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How ready are we to cope with climate change? Extent of adaptation to sea level rise and coastal risks in local planning documents of southern France

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ABSTRACT

Sea-level rise and related risks are an aspect of climate change that deeply affects coastal areas worldwide and calls for adaptive responses. Spatial planning is one key to adaptation, in particular at local level, where coastal risks might be experienced and solutions need to be developed. However, local spatial planning is a complex process involving various governance levels and decision-makers in specific social, cultural, economic and geographical contexts. Focusing on Provence-Alpes-Côte d'Azur region in southern France, this article proposes an analysis of the extent to which coastal risks are taken into account in the town planning documents of 65 coastal municipalities. The objective is to assess how seriously sea-level rise, coastal risks and adaptation are addressed in spatial planning. Results show that there is still a long way to go. Local development strategies often run counter to the idea of adapting, while local authorities and central government need to take a more collaborative approach. This work also shows the relevance of using spatial planning documents to reveal territories' attitudes to adaptive policies, and the crucial role played by interaction between decisional levels.

1. Introduction

Climate change and the resulting environmental risks have a particular resonance for coastal territories (Hoegh-Guldberg et al., 2018). Ocean and sea coasts, where a significant part of the world's population live, are directly exposed to sea-level rise and more frequent storm surges (Chaumillon et al., 2017; Neumann et al., 2015; Small and Nicholls, 2003; Nicholls, 1995). Governments and local public authorities are thus faced with the challenge of developing adaptation strategies that combine anticipating coastline morphodynamics, maintaining populations and activities, avoiding damage to properties and people in the event of a disaster and, finally, gradually reorganising coastal settlements (Nicholls, 2011).

At different design and implementation scales, spatial and urban planning are fundamental to the adaptation process (Birchall, 2020; Rocle et al., 2020; Losada et al., 2019; López-Dóriga et al., 2020; Reiblich et al., 2019; Flannery et al., 2015). However, this is a highly sensitive issue due to the need to achieve the right balance between maintaining economic and social development and ensuring the proper ecological status of fragile environments in areas subject to strong demographic, economic, tourist and urban pressures (Robert et al., 2019;

Falco, 2017; Prévost and Robert, 2016; Pons and Rullan, 2014; Romano and Zullo, 2014; Gangai and Ramachandran, 2010; Crawford, 2007). Planning adaptive land use requires a thorough knowledge of natural hazards, territorial vulnerability, risks and disasters. Several studies on coastal morphodynamics and their potential short- and medium-term evolution explicitly aim to support spatial planning and territorial risk management (Breili et al., 2020; Sekovski et al., 2020; Martínez-Graña et al., 2018; Chaumillon et al., 2017; Le Roy et al., 2016; Haigh et al., 2014; Maspataud et al., 2013; Debaine and Robin, 2012; Raji et al., 2011). Research has also attempted to objectify the human stakes involved in sea-level rise scenarios, modification of the coastline, or increase in areas subject to flooding (Gargiulo et al., 2020; Gil-Guirado et al., 2019; Mavromatidi et al., 2018; Song et al., 2016; Muis et al., 2015).

However, despite the growing body of knowledge concerning hazards and possible scenarios, questions remain about how it feeds into public policies. Several international studies show that coastal risks are not, or only poorly, taken into account in the spatial planning of coastal territories: for instance in the United States (Birchall, 2020; Berke et al., 2018; Berke et al., 2015), in India (Dhiman et al., 2019a; Dhiman et al., 2019b), in Indonesia (Suroso and Firman, 2018; Muis et al., 2015), in

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Ireland (Flannery et al., 2015). In their review of multidisciplinary scientific work concerning the risk of storm surge, Chaumillon et al. (2017) conclude that most of the academic knowledge remains largely ignored in policy decisions and planning.

To assess whether this lack of transfer of knowledge to public policies also applies in France, our study addressed three questions. How is coastal risk prevention designed and implemented in urban planning? To what extent does spatial planning consider hazard data and assessment of territorial vulnerability on the coast? Are coastal risks a shared issue among public authorities, as suggested by the integrated management and sustainable development concepts? Taking the example of Provence-Alpes-Côte d'Azur, one of the three Mediterranean administrative regions of France, the objective of this article is to assess the extent to which coastal risk is addressed in town planning policies. Indeed, although climate change is a global issue, adaptation to climate change and sea-level rise is critical at the local scale, because it is locally that problems arise and that solutions must be found. Being locally designed and implemented, French local planning documents are appropriate sources of information on the local way of thinking about spatial planning, environmental management and, consequently, climate change and how to adapt to it. To ensure coverage of the full range of potential situations, our comparative study includes all the 65 coastal communes of the region. Town planning documents are analysed and compared to each other and to the French risk prevention and spatial planning framework. The study seeks to characterise practices in relation to the adaptation principles recommended by the French State and international institutions. It also explores non-mainstream cases, looking for factors that may be suggested by unexpected local attitudes to coastal risk.

2. Spatial planning and risk prevention in French coastal areas: the situation

2.1. Responsibility shared among different institutions

In France, following the first decentralisation laws of the 1980s and subsequent reforms, several areas of public policy are now in the hands of local authorities, including spatial and town planning. While conforming to laws and to framework documents drawn up by the French State, spatial planning strategies, development plans and local town planning regulations are produced by local executive bodies who, accordingly, have the power to grant or refuse requests for building permits (Prévoist and Robert, 2016). At the regional and municipal levels, planning documents are concerted political tools, the preparation and final approval of which are the responsibility of local elected representatives. They deliver both a clear description of projected local development and the detailed planning rules governing its implementation. In this context, the State's role is relatively secondary. It mainly consists in checking whether town planning documents produced by local authorities comply with the regulations under current law.

However, regarding the prevention of natural risks, the State remains a major player, public security being one of its sovereign missions. Accordingly, government services (like the Ministry of Ecology, "Ministère de la transition écologique" and its headquarters at regional level, DREAL; research institutes supporting public policies, like BRGM and CEREMA; etc.) have long produced the data and recommendations behind many public policies on planning and risk prevention/management. For example, the "knowledge dissemination" procedure (PAC, "Porter à connaissance") allows the State to communicate to local authorities the factual data that must be considered so as best to incorporate natural risks into urban planning, and to remind them of the appropriate regulatory framework. The State is also empowered to prescribe plans for the prevention of foreseeable natural risks (PPR, "Plan de prévention des risques"), instituted in 1995 to replace previous plans in operation since 1982 (Tifine, 2013). With the aim of preventing

risks at the local level, the PPR provides a spatial delimitation of risks and regulates building rights in exposed areas, laying down regulations that govern the planning documents produced by local authorities (the PPR is a public utility easement). In other words, town planning documents must incorporate the provisions contained in a PPR.

2.2. A national context strongly influenced by storm Xynthia

For the past decade, the central role played by the French State in preventing natural risks has been openly debated, principally due to several disasters that have highlighted the poor articulation of public policies on town planning and risk prevention. A pivotal event was the storm Xynthia, which hit the French Atlantic coast on February 28, 2010, causing coastal flooding and the death of nearly 50 people (Chauveau et al., 2011; Vinet et al., 2011; Kolen et al., 2013). It revealed a contradiction between local, concerted town planning management and the technocratic and centralised approaches to risk management (Mercier and Chadenas, 2012). The storm and its economic and social consequences revealed that the continuing central government prerogatives around natural risks are less and less acceptable to local elected officials, who today bear almost full responsibility politically, financially and criminally for the public policies implemented within their territories (Perherin et al., 2017; Goetz, 2016; Decrop, 2014).

