



# Factorial structure of the coastal flooding risk perception and validation of a French coastal flooding risk evaluation scale (CFRES) for non-experts



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## ABSTRACT

In a worrying context of increased coastal risks, we chose to determine the risk perception structure and validate a specific scale for coastal flooding using structural equation modeling and model comparison. The questionnaire is inspired by previous works on psychometric paradigm. Four principal environmental risk perception factors were isolated. This factorial structure was then confirmed in a cross-validation applied to a second sample of 291 participants plus a third sample of  $n = 315$ . Finally, a model comparison was performed to confirm the existence of a second-order factor “Risk Perception”. Primary results about risk perception are consistent with the existing literature: even if inhabitants of areas at risk of coastal flooding are aware of this risk, they feel little concerned by this risk for themselves and do not implement means of protection, even if they make a pessimistic assessment on a broader scale and for others.

## 1. Introduction

Environmental risks are a special category within the risk study because of their particular characteristics: most of them are unpredictable, as difficult to discern and to predict on a temporal and geographical scale (Fleury-Bahi, 2010). Moreover, they do not only threaten the said place of risk but also larger areas (regions, countries, the world) (Beck, 2013). Moreover, non-experts cannot assess environmental risks merely through the senses. It is therefore impossible to rely on an experience or a concrete perception of risk (Peretti-Watel, 2010). Information needs to be gathered about the risk to mentally reconstruct it (Gattig and Hendrickx, 2007).

Indeed, scientific knowledge of risk does not guarantee the adoption of adapted behavior to deal with the threat (Vanderlinden et al., 2017; Weiss et al., 2011). Among non-experts, this conceptualization is at least partly made in terms of affect, feelings and values (Chauvin, 2014; Vanderlinden et al., 2017). Thus a good understanding of these non-experts' perceptions is necessary to adapt the measures taken to face the risk (Goeldner-Gianella, 2007; Weiss et al., 2006), in order to avoid any misunderstandings or rejections of public policies by inhabitants (Goeldner-Gianella, 2007; Roca et al., 2011). Previous research have

sought to determine how coastal flooding risk is perceived by stakeholders in areas at risk, or how they perceive risk management policies (Costas et al., 2015; Goeldner-Gianella, 2007; Michel-Guillou and Meur-Ferec, 2016; Roca et al., 2011; Schmidt et al., 2013) but they rely mostly on qualitative approach. On this point precisely, social psychology allows us to better understand the phenomena that underlie the perception of risk and its management by individuals. Indeed, it is crucial to identify more accurately public's perception of coastal risks to develop better communication methods, improve public knowledge and behaviors and avoid systematic rejection of risk management policies (Goeldner-Gianella, 2007; González-Riancho et al., 2015).

### 1.1. The psychometric paradigm of risk

In traditional models, risk assessment is considered as a complex process which requires an understanding of the complexity of the environment in order to make a risk assessment. Risk is then considered as an equation whose aim is to maximize earnings and minimize losses in order to account for the dangerousness of investments (Cadet and Kouabénan, 2005; Leneveu and Laville, 2012; von Neumann and Morgenstern, 2007). These models are unable to account for how non-

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expert individuals perceive risk because they do not take into account how individual factors will affect risk assessment (Chauvin and Hermand, 2006). Faced with these obvious limitations (Sowby, 1965; Starr, 1969), the psychometric paradigm makes it possible to comprehend the way non-experts evaluate a risk – which we consider generally as a “naive” risk assessment (Chauvin, 2014).

Developed in the 1970s and 1980s by a team of researchers led by Slovic, the objective of the psychometric approach of risk is to account for the “complex and subtle” (Chauvin and Hermand, 2008, pp. 345) opinions of non-experts on modern risks that are complex, imperceptible and difficult to predict (Fischhoff et al., 1978).

The psychometric paradigm seeks to quantify individuals' subjective opinions about risks (Slovic, 1987). Initially, these different evaluations were compared with the risk properties (risk status, associated benefit, number of deaths, etc.), which allowed the establishment of a factorial risk structure - that is to say a “cognitive map” of risks (Slovic, 1992). On the other hand, such analyzes had also made it possible to establish personality profiles of risks, which were useful for explaining and predicting individuals' responses to risks (Slovic, 1992).

Furthermore, these works led to the identification of three “higher order” factors (Chauvin and Hermand, 2008, pp. 357) which would explain how risks are perceived: the fear inspired into individuals by the risk, knowledge of risk and perceived risk exposure. The extent to which the risks would be assessed on these three characteristics (Fear, Knowledge and Risk Exposure) would explain most of the risk assessment variability (Slovic, 1992). Many research studies have used the psychometric paradigm so far and “it has virtually always been possible to demonstrate that the factor structure is fairly invariant” (Sjöberg et al., 2004, pp. 16) even if the risk characteristics identified by the psychometric paradigm are not necessarily universal (Sjöberg et al., 2004).

