



## Distinctive features of spatial planning nearby estuaries – An exploratory analysis of water-related rules in municipal master plans in Portugal

Carla Rodrigues<sup>a,\*</sup>, Teresa Fidélis<sup>b</sup>

<sup>a</sup> Coimbra College of Agriculture, Polytechnic Institute of Coimbra, 3045-601, Coimbra, Portugal

<sup>b</sup> GOVCOP, Department of Environment and Planning, University of Aveiro, 3810-193, Aveiro, Portugal

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### ABSTRACT

Land-use types and related intensities are often associated with pressures and disturbances on estuarine environmental values and ecosystem services provided by water. Although with varied legal frameworks across countries, broadly, spatial planning has been expected to contribute to the protection of environmentally sensitive areas, such as estuaries. Among the various planning tools are the plan's land-use control rules. This article studies the incorporation of water-related terms in the regulations of municipal master plans to assess if land-use rules established on estuarine areas are significantly different from others, such as in upstream areas. It does so by developing a content analysis of a set of plans' regulations located in estuarine and upstream areas of two river basins of Mainland Portugal. The results show greater incorporation of water-related terms in plans' regulations located in estuarine areas. Moreover, they show a greater diversity of water-related topics, types, and focus of rules on estuarine areas, whereas on upstream areas the regulatory approaches look poorer. Although the incorporation of water-related terms is globally higher in younger plans, and to a certain extent, in more artificialized and dense territories, a clear distinctiveness of water-related concerns in land-use regulations of municipal plans on estuarine areas remains visible. Surprisingly, the results bring to the fore fragilities of land-use regulations on upstream areas worthy of attention in future studies. The methodology used for content analysis disclosed a valuable path for future research as it is easily expandable to take into consideration different land-uses or to be applied to different regions, to further refine if the distinctive features are explicitly related with estuarine areas or with other types of water problems.

### 1. Introduction

The EU spatial planning discourse, through the so-called EU territorial cohesion policy (EC, 2011, 2020) considers the integration of spatial and environmental concerns, such as water resources, as critical drivers for sustainability. It stresses the importance of place-based approaches to policymaking as they contribute better to protect the ecological values and environmental quality. The role of spatial planning to protect environmental values, by preventing the fragmentation of habitats and by fostering the implementation of nature-based solutions and green and blue infrastructures, is underlined, especially nearby environmentally sensitive areas. In certain sensitive areas where the environmental and economic interests often collide, like in estuaries, a successful contribution from spatial planning lies, among other issues, in the adoption of spatial models and land-use control rules capable of restraining the impacts generated by particular types, intensities and

styles of land-use including of urbanization, industrial or tourism development, over estuarine water resources. The protection of water resources and estuaries from the impacts of land-use, is stressed by the EEA (2018), the Water Framework Directive (WFD) (2000/60/EC of 23.10) and to a certain extent, the Directives related to Natura 2000 (2009/147/EC of 30.11, and the Floods Directive (2007/60/EC of 23.10).

Rules set out by land-use plans are relevant tools for achieving environmental objectives (OECD, 2012; Wurzel et al., 2013; Gunningham and Holley, 2016), and for communicating environmental and spatial public policies (Norton, 2008). They seek to change the behaviour of individuals, business or other entities in ways that generate positive impacts. Some initiatives from different fields including legislative (OECD, 2010; EU, 2016), water governance (OECD, 2011, 2017) or spatial planning (OECD, 2015), among others, stress the need for simple, straightforward, transparent ruling approaches, able to promote

\* Corresponding author.

E-mail addresses: [carlar@esac.pt](mailto:carlar@esac.pt) (C. Rodrigues), [teresafidelis@ua.pt](mailto:teresafidelis@ua.pt) (T. Fidélis).

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effective compliance with planning and environmental objectives.

Municipal master plans set out a spatial framework for new development and a set of rules or guidelines to support decision-making processes and permits. They also pursue the implementation of policies from upper levels concerning the use and development of land as well as environmental protection (van Leeuwen et al., 2007; Christophe and Tina, 2015). Despite the upsurge in many countries of estuary plans (Carvalho and Fidélis, 2013; Villiers, 2016; Daniell et al., 2020; Slater and Claydon, 2020) capable of covering the broader boundaries of estuarine areas, municipal master plans should reflect particular sensitivity to corresponding territorial environmental values. The land-use control rules around the estuaries should be capable of reflecting the environmental values likely to be affected by particular land-use types and intensities while contributing to reducing potential conflicts. The land-use rules are tools to communicate particular concerns, and therefore have special relevance in places where conflicting interests are at stake, as in estuaries (Gibbs et al., 2007; Fidélis and Roebeling, 2014; Zorrilla-Miras et al., 2014). In the Portuguese context, the criticisms over the protection of estuaries have called for guidelines from river basin plans and regional spatial development plans in order to enhance the contribution of municipal master plans over estuaries. However, few studies, if none, were found about how municipal master plans incorporate concerns over nearby estuaries.

To overcome that gap, this article studies the incorporation of water-related terms in the regulations of municipal master plans with the purpose of assessing if land-use rules established on estuarine areas are significantly different from others, such as on upstream areas. It does so by developing a discourse analysis of a set of plans' regulations located in two river basins of Mainland Portugal. The article is structured into seven sections. After this introduction, Section 2 presents a brief literature context on the role of spatial plans regulations for the protection of estuaries. Section 3 introduces central contextual landscape for the protection of estuaries in the Portuguese spatial and water resources planning frameworks. Section 4 describes the methodological approach and the analytical tool supporting the analysis of the plans' regulations, and the database used. Section 5 outlines the main findings, and Section 6 discusses the results in light of the methodology and the literature. Section 7 concludes and suggests future paths for spatial planning practice and research.

## 2. The land-use control around estuaries in the literature

Estuaries are complex and highly dynamic ecosystems, have essential ecological, landscape, economic and social value, play a vital role in the conservation of nature and biodiversity, and offer a variety of goods and services (Barbier, 2017; Whitfield, 2017). Due to their features and locations, estuaries provide rich habitats of flora and fauna (Constanza et al., 2017) and support a wide range of economic activities, e.g. urban, industrial and touristic activities. Estuaries often include ecosystems particularly vulnerable to anthropogenic pressures, and land-use, which may compromise their values and functions and threaten the uses that depend on them (Elliott and Whitfield, 2011; Barbier, 2017; Riley et al., 2018). Several authors have stressed that the health of estuarine water resources is strongly dependent on the types and intensity of land-uses and human activities and practices associated, placed nearby estuary banks, and also in upstream areas (Tecchio et al., 2016; Lopes et al., 2017; Paerl, 2018; Panton et al., 2020, among others). Agricultural uses and practices are responsible for diffuse pollution and eutrophication (Rocha et al., 2015). Forest loss leads to increase erosion and surface runoff (Meneses et al., 2015). The urban and industrial land-uses, and as well, port infrastructures, tourism and recreation activities, usually translate into land imperviousness, a decrease of groundwater recharge, increased surface runoff and water pollution, overburden on water utilities (water supply and wastewater treatment) and increased sediment load on water bodies, among other impacts (Flandroy et al., 2018; Jordan et al., 2018; Kertész et al., 2019). These impacts, if combined

with the potential effects of climate change, may aggravate risks of water quality, floods, droughts or scarcity (Robins et al., 2016; Vargas et al., 2017; IPCC, 2018).

