Key Points:
- Risk perceptions as a driver for policy acceptance
- Cultures of risk as basis for policy design to face a risk
- Importance of studies on risk perception to analyse the potential impact of policy decisions

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How to Shape Climate Risk Policies After the Paris Agreement? The Importance of Perceptions as a Driver for Climate Risk Management

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Abstract Risk perception research has played an influential role in supporting risk management and risk communication policy. Risk perception studies are popular across a range of disciplines in the social and natural sciences for a wide range of hazard types. Their results have helped to articulate the complex individual, relational, structural, and environmental factors influencing people's behavior. Connections between individual and collective behaviors and norms impacting global climate change, and consequently, local disaster risk, however, are infrequently included in disaster risk management. This paper presents results from two diverse and complementary European risk perception studies examining both natural and anthropogenic hazards. Research gaps and recommendations for developing more comprehensive risk management strategies are presented.

1. Introduction

Risk perception plays an important role when reacting to hazards (Renn, 1990), and can be influential in determining how people choose to mitigate the risk of those hazards (Martin et al., 2009). However, perceived risk does not always correspond with scientific analysis views (Science Communication Unit, 2014), because risk perception is a combination of social, cultural, political, and emotional factors, as well as of innate influences (Renn & Rohrmann, 2000). Individual and social characteristics determine risk perception and influence the way we react (Schmidt, 2004). This can mean that reactions to a risk might be pertinent if the risk is perceived as such or these reactions are shape by a history of risk management (e.g., areas with institutions that have a long history of dealing with hazards). In contrast, they might be inimical and produce harm (e.g., building too close to flood levees that may not be safe under changing climate conditions). Therefore, understanding climate risks and how they are perceived is a crucial step for creating management initiatives and policies to promote awareness across groups dealing with climate risks management (Science Communication Unit, 2014). In light of the implementation of the Paris Agreement from national to local level, the analysis of risk perception is even more important for predetermining whether people are going to follow any proposed policy measure. In the case people might not consider a particular climate risk as such, they will not react the proposed policy measures.

Considering that risk perception has long been identified as an important driver of risk management practices (Renn, 1998), it is primordial to include risk perception analysis in the design of clever climate risk policies, because policy actions are taken according to the assumptions made by certain groups surrounding a risk. If we do not succeed in taking this premise into account, climate risk policies might fail and the goals of the Paris agreement will barely be reached.

With this paper we show the importance of including perceptions into the design of climate change policies. The line between adaptation and risk management policies is very thin and in some cases, as in view of the assessment of adaptation and risk management needs, the methodologies behind tend to be very similar. Therefore we will refer in this paper to adaptation and risk management similarly.

This paper presents findings from two complementary European research projects examining risk perception in relation to natural and anthropogenic hazards: ENHANCE and TACTIC.

2. The Study of Risk Perception

Risk perception research has grown substantially over the past decade, especially in the disaster sciences, generating many useful insights for risk management. Often referencing its roots in psychology, risk perception is commonly assessed as an explanatory factor or variable for predicting or explaining people's preparedness behaviors, that is, protective actions they take to mitigate hazard risk. While there was an initial emphasis on cognitive factors in early risk perception studies, the scope and scale of studies have grown to encompass more diverse cognitive, social, normative, and environmental factors influencing people's behavior, and from diverse theoretical perspectives. Risk perception has in effect become a boundary term; something that facilitates discussion across disciplinary and professional divides and provides a bridging function linking people, professions, and practices in new ways (Gieryn, 1999). The diversity of risk perception studies range across a variety of disciplinary approaches and contexts has contributed many insights, but also a vagueness in shared terminology. Furthermore, gaps emerge in understanding how, and if, individuals link experiences of climate change back to their individual/collective behaviors regarding hazard mitigation.

2.1. Risk and Risk Perception from a Cultural Perspective

Risk has been defined as "the combination of the probability of the occurrence of an event and its negative consequences" (UNISDR, 2009, p. 25). However, it is important to consider risk not only within the constraints of this combination. Risk differs among cultures, and their appraisals are related to different factors such as causes, benefits, context, circumstances, or harm. The perception of risk changes according to how risk is defined by individuals and groups.

Risk perception can be interpreted as a subjective evaluation of the probability of a specific risk to occur and its consequences (Royal Society, 1983, p. 34; Sjöberg et al., 2016, p. 8). Risk perception is a mental model acquired over time that shapes the different types of attitudes, judgments, and reactions to a threat (Kearney, 1997). People build their own interpretation of what they consider a risk, based on their experiences, political ideologies, beliefs toward the risk, circumstances around the process of risk, the magnitude of the risk contemplated, or the familiarity with the hazard (Renn, 1985; Slovic, 1987). Risk situations similar to past one facilitate the management of the current risk and also decrease the feeling of risk (Aven & Renn, 2010).