As a consequence, the 2010s saw an increasing number of initiatives and reforms aimed at involving both local stakeholders and central government services in better prevention and management of natural risks, in particular flood risk. In 2010 and 2011, the European directive on flood risk management (2007) was transposed into French law, resulting in a National Flood Risk Management Strategy aimed at ensuring consistent country-wide policies (2014). It also led to flood prevention action programs (PAPI) driven by local authorities and contracted with the State to implement integrated risk management (Cabal et al., 2016; Guillier, 2016). Then, new decentralisation laws in 2014 and 2015 assigned the management of aquatic environments and flood prevention (GEMAPI) to local authorities. They are now empowered to create, manage and maintain protective works, develop watersheds and, accordingly, incorporate flood risk, including coastal flooding, in town planning documents. In force since January 2018, and mandatory since January 2020, GEMAPI is managed by intermunicipal public authorities. Moreover, immediately after Xynthia, a ministerial circular dated 27 July, 2011 specified a method for taking into account coastal flooding in flood-oriented PPR in coastal communes, and a National Strategy for Integrated Coastline Management (SNGITC) was initiated in 2012 (Rulleau and Rey-Valette, 2017). In short, the highly centralised French model of prevention and management of natural risks has undergone serious changes since 2010.

2.3. Political will to start adapting coastal territories to climate change and related risks

During the 2010s, the French authorities also did some thinking around adaptation to climate change through initiatives developed at a local level. In coastal areas, the SNGITC constitutes the reference framework. Its aim is to change the approach to coastal development, share knowledge on current social and environmental dynamics and define strategies for sustainable development. Adaptation to climate change and natural risks is actually based on the principle of liveability, part of the sustainable development concept. The first action program (2012–2015) made it possible to consolidate knowledge of flooding and erosion hazards within French territory, and to develop urban planning practices integrating coastline management. It also provided for experiments and reflection in three areas: ecological engineering to combat coastal erosion; relocating activities and properties to spatially reorganise territories; incorporating risk into spatial planning at inter-municipal level (Rocle and Salles, 2018). This program involved many different stakeholders, such as communities, government services,

researchers, planning professionals, nature protection bodies, etc. (Fouquieray et al., 2018; Guéguen and Renard, 2017). It was followed by another (2016–2019) which further promoted a global approach to integrated coastal management, taking an ecological transition perspective (MTES, 2019). In 2016, this work led to a bill targeting coastal area adaptation to climate change. Adopted by the National Assembly in January 2017, the bill proposed to meet "the need to preserve spaces and secure populations, while organising the conditions for maintaining the dynamics and sustainable development of our coasts" (Assemblée Nationale, 2017) and showed a clear will to modify coastal management. However, it has not yet completed its legislative process, and may never be finalised. With the election of President Macron and the June 2017 change of majority in the National Assembly, current French policy shows a weaker commitment towards climate change adaptation. While there has clearly been progress in coastal natural risk prevention and in the attention paid to adapting coastal areas to climate change during the last decade, some resistance persists.

3. Research design and methodology

3.1. Study area

Provence-Alpes-Côte d'Azur (PACA) region is famous worldwide for the beauty of its coast and its seaside towns (Nice, Cannes, Saint-Tropez), as well as for its sizeable ports (Marseille, Toulon). An international tourism centre, it features strong real estate activity reflected by intense urbanisation and widespread urban sprawl (Fig. 1). In 2015, its 65 coastal communes had more than 2.5 million inhabitants, i.e., a density of 733 inhabitants/km², 2.5 times more than French coastal

communes and 6.2 times more than the general French population density (INSEE, 2018). The coastal zone contains key infrastructures: three major airports (Marseille, Nice and Toulon); the number one port in France for all traffic, and number five in the Mediterranean for cruising (Marseille); the arsenal and military port of Toulon; the main oil industry cluster in France (Gulf of Fos-sur-Mer); major "waterfront" resorts totalling several thousand dwellings; etc. This concentration of population, facilities and jobs gives the coast a major role in the regional territory, which may be a barrier to initiating public policies that target adaptation to sea level rise and coastal risks.

With several mountain ranges literally facing the sea, the coastal zone offers few low-lying areas, with the notable exception of the Camargue and the gulf of Fos-sur-Mer, to the West. The coast is particularly indented, with deep gulfs, sandy spurs penetrating into the sea, capes, islands (near Hyères) and a very large inland lagoon (Etang de Berre). Interestingly, the region has not been hit by spectacular marine flooding or major erosive phenomena, unlike other French coasts (Chauveau et al., 2011; Mercier and Chadenas, 2012; Le Cozannet et al., 2013; Mallet et al., 2014; Rey-Valette et al., 2012). However, floods and severe storm surges combined with intense rains regularly do damage, endanger buildings, produce transport paralysis and cause human casualties (Chalvet and Claeys, 2011; Vinet et al., 2011). Most of the region's low coasts are eroding and almost everywhere, hard rock cliffs are weakened and beaches regress (Brunel and Sabatier, 2007; Cohen and Anthony, 2007). In response, protective structures are installed and beach nourishment is regularly practised in seaside towns (Lambert et al., 2007).

One key characteristic of the Provence-Alpes-Côte d'Azur coastal zone is that it has been strongly transformed by coastal development

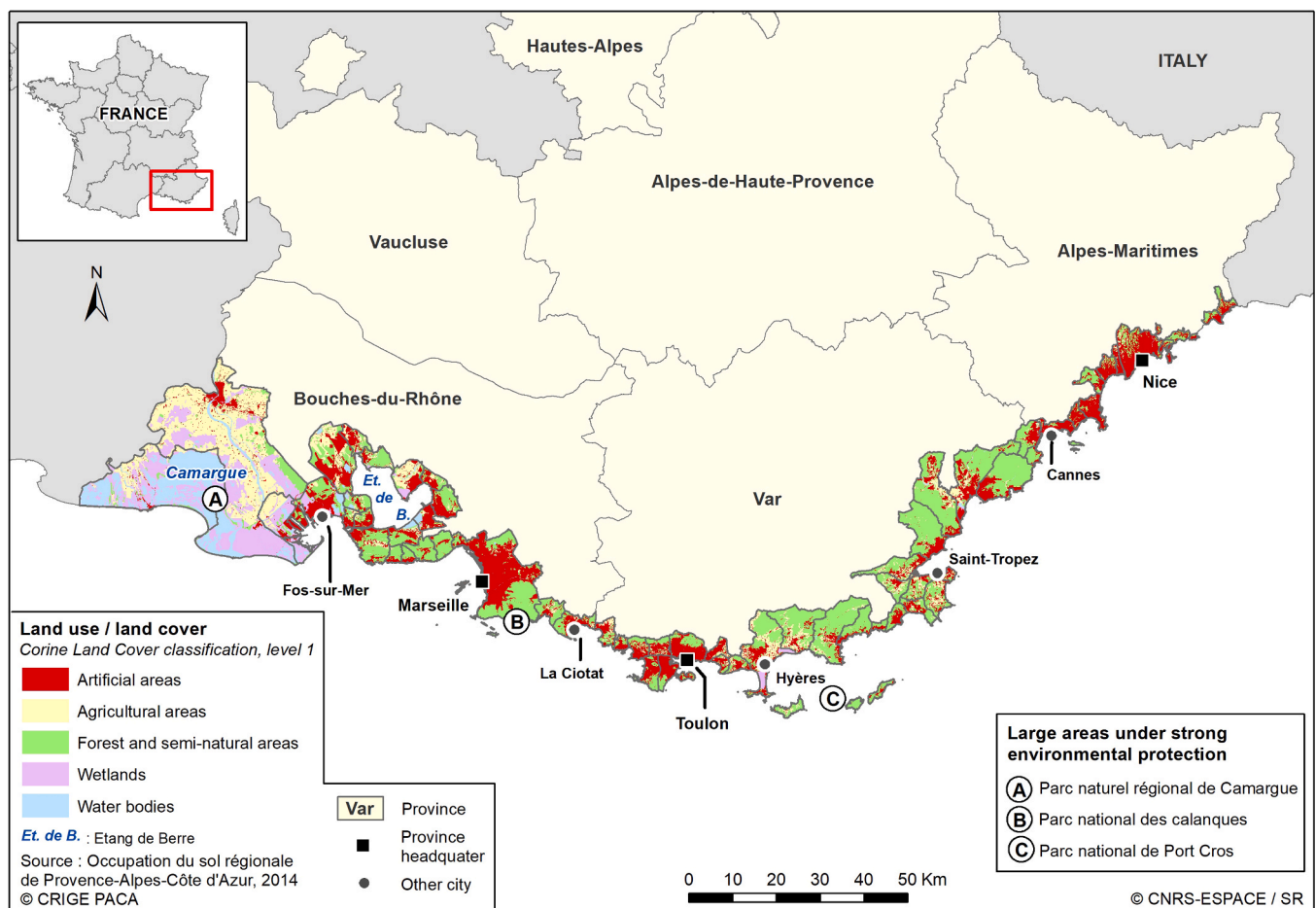


Fig. 1. Land use and land cover in Provence-Alpes-Côte d'Azur coastal communes.

