans (© A.I. Lillebø)

2.4 Knowledge gaps

The Ria de Aveiro has been the focus of considerable research during the last two decades, and more than 120 scientific publications have been written covering multidisciplinary issues. However, there are still research gaps regarding the system's ecohydrology and other issues,

and we consider it highly important to increase our knowledge about the effects of these changes on the processes and functions in the Ria. Relevant examples are: i) the effects of the changes in the system's tidal prism, water velocity and increased turbidity on seagrass communities, and consequently on related processes and functions. This is important because seagrass communities comprises suitable habitats and nursery ground for several key ecological and economic species, and they also act as sediment stabilizers and as mediators of biogeochemical cycles, including the sequestration of carbon; ii) the implications of the decrease of the salt marsh area in the Baixo Vouga Lagunar due to the increase in saltwater inundation period, specifically the negative effects on the role of salt marshes in the carbon cycle and in nutrients biogeochemical cycles, as well as in the soil retention and biodiversity; iii) the consequences of the surface saltwater intrusion in the Baixo Vouga Lagunar farmlands, specifically for land use, which also entails socio-economic challenges, and for biodiversity; iv) the implications of collapsing salt pans for wader populations.

Knowledge gaps also exist regarding the Ria's ecosystem services, namely on the collaborative research between ecology and socio-economy, and particularly on the identification and valuation of the provided services. Relevant examples are: i) the Ria's capacity to sustain shellfishing and recreational fishing (including bait digging), since it is recognised that the known numbers are greatly underestimated; ii) the ecologic impact of the exotic species Manila clam (*Ruditapes Philippinarum*), and the evaluation of its socio-economic impacts on the local populations; iii) the capacity and potential for increased tourist and recreational activities in the Ria; iv) assessment of trade-offs among ecosystem services under alternative management scenarios.

The Ria's natural capital is an important factor for the development of the municipalities situated in the lagoon area. In the context of climate change it is crucial to improve the knowledge of the resilience of the Ria de Aveiro coastal lagoon.

3 The Management Story

3.1 Socio-economic, livelihood and political issues

The Ria de Aveiro watershed area includes 11 counties, (Águeda, Abergaria-a-Velha, Aveiro, Estarreja, Ílhavo, Mira, Murtosa, Oliveira do Bairro, Ovar, Sever do Vouga and Vagos) with a population of 353 688 inhabitants (2011 census). Currently, activities belonging to the

secondary and tertiary sector are predominating in this area (see Annex 5, Table 5.3). Nevertheless, the local population still has strong farming and fishing traditions, which continue to play an important role in socio-cultural aspects, and provide additional income for many families.

Concerning the distribution of employment by sector of activity, according to the 2001 Census, the primary sector had a relatively low representation in all counties. The secondary and tertiary sectors were responsible for the employment of 47 and 48% of the population, respectively. However, in the Baixo Vouga Lagunar, the active population is exclusively linked to the primary sector, or uses the “*bocage*” family farms in addition to other activities.

3.1.1 Agriculture and livestock

According to the last RGA – Agricultural Census (1999), 12 201 farm holdings were registered in the lagoon watershed area, corresponding to approximately 41 000 ha of land (about half of these were part of the classified Useful Agricultural Surface (SAU – *Superfície Agrícola Útil*), and employing approximately 12% of the population (approximately 41 189 individuals). In 1999, 6579 farmers were registered, but only 1/5 of them worked full time on their farms (only in Murtosa and Sever do Vouga full-time dedication was around 50%).

The livestock production in the lagoon watershed area is characterized by pasture farming and stabling for pigs and poultry.

3.1.2 Port facilities and fishing

Aveiro’s harbour is the most important Portuguese port in terms of movement of steel products, liquid loads and mixed cargo containers. It is also one of Portugal’s busiest fishing ports accounting for approximately 6% of the total continental fish landings. Most of these landings are made by Portuguese vessels, although some occasional landings are made by foreign vessels (EC, 2010). Commercial activities in the port of Aveiro have grown considerably during the last decade. Also the maritime traffic has increased substantially at a rate of 4.1% per year (EU, 2010). It is worth noting that, in addition to the artisan catches, recreational fishing is an important activity in terms of the number of total catches within the lagoon.

The fishing sector is relevant in terms of employment, wealth creation and local socio-cultural identity. Fisheries are the basis of an important and diverse economic activity in Ria

de Aveiro, namely: offshore fishing, inshore fishing, local professional fishing, shellfishing, aquaculture, preparation and processing industry, storage, transport and distribution, marketing, business support services, salt-production, port activities, tourism and catering. The number of offshore boats has decreased since 2005 due to dwindling fish stocks (EC, 2010). According to Pombo (2005) there were 6940 recreational boats registered in the Port of Aveiro. As this activity is of utmost importance to the local economy, it is essential to be able to discern whether these catches are affecting and/or putting to risk the fish stocks of the lagoon (Pombo, 2005).

In 2010, approximately 10 000 tonnes of fish were unloaded in the north-central delegation of DOCAPESCA – Portos e Lotas SA (excluding the Figueira da Foz) (Table 3.1).

