Recommendations

The last few years have seen a number of natural disasters that have been accompanied by major damage to industrial facilities. These events have demonstrated the potential for natural hazards, such as earthquakes, floods, storms, etc., to trigger fires, explosions and toxic or radioactive releases at hazardous installations that use or store hazardous substances. These so-called Natech accidents are a recurring but often overlooked feature of many natural-disaster situations. In addition, chemical and nuclear activities are an increasingly important source or risk of such accidents owing to increased industrialisation and urbanisation.

Unfortunately, disaster risk-reduction frameworks have not commonly addressed technological risks. The Sendai Framework for Action recognises the importance of technological hazards and promotes an all-hazards approach to disaster risk reduction. This includes hazardous situations arising from man-made activities due to human error, mechanical failure and natural hazards.

Chemical risk

Chemical accidents continue to occur relatively frequently in industrialised and developing countries alike, which raises questions about the adequacy of current risk-reduction efforts. The causes underlying chemical accidents are largely assumed to be systemic. Most chemical accidents today are caused by violations of well-known principles for chemicals risk management, which have led to insufficient control measures.

From the forensic analysis of chemical accident reports, a number of underlying causes have emerged, one or several of which can affect a chemical installation to create conditions conducive to disaster. These causes include:

- A lack of visibility due to a lack of published statistics on accident frequency and a reporting bias towards high-consequence accidents, which are a mere fraction of the many smaller chemical accidents that occur each week.
- The challenge to manage across boundaries, when chemical and mechanical engineers commonly assigned to chemicals risk management have little training in human or organisational factors.
- A failure to learn lessons from past accidents and near misses.
- Economic pressure and a trend towards optimisation, which can undermine risk management when decisions are made without due consideration of their impacts on safety risks.
- Failure to apply risk-management knowledge by both individuals and organisations due to a lack of awareness and education, or inattention to inherent safety.
- Insufficient risk communication and disconnection from risk management due to the globalisation of hazardous industries, which places a distance between corporate leaders and the sites they manage.

- Outsourcing of critical expertise or distribution of limited expertise over many sites, making it less accessible when needed.
- Governments do commonly not proactively engage in managing chemical-accident risks until after a serious accident, and accident management is focused on emergency preparedness and response rather than prevention.
- Complacency in government and industry due to the incorrect perception that chemical accidents are no longer a threat, thereby causing a decrease in resources for enforcement and risk management.
- Based on the identified accident causes, a number of areas for further study and experimentation to reduce chemical accident risks should be explored, and it is recommended that the following occur:
- Motivation of corporate and government leadership by exploring new models for risk governance, and promotion of a positive safety culture by fostering risk awareness. Enforcement will need a new strategy to drive industrial safety practice.
- Promotion of systematic accident reporting, data collection and exchange to raise awareness of the potential consequences of chemical accidents. These data should be used to learn lessons from accidents and near misses.
- Development of strategies to combat labour market deficiencies related to process-safety expertise.
- Creation of cheap and easy access to risk-management knowledge and tools, including to risk-assessment competence urgently needed in all areas of the world.
- Building of awareness of chemical risks and how to manage them in developing countries.
- Fostering of regional and international networks and collaboration on chemical accident risk management to create pressure and give developing countries easy access to expertise and technical support.

Nuclear risk

Accidents at nuclear facilities, regardless of the accident trigger, have the potential to cause a disaster. In the EU, a nuclear safety framework aims to ensure that people and the environment are protected from the harmful effects of ionising radiation. The basis of this framework is the defence-in-depth approach, a key concept by which to reach an appropriate level of protection from nuclear risks, and an adequate safety culture.

After several major nuclear accidents, safety assessment methodologies have been continuously improved, and the design of a NPP follows a set of rules and practices that ensure a high safety level. At the design stage, a set of accident conditions is identified that can result from different initiating events, and this set is examined using a conservative, deterministic safety assessment. This is complemented by a PSA, which provides a methodological approach to identifying accident sequences that can follow from a wide range of initiating events, as well as to determining accident frequencies and consequences. The challenge is to make certain that the list of considered initiating events is complete.

Many different protective activities form the basis of ensuring the safety of nuclear facilities, both during normal operation and in the case of accidents. However, the nuclear industry still faces a number of challenges that need to be addressed. The following are therefore recommended:

- Further assess the impacts on the safety of nuclear activities of human and organisational factors (e.g. training, management of change, evolution of regulations and associated requirements), of ageing effects on nuclear facilities and of financial concerns.
- Improve knowledge of the identification and modelling of natural hazards to support safety studies for nuclear facilities.
- Share good practice on emergency responses at local, national and international levels between nuclear and non-nuclear industrial activities to increase the efficiency of emergency-response plans.
- Promote research on the resilience of human organisations in the face of complex situations in nuclear industries and other areas with similar requirements.

Natech risk

Natech accidents are a technological 'secondary effect' of natural hazards and have caused many major and long-term social, environmental and economic impacts. National and international initiatives have been launched to examine the specific aspects of Natech risk and to support its reduction.

The forensic analysis of Natech accident records has allowed the preparation of lessons learned across different triggering natural hazards that support the reduction of Natech risks. This includes the setting up of a dedicated Natech accident database to foster the easy and free sharing of accident data. Accident analyses also show that there is an increased risk of cascading effects during Natech accidents. In general, Natech risk reduction pays off, and several structural, as well as organisational, accident prevention and consequence mitigation measures are available.

Studies on the status of Natech risk management in EU Member States and OECD Member Countries have highlighted deficiencies in existing safety legislation and the need to consider this risk more explicitly. Conventional technological risk-assessment methodologies need to be expanded to be applicable to Natech risk assessment and only a very few methodologies and tools are available for this purpose.

