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DETERMINANT FACTORS OF PROTECTIVE BEHAVIORS REGARDING EROSION AND COASTAL FLOODING RISK

Abstract

The increasing vulnerability of coastal areas to climate change and hazards has the authorities seeking the best way to protect the population. Because it is essential for citizens to contribute to their own protection, it is increasingly necessary to take their knowledge and perceptions into account. Two studies have been conducted to identify the factors that could explain protective behavior regarding coastal erosion and flooding risks: a qualitative study using interviews with 32 inhabitants of municipalities exposed to coastal risks, and a quantitative study using questionnaires with 237 participants exposed to coastal erosion (N = 116) and coastal flooding (N = 121). Thematic content and statistical analysis (multiple linear regression) have been used. The results indicate that flooding is considered a personal risk with heightened involvement, and thus necessitates personal action for self-protection. Erosion appears to be a collective risk, impacting all inhabitants, as well as being slower and easier to anticipate. The physical characteristics of the phenomenon will thus determine the dynamics and functioning of social knowledge on risk assessment and on the motivation to protect oneself.

Key words: Protective behavior; Coastal risk; Risk perception; Vulnerability indicator; Place attachment.

1. INTRODUCTION

Coastal risks, notably sea flooding or coastal erosion, remain poorly known in the perspective of how they are assessed by the general public and the type of protective or adaptive action envisaged (Flanquart, 2012; Idier et al., 2013). Research shows that the inhabitants of exposed areas tend to underestimate such risks (for example, see Michel-Guillou & Meur-Ferec, 2017). Yet these risks impact regions and populations, with significant economic issues also at stake. The increasing vulnerability of coastal areas to climate change and hazards is now clearly established (Adger, Hugues, Folke, Carpenter, & Rockström, 2005). It is also established that this vulnerability is exacerbated in towns that rely on tourism (Albers & Deppisch, 2013). Indeed, even if the expected rise in sea levels in 2100 is already worrying (Church & White, 2006), there are also high human and economic stakes in these areas

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(Meur-Férec, Deboudt, & Morel, 2008; Vinet, Defossez, Rey & Boissier, 2012). In addition to the expected rise in sea level, there is strong anthropic pressure on coastal areas, increasing the vulnerability of regions to coastal risks. In France, many measures have been implemented to improve the adaptation of coastal lands to climate change. The Civil Security Modernization Act of 2004 places the citizen at the heart of the security issue. This principle poses a dual challenge: ensuring that citizens contribute to their own protection by adapting their behavior, and developing a culture of risk preparedness. In this sense, it is increasingly necessary to take citizens' knowledge and perceptions into account.

Implementation of protective behavior in the face of coastal risks depends on the assessment of these risks and on the beliefs developed around them, particularly with regard to perceived control or effectiveness of the behavior (Terpstra, 2011). Indeed, we work on the basis that the nature of the risk is not the only parameter that determines the protective behavior of individuals exposed to coastal risk (Meur-Ferec et al., 2012; Hellequin et al., 2013). Variables specific to the event, such as its unpredictability or its temporality, and more importantly the perception and the feeling of control that the individuals experience, will explain the adoption or not of preventive or adaptive actions (Lemée et al., 2019; Navarro et al. 2016). In addition, objective or environmental factors are likely to explain these motivations for protection (distance from the defense structures, distance from the coastline, architectural characteristics of housing, for example) (Adger and Kelly, 1999), but individual or dispositional factors as well as variables linked to the social environment will also contribute to this protective behavior.

Based on these observations, our general objective is to identify the determining factors behind behavioral intentions for self-protection in populations exposed to coastal risks. Risk assessment will not necessarily lead to an action: it does not systematically produce protective or preventive behavior. Indeed, perceiving the risk, being aware of its existence, is not a sufficient factor, even though it is requisite, to generate adaptive behavior (Navarro et al., 2020a). A multifactorial, dynamic and contextualized approach is thus necessary: multifactorial, because the risk perception factor alone is insufficient to explain protective behavior. Other dispositional factors must be identified. Contextualized, because situational factors specific to the context will also determine these dispositional factors and *in fine* protective behavior. Dynamic, because these dispositional or situational factors will evolve according to the type of threat. Taking citizens' knowledge and perceptions into account is

becoming increasingly necessary in risk management. Inhabitants of coastal areas are constantly confronted with minor or major life events such as storms, erosion or flooding, which could be perceived as sources of threat and lead to emotional disturbances (Ray, Lindop, & Gibson, 1982). Such an effect is even reinforced in the case of vulnerable populations who are less able to cope with the risk and its consequences (Adger, 1999). ***Coastal flooding risk*** refers to a temporary flooding of the coastal area by sea in severe weather and tide conditions (Ramsay & Bell, 2008). This phenomenon is relatively rare but it is alarming and generally destructive as it results from the combination of extreme climatic phenomena (atmospheric depression, storms, etc.) and strong tides (Chaumillon et al., 2017). ***Coastal erosion risk*** can be considered as resulting from a negative sediment balance in the coastal system (Aubié & Tastet, 2000; Komar, 1983). Furthermore, it is necessary to highlight some possible differences between coastal flooding risk and coastal erosion risk. Indeed, until now, no research has examined how these two types of coastal risks, given their physical specificities, are assessed and managed by non-experts.

1.1. Factors influencing protective behavior: a concept map

In psychology, predictive behavioral models in general and models predicting protective behavior in particular can be identified. We drew on this literature, enriching it with specific knowledge of adaptation to environmental risks, and more precisely to coastal risks, in order to propose a concept map enabling us to meet our objective.

The Protection Motivation Theory (PMT, Rogers, 1975), for example, suggests that individuals will not be motivated to adopt protective behavior when the level of threat assessment is low. If the threat assessment is moderate or high, the implementation of protective behavior will depend on the evaluation of the action's efficiency. Thus, evaluating the action's efficiency as high will increase the individual's motivation to engage in behavior aiming to reduce the threat and protect themselves. The opposite situation will encourage ill-adapted behavior (fatalism or denial, for example) (Bamberg et al., 2017). The revision of the PMT (Rogers, 1983) incorporates self-efficacy expectancy (Bandura, 1977) as a cognitive mediating process. Self-efficacy theory maintains that all processes of psychological change operate through shifts in the individual's expectancies of personal mastery or efficacy (Bandura, 1982). Thus, this theory puts forward the existence of an assessment of the risk, of its severity or perceived vulnerability, i.e. risk perception, in the sense proposed by Slovic

(1987), as well as an assessment of perceived efficacy, which together explain the motivation to act, i.e. behavioral intention (Navarro et al., 2020a; 2020b).