Table 3.1 | Unloaded quantity. Source: DOCAPESCA – Portos e Lotas SA website,

<http://www.docapesca.pt/pt/estatisticas/mensais.html>

	Kg	Euros	€ / Kg
Aveiro	7 365 502	11 915 771	1.62
Vagueira	97 651	160 905	1.65
Torreira	1 970 761	2 006 312	1.02
Mira	662 536	853 969	1.29
Total	10 096 450	14 936 957	----

Harvesting of shellfish and bait digging are common along the shallow subtidal and intertidal flats of the lagoon. Cunha *et al.* (2005) estimated that bait harvesting in the Canal de Mira is very intense, approximately 4 364 620 individuals of *Diopatra neapolitana* (solitary tube worm) are caught per year, corresponding to an annual income of more than 327 346 € (values estimated from catches between May 2001 and April 2002). The actual potential value is much higher since several other worm species are collected and sold for bait (e.g. ragworm (*Nereis diversicolor*) and catworm (*Nephtys hombergii*)), whilst clams are sold for human consumption (e.g. common cockle (*Cardium edule*), european razor clam (*Solen marginatus*) and flat furrow clam (*Scrobicularia plana*)) (Cunha et al., 2005). The relative abundance, the ease of capture, and the growing commercial value make these species an important economic resource for coastal communities. Moreover, in the present context of global and national crises, bait digging provides work or additional income for the local population. Bivalve exploitation has an important socio-economic role for the shellfishing

communities of the Ria de Aveiro. It involves nearly 1000 workers and ca. 1100 tonnes are harvested (corresponding to 1,6 million €) (DRAPC, 2008; http://www.drapc.min-agricultura.pt/base/documentos/brochura_pescas_vf.pdf).

3.1.3 Aquaculture

Aquaculture in the Ria de Aveiro can be divided into fish and shellfish aquaculture. The most relevant fish species for production are gilthead seabream (*Sparus aurata*), seabass (*Dicentrarchus labrax*) and turbot (*Psetta maxima*) (ParquExpo, 2010). These species are usually produced in a semi-intensive open production system, in abandoned salt pans that were converted into aquaculture ponds (Figure 3.1). Regarding shellfish, relevant examples are the Japanese oyster (*Crassostrea gigas*) and the clam *Ruditapes decussates* which are cultivated in the Canal de Mira (Neto, 2011).

In the last few years, the capacity for fish aquaculture in the Aveiro region increased substantially as a result of the establishment of two new aquaculture units. The two new units are focused on flatfish production with two different production systems: The AQUACRIA Piscícolas S.A. (Torreira) is an intensive recirculated fish farm, whilst ACUINOVA - Atividades Piscícolas, S.A. (Pescanova Group - Mira) is an intensive fish farm operating in a flow-through open system.



Figure 3.1 | Salt pans converted into aquaculture ponds. Source: MultiAveiro, Estudo de Revitalização e Valorização Económica do Salgado de Aveiro (Study for the revitalization and economic valorisation of the Aveiro salt pans), December, 2007

3.1.4 Salt production

In the Ria de Aveiro, the salt pans areas, named the ‘Salgado de Aveiro’, are located within the parishes of Glória, Aradas, Vera-Cruz and Esgueira (part of the Aveiro municipality), and the parish of S. Salvador (part of the Ílhavo municipality). The area corresponds to approximately 2600 ha including productive and non-productive salt pans. The “Salgado de Aveiro” is organized into the following five groups: Grupo do Norte, Grupo do Mar, Grupo de Monte Farinha, Grupo de S. Roque, and Grupo do Sul (<http://ecosal-atlantis.ua.pt/index.php?q=content/salgado-de-aveiro>). Salt production within the Ria de Aveiro has been of economic importance for centuries, but has sharply declined during the last few decades (51 000 tonnes in 1972, 25 000 tonnes in 1982, 5000 tonnes in 1992, 500 tonnes in 2002 (Portela, 2006)). In 2006, the production of salt in the Ria de Aveiro was limited to 11 salt pans with a total area of 36 ha (874 tonnes – corresponding to 1,14% of the national production), (Figure 3.2). Based on figures for 2007, only 4% of the 252 salt pans were operational; 18% had been converted into fish farms, whilst the majority was abandoned (UNAVE, 2008; Portela, 2011). During the 1980’s and 90’s semi-intensive fish farming took over the local salt business at a rate of 13 salt pans per year, sponsored by financial incentives and the fact that aquaculture can provide a constant income. The main fish species produced are seabass, seabream and eel. To date, intensive fish farming is still not permitted in the lagoon; although economically attractive, it could negatively affect the environmental quality of the lagoon (Martins, 2005). Furthermore, large scale fish farming “leads to the impoverishment of the salt pan landscape and to an aggravation of the conflicts with farmers. Exotic species can be introduced as well; causing ecological imbalances that affect feeding and nesting birds” (Rodrigues *et al.*, 2011, p11). The recent recovery of salt pans in Aveiro was mainly undertaken for aquaculture purposes, with the exception of two salt pans that were recovered for salt production owned by the University of Aveiro and the Municipality of Aveiro (Martins, 2005). The Troncalhada salt pan is also an eco-museum showcasing traditional activities in the Ria.



Figure 3.2 | Active salt pans with salt-production. Source: MultiAveiro, Estudo de Revitalização e Valorização Económica do Salgado de Aveiro, Dezembro de 2007

Presently, there are eight active salt pans in the Ria de Aveiro, occupying about 15 km² (Silva, 2010). The abandoned salt pans tend to collapse and become permanently flooded (Picado *et al* 2010; Silva, 2010). The marine salt produced is still regarded as a trademark of the Ria de Aveiro and represents an element of identity and specificity for the region. In this context, every year in July the city of Aveiro hosts an international salt festival. Also, the Troncalhada salt pan ecomuseum (<http://www.aveiro.eu>) emerged from this cultural heritage perspective.

3.1.5 Industries

The industry sector is currently the most important activity in the Aveiro region, with several industrial complexes and factories with recognised national importance (see Annex 5, Table 5.4).

Food, beverage and tobacco industries (DA) as well as metallurgical industry and metal products (DJ) are the main industrial sectors, and are represented in many counties. The DJ industries are distributed over four counties: Sever do Vouga hosts 49,5%, Águeda 36,4%,

Albergaria-a-Velha 27,8% and Oliveira do Bairro 27,1%. The local specializations are as follows: textile and footwear in Ovar, wood and paper in Aveiro, chemical manufacturing in Estarreja and non-metallic mineral products in Oliveira do Bairro and Vagos. Ílhavo hosts 60% of the Portuguese fish preparation and processing industries, where salt cod (“*bacalhau*”) is of particular importance, economically and socially. Every year, in August, Ílhavo hosts the codfish gastronomic festival.

