Chapter 1

Psychological reactions to environmental hazards

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1.1 WHY STUDY PSYCHOLOGICAL REACTIONS TO ENVIRONMENTAL HAZARDS?

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Let us start with some excerpts from 'Expertise developed for the Parliamentary Committee on Environmental Protection, Natural Resources and Forestry' by Eryk Bobiński and Janusz Żelaziński (1997).

> … Flooding was caused by heavy rain in the south of the country [Poland] on 3–8 July. […] A special feature of this atmospheric situation was high intensity rainfall of long duration over a great territorial range covering Poland, the Czech Republic, Austria and Slovakia.
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> Flood waves from mountain tributaries reached the [River] Oder. Tanks on the Nysa Kłodzka [tributary of the River Odra], which were intended to stop the wave on the river so that it reached the Oder after passing its peak, did not accomplish the task. […] In result, [a town] Nysa was submerged, and then, by the overlapping waves, Wroclaw.

Negative events such as the flood described above generally cannot be prevented. This applies not only to floods but also many other natural hazards such as hurricanes, earthquakes, etc. Risks of this type are characterized by two features: (a) they occur relatively rarely (the probability of their occurring at a given time is low); and (b) their negative consequences are great (they are catastrophic). Indeed, in the flood described above, the highest observed water levels in a hundred years were exceeded. Some of the causes of the floods were said by the authors of the above report to be as follows:

> Almost all of the flood control structures and technical equipment – embankments and reservoirs on the mountain tributaries of the Oder – failed. Embankments were breached in many places throughout the length of the Oder. On some sections of the Oder, water simply poured through shafts, including those built in recent years. The large reservoirs on the Nysa Kłodzka proved useless, even during the first flood. Lowering bandwidth contributed to an increase in the flooded area of the city.
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> Important elements of the former German infrastructure, such as flood polders and canal reliefs built in the communist era and following years, were utilized incorrectly with respect to their intended purposes. Polders were settled or utilized for agricultural purposes. Obstructions occurred in the relief channels. As a result, these structures did not fulfil their task.
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> It can be assumed with high probability that if the structures had been operational and in use at the right time the extent of the damage would be smaller. However, the flooding of these cities could not have been avoided because the maximum flow of the Oder was much greater than that assumed in the planning of these structures.
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> Moreover … in the past 50 years there has been a sharp increase in building and investment in areas of increased flood risk.

Evidently, employers, households and local governments in the Oder region, and central government, news media, etc., were unaware of the flood risks and lacked

knowledge of potential losses, the probability of floods on such an enormous scale, and what they could do to limit the threat to life, health and property.

The long-term absence of floods not only led to a diminished fear of the threat, but also a belief developed that dikes and reservoirs provided effective protection against flooding. According to the authors of the report, some people began to consider this state of affairs as a beneficial effect of hydrological investments. There was an illusion that 'we already know how to prevent floods, and thanks to this we can put buildings on floodplains'.

As previously mentioned, many natural hazards cannot be prevented. However, we can try to anticipate them and take action aimed at reducing their negative consequences, and the above report reveals several problems that need to be solved before, during and after floods. Three of such problems mentioned in the report are:

> … The system of warnings, information and evacuation of affected populations turned out to be defective, worked too late, and in the first days of the floods was chaotic. A particularly acute problem was lack of communication in the areas flooded, because communication was based mainly on a network of landlines …
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> … Residents of threatened towns and villages generally did not respond to calls for evacuation. The reason for this was either a disbelief in the warnings or a fear for unattended property left behind. When homes were flooded evacuation was very difficult, as it required the use of boats, amphibious craft or helicopters …
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> … When considering flood protection programmes one should start by establishing priorities: whether they are the protection of large cities or something else. Protection of agricultural land increases the flood risk of large cities and vice versa. At the same time, there is no way to protect everything. After establishing a hierarchy of objectives, quasi-optimal solutions limiting losses in other places should be considered.

In order to minimize possible losses for this type of hazard one needs to: (1) accurately identify the dangers; and (2) adequately react in the case of disaster. Nowadays we are increasingly aware that reduction of flood risk and mitigating the effects of floods are not problems which can be solved solely by engineers and other experts. The engagement of threatened residents, local government and other administrative entities plays a crucial role in these processes. To efficiently motivate people to undertake adequate preventive actions, the following issues need to be considered:

(1) How to inform people of the possibility of floods and flood damage so that they are aware of the risks, including knowledge of the probability of floods and the likely scale of their consequences.
(2) How to make people aware that there are actions that can be taken to limit the threat to their life, health and property.