encroaching on the coastline itself. Many examples can be found: land reclaimed from the sea and marshes to develop industrial, commercial and military port facilities (Marseille, Fos-sur-Mer, Toulon, La Ciotat, and La Seyne-sur-Mer near Toulon), as well as yachting harbours (in almost every town) and residential condominiums (Marina Baie des Anges in Villeneuve-Loubet, Port-Grimaud and Marines de Cogolin, in the Gulf of Saint-Tropez); seaside promenades partly or entirely built over beaches (Promenade des Anglais in Nice, Croisette in Cannes); artificial beaches (the Prado beaches in Marseille, and in many other communes); dykes, groynes and breakwaters to protect beaches and the coast (almost everywhere). Even Nice and Marseille airports are partially built over the sea. Except where the coastal zone is unsuitable for development due to its topography or to geographically extensive environmental protection measures (Calanques national park, Port-Cros national park, Camargue natural regional park), dense residential areas are often located very close to the sea. Obviously, climate change and related risks currently challenge these coastal uses and development. It is therefore relevant to investigate how they are treated in local spatial planning documents.

3.2. Data collection

The data collected for the analysis are the coastal communes' town planning documents. For a given territory, these documents detail the political, social and economic priorities orienting future development, and the regulations ensuring their respect within the specific geographical context. By law, town planning documents must consider natural risks in order to increase local territorial resilience. In addition, other regulatory documents related to different levels of the French political and administrative system were collected (Fig. 2):

- the Regional Scheme for Territorial Planning, Sustainable Development and Equality (SRADDET), based on the 2015 law on the New Territorial Organisation of the Republic (known as the NOTRe Law);
- the Inter-municipal Urban Plan (SCOT), based on the Solidarity and Urban Renewal Law (SRU) of 2000;
- the Local Urban Plan (PLU), and its recent variant the PLUi (local inter-municipal urban plan), also based on the SRU law.

From regional to local levels, these documents must be compatible (each level must be consistent with the higher level) and their provisions become increasingly detailed, both spatially and in terms of regulation.

Incorporating all the spatial planning provisions, PLU thus appeared the most relevant document to analyse. However, to explore the rationale behind local spatial planning, and its coherence, SCOT and SRADDET were also consulted, as well as PPR produced by the State.

In total, several dozen regulatory documents were collected and 120 analysed (1 SRADDET, 7 SCOT, 56 PLU, 2 PLUi, 54 PPR). Regarding the PLU, a document regularly modified and revised as authorised by law, several were not yet approved at the study reference date (July 2019). Indeed, technical, political, or even legal difficulties can be encountered when designing a PLU, which can lead to its being approved long after the final step in the process (subject to adjustments), and sometimes to its cancellation. Where some parts of these documents in the making were available, they were consulted but not included in the analysis, because our focus was on regulatory documents currently in force, listed in [Appendix A](#).

3.3. Content analysis, database building, and statistical and cartographic processing

Town planning documents were analysed to extract factual data on the 65 communes in terms of urban planning and risk management related to the sea. First, communes were divided into two categories: those without a PLU (9) and those with a PLU (56). For the latter, data were extracted following a stratified protocol consisting in successively analysing the different sub-documents composing a PLU: PADD, Presentation report, Written rules, and Graphic rules (Fig. 3).

First, the PADD (Planning and Sustainable Development Project) was analysed (manual reading and computer-assisted text search) for any mention of risks linked to the sea, and the risks were listed (coastal flooding, marine erosion, beach erosion, coastal erosion, storm surge, etc.) under three categories: coastal flooding, erosion, coastal flooding and erosion (Fig. 3A). A PADD is a synthetic description of the territory and its social, economic, cultural and environmental trajectory, and the local political project of the municipality for a sustainable development. The fact that coastal risks are mentioned demonstrates the local authorities' awareness of specific environmental dynamics likely to influence planning and development directions in the future.

Second, we analysed the RP, the presentation report (Fig. 3B). This sub-document describes the territory in detail, based on existing or specifically commissioned studies (environment, economy, housing, demography, etc.) and factors brought to the attention of the municipality by government services. It highlights the special features and

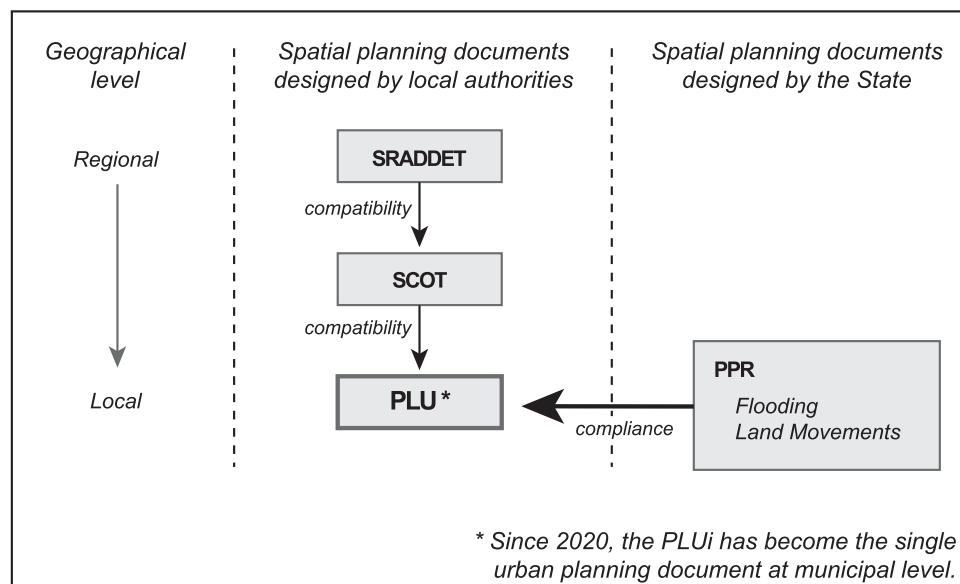


Fig. 2. Spatial planning documents collected and studied.