3.1.6 Tourism and recreational activities

Tourism is a sector with high strategic value to all counties in the lagoon watershed. On the coastline, beach tourism has a long tradition, especially in Ílhavo (Costa Nova beach, since the XIX century, and Barra beach) and Aveiro county (São Jacinto beach). The main tourists come from Aveiro city and from neighbouring counties. Traditionally, many Portuguese emigrants return during the summer period, spending their holidays at the lagoon’s coastline and in the watershed area. In addition, these beaches are the closest seaside getaways to some Spanish cities such as Salamanca and Madrid; thus, many Spanish tourists visit during the summer period. Several festivals devoted to local products and traditional activities such as the “*moliceiros*” sailing race take place in the lagoon during summer, as well as several religious celebrations that gather the local population and lots of tourists.

The rich natural capital of the Ria de Aveiro provides optimum conditions for recreational and ecotourism activities including the traditional “*moliceiro*” boat trips, sports activities (e.g. sailing, wind-surfing, kite-surfing and kayaking), walking and biking in the diverse landscape (e.g. salt pans, S. Jacinto dunes, salt marshes, farmlands, quays and canals), fishing, and birdwatching. Its central geographic location between Lisbon and Porto and good transport connections make it easily accessible from within Portugal as well as from Spain.

The Baixo Vouga Lagunar deserves special attention not only for its agricultural but also for its undeniable environmental value. Baixo Vouga Lagunar is circa 4600 ha, and encompasses important ecosystems integrated in the Natura 2000 Network and in the Special Protection Area of the Ria de Aveiro. The main tourist attractions are walking and nature observations. Between 2000 and 2006, there was a significant increase in the number of establishments and lodging capacity in the Baixo Vouga region. However, between 2006 and 2010 there was a decrease in the number of establishments while the lodging capacity increased moderately

(Table 3.2). During the same period, the number of guests and nights spent in hotels increased (Table 3.3).

Table 3.2 | Establishments and lodging capacity in the Baixo Vouga region (2000, 2006 and 2010). Source: INE, Anuários Regionais do Centro (2001, 2007 and 2011)

Year	Establishments				Lodging capacity			
	Total	Hotels	Boarding houses	Others	Total	Hotels	Boarding houses	Others
2000	57	15	35	7	4 180	2 077	1 321	782
2006	71	23	36	12	5 061	2 863	1 210	988
2010	65	30	24	11	5 087	3 428	782	877

Table 3.3 | Nights spent and number of guests in establishments in the Baixo Vouga region (2000, 2006 and 2010). Source: INE, Anuários Regionais do Centro (2001, 2007 and 2011)

Year	Nights				Guests			
	Total	Hotels	Boarding houses	Others	Total	Hotels	Boarding houses	Others
2000	402 182	258 859	63 432	79 891	187 994	122 044	34 763	31 187
2006	407 378	280 097	76 060	51 221	222 529	148 069	40 353	33 107
2010	488 441	365 912	48 336	74 193	290 152	204 201	30 288	55 663

Regarding recreational fishing activities, many fishermen are part of local fishing associations. According to the Portuguese Federation of Recreational Fishing, in 2011, the Recreational Fishing Association of Aveiro and Beira Littoral included 31 of these local associations. Nine of these associations, involving 92 fishermen, are using the Ria for recreational fishing (Table 3.4).

Table 3.4 | Recreational fishing in the Ria de Aveiro – participants per association (2011). Source: FPPD, 2011; http://www.fppd.pt/Uploads/file/Estat%C3%ADstica/2011/Atleta_Clube_ARPDABL.pdf

Association	Participants
Assoc. Cult. Desp. Os Ilhavs	12
Associação Moradores da Praia da Tocha	11
Casa Do Pessoal Do Porto De Aveiro	15

Deliverable D2.1b

Centro Cultura E Desporto De Santa Joana	6
Centro Cultural De Barro	15
Clube Pesca Desportiva Amigos Caixa	9
Clube Pesca Desportiva Calvão	9
Clube Recreativo Pesca Mira	15
Total	92

3.2 Institutions, laws and conflicts

The initial part of this section will consider (i) the relevance and applicability of EU law including the Water Framework Directive (WFD) and the Marine Strategy Directive (MSD), and (ii) the national and local regulatory structures and provisions. Later sections then present the (iii) findings of the preliminary stakeholder and social group mapping, an exercise conducted in order to aid the identification of the respective key stakeholder groups (e.g. fisheries groups, community based organisations, farmer associations, industry representatives, conservation groups) and any conflicts or tensions, and (iv) the tabulation of relevant institutions, stakeholders and entities identified so far.

3.2.1 The EU Water Framework Directive and Marine Strategy Directive

In 1998, Portugal and Spain signed the Convention on Cooperation for the Protection and Sustainable Use of Waters of the Luso-Spanish River Basins. Most of them have their upstream basins in Spain and flow into Portugal. This protocol was revised by the Resolution of the Assembly of the Republic no. No. 62/2008 of 14 November (Source in English: <http://register.consilium.europa.eu/pdf/en/08/st07/st07167.en08.pdf>; Source <http://snirh.pt>; Source in English <http://www.google.com/translate?hl=en&langpair=pt|en&u=http://snirh.pt>).

In the meantime, the Marine Strategy Directive (MSD, 2008/56/EC) applies to marine waters, which are defined as territorial waters, i.e. extending from the baseline to the extent of states' exercise of jurisdictional rights; or coastal waters - as defined by the WFD, but only insofar as activities are not controlled by the WFD. It is not clear which, if any, activities would be addressed by the MSD, but not controlled in coastal waters by the WFD (Hey, 2009).