Thus, studying risks of this type involves considering the answers to two related questions. First, how do people estimate low probabilities? Second, when and why are people willing to protect themselves against risks with low probabilities and

high stakes? The present book is devoted to answering these questions, examining evidence concerning: (1) how laypeople perceive the threat of floods; and (2) how they make different types of decisions to protect themselves against risks with low probabilities and high stakes.

In our approach, we refer to the multistage Protective Action Decision Model (PADM) created by Lindell and Perry (2012). These authors describe several phases of the protective action decision-making process, which starts with an individual observing environmental and social cues. This leads to the perception of a threat. In turn, the perception of a threat associated with the probability of a disaster and its consequences motivates people to solve several decision problems in order to take protective action. In the book, we focus on the key psychological processes described by the PADM, considering people's behavioural responses to environmental disasters in general and flood hazards in particular. Previous research devoted to these key psychological processes is reviewed and some of our own research devoted to the study of these processes is covered. The book does not offer ready-made formulas as to what to do, but presents valuable knowledge that can, and must, be used when formulating a plan to manage flood hazards and to mitigate the effects of floods.

1.2 ENVIRONMENTAL CUES, SOCIAL CUES, WARNINGS, AND PREDECISIONAL INFORMATION SEARCH

Environmental cues, social cues and warnings of environmental disaster are signals of threat, arising either from the environment (in the case of flood hazards these are meteorological, hydrological, etc.), from observations of others' behaviour, or from messages intentionally transmitted to recipients (communication of information being via a variety of different channels). There is much research on the perception of environmental and social cues. For example, Kakimoto and Yamada (2014) studied factors determining evacuation rates in the Tatsuda area of Japan and found that two main determinants of the decision to evacuate were whether or not a household independently checked river conditions (an environmental cue) and the advice of neighbours in making a decision (a social cue).

Typically, perceptions of the intensity of severe weather conditions act as short-term environmental cues signalling flooding. Key environmental factors contributing to flooding are rainfall intensity and its duration. Thus, disaster education centres alert endangered people to the possibility of a flood in cases where it has been raining hard for many hours or raining steadily for several days. Rainfall intensity and duration are relatively easily observed by laypeople, however, it is more difficult for them to observe long-term environmental factors contributing to flooding, such as topography, soil conditions and ground cover. Disaster education centres provide such information and training.

Social cues arise from observations of other people's behaviour. Even when peers do not explicitly transmit warning messages, their behaviour can serve as a social

cue to take protective action. For example, when neighbours are seen packing their cars in preparation for evacuation, people in the risk area observing this behaviour can be alerted to the need to consider feasible protective actions (Huang *et al*. 2012). MacKay (1841/1932) noted that Londoners imitated the behaviour of their neighbours and left the city in panic after a series of minor earth tremors in 1561. People are also likely to consider certain actions as a result of reading or hearing about the protective behaviour of others.

Social cues are particularly powerful in conditions of high uncertainty, when people are unsure of how they should behave; natural disasters are one such situation. As noted by Cialdini (2009), in such situations people believe that they are less likely to behave inappropriately if they follow the actions of other people surrounding them. For instance, friends and neighbours often influence a person's decision as to what to do in the case of evacuations. Other factors positively influencing evacuation decisions are membership of a strong social network (Gruntfest, 1997), and being responsible for children (Fischer *et al.* 1995) or people with medical needs (Bateman & Edwards, 2002). Finally, people are also made aware of when it is appropriate to evacuate by listening to the recommendations of relevant authorities.

Risk communication researchers (e.g., Mileti, 1995; Glik, 2007) have enumerated several conditions influencing people's responses to hazard warnings. The first is the reception of a warning signal. Studies show that even when signals are highly visible people may not pay attention to them – a phenomenon known as inattentional blindness. Simons and Chabris (1999) demonstrated this in a study known as the Invisible Gorilla Test. Subjects were asked to watch a short video of a basketball game. A group of people were passing a basketball around. Some players were wearing black, and others white, T-shirts. The subjects were told to count the number of passes made by the white-shirted team. During the action a person walked through the scene wearing a gorilla suit. After watching the video the subjects were asked if they noticed whether anything strange had taken place. In the original experiment, and in most replications, about 50% of the subjects did not notice the gorilla. The failure to perceive it is attributed to engagement in the difficult task of counting the number of passes of the ball made by the team in white shirts. Simons and Chabris concluded that people only perceive objects and details that receive their focused attention.

After a signal is received a person must understand it, and there are many reasons why people misunderstand information they receive. In 1960, during a flood in Lamar, Prowers County the police were attempting to warn people and to help them evacuate the area throughout the night. The police chief later noticed that inhabitants had not understood the warning signals he had been giving: '*A lot of people told me that they heard the siren on the police cars as they drove down the street and they got up to see who they were chasing, paid no attention to the water and went back to bed. The next thing they knew they were floating*.'