Another classic model in psychology that also introduces the notion of behavioral intention is the Theory of Planned Behaviour (TPB, Ajzen, 1991). The TPB includes the concept of perceived behavioral control, which originates in self-efficacy theory (Bandura, 1977), itself stemming from social cognitive theory. Indeed, it is a theory which aims to predict intention and behavior. According to the TPB, the voluntary adoption of a certain behavior solely depends on the motivation of the behavioral intention. Ajzen (1991) identifies three specifiers of behavioral intention: attitude (efficiency and perceived behavioral satisfaction), subjective norms, and the perception of behavioral control (or the feeling of self-efficacy). In this model, behavioral intention is seen as the result of the assessment of the positive and negative consequences of the choice between behavioral alternatives, as well as the assessment of the perceived difficulty regarding behavior adoption and the reasons indicating a moral obligation for its executing it.

However, these models, which tried to highlight the factors that could influence motivation or resistance to adopting new protective behavior, turned out to be limited in that they give insufficient consideration to contextual aspects, whether physical or social (Moser, 2009). Hence we aim to fill the gaps of this conceptual framework in our study, with situational variables such as the physical characteristics of vulnerability (Chadenas et al., 2013; Mercier & Chadenas, 2012; Creach et al., 2015), and psychosocial variables, by taking into account social norm and trust in institutions (Portinga & Pidgeon, 2003; Siegrist, 2019), while trying to assess the explanatory power or the role played by these factors in understanding the possible adoption of protective behavior. A concept map is thus proposed, indicating the complexity of the factors which influence behavioral intention and, *in fine,* protective behavior (Figure 1).

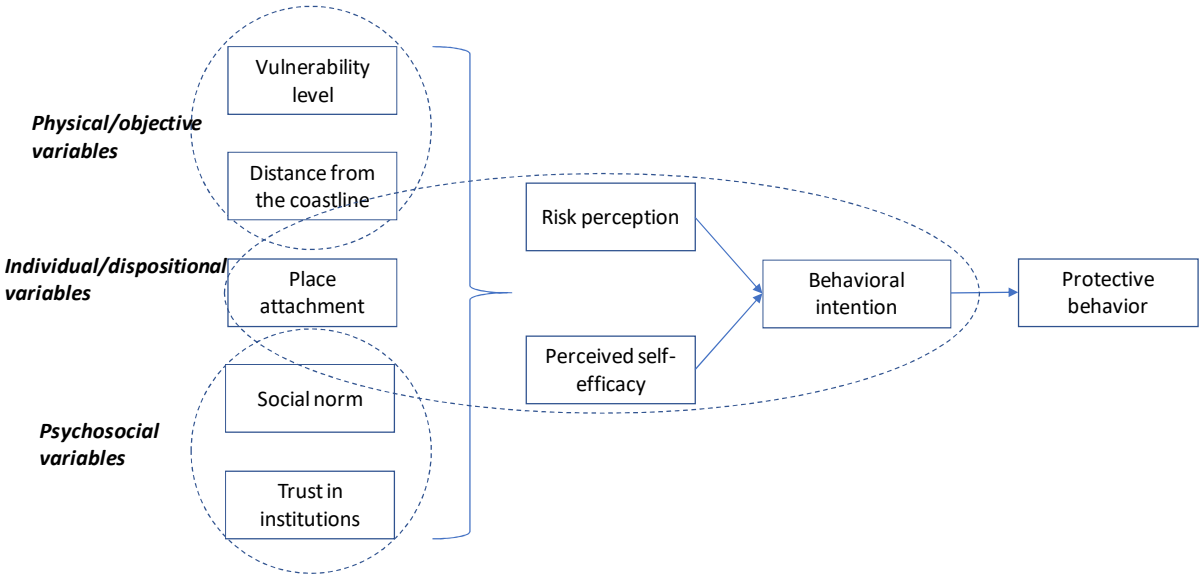

Figure 1: Concept map

Indeed, our concept map is formed of physical or situational variables, psychosocial variables, and dispositional or individual variables, repeated and grouping variables identified separately in the literature (Adger et al., 2005; Bamberg et al., 2017; Navarro et al., 2020a; Terpstra, 2011). The first variables refer to the physical or even objective characteristics of the environment, enabling the identification *a priori* of an intrinsic level of an individual's vulnerability. These characteristics refer to coastline distance, its nature (sandy, rocky), but also the type of housing, the altitude at which this housing is located, and the physical characteristics making it more or less vulnerable to risks (Chadenas et al., 2013; Creach et al., 2015; Robin, 2002). Psychosocial variables are also taken into account, such as social norm, or rather subjective norm, which refers to the social pressure that an individual perceives regarding the adoption or the non-adoption of a behavior (Lo, 2013). It is influenced by the individual's social circle (Ajzen & Fishbein, 1997). Likewise, trust in institutions, specifically governmental institutions, is an increasingly studied variable in research on risk evaluation (Poortinga & Pidgeon, 2003) or coastal risk management (Bertoldo et al., 2020). This variable refers to the level of trust shown in an institution, in its ability, its legitimacy and its competence to manage a risk. Trust is a mechanism that allows an environment's complexity to be reduced. It enables people to maintain their capacity to act in a complex environment: trust is needed to construct a more complex social environment and the importance of trust varies according to the risk and the social group (Siegrist, 2019).

Originating in classic psychology models, the aforementioned dispositional factors linked to behavioral intention such as risk perception (Slovic, 1987) and perceived self-efficacy (Bandura, 1982; Navarro et al., 2016) are also included in our conceptual model. According to the literature, place attachment is likewise a significant factor in coastal risk perception (Lemée, Fleury-Bahi & Navarro, 2019; Navarro et al., 2020a) and more broadly in environmental risk perception (Bonaiuto et al., 2016). Place attachment has also been identified as a variable with a fundamental role in the feeling of vulnerability in the face of risks (Michel-Guillou & Meur-Ferec, 2017; Navarro & Michel-Guillou, 2014) as it stems from the hypothesis that a place which is assessed positively contributes to a strong emotional awareness of belonging both to a place and to a localized group (Félonneau, 2003). The concept of place attachment refers to the subjective relation that individuals sustain with an environment (Moser, 2009) and may convey a positive emotional link with a place (Shumaker & Taylor, 1983; Low & Altman, 1992), thus leading the individual to remain spatially and temporally close to this place (Hidalgo & Hernandez, 2001). However, there is no consensus about its role in the relationship between environmental risk perception and coping behavior. Place attachment relates to reduced risk perception in some contexts and higher levels of risk perception in other cases (Bonaiuto et al., 2016). Studies have shown that place attachment diminishes environmental risk coping intentions when associated with high risk perception (De Dominicis et al., 2015). Other studies show that place attachment contributes to amplifying high probability risks and reduces the perception of low probability ones. These same studies also show that place attachment is associated with the "risk control" dimension. (Bernardo, 2013).