With respect to the effective reduction of Natech risks, several research and policy gaps still need to be closed in a collaborative effort between regulators, industry and academia. Public–private partnerships could be helpful in this context. More specifically, it is recommended that:

- Existing legislation that regulates hazardous industrial activities should be enforced. Where missing, legislation for reducing Natech risks should be developed and implemented.
- Risk communication on Natech risks should be improved between industry

and all levels of government to ensure a free and effective flow of information that enables a realistic assessment of the associated risk.

- Government should promote and facilitate the sharing of Natech accident data for future Natech risk reduction.
- An inventory of best practices for Natech risk reduction should be set up and disseminated to all stakeholders.
- Research should focus on the development of Natech risk assessment methodologies and tools, as well as guidance on Natech risk management for industry and at the community level.
- Competent authorities and workers at hazardous installations should receive targeted training to be able to handle the challenges associated with Natech accidents.
- Additional awareness-raising efforts are needed to help stakeholders recognise the vulnerability of hazardous industry to natural-hazard impact. In this context, the effects of climate change on natural-hazard frequencies and/or severities need to be factored in.

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Communicating disaster risk

Kees F. Boersma
Coordinating lead author

Teun Terpstra
Lead author 4.1

Ann Enander
Jan Gutteling
Christian Kuhlicke

Tina Comes
Lead author 4.2

Anouck Adrot
Caroline Rizza

Irina Stanciugelu
Lead author 4.3

Aurel Bilanici
Ian Cameron

David Allen
Lead author 4.4

Eve Coles
Terhi Kankaanranta
Caroline Mcmullan
David Mobach
Alistair Norman
Tanja Perko
Kari Pylvas
Niek Wijngaards

4 Communicating disaster risk

CONTENTS

Introduction

The communication of disaster risk is inherently a social process. It aims to prevent and mitigate harm caused by disasters, prepare the population for a disaster, disseminate information during disasters and nurture the recovery. Disaster risk communication plays a vital role during all four stages of the disaster cycle: mitigation and prevention, preparedness, response and recovery. This chapter aims at translating scientific insights in disaster risk communication to decision-makers to eventually enable communities to respond effectively to damaging events. It builds on the idea that using insights from (communication) science is essential for effective decision-making to improve lives, livelihoods and health (Aitsi-Selmi et al., 2016; Dickinson et al., 2016).

Risk communication in disasters has traditionally been a one-way, unilinear and top-down transfer of information from authorities to the public (Krimsky, 2009). The current literature on disaster risk communication, in contrast, sees communication between authorities and the public about disasters as an outcome of interactions. Although there is no closure on the effectiveness of new communication strategies due to the lack of systematic studies (Bradley et al., 2014), there is growing empirical evidence that a two-way dialogue between the public and professionals is more effective than the traditional unidirectional model of disaster risk communication (Treurniet et al., 2015). The non-linear, multi-directional approach to risk communication is consistent with a political landscape where the legitimation is gained through negotiation and deliberation.

Chapter 4.1 shows that for disaster risk communication to be successful, public perception should be taken into consideration. This involves both a cognitive and affective dimension (understanding and feeling) and is related to trust in protection measurements and mitigation processes. In the process of communication, policymakers should not underestimate the cognitive paradox: a higher trust in protection hampers the preparedness intentions (Terpstra et al., 2009; Lundgren and McMakin, 2013). This relates to the affective dimension, which is influenced by the way risk is communicated. Presenting the same information about risk in different ways, for example mortality versus survival rates, will influence people's perceptions (Slovic, 1993). Unidirectional ways of risk communication can reinforce negative feelings such as fear and powerlessness. In contrast, a two-way, more inclusive communication mode will give citizens the feeling that self-help and solidarity are indeed appreciated by the formal authorities. This communication strategy opens the possibility to build upon both the cognitive and the affective responses in relation to previous experiences with disastrous situations. However, whilst the literature highlights the importance of the non-linear multi-directional approach of communication, research into actual communication practices indicates that a majority still

relies on the one-way form of communication (Höppner et al., 2012).

As Chapter 4.2 on decision-making with uncertainty highlights, disaster risk communication takes place through many different communication channels, including face-to-face conversations, telephone calls, group meetings, mass media such as television, instant messaging and interactive social media, in particular Facebook and Twitter. These communication channels, however, are not considered to be neutral. Today's society's social structure, made up of networks powered by information and communications technologies (ICTs) (Castells, 2009), has shaped and influenced decision-making in disaster risk reduction (DRR) and disaster risk management (DRM). Decision-making under uncertainty starts with the question about what the decision-maker knows and where the gaps in the existing knowledge and information are (Ben-Haim, 2006). Consistent with the multi-directional approach to risk communication, recent studies show that for decision-making at times of uncertainty to be successful, a top-down, command and control approach should be abandoned, and should instead involve the public. Formal authorities, in other words, do not have the monopoly in making decisions about the disaster cycle.

The implementation and use of ICTs including social media provide opportunities for engaging citizens in disaster risk communication by both disseminating information to the public and accessing information from them. ICTs have great potential for enabling effectively communicating community-relevant information, in particular in situations in which people are geographically dispersed (Shklovski et al., 2008; Stal, 2013).

Chapter 4.3 on last mile communication builds upon the recent empirical insights on effective early warning systems. The term 'last mile' is understood as a synonym for the immediate affected area and population (Taubenböck et al., 2009). The chapter shows that the impact of the ICT and social media response are influenced by: 1) large-scale power blackouts and the disabling of information and telecommunications networks and 2) the demographics of the disaster including the willingness of people and their organisations to collaborate in sharing, managing and communicating disaster information and their (dis)ability in accessing resources online. Both the vulnerability of the networks and the particularities of the users require innovative solutions.