The mental models that people have about risk work as a lens used to see how new information are evaluated and perceived (Jungermann et al., 1988). Therefore, possible reactions to scientific evidence on future climatic risks might be dependent on existing experience with the particular climate risk. All these mental models are influenced by communication processes as well as cultural backgrounds (Morgan et al., 1992).

There are two dimensions of risk perception: the individual dimension based on the strictly cognitive processes and heuristics from each person; and the collective dimension in which social context and cultural backgrounds influence the perception shaping the mental model of what risk is and how to manage it, also meaning the enactment of policies or the response to policies. Both dimensions are important when measuring the level of acceptance of climate policies and the possible behavioral changes that those might imply at the individual level.

2.2. Risk Perception and Behavioral Change at the Community-Level

Mental models are a useful lens for understanding personal construction or "maps" of risk, information that are vital for informing risk communication strategies and various prevention measures. In order to understand how risk perceptions may influence behavioral change at the local community level it becomes necessary to understand not only how perceptions vary but also how these differences may interact.

Examining risk perception and hazard preparedness for floods, earthquakes, epidemics, terrorism, mixed results were found regarding the strength of the risk perception and behavior relationship (Shreve et al., 2014). In part, this is due to the method, as risk perception is commonly measured through surveys, which represent a snapshot in time, rather than how people respond to risk in a social context, or to repeated exposure (Renn, 1998). Furthermore, researchers sometimes fail to distinguish between voluntary and involuntary risk (Starr, 1969; Wilkinson, 2001). Results show the strength of the risk perception and preparedness relationship varied with hazard type and preparedness activities. Studies examining earthquakes and

terrorism reported comparatively weak links between risk perception and preparedness actions. Stronger relationships were reported for some epidemic preparedness activities such as hand-washing but not for others. Health behavior studies help to explain these discrepancies, recommending that specificity is required when considering the type, expected outcome, and intended benefits/beneficiaries of preparedness actions (Brewer et al., 2007). For example, if a person believes flu vaccines are ineffective or that the consequence of getting sick would be relatively minor, they are unlikely to become vaccinated. Other cognitive factors such as self-efficacy, coping, psychological bias, social factors such as trust, material constraints, and the regulatory context, may further influence a person's capacity and/or decision to adopt preparedness behaviors.

Across hazard types examined, preparedness actions taken were minimal and frequently related to lower cost measures such as stockpiling food and emergency supplies with some exceptions; these actions are beneficial in the initial disaster recovery phase, but then have no substantive benefit for mitigation. Relatively recent community-level models of hazard preparedness, which map the complexity of individual and relational factors leading to hazard preparedness behaviors such as Paton (2003, 2008), capture the dominant cognitive, normative, and social factors identified in the risk perception literature influencing people's preparedness behaviors, therefore providing a useful tool for local emergency/disaster risk managers (Shreve et al., 2016).

In summary of the theoretical basis for the two separate European risk perception projects discussed here, the ENHANCE project made use of the Protection Motivation Theory (Rogers, 1975, 1983) and the Cultural Theory of Risk (Douglas & Wildavsky, 1982), also taking into account the psychological perspective of risk (Fischhoff et al., 1978; Starr, 1969). The TACTIC project examined risk perception studies for different hazard types (floods, earthquakes, epidemics, terrorism) assessing diverse theoretical and methodological approaches with the aim of better understanding pathways between risk perception and adoption of preparedness behaviors for a local community-level "multi-hazard" context. TACTIC utilized Paton's (2003, 2008) work on social-cognitive model of community-level preparedness to inform the development of its risk perception surveys. In both projects the climatic disruptions component is omnipresent.

3. Case Studies and Analysis of Risk Perception

To analyze risk perception and how this influences reactions and measures/policies formulation, two different approaches were chosen in each project. Every hazard type examined under both projects presents not only both unique challenges and commonalities for hazard preparedness and risk management, but also for policy acceptance. Both projects provide us with what is essential to take into account when designing climate risk policies.

3.1. Insights from ENHANCE

The main goal of the ENHANCE project was to gain insights from managing risks through multi-sectoral partnerships (MSPs). A tenet of ENHANCE was to understand what kind of risk management cultures exist, and identify and assess indicators that represent cultures of risk. The underlying aim was to gain an understanding for the premises for an effective climate extreme event risk management. The climate hazards contemplated in ENHANCE were floods, forest fires, and droughts.