The scientific community has studied estuaries through numerous perspectives. Despite the recognized vulnerability to impacts of land-use change and their particularities nearby estuaries, and various studies the relevance of land-use planning and control for the protection of estuaries, studies on land-use control regulations nearby estuaries have been scantily explored in the literature. This statement is based on a brief bibliometric analysis using the Scopus platform and represented in Fig. 1.

The land-use planning concerns around estuaries have been stressed, for instance, under modelling approaches to assess the influence of land cover, changes and practices, to simulate landscape development scenarios and impacts which promote water resources protection (Rocha et al., 2015; Wu et al., 2017; Chi et al., 2020). It has also been raised under the topics of integrated and adaptive planning approaches (Lonsdale et al., 2015; Schoonees et al., 2019), collaborative approaches (Newton and Elliott, 2016; Gross and Hagy, 2017) or legal frameworks analysis (Fidélis and Carvalho, 2015; Pinto and Kondolf, 2016; Paterson, 2018). Among them, relevant recommendations emerge as the integration of environmental concerns, such as water resources into spatial planning (Waltham, and Connolly, 2011; Fidélis and Roebeling, 2014; Serrao-Neumann et al., 2017) or ecosystem services (Rogers et al., 2019) and the restriction of new development options to environmental limits in place. Serrao-Neumann et al. (2017) add the need for plans covering contiguous territorial areas with shared natural structuring elements, such as estuaries and rivers, to coordinate their spatial development models and ensure a mutual commitment to harmonize their interests. Worth mentioning is also the contribution from Keesstra et al. (2018) on the relevance of nature-based solutions to enhance water protection and prevent impacts from artificialized areas around estuaries. The contributions focusing on land-use control and regulations around estuaries are scarce. The few existing, stress need to strengthen the efficiency of land-use control at the local level (Dai et al., 2010; Christophe and Tina, 2015), the relevance of regulatory measures to support decision-makers (Windolf et al., 2012; Riley et al., 2018) and the precise allocation of responsibilities between the fields of water management and land-use planning (Christophe and Tina, 2015). None, however, develops aspects associated with the formulation of land-use control rules.

By studying the integration of water concerns into municipal master plans around estuaries, this article offers a new and singular contribution to enrich the existing studies on spatial planning around estuaries and how land-use regulations are integrating water and estuarine related concerns.

## 3. Main features of estuarine protection in Portugal

The protection of estuarine areas through the contribution of spatial planning in the Portuguese context is discussed by several authors (Carvalho and Fidélis, 2013; Mascarenhas et al., 2014; Fidélis and Carvalho, 2015; Lillebø et al., 2019; Cavaco and Costa, 2020, among others). Two major legislative frameworks structure the control of land-use in estuarine areas, namely, the spatial planning and water resources planning.<sup>1</sup> The Spatial Planning Framework law considers the protection of estuaries indirectly, by mentioning the coastal zone, the riverbanks and the strengthening of the territory's resilience to the effects of extreme events. It also foresees the principles of transversality and integration of environmental policies, as well as of environmental responsibility. Besides, spatial plans aim to mitigate conflicts, such as in estuarine areas, where spatial development and water quality often

<sup>1</sup> based in the Law No 74/2017, of 16.08 and Law No. 58/2005 of 29.12, altered by Decree-Law No. 245/2009 of 22.09 and Decree-Law No. 130/2012 of 22.06 and subsequent amendments, respectively.

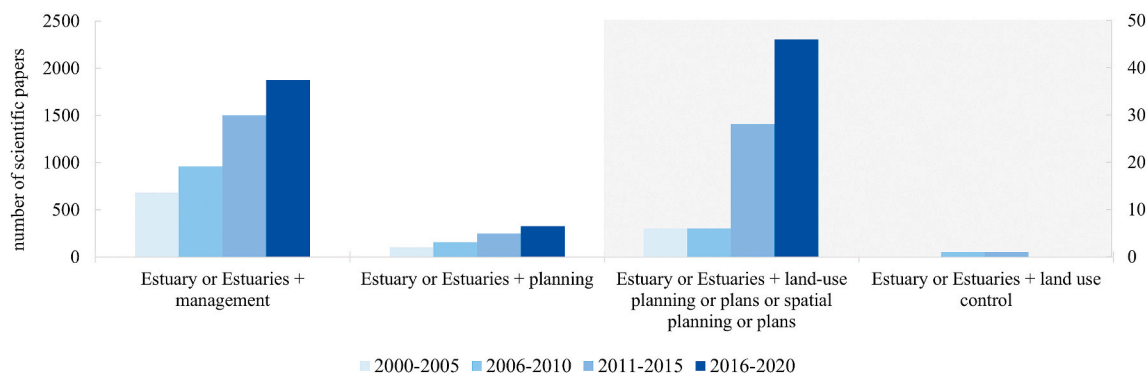


Fig. 1. Evolution of articles in Scopus since 2000 related to estuaries, land-use planning and land-use regulation.

collide. They are also to articulate with sectoral plans with spatial relevance, as the case of water resources plans, while providing territorial-based criteria and guidelines for their contents. The Water Law, which transposes the WFD, foresees the protection of estuaries by stating that the water protection objectives and quality standards is not limited to the water bodies but also the territory in close connection with it, such as the banks of estuarine areas. Both laws, foresee the adoption of estuary plans expected to play a role in guiding water uses, activities and land-use around estuary areas. Although a dedicated legal regime was adopted in 2008 (Decree Law No 129/2008 of 21.07), and some estuary plans were drafted, none has been approved until today.

