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Pierre Cornut, Nathalie Long and Clémentine Harel

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Introduction, state of the art and objectives

1 In its strategy for adaptation to climate change (Malecki, 2021), the European Union notes that even though there is an increase in awareness-raising measures, discussions on institutional organisation and the development of public policies, very few adaptation solutions are actually being implemented on the ground. The UN makes the same observation in its report on the gap between adaptation needs and prospects (Neufeldt, Christiansen & Thomas, 2021) and moreover, points that there is very little evidence to prove the effectiveness of adaptation solutions. Indeed, Berrang-Ford *et al.* (2021), from a review of 1682 scientific articles on adaptation to climate change, found that the results in terms of risk reduction were negligible, fragmented, poorly documented, and closely linked to local contexts. However, the literature and institutional documents widely emphasise the importance of anticipating and planning these adaptations as early as possible (Mineo-Kleiner & Meur-Ferec, 2016; IPCC, 2022).

2 The causes of this inertia are partly historical and cultural: most of the time, coastal areas with numerous residential, economic, productive, recreational, heritage and cultural issues have been on a path of dependency for several centuries (Rocle *et al.*, 2020); they have followed a risk management trajectory from which it is difficult to extricate oneself and branch off. The strategy has been to fight against marine hazards:

these areas have mostly used hard defences such as riprap, dikes or groynes, sometimes for several centuries (Pranzini, Wetzel & Williams, 2015). Only recently have ‘soft’ solutions, called nature-based solution, emerged, such as re-sanding or re-vegetation of beach tops but are rarely used for coastal cities (Louarn *et al.*, 2025). Another, harsher solution is the deconstruction and relocation of human assets such as housing (Williams *et al.,* 2018), a measure that can be applied as an immediate response to an extreme event, in the post-crisis repair phase. Each of these measures will have a different environmental impact and affect various social groups within, raising the question of acceptability among the populations concerned. Indeed, Rey-Valette *et al.* (2018) show, through surveys conducted in the south of France, that part of the population not exposed to risk is rather in favour of relocation, while in contrast, the population exposed to risk is more attached to their individual well-being, which is linked to the proximity of coastal amenities and to the place itself. Similarly, Lambert *et al.* (2019) examine the environmental, social, economic and legal vulnerabilities of exposed populations and the links between these vulnerabilities and public operations aimed at defending against the sea or relocating exposed populations. The study reveals numerous inequalities, with the general interest (which should guide all public operations) being poorly defined and often overridden by a range of specific and economic interests of owners of high-value property. These individuals have significant influence and capacity to lobby public authorities. This result highlights the need for innovative land governance procedures. For example, in the event of relocation, Lambert (2016) proposes the implementation of procedures that spread the loss of ownership over time and introduces social equity criteria. Meur-Ferec *et al.* (2022) also emphasise the complexity and technical expertise required for the implementation of adaptation strategies along coastlines. In order to remain compliant with public policies that are sometimes contradictory in terms of their objectives (risk management policy, urban planning, biodiversity preservation, etc.), local authorities require support from specialised structures to master the legal tools and possible sources of funding.

3 When coastal areas are attractive, they are characterised by major inequalities in terms of access to land and recreational activities (e.g. privatisation of beaches). This attractiveness leads to spatial segregation, with the poorest households settling further away from the coast, where land costs are cheaper, a phenomenon that is similar to the classic urban center-periphery gradient (Frenkel & Israel, 2018; Schaeffer *et al.*, 2016). This explains why, if one assumes that a society is unequal by definition, according to the theory of sociologist Durkheim (1964) which shows that a social system cannot be maintained without a certain degree of social cohesion and solidarity, this characteristic is reinforced in attractive coastal areas. Spatial correlations can be observed between the location of certain social groups, their environmental quality and their exposure to risks. Studies on environmental policies have for example shown that the poorest populations are often the most exposed to coastal risks (Brulle & Pellow (2006); Dolan & Wallace, 2012; Mojica Vélez, Barrasa García & Espinoza Tenorio, 2018). However, the situation can be more complex in the case of attractive coastlines: the wealthiest households, those with sufficient income, have access to coastal land, which is sought after for its proximity to the sea and coastal views (Robert, 2018). However, Claeyes *et al.* (2019) demonstrate that this is not always the case by comparing a municipality in south-eastern mainland France with a municipality in Guadeloupe, where the lower classes and even the poor live near the coast. Claeyes *et al.* (2017) also

demonstrate that in Carry-le-Rouet, a town on the Mediterranean coast, wealthy households are now exposed to erosion hazards, while urban and risk management policies are struggling to implement measures that are nevertheless supported by mandatory institutional documents. In the same context, Kolb, Long & Marty, 2014 also show that for most of the mainland France coastline, this dual effect of socially differentiated accessibility and vulnerability makes the coast a particularly favourable area for environmental inequalities (EIs).