Many potential obstacles can prevent a message from successfully reaching a recipient in the form a sender intends. In the above example the sender intended to

convey a warning about the approaching flood but the recipients (mis)understood that the police were chasing criminals. It may be said that this was a result of poor encoding on the part of the message's sender, which led recipients to decode the meaning of the message in a way different from that intended by its sender.

Several authors (e.g., Mileti & Sorenson, 1990) emphasize that the response to a signal strongly depends on its perceived credibility. In turn, credibility is determined by features such the consistency, accuracy and clarity of a message.

- The consistency of a message determines both its ease of understanding and belief in the warning it contains. A message is inconsistent when it contains contradictory elements. Worth and McLuckie (1977) give the example of an inconsistent message to a flood threatened community which came from a sound truck. The recording of the flood warning alert was mixed with a previously used standard advertisement for a movie theatre, thus: '*An all-time record flood is going to inundate the city. You must evacuate the city immediately. (Pause) The Theatre is presenting two exciting features tonight.*'
- Even when substantive signals are not contradictory, people may feel emotional inconsistency, fluctuating between different psychological states such as sadness and happiness (Frijda, 1986). For such reasons, it is difficult to treat a flood warning seriously when the weather is good, and hard to start to evacuate when your neighbours are still at home. So people may wait to evacuate until they see the weather start to deteriorate or their neighbours start to evacuate.
- Another determinant of warning credibility is message accuracy: is it correct and precise? It is not always easy to avoid errors in the accuracy of warnings. Errors are easily made when a situation evolves and information is not updated.
- A warning's clarity is yet another factor underlying its credibility. A message is unclear if it can be interpreted or perceived in more than one way. A clear message is free of ambiguity and potential for misinterpretation. The following case, reported by Lachman et al. (1961), is highly instructive: When a tsunami struck Hilo, Hawaii on May 22–23, 1960, several inhabitants reported that they did not interpret the siren warnings before the tsunami as warnings to evacuate their homes immediately, rather, they waited for further information, including another warning.

When people face a decision problem which needs to be solved they usually start by looking for relevant information. Quite often, the immediately available information is insufficient and people therefore search for additional information. Research shows that in situations of risk and uncertainty people exhibit little interest in information about the probabilities of possible outcomes (e.g., Tyszka & Zaleśkiewicz, 2006; Huber, 2007). In particular, Huber and his colleagues (Huber *et al.* 1997; Huber *et al.* 2001; Huber & Huber, 2008; Huber *et al.* 2011) have performed

intensive studies of people's behaviour in so-called naturalistic decision scenarios, where a decision-maker receives a minimal description of a decision task and has to ask questions to obtain the additional information that they think is necessary to make a decision. Their main finding is that only a minority of individuals are interested in the probabilities of the aversive consequences of decision alternatives. Instead, they look for information about what Huber terms risk defusing operators (RDOs). These are actions which can defuse the possible negative consequences of a choice. If, for example, we consider a decision about the location of a technical facility such as a power plant, specific positive consequences (e.g., accessibility and network connections) and negative consequences (e.g., citizens' resistance) may occur in different locations. Natural disasters involve specific types of risky negative consequences that vary vastly in their probability and severity across alternatives, ranging from minor incidents to catastrophic hazards. Here, risk defusing measures impact both final security levels and project costs. Thus, actions which can defuse the possible negative consequences of our choices are often rational behaviours. However, biased choices can occur when probability information is not sought out and, in consequence, not taken into account.

Huber and his colleagues have concentrated mainly on naturalistic situations in which the decision-maker has control over the occurrence of risky events (cf. Huber *et al.* 1997). In Chapter 2 of the present volume we present experimental research where we tested the hypothesis that, when dealing with natural hazards (where the occurrence of a risky event cannot be influenced), people may pay more attention to probabilities. This hypothesis was supported: we found that in such cases people tend to acquire more information about probabilities. Moreover, this interest increases with the importance of the decision problem.

We speculate that even when people do not ask for probability information it may be worthwhile providing it to them. Inhabitants of areas exposed to natural disasters (including floods) may use and benefit from information about the likelihood of such catastrophic events.

There is anecdotal evidence that likelihood information may actually be employed in some catastrophic circumstances. Angelina Jolie Pitt, who lost her mother, grandmother and aunt to cancer, has said that she decided to have a preventive double mastectomy immediately subsequent to a blood test where doctors gave her an estimated 87% risk of developing breast cancer (Angelina Jolie Pitt: Diary of a Surgery, New York Times, March 24, 2015).