The National Spatial Policy Program (PNPOT), the primary reference spatial planning document, refers the protection of estuarine areas in the main objectives, and in a measure dedicated to the need to strengthen ecological connectivity (PNPOT, 2019, M4.2<sup>2</sup>). It also stresses that more robust guidelines should be developed for municipal plans. The National Water Plan includes estuaries in the objectives, by stating the need to protect and restore natural ecosystems, and to promote the resilience of water and humanized systems to the effects of risks associated with climate change. Other references to estuaries are made under the characterization of national resources, namely by mentioning the Plan for the Development and Protection of the Environmental Quality of the Tagus Estuary, and under the identification of some estuarine areas, such as the Vouga (Ria de Aveiro) and the Mondego Estuary, as areas

with significant potential flood risks. Besides these, no further specific references appear in measures, actions, targets or assessment indicators. The protection of estuaries is also mentioned on the Regional Spatial Development Plans, which transpose the PNPOT at the regional level, and on the River Basin Management Plans. The first establishes major guidelines for spatial development. The second, seek the implementation of the WFD objectives and measures at the level of hydrographic regions. Many of these plans include specific aims and measures to reduce human pressures and climate change risks and to improve the territorial connectivity but they are only binding on public authorities and not on privates. Moreover, the measures of River Basin Management Plans associated with land-use have been losing expression in the most recent plans (Fidélis and Rodrigues, 2019) weakening their influence on municipal master plans. The protection of certain estuaries is also mentioned on nature conservation plans or Natura 2000 management plans when covering parts of estuarine areas. These, however, mainly focus on the protection of natural values and hardly influence land-use activities outside classified areas

Ultimately, then, the municipal master plans end-up assuming a particular relevance for the protection of estuaries as they must translate the aims of upper level spatial and sector plans into the spatial development model and related rules (Carvalho and Fidélis, 2013; Fidélis and Carvalho, 2015). These plans, with a regulatory approach binding both public authorities and privates, materialize the guidelines of

Table 1

Aims and main documents of the Portuguese Municipal Master Plans (Decree-Law No. 80/2015 of 14.05).

Aims	Documents
a) The translation of the territorial development framework established in the national and regional programs;	- Report - explains the objectives of the spatial development model and its rationale, supported by the assessment of environmental, economic, social and cultural conditions
b) The territorial expression of the local development strategy;	- Land-use constraints - identifies existing public utility restrictions, including reserves and protection areas, which may prevent or condition development
c) The articulation of sectoral policies with a local impact;	- Spatial Model - represents the zones of protection and safeguarding of natural resources and values
d) The basis for a programmed management of the municipal territory;	- Environmental report - identifies, describes and assesses any significant effects of the plan on the environment and the alternatives took into account
e) The definition of the ecological structure for environmental protection and enhancement;	- Implementation Program - defines the priority interventions and the provisions to be undertaken by the State and the municipality for the plan implementation
f) The principles and rules for ensuring environmental quality, landscape integrity and the preservation of cultural heritage;	- Regulations - establishes the rules of land-use control and related the indicators
g) The principles and criteria underlying options for the location of infrastructure, equipment, services and functions;	
h) The criteria for the location and distribution of industrial, storage and logistics, tourism, commercial and service activities;	
i) The parameters of land-use;	
j) Parameters of use and enjoyment of public space;	
k) Other relevant indicators for the elaboration of other territorial programs and plans.	

<sup>2</sup> Decree-Law No 99/2019 of 05.09.

higher-level plans and including those from national and regional levels regarding spatial development, water resources and other sectors. They are the critical tool of the Portuguese territorial planning system and play an essential role in the valorization of environmental assets, as they establish the rules of land-use, location and intensity of human activities. They seek to establish land-use control strategies and rules, accommodating expectations of economic development while safeguarding the protection of natural values and resources, such as water. These plans include a set of aims and documents, as mentioned in Table 1.

The regulations' document, highlighted in bold, establishes the rules of the plan that apply to the land-use control of the municipality. This document is the primary tool that directly and immediately binds citizens, companies and public agencies. By establishing rules to implement the spatial development model, and by framing land-use permits, this document is particularly representative of the development model of the plan and most recognized by the local communities. Despite the importance of these plans, there is still limited research on how water resources are incorporated into spatial planning regulations at the local level. Land-use planning regulations are the type of document that this article uses to assess the embeddedness of water in the planning discourse and the potential differences among plans covering areas nearby estuary or away from them.

#### 4. Method and database

##### 4.1. Assumptions and models

Regulatory spatial plans establish rules to assure the implementation of a particular spatial model and related aims. In general, they also seek the protection of environmental values and conditions (Lambin et al., 2014) while prohibiting, constraining or encouraging particular behaviour (Ayres and Braithwaite, 1992; Braithwaite, 2002) over a specific territory. The way they are written reflects the discourse assimilated by the planning authorities and plays a relevant role in communicating their purpose to safeguard environmental values (Sonnett et al., 2006). The narrative adopted by policy documents plays a pertinent role in the adoption of appropriate or innovative practices and may assume particular relevance where different interests and potential conflicting interest and players are at stake. Like other policy documents, regulations are produced by specific policy actors and reflect how they perceive reality and intervene in it (Fischhendler and Kratz 2012). Content analysis is frequently used as a tool to assess the embeddedness of particular themes in policy documents (Sharp and Richardson, 2001) and to understand their institutionalization (Phillips et al., 2004). The stronger the inclusion of particular terms associated with certain concepts or challenges, the greater is the likelihood of their assimilation by target actors, their incorporation in other sector policy documents (Phillips et al., 2004), and the enhancement of decision-making (Runhaar et al., 2013). Moreover, regulatory approaches (Ayres and Braithwaite, 1992) are enriched, as defended by Gunningham (2011) with the concept of responsive regulation, when embodied in different types of constraints, namely prohibitive, conditioning, encouraging, as well as different kinds of activities and practices. Strong incorporation of particular policy terms and their association into different regulatory approaches may compensate specific weaknesses, incentivize stakeholders to adopt preventive and innovative strategies, while challenging users to up-grade strategies, techniques, and practices, and to fostering creative solutions (Nielsen and Parker, 2009; Kolieb, 2015). Supporting rules with indicators may also facilitate the adoption of innovative strategies, such as nature-based solutions (Keesstra et al., 2018).

Having in mind the assumptions mentioned above, and the research questions (section 1), we designed the following analytical tool to assess if the embeddedness of water-related terms in spatial planning regulations on estuarine areas are significantly different from other areas. For comparison purposes upstream areas were used. Fig. 2 resumes the

theoretical assumptions schematically on regulatory approaches and the analytical tool created to assess the embeddedness of water-related terms in plans' regulations.