4 One of the main social dynamics at the root of environmental inequalities is the functioning of the market economy. Profit maximization compromises society's ability to ensure the safety and well-being of its citizens in the face of risk, creating a "risk society" (Beck, 1986) in which the (uneven) distribution of wealth is superimposed on the (uneven) distribution of environmental quality, thereby producing environmental injustice. As Dolan and Wallace (2012) also show, the unstopped process of coastal urbanization increases the exposure of even more people to natural hazards, while placing ever-greater burdens on the very institutions that allow this urbanization to occur, since they must simultaneously ensure their safety and well-being. In addition, Seto *et al.* (2011) demonstrate that urbanisation is greater in coastal areas than inland, with high levels of land use change in China and south-west Asia and lower levels in Europe, North America and Oceania. This trend should continue and even increase over the coming decades (Neumann *et al.,* 2015).

5 The main reason for the expanding urbanization of some coasts lies in their socio-cultural and economic aspects through a process of littoralisation (Dachary-Bernard *et al.*, 2011) and their environmental and aesthetic value. The coast can be perceived as a natural amenity, where amenity is defined as an element that makes an environment more attractive as a place to live (Power, 2005). Several studies have shown that proximity to an attractive coastline has an impact on land prices, and that households living near amenities have higher incomes (Costanza *et al.*, 2006; Dachary-Bernard *et al.*, 2011; Schaeffer *et al.,* 2016; Lee & Lin, 2018). This spatial differentiation of households according to income is generally linked to the presence of natural, cultural, urban or other amenities (Schaeffer *et al.,* 2016). Lee and Lin (2018) also show, for coastal American cities, that these situations are time-stable, i.e. that amenities that are permanent over time, such as a coastline, anchor high-income populations close to these areas. Similarly, in France, Cazaux (2022), based on observations of land and real estate prices between 2010 and 2016, finds no price decline due to exposure of real estate to coastal risks. Using an economic model, Walls, Magliocca, and McConnell (2018) similarly show that coastal areas in the Mid-Atlantic region of the United States continue to urbanize despite the increase in storms. However, at the end of the simulation period, they also note that land and house prices could fall near the coast, suggesting that lower-income households would move to these areas which have been devalued by increased exposure to natural hazards.

6 Environmental inequalities (EIs) are a key indicator for analysing the processes of socio-environmental disparities in a given area. EIs are defined as differences between social groups in terms of the environment, which are partly determined by the state and quality of the environment and partly by the structure of society (Deldrève & Candau 2015; Pye *et al.,* 2008). As mentioned by Mavromatidi *et al.* (2018), social groups can also be characterised by a certain social vulnerability which, when combined with exposure to risks, leads to significant environmental inequalities in coastal cities.

Conversely, if social groups are only exposed but not socially vulnerable, then they have the capacity to to protect themselves or influence public policy.

7 These findings underscore the importance for policymakers to implement public policies that reduce spatial segregation because, as shown by Brulle and Pellow (2006), the poorest populations are often the most disadvantaged by environmental policies, the most socially vulnerable, and the most exposed to risks. Yet, a society marked by major inequalities may appear less cohesive in the event of a disaster. The increase in inequalities, particularly where the environment is concerned, exacerbates social tensions, reduces acceptance of environmental policies, increases socio-environmental risks and therefore reduces the preventive impact of adaptation measures (Long, Bazart & Rey-Valette, 2022; Uslaner & Brown, 2005; Wilkinson & Pickett, 2009). In other words, considering the societal impacts of coastal risk adaptation measures is essential if we are to cope with climate change, in a fair and equitable ways (Klinsky *et al.,* 2017a).

8 The aim of this paper is to quantify environmental inequalities in the Charente channel area (Charente Maritime, France, Figure 1) and to compare them with the different adaptation strategies adopted by local authorities.

9 Firstly, three hypotheses from the literature are tested: 1/ coastal attractiveness is reflected in a difference in land prices between the coast and inland areas; 2/ poorer populations have less access to coastal amenities than wealthier populations; 3/ poorer populations are more exposed to marine and weather hazards. Secondly, we compare the estimated EIs with the adaptation strategies that have been implemented along this coastline since 2010. The discussion of our results, as a first attempt to interpret the social impacts of adaptation policies in this area, shows that the hypothesis of non-neutrality of these policies in terms of EI is tenable.