1.3 PERCEPTION OF ENVIRONMENTAL THREATS

1.3.1 The difference between expert and lay conceptions of risk

Environmental cues, social cues and warnings direct people's attention to an environmental threat. But how do people perceive risks? Much research effort has

been devoted to understanding the factors that determine beliefs about perceived risks and vulnerabilities, and to understanding the relationship between perceived risks and protective behaviour. Generally, risk is described as a combination of the perceived probability and perceived severity of a hazard's consequences. For some hazards (e.g., car accidents, fires, etc.) statistical data are available so that we can determine their frequencies and severity. In such cases experts may use quantitative measures of the riskiness associated with a given hazard, such as expected fatalities.

However, research shows that laypeople's perceptions of risk are not highly correlated with measures of probability and the severity of negative consequences (Covello & Johnson, 1987; Slovic, 2000). Evidently, other factors must influence people's understanding of risk. Personal experience, memory and other cognitive and emotional factors may influence the way people perceive different risks. In practice, individuals and societies seem to select particular risks for attention and tend to exaggerate them, while other risks are minimized.

Together with many collaborators, Slovic has studied different risks, asking laypeople to assess them on a long list of dimensions. For example, Fischhoff *et al.* (1978) found people's judgments of riskiness to be correlated with several characteristics, such as novelty versus familiarity, controllability versus uncontrollability, catastrophic versus chronic risks, immediate versus delayed effects, and several others. Specifically, findings from such research efforts are as follows:

- *Novelty*: People are more afraid of risks which are novel than risks which are old and familiar. Familiarity means that an individual affected by a risk knows about the risk and its consequences. People are accustomed to old risks. Perceptions of a risk that has been present for a long period become attenuated due to habituation, even if the risk remains unchanged.
- *Controllability*: Risks perceived to be under one's own control are more acceptable than risks perceived to be controlled by others or not controllable at all. Floods and other natural hazards cannot be avoided by personal skill or diligence, they are uncontrollable, and thus are commonly perceived as highly risky.
- *Catastrophic risks*: People are less sensitive to risks that kill people one at a time (chronic risks) than to risks that kill large numbers of people in a single episode (catastrophic risks). Floods and other natural hazards often have a catastrophic character, and so are perceived as highly risky.
- *Immediacy of effects*: People are more afraid of the risk of immediate death than of death that may occur at some later time. Thus, the risk of putting a home in a flood-prone area is not perceived as high as it actually is.

Further analysis of people's judgements of riskiness leads to the identification of two basic qualitative factors in risk perception: '*unknown risk*' and '*dread risk*' (Slovic, 2000). The former refers, among other things, to a hazard's familiarity/unfamiliarity, observability/lack of observability, and whether it has

delayed consequences. The latter factor refers among other things to a hazard's controllability, evocation of fear, and effect on future generations. This factor seems to be strongly related to the emotions evoked by the hazard.

1.3.2 Risk and emotion

Apart from the above-described dimensions, when personally experiencing, or even when reading about, natural disasters such as floods, earthquakes, etc., we may feel threatened, worried, angry, sad or experience other similar emotions. Thus, perceptions of environmental threats are not limited to cognitive reactions. Increasingly, research shows that emotions are a particularly important factor affecting perceptions of environmental risk.

There is a long line of psychological research showing how emotions influence human judgement and decision-making. For example, Forgas (1995) proposed the affect infusion model in which emotionally loaded information influences cognitive processes, and interferes with a person's thoughts and may change them. According to Forgas, the more complex and unusual a situation is, the stronger the affective infusion. In well-known, typical, uncomplicated situations, people are more likely to choose decision strategies that are immune to affective infusion.

The role of affect in decision-making was vividly presented by Antonio Damasio in his 1994 book 'Descartes' Error: Emotion, Reason, and the Human Brain'. As a neurologist, Damasio observed patients with damage to the ventromedial frontal cortex of the brain. Such damage does not impact upon cognitive processes such as memory, capacity for logical thought, etc., but it impairs emotions. Damasio hypothesized that this type of brain damage may destroy an individual's ability to make rational decisions.

He tested the hypothesis in a decision-making experiment using the Iowa Gambling Task. Subjects were asked to select cards from any of four decks. Selecting a card resulted in a gain or loss of a certain amount of money. Decks of cards differed in terms of the size and frequency of losses and gains they generated. Two of the four decks contained higher cash prizes compared to the other two decks, but they simultaneously generated very high losses, making use of these decks unprofitable and producing an overall loss. The two other decks involved relatively lower losses and their use resulted in the task being completed with a positive balance. Thus, the first two decks were relatively unsafe and harmful in the long run, while the two other decks were relatively safe and beneficial in the long run. Damasio found that normal subjects learned to avoid the harmful decks, but people with frontal lobe damage did not, and lost a great deal of money. Damasio concluded that the brain's emotional systems not only influence risk perception, but also that their malfunctioning may lead to deterioration in decision-making.