The tool was implemented through five major steps as follows:

- i) Identification and classification of water-related terms found in the plans' regulations into four significant topics inspired in the works of EEA (2018), IPCC (2018) and Kertész et al. (2019), namely:
  - a) broad terms of water resources ('water', 'water resources', 'water domain', 'hydrological regime', 'hydrofluvial', 'hydrominerals resources' and 'hydrographic network');
  - b) terms related to water bodies ('groundwater', 'aquifer', 'river', 'lagoon', 'waterline' 'riverbed', 'streams', 'water reservoir' and 'dam');
  - c) terms related to water types and uses ('water supply', 'use of water', 'reuse of water', 'sewerage', 'drainage' 'surface runoff', 'wastewater' and 'diffuse pollution');
  - d) terms related to territorial and risk issues ('banks', 'infiltration', 'impervious surface', 'headwater', 'floods', 'drought' and 'scarcity').
- ii) Computing the frequency of the terms found in the regulations using the following equation:

$$\frac{\sum \text{number of times each term is mentioned in the plan}}{\text{total number of words of the plan}} \times 100$$

- iii) Comparing the results in plans located in estuarine locations with plans located in upstream areas within the same river basin.
- iv) Computing the frequency of the terms that appear associated with particular features rules, namely:
  - a) type of rule, i.e., if the terms appear in a prohibitive, required, conditioned, allowed or encouraged rule;
  - b) focus of the rule, i.e., is the terms appear in rules applied to types of activities, types of practices and whether the rules include quantitative indicators
  - c) computing using the following equation:

$$\frac{\sum \text{number of times each term appears associated with a rule with a particular feature}}{\text{total number of words of the plan}} \times 100$$

- v) Comparing the results of plans located in estuarine locations with plans located in upstream areas of the river basin.

##### 4.2. Case studies and database

We then implemented the analytical tool to study the regulations of twelve municipal master plans, half located in the estuarine and half in the upstream areas of two river basins, namely of the Vouga and the Mondego rivers, located in central Portugal. The municipalities are signaled in Fig. 3 with a darker grey shade.

The Vouga River rises in the Serra da Lapa, travels approximately 148 km in the NE-SW direction and flows into the estuarine area known as Ria de Aveiro where other rivers also converge. The Vouga river basin is the third largest basin fully within Portuguese territory and comprises a total area of approximately 3680 km<sup>2</sup>. The primary water uses in the Vouga river basin area mainly associated with the agricultural sector, followed by urban supply and industry (RBMP-HR4, 2011, 2016). The estuarine area covers approximately 80 km<sup>2</sup> and has a lagoon shoreline of more than 150 km (Lopes et al., 2013), constituting a complex wetland and hydrodynamic system (Araújo et al., 2008). The Vouga estuarine area includes environmental protection statutes, namely a Natural Reserve and areas classified as National Ecological Reserve and Natura 2000 (Birds (2009/147/EC, 30.11) and Habitats Directives



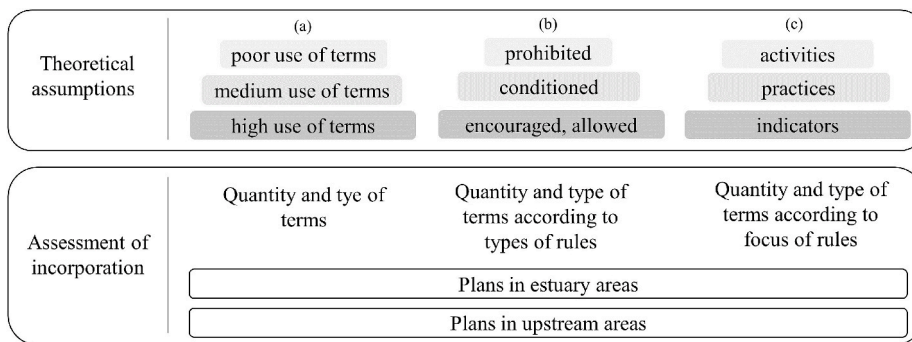


Fig. 2. Analytical tool designed on the (a) institutionalization model of Phillips et al. (2004), the (b) regulatory pyramid of Ayres and Braithwaite (1992) and the responsive regulation from Gunningham (2011).

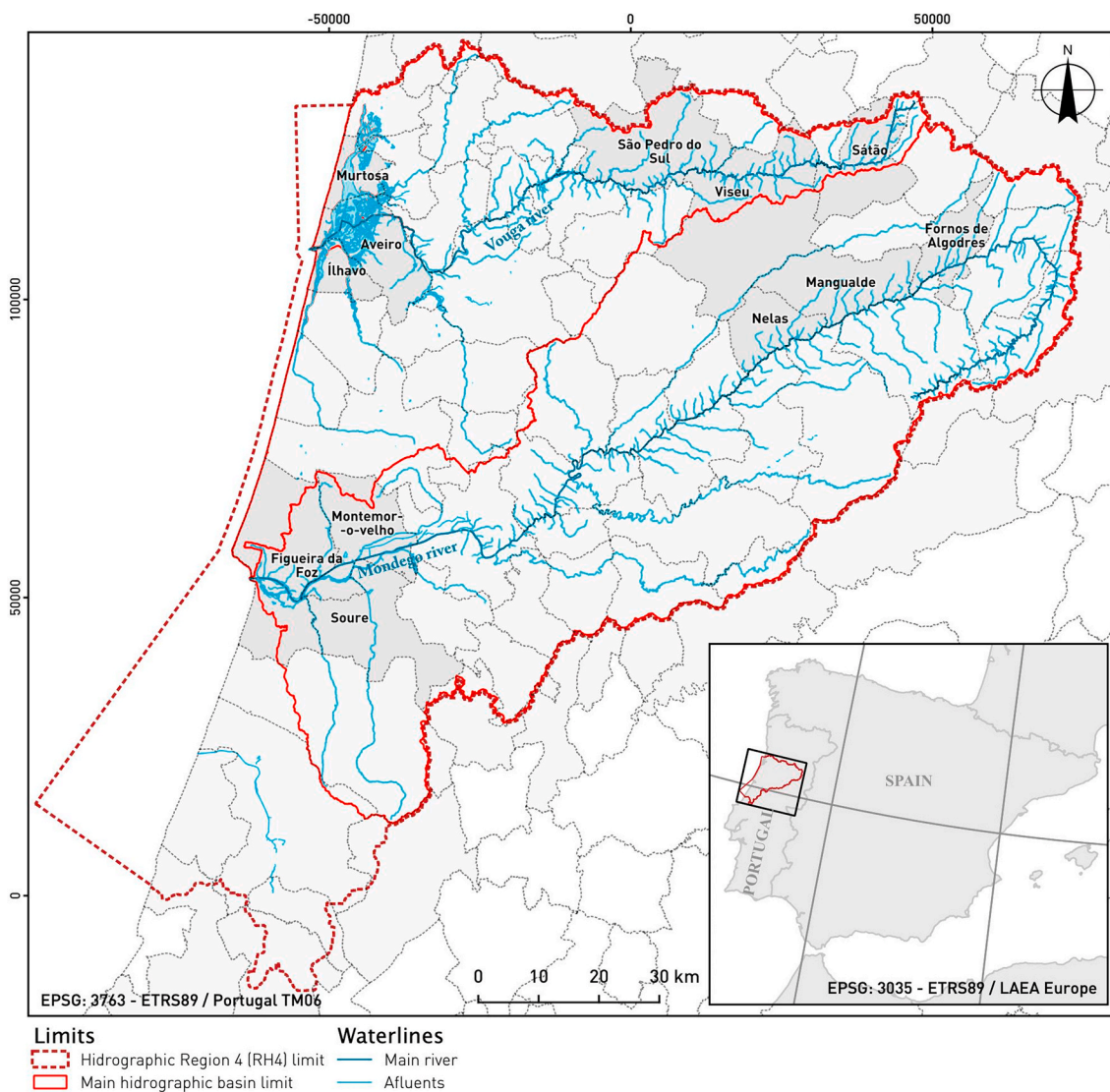


Fig. 3. Basins of Vouga and Mondego Rivers with municipalities covered by the selected plans highlighted in dark grey.