Presentation of the study area: the Charente coastline

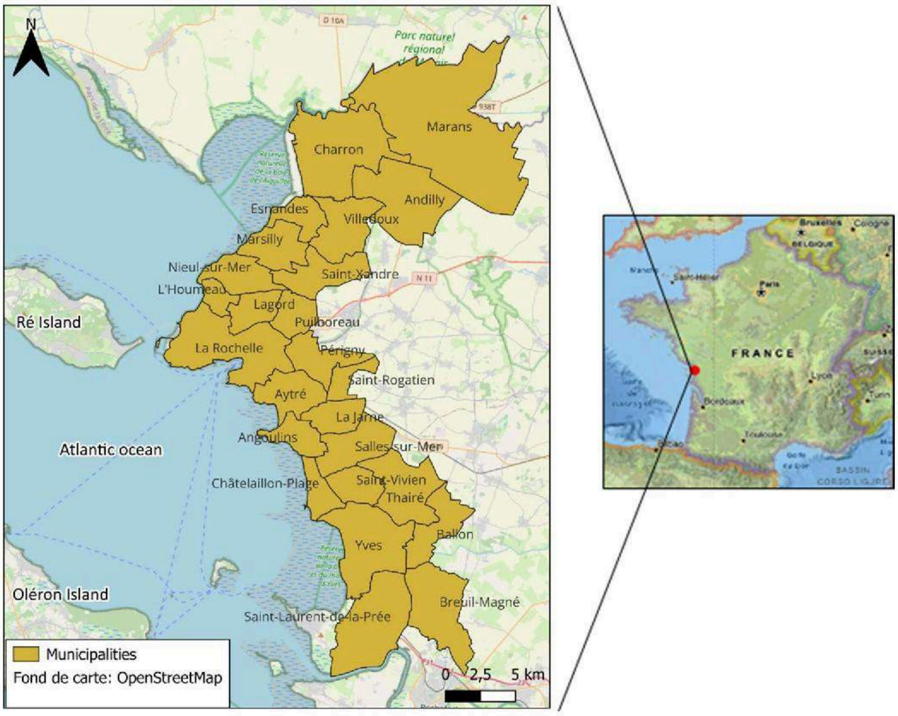
10 The Charente channel coastline (Figure 1) is a relevant geographic area for the analysis of EIs, as it includes rural and urban communities with varying levels of exposure to marine hazards and contrasting environmental and socioeconomic profiles. Comprising 25 municipalities, our study area is highly attractive and urbanized: 50% of the population lives in La Rochelle (around 75,000 inhabitants in 2015, source INSEE), where the majority of jobs, services and infrastructure are also located. To the south of La Rochelle is the seaside resort of Châtelaillon-Plage.

11 The coastal geomorphology of the Charente channel is very diverse: from north to south, there are marshy areas (Charron), then cliffs as far as the northern edge of La Rochelle, then a more sandy-muddy coastline (from Aytré to Châtelaillon-Plage) and finally more marshy areas again (Saint-Laurent-de-la-Prée). Property prices seem to vary according to these types of coastlines and their supposed attractiveness. The average price per square metre is €1566 in the marshy Charron, €3078 in balneary Châtelaillon-Plage and €2079 in Saint-Laurent-de-la-Prée which is marshy but also includes high valued natural areas (calculations based on DVF+ data, see below).

12 The entire area was severely affected by the storm Xynthia in February 2010. Significant material damage and fatalities were reported (Chauveau *et al.,* 2011). In the aftermath of this event, flood protection plans were implemented, often resulting in the construction of hard defences (MEDDTL 2011). Some areas in Charron (around 200

dwellings) and Aytré (40 dwellings) were also deconstructed. A minority of softer solutions, such as re-sanding beaches and replanting dunes, complete the protection plans.

Figure 1. Presentation of the study area.



Method and data

Data

13 We define *three types of inequality* by calculating indicators that allow us to synthesize several different pieces of information provided by variables into a single data.

14 First, *natural inequalities* correspond to spatial differences in access to areas of a good environmental quality. To define these amenities, the following information has been used: protected areas, areas corresponding to blue and green belts, unbuilt or watered areas, natural diversity in land use, distance to the beach and distance to the coast (Table 1).

Table 1. Variables contributing to the natural amenity indicator.

Variables	Data source	Date of the data
Protected area (5 types of space: ZNIEFF* 1 and 2, SRCE*, ZICO*, APPB*) and natural reserve area	DREAL17*	2013
Natural diversity of land occupation (Simpson's index)	Urban Atlas	2012

Area of green spaces	BD TOPO IGN*	2011
Area in the green belt (ha)	Ecological coherence scheme	2015
Area in the blue belt (ha)	Ecological coherence scheme	2015
Distance to a beach (m)	DDASS*	2014
Water surface (ha)	BD TOPO IGN	2011
Unbuilt area (ha)	URBAN ATLAS	2012
Distance to the coast (m)	BD TOPO IGN	2011

All acronyms marked with a * are defined at the end of the paper.

15 Second, to quantify the *inequality of exposure to natural hazards*, the four main types of information selected are: rising groundwater tables, submersion, erosion and flooding (Table 2).

Table 2. Variables contributing to the natural risk exposure indicator.

Variables (ha)	Data source	Date of the data
Area exposed to ground water lift	BRGM*	2011
Area exposed to submersion	DDTM17*	2014
Area exposed to erosion	DDTM17	2009
Area exposed to floods	DDTM17	2009

All acronyms marked with a * are defined at the end of the paper.