Adequately designing, implementing and using ICTs are equally important aspects of innovation to make full use of social and technical capacities to improve actual practices in risk communication. Innovation in disaster risk communication is not neutral, but embedded in social and cultural practices. For example, a recent qualitative study assesses the role of age and ethnic and cultural background in the conceptualisation of colour systems used as part of the Heat Health Watch System and the National Severe Weather Warning Service (Tang and Rundblad, 2015).

The final chapter of this part, on innovation and good practices, builds on

these ideas and addresses both the technical and the social/cultural dimension of innovation. Communities and evolving decentralised approaches of disaster risk communication are discussed in the context of ICTs development and use. The chapter takes a people-centred approach by focusing on the challenges of communicating with millennials — technologically sophisticated multitaskers (Hartman and McCambridge, 2011) — as an example of how people with specific backgrounds deal with risk communication technologies at times of uncertainty. Finally, it discusses innovations which allow rich media channels to be utilised, including netcentric operations (Boersma et al., 2012) aiming at delivering better targeted actionable risk information to diverse agents across multi-cultural, multi-disciplinary and multi-jurisdictional boundaries.

This Chapter 4 provides scientists, practitioners and policymakers the state-of-the-art knowledge to improve their understanding on communicating disaster risk. It combines insights from psychological, social and computer sciences and presents good practices for those involved in risk communication practices.

4.1 Public perception of risk

***Teun Terpstra**, Ann Enader, Jan Gutteling, Christian Kuhlicke*

4.1.1 Introduction

As with any scientific domain, the field of risk perception also embraces many subfields and topics. These have been discussed in literature reviews that have sometimes focused on particular hazards, such as seismic hazards (Lindell and Perry, 2000), flood hazards (Kellens et al., 2012), genetically modified foods (Pin and Gutteling, 2008) or multiple hazards (Wachinger et al., 2013; Shreve et al. 2014).

Others have focused on theoretical frameworks such as people's protective action decisions (Mileti and Sorensen, 1990; Lindell and Perry, 2004; 2012), their information seeking (Griffin et al., 2004; Ter Huurne, 2008), how risk is culturally construed (e.g. Steg and Sievers, 2000; Engel et al., 2014) and socially amplified (Kasperson and Kasperson, 1996), or on specific psychological mechanisms such as the role of trust (e.g. Midden and Huijts, 2009; Frewer et al., 2003; Haynes et al, 2008), perceived responsibility (e.g. Mulilis and Duval, 2003; Terpstra and Gutteling, 2008), fear and efficacy beliefs (e.g. Witte, 1994) and cognition and affect (Slovic et al., 2007; Loewenstein et al, 2001).

Understanding how people perceive risks is an important factor contributing to successful risk communication.

Understanding how people perceive risks is one important factor contributing to successful risk communication (e.g. Frewer, 2004; McComas, 2006; Slovic, 2000). However, this chapter is not an attempt to review the risk perception literature. Instead we focus on different approaches in risk communication and illustrate the working of perceptual factors by presenting a number of topical cases. To set the ground, the Chapter 4.1.2 presents different approaches in risk communication. The presented cases comprise capacity building (Chapter 4.1.3), evacuation (Chapter 4.1.4), emergency alerts (Chapter 4.1.5), social media (Chapter 4.1.6) and news media (Chapter 4.1.7). Although some of these chapters focus on certain risks in particular, it is not so much the risk but rather the described socio-psychological processes that are relevant. We conclude with some general remarks (Chapter 4.1.8).

4.1.2 Approaches in risk communication

A long tradition in risk communication has relied on the idea that simply informing and educating lay people will increase their understanding and awareness of risk. This one-way information flow from expert to lay is often associated with the so-called

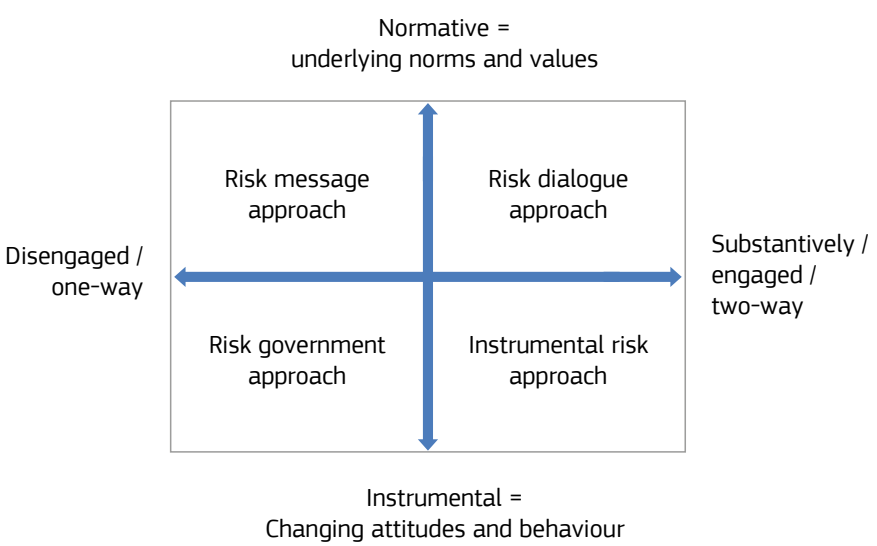
deficit model, as experts holding superior knowledge communicate to the less informed.

Many communicative activities are nowadays intending to change behaviour; others are concerned with norms and values. In addition, risk communication can take place in a disengaged (one-way) and in a more engaged (two-way) manner.