(92/43/EEC, 25.5)). The estuarine area is surrounded by several medium-sized cities with approximately 300 000 in-habitants in total, and with artificialized areas, including urban and industrial, mercantile and fishing harbours, aquaculture, salt-works, agriculture and tourism areas. Despite the increasing environmental regulations and infrastructures, water pollution remains reported due to the input of

effluents from several anthropogenic activities nearby the estuary, alongside diffuse pollution associated with land-use and agricultural activities (Lopes et al., 2017), sewage treatment systems (Rada et al., 2016), and sediment contamination (Stoichev et al., 2019). In opposition, upstream areas of the river basin are broadly less artificialized, less dense, with scattered urban centers, and mainly dominated by forest and

agricultural areas. The water pressures are associated with the urban and agricultural sectors.

The Mondego River rises in the Serra da Estrela, travels approximately 258 km in the NE-SW direction and flows into Figueira da Foz. The Mondego River is the largest river fully within Portuguese territory with a basin covering an area of 6645 km<sup>2</sup> (the second largest basin entirely national). The primary water uses in the Mondego river basin area are mainly to agricultural, urban and industrial sectors (RBMP-HR4, 2011, 2016). The Mondego estuary covers approximately 16 km<sup>2</sup>, and it comprises a northern and southern arm separated by an island called Murraceira (Castro et al., 2016). This estuary also includes areas of the National Ecological Reserve, a RAMSAR site and although not classified as Natura 2000, it has recognized value for birds (Martinho et al., 2007). The estuarine area, especially on the northern margin, is surrounded by an urban area not reaching 90 000 in-habitants in total, followed by agricultural and some industrial activities. The Mondego estuary has been under severe environmental stress with water quality problems (Vasconcelos et al., 2007; Bessa et al., 2018), due to human activities, industries (mostly paper mills), salt-works and aquaculture farms and nutrients discharge from agricultural lands of the low Mondego River valley. The upstream areas are dominated by scattered population, low artificialization, low population density and mostly with farming and forestry activities. The central pressures on the water are associated with the urban and agricultural sectors. Both river basins are covered by the same Hydrographic Management Plan implementing the EU WFD (RBMP-HR4, 2016).

Table 2 shows the database of the total water-related words identified in the plans, the dates of enactment of the plans and two selected indicators of the municipalities, namely population density and proportion of artificial land. These indicators are used as control factors to uncover eventual masking of the findings, i.e., higher levels of water-related terms occurring in areas with higher density, artificialization, or with more recent plans in place.

We undertook the analysis of the water-related terms mentioned in the plans' regulations by using the webQDA<sup>3</sup> quantitative analysis software tool. The municipal master plans regulations used for the research undertaken in this article, are available in the Portuguese Official Journal. The next section deepens the analysis of the water-related terms included in the plans' regulations.

## 5. Findings

This section presents the findings of how water-related terms are incorporated into a set of municipal master plans' regulations. The presentation first focuses on the analysis of the terms mentioned according to four major topics, and second, focuses on the types and focus of rules in which they appear, and third assessing the influence of three indicators on the results. To better clarify the scope of this research, a few examples of water-related terms, types or focus of rules, are presented below:

- 'for the abstraction of **ground** and **surface water**, activities that are liable to pollute groundwater are prohibited within a 200 m radius, either by infiltration or by being able to modify the flows in the abstractions' (Regulation of Fornos de Algodres municipal master plan<sup>4</sup>);
- 'improvement works on urban infrastructures should avoid the degradation and destruction of natural values, and interventions on the **banks and beds of water lines** should ensure the ecological conditions, enhancing **infiltration**, and ensuring the maintenance of the **riparian gallery**.' (Regulation of Viseu municipal master plan<sup>5</sup>)

- 'in the coastal protection zone (...) works to unblock and regulate **water lines** that aim at maintaining, improving or replacing the **natural runoff system** are allowed' (Regulation of Aveiro municipal master plan - version in public consultation)
- 'the installation of units for greenhouses must obey a correct integration in the land and landscape and guarantee the **treatment of effluents and drainage of rainwater**.' (Regulation of Figueira da Foz municipal master plan<sup>6</sup>)
- 'urban subdivision for housing, commerce, services, equipment and tourist developments is allowed, provided that the maximum **waterproofing index** is 0.85.' (Regulation of Ílhavo municipal master plan<sup>7</sup>).

### 5.1. Incorporation of water-related terms by topics

The incorporation of water-related terms in the plans' regulations is represented in Fig. 4. The graphics on the first line refer to the total number of water-related terms found in the documents. The graphics on the subsequent lines refer to the number of water-related terms of each major topic, as mentioned in the description of the analytical steps, in section 4.

The findings reveal relevant differences between the use of terms by the plans' regulations located in the estuarine and in the upstream areas on both rivers, namely:

- Nearly all plans on estuarine locations show higher percentages of water-related terms in comparison with plans on upstream locations;
- The major differences, though, are not explained by the use of broad water resources' terms as they appear quite similar in plans of both locations, as shown in the topic a. of the graphics; - Still, among the two estuarine areas, the plans' regulations of the Vouga river are stronger in mentioning terms related to water bodies, namely river, lagoon and riverbed, and waterline;
- The differences are explained, to a certain extent, by the use of terms related to water bodies (shown in the topic c. of the graphics) and, especially, by the use of terms related to water types and uses (drainage and surface runoff, wastewater and diffuse pollution), as well as, by the use of terms related with territorial and risk issues (banks, impervious surfaces, floods), as shown in the topics c. and d. of the graphics, respectively;
- The use of terms related with water bodies is also higher in plans' regulations located in estuarine areas.