16 Third, *a socio-demographic indicator* is proposed to identify and characterize the different social groups. It is made up of variables defining the composition of households, housing property status, average income, age groups (children, active and retired population) and the proportion of low-income households (Table 3).

Table 3. Variables contributing to the socio-demographic indicator.

Variables	Data source	Date of the data
% one-person households	INSEE*	2017
% Homeowner households	INSEE	2017
% low-income households	INSEE	2017

% 0–17 year-old individuals in total population (children)	INSEE	2017
% 25-64 year-old individuals in total population (active population)	INSEE	2017
% >65 year-old individuals in total population (retired population)	INSEE	2017
Average income per individual	INSEE	2017

All acronyms marked with a * are defined at the end of the paper.

17 Finally, in order to analyse the spatial distribution of the real-estate value, the average housing price has been added to the database. This average price is calculated using the "DVF+ open-data" spatial database provided by the Direction Générale de l'Aménagement, du Logement et de la Nature (DGALN*) and CEREMA*. This database is the result of the structuring of "land value requests" files, which register, from notarial deeds and cadastral information, real estate transactions that have taken place since 2014[1]. In our study area, we collected real estate transactions between January 2014 and October 2022.

Method

Data preparation

18 The above 20 variables are originally surface or point variables. To be able to summarise them in the form of an indicator, they all need to have the same spatial reference unit. The INSEE* reference grid, made up of 200 m x 200 m cells, was used because it provides the greatest possible precision. Using ArcGIS 10.6 (ESRI) and QGIS3.16 software, the selected variables were transposed onto this reference grid at the cell level.

19 The variables in tables 1 and 2 are calculated as simple percentages of the different types of surface for each cell. The Simpson index is calculated on the basis of the different land uses in each cell (there are 5 types of surface: agricultural, forest, grassland, grassed areas in open spaces with little or no vegetation, wetlands and water surfaces). Distances to the coast or the beach are estimated using buffers of 250m, 500m, 1000m, 2500m, 5000m and 10000m from the amenity and a value of 1 to 6, respectively, assigned to each cell by spatial join.

20 The socio-economic variables (Table 3), directly taken from the INSEE databases, did not need to be processed.

21 Finally, to calculate the average selling price per m^2 of houses and flats for each cell, a series of treatments was carried out. Non-residential sales and properties of less than $9m^2$ have been removed. The remaining properties are defined by their location, the type of accommodation (apartment/house), the selling price, the surface and various other descriptive data. For each INSEE square, the average price per square metre of residential property was calculated by geoprocessing tools, using Q-GIS software.

Statistical processing at cell level

22 The indicators are derived from a principal component analysis (PCA) applied to each matrix of variables. This method transforms related variables into new variables, the 'principal components', which are independent of each other and better explain the variance in the data. The processing was carried out using R-Studio software, making sure to standardise the data beforehand.

23 Each PCA focuses on a thematic set of data related to EIs: the level of natural amenity, exposure to natural hazards and the socio-economic level of the population. Based on the correlations between the variables and the axes, some components are selected for representing the relevant EI indicators. Natural amenity and exposure to natural hazards are then compared with the spatial distribution of social groups and real estate prices.

Statistical processing at municipality level

24 The matrix of indicators is spatially incomplete. First, uninhabited areas do not have socioeconomic data, and second, real estate prices are calculated only where sales have been made during the 9 years studied. Conversely, areas with a high level of natural amenity are often uninhabited. At the cell scale, a calculation of correlations between the presence of natural amenities and the number of inhabitants would therefore be inconclusive, as the indicators are not calculated on the same portions of land. In order to analyse the interactions between environmental inequalities, land prices and the spatial distribution of different social groups, the municipal scale is therefore more relevant.

25 Using the geoprocessing functions of Q-GIS, each municipality is characterized by the average value of the cells in its territory. The municipalities are then ranked in relation to the overall average for the indicator: a value between 1 and 5 is assigned according to the deviation of the municipality from the average for all municipalities (1 very low - 2 low - 3 average - 4 high - 5 very high)[2]. This analysis is limited to municipalities subject to coastal risks, at least over part of their territory. This gives us a matrix of 17 municipalities and 5 average indicators between 1 and 5. The spatial correlations between the indicators for each municipality can then be calculated.