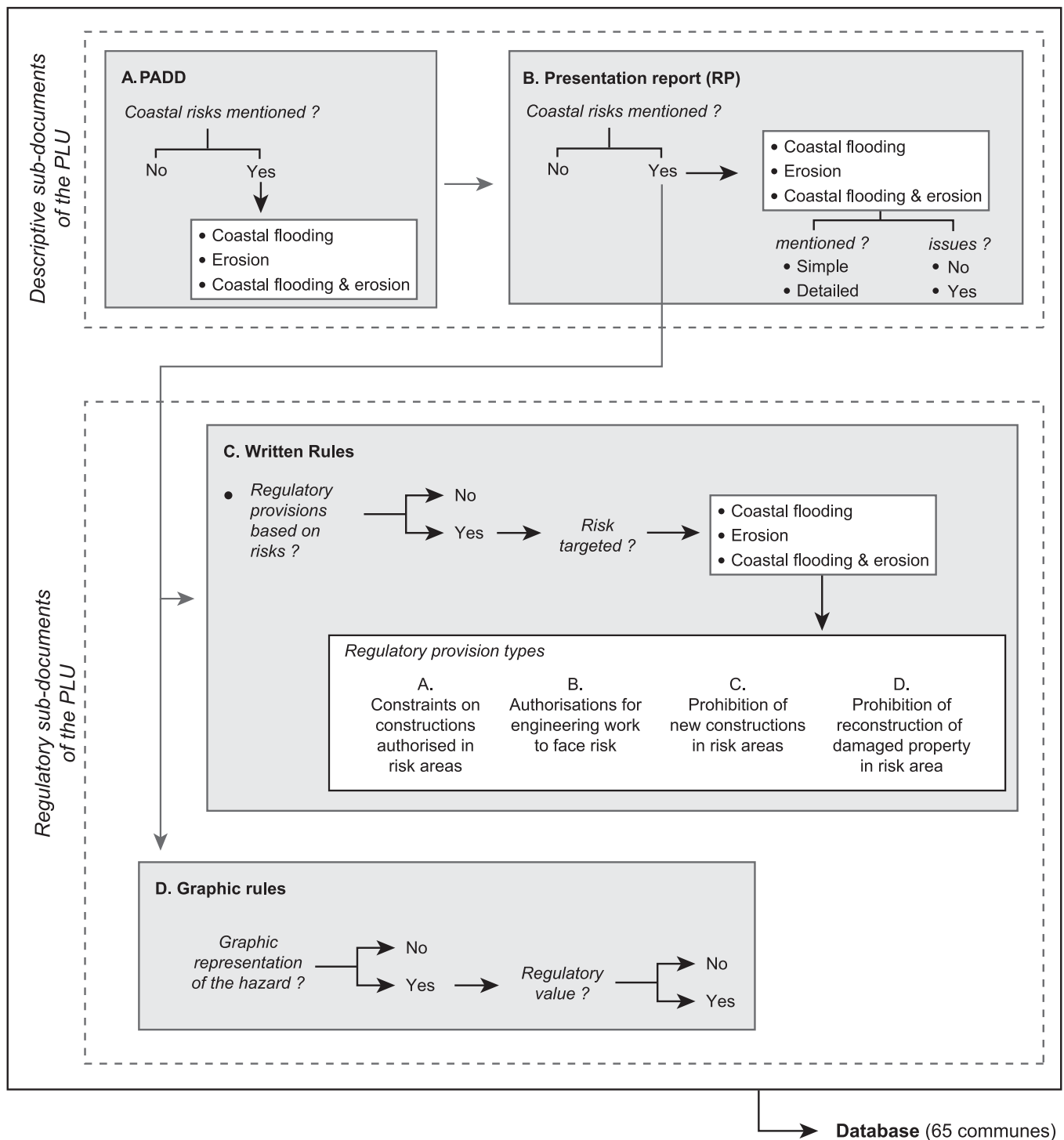


Fig. 3. Analytical workflow for PLU.

challenges of the territory, and explains the reasons for the development guidelines and regulatory provisions included in the town planning rules (described in the other sub-documents of the PLU). Coastal risks are then mentioned in more or less detail, depending on existing knowledge, and there may be a description of the issues involved for the territory. We extracted and categorised data related to the description of coastal risks in three groups: no mention, simple mention (risk mentioned but not detailed or mapped), detailed description (map, figures, etc.).

The two other sub-documents composing the PLU are the written and the graphic rules. They form the local legal reference in terms of building rights and are therefore enforceable against third parties. These two

complementary PLU components set out uses and constructability rights (written rules) and represent these rights in space by means of zoning on maps (graphic rules). They were analysed in two stages (Fig. 3C and D). We studied the written rules to determine whether the existence of risks (as described in RP) gave rise to regulatory provisions and, if so, we divided these provisions into four categories. We then examined the graphic rules and described the graphic representation of the hazards, distinguishing between graphic representations with regulatory value and those with a simply informative function.

Facts and figures extracted from the PLU were stored in a data table (Appendix B) organised so as to document the consideration of risks in

urban planning. Since our methodological references come from quantitative geography, we coded and stored the data in such a way as to facilitate statistical treatments and thematic mapping. Connected to a geographic database with a GIS (ArcGis), our data set was enriched by measurements of the coastline of each commune. Then descriptive statistics were computed to determine the extent to which coastal risks are considered in urban planning (how many municipalities mention these risks? how many have taken regulatory measures? what types? which part of the region's coastline is concerned? etc.), and communes were categorised accordingly. They were also mapped to reveal possible local effects (e.g., highlighting geographic areas where risks seem to be ignored versus areas where risks are taken into account by all municipalities).

4. Results

4.1. A real but disparate consideration of coastal risk

4.1.1. Heterogeneous mention of coastal hazards and risks in town planning documents

The urban planning documents in force in July 2019 indicate that the coast of Provence-Alpes-Côte d'Azur is considered to be moderately exposed to risks of marine origin, both regarding number of towns and length of coastline (Table 1). Degrees of response vary. Some communes have no PLU and therefore have not developed any policy to specifically address coastal risk. Others have a PLU but do not mention any sea-linked risk in the PADD or RP sub-documents. The majority of those mentioning risk evoke both flooding and marine erosion (18), and these communes contain the highest share of the region's coastline (46.4%). In other words, while this entire length of coastline is not necessarily affected by these hazards, the communes involved mention them in the RP of their PLU. Finally, although it is not linked to climate change, the tsunami is another coastal risk mentioned in the PLU of some municipalities.

The geographic distribution of the risks shows some heterogeneity (Fig. 4). In some sections of the coast, communes provide a relatively similar risk description, reflecting a relative geographical coherence: Camargue for flooding (Fig. 4, A1), Corniche des Maures for erosion (A2), Baie de Fréjus (A3) and Baie de Cannes (A4) for flooding. However, in other sections the situation is more uneven, with communes not acknowledging the same coastal risks although they occupy geographic locations where the natural environment dynamics are relatively comparable: Côte bleue (B1), Rade d'Hyères (B2), Baie des Anges (B3), Riviera niçoise (B4).

4.1.2. Varying level of detail on coastal risk in PLU presentation reports

In the RP, sea-linked hazards and risks are documented in a more or less detailed way. There is very uneven presentation of hazard location,

past events, future hazard frequency and intensity assessment, spatial delimitation of risk areas, etc. (Table 2).

Of the 54 communes with a PLU whose RP was studied, only 19 offer a detailed description of coastal risks, and only 15 consider these risks as an issue. These communes account for respectively 48% and 39% of the region's coastline. Thus, while local planning documents evoking coastal risks cover almost 78% of the region's coastline (Table 1), the risks are only described in detail for less than 50% of the total length of the coast. This raises questions about the possible effects of this gap, in particular about how it may impede appropriate planning.

4.1.3. Frequent but rather weak regulatory provisions

Of the 34 coastal communes with a PLU whose RP mentions coastal floods and erosion, only 23 have urban planning regulations which include building and planning rules related to these risks. These communes account for 60% of the total length of the region's coast (Appendix C).

We classified regulatory provisions into four types, from A to D, according to their increasing degree of constraint for the inhabitants, the planning and the economy of the territories, but also to how daring and ambitious they are in terms of adaptation to coastal risks. The categories are:

- constraints on construction authorised in risk areas (A);
- authorisations for engineering work to combat risks, in particular dams and riprap (B);
- prohibition of any new construction in risk areas, except in the public interest (C);
- prohibition of reconstruction of damaged property in risk areas, strategic measures to organise relocation (D).