It is thus necessary to identify the role played by the above-mentioned factors, and recognized in the literature as being able to influence motivation and the adopting of protective behavior in the face of coastal risks such as flooding and erosion. Studies have shown that even though these two phenomena are generally analyzed together, they are not perceived or evaluated by inhabitants in the same way (Lemée et al., 2019). Knowledge, fear, or even the adaptive strategies mentioned by the individuals show that they are two very distinct phenomena, or that they refer to different assessment processes. This point is fundamental as it indicates that they cannot be managed in identical fashion, for the public will not process the information nor react in the same way for both risks. This is why we propose to analyze them separately, in order to compare and contrast them.

We are therefore seeking to identify the role played by the factors pinpointed in the literature as explanatory for the adopting or not of protective behavior when faced with coastal risks. We aim to identify this dynamic for both risks, handled separately as they each refer to a different physical and social reality, which can generate a differentiation in how they are understood and in the actions carried out. Two studies were thus conducted in order to identify the factors that could explain protective behavior regarding coastal erosion and coastal flooding risks:

- A qualitative study using interviews, seeking to identify the knowledge and judgments of the inhabitants exposed to coastal risks regarding these threats and their management. This study sought to update the psychosocial variables previously identified in the literature in this population, to observe their relevance and to clarify their knowledge of the protective behavior requiring to be implemented in the face of coastal risks.
- A quantitative study using questionnaires, seeking to test the role played by the variables identified in the concept map. Some of these variables were constructed ad hoc for this study using the results of Study 1, in particular the protective behavior scale, adapted to each type of risk (coastal flooding and erosion).

Both studies were carried out between 2018 and 2020, on the Baie de Bourgneuf, in areas at risk of coastal flooding and erosion in the Pays de la Loire, a region in western France. This particular area, stretching over a 400-km long coastline, was chosen because it is exposed to coastal flooding and erosion (see Figure 2) and is experiencing strong demographic pressure. Given this context, the dialogue between the different actors can be quite tense.

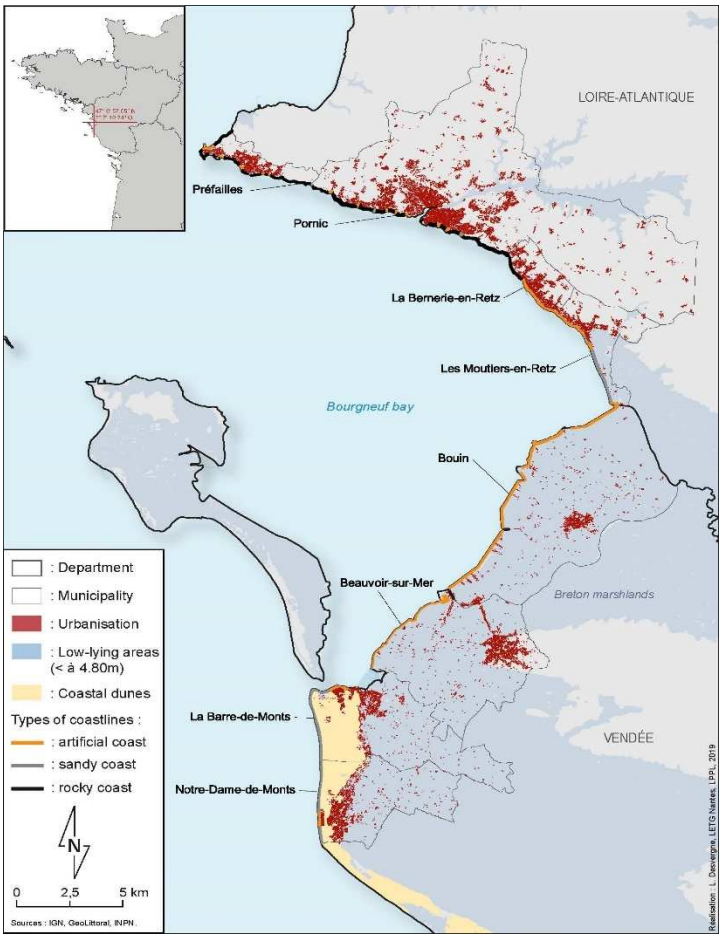

Figure 2: Site selection map

2. Study 1: Qualitative survey

Through a qualitative approach, the aim of this study was to identify the opinions, attitudes and beliefs regarding exposure, risk perception and adaptation to coastal flooding and erosion risks. This study seeks more precisely to identify the knowledge and opinions of the inhabitants of areas vulnerable to coastal risks on the protective behaviors to be implemented, their relevance and their interest. This content will be used to create a tool (scale) that can then be used in a quantitative study.

2.1. Method

2.1.1. Site selection and participants

In our research area, the sites were selected on the basis of the Coastal Risk Prevention Plan (CRPP), which defines various perimeters corresponding to different flood or erosion scenarios for each risk zone. On the basis of the areas which were identified (risk map in the CRPP), the inhabitants of the exposed neighborhoods were approached personally or through

a letter left in their letterbox. Once contact had been made and on a voluntary basis, an appointment was scheduled for the interview. 32 participants (mean age = 63 years, *SD* = 14; 62.5% of participants are male) were interviewed in their place of residence. All the participants were living within these risk areas at the time of data collection. Participants were recruited inside these risk areas and were therefore exposed to coastal flooding (n=19) for the towns of La-Barre-de-Monts and La Guerinière, and coastal erosion (n=13) for Saint-Hilaire-de-Riez. Most of the interviewees lived in their main residence (62.5%), which they own (81%). The participants have an average duration of residence of 24 years (*SD* = 21) in their town. Retired people compose 72% of the sample, which explains the high average age of our sample, knowing that they usually represent 45% of the population of the towns in Pays de Loire (Observatoire des Territoires, 2019), even though the average is 26.9 % in France, proving how attractive this coast is for this age group.

Table 1 – Demographic characteristics of sample study 1

	N=32	**%**
Gender		
Male	20	62.5
Female	12	37.5
Work situation		
In work	5	15.6
Retired	23	71.9
No answer	4	12.5
Level of education		
Elementary school	3	9.4
High school	11	34.4
French Baccalaureate	9	28.1
Undergraduate	1	3.1
Master's and above	8	25
Residence status		
Main	20	62.5
Second home	12	37.5
Inhabitant's status		
Owner	26	81.3
Tenant	6	18.8

2.1.2. Material and procedure

A semi-directive interview guide was elaborated. It tackled six main themes: residence area, relation to risk (erosion/flooding), protective behavior, risk management policies, climate change and socio-demographic information regarding the participants. The latter all signed a consent form which informed them of the study's objective and of their right to stop the

interview when they wished without giving any justification. They authorized the audio recording of the interactions. The interviews were fully transcribed and underwent a categorical content analysis (Bardin, 1996; Berelson, 1952), based on the thematic grouping of elements of responses collected during the interviews. After a first reading of the whole set of data, the interviewee responses were divided into units of meaning. These units were collected and classified by common topics, which belonged to thematic categories based on the interview guide.