Results

EI indicators

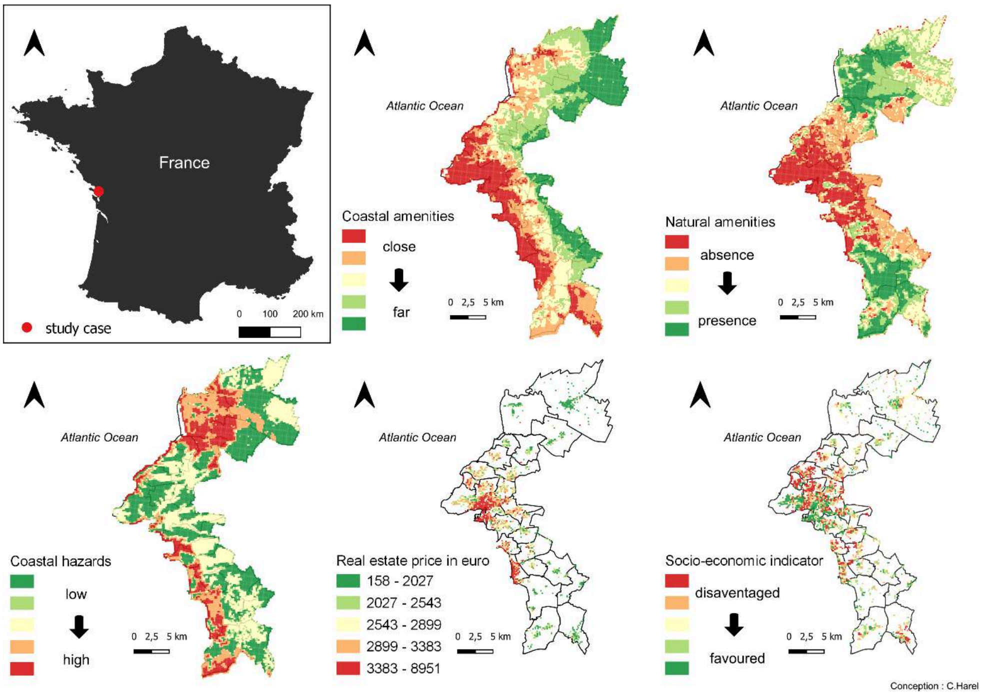
26 The first two indicators are derived from the PCA on natural amenity variables, which accounts for 45% of the cumulative variance on the first two components. The first component is strongly correlated with the presence of various protected natural areas - thus constituting an indicator of natural amenity - while the second component is strongly correlated with distances to the coast and beach - constituting an indicator of coastal amenity (Table 4).

Table 4. Correlation of the variables with the first two components of the PCA for the natural amenity indicator (values in **bold** underline the most contributing variables).

Variables	Correlation coefficient	
	Component 1	Component 2
% of protected area (ZNIEFF1)	**0.77**	-0.25
% of protected area (ZNIEFF2)	**0.82**	0.19
% of protected area (ZICO)	**0.80**	-0.13
% of protected area (APPB)	0.55	0.12
% of protected area (SRCE)	**0.77**	-0.35
% of natural reserve area	0.08	-0.22
Natural diversity of land occupation (Simpson's index)	0.35	0.10
% of unbuilt area	0.39	**0.58**
% of water surface	**0.76**	-0.00
Distance to the coast	-0.10	**0.83**
Distance to a beach	0.43	**0.69**

27 Spatially, the natural amenity indicator reveals the wetlands and natural areas in the north and south of the study area, while coastal amenity is very logically linked to distance from the coastline, with a gradient from sea to inland (Figure 2).

Figure 2. Spatial patterns of the IE indicators.



28 The first component is correlated with inland flood and groundwater lift indicators. The second component, which is strongly correlated with submersion and marine erosion, is used as an indicator of coastal hazard. Spatially, this indicator combines areas subject to erosion, such as the cliffs to the north of La Rochelle, and areas subject to marine submersion, such as Charron to the north or in the coastal municipalities to the south of the study area (Figure 1).

29 The third indicator is derived from the PCA on risk exposure, which gives the following results on the first two components, accounting for 57.6% of the total variance (Table 5).

Table 5. Correlation of the variables with the first two components of the PCA for the risk exposure indicator (values in **bold** underline the most contributing variables).

Variables	Correlation coefficient	
	Component 1 (32,4% variance)	Component 2 (25,1% variance)
% of area exposed to submersion	0,365	**0,743**
% of area exposed erosion	-0,263	**0,629**
% of area exposed to flood	**0,695**	-0,230
% of area exposed to groundwater lift	**0,782**	0,069

30 The fourth indicator comes from the PCA on socio-economic profiles. The first two components account for 64.45% of the variance (Table 6). The first component

contrasts areas characterised by homeowners, retired and high-income households on the one hand, and areas characterised by low-income, active, single-person households on the other. This component is used as a socio-economic indicator. For the record, the second component, not kept, opposes families with retired or single-person households (Table 6).

Table 6. Correlation of the variables with the first two components of the PCA for the social profile indicator.

Variables	Correlation coefficient	
	Component 1 (36,63% variance)	Component 2 (27,82% variance)
% of one-person households	-0,31	0,76
% of owner households	0,71	-0,39
% of low income households	-0,82	0,25
% of children (0-17 yr)	-0,42	-0,64
% of active individuals (25-64 yr)	-0,23	-0,48
% of retired individuals (>65 yr)	0,54	0,75
Mean income of individuals	0,84	-0,26

31 This socio-economic indicator shows a centre-periphery pattern around La Rochelle (Figure 2). The least well-off households are to be found in the social housing districts to the west, east and south of the city centre. The most affluent households are located in the first ring of suburban municipalities, as well as in the immediate vicinity of the city center of La Rochelle, in the “quartier de la Genette” on the edge of the Charruyer park. Beyond La Rochelle and the first outlying communes, the increasingly rural communes are made up of households that are gradually modest or in a fairly average situation.