Significant legal and policy issues arise in particular from the relationship between the WFD and the MSD. Both Directives consider ecological diversity, but whereas the goal of the WFD is good ecological status, the goal of the MSD is good environmental status. The precise meanings and relationship between these terms is unclear, and indeed the same words may be used in some of the Community languages (Mee *et al.*, 2008). The WFD planning process should now be complete for the first round of river basin management plans, though not all member states have reached this goal; but it is increasingly recognized that the process, whilst generally positive, is much more complex and time consuming than previously understood, especially around ecological quality and socio-economic impacts, as well as disproportionate costs (Hering *et al.*, 2010). The same issues will arise under the MSD, but the planning process is less clearly articulated, and the stakeholder participation elements even less well defined than in the WFD.

3.2.2 The national and local regulatory structures and provisions

The policies and practices underpinning spatial planning in Portugal involve both multi-sector and multi-level tools for standardisation and operations. These tools are allocated to various organisations reporting either directly or indirectly to four ministries. In essence, coastal interventions are composed of tools developed at one of three hierarchical levels: national, regional and municipal (ANCORIM, 2011; <http://ancorim.aquitaine.fr>). At national level, the Portuguese National Programme for Spatial Planning sets out the main guidelines, and provides the national framework for other tools such as the Sector Plans (e.g. transport, energy, health, education, tourism, agriculture, forest, environment) and the Special Spatial Planning tools, including the Coastal Zone Management Plans, Estuary Spatial Planning and Management Plans, Reservoirs Spatial Planning and Land Use Plan, and Protected Areas Land Use and Management Plans. At a regional level, the Regional Spatial Planning Plans define the regional strategy for territorial development. At municipal level, Intermunicipal Spatial Planning Plans ensure the articulation between the Regional Spatial Planning Plans and the Municipal Spatial Planning and Land Use Plans. Despite the effort to execute these standardisation and operational initiatives in an integrated manner, this isn't an easy task, at least horizontally, once the initiatives are scattered across several ministries with executive powers in this area. Focusing on the Ria de Aveiro and the project goals, we highlight the:

- Sector Plans: Maritime Spatial Plan, Vouga Watershed Management Plan, Special Protection Area Ria de Aveiro;

› Special Spatial Plans: S. Jacinto Nature Reserve Protected Area Land Use and Management Plan, Coastal Zone Management Plan of Ovar - Marinha Grande, Vouga Estuary Spatial Planning and Management Plan;

- › Regional Spatial Planning Plan for the central region of Portugal;
- › Intermunicipal Spatial Planning Plan UNIR@RIA;
- › Municipal Spatial Planning and Land Use Plans of Ovar, Estarreja, Murtosa, Albergaria-a-Velha, Aveiro, Ílhavo, Vagos and Mira.

Table 3.5 gives an overview over some tools for application domains considered important within the LAGOONS project ([Carvalho and Fidélis, 2011](#)).

Table 3.5 | Tools for application domains considered important within the project

Domain	Tool
Spatial Planning	National Programme for Spatial Planning Regional Spatial Planning Plan Intermunicipal Spatial Planning Plan Municipal Spatial Planning and Land Use Plan Reservoirs Spatial Planning and Land Use Plan Coastal Zone Management Plan Estuary Spatial Planning and Management Plan
Water Resources	Water National Plan Watershed Management Plan
Nature Conservation	National Natura 2000 Management Plan Protected Areas Land Use and Management Plan
Sea	Maritime Spatial Plan
Harbours and Maritime Transports	Maritime and Harbours Sector National Programme
Tourism	Tourism National Strategic Plan
Fisheries and Aquaculture	Fisheries National Strategic Plan (2007-2013)
Forestry	Forestry Regional Management Plan

We also highlight the Polis Litoral Ria de Aveiro, an intervention programme for the improvement and recovery of the lagoon. Figure 3.3 shows a schematic representation of the territorial incidence of some of these plans and programmes on the Ria de Aveiro region.

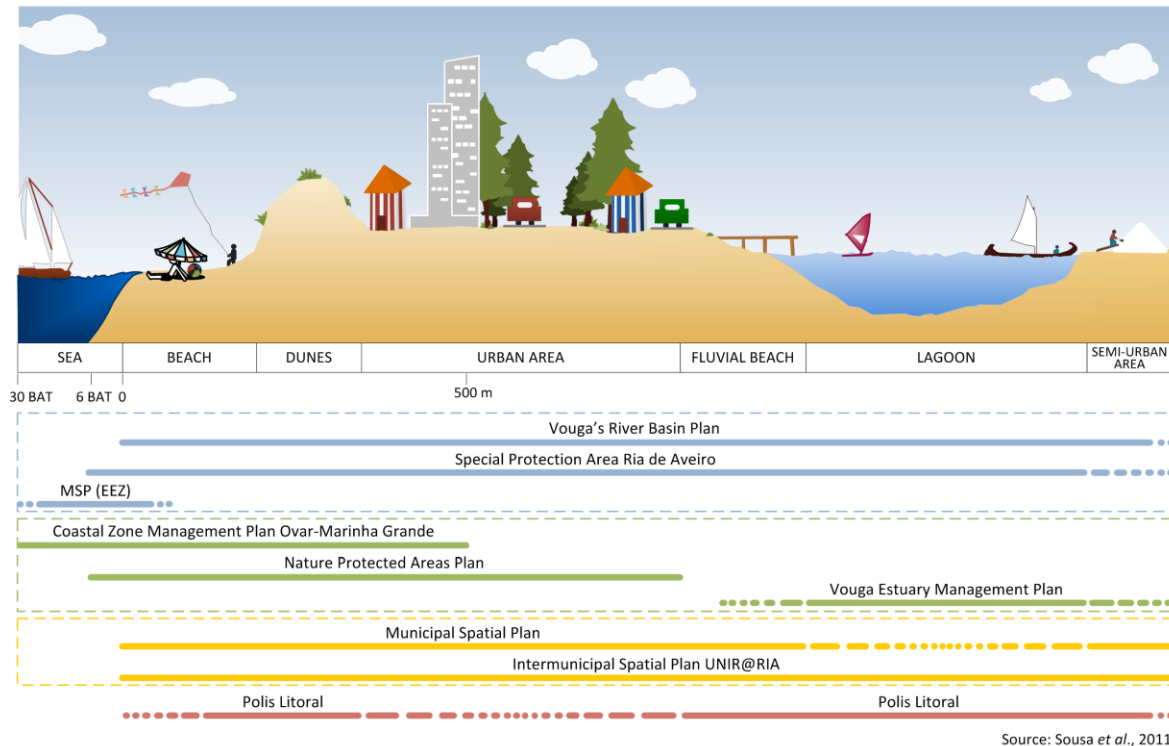


Figure 3.3 | Territorial incidence of some of the plans and programmes on the Ria de Aveiro watershed area.