2.2. Results study 1

2.2.1. Place of residency and categories of inhabitants

Place of residency is described in terms of advantages and drawbacks, thus expressing a certain place attachment according to different spatial levels:

- The individual and familiar level, and accommodation: the advantages mentioned describe places with fine scenery, a beautiful view, pure air, a peaceful place especially in the winter, with the sea and the beach nearby. Some participants chose the housing for health reasons. High residential satisfaction is reported. The drawbacks are identified as the damp, poor insulation and anxiety during the strong winter storms.
- The interpersonal level, the immediate surroundings, the neighborhood: the advantages once again are given as peacefulness, a feeling of security and soothing calm. The only drawback mentioned is the presence of large apartment buildings nearby.
- The collective level, the town: participants speak of a friendly, lively municipality, especially according to the interviewees living in second homes. Sea-related activities are a passion for most of them. The drawbacks cited are high taxes and the influx of summer holidaymakers.

Five categories of users of the coastal areas have been distinguished by the participants, according to their place identification and more broadly to their involvement in the life of the municipality:

1. The autochthons and their families, who perceive coastal risks as being familiar: they are used to them as they grew up with these risks and have experienced them throughout their lives.
2. The non-autochthons who have owned a home in the municipality for a long time and live there all year round, and who are more or less engaged in community life. Autochthons listen to them and accept them well.

3. The non-autochthons who have been homeowners for a long time but do not live there all year (second homes) and are not involved in community life.
4. The tenants and new homeowners (main residence) who engage in community life, but who consider that they have very little leeway.
5. The summer tourists who come to the area simply to enjoy themselves, many of whom damage the work accomplished during the year, but who make a major contribution to the region's wealth.

2.2.2. Relation to risk: regarding the risk and notably the feeling of vulnerability and risk awareness, differences emerge according to the type of phenomenon.

Erosion risk: Erosion risk is often unknown, and when it is known, it is considered as a global risk, generalized to all coastlines, temporally distant, gradual or evolving, affecting the homes which are closest to the sea. Even if the retreat of the coastline is acknowledged, there is no feeling of vulnerability. Participants consider this to be a rather normal and natural evolution which is not worrying as they see the erosion happening gradually: *"the sand gradually eats away at the land, the buildings keep getting closer, the rocks crumble and crack, it can get as bad as rockfalls"*. Some do not consider it as a risk. Some find the protection structures excessive. In sum, they do not worry about erosion risk per se but feel worried about the fact they could be forced to leave because of it.

Flooding risk: this risk is known to all the participants and is accepted, even if it is considered as dangerous, frightening, serious, worrying and unpredictable. Assessment of the extent of the damage that sea flooding could cause is linked to previous personal experiences or to the traumatizing experiences of acquaintances. This risk is global and generalized to all coastlines (which seems to diminish its impact). Furthermore, they believe it is a risk about which nothing can be done. They feel vulnerable but cannot identify any resources that will enable them to face it. It is inevitable but most of them view it as temporally distant, because some project it as happening in 100 years' time, and others in 50 years' time. The oldest participants do not imagine disasters happening in their lifetime. According to them, this is a risk that concerns future generations, but not them. They view flooding as remaining an exceptional event, with a low probability of occurrence. However, the powerful storms are frightening and trigger fear of an imminent disaster every time.

2.2.3. Level of information and role of the authorities: in terms of information, flooding risk is fairly well known, described and characterized, although often underestimated. Inversely, erosion risk is less well known and thus little evaluated.

Regarding flooding risk, there is knowledge of the basic information, the risk areas are identified, and the preparation and behavior to adopt should there be a flooding event is known. This stands in contrast to the risk of erosion, as participants say they have been given no information by the institutions. This risk is noted through the protection work implemented in the public space, visible in the modification of walking paths traced to protect the coastal cliff, forcing people to change their habits.

In general, year-round residents and homeowners are better informed about the risks than second-home owners and tenants. The information channels are mostly posters, municipal newsletters, or pamphlets available in the town hall. They consider that the information is not brought to them and there is not enough communication around this issue. They attribute this lack of communication to the fact that the municipal authorities do not wish to alarm the population (notably investors) or tourists (summer holidaymakers). Thus, according to them, the information is given or withheld according to the financial and economic stakes, especially as the period for communicating on the risk is carefully chosen. This manner of proceeding discredits the information and the institutions in charge of risk management.

However, some participants express a degree of trust in the information given, as well as trust in the authorities. This trust can be explained because *"it's their job, their role, their function, they tax us for this"*. Participants who trust in the authorities find them responsive: they consider that the modifications of land use are adapted and need to be maintained in order to cope with a disaster. In general, they are aware of the risk. Inversely, some are suspicious of the authorities as they consider that *"there are conflicts between the ecological and financial interests"*. They suspect a financial and economic logic to be hidden behind the coastal risk awareness campaigns, hence their strong resistance towards the institutions when protective and preventive behavior is suggested. Most of the participants assert that they are not informed of the financial aid available for risk adaptation.

2.2.4. Attitude, beliefs and protective behavior

Some participants, notably those who live in second homes, claim they feel strong social pressure in that the "others", i.e. the permanent residents or those who were born in the region, do nothing to prevent or protect themselves from the risk. The latter assert that if the risk has not yet appeared, this means it will not appear, notably regarding flooding: *"there has*

never been a flood here, it happens more in other towns". In their view, flooding remains unlikely. Regarding erosion risk, some consider that the problem can be avoided, that one can see the risk coming and it can be remedied.

Regarding the implementing of adaptive or protective behavior, the tendency is to minimize or trivialize the risk in order to minimize the need to adapt or act. Some interviewees mention resistance toward building coastal protection structures or even resistance to adopting preventive behavior. Overall, we note a delegation of responsibility to the insurance companies, the local authorities, or even the state's institutions, for respondents consider it to be these instances' duty. A form of incredulity and risk denial is observed in certain participants, homeowners and those born in the region. The autochthon category (the oldest) say that they are not consulted by the authorities, even though they know the sea and the region better than anyone else.

When protective behavior is mentioned, most participants describe behavior that is environmentally friendly or aims to limit climate change. They refer to a sort of environmental awareness and the adopting of behavior such as sorting waste, zero-waste consumption, collecting waste on the coast, no packaging, etc. Preventive and protective behavior regarding the risk refers to preparing a survival kit, an evacuation plan in the event of an alert, adapting the home (bedding upstairs), buying a boat, actively seeking information on the behavior to adopt in the event of an alert (such as going upstairs or going to one of the highest points in the municipality), making the recommended structural modifications (adding a skylight, building another floor and/or a shelter room), individual actions of reinforcing rip-rap, collective actions with volunteer associations, and respecting the local authorities' instructions (not walking on the dunes or the cliffs).