Most of the measures concern coastal floods (Appendix D) and the most frequently adopted provisions fall under types A (19 communes, 56.4% of the regional coast) and C (18 communes, 44.5% of the coast). They have the least impact on public finances, since they mainly affect private property and do not involve any investment by the community, a priori. For example, type A provisions can include the banning of habitable ground floors or underground garages in residential buildings. Stricter regulations in terms of constructability and development (type D) are much less common (4 communes, 12% of the coast). They affect private owners, but also involve communities, both politically and financially. By prohibiting the reconstruction of property destroyed by a disaster, or planning the demolition of equipment and facilities located in a risk zone to reconstruct them elsewhere, local authorities may arouse resentment and may find it difficult to obtain the financial means to carry out these policies. Type C (9 communes, 18.4% of the coast) illustrates territories' willingness to protect themselves against the onslaught of the sea by authorising construction of protective structures on the shore. These provisions are found in communes that stress the fragility of their beaches and highlight this as an issue for local development.

Fig. 5 provides a summary of the different situations within the region. Overall, the coastline features relatively weak regulatory provisions relating to coastal risks. Apart from the Camargue, there is no large territorial subset where measures are aimed at reducing and anticipating these risks. There are cases all along the coast of neighbouring communes that differ widely in their town planning regulations with regard to coastal risks. This finding suggests a disparity in local public policies, or at least the absence of a common culture of risk management through town planning. Where they exist, regulatory provisions are rather slim, most often "cheap and easy" measures (types A and C). Territorial projects laying the groundwork for a new way of planning and inhabiting the coast are rare.

Table 1

Mention of coastal risks in town planning documents in force in July 2019.

Mention of coastal risks in town planning documents	No_Com	Coast_Ig	Coast_Ig-R
PLU. Coastal flooding and erosion mentioned in RP	18	472,976	46.4
PLU. Coastal flooding mentioned in RP	6	183,510	18.0
PLU. Erosion mentioned in RP	10	134,538	13.2
PLU. No risk mentioned	20	99,726	9.8
PLU. RP not available	2	17,063	1.7
No PLU	9	110,589	10.9
Total	65	1,018,402	100.0

No_Com: number of communes.

Coast_Ig: cumulative length of the coastline (calculated with GIS and BD TOPO® from IGN) in metres.

Coast_Ig-R: cumulative length of the coastline in percentage of the total length of the region's coastline.

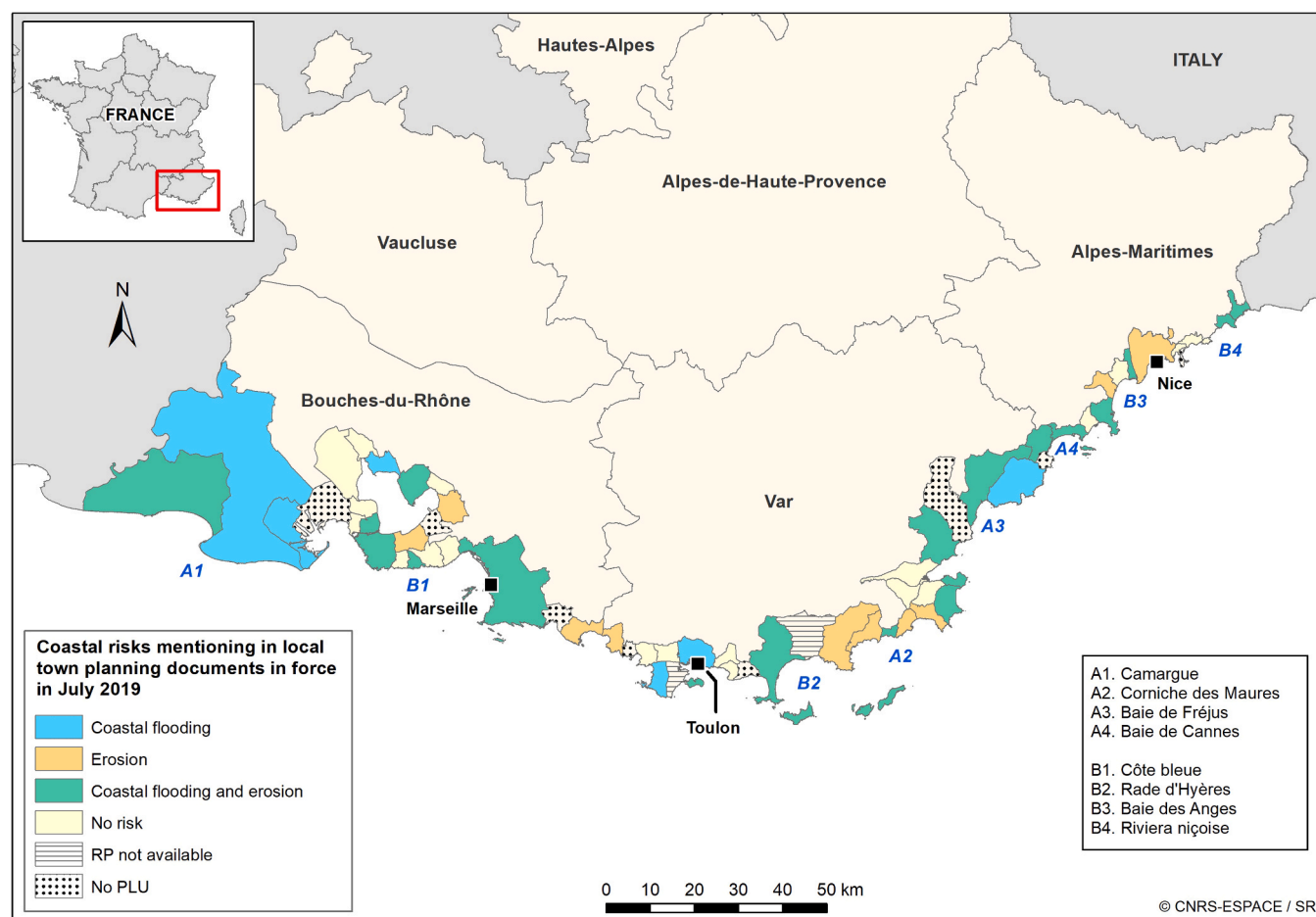


Fig. 4. Geography of mention of coastal risks in town planning documents in force.

Table 2
Mention of risks in RP: level of detail.

Mention of risks in RP	No_Com ^a	Coast_Ig ^a	Coast_Ig-R ^a
No mention	20	99,726	9.8
Simple mention	15	302,427	29.7
Detailed mention	19	488,597	48.0
Communes with PLU	54	890,750	87.5
Communes where risks are mentioned as issues	15	395,749	38.9
Region	65	1,018,402	

^a See Table 1 for variable definition.

4.2. The State influence

4.2.1. PPR rarely address coastal issues

The region's coastline is the subject of many PPR, in particular flood PPR (Appendix E). However, very few really address coastal risks because most date back to before the circular of 27 July, 2011 mentioned in Section 2.2 (Appendix F). Moreover, they take a "continental" view of hazards: most flood PPR (PPR-I), concerning 32 communes, do not deal with coastal flooding. Floods are analysed with a watershed focus, and their extension in the coastal plain is not assessed in the light of deteriorating weather and sea conditions. Only 4 PPR-I, approved between 2014 and 2017, effectively address coastal floods, PPR-I-SM (Appendix F). Nor are land-movement PPR (PPR-MT) more relevant to preventing coastal erosion (22 communes), also being rather detached from truly coastal issues. For the most part, PPR-MT concern shrinkage-swelling of clays, landslides linked to a lithology conducive to

rock instabilities because of water infiltration from the surface, or even falling rocks, which are not due to or not presented in relation to their seaside location. Apart from a few that establish a link with the dynamics of the coastline, these PPR do not address coastal erosion risk prevention.