3.2.3 Institutions, stakeholders and social groups

The Ria de Aveiro's unique environmental, cultural and socio-economic features have strongly influenced its local economy through the development of activities such as salt production, harvesting of seaweed, shellfish gathering, fishing, aquaculture, agriculture and shipping industry. This complex ecosystem not only supports high added value economic activities, but is also intertwined with a rich socio-cultural heritage which faces increasing pressures and inappropriate changes that put at risk its ecological balance and heritage, and requires more adaptive and sustainable management policies (<https://webgate.ec.europa.eu/fpfis/cms/farnet/content/flag-factsheet-portugal-ria-de-aveiro>).

Table 3.6 lists and describes the institutions and stakeholders currently identified for the area followed by a further listing of likely stakeholders.

Table 3.6 | Institutions and stakeholders - Aveiro

Institution	Type	Description	Website
ICNF I.P. - Instituto Conservação da Natureza e Florestas (Institute of Nature Conservation and Forestry) <i>Formerly: ICNB-Instituto da Conservação da Natureza e Biodiversidade</i> (Portuguese Institute for Nature Conservation and Biodiversity)	National government body - part of the Portuguese Ministry for Agriculture, Sea, Environment and Spatial Planning.	The Institute carries out the tasks of the Ministry of Agriculture, Sea, Environment and Spatial Planning. The ICNB's mission is to propose, monitor and ensure implementation of policies on nature conservation and biodiversity and protected areas management, seeking public recognition and appreciation of the natural heritage.	http://portal.icnb.pt
INAG-Instituto da Água I.P. (Portuguese National Water Institute)	National government body	Central body with jurisdiction over the entire national territory. A public institution within the administration of indirect rule, endowed with administrative autonomy and its own assets. The INAG, IP continues assignments for Ministry of Agriculture, Sea, Environment and Spatial Planning under supervision and tutelage of their minister. The INAG, IP, such as the National Water Authority, is intended to propose, monitor and ensure implementation of national policy in the field of resources water to ensure their sustainable management, and ensure the effective implementation of the Water Law.	www.inag.pt
ITP-Turismo de Portugal I.P. (Portuguese Institute for Tourism).	National body	Turismo de Portugal, I.P. is the state-owned Portuguese tourism authority, responsible for promotion, enhancement and sustainability of all tourism activities in the country. Formed in 2007, after the merger of four institutions (Instituto de Turismo de Portugal (ITP), Instituto de Formação Turística (INFTUR), Inspeção Geral de Jogos (IGJ) and Direcção Geral do Turismo (DGT), that handled different aspects of the development, investment, promotion, regulation and education of tourism activities in Portugal.	http://www.visitportugal.com/Cultures/pt-PT/default.html
APA-Agência Portuguesa do Ambiente I.P. (Portuguese Environmental Agency) <i>Integrates the competences of the former:</i> ARHcentro, I.P. -Administração	National government	A public institution within the administration of the Ministry of Agriculture, Sea, Environment and Spatial Planning	http://www.arhcentro.pt/web site/

da Região Hidrográfica do Centro (Hydrographic Regional Board).			
Município de Aveiro (Municipality of Aveiro)	Local government		http://www.cm-aveiro.pt/www/
All Municipalities (Ovar, Murtosa, Estarreja, Aveiro, Ílhavo, Vagos e Mira)	Local government		
Direcção Regional de Agricultura e Pescas do Centro (Centro Regional Directorate for Agriculture and Fisheries)	Regional		http://www.drapc.min-agricultura.pt/home.php
CCDR Centro – Comissão de Coordenação e do Desenvolvimento Regional do Centro (Centro Regional Coordination and Development Commission)	Regional		https://www.ccdrc.pt/
Stakeholders	Type	Description	Website
Polis Litoral Ria de Aveiro (Society of Rehabilitation and Improvement of the Ria de Aveiro SA)	Public Limited Company	Formed for implementing rehabilitation and recovery of the Ria de Aveiro. A public limited company - publicly owned, mostly constituted of the State (56%) and minority municipalities by CIRA (44%). This also includes an advisory board made up of several entities with relevance and responsibilities within this area.	http://www.polisriadeaveiro.pt
Associação da Lavoura do Distrito de Aveiro (Farming association of Aveiro district).	Local association	Farmer's association for the municipality.	http://associacaolavouradistritoaveiro.blogspot.com/
O Grupo de Acção Costeira da Região de Aveiro - Coastal Action Group - Region of Aveiro (GAC-RA).	Local/Regional	The Action Group for Coastal Region of Aveiro (GAC-RA) is a partnership that aims to mobilize local authorities, individuals and collectives, public and private, and fishing communities in general, the process of sustainable development of coastal area of relevant technical intervention, according to the set on Axis 4 - Sustainable Development of the Fishing Areas - Fishing Operational Programme 2007-2013 - PROMAR (Administrative Rule no. 828-A/2008, August 8). GAC-RA is a	http://www.regiaodeaveiro.pt/PageGen.aspx?WMCM_PaginaId=29289&projectId=10