Major societal events such as natural disasters may strongly influence people's feelings. In the face of such events, people tend to react emotionally, making emotion-laden decisions (Lerner *et al.* 2003), and also express generalized anxiety

and depression (Lau *et al*. 2006). Indeed, after the 2004 tsunami disaster which affected parts of Indonesia, Sri Lanka, India and Thailand. Västfjäll *et al*. (2008) tested how the affect elicited by thinking about this disaster influenced risk perceptions and future time perspectives in Swedish people not directly affected by the disaster. It was found that participants reminded about the tsunami (they were asked to write down the first three images that came to mind when hearing the word 'tsunami') considered their life as more finite and saw fewer opportunities than participants in a control condition who were not reminded about the tsunami. Moreover, participants reminded of the tsunami reported more pessimistic risk estimates than participants in the control condition.

In addition to the above, Slovic *et al*. (2007) have shown that positive or negative affective feelings can provide powerful guidance to human judgement and decision-making. People may use their affective reactions to a target to evaluate it, and affect may serve as a cue for judgements. For example, if someone sees a house which has been abandoned during a natural disaster ransacked by looters, the very term 'evacuation' may have negative connotations for many years to come. Slovic *et al*. termed the phenomenon whereby people make a judgement based only on emotions the affect heuristic, and this heuristic makes it possible to perceive a thing as good or bad quickly without further consideration.

In Chapter 5 of the present volume we report research on the different emotions which accompany risky events. In particular, it is shown that human judgement and decision-making is strongly influenced by affective feelings when risks or potential damage are attributable to humans. When human action is seen as the cause of harm, a situation is perceived as more dangerous, damage is considered to be more severe, and higher compensation is recommended for victims. Other research shows that human-made risks are seen as less acceptable than naturally occurring risks. People seem to believe that damage caused by humans can be avoided by more cautious behaviour or by having better knowledge. Moreover, emotional responses to human-made hazards are generally stronger than those evoked by natural hazards.

As we will see, negative feelings such as fear and worry are not only associated with risk perceptions but also with risky decision-making. Two chapters in the present volume report research on how negative feelings influence self-protective behaviour (Tyszka & Konieczny, 2016) and purchasing insurance (see Chapter 7).

1.3.3 Problems with the perception of probabilities

A significant body of research over the last several decades has demonstrated numerous problems with people's perceptions of probabilities, which are an important component of risk evaluations.

Numerous studies (see, e.g., Tyszka & Sawicki, 2011) have demonstrated that most people, even educated people, cannot comprehend and/or properly

understand **information about numerical values of probabilities**. For example, when Yamagishi (1997) asked respondents to evaluate the risk of death due to different causes he found that judgements of the degree of riskiness were affected by the number of deaths, rather than by the proportion of fatal cases, caused by a given disease. People perceived the risk as higher when the proportion of fatal cases was given as 1286 out of 10,000 infected cases than when it was given as 12.86 out of 100.

Another problem is that people are **insensitive to changes in the magnitude of probabilities**. Perception of probabilities, and of differences in probabilities, depends on the way information about probabilities is transmitted. The most serious limitation is people's insensitivity to changes in the magnitude of small probabilities. Kunreuther *et al.* (2001) tried to overcome this insensitivity by comparing various ways to improve sensitivity to very low probabilities. They claimed that the best way of communicating probabilities to laypeople is to make scenarios which allow comparisons to be available, which allows people to judge differences between probabilities.

As previously mentioned, a characteristic feature of natural hazards such as floods is that they occur relatively rarely and therefore their probability of occurrence at any given time is very low. People have problems in understanding and reacting to such low probabilities. As shown by Kunreuther *et al.* (2001) and many others (e.g., Lave & Lave, 1991), people either overestimate or, to the contrary, ignore very low probabilities. One example of ignoring low probabilities is the Oder flood disaster described in Section 1, where water levels reached a level not seen in over one hundred years. Lack of recent personal experience of negative events seems to be one of the most critical factors responsible for people ignoring 'unlikely threats'. On the other hand, the recent occurrence of an event increases the subjective likelihood that the same event will be repeated in the near future. This makes people particularly vulnerable to specific (emotionally loaded) threats of future events associated with recently occurring events. For example, although millions of birds have been infected with the avian influenza virus since its discovery in 1878, only a few hundred people have died from it according to the World Health Organization (August 10, 2012). Nevertheless, in periods after a few people have died from avian influenza, millions of people panic and behave as though the probability of becoming infected is very high (this is mainly due to the enormous media interest). The same effect can be observed for natural disasters: immediately after a flood people often overestimate the likelihood of the next one.