For a number of years a broad shift has been taking place throughout Europe (and beyond), characterised by, on the one side, 'a right to know', and on the other side by a stronger focus on 'individual responsibility' of citizens to be prepared for incidents and disasters. As a result, communicative activities that place responsibility for preparedness actions in the hands of citizens are gaining relevance (Wachinger et al., 2013; Walker et al., 2014; Begg et al., 2016). Many are now following a rather instrumentalist rationale intending to change behaviour or attitudes; others are rather concerned with norms and values that underpin, for example, established governance and decision-making structures. At the same time, risk communication can take place in a disengaged, one-way manner as well as in a more engaged, two-way manner (Treurniet et al., 2015). Based on these two dimensions, four approaches of risk communication can be distinguished (based on Demeritt and Nobert, 2014; Wardman, 2008): risk message, risk dialogue, risk government and instrumentalist risk. These approaches can be seen as archetypes suggesting different ways to achieve one's risk communication goals. In practice, examples of risk communication often contain features of multiple approaches (for more details see Kuhlicke et al., 2016).

FIGURE 4.1

Different approaches in risk communication.
Source: Based on Wardman (2008) and Demerit and Nobert (2014)



4.1.2.1 Risk message approach

This type of risk communication is a one-way flow of information concerned with 'transmitting risk information without distortion, bias or misunderstanding' (Demeritt and Nobert, 2014). Fundamentally, this model is based on the idea that responsible organisations are transparent about how they assess risks, what kind of outcomes risk assessments generate and how risks are managed. For instance, by designing risk maps in a way that renders them intuitively understandable, the sender tries to encode the message in such a manner as to increase the likelihood that the receiver will be able to decode the message and draw his or her own conclusion on what to do or not to do (Meyer et al., 2012).

4.1.2.2 Risk dialogue approach

In the risk dialogue approach the distinction between senders and recipients or between certified risk experts and the at-risk lay public is a blur. Exchange forms are based on the assumption that both have a say in the decision-making process. The design of participatory processes depends on its purpose. A common typology is to distinguish between a substantive and an instrumentalist rationale

(Stirling, 2006). The substantive rationale usually aims at increasing the breadth and depth of knowledge that contributes to a decision, as participation allows for the inclusion of tacit or local knowledge that can improve the quality of risk assessments and risk maps, as well as of the management process itself (see Meyer et al., 2012). In the instrumentalist rationale, there is a stronger focus on building trust between actors and on raising awareness and motivation for taking actions to mitigate the impacts of hazards (see Wachinger et al., 2013). The relevance of dialogical forms of communication is also highlighted by many national and European legalisations (Höppner et al., 2010).

4.1.2.3 Risk government approach

Communication within the risk government approach aims at changing attitudes and behaviours, but it does so in a less instrumentalist and explicitly persuasive manner compared to the instrumentalist risk approach. While the latter is opaque about its intention, the government model relies on '… logics of individual choice and self-discipline, rather than explaining new norms of conduct as being imposed from above through coercion' (Demeritt and Nobert, 2014).

In many European countries insurance companies, for instance, offer more affordable insurance premiums if clients voluntarily participate in regular preventive medical check-ups and, by doing so, aim at activating individuals' personal risk awareness and inviting them to consider the negative consequences of smoking or of excessive lifestyle choices; thus creating awareness of their own choices and decisions and the negative consequences these might have on their lives.

4.1.2.4 Instrumentalist risk approach

The instrumentalist risk approach aims at actively changing people's behaviour and pays close attention to the 'interactions between information, attitudes and behaviour' (Demeritt and Nobert, 2014). Due to the increasing prominence of this model, many empirical studies focus on understanding the factors that motivate individuals to take responsibility and action in order to increase their preparedness (Shreve et al., 2014). This type of communication may take many different forms. Quite common are the use of printed booklets or brochures that encourage residents at risk to increase their preparedness. The EU project Tactic has collected a multitude of such examples, which can be accessed through the online platform (TACTIC project, 2017). Also more formalised ways of trying to change people's habits are increasingly established. For instance, in the German state of Saxony citizens are required by law to take precautionary actions to increase their preparedness (Ueberham et al., 2016).

4.1.3 Capacity building through one-way risk communication

The EU Seveso and Floods Directives have made public risk communication an obligatory task of risk management in EU countries. Government websites, dedicated hazard and risk maps and brochures are common methods to inform the general public about risk and possible ways to increase their preparedness. These methods provide information about risks in a non-dialogic fashion and can be seen as examples of the 'risk message approach'. Transmitting risk information without distortion, bias or misunderstanding is a challenge, however, both from a normative and a practical perspective.

From a normative perspective, 'without distortion, bias or misunderstanding' does not mean that the content and tone of the risk communication is 'value free'. Senders of risk messages, either risk experts or policymakers, have their own perceptions of the problem and interests. These are informed by societal norms, political agendas and personal opinions — which are hardly ever universally shared in society. In addition, providing information that is to be understood by many people with different backgrounds often requires focusing on the most 'important' (i.e. certain) aspects and simplification of information. This results in deliberate and chance choices in content (wording and images) and tone, which in turn influences people's perceptions and attitudes in different gradations (also see Chapter 4.1.5).

From a practical perspective, 'transmitting risk information' is hardly ever an objective on its own. A common complementary objective of providing information is to enhance risk awareness and to provide infor-

mation about individual preparedness actions. This reflects a cross-over between risk message and risk government approaches. The goal is usually to convey a message drafted by a responsible organisation to those who are 'supposed to need' this message in order to be better prepared for disasters.