Except for Camargue and Fréjus, current PPR cannot help the State to influence local town planning regulations so that they take into account risks related to the sea. It is difficult to imagine this situation changing, since today there is substantial resistance to PPR in these territories, where multiple challenges coexist. The approval of some PPR-I in force in 2019 took many years (more than 10 years for 7 of them).

4.2.2. Recent and more explicit PAC procedures

Following the storm Xynthia and several catastrophic events on the regional coast during the 2010s (deadly floods in June 2010, January and November 2014 on the Var coast; in October 2015 on the Alpes-Maritimes coast), the State developed a strategy complementary to the PPR. To obtain objective and recent data on coastal flooding, it commissioned studies which it then brought to the attention of local authorities (under the "knowledge dissemination" or PAC procedure), obliging them to take this information into account in all subsequent urban planning decisions, and to update PLU accordingly in future revisions. This PAC concerning risks has a weaker regulatory scope than PPR, because it does not impose urban zoning with specific building regulations. However, it does oblige communes to consider marine flood hazard and to update urban planning accordingly.

As of July 2019, almost all communes in the region's coast had been officially informed by the State about risks linked to the sea (Fig. 6). The latest major step in this procedure followed a study commissioned from

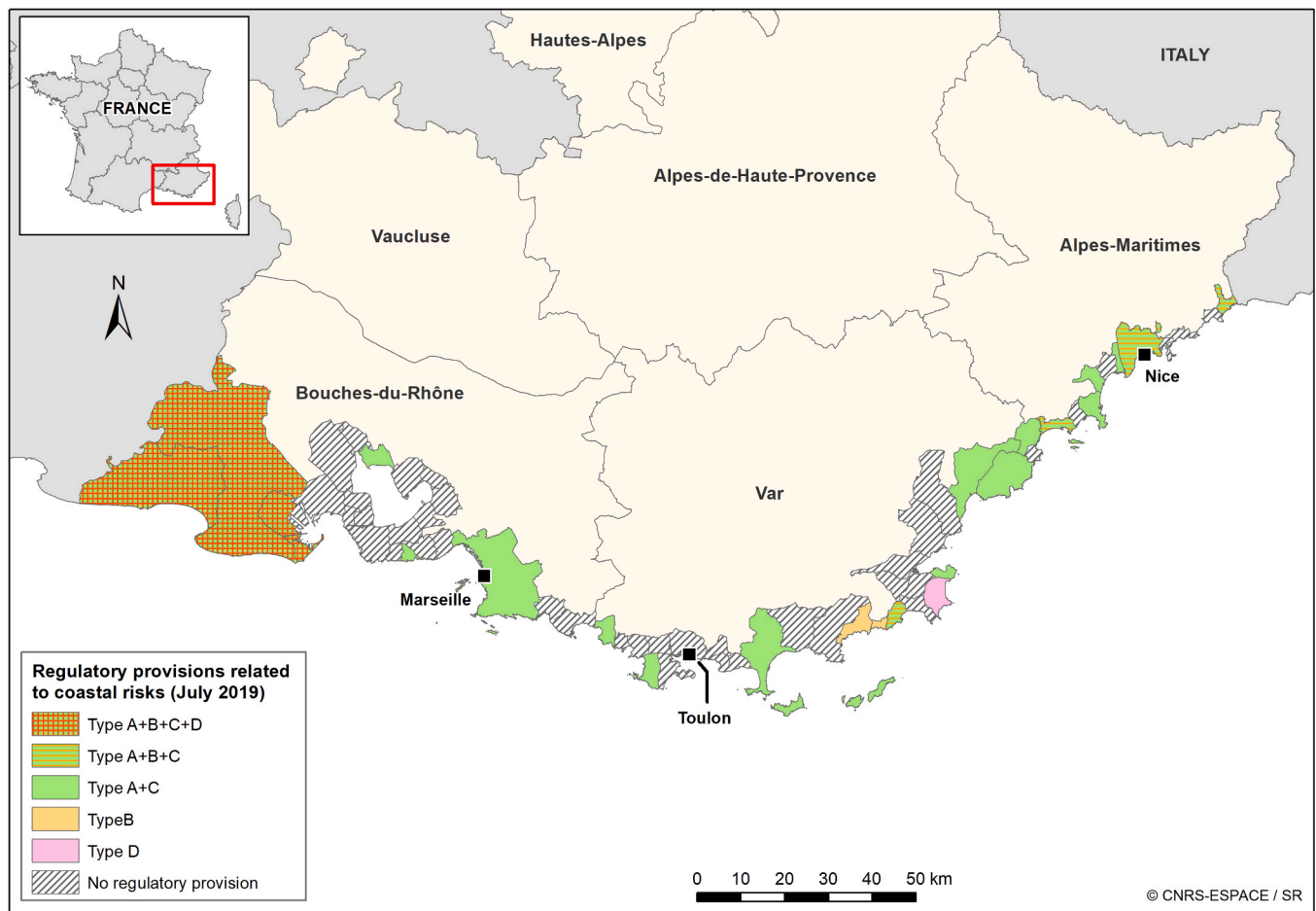


Fig. 5. Communes whose PLU includes regulatory provisions related to coastal risks.

the BRGM geological survey (Stéphanian et al., 2017), which enabled the prefects to make a PAC for the coastal communes of the Var and the Alpes-Maritimes. To date, only the banks of the Etang de Berre remain to be addressed by such a study, while a large part of the Bouches-du-Rhône coast (covered by this study) has not yet been the subject of a PAC.

4.2.3. Combined influence of PPR and PAC

Analysis of the PLU reveals a definite influence of PPR and PAC on local policies. Of the 23 communes whose PLU proposes regulatory provisions linked to coastal risks, 15 rely on the arguments provided by the State (10 on a PAC and 5 on a PPR). This represents more than 83% of the coast covered by local town planning regulations taking into account coastal risks, and about 50% of the region's total coastline (Fig. 7). Although recent, State intervention is therefore starting to pay off. Nevertheless, only the future will show whether communes are prepared to change their planning patterns. Today, regulations are still insufficiently detailed and only 8 municipalities address coastal risks in their PLU without being obliged to do so by the State. Coastal flooding and erosion are dreaded on the region's coast, but the desire to stay there is extremely strong and the economic stakes are high. The drafting of RP and regulations in certain PLU sometimes tends to minimise the risks and/or to encourage developments that could shortly be placed at risk.

5. Discussion

5.1. Structural explanations for the poor knowledge regarding risks

Both in terms of natural hazards and vulnerability of territories, the

PLU examined here contain relatively little information on coastal risks. Most include sparse data on coastal floods and erosion in their descriptive sub-documents (PADD and RP), and none provides an assessment of the consequences of sea-level rise for the territory. This is quite surprising in a region so oriented towards beach tourism. In fact, the town planning documents do not really address climate change, sea level rise and coastal risks, in terms of adaptation. For example, no attention is paid to any possible loss of beach tourism and the ensuing impact on the local economy. This lack of coverage may be explained by the "fragmented nature of coastal governance" also observed in Ireland by Flannery et al. (2015). In France, division of powers has long prevailed between the State (natural risk prevention) and local authorities (land planning). Thus, we can assume that until the GEMAPI reform, local authorities did not consider themselves responsible for funding risk studies on their territories. Meanwhile the State, stretched to its financial limits by its sovereign missions, was unable to undertake a thorough climate change risk assessment on the coast until Xynthia brought to light the shortcomings in public action. It has only been possible to properly integrate risks into local planning since the mid-2010s, thanks to the empowerment of local authorities and the State's new stance. That said, our results show that these new provisions have not yet generated new practices, as relevant regulations are still lacking locally. Another explanation for the limited knowledge concerning risks could be climate change trivialisation by local elected officials. Without denying it, they may not consider it a priority compared to other issues they have to deal with on a daily basis, an attitude observed in other studies (Birchall, 2020; Bowden et al., 2019). Except on rare occasions, local authorities have shown little interest in exploring the issue of adaptation to climate change, in particular by taking advantage of the region's scientific