### 5.2. Incorporation of water-related terms by types and focus of rules

The incorporation of water-related terms according to the types and focus of the rules is represented in Fig. 5. Like previously, the graphics on the first line refer to the total number of water-related terms found in the rules. The graphics on the subsequent lines refer each major topic as mentioned in the description of the analytical steps, in section 4. The findings show that the differences of the incorporation of water-related terms according to the types and focus of the rules, between estuarine and upstream locations, are more blurred. Still, a few of main features can be highlighted:

- Broadly, in plans located on estuarine areas, water-related terms tend to be more frequently mentioned in impeditive rules, i.e., prohibitive and required, in comparison to the plans located on upstream area. Moreover, they are mainly associated with rules about activities, followed by practices and then indicators, whereas on the upstream locations the use of these are scarce;

<sup>3</sup> <https://www.webqda.net/>.

<sup>4</sup> Portuguese Official Journal, Notice No 13012/2016 of 24.11.

<sup>5</sup> Portuguese Official Journal, Notice No 12115/2013 of 30.09.

<sup>6</sup> Portuguese Official Journal, Notice No 10633/2017 of 15.09.

<sup>7</sup> Portuguese Official Journal, Notice No 5423/2014 of 29.04.

**Table 2**  
Database of terms of the regulations of Municipal Master Plans considered for analysis.

	Municipality	Date of plan	Total number of words in the plan	Number of water-related words in the plan	Percentage of water-related words per plan (%)	Population <sup>b</sup> (inhabitant)	Population density <sup>b</sup> (inhabitant/km <sup>2</sup> )	Artificialized territories <sup>b</sup> (km <sup>2</sup> )	Artificialized territories/ municipality area (%)
River Vouga	<i>Estuarine area</i>	2014	18559	131	0,71	38552	526,7	18,94	25,78
	Ílhavo								
	Murtosa	2015	14280	73	0,51	10262	140,6	6,43	8,80
	Aveiro <sup>a</sup>	2019	21720	209	0,96	78325	398,5	35,19	17,81
	<i>Average</i>	2016	18186	138	0,73	42380	355,3	20,19	17,46
	<i>Upstream area</i>	2013	13380	75	0,56	11591	57,3	7,63	3,78
	Sátão								
	Viseu	2013	41920	137	0,33	97120	191,8	49,53	9,77
	São Pedro do Sul	2018	4346	21	0,48	15446	44,1	11,47	3,29
River Mondego	<i>Average</i>	2015	19882	78	0,46	41386	97,73	22,88	5,61
	<i>Estuarine area</i>	2017	26363	253	0,96	58807	155	41,87	11,05
	Figueira da Foz								
	Montemor-o-Velho	2017	28886	179	0,62	25227	110,2	20,9	9,13
	Source	2018	8480	79	0,93	17199	64,6	15,39	5,81
	<i>Average</i>	2017	21243	170	0,84	33744	109,93	26,05	8,66
	<i>Upstream area</i>	2016	9304	53	0,57	4545	34,4	4,10	3,12
	Fornos de Algodres								
	Mangualde	2013	18439	93	0,50	18564	84,4	13,54	6,18
	Nelas	2014	17111	59	0,34	13002	103,2	9,40	7,48
<i>Average</i>	2014	14951	68	0,47	12037	74,0	9,01	5,59	

<sup>a</sup> version in public consultation.

<sup>b</sup> available at [https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine\\_unid\\_territorial&menuBOUI=13707095&contexto=ut&selTab=tab3](https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_unid_territorial&menuBOUI=13707095&contexto=ut&selTab=tab3) obtained through INE (National Institute of Statistics). The population data is of 2019 and the artificial territories of 2018

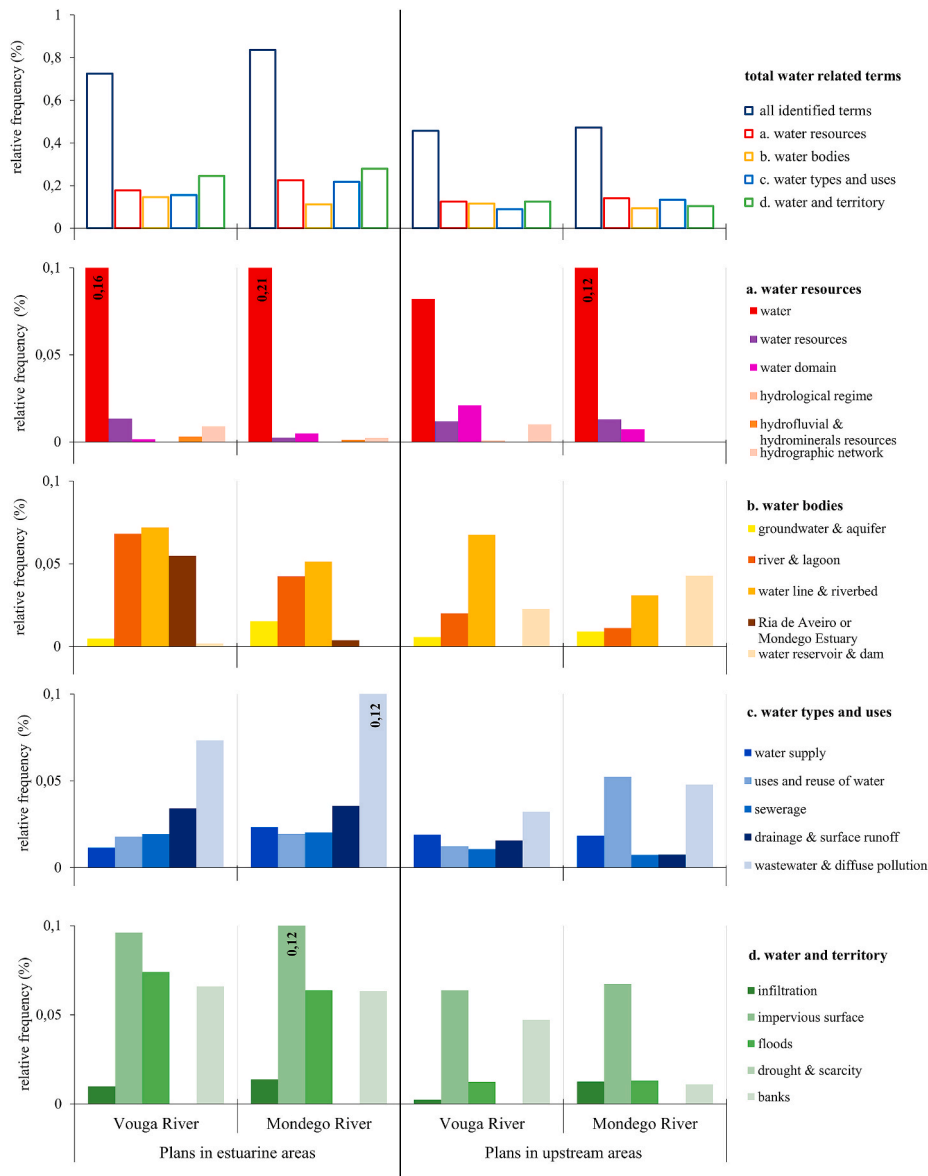


Fig. 4. Incorporation of water-related terms in plans' regulations in estuarine and upstream locations.