According to this approach, therefore, risk can be understood as a multidimensional concept based on psychological, social, cultural and political dimensions. These dimensions and their interrelations are measurable and quantifiable (Fischhoff et al., 1978; Slovic, 1987). However, whilst the literature on the psychometric paradigm is abundant, there are no risk perception scales available specifically dedicated to an environmental risk context, or a scale that would present a simple and easily adaptable structure.

### 1.2. Coastal flooding risk

Coastal areas are small spaces with a high concentration of various vulnerabilities. Not only are these areas exposed to coastal risks but there are also strong human and economic stakes (Lins-de-Barros, 2017; Meur-Férec et al., 2008; Vinet et al., 2012). However, it seems that the absence of major coastal flooding events since the beginning of World War II has resulted in the loss of knowledge of coastal flooding risks amongst inhabitants (Chevillot-Miot and Mercier, 2014).

The phenomenon of coastal flooding can be defined as “a temporary flooding of the coastal zone by sea in severe weather and tide conditions” (Ministère de l'Écologie, du Développement Durable et de l'Énergie, 2016). It is a relatively rare but impressive and generally brutal phenomenon that results from the combination of extreme climatic phenomena (atmospheric depression, storms, etc.) and strong tides (Chaumillon et al., 2017). On the French coast, even if the accelerated global sea-level rise would certainly affect coastal zones and amplify the risk of flooding (Dolan and Walker, 2006; Pirazzoli et al., 2006; Wadey et al., 2015), the impact of climate change on coastal flooding risks is actively explored and further research is still necessary (FitzGerald et al., 2008; Hénaff et al., 2014; Nicholls and Cazenave, 2010).

In addition to the expected sea levels rise in 2100 (Church and White, 2006; IPCC, 2007), one can add real estate development practices in coastal areas, strong anthropogenic pressure on the coasts and concentration issues (Idier et al., 2013; Nicholls, 2002), which increase

the vulnerability of coastal areas to risk of coastal flooding. In France, it is estimated that five million people are living in a coastal flood zone, following a rise of two meters (Kolen et al., 2010).

Several studies give a list of measures to reduce vulnerability and their costs and proposed a whole methodology for identify strategies that are efficient with regard to their costs (Creach et al., 2015; Goeldner-Gianella et al., 2015; Lumbroso and Vinet, 2011).

### 1.3. Aims and objectives

The main objective of this study is to identify the factorial structure of coastal flooding risk perception.

More precisely, this study has two objectives:

1. To investigate to what extent the factors explaining risk perception identified by the psychometric paradigm (Chauvin and Hermand, 2008; Slovic, 1992) are pertinent for flooding and coastal risks.
2. In the absence of a satisfactory scale to accurately assess coastal flooding risk perception by non-experts, to develop and validate a scale which is able to measure characteristics of risk perception of coastal flooding and which takes into account specific aspects of coastal flooding risk perception.

## 2. Method

### 2.1. Sample and procedure

Data were obtained from two studies conducted on different areas at risk of coastal flooding located in mainland and Caribbean regions of France.

For the first study, data were obtained from a quota sampling of 582 participants (mean age = 46; *SD* = 19; min = 17; max = 96). They were all living in six different areas at risk of coastal flooding located in Guadeloupe, a French overseas department, an island in the Lesser Antilles in the Caribbean. More precisely, those areas face the Caribbean Sea on the Atlantic Ocean Sea. They are mostly exposed to hurricane-induced storm surges. The sample was composed of 225 men and 357 women (Table 1). Site selection was based on coastal risk prevention plans published by the French state. Maps represent areas exposed to coastal flood phenomenon; they are taken from the TRI document (“Territoires à Risques Importants d'inondation” equivalent for territories with important flood risks). All the participants were living inside these risk areas at the time of the questionnaire.

The survey was carried out during summer 2016. Face-to-face interviews were conducted at home by professional interviewers. The mean duration for completing the questionnaire was 25 min for the complete questionnaire of the CLIMATRisk program, and 10 min for the risk perception scale on which this paper is focused. Participation was voluntary and all responses were confidential and anonymous.

For the second study, the sample is composed of 315 adult participants (mean age = 47; *SD* = 15) (Table 2). As for study 1, they were all living on sites at risk of coastal flooding, this time located in the western coastal region of France. Site selection was also based on coastal risk prevention plans.

Instructions on how to complete the questionnaire were given to the participants before the statements. They were asked to respond to each statement by selecting the answer that best fitted their opinion on a five-point scale, ranging from “completely disagree” to “completely agree”.

### 2.2. Measure of coastal flooding risk perception

The questionnaire is based on previous works on psychometric paradigm of risk: some of our items were based on exploratory interviews conducted on two French sites at risk of coastal flooding (*n* = 25) but we also used items from a flooding risk assessment scale previously

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