While such measures have a relatively low cost (Lundgren and McMakin, 2013) and are in many cases essential for getting a certain message across (e.g. warning), non-dialogic risk communication on its own seems limited in its impact on most people's attitudes, active engagement and preparedness behaviour (Moser, 2010). The reason is that changes in attitudes and behaviour are the end result of a complex social-psychological process, and the route to this end result differs greatly between people and communities. Risk communication from authorities will not lead to protective action decision-making unless people receive, heed and comprehend the socially transmitted risk information (Lindell and Perry, 2004). For people to act upon a risk message they must perceive its relevance as well as a sense of urgency. What is relevant or urgent for one person may not be so for others. For instance, changing the battery of a smoke detector may be linked to a personality trait (e.g. high risk aversion or a prevention orientation; e.g. De Boer et al., 2014), previous experience with fire risk, willingness to adhere to a perceived social norm (e.g. "I should have a working smoke detector") or because of practical circumstances (e.g. being a smoker). However, even with these factors present, one may fail to take action. For instance, dealing with risk may arouse negative affect in people, which may in turn result in attempts to control their feelings instead of taking action (e.g. denial), as one may feel unable to perform required actions (low self-efficacy), have little faith in the protective action itself or action is hampered due to practical response barriers (e.g. having other priorities).

There is no such thing as 'one size fits all' in risk communication. Resilient behaviour is more likely when there is a mix of communicative approaches and other types of measures in place. Risk communication is based on a thorough understanding of risk perceptions and capacities that are shaped through the historical and local context.

Evaluations of a campaign about communicating flood risk, organised by the city of Zurich, showed that one-way risk communication can improve flood preparedness to some extent; i.e. home owners' flood awareness and their intentions to implement protective actions did increase (Maidl and Buchecker, 2015).

The majority of respondents felt better informed after the information campaign (only 17 % reported that the campaign did not increase their knowledge) and regression analyses revealed that the perceived usefulness of the material provided had the strongest effects on flood preparedness intentions. A perceived need for information had greater effects on preparedness intentions than risk awareness itself, underlining that the motivation to do something increased through the information campaign. However, since the overall effect of the information campaign was rather low, the authors argued that a single-event campaign is unlikely to have profoundly positive effects on preparedness behaviour and therefore needs to be embedded in a long-term risk communication campaign.

Empirical studies also indicate that it is not so much the information itself that is of relevance but rather the wider context within which such information is communicated. Engel et al. (2014), for instance, focus on the role of disaster subculture as a way to explain how two neighbouring communities have developed different strategies and practices to deal with flood events. These subcultures featured differences in beliefs, knowledge, symbols and preparedness and response patterns. Their findings suggest risk communication would require different approaches in both communities.

Therefore, what is feasible and effective in one context may be difficult or ineffective somewhere else. There is no such thing as 'one size fits all' in risk communication. Resilient behaviour is more likely when there is a mix of communicative approaches and other types of measures in place based on a thorough understanding of risk perceptions and capacities that

are shaped through the historical and local context. Finding the right mix of measures is therefore a challenge.

4.1.4 Developing flood evacuation strategies through dialogue

In an attempt to hit the right note in risk communication, this paragraph presents a case study that tested effects of different risk communication storylines on citizens' flood evacuation intentions in the city of Dordrecht (Terpstra and Vreugdenhil, 2015). Dordrecht is located on an island in the Dutch river delta. A potentially dangerous situation occurs when high river discharges result in high water levels that are suddenly further increased by a storm surge pushing sea water into the river delta. Evacuation models indicate that in such a case only between 10-20 % of the population will be able to leave the city before the levees break. When they do, water depths may vary between 2-5 metres and the best chance of survival is to seek shelter in homes on a higher floor or in a high building in the neighbourhood. To reduce the potential number of casualties, the authorities aim to develop and communicate a strategy based on sheltering at home or in a public building.

In 2015 the municipality started a risk dialogue by involving citizens in focus groups to understand their flood perceptions, their evacuation attitudes and their concerns and suggestions. To gain further insight into the level of support for 'staying at home' or 'going to a public shelter', a questionnaire survey was performed. The questions asked were embedded in two different storylines, which reflected two different communication frames that emerged from previously held focus groups. 'Framing' in communication refers to the systematic use of words and symbols reflecting underlying norms and values. For a risk dialogue it is important that people are able to relate to the norms and values and support the frame that is used. Framing can also be regarded as a form of nudging. Nudging refers to '…any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any option or significantly changing their economic incentives.' (Thaler, Sunstein, 2009). A more pessimistic 'Self-frame' emphasised that in case of a flood, people are on their own for a few days and food, water and utilities are unavailable and they eventually have to evacuate from the flooded area on their own.

Cognitive (beliefs) and affective (feelings) factors are important predictors of attitudes. These are influenced by the way risk information is framed in communication messages.

The more optimistic 'Together-frame' emphasised the community perspective meaning that people are in it together and will try to help each other, and authorities will assist in evacuation where needed and arrange basic stocks of food, water and utilities in shelters. All respondents (about 625 citizens) answered questions related to their efficacy beliefs, feelings and support for two evacuation options (staying at home, going to a public shelter) and their current evacuation intentions. More questions were asked, but for our purposes we will discuss this subset. On a 1-10 scale, both strategies received higher rates in the Together-frame—i.e. staying at home (Self-frame: 6.2 vs. Together-frame: 6.3) and going to a public shelter (Self-frame: 5.2 vs. Together-frame: 6.0). Remarkable, however, is the fact that both strategies were rejected by a substantial number of respondents: about 27-28 % rejected staying at home while 36-52 % rejected going to a shelter (upper limit % reflects rejection in the Self-frame).