32 Finally, the average real estate price shows a dual trend: first, a price increase towards the coastline, particularly in areas with high coastal amenities, and then, an urban effect of La Rochelle, with prices falling from the city centre towards the inner suburbs, where the classic suburbanisation of middle and upper middle class families is taking place. Beyond the inner suburbs, the municipalities show the lowest real estate prices, both inland and along the coast, which is muddy and therefore unattractive.

Analysis at municipality level

33 Calculated at municipality level, the correlations between the indicators highlight three types of relationship (Table 7).

Table 7. Correlation matrix (Pearson) of EI indicators at the municipality level.

	Natural amenity	Coastal amenity	Real estate price	Socio-economic level	Coastal hazard
Natural amenity	1	-0.35	-0.64	-0.47	0.58
Coastal amenity		1	0.83	0.2	0.32
Real estate price			1	0.47	-0.03
Socio-economic level				1	-0.04
Coastal hazard					1
Significance level at 95%. = 0.48 Correlations in green are less than -0.48 and in red greater than 0.48.					

- Real estate price and coastal amenity are correlated at 0.83: proximity to the coastline is therefore important in terms of attractiveness and thus, land pressure. However, socio-economic level and coastal amenity are not correlated, which can be explained by the presence of second homes on prices, as socio-economic level is calculated on the basis of indicators for the place of main residence. This effect is confirmed by the absence of any significant correlation (0.47) between real estate price and socio-economic level (see the discussion section below).
- There is no significant correlation between exposure to coastal hazard and socio-economic level (-0.04) nor property price (-0.03). Exposure to risk therefore has no repellent effect.
- Coastal hazard is correlated with natural amenity (0.58): the majority of submersible surfaces are marshes (the presence of which makes a strong contribution to the amenity indicator). The price of land is inversely correlated with natural amenity at -0.64, showing the low attractiveness of municipalities with wet or marshy land.

34 We can therefore conclude that:

1. *the coastline, considered a natural amenity and therefore attractive, leads to an increase in the real estate price;*
2. the hypothesis of socially differentiated access to coastal amenities is less easily verified. The correlations between distance from the coast and the socio-economic profiles of households are not significant. However, when we use the average real estate price as a socio-economic indicator, the correlation with coastal amenity is significant and strongly positive. This is due to the presence of second homes: classic socio-economic indicators do not reflect the wealth of all coastal dwellers, as they relate only to those living in primary residences and not to all owners. So *there is indeed socially differentiated access to coastal amenities, at least in terms of access to housing*;
3. *the poorest populations are not more exposed to coastal risks than the richest*, since the correlations are not significant.

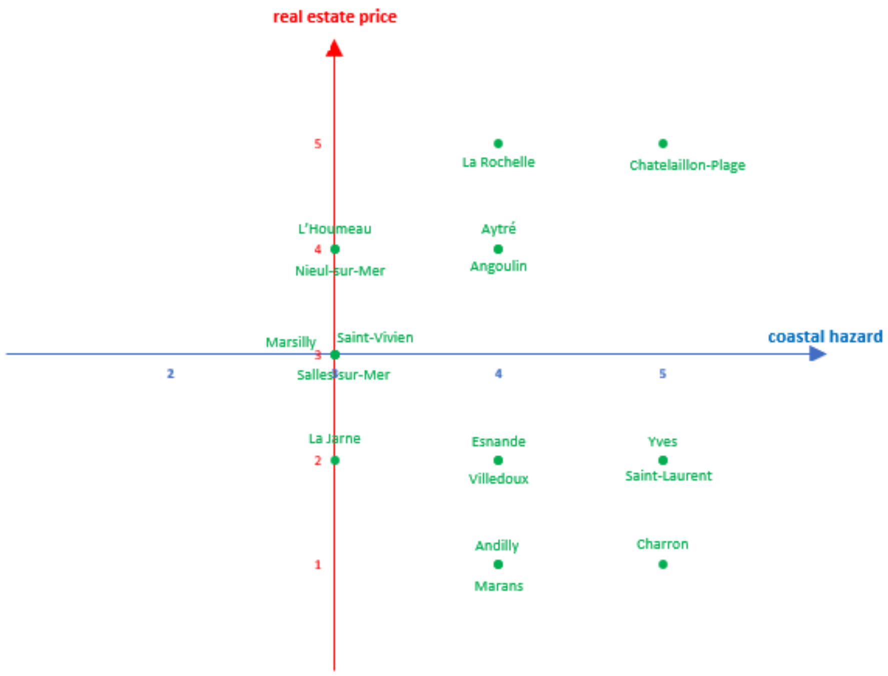
35 In the coastal area of the Charente channel, the quantitative analyses therefore confirm the existence of environmental inequalities in terms of access to coastal amenities, which reinforces our previous qualitative analyses (Long, Bazart & Rey-Valette, 2022).