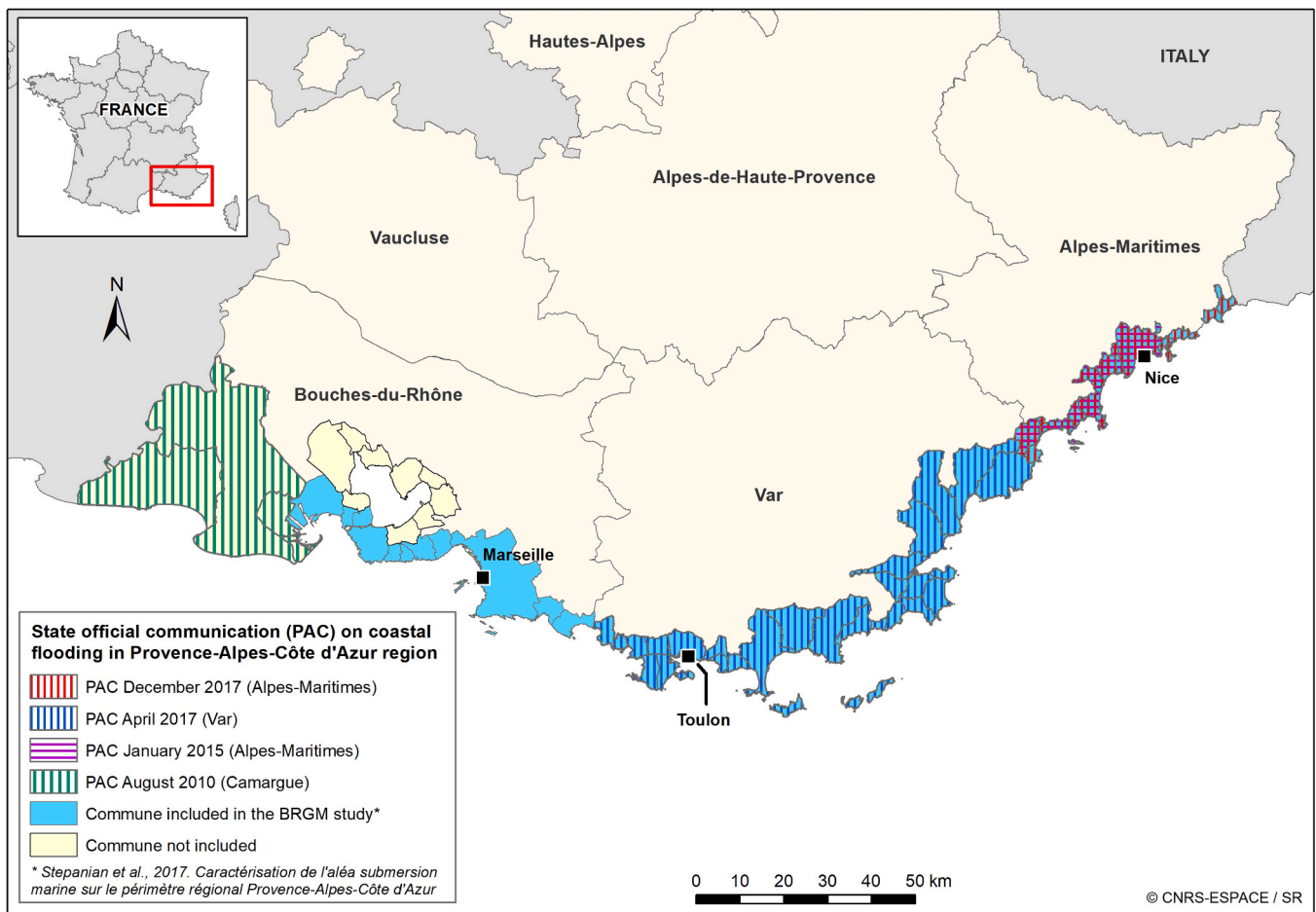


Fig. 6. Distribution over time of PAC concerning coastal flooding in the region.

resources (Stépanian et al., 2014; Le Roy et al., 2016).

5.2. Institutional resistance to adaptation

The poor awareness of risks is also due to other factors. Since climate change and coastal disasters have been common knowledge for years, local urban planning documents could be expected to take them more seriously. For instance, in already urbanised areas, it is surprising that planning regulations continue to allow urban densification and renewal so close to the shore. The many prestigious facilities continuing to be developed as close as possible to the seashore over the past decade (e.g. Terrasses du Port shopping centre, Joliette theatre, Villa Méditerranée centre and MUSEM museum in Marseille; Jean Cocteau museum in Menton), suggests a certain inertia prevailing in the development of the region's coast. This is in line with Gibbs' (2013) reflections concerning the anchoring of human communities on the coast induced by heavy and costly infrastructures built in the past, preventing the emergence of an alternative vision of coastal settlements and complicating any strategic retreat. It is also consistent with the view that the coast simply attracts people, so that certain economic actors are always ready to accept risks. Although awareness of these risks can create fear and deter certain investors, a property located by the sea retains strong drawing power and high value for many others (De Koning et al., 2019).

In addition to this inertia, there may be a politico-institutional resistance to adaptation, making it difficult to give up developing the waterside. Local authorities may have trouble envisaging economic development that steps back from the sea. This institutional resistance could join other forms of resistance to adaptation already described in the literature on the social impacts of climate change studied through

people's social values (Graham et al., 2013). For instance, inhabitants can find it difficult to imagine leaving a place they have long lived in and are attached to, or can resist leaving accommodation acquired through lifelong saving (Rey-Valette et al., 2019; Rulleau and Rey-Valette, 2017; Michel-Guillou et al., 2016). Resistance can also take the form of denial of the danger that climate change implies, due to collective inability to think about the future and unwillingness to change life style. This leads to a "wait and see" attitude or, conversely, to a call for the construction of protective works when risk is more concrete, in both cases excluding the prospect of leaving (Bowden et al., 2019; Poumadère et al., 2015). Thus, like inhabitants, local authorities may trivialise sea-level rise and risks associated with climate change to avoid questioning their social and ecological trajectory and the urban development constituting their landscape identity. Like some of their voters, local elected officials could thus find themselves unable to plan for adaptation, and this could be reflected in the urban planning documents.

5.3. Prospects for adaptation through shared knowledge and risk management

The SNGITC has opened new horizons in France. Its implementation has lagged behind in Provence-Alpes-Côte d'Azur region, but one of its flagship actions - creation of a tool to gather and share knowledge on coastline dynamics, management and spatial planning policies in line with adaptation - was initiated in 2018. Driven by the regional office of the Ministry of Ecology (DREAL-PACA), this approach aims to bring together stakeholders from local authorities (municipalities, departments and regions), central government services, experts in geomatics, scientists, state agencies such as BRGM and CEREMA, innovative