- Once more, it is the use of terms related with the topics water types and uses and territorial and risks issues, that explain these major differences between estuarine and upstream locations;
- Parallely to the higher incorporation of water-related terms in plans' regulations located in estuarine areas, it is also noticeable a greater diversity of types and types of focus of the rules, especially on topics on territorial risk issues, whereas on upstream areas the regulatory approaches appear poorer;
- A higher prominence of terms in rules focused on indicators found in estuarine locations, is mainly explained by the contribution of territorial and risk' related issues;
- The incorporation of terms in plans located in estuarine area of Mondego river is higher in most types and focus of rules by most of the topics.

5.3. Influence of three indicators

As mentioned in section 4, the territorial differences between estuarine and upstream areas are marked in both estuaries of Vouga and Mondego, by high population density and proportion of artificial

territories. Moreover, the plans' regulations have not been enacted on the same dates. Fig. 6 reminds three indicators of Table 2 presented in section 4, namely population density, the proportion of artificialized territories and dates of enactment of the plans, and then, co-relates them with the percentage of water-related words of each plan' regulation. The density or the artificialization of municipalities does not explain the variations of incorporation of water-related terms in plan' regulations. The date of enactment of the plan, however, though not explicatory, does influence the results. Yet, even in most recent plans, a difference between the incorporation of water-related terms in estuarine areas remains visible in comparison with upstream areas.

6. Discussion

Globally, the results showed greater incorporation of water-related terms in plans' regulations located in estuarine areas. The findings showed consistent differences in the incorporation of water-related terms in plans located in estuarine areas compared to upstream areas. Parallely to the higher incorporation of water-related terms in plans' regulations located in estuarine areas, it is also noticeable a greater



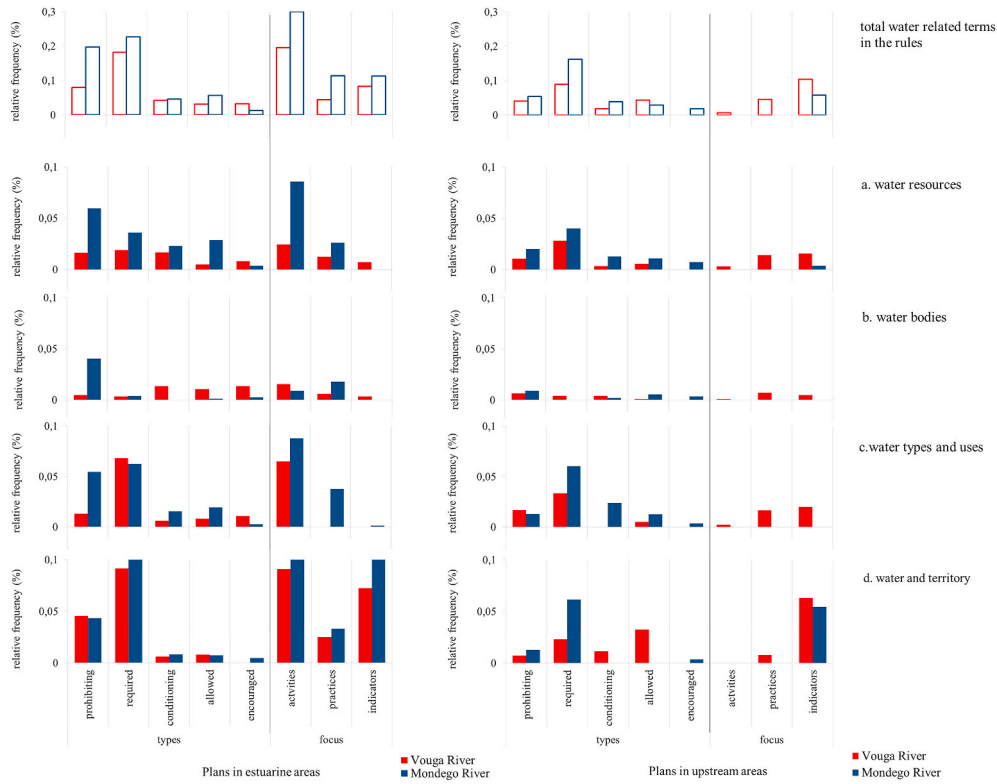


Fig. 5. Incorporation of water-related terms in plans' regulations in estuarine and upstream locations according to the type and focus of rules.

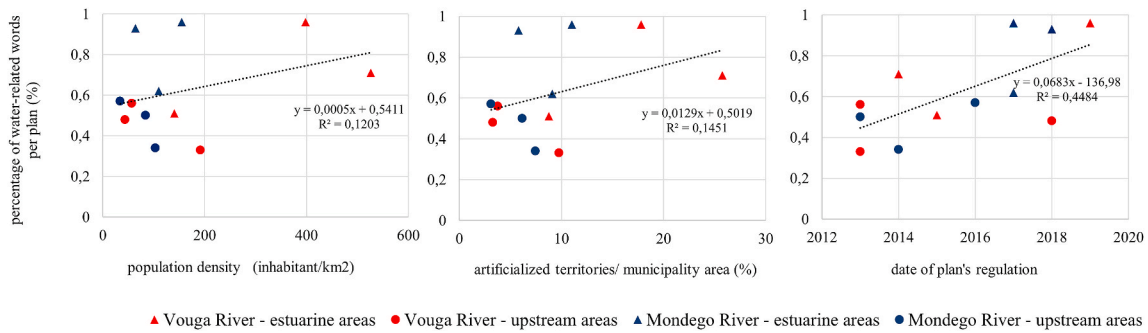


Fig. 6. Relationship between the use of water-related terms with population density, percentage of artificial territories and date of plans enactment.

diversity of types and types of focus of the rules, especially on topics on territorial risk issues. In contrast, on upstream areas the regulatory approaches appear more deficient. Finally, the data analysis showed that the incorporation of water-related terms is more influenced by the date of the plans then by the artificialization of the territory or the density of population. Still, even among the most recent plans, it remains visible a difference between the incorporation of water-related terms in estuarine areas in comparison with upstream areas. Although the two river basins are not significantly different and are covered by the same hydrographic region management plan, as described in section 4, the regulations of Mondego river, show more significant differences of the incorporation of water-related terms between the estuarine and upstream areas if compared with the plans for the Vouga river. These results are discussed in the next paragraphs having into consideration the methodology and database used, the Portuguese landscape of estuary protection and, finally, the literature background.