A comparison of environmental inequalities and adaptation strategies following storm Xynthia

36 In the aftermath of storm Xynthia in 2010, some of the coastal adaptation practices[3] can be linked to the profiles of municipalities and their inhabitants, as shown by our empirical work.

37 Based on the above results, we have positioned the 17 municipalities exposed to coastal risk in our study area in relation to two EI indicators: coastal hazard (marine submersion and erosion) and the socio-economic level of property owners, estimated by the average real estate price. Using the averages calculated above, the municipalities are positioned on a graph where the abscissa indicates the level of risk and the ordinate the real estate price[4] (Figure 3).

Figure 3. Environmental inequalities typology of the municipalities.



The graph shows the position of each municipality according to its exposure to coastal hazards (horizontal axis) and real estate prices (vertical axis), relative to the mean values for all municipalities (centre of the graph). For instance, Châtelaillon-Plage and Charron have the same level of exposure compared to the mean, but the former has higher property prices than the latter. See section above for the methodology.

38 This graph allows us to establish a typology of municipalities according to their profile in terms of coastal environmental inequalities.

39 When comparing this typology with adaptation practices, we note that:

- The dykes were built mainly in communes with a high coastal risk and a high level of property price (La Rochelle, Châtelaillon), where the owners are relatively well-off;

- The deconstructions (i.e. strategic retreat) were mainly carried out in the municipality of Charron, where the risk is high but the property price is low, and where the population is more modest.
- A hybrid case of dike and deconstruction was carried out in Aytré, where the risk is high and real estate price is expensive, but less so than in the first two communes above.

40 These first observations are only partial, but they indicate a tendency which is to protect the wealthiest populations and municipalities with dykes. Of course this is an initial approach that does not claim, at this stage, to systematically compare existing EIs and the adaptation strategies put in place in municipalities. It nevertheless allows us to state that our hypothesis is tenable and worth exploring further: coastal adaptation methods are not neutral in terms of environmental inequality.

Discussion

41 The literature on EIs highlights their importance in enabling territories to be more cohesive and therefore more resilient to climate change (see above). These IEs have a particular geographical configuration, especially along the coasts, where adaptation strategies need to consider the level of risk and the issues at stake in each part of the territory. However, the spatial quantification of IEs is a scientific challenge. We have tried to meet this challenge on the Charente channel coastline, using the environmental and socio-economic data available at different scales. However, this research has its limitations.

42 Firstly, the presence of second homes, which is particularly strong in attractive coastal areas, masks the socio-spatial patterns that are estimated by statistical data based on the place of main residence. Inequalities in access to coastal amenities are therefore difficult to identify, unless data on property prices is used. To overcome this difficulty, we have used a municipal breakdown to smooth out the trends calculated at the 200m grid level.

43 Secondly, the relationship between existing EIs and adaptation strategies needs to be further explored, and at this stage we have only provided partial illustrations. Moreover, its systematisation needs to add a qualitative approach complementary to the one presented here. Although the national legal framework has an egalitarian objective, it is implemented by local or inter-municipal authorities, which are not equal in their capacity for political action. For example, Harel, Long & Cornut (2024) reveal inequalities in the way municipalities deal with risk, both in terms of the types of measures taken and the speed with which they are implemented. And even at the individual level, this study suggests that residents are treated unequally, depending on whether they are protected by collective works or have to protect themselves individually with the help of subsidies.

44 Finally, our conclusions cannot be generalised at this stage. Although the selected coastal area is very diverse, it is nevertheless part of a specific regional and national context. As example, we find a similar case in Carry-Le-Rouet, on the Mediterranean coast, where districts along the coast are also occupied by wealthy households and are now exposed to the risk of erosion (Claeys *et al.*, 2017). However, Cazaux (2022) has shown that there is no relation between exposure to coastal risks and high land prices, which can inform about the presence of wealthy households. A generalisation would

require the study of other types of coastline in the French context as well as in other legal contexts of adaptation to risks.

Conclusion

45 The aim of this paper was to quantify EIs on the Charente coast and to assess the impact on them of adaptation strategies to submersions and storms. Our results show firstly that the attractiveness of the coast does indeed leads to higher property prices and that, from a residential point of view at least, there is a socially differentiated access to coastal amenities. Secondly, unlike in other geographical contexts, poor populations are no more subject to hazards than rich populations. Finally, it seems likely, at least at first glance, that adaptation strategies in coastal areas will accentuate existing EIs.