2.3. Synthesis of results of Study 1

Generally speaking, participants feel more exposed to the risk of flooding than they do for erosion, even if they live in an erosion-risk area. A distancing from the danger can be observed for both types of risk. This distance is spatial as well as temporal, and even psychological through minimization or denial and the illusion that erosion risk remains stable. While there is a feeling of control regarding erosion risk, owing to the maintenance of protective measures which make the risk "visible", a total lack of control is observed regarding a potential flooding event, with the individuals waiting for it to happen in order to face it and repair the damage. Regarding flooding risk, the youngest participants show anticipation of the negative consequences, which generate fear or anxiety and a feeling of lack

of self-efficacy. They avoid thinking about it and organize themselves so as to evacuate rapidly should there be an emergency.

This feeling of vulnerability is more present in inhabitants of the zones at risk of sea flooding, and is on the contrary very reduced for the inhabitants of the erosion-risk zones. The events' natural causes enable respondents to give meaning to such events, because "nature is too strong", or "nature reclaims its rights". Other explanations are linked to "God's will" or even claim that climate change is a "natural evolution". These explanations originate in a weak feeling of self-efficacy or from a form of fatalism, identified in the majority of participants.

Nonetheless, some mention human-related causes, and an attribution to an internal locus of control can be noted, explaining the adopting of forms of ecological behavior on a personal level in the form of a subjective norm linked to "ecological awareness". However, responsibility is fundamentally delegated to the experts and elected politicians who give planning permission for flood-risk zones, and to public policies, institutions, and insurance companies.

3. Study 2: Quantitative survey

3.1. Method

3.1.1. Site selection and participants

The data was obtained from a quota sampling of 237 participants (mean age = 58; *SD* = 16), divided into two sub-samples: exposed to coastal erosion (N = 116) and exposed to coastal flooding (N = 121) (Table 2).

Table 2: Number of participants per municipality

	Erosion	Flooding	Total
Beauvoir-sur-Mer	-	32	32
Bouin	-	11	11
La Barre-de-Monts	-	25	25
Préfailles	21	-	21
La Bernerie-en-Retz	28	-	28
Les Moutiers-en-Retz	8	7	15
Notre-Dame-de-Monts	31	25	56
Pornic	28	21	49

The participants were recruited directly at home (c.f. Study 1) or at their workplace, but always in areas considered vulnerable to coastal risks according to official documents (risk maps). They signed an informed consent form and the average response time was about 30

minutes. The participants have an average duration of residence in their town of 21 years (*SD* = 20). 64% of participants are female (see Table 3).

Table 3 – Demographic characteristics of sample study 2

	Erosion		Flooding	
Age	M = 59; *SD* = 14		M = 58; *SD* = 18	
Average duration of residence in their town	M = 22.6; *SD* = 19		M = 20; *SD* = 21	
	N=116	**%**	**N=121**	**%**
Gender				
Male	48	40.5	37	30.6
Female	68	58.6	83	68.6
Work situation				
Working	58	50	61	50.4
Retired	49	42.2	53	43.8
Not working	9	7.8	7	5.8
Status of residency				
Main	83	71.6	114	94.2
Second-home owner	33	28.4	7	5.8
Inhabitant's status				
Owner	98	84.5	98	81.0
Tenant	18	15.5	22	18.2

3.1.2. Measures

Based on the concept map (Figure 1), we propose an assessment for each variable:

Assessment of protective behavior: a scale measuring the respondents' tendency to adopt protective behavior for themselves and their housing was built for each of the phenomena. Based on the results of Study 1 and official documents, we identified a certain number of types of recommended protective behavior. Participants responded to six items (for example, "I make the structural changes in my place of residence" or "I'm considering leaving my housing") on a five-point Likert scale ranging from "never" to "always". This variable measures declarations of behavior. There is no verifying of whether or not the behavior was indeed adopted.

Physical or situational variables:

- *Vulnerability level:* a vulnerability indicator was calculated on the basis of an approach of linking coded objects (Robin, 2002). Thus, by intersection and union of levels of information and weighting, it is possible to create risk models that can be spatialized. We used a multi-criteria approach whose main aim was to identify the residences of the respondents by using GPS points, as they lived in areas of diverse vulnerability. A certain

number of variables were chosen and formalized: coastline evolution, presence in a flooding and/or erosion zone, potential water depth, duration of presence in a flooding and/or erosion zone, the residence's architectural type and distance from the coastline if there is no defense structure, or the distance from a protection structure. Each variable is coded, which enables the calculation of a vulnerability indicator ranging from 1 to 10, i.e. from very low to very high.

- *Distance from the coastline:* this variable was analyzed independently from the other variables of psychological vulnerability, as it has been shown to have a strong explanatory capacity regarding coping strategies (Navarro et al., 2020a, 2020b). The intention was to test it independently from the others. A GIS (geographic information system) analysis was used to measure distance from the sea through recording the distance in meters between the place of residence (GPS coordinates were recorded when the survey was carried out) and the coastline.

Psychosocial variables:

To examine these two variables, we did not find a specific scale, thus we proposed scales constructed *ad hoc* on the basis of the results of Study 1.

- *Subjective social norm*: Participants answered five items (for example, "the people who are important to me would recommend that I adapt to the flooding/coastal erosion risk") on a five-point Likert scale according to their level of agreement. Some items are adapted to each type of risk.
- *Trust in institutions*: the participants were questioned about their level of trust (with a five-point Likert scale ranging from "no trust at all" to "absolute trust") in five institutions or organizations: the French state, the grouping of local councils, the municipality, scientific experts and resident associations. The questions regarded these instances' role in protection against coastal risks.

Dispositional variables:

- *Behavioral intention:* To examine this variable, we did not find a specific scale, which is why we proposed a scale on the basis of the results of Study 1. A behavioral intention scale was proposed, with five items indicating a certain wish or motivation to act towards protecting oneself from the risks. For each item (for example, "I intend to modify my environment to avoid a disaster"), participants answered on a five-point Likert scale ranging from "most probably not" to "most probably yes".