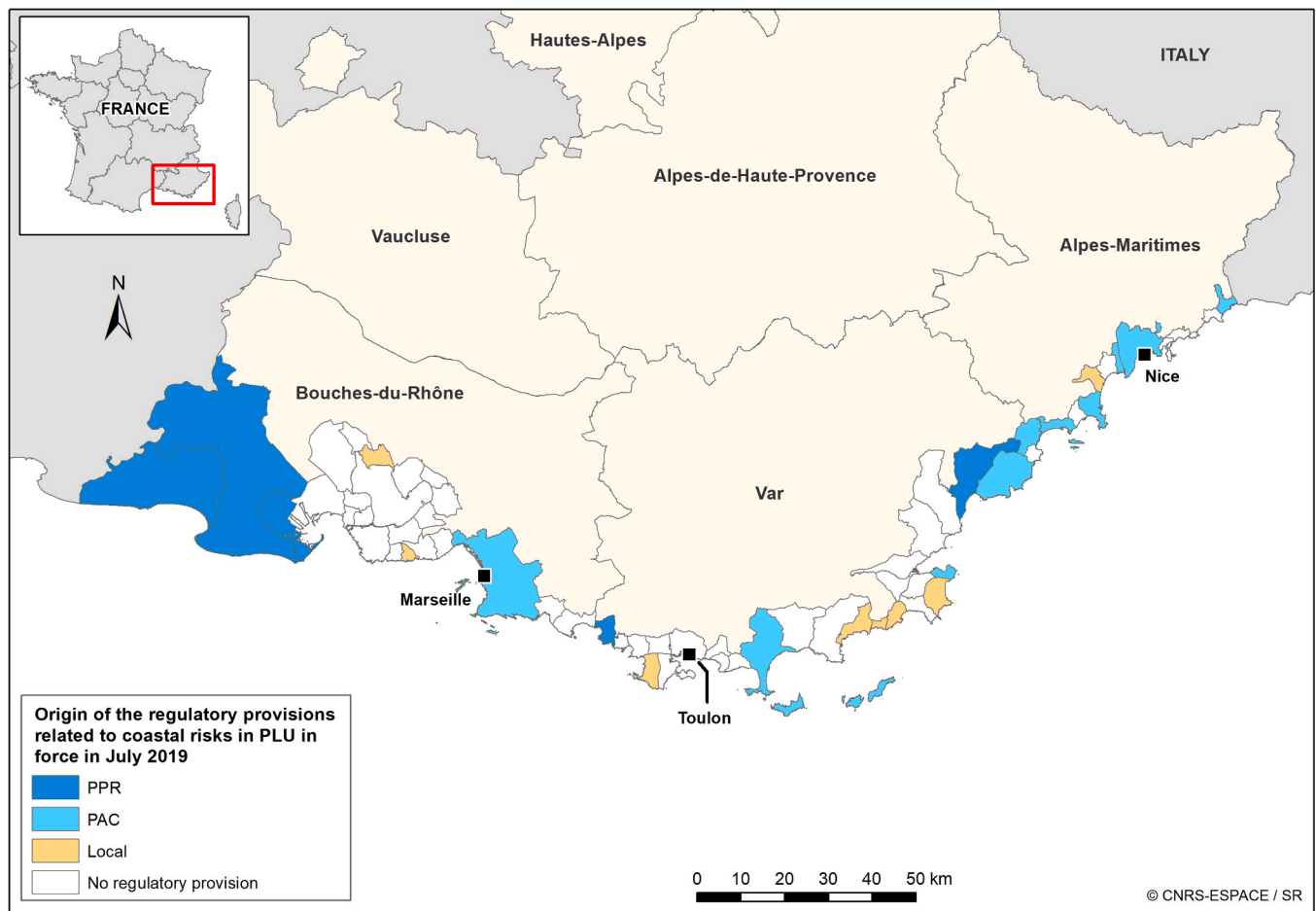


Fig. 7. Communes with regulatory provisions related to coastal risks following a PPR, a PAC or a local initiative.

coastal engineering companies. The objective is to build a knowledge base on the internet, gathering scientific data, feedback, testimonials, etc. on topics like the following: risks and the means to assess them; past catastrophic events; public policy actions implemented; soft or more technical solutions; scientific experts and industrial players. This approach has also led to a network of stakeholders that is already partly up and running.

Thus, the idea of adaptation is being disseminated. As [Birchall \(2020\)](#) reminds us, an actor participating in local community affairs can always either support or, on the contrary, marginalise a discourse on climate change adaptation. Therefore, spreading knowledge, reporting on solutions found in different places and creating conditions for open governance within which exchanges, discussions and debates can take place are prerequisites for wise and sustainable risk management. Adaptation to climate change being a complex collective action, it can be achieved only through an integrated approach. Findings from work aimed at objectifying risks and helping to manage them ([Baillis et al., 2020](#); [López-Dóriga et al., 2020](#); [Rocle et al., 2020](#); [Sekovski et al., 2020](#); [Gil-Guirado et al., 2019](#); [Mavromatidi et al., 2018](#)) show the need to go beyond sectoral approaches and create conditions ensuring that assessments are shared among specialists, decision-makers and the public. In this effort, local approaches and spatial planning occupy a central place ([Reiblich et al., 2019](#)), but the connection with local actors is an imperative that should not be relegated to the background. Integrating local knowledge into risk management, and therefore into spatial planning, is a necessity ([Nakanishi and Black, 2018](#)), just as it is essential to take a critical approach to public policies ([López-Martínez et al., 2017](#)).

6. Conclusion

On the coast, adapting to climate change through spatial planning is a challenge. Our results show a discrepancy between principles requiring the inclusion of ecological issues and environmental risks in land planning documents and the actual content thereof. For the Provence-Alpes-Côte d'Azur region in France, this study clearly shows that an agenda for adaptation to coastal risks is still not being strongly implemented in local urban planning, despite the provisions made under French public policies. Four obstacles are highlighted.

First, until recently, the articulation of public policies between central government and local authorities did not work. The State was responsible for preventing natural risks but had decreasing technical, human and financial means to perform this function, while local authorities' responsibilities for land planning increased under successive decentralisation laws. This situation precluded fruitful and effective cooperation aimed at preventing natural risks and promoting adaptation in land planning.

Second, as a consequence, the urban planning documents currently in force continue to take little account of coastal risks and are relatively unambitious in addressing them. Many do not even mention their existence. This is linked to local authorities' responsibility for spatial planning, town planning and economic development, in a region where tourism and real estate are highly developed on the coast. Therefore, local decision-makers may pay greater attention to economic issues than to risks, which do not officially fall under their responsibility.

Third, the need for a State guaranteeing balanced policies, freed from dealing with local and immediate issues or interests, is still strong. The effect of the PAC related to coastal flooding in the region is a good

example, since it enabled coastal risks to appear more clearly in local planning documents after 2017. For various reasons, it is highly unlikely that communities would have got there on their own, which suggests that adaptation policies will only come from combining bottom-up and top-down initiatives, in an openly and calmly debated approach, as Lambert et al. (2019) points out.

Fourth, despite the very significant increase in scientific knowledge on climate change, coastal hazards, risk objectification, or inhabitants' perceptions, local town planning documents seem to ignore this knowledge and expertise. Yet, it is through knowledge dissemination and skill sharing on risk management that spatial planning can gain in efficiency, primarily at the decision-makers' level. Because, as Birchall (2020) reminds us, "until leadership and decision-makers can fully appreciate that persistent extreme weather and climate variability is the new normal, it will remain difficult for communities to implement an agenda for climate change adaptation". This is the challenge for the regional approach to coastline management currently implemented in Provence-Alpes-Côte d'Azur.

This article highlights the relevance of studying local spatial planning documents to shed light on coastal territories' preparedness for adaptation to climate change and coastal risks, and on the role played by the interaction between decisional/management levels. However, the investigation needs to be deepened. To do so, we are currently conducting interviews with those responsible for local policies in the communes examined here, to explore their representations of coastal risks and their vision of the future. Likewise, with the objective of framing the issue as broadly as possible, we are working with residents of communes particularly exposed to risks.

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CRediT authorship contribution statement

Samuel Robert: Conceptualisation, Data curation, Formal analysis, Methodology, Visualisation, Writing - review & editing.

Alexandra Schleyer-Lindenmann: Funding acquisition, Project administration, Writing - review & editing.

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Declaration of interests

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105354.

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