To further explain these results, the authors evaluated respondents' efficacy beliefs and fear-related feelings. Efficacy beliefs reflect the extent to which a person believes a protective action is effective in the protection of people and/or property (e.g. Lindell and Perry, 2004, 2012). Fear-related feelings such as dread is a negative affective state. Affective states influence people's judgements (Loewenstein et al., 2001; Slovic et al., 2007) and can be unlocked by framing information (Terpstra et al., 2014). For instance, Finucane et al. (2000) performed framing experiments to influence perceived risks and benefits of nuclear power, natural gas and food preservatives. Their experiments showed that when information portrayed the benefits as high (or risks as low), the subsequent experience of positive affect

caused subjects to perceive risks of nuclear technology as low (or benefits as high). Conversely, when risks were framed as high (or benefits as low), the subsequent experience of negative affect caused subjects to perceive benefits of nuclear technology as low (or risks as high).

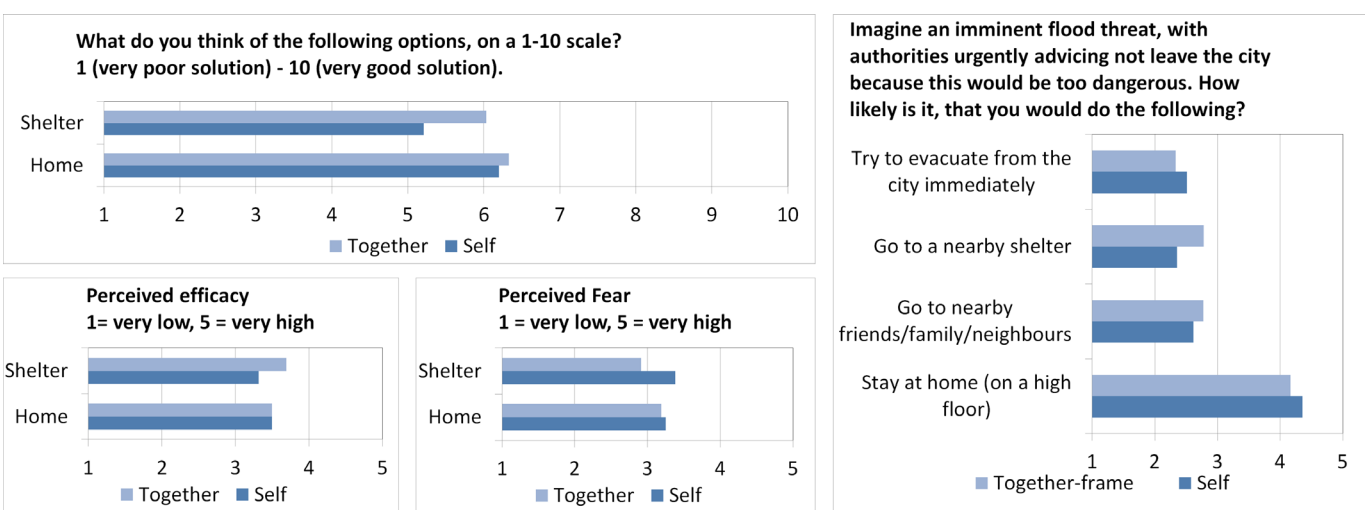
In line with experiments of Finucane et al., additional analyses of the Dutch flood risk data showed that respondents held more favourable attitudes in the more optimistic Together-frame since this frame resulted in lower negative affect/fear and higher efficacy beliefs. Specifically, staying at home received a (marginally) higher score in the Together-frame because it evoked slightly lower levels of negative affect/fear. Going to a public shelter received a higher score in the Together-frame because this frame evoked lower levels of negative affect/fear and higher trust in the efficacy ('being safe') of a public shelter.

Respondents' intentions also revealed an interesting pattern. Staying at home was regarded as likely by about 88 % of the respondents, while going to a nearby shelter or going to family, friends or neighbours was regarded as likely by a substantially smaller number of people (25 % and 28 %, respectively). So even though attitudes towards staying at home and going to a public shelter are similar (at least in the Together-frame), the majority preferred to stay at home. Finally, the fact that 19 % of the respondents considered leaving the city, even though the authorities urge them not to, is remarkable. These people may unnecessarily risk their lives. Their intention to flee the city is correlated with their attitude towards staying at home or going to a public building. That is, respondents who hold less favourable attitudes towards staying at home or going to a shelter are more likely to flee the city in case of an urgent flood threat.

Overall, the meagre level of support for staying at home or going to a public shelter suggests that these strategies can be further detailed. A clear action plan on how citizens are supported prior to a flood (e.g. food and water supply and setup and arrangements in shelters) and afterwards (e.g. a rescue plan) is an important starting point. Based on a further risk dialogue with citizens, experts in flood risk management, utilities, medical and rescue services, it seems that such a plan can be developed. In addition, developing a positive yet realistic storyline for risk

FIGURE 4.2

Perceived fear, efficacy, support and intentions regarding flood evacuation. Source: Terpstra and Vreugdenhil (2015).



communication based on the capacities available in the local communities (e.g. neighbourhoods) can help to gain further support among citizens and reduce chances that people risk their lives by fleeing the city while the levees are about to break.

4.1.5 Facilitating public response through wireless emergency alerts

In the case of an imminent threat, authorities require communication channels that deliver warnings accurately and quickly to a potentially large number of people. A relatively new development is the so-called Wireless Emergency Alerts (WEA). Several countries have started sending out WEA to mobile phones and other devices aiming to alert people at risk and help them to react adequately (Gutteling et al., 2014). As one-way communication tools, WEA are an example of the risk government model. Many of these systems are based on the mobile phone broadcast technology. There is no need to have Wi-Fi or internet or to subscribe to the service. However, technological development and its implementation has outpaced studies on the effectiveness and limitations (Bean et al., 2015). To date, only a few studies have evaluated mobile device-delivered warning messages (Sutton et al., 2014; Terpstra et al, 2012).