Chapters 3 and 4 of the book are devoted to studies of people's reactions to small probabilities. Chapter 3 focuses on situations when people tend to underestimate (or completely ignore) and overestimate small probabilities. In particular, Hertwig *et al.* (2004) introduced an important distinction between decisions from descriptions and decisions from experience. In decisions from descriptions,

people are explicitly provided with probability distributions of potential outcomes, while in decisions from experience people must learn these distributions through sampling. Hertwig *et al.* (2004) and others (e.g., Fox & Hadar, 2006) have shown that decisions from experience and decisions from description can lead to different probability assessments of rare events. In decisions from descriptions people tend to overestimate small probabilities, but in decisions from experience decision-makers typically underestimate the probability of rare events. The chapter reviews further research showing several reasons why people may underestimate (or completely ignore) and overestimate small probabilities.

Chapter 4 is devoted to the issue of how probabilistic information should be communicated effectively to laypeople. The problem is that laypeople are not familiar with the very concept of probability. Different formats have been used, including numbers (e.g., frequencies and percentages), pictures (e.g., pie charts, pictograms and graphs) and verbal descriptions. The authors, however, propose a new format where probability information is presented in the form of a sequential display of frequencies. A sequence of pictures is displayed where people can observe how often a particular type of event has occurred in a given time period or space. The chapter reports two experiments showing that such a format can be very useful in communicating probabilities of very rare hazards such as floods.

1.4 DECISION-MAKING

Before, during, and after a flood there are numerous decision problems to be solved by individuals, households, and local and central governments. The focus of this volume is on the flood-related decision-making of households and individuals. Four types of decisions are prototypical:

(1) An individual may consider whether to remain in, or relocate to, a floodplain. In contemplating the choice between the localization of one's new house or business on a floodplain versus a completely safe place, one may compare the pros and cons of both alternatives. Choosing the floodplain may have advantages (e.g., lower price, an attractive landscape), but also may have disadvantages (e.g., possible damage to health and/or property).
(2) Then, one may be concerned with the question of whether to purchase flood insurance. Purchasing flood insurance provides peace of mind and in the event of a flood allows the recovery of some losses, but, on the other hand, it requires payment of insurance premiums, which are an unwelcome expense (especially when a flood does not occur).
(3) One may also need to answer the question '*do I need to take protective action*?' Several protective actions (e.g., the construction or improvement of a levee), and their costs and benefits may be considered.
(4) During a flood one may be warned to evacuate from a dangerous place, the choice being to comply with the warning, not comply with the warning

at all, or postpone evacuation. The possibility of losing one's life if one does not comply with the warning will be a consideration, along with the possibility of losing property (due to looting) if one does comply with the warning, and many more probable consequences may also be considered.

Of course, there is a large variety of complex decision problems to be considered before, during, and after a flood: often an individual faces not just one decision problem but a series of decisions. For example, when the question '*do I need to take protective action*?' is answered positively, one is motivated to engage in a search for protective actions, and after establishing that at least one protective action is available one has to search for the most satisfactory method of protection.

When an individual receives a signal concerning an environmental threat the first natural question is: '*Is there really a threat that I need to pay attention to*?' Research shows that the answer to this question is quite often negative. People try to avoid facing undesirable realities and therefore tend to see positive outcomes as being more likely than negative outcomes. Thus, in the context of natural hazards, people may try to view the environment as safe, even in the face of evidence to the contrary. Such a tendency is known as unrealistic optimism (overestimating the likelihood of positive events and underestimating the likelihood of negative events). This is a well-documented psychological phenomenon. People are optimistic in assessing whether they will be the victim of a disaster (Camerer & Kunreuther, 1989). Even when they reside in a flood-prone area, they tend to believe that they will not be the victim of a flood (Krasovskaia *et al*. 2001). Unrealistic optimism may be just one reason why people are under-prepared for hazards and why the take-up rate of insurance is generally observed to be too low (Dixon *et al*. 2006); it is low even when it is highly subsidized in order to encourage take-up. Houses are built on floodplains even when the probability of serious flooding is quite high, and people refuse to evacuate, even when there is a risk to life.