The project used the following approach: (1) Analysis of the regional culturally embedded perception of risks and of the recent handling of risk events; (2) categorization of risk management practices shaped by risk perceptions within MSPs; and (3) examination of the management of past risk events and the implicit assumptions about future risks and how these assumptions relate to concrete policies and measures. With these three steps we were able to categorize risk management culture components. Our stakeholders were representatives of organizations managing climate risks from the following private and public sectors: environment, agriculture, industry, forestry, transport, emergency services, and risk protection. The stakeholder activities also include civil protection, risk monitoring, and capacity building to increase the effectiveness of extreme events management.

The Cultural theory of risk (Douglas & Wildavsky, 1982) and the Protection Motivation Theory and the Framing theory (Slovic et al., 1982) were the basis for the analytical frame. In our analysis we tried to capture (1) the understanding of risk and the perceived probability of adverse extreme events; (2) social

Table 1.
Risk Management Culture Criteria (Máñez Costa et al., 2016)

Criterion	Description
Decision making	Decision-making processes were made on a consensus basis, involving all members affected by a risk
Participation	Mechanisms of participation exist for regulating the involvement of members
Transparency and efficiency	Full transparency is considered key to obtain efficient management results. This includes access to data and tools to analyze the risk.
Risk knowledge	Expertise in managing the risk is available. Risk knowledge includes formal and informal sources of risk knowledge.
	Historical risk knowledge is available (i.e. learning from the past to face the future)
Ways of risk knowledge storage	Protocols for collecting and recording hazard and risk data exist
	Systematic monitoring is available
	Sensing networks and remote sensing is in place
	Geographical information systems are already implemented for monitoring the risk
	Warning systems have been developed
Risk management items	Based on past experiences and informal knowledge, the following items are already implemented: emergency and contingency plans and awareness raising campaigns.
	Based on formal knowledge, a combination of risk management models, new prevention techniques, construction of new prevention infrastructures, improvement of monitoring networks and simulation models are developed in close collaboration with formal knowledge institutions (as universities and research centers)

and cultural interpretations of risks as well as experiences and traditional strategies, and (3) the resulting management.

Our results show that climate risk management culture is a critical element in determining which climate policy or management approach is chosen in a situation of climatic risks (see Table 1). In cases in which a risk culture is weak or nonexistent, or the perception of a risk is not available, the ability of reacting to a possible risk might be very low.

The criteria of risk cultures denote the channels that might be useful to take into account when designing climate policies.

3.2. Insights from TACTIC

TACTIC adopted a participatory approach engaging local communities throughout Europe in the co-development of an online preparedness self-assessment and learning platform to support hazard preparedness throughout. Examining case studies of floods, earthquakes, epidemics, and terrorism, TAC-TIC involved a diverse group of over 250 local and international participants. Each of the study sites in England, Turkey, and Central Europe along the borders with Germany, Czech Republic, and Poland, have experienced actual or potential large-scale and/or cross-border disasters and crises. Local project participants were predominantly community volunteers, local authorities, local agencies, community-based and faith-based organizations, and local businesses. Local and international advisory boards composed of subject matter experts in the risk perception and risk management fields provided feedback on the project and deliverables through meetings and peer-review.

In the first phase of research, a desk-review of the risk perception and hazard preparedness literature was conducted to identify best-suited models or theories for community-level hazard preparedness, as well as

risk communication to inform the development of the preparedness self-assessment surveys (Shreve et al., 2014).

In phase two of the project, local participants were engaged through interviews, focus group discussions or meetings, and two community-level workshops, in evaluating the main components of TACTIC's online platform: the preparedness self-assessment surveys for (1) individuals and (2) organizations tasked with risk management responsibilities, as well as the library of "good practices," which houses preparedness activities and educational materials from trusted sources. In the third phase of research, a long-term learning framework was developed for a "multi-hazard" context. Each of the hazard types examined under TACTIC presented both unique challenges and commonalities for hazard preparedness and risk management.

The root causes of hazard risk for all hazard types examined can be linked to both internal and external behaviors and drivers. However, holistically incentivizing preparedness with this in mind is challenging (Kuhlicke et al., 2016). More tangible or "hard" mitigation measures such as flood walls, building with earthquake resistant materials or utilizing vaccination and sanitary measures to reduce epidemic risk, tend to be emphasized over "soft" measures and less visible sources of risk. For example, infrequently are the impacts of individual/collective food choices considered in discussions of global climate change or local hazard preparedness. Similarly, the potential implications of policy or the effectiveness of local communities with social integration are often excluded from terrorism preparedness discussions.