A United States report lists several general insights necessary to facilitate adequate public reactions to WEA, among which: (1) effects should be studied after real events, not in hypothetical situations; (2) people need to be trained to properly understand the warning system; (3) the alert needs to attract attention; (4) people seek social confirmation of a warning message before taking protective action; and (5) warnings must contain information that is important to the public (Committee on Public Response, 2013). This chapter describes a recent Dutch study on the public's reactions, which is partly based on these general insights.

In the study people were questioned some time after the implementation of the WEA system in real local emergency situations in three Dutch cities. In the first two cases the emergencies were large fires in non-residential industrial areas with a release of potentially hazardous smoke and soot particles to nearby residential areas. The third situation was a large fire in a historic city centre, causing one casualty. Randomly selected mobile and land-line phone numbers of people living in the broadcast area were dialled by trained agency interviewers, asking whether they had received the WEA. In the Netherlands the WEA system is known as NL-Alert. If they had, some additional questions were asked (e.g. their self-reported behaviour) and people were invited to complete an additional online questionnaire measuring psychological and behavioural determinants derived from conceptual models on risk communication (Witte and Allen, 2000; Floyd et al., 2000; Lindell and Perry, 2012).

These models suggest that receivers of warning messages first assess the threat level, creating some level of personal urgency, and subsequently assess their ability to personally cope with the emergency situation. Coping appraisal is related to one's belief to be able to perform the recommended behaviour and one's belief in the adequacy of the provided advice. When the threat is seen as personally relevant, and the coping appraisal is positive then one will decide to execute the recommended adaptive behaviour. However, when the threat is seen as relevant but coping is seen as impossible, some psychological reframing of the situation (e.g. psychological denial or defensive behavioural avoidance) is a likely reaction. In recent years, studies have shown that in emergency situations the individual is an information seeker but also an information source for others. Existing research suggests that perceived information sufficiency — that is, to which level one is satisfied with one's information position — predicts additional information seeking and information sharing. Also, the perceived quality of the warning message is an important indicator of its effectiveness (Renn and Levine, 1991; Earle, 2010).

Wireless emergency alerts (WEA) are a relatively new method to deliver warnings to a potentially large number of people.

Looking in more detail at the public's reactions to receiving the WEA, some findings are noteworthy. An example of the WEA is this message that was sent to inhabitants:

NL-Alert 20-01-2013 14.50 Setheweg Meppel. Major fire. Keep clear of the smoke!

Close windows and doors. Turn off ventilation. New message follows.

The structure of all Dutch WEAs is similar: sender (NL-Alert date and time), threat (major fire), location (Setheweg Meppel) and advice (*Keep clear of the smoke! Close windows and doors. Turn off ventilation. New message follows*). The respondents' reactions were measured on five-point scales (see Table 4.1).

Overall, the scores indicate that the emergencies had relatively little personal impact for most participants. However, even in these relatively low impact situations, there are some noteworthy findings. On average, respondents valued their coping abilities as relatively high and clearly indicated that the included message components (sender, threat, location and advice) were regarded as clear, complete and reliable (message quality). In addition, respondents did not perceive high expectations to be knowledgeable and responsible with regard to their behaviour in these situations (social norms). In absolute terms, perceived fear and perceived threat were not high, although they were somewhat higher in the Leeuwarden case. This seems reasonable since the Meppel and Oisterwijk fires occurred at some distance from residential areas, while the fire in Leeuwarden took place in the historic city centre. In addition, compared to the Meppel and Oisterwijk cases, respondents from Leeuwarden were somewhat less satisfied with the information received and reported more avoidance (i.e. to continue with what one was doing) and less adaptive behaviour (i.e. to comply with the advice and seek and share information). Two alternative explanations come to mind. First, emergency services in Leeuwarden failed to describe the location of the fire, which may have caused lower levels of satisfaction with the information provided, and they did not mention any personal threat, which resulted in higher disinterest in the situation. Second, higher levels of perceived threat and fear may have caused stronger fear control responses, resulting in more avoidance reactions and less adaptive behaviour. Even though the sample was small and these incidents had relatively little personal impact, correlations did provide some support for these explanations. Adaptive behaviour was predicted by higher perceived fear, seeking social

TABLE 4.1

Mean (standard deviation) for the measured determinants after three WEA cases. Source: Gutteling et al. (2014)

	Case 1 (Meppel)	Case 2 (Oisterwijk)	Case 3 (Leeuwarden)
N=	175	181	287
Self-reported Behaviour			
Adaptive (a)	1.71 (0.26)	1.69 (0.29)	1.55 (0.29)
Avoidance (b)	1.17 (0.38)	1.12 (0.33)	1.46 (0.50)
Perceived social norms (c)	2.37 (1.10)	2.30 (1.03)	2.13 (0.99)
Efficacy beliefs (c)	3.93 (0.93)	3.90 (1.06)	3.97 (1.04)
Perceived threat (c)	2.41 (0.82)	2.59 (0.86)	2.90 (0.82)
Perceived fear (c)	1.72 (0.62)	1.69 (0.57)	2.32 (0.69)
Perceived message quality (c)	4.31 (0.77)	4.37 (0.75)	4.32 (0.81) (e)
Perceived information sufficiency (d)	3.59 (1.11)	3.63 (1.11)	2.98 (0.82)

a. telephone: 1 = none of the adaptive actions taken, 2 = all adaptive actions taken
b. telephone: 1 = no avoidance, 2 = complete avoidance
c. online: 1 = low, 5 = high
d. online: 1 = dissatisfied, 5 = satisfied
e. In Leeuwarden the component 'location' was missing and therefore not evaluated

confirmation and perceived warning quality. Stronger avoidance was predicted by higher levels of perceived risk, fear and higher perceived expectations from one's social environment. Overall, the study presents a favourable impression of the public's evaluation of the WEA system; however, more research is needed with other types of emergency situations to fully understand the psychological, behavioural and communicative reactions of receivers.