Of course, unrealistic optimism is not the only reason why people fail to take mitigating measures against flooding. When one decides to buy insurance or take mitigating measures one experiences definite and immediate costs. On the other hand, the potential benefits – the reduction of losses in the event of a disaster – are both uncertain and delayed. As is known from prospect theory (Kahneman & Tversky, 1979, 1992) and from numerous studies (e.g., Wu & Gonzales, 1996; Abdellaoui, 2000), people are risk averse in the domain of gains and risk seeking in the domain of losses. Thus, they may tolerate even huge potential losses if these are not certain. Moreover, the reluctance to worry about potential losses from floods or other natural hazards may be affected not only by the fact that they are uncertain, but also by the fact that they are delayed. As shown by much research on delayed gains and losses, people care strongly about immediate payoffs and much less about delayed payoffs (Kunreuther *et al*. 2013). When offered a choice between two positive payoffs, people prefer a smaller immediate gain to a larger later gain. Conversely, when offered a choice between two negative payoffs, people usually

prefer a larger later loss to a smaller immediate loss. The tendency to prefer the present makes people rather reluctant to care about future losses. In combination, uncertainty and the delaying of potential losses may result in the perception that a threat is not worth considering. People are often myopic and take into account only the short-term and certain consequences of their actions (Kunreuther, 2006).

Finally, let us mention yet another possible reason why people ignore potential losses. Agencies responsible for risk management make various efforts to protect the public against hazards. Such activity may lead to the so-called safety illusion, that is, to a diminution of people's concerns about residual risks. For example, owners of properties behind levees may ignore the residual risks. Some researchers (e.g., Wilde, 1982) claim that people have a level of risk with which they feel comfortable, and they tend to adjust the riskiness of their behaviour to this level. For example, people tend to drive faster when they have airbags and other newly introduced safety measures. In such situations people behave less cautiously and risks return to their previous level. This is referred to as the risk homeostasis theory. The safety illusion phenomenon is discussed in Chapter 9 where a relevant field study is presented. Subsequently, Chapter 10 raises the issue of how to make people aware that dikes and other flood protection measures are never 100% effective: they are never sufficient to counter extremely rare events.

1.4.1 Determinants of protective actions and insurance decisions

1.4.1.1 Threat perception: the probability and severity of consequences

It is tempting to use the decision theory approach in describing human flood risk-related decision-making. This approach assumes that a decision-maker considers a range of possible outcomes for each alternative course of action and the likelihood associated with each outcome. Thus, when an individual is considering whether to purchase flood insurance, on the one hand, they should take into account both the magnitude and the probability of potential losses in the event of a flood, and, on the other hand, they should consider the insurance premium. When one is making a decision about evacuation, one should identify the possible harms to one's life that may occur by remaining at home, how probable theses harms are, etc.

To illustrate the main idea of this approach, imagine that you have a choice between buying a more expensive house located in a safe place or a cheaper house on a floodplain. According to decision theory, when the decision-maker is risk neutral they may use the criterion of maximizing expected value. The expected value is the overall value of a risky option as given by multiplying the value of each of its outcomes by the probabilities associated with each outcome and then summing these products. Let us assume that the price of a house located on the floodplain is $100,000 as compared with the $120,000 price of a house in the safe

location. The probability of a serious flood in one's life-time equals 20% (according to insurance experts). In such a situation paying the extra $20,000 for the safe location of the house is equal to the expected value of a lottery in which one can lose $100,000 with a 20% probability. The expected value of a loss is the same: $20,000 (0.20 × $100,000). According to this analysis, if the price of the house on the floodplain is greater than $100,000 it will not be profitable to buy it.

Modern decision theory suggests that a decision-maker can be risk averse and prefer a certain to an uncertain outcome even when the expected value of the risky alternative is greater than that of the certain alternative. The theory assumes that people actually maximize expected utility rather than expected value by including attitude towards risk. The most popular theory of decision-making under risk is Kahneman and Tversky's (1979) prospect theory. According to this theory, the overall value of a risky option is given by the sum of the subjective values of outcomes multiplied by the decision weights associated with the probabilities of the outcomes.

Irrespective of the specific model involved, the decision theory approach assumes that the probabilities and severities of consequences are prime determinants of attitudes towards precautionary behaviours. In a study presented in Chapter 6 of this volume Tyszka and Konieczny compared both perceptions of flood threat and self-protective behaviour between residents of two types of region: one being protected by flood levees and the other being unprotected. Differences in perceptions of flood threat and self-protective behaviour were found between these regions. Surprisingly though, there was no support for the hypothesis that perceived probability of damage and perceived magnitude of damage caused by floods influence willingness to take protective actions. Thus, despite the common presumption and some empirical findings (see Lindell & Perry, 2012) that perceptions of risk are an important factor influencing the taking of protective actions, this idea is not supported by Tyszka and Konieczny's research. The finding that residents' flood risk perceptions were not related to the number of protective actions taken is not exceptional: Horney *et al*. (2010) failed to find a correlation between residents' risk perceptions and evacuation from the path of Hurricane Isabel in North Carolina in 2003. So the expectation that perceptions of high risk of property damage or injury are a sufficient condition for precautionary decisions is not justified. This supports Camerer and Kunreuther's (1989) claim that economic decision theory does not provide an adequate account of insurance-related behaviour and leaves room for education and intervention by policymakers and relevant authorities.