4. Conclusion and Gaps — Contributions to the IPCC Special Report for 2018

Case studies show a high dependency between the risk perceived and the possible reactions to these risks. The relation between a natural hazard event, risk perception, and risk management can be represented in a circle, in which each of them acts as a function of the other (Máñez Costa et al., 2016). Results show that a culture of risk is always associated with policy measures and preparedness to the risk perceived. This affirmation presupposes that any climate risk-related policy measure should take the risk perception of the population targeted into account if an efficient policy implementation is to be achieved.

Risk perception studies have played an important role in local and national risk management strategies for natural hazards in many countries. The root causes, emerging or amplified through human behavior, and compounding consequences of global climate change on disaster risk; however, are rarely incorporated into local level disaster planning. Results of this work help to identify gaps in understanding pathways between risk perception and the adoption of hazard preparedness behaviors. Addressing these gaps can support the development of more appropriate climate risk policies to achieve the goals of the Paris Agreement.

Often, preparedness and management in the face of a climate threat influences the degree of risk perceived, for example, the higher the preparedness, the lower the perceived risk. This is also referred to as "The levee effect" (Tobin, 1995). High confidence in flood preparedness measures (dykes) and low flood risk perception in the Waddensee Region in Germany, the Netherlands, and Demark, demonstrate this principle for floods. This principle has been demonstrated for slow-onset hazards such as drought as well, exemplified by the Jucar River Basin in Spain, where historical management has lowered drought risk perception. In both cases, risk management might follow past strategies, without reacting to new proposed climate management or policy measures. Another important factor influencing risk perception is experience of extreme events. This can enhance perception within a period of several years, as shown after the event of the volcanic eruptions in Iceland, consequentially raising the risk management debate in other countries (see for more examples ENHANCE, 2016).

Several important questions remain partly unanswered, first: does repeated experience due to more frequent occurrence of climate-related extreme events lead to adaptation behavior — and, if so, what are the limits of such individual or institutional adaptive actions, how are they defined, and what is the link back to people's perceptions regarding future risks and their individual and collective resources? The body of evidence developed from hazard risk perception studies, especially natural hazards, can be used to inform this line of inquiry, but further work is needed.

A second question emerges regarding the links between experience of (climate related) harmful events back to the more global dimension of climate change and behaviors such as "foodprints" and emission

contributions, which are less emphasized in emergency and disaster risk management as preparedness or adaptation strategies. There is a need to understand whether high-risk awareness indeed leads to increased individual and collective awareness with regard to individual actions in order to mitigate the consequences of climate change.

A third question is how to effectively integrate disaster risk management with resilience? Disaster risk management tends to adopt a short-term and anthropocentric view of disasters, emphasizing events associated with one or few cascading hazards, and focused on human and economic impacts. While an anthropocentric focus is necessary to a degree to protect human life, failing to consider the interconnectedness with ecosystem resilience and longer-term social-ecological resilience only serves to produce additional risk and uncertainty. There is a need to also emphasize what ecosystem services such as flood regulation, provisioning services, and loss and impacts on other species besides humans, occur during disasters, and how this in turn impacts future disaster risk. Without understanding ecosystem function, it is impossible to gauge uncertainty, and thus to effectively model local or global climate change impacts or critical thresholds and tipping points (Levin, 1992; Levin et al., 2013). Integrating risk and resilience analyses is a complex task requiring collaboration among many partners (Convertino et al., 2013). While risk and resilience approaches differ, they are, and need to be, complementary (Park et al., 2013). Case studies integrating risk and resilience approaches in engineering systems (cf Park et al., 2013), utilizing complex adaptive systems theory (cf Levin et al., 2013) or risk management (cf Convertino et al., 2013; Convertino & Valverde, 1982), risk governance and policy perspectives (cf Levin et al., 2013; Linkov et al., 2013) are addressing many of these complexities, and this is an area that should receive further attention.

A fourth question is how awareness rising can work in areas or policy arenas in which the perception of climate change as a risk is very low or even denied. In these cases, the successful implementation of policies to reduce CO_2 emissions will be jeopardized, and the targets described in the Paris Agreement barely reached.

With this paper we show that climate risk perception analysis is the first step in understanding how local cultures identify and manage climate risks and how risk cultures work. Assuming that risk perception drives how people will behave and manage any future climate risk, future climate policies to target the Paris Agreement should take this premise into account and may subsequently avoid procrastination and policy failure.

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