46 Adapting to climate change is not just a matter of civil engineering; it also requires an understanding of social, economic and political mechanisms, each of which has specific geographical patterns. Similarly to what Klinsky *et al.* (2017b) stated about the importance of equity for climate change policies, social cohesion will be decisive in enabling coastal areas to be more resilient in the future. Understanding environmental inequalities in coastal areas is therefore crucial if our societies are to adapt to rising sea levels and more extreme weather events.

*Acronyms

47 APPB: arrêté préfectoral de protection de biotope - prefectural order of biotope protection
BD TOPO IGN: topographic database from the National Geographic Institute
BRGM: Service Géologique National - French geological survey
CEREMA: Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (Centre for studies and expertise on risks, the environment, mobility and development)
DDASS: Direction départementale des affaires sanitaires et sociales - Departmental Directorate of Health and Social Affairs
DDTM17: Direction départementale des Territoires et de la Mer de Charente Maritime (17) - Departmental Directorate for Territories and the Sea for the Charente Maritime Department (nb17)
DGALN: Direction générale de l'Aménagement, du Logement et de la Nature - Directorate-General for Planning, Housing and Nature
DREAL17: Direction régionale de l'Environnement, de l'Aménagement et du Logement pour le Département de Charente Maritime (17) - Regional directorate for the environment, planning and housing for the Charente Maritime Department (nb17)
INSEE: Institut National de la Statistique et Etudes Economiques - The National Institute of Statistics and Economic Studies
SRCE: Schéma régional de cohérence écologique - regional ecological coherence scheme

ZICO: Zone importante pour la conservation des oiseaux - important area for bird conservation
ZNIEFF: Zone naturelle d'intérêt écologique, faunistique et floristique - natural area of fauna and flora ecological interest

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NOTES

1. In French "demandes de valeurs foncières (DVF)", http://doc-datafoncier.cerema.fr/dv3f/tuto/objectif_tutoriel

2. This classification was carried out by i) mapping the variable with a 5-class classification using natural breaks (Jenks); and ii) adapting these class limits in the histogram of values in relation to the deviation from the mean. This makes it possible to combine a deviation from the average *and* a grouping of municipalities with a similar profile. It should be noted that we validated this method by also carrying out another 5-class classification, visually, indicator by indicator. As both methods gave the same results, the automatic method, which is much less tedious, was retained and will enable us to reproduce it in our future research.

3. See MEDDTL/DGPR, 2011 (*op. cit.*) or the assessment carried out by the Ministry of Ecology.

4. See section above for the methodology.

ABSTRACTS

The presence of environmental inequalities (EI) is analysed empirically on the coast of Charente Maritime, France. The attractiveness of the coast has led to an increase in the price of land, limiting access to coastal amenities for the poorest parts of the population. Exposure to natural hazards is not, however, accentuated for these social groups, unlike in other contexts explored in the literature. In relation to strategies for adapting to coastal hazards after the Xynthia storm in 2010 (mainly the construction of dykes and the deconstruction of dwellings), this paper shows that, at first glance, existing EIs are reinforced: wealthy populations and municipalities are the first to be protected by dykes. Although empirical analysis remains a scientific challenge, the hypothesis that coastal adaptation methods are not neutral in terms of EI is tenable and worth exploring, because social cohesion is essential for greater resilience in the face of climate change.

La présence d'inégalités environnementales (IE) est analysée empiriquement sur le littoral de Charente Maritime, France. L'attractivité littorale provoque une augmentation du prix du foncier, limitant l'accès des populations les plus modestes aux aménités littorales. L'exposition aux aléas naturels n'est pas pour autant accentuée pour ces groupes sociaux, contrairement à d'autres contextes explorés dans la littérature. En lien avec les stratégies d'adaptation aux risques littoraux après la tempête Xynthia de 2010 (principalement des constructions de digues et déconstructions d'habitations), l'article montre qu'en première approche, les IE existantes sont renforcées, les populations et communes riches étant les premières protégées par des digues. Même si l'analyse empirique demeure un défi scientifique, l'hypothèse selon laquelle les modes d'adaptation littorale ne sont pas neutres en termes d'IE est tenable et intéressante à explorer, car la cohésion sociale est essentielle pour une résilience accrue face aux changements climatiques.

INDEX

Mots-clés: inégalités environnementales, littoral, stratégies d'adaptation aux risques, analyse spatiale, Charente Maritime
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AUTHORS

PIERRE CORNUT

Professeur, Faculté d'Architecture et d'Urbanisme, Université de Mons (UMONS)
ORCID 0009-0007-3562-228X
pierre.cornut@umons.ac.be

NATHALIE LONG

Directrice de recherche, UMR LIENSs, CNRS - La Rochelle Université
ORCID 0000-0002-7064-7278
nathalie.long@univ-lr.fr

CLÉMENTINE HAREL

Doctorante, UMR LIENSs, La Rochelle Université & Faculté d'Architecture et d'Urbanisme, Université de Mons (UMONS)
ORCID 0009-0004-2405-4289
clementine.harel@univ-lr.fr