One problem with the decision theory approach is that even when an individual analyses the consequences and probabilities of alternative actions, and forms the intention to take protective action, impediments may exist to implementing these intentions. The implementation of our intentions is conditioned upon several situational facilitators and/or impediments in the physical and social environment. A person can decide that they should evacuate, but the lack of a safe place or safe

route can impede the implementation of such action. Also, a person may decide to purchase insurance but lack the financial means to follow through on their intention, etc.

Research shows that many different factors influence people's decisions to take protective actions and purchase flood insurance. Some of these involve individual differences. For example, Schade *et al.* (2012) found that tendency to worry (measured as a personality variable) influenced willingness to pay for protective measures. Also, Michailova and Tyszka (2016) found that individual rates of discounting were a negative predictor of people's decisions to insure themselves against flooding, that is, the more impatient a person was, the less inclined they were to buy flood insurance. At the same time, they found that risk aversion in the domain of losses was a positive predictor of the decision to acquire flood insurance, that is, the more risk averse a person was, the more inclined they were to buy flood insurance.

The above said, personality traits are not the only determinants of willingness to pay for protective measures; various situational factors can also be crucial. Two of the most commonly cited situational factors are personal experience and peer influence (social norms). The second part of the book reports studies focused mainly on these two factors, addressing both the issue of how they influence a person's willingness to take preventive actions in areas susceptible to severe flooding, and how they influence the purchasing of insurance against flooding.

1.4.1.2 Personal experience

Several research efforts show that one of the most crucial factors determining both threat perceptions and preventive decisions is previous personal experience of a disaster (see Weinstein, 1989; for a review). This research shows that experience of flood damage leads to greater fear, higher subjective probabilities of future disaster, more frequent purchasing of insurance, and to higher willingness to take preventive actions. However, it is not completely clear why personal experience is so important. Different mechanisms for the above effects can be considered. For example, Zaalberg *et al.* (2009) showed that the relationship between self-protective behaviour and personal experience may be mediated by beliefs about the effectiveness of protective measures. Why would one adopt a protective measure that one considers to be inefficient?

Perhaps the most powerful mechanism determining whether personal experience has an influence on mitigating behaviour is negative affect. Siegrist and Gutscher (2008) compared people who were affected by a severe flood disaster with people who were not affected but who also lived in flood-prone areas. They found that people who had not experienced flooding underestimated the negative affect associated with flooding. This finding was tested further in an experiment by Sobków *et al.* reported in Chapter 7 of this book. The authors confirmed two hypotheses in laboratory experiments. First, personal experience of a disaster increased the amount people paid to insure themselves against a natural hazard.

Second, emotional feelings of worry, rather than cognitive evaluations of subjective probabilities, mediated the relationship between personal experience of disaster and the amount paid to buy insurance. Thus, increases in the amount people are prepared to pay to buy insurance, and taking preventive actions in general, seem to be affected by personal experience via anticipation of the negative emotional consequences of natural disasters.

Despite the above, we agree with the conclusion of the PADM's originators that, despite extensive theorizing and data collection, the factors that motivate people to take protective action are still not entirely clear. After all, some people do not take any mitigating measures even after experiencing severe floods.

1.4.1.3 Social norms

There are many studies of the impact of social norms on human behaviour during life-threatening situations. One such study is that of Susan Cutter and Kent Barnes (1982). On March 28, 1979 on Three Mile Island in Pennsylvania there was a nuclear power plant accident: a partial meltdown of one of the two reactors. Cutter and Barnes studied people's propensity to voluntarily evacuate after the accident. In addition to such obvious motivators as obtaining appropriate information and being close to the site of the incident, the decisions of neighbours, relatives and friends were identified as an important factor in evacuation decisions.

In Chapter 6, Tyszka and Konieczny report research identifying social norms as the most important factor determining willingness to take preventive actions against floods. Here, people positively answering the question '*do your neighbours undertake any preventive actions against the consequences of floods*' tended to take preventive actions themselves.

Additionally, Krawczyk *et al.* report an experiment in Chapter 8 where they studied peer effects in insurance take-up choices. Here, the authors analyse and discuss various possible mechanisms of peer influence. They confirm that not only observing one's own losses, but also observing others' losses, may affect decisions to purchase insurance. However, observing another person's loss has a weaker influence upon behaviour than experiencing a loss oneself. It may be said that a decision-maker puts too little weight on relevant information emanating from other people. In their experiment the authors did not find support for another possible peer effect in that people were not directly affected by others in their decisions to buy insurance. Nevertheless, as mentioned earlier, there are many observations of the working of such a mechanism across many situations.

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