		intermediate body that interacts between the promoters and the managing authority PROMAR.	
Comunidade Intermunicipal da Ria de Aveiro (Intermunicipal Community for Ria de Aveiro).	Regional/local	A public institution with associative nature and geographical scope which aims to realise common interests shared by the local municipalities. Created in October 2008, based on the association of eleven municipalities that want to be known as the "Region of Aveiro."	http://www.regiaodeaveiro.pt/PageGen.aspx
Associação de Produtores e Marnotos da Ria de Aveiro (Association of Producers and Marnotos of Ria de Aveiro)	Local	Founded on 1 st Aug 2007 - the same time as the formation of the Federation of European Producers of Artisan Sea Salt - Fena.Sal, which will represent the various local associations and negotiate with the EU on their behalf. A community that unites producers of salt, marnotos, House and University of Aveiro (UA) around the salt sector organization and dynamics of salt in the region.	http://www.aveiro.co.pt/noticia.aspx?id=70461&notic=Aveiro:%20Associa%C3%A7%C3%A3o%20de%20Produtores%20e%20Marnotos%20da%20Ria%20constitu%C3%ADda%20ontem
Reserva Natural das Dunas de S. Jacinto (Natural Reserve of Dunes of S. Jacinto).	Regional/local	With a land area of approximately 700 ha located at the southern end of the strip of sand that separates the north arm of the "Ria de Aveiro" the Atlantic Ocean. It belongs to the parish of St. Jacinto and the county and district of Aveiro.	http://portal.icnb.pt/ICNPortal/vPT2007-AP-DunasSJacinto/Visitar+Area+Protegida/Como+Chegar/
Research Centres			
University of Aveiro	Public Institution	The UA is a highly regarded institution of research led education, constituted by university departments, research units, polytechnic schools, interface units, and a vocational education network.	https://www.ua.pt/
CESAM	Associated Laboratory	Associated Laboratory since 2005, CESAM includes around 400 researchers, 150 with a PhD degree, and six departments of the University of Aveiro: Environment and Planning, Biology, Civil Engineering, Physics, Chemistry and Geosciences; it also includes members from the Faculty of Sciences, of the University of Lisbon. CESAM's mission is to develop fundamental research in the Coastal and Marine Environment, in an integrated manner.	http://www.cesam.ua.pt/

3.2.3.1 *Other relevant stakeholders/institutions Aveiro:*

- AIB (Associação dos Industriais de Bacalhau) and ADAPLA – based in Aveiro;
- ADAPI (Associação dos Armadores da Pesca Industrial);
- APARA (Associação da Pesca Artesanal da Ria de Aveiro) – represents local fishing companies;
- AIDA (Associação Industrial do Distrito de Aveiro) the Industrial Association of the District of Aveiro;
- APA SA – Aveiro Port Authority;
- AGIR (Aveiro Association to Develop Regeneration of Local Commerce on the Town Centre);
- Aquaculture;
- Associação de Criadores da Raça Marinhola;
- Turismo Centro de Portugal (<http://www.turismodocentro.pt/pt/?zona=3>);
- SPEA - Sociedade Portuguesa para o Estudo das Aves (Portuguese partner of BirdLife International);
- Local ceramics industry;
- BioRia Project (<http://www.bioria.com/>);
- Nautical/ sports/ leisure institutions (e.g. clube de vela da costa nova, sporting clube de Aveiro, tulha, etc).

3.3 Knowledge gaps

Since Portugal became an EU member in 1986, the national legal and administrative system has undergone profound changes. In this context, the introduction of a multidisciplinary and integrated approach enabled the development of new methodologies to promote an integrated development and management of coastal systems.

However, there is still a need to fill the existing gaps on the: i) protection of Ria de Aveiro's natural and cultural capital, which is considered insufficient given the ecosystem and biodiversity value and benefits not only for the local community, but also at regional and

national level; ii) application of mechanisms for active participation (not only of stakeholders, but also ordinary citizens, as users of the Ria de Aveiro) in the decision-making process; iii) understanding on the evolution of the lagoon social-ecological system; iv) understanding and integrating on management system of the lagoon's resilience and adaptability for human and natural change.

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5 Annexes

Tabela 5.1 | Floods data between 1857 and 2005 (source: SECURia project)

Year	Month	Day	County	Parish
1857	January	13	Ovar	Ovar
1912	February	2	Ovar	Ovar
1957	December	11	Ovar	Ovar
1969	November	13	Ovar	Ovar
1971	January	24	Ovar	Ovar
	January	27	Ovar	Ovar
	January	28	Ovar	Ovar
1980	December	31	Ovar	Ovar
1995	December	25	Albergaria-a-Velha	Angeja
	December	25	Aveiro	Cacia
	December	25	Aveiro	Esgueira
2000	December	30	Ovar	Válega
2001	January	5	Aveiro	Esgueira
	January	6	Aveiro	Esgueira
	January	26	Aveiro	Esgueira
	January	27	Estarreja	Fermelã
	March	21	Ovar	Maceda
	March	21	Ovar	Ovar
2005	November	19	Ovar	Esmoriz

Tabela 5.2 | Floods data between 2006 and 2011 (source: ADAPTARia project)

Year	Month	Day	County	Parish
2006	May	9	Ovar	Ovar
	June	2	Aveiro	Vera Cruz
	August	16	Ovar	Cortegaça
	September	24	Ovar	Cortegaça
	October	25	Aveiro	Vera Cruz
	November	3	Estarreja	Salreu
	November	23	Estarreja	Salreu
	November	24	Ílhavo	Gafanha da Nazaré
	November	27	Ovar	Ovar
	November	27	Ovar	Ovar
	November	27	Ílhavo	Gafanha da Nazaré
	December	5	Ílhavo	Gafanha da Encarnação