- *Coastal flooding and coastal erosion risk perception:* This is a psychometrically validated scale which contains 14 items measuring risk perception of coastal flooding or coastal erosion (Lemée et al., 2018). For every item (e.g. "People living in coastal flooding/erosion risk areas will be exposed to increasing risk of flooding", "I am worried by the coastal flooding/erosion risk I am exposed to"), the participants were asked to identify their degree of agreement on a five-point scale.
- *Perceived self-efficacy:* we used a French adaptation (Navarro et al., 2020a) of the scale proposed by Navarro et al. (2016) for flood risk. For every item (for example, "My possibilities of action regarding coastal flooding/erosion are very significant"), participants were asked to measure their degree of agreement on a five-point scale.
- *Place attachment scale* (Hernández, Hidalgo, Salazar-Laplace & Hess, 2007; Hidalgo & Hernández, 2001). For every item (for example: "I feel at home in this neighborhood"), the participants were asked to identify their degree of agreement on a five-point scale.

3.1.3. Data analysis

Descriptive analyses were conducted together with analyses verifying the internal reliability and validity of the measures (Cronbach's alpha and a factor analysis of the principal components, notably). Next, once the reliability of the scales was confirmed, four models of multiple linear regression were created. Each model corresponds to a dependent variable (DV), hypothetically explained by a series of independent variables (IV). It is in fact an exploratory analysis of the various variables that can *in fine* explain protective behavior. The links between the variables are not proved in the literature, but assumed. In this sense, the aim is to test different prediction links between the variables in order to empirically identify links that can be explained theoretically, for two different risk objects. This is a statistical tool normally used to study multidimensional data. For exploratory work such as ours, the progressive methods are adapted. We used the structured analysis method as it is less likely to make type II mistakes. The objective is to identify the explanatory power of the independent variables on the dependent variable, when they are analyzed simultaneously. In other words, the aim is to assess the overall explanatory power of the model as well as the influence of the variables in order to identify those which will prove to be the most pertinent. Four indicators are observed: assessment of the quality of the model with a variance analysis (ANOVA) and its F value; assessment of the adjustment and variance explained by the model (R^2); the autocorrelation test or error independence test, verified with the Durbin-Watson statistic for

which a value close to two indicates an absence of correlation; and lastly, assessment of the regression equation parameters, taking into account the standardized beta value (β) and its significance.

3.2. Results for Study 2

3.2.1. Descriptive analyses and reliability

A reliability analysis was carried out for each scale, including those which had already been validated in the scientific literature. A factor analysis of the principal components was used for the scales built for the purpose of this study. Table 4 presents the descriptive data and the reliability test (Cronbach's Alpha) of each scale.

Table 4: Descriptive analyses and reliability

	Coastal erosion risk (N=116)			Coastal flooding risk (N=121)		
Variable	M	SD	α	M	SD	α
Protective behavior	1.62	.649	.65	1.86	.688	.72
Behavioral intention	2.47	1.056	.74	2.28	1.187	.80
Risk perception of coastal flooding/erosion	3.47	.583	.79	3.59	.720	.79
Perceived self-efficacy	2.35	.967	.76	2.26	1.024	.77
Place attachment	3.95	.741	.92	3.94	.941	.94
Subjective social norm	3.26	1.020	.89	3.22	1.061	.89
Trust in institutions	3.47	.752	.65	3.40	.985	.72

3.2.2. Regression analysis

Four models of multiple linear regression were created. Each model corresponds to a DV that can be explained by a certain number of IVs. There are four DVs. Protective behavior is predicted by situational variables (level of vulnerability and distance from the coastline), by dispositional variables (behavioral intention, risk perception, perceived self-efficacy and place attachment) and finally by psychosocial variables (subjective norm and trust in institutions). The second DV is behavioral intention, which is predicted by the situational variables and the other dispositional variables, as well as the psychosocial variables. The third DV is perceived

self-efficacy, predicted by the situational variables, place attachment as well as psychosocial variables. Finally, the DV "risk perception" is predicted by situational variables, place attachment and the psychosocial variables.

Firstly, the results show that the four models are of good quality as the ANOVA is significant. Then, we note that for the first two DVs (protective behavior and behavioral intention), the explained total variance is relatively low (24% and 27%, respectively), but it improves for the other two DV variables (37% and 46%, respectively) for coastal erosion risk. We observe the opposite effect for coastal flooding risk (61% and 32% for the first DVs and 24% and 27% for the other DVs). The error independence test or Durbin-Watson test indicates an absence of correlation as each model's value is close to two, corresponding to what was expected. Finally, the results show which variables have a capacity to predict DVs, when their beta (β) is significant. This result enables us to identify the pertinence of these variables, as well as the differences for each phenomenon or risk under study.

Indeed, a result which highlights this difference is the absence of a predictive effect of the situational variables on protective behavior, on the intention to act or even on risk perception in the case of sea flooding. On the contrary, these same variables play a significant role in the explanation of behavioral intention, perceived self-efficacy as well as risk perception in the case of erosion. The greater the vulnerability, the more the inhabitants of the erosion-risk areas develop a feeling of self-efficacy as well as the intention to act to protect themselves, with this intention being a possible explanation for behavior, according to the theoretical hypothesis. Still regarding erosion, this feeling of self-efficacy is predicted not only by the situational variables but also by the dispositional variables such as place attachment. It is also explained by the subjective norm, and the variable of "trust in institutions" plays no role in this dynamic. To summarize, protective behavior in the face of coastal erosion risk is explained by all of the variables proposed, whether they are situational, dispositional or psychosocial. Risk perception and perceived self-efficacy could play an intermediate role between the situational variables and the intention to act, with the latter playing a mediating role between these variables and behavior (see Figure 3).

Table 5: Multiple Linear Regression Analysis

		Coastal Erosion (N=116)							Coastal Flooding (N=121)						
Variables to predict (IV)	Predictive variables (DV)	*R*	R^2	ΔR^2	*F*	DW	β	t	*R*	R^2	ΔR^2	*F*	DW	β	t
Protective behavior		.49	.24	.18	3.95***	2.13			.78	.61	.53	7.76***	2.02		
	Distance from coastline						.10	.94						.08	.56
	Vulnerability indicator						.02	.25						-.02	-.11
	Place attachment						.11	1.11						-.11	-.90
	Risk perception						-.09	-.76						-.11	-.97
	Perceived self-efficacy						.15	1.32						.28	2.58**
	Behavioral intention						.43	4.26***						-.16	-1.42
	Subjective social norm						-.03	-.23						.32	2.35*
	Trust in institutions						.06	.62						.56	4.91***
Behavioral intention		.53	.27	.22	4.89***	1.94			.57	.32	.21	2.76**	1.98		
	Distance from coastline						.18	1.85						.04	.21
	Vulnerability indicator						.18	2.00*						-.15	-.77
	Place attachment						.016	.158						-.04	-.25
	Risk perception						.40	3.62***						..03	.18
	Perceived self-efficacy						.13	1.19						-.09	-.65
	Subjective social norm						.05	.43						.59	3.80***
	Trust in institutions						.02	.16						.01	.04
Perceived self-efficacy		.62	.37	.35	12.84***	1.92			.49	.24	.16	3.09*	1.90		
	Distance from coastline						.33	4.08***						-.18	-.93
	Vulnerability indicator						.19	2.46*						-.31	-1.63
	Place attachment						.19	2.34*						.08	.56
	Subjective social norm						.44	5.27***						.32	2.729*
	Trust in institutions						-.01	-.22						.19	1.34
Risk perception		.68	.46	.43	12.76***	2.11			.52	.27	.20	3.60**	2.01		
	Distance from coastline						.31	3.86***						-.17	-.92
	Vulnerability indicator						.11	.14						-.18	-.96
	Place attachment						.05	.64						-.10	-.75
	Subjective social norm						.46	5.59***						.47	3.44**
	Trust in institutions						.05	.46						.09	.07

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. DW: Durbin Watson test.