### 6.1. About the methodology

This exploratory study was based on a simple and straightforward methodology, supported by detailed assumptions and calculus. The analysis used a small number of plans' regulations (twelve plans of two river basins, six plans in each). For this, some limitations must be taken into consideration for sifting extrapolations and conclusions. Also, it only looked at the narratives of rules, not including a spatial analysis to assess whether the regulations incorporating water-related values are related to specific estuarine or upstream areas and associated vulnerabilities. Moreover, it did not analyse the articulation between the rules of nearby plans with regards to estuarine or upstream areas. Despite these limitations, the methodology showed potential to assess the concern of municipal spatial planning about water issues, and ultimately, to evaluate the sensitivities of land regulations to different water-territory nexus specificities such those associated with the estuarine or upstream areas, and the adopted regulatory practices. Its application on a broader scale, including more plans and more river basins could further boost the value of the results. The methodology can

also be useful during the planning process as a self-assessment tool, by looking at the narratives adopted and their ability to engage different stakeholder in the water protection, the types of regulatory approaches assumed by the land-use regulations, and the way their narratives corroborate with other public policies and water governance tools. Furthermore, the methodology is easily expandable to take into consideration different land-uses or to be applied to different regions, to further refine if the distinctive features are explicitly related with estuarine areas or with other types of water problems.

### 6.2. About the Portuguese landscape of estuary protection

As the higher incorporation of water-related words in estuarine areas is not explained neither by the levels artificialization nor by human density, it remains open the probability of a stronger sensitiveness of spatial planning regarding water concerns in these areas. Despite the lack of concrete guidelines from upper-level plans on the integration of estuary concerns in municipal spatial planning, the lack of dedicated plans for estuary protection (Fidélis and Roebeling, 2014; Fidélis and Carvalho, 2015), as mentioned in section 3, and the fragile guidance of river basin management plans over municipal master plans (Fidélis and Rodrigues, 2019), the results of this research, suggest an increasing sensitiveness of municipal spatial planning regarding water-related issues on locations over, or nearby, estuaries, in comparison to upstream places. Guidelines from upper-level plans remain relevant to assure the articulation of strategies and rules around estuarine areas among different municipalities. Furthermore, although the research was focused on the sensitiveness of spatial planning on estuarine locations, the results also brought to the fore fragile incorporation of water-related terms, and a more impoverished diversity of rules in upstream areas. This finding can be critical as these locations have specificities linked to headwater streams, with potential impacts over the function of entire river basin, including estuaries. Although issues related to scarcity and floods are being dealt by an increasing number of climate change plans at the local level, they need to be incorporated into the municipal master plans' regulations because it is these that translate them into land-use rules.

### 6.3. About the literature

The literature stresses major types and intensity of land-uses nearby estuaries likely to cause significant disturbances to estuarine water resources (Elliott and Whitfield, 2011; Riley et al., 2018; Paerl, 2018; Panton et al., 2020). The analysis of the plans' regulations, mainly focused on public land, and urban and industrial areas, showed that rules included references to the protection of bodies of surface water (river, lagoon, riverbed) echoing the work of Rocha et al. (2015) and Lopes et al. (2017). The results reflect some of the concerns found in the literature, mainly associated with surface runoff, wastewater treatment and diffuse pollution (Lopes et al., 2017), impervious surfaces, floods and reference to the banks (Panton et al., 2020). Still, there are concerns associated with water utilities and potential effects of climate change that hardly appear in the narrative of the rules (Paerl, 2018; IPCC, 2018). In addition to these, other recommendations emerging from the literature are weakly reflected, or absent, in water-related rules, namely those associated with groundwater (water bodies), water supply and water reuse, sewerage (Paerl, 2018), infiltration, relevant for aquifer recharging, and water scarcity (Robins et al., 2016; Vargas et al., 2017). The results suggest that there is room to reinforce the narrative of the rules with regards to water concerns. Such reinforcement may increase the understanding of the land-use/water nexus and facilitate the engagement of different land users towards water protection through land-use types, intensities or styles (Runhaar et al., 2013; Serrao-Neumann et al., 2017; Riley et al., 2018). Concerning the incorporation of water-related terms according to the types and focus of the rules, the results show that terms are more often associated with impeditive rules

and activity-oriented rules, contrary to what is recommended by the literature (Ayles and Braithwaite, 1992; Gunningham, 2011). The reduced mixing of regulatory approaches, with little encouraging rules in place and involving practices is likely to aggravate conflicts and hinder innovative and flexible land-use strategies to safeguard water (Kolieb, 2015). The study developed focused primarily on estuary literature but reading contributions from other areas of knowledge (Jacobs et al., 2016) may be useful to further research and develop the design of water-related land-use rules nearby estuaries. The method used has produced valuable results not only for assessing regulatory practices and the sensitivity of spatial planning at the municipal level to water issues in estuarine areas but also for encouraging research into approaches to water protection through the land-use rules adopted by municipal plans.

## 7. Conclusions

This article studies the incorporation of water-related terms in the regulations of municipal master plans to assess whether land-use rules established on estuarine areas are significantly different from others, such as in upstream areas. It did so by developing a content analysis of a set of plans' regulations located in two river basins of Central Portugal. The results showed greater incorporation of water-related terms in plan' regulations located in estuarine areas. Parallely, it is also noticeable a greater diversity of types and types of focus of the rules, especially on topics on territorial risk issues, whereas on upstream areas the regulatory approaches appear more deficient. Although the incorporation of water-related terms is globally higher in younger plans, and to a certain extent, in more artificialized and dense territories, a clear distinctiveness of water-related concerns in land-use regulations of municipal plans on estuarine areas remains visible. Surprisingly, the results bring to the fore fragilities of land-use regulations on upstream areas worthy of attention in future studies.

Further research is necessary, though, to explain if they are specifically related with estuarine or with other types of water problems, such as the level of flood risk or the existence of protected areas. Nevertheless, the results bring to the fore fragilities of land-use regulations on upstream areas worthy of attention in future studies. Despite the upsurge in many countries of estuary plans capable of covering the wider boundaries of estuarine areas, municipal master plans should reflect particular sensitiveness to related territorial environmental values. The land-use control rules around the estuaries should be capable of reflecting the environmental values likely to be affected by particular land-use types and intensities while contributing to reducing potential conflicts. The literature on estuaries has widely stressed the need to control the impacts of land-use control, but little attention has been given to study of the way real plans are establishing rules for such requirement. By looking at the integration of water concerns into municipal master plans around estuaries, this article offered a singular methodology with the potential to develop comparative studies and to enrich the research topic further. The methodology used for content analysis disclosed a valuable path for future research as it is easily expandable to take into consideration different land-uses or to be applied to different regions, to further refine if the distinctive features of land use rules are explicitly related with estuarine areas or with other types of water problems.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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