Year	Month	Day	County	Parish
2007	February	20	Ovar	Esmoriz
	February	22	Ovar	Esmoriz
	February	24	Vagos	Gafanha da Boa Hora
	March	2	Vagos	Gafanha da Boa Hora
	June	16	Ovar	Ovar
	August	15	Ovar	Ovar
	November	19	Ovar	Esmoriz
	November	22	Ovar	Ovar
	December	13	Ílhavo	Gafanha da Encarnação
2008	March	12	Ílhavo	Gafanha da Encarnação
	May	26	Ovar	Ovar
	September	5	Ovar	Esmoriz
	September	5	Ovar	Cortegaça
	September	22	Ovar	Cortegaça
	September	22	Ovar	Ovar
	September	19	Aveiro	Vera Cruz
2009	January	13	Ílhavo	Gafanha da Nazaré
	January	30	Ovar	Ovar
	January	30	Ílhavo	Gafanha da Nazaré
	February	1	Ovar	Cortegaça
	February	1	Ovar	Ovar
	February	6	Ílhavo	Gafanha da Nazaré
	February	17	Murtosa	Torreira
	February	28	Aveiro	Vera Cruz
	May	24	Aveiro	Vera Cruz
	October	5	Ílhavo	Gafanha da Nazaré
	October	7	Ovar	Ovar
	October	7	Ovar	Esmoriz
	October	20	Ílhavo	Gafanha da Nazaré
	October	21	Ílhavo	Gafanha da Nazaré
	November	1	Ovar	Esmoriz
	November	9	Ovar	Esmoriz
	November	13	Ovar	Esmoriz
	November	15	Ovar	Esmoriz
	November	15	Ovar	Ovar
	November	16	Ovar	Ovar
	November	17	Ovar	Ovar

Year	Month	Day	County	Parish
	December	6	Ovar	Cortegeça
	December	21	Ovar	Esmoriz
	December	22	Ovar	Esmoriz
	December	31	Ovar	Cortegeça
2010	January	1	Ílhavo	Gafanha da Encarnação
	January	4	Aveiro	Vera Cruz
	January	10	Ílhavo	Gafanha da Nazaré
	January	12	Ovar	Esmoriz
	January	13	Estarreja	Beduído
	February	18	Ovar	Ovar
	February	27	Aveiro	São Jacinto
	February	28	Aveiro	São Jacinto
	February	28	Ovar	Ovar
	March	1	Ílhavo	Gafanha da Nazaré
	April	21	Ílhavo	Gafanha da Nazaré
	June	10	Ílhavo	Gafanha da Nazaré
	August	7	Ílhavo	Gafanha da Nazaré
	October	3	Aveiro	Esgueira
	October	3	Ovar	Esmoriz
	October	8	Ovar	Esmoriz
	October	8	Aveiro	São Jacinto
	October	9	Ovar	Ovar
	October	9	Ílhavo	Gafanha da Nazaré
	October	12	Murtosa	Torreira
	October	29	Ovar	Ovar
	October	30	Estarreja	Beduído
	October	30	Estarreja	Salreu
	November	9	Ovar	Esmoriz
	November	9	Ovar	Ovar
	November	9	Ílhavo	Gafanha da Nazaré
	December	6	Ílhavo	Gafanha da Nazaré
	December	6	Murtosa	Torreira
	December	7	Aveiro	Vera Cruz
2011	January	6	Ovar	Ovar
	February	16	Ovar	Cortegeça
	February	16	Ovar	Esmoriz
	February	18	Ovar	Esmoriz

Year	Month	Day	County	Parish
	February	21	Ovar	Esmoriz

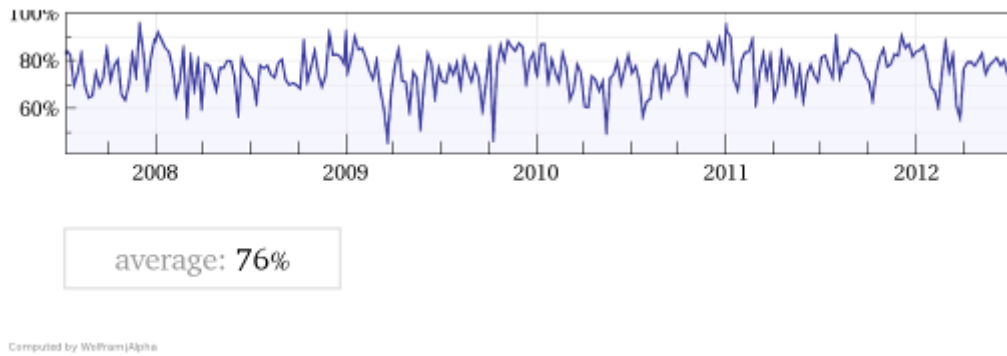


Figure 5.1 | Humidity; Source: <http://www.wolframalpha.com>.

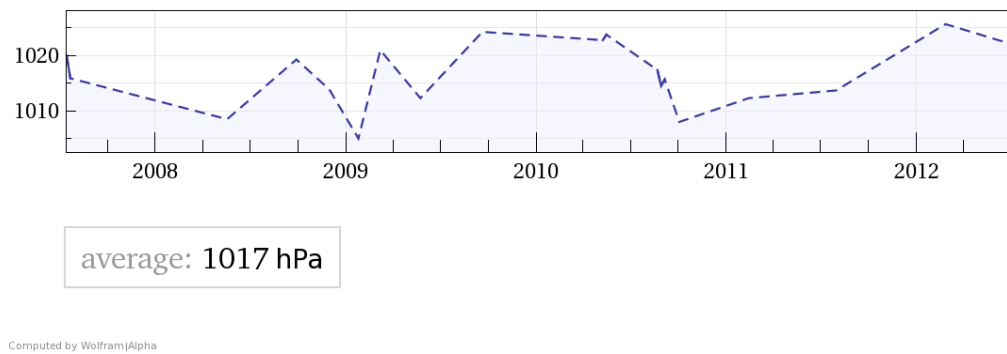


Figure 5.2 | Pressure; Source: <http://www.wolframalpha.com>.