In the case of inhabitants exposed to flood risk, not only do the situational variables have no determining role regarding motivation or protective behavior, as has just been observed, but the dispositional variables explain neither this intention to protect oneself nor even the types of behavior. The feeling of self-efficacy alone predicts protective behavior, which corresponds to the theoretical hypotheses. In the case of flooding, the psychosocial variables are those that play a fundamental role in predicting behavior, as the subjective norm could explain not only risk perception and self-efficacy but also the intention to protect oneself and protective behavior, in a direct manner. This is also the case for trust in institutions, which directly explains protective behavior. In other words, the more sensitive individuals are to the social pressure to adopt protective behavior and the more they trust the institutions, the more they will try to establish such behavior to protect themselves from sea flooding.

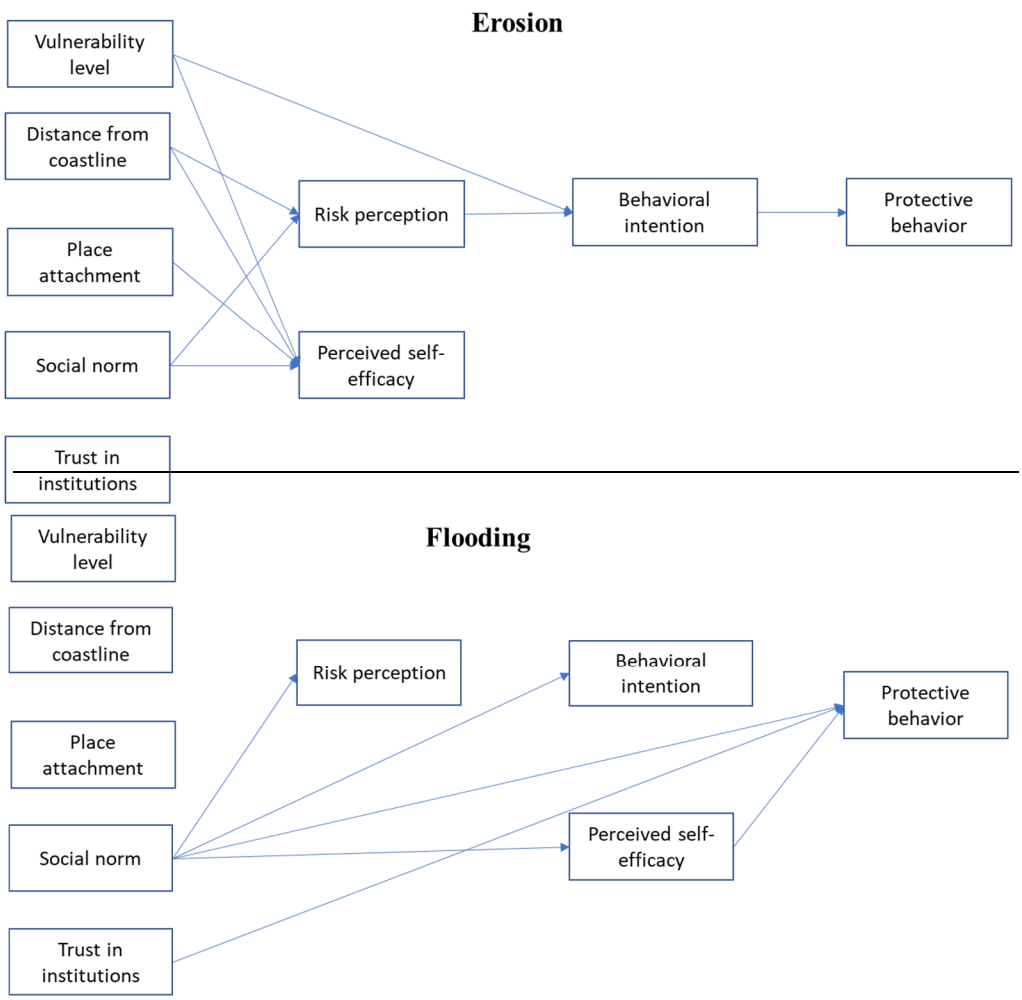

Figure 3: Synthetic map of the significant relations (regression analysis)

4. Discussion

This article proposed to identify the role played by a certain number of variables, identified in the literature as able to have an influence on how coastal risks are assessed by the at-risk inhabitants, and more particularly on the types of behavior identified and established to protect oneself from erosion and sea flooding. These various factors, of different epistemological nature, are proposed by researchers who work in different disciplines but who are interested in the same objects of study. Independent studies, notably in geography or psychology, give an incomplete perspective each time. This work was conducted with an objective of interdisciplinary complementarity, combining these different factors. This work also combined qualitative and quantitative approaches, as well as geospatial modeling in order to lead to a crossing of the physical or situational factors and the psychological and/or psychosocial factors. These variables were built in such a way as to enable the testing, with an exploratory aim, of the predictive capacity of these variables on intention and protective behavior.

A second important element to retain is the pertinence or even the necessity of handling these two phenomena separately, so as to analyze each of them in their physical and social specificities. Certain studies have shown the impact that the nature itself of the phenomenon, the characteristics of the hazard, has on its assessment by non-expert individuals, thus justifying differentiated analysis (Lemée et al., 2019). Indeed, invariant factors influence the feeling of vulnerability, risk perception, the feeling of self-efficacy (Navarro et al., 2020b), or even risk awareness, which is considered as a predictor of protective behavior, as well as environmental identity or the relationship to nature (Ivčević et al., 2020). This distinction was observed to be pertinent in our study as, from the viewpoints of social knowledge, of vulnerability assessment or adaptive strategies, these are indeed two distinct objects that rely on different processes and correspond to different psychosocial dynamics. Indeed, regarding risk assessment, risk perception or the feeling of vulnerability that coastal flooding provokes, such an event appears to be a well-known risk which generates feelings of fear, whereas erosion remains poorly known and does not necessarily trigger very extreme worry, according to the results of the qualitative study in particular. Flooding is experienced as a more personal risk, with heightened involvement, and thus necessitates personal action for self-protection. Participants describe a sudden risk, which is therefore harder to assess or anticipate. Erosion, however, appears to be a more collective risk, impacting all inhabitants, as well as being

slower and easier to anticipate. This could explain that the objective situational variables linked to structural vulnerability play a role in this case, contrary to flooding. In other words, according to the respondents, erosion is a slow, collective phenomenon that can be anticipated, whereas flooding is a sudden phenomenon necessitating urgent management and which is not easily anticipated.