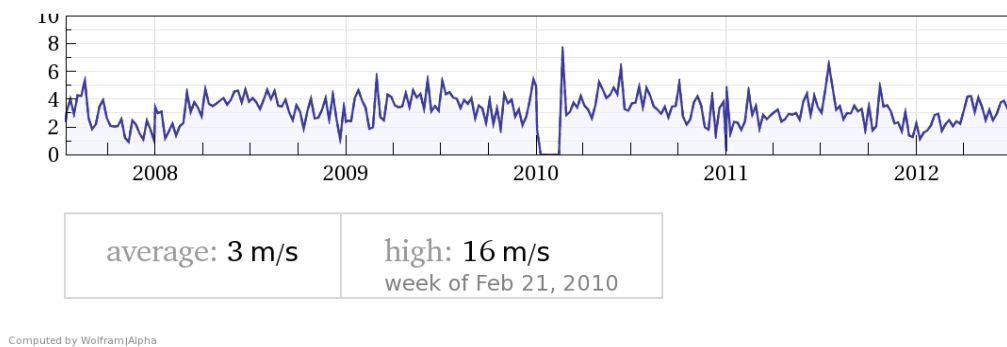


Figure 5.3 | Wind speed; Source: <http://www.wolframalpha.com>.

Table 5.3 | Active and employed population by sector (2001) Source: Instituto Nacional de Estatística, Censos 2001.

Territorial Units	Resident Population	Active Population	Employed population by sector (2001)						
	2001	2001	Primary		Secondary		Tertiary		Total
PORTUGAL	9 833 014	4 990 208	231 656	5%	1 632 638	35%	2 786 663	60%	4 650 947
Central region	1 763 119	1 067 864	68 479	7%	383 536	38%	554 358	55%	1 006 373
Baixo Vouga	336 637	189 579	8 325	5%	83 915	47%	87 379	49%	179 619
Águeda	49 041	24 600	501	2%	14 297	60%	9 087	38%	23 885
Albergaria-a- Velha	24 638	11 812	494	4%	5 862	52%	4 884	43%	11 240
Aveiro	73 335	37 881	741	2%	12 390	35%	22 723	63%	35 854
Estarreja	28 182	13 013	516	4%	6 011	50%	5 608	46%	12 135
Ílhavo	37 209	18 243	970	6%	6 920	40%	9 380	54%	17 270
Mira	12 872	5 629	677	13%	1 749	34%	2 755	53%	5 181
Murtosa	9 458	4 065	730	19%	1 421	37%	1 641	43%	3 792
Oliveira do Bairro	21 164	10 209	766	8%	4 807	49%	4 151	43%	9 724
Ovar	55 198	28 425	544	2%	14 782	56%	11 276	42%	26 602
Sever do Vouga	13 186	5 749	403	7%	2 866	53%	2 139	40%	5 408
Vagos	22 017	10 576	1 250	13%	4 287	43%	4 454	45%	9 991
Total Ria de Aveiro	346 300	170 202	7 592	5%	75 392	47%	78 098	48%	161 082

Table 5.4 | Industry sector (2004) Source: Instituto Nacional de Estatística, Anuário Regional do Centro, 2005.

Territorial Units	Total	DA	DB	DC	DD	DE	DF+DG	DH	DI	DJ	DK	DL	DM	DN
		[%]												
PORTUGAL	52 122	13.5	18.3	4.3	8.1	9.3	2.1	2.2	7.1	14.8	6.0	3.2	1.6	9.6

Central region	12 019	17.3	7.2	1.8	9.2	6.6	2.2	3.6	11.5	17.8	8.7	3.0	2.0	9.0
Baixo Vouga	2 653	13.2	5.6	1.2	8.5	6.7	2.2	3.4	9.8	25.3	7.3	4.0	4.3	8.5
Águeda	640	5.2	5.2	0.2	4.8	4.8	0.5	3.9	10.2	36.4	7.5	3.1	6.6	11.7
Albergaria-a-Velha	162	8.0	9.3	0.6	11.7	4.3	1.9	3.7	5.6	27.8	14.2	3.7	5.6	3.7
Aveiro	427	19.2	3.0	-	5.4	8.4	3.5	0.9	11.0	21.5	9.1	6.8	2.8	8.2
Estarreja	109	17.4	4.6	1.8	8.3	5.5	8.3	1.8	3.7	22.0	9.2	5.5	-	11.9
Ílhavo	192	24.5	4.7	-	6.8	3.1	1.0	3.6	8.9	21.4	10.9	3.6	7.8	3.6
Mira	41	17.1	2.4	-	22.0	4.9	2.4	-	17.1	9.8	2.4	2.4	2.4	17.1
Murtosa	29	17.2	-	-	17.2	24.1	3.4	3.4	-	20.7	3.4	-	-	10.3
Oliveira do Bairro	210	11.4	3.8	-	5.7	5.7	1.4	2.4	20.5	27.1	8.6	1.4	4.3	7.6
Ovar	358	9.8	13.7	7.5	12.3	7.8	3.6	3.9	2.8	13.1	3.6	7.8	2.5	11.5
Sever do Vouga	105	8.6	1.9	1.9	12.4	7.6	1.0	1.0	1.9	49.5	3.8	1.0	2.9	6.7
Vagos	106	11.3	1.9	-	11.3	3.8	2.8	5.7	20.8	23.6	8.5	2.8	2.8	4.7

DA – Food, beverages and tobacco industries; DB – Textiles industry; DC – Manufacture of leather and leather products; DD – Manufacture of wood and cork; DE – Manufacture of pulp, paper and paperboard and paper products; publishing and printing; DF – Manufacture of coke, refined petroleum products and nuclear fuel; DG – Manufacture of chemical products and synthetic or artificial fibers; DH – Manufacture of rubber and plastic products; DI – Manufacture of other non-metallic mineral products; DJ – Metallurgical industry and metal products; DK – Manufacture of machinery and equipment, n.e.; DL – Manufacture of electrical and optical equipment; DM – Manufacture of transports equipment; DN – Manufacturing industries, n.e..