The physical characteristics of the phenomenon will thus determine the dynamics and functioning of social knowledge on risk assessment and on the motivation to protect oneself. However, the implementation of protective behavior is related more to perceived indicators, such as distance to the sea, rather than to actual physical vulnerability. Other work in this direction has highlighted that physical vulnerability is linked to the intention to carry out protective behavior. The presence of a defense structure against coastal flooding could be considered as a visual cue and be a good predictor of the willingness to carry out protective behavior. On the contrary, people in the most vulnerable situation do not demonstrate a higher level of willingness to adopt protective behavior, just as participants who live in residential buildings have demonstrated a lower level of willingness to adopt such behavior. Therefore, housing vulnerability is not seen as a criterion that encourages participants to better protect themselves (Lemée et al., 2020).

The suggested theoretical model, inspired from the protection motivation theory (Rogers, 1975) and the theory of planned behavior (Azjen, 1991) proposes that the intention or motivation to protect oneself, to act, is the result of upstream variables and mediates the adopting or not of this behavior. This logic is clearly observed in the case of erosion but not for flooding, which corresponds to the theoretical expectations in terms of attitude (Ajzen and Fishbein, 1997). However, behavior is mostly explained by social variables or variables linked to the influence of others on behavior. On the one hand, the process which emerges for erosion is fundamentally related to the more individual or dispositional factors, such as risk perception or even place attachment, while remaining influenced by the inherent or objective conditions of the exposure to risk. On the other hand, regarding perception of flood risk, motivation and protective behavior are fundamentally determined by social pressure and the role of the institutions responsible for managing flood hazard, institutions in which the respondents show strong trust (Bertoldo, et al., 2020). In no way is flood risk sensitive to vulnerability conditions, maybe since it is considered as “exceptional”, contrary to erosion which is sometimes even considered as “progressive” (Study 1). In the case of flooding,

behavior may mostly be linked to social pressure and to the urgent nature of the latter. These results highlight the limits of the theoretical models used, as behavior might not systematically be the result of an assessment process, nor directly linked to a form of motivation forming an intra-individual or dispositional level in the individual (Maddux & Rogers, 1983). However, these results enable the reinforcement of the idea that these models for explaining protective behavior should integrate further the influence of the physical and social context within the explanation of this behavior (Moser, 2009). Motivation mediation is not systematically necessary. It can be pertinent and adaptive for certain types of behavior or situations, but not necessarily for other situations in which behavior could be directly influenced by the social and material environment.

From a qualitative viewpoint, the two phenomena are considered as "natural" and "common to all coastlines", or in other words, as "normal" for this type of region. This is a common characteristic of the non-expert's risk assessment. However, the dynamics of each phenomenon and the stakes in terms of management, adaptation, or even protection of the populations, are different. Indeed, the participants have integrated this to a very great degree, which explains why the model does not function in the same way or why the explanatory variables are not activated in the same manner. An element which we did not take into account and which could be considered as a limit to our study is the temporal perspective (Guignard, Bertoldo, Goula, and Apostolidis, 2015), because each phenomenon evolves differently and corresponds to a different timescale in terms of social knowledge. For future studies, this temporal perspective needs to be integrated in order to make a detailed observation of the role of this temporal conception of phenomena on the feeling of vulnerability and on adaptive strategies. This element would be all the more pertinent to analyze as the distinction made between the two types of risks by the respondents can be linked to the fact that Storm Xynthia (February 2010) impacted the coast under study and that the various institutions responded and are still suggesting adaptations today, while coastline erosion has failed to mobilize the region in the same way over the same timescale. Another possible limit of our study regards the sampling of Study 2, as the analyses, although satisfactory, did not enable us to conduct more complex analyses such as path models or structural equation models, which necessitate a greater number of participants. However, our analysis gains in quality as we targeted participants living in the at-risk zones, a population with awareness of the subject of our research. This makes data collection harder as the number of respondents is lower. Future research should broaden the quantitative samples in

order to carry out more thorough analyses and validate our theoretical model. Finally, this work should also integrate a section dedicated to risk communication, or more concretely to the analysis of the perceptions and knowledge of the inhabitants of the risk-prone areas regarding the official documents on coastal risks and notably the usage of risk maps. Indeed, this aspect is still little studied and could lead to indications as to how individuals understand official information, and how that influences motivation to protect oneself. Research in this direction is underway.

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Annex 1: scales created specifically for this study

Assessment of protective behavior:

Erosion	Flooding	Never/always
1. I make structural changes to my residence	1. I make structural changes to my residence	1 2 3 4 5
2. I plant trees and/or marram grass	2. I take part in evacuation drills	1 2 3 4 5
3. I place rip-rap around my house	3. I reinforce the defense structures surrounding my house	1 2 3 4 5
4. I reinforce the rip-rap around my house	4. I keep my valuable objects high off the ground	1 2 3 4 5
5. I respect the authorities' guidelines regarding defense structures	5. I identify an elevated location in the municipality	1 2 3 4 5
6. I am considering moving out of my accommodation	6. I stock drinking water and food	1 2 3 4 5

Subjective social norm

	Strongly disagree/ Strongly agree				
1. The people who are important to me would recommend that I adapt to the risk of erosion	1	2	3	4	5
2. The people who are important to me should adapt to the risk of erosion	1	2	3	4	5
3. If I adapt to the risk of erosion, the people who are important to me will also adapt.	1	2	3	4	5
4. The other inhabitants would recommend that I adapt to the risk of erosion.	1	2	3	4	5
5. The other inhabitants should adapt to the risk of erosion.	1	2	3	4	5

Trust in institutions

	no trust at all				absolute trust
1. French state	1	2	3	4	5
2. local councils	1	2	3	4	5
3. the municipality	1	2	3	4	5
4. scientific experts	1	2	3	4	5
5. resident associations	1	2	3	4	5

Behavioral intention

	most probably not				most probably yes
1. I intend to modify my environment in order to avert a disaster	1	2	3	4	5
2. I intend to set up my own prevention plan	1	2	3	4	5
3. I intend to fix objectives for myself	1	2	3	4	5
4. I intend to participate more in civil prevention activities	1	2	3	4	5
5. I consider myself capable of following a prevention plan	1	2	3	4	5