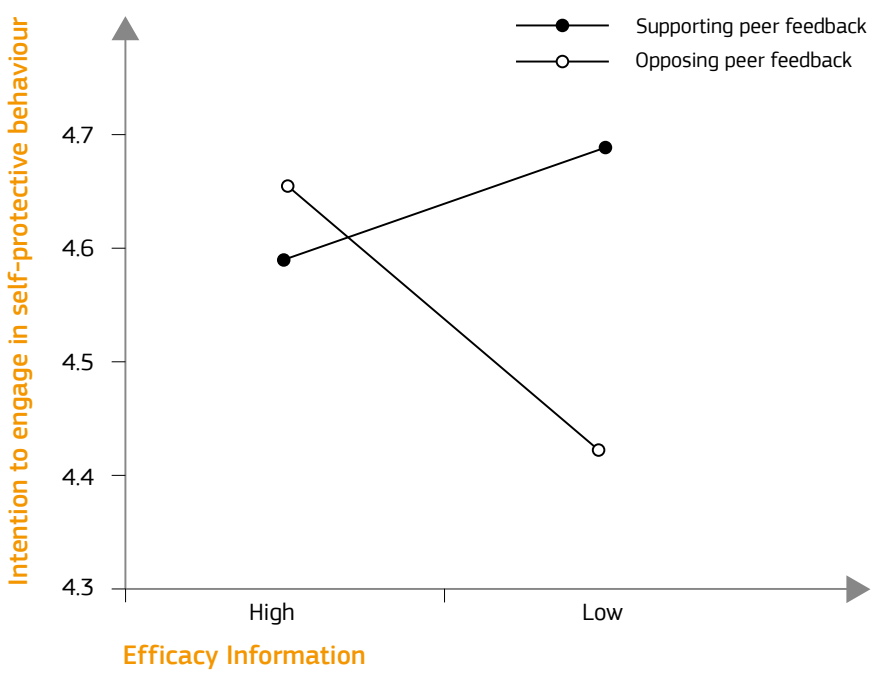
4.1.6 Effects of interaction on social media in emergencies

Social media (Twitter, Facebook, blogs, etc.) have been under the attention of risk and disaster managers longer than WEA. Social media and WEA provide similar possibilities to inform the public of imminent emergencies. However, social media also allow for feedback in the form of user-generated content (opinions, observations, etc.) or geospatial information (Palen et al., 2009; Terpstra et al., 2012; Feldman et al., 2016; Houston et al., 2014; Committee on Public Response to Alerts and Warnings using Social Media, 2013; and many others). This chapter aims to describe studies on the effectiveness of social media in emergencies. The use of social media with the objective to influence people's behaviour is therefore an example of the instrumentalist risk approach.

Social media are intensively used in times of crises to share information and support or oppose opinions. A recent study indicates that when official information is regarded as effective, peer feedback is less influential.

FIGURE 4.3

Interaction effect between efficacy beliefs and peer feedback on the intention to engage in self-protective behaviour.
Source: Verroen et al. (2013)



As with WEA, there are few empirical studies indicating at a general level what the impact of social media disaster information is or how social media can be designed to be effective disaster-warning tools. The number of studies that have analysed social media messages after real incidents and disasters is steadily growing. A United States study analysing the use of Twitter after a disaster (the Tennessee River dam break) indicated that the amount of information shared by citizens — even those not in the direct vicinity of the emergency location — is considerably greater than the 'official' information from governmental organisations and the company (Sutton, 2010).

Twitter users also tended to be critical toward the official information and corrected wrong information. Starbird and Palen (2010) studied Twitter messages after the Red River flood of 1997 and the the Oklahoma wildfires and found that Twitter messages from those directly involved in the situation

are retweeted relatively often. Information provided by local news media are also retweeted relatively often. A Dutch study analysed Twitter messages just before, during and immediately after a huge storm which hit a large public open air music event (Terpstra et al, 2012). In the Twitter messages, weather predictions were found as well as rumours and messages that were focusing on providing help after the emergency. When the scale of the emergency became evident, one person took the initiative to organise the inhabitants of a nearby town to provide help (places to spend the night, food and drink, showers, clothing, Wi-Fi, etc.). The data suggested that some of the Good Samaritans were Twitter novices.

An important downside of analysing communication after real events is the difficulty in analysing cause–effect relations of communication messages. This requires communication experiments in a controlled setting where researchers can manipulate perceptual factors by providing different information to separate groups and compare their responses. Although such studies are quite common in communication research, applications to social media are scarce.

Verroen et al. (2013) focused on a typical characteristic of social media communication: people's positive and negative feedback on an earlier distributed message. The message contained emergency information in the context of a high-impact risk, namely the derailment of a freight train carrying a highly flammable and toxic substance. These authors were interested in the interplay of the perceived efficacy of the emergency information and peer feedback, such as responses on social network sites (e.g. Twitter) and the effect of this interplay on the intention to engage in self-protective behaviour.

The study pitted high- and low-efficacy information messages against supporting (positive) and opposing (negative) peer feedback (N =242). Although the study used a hypothetical emergency situation, the participants were selected based on the fact that they lived in an area close to an existing railroad track used by these high-risk trains. Results showed a significant interaction effect between efficacy information in a news article and peer feedback from Twitter messages on both the intention to engage in self-protective behaviour (see Figure 4.2) and the levels of involvement.

Participants who received the news article with more efficacy information were similarly influenced by supporting or opposing peer feedback via Twitter messages.

However, among those who received a low efficacious news article, the effect of peer feedback on these two variables was significantly stronger. Supporting peer feedback (that is peer feedback that supported the advice in the news article) resulted in a significantly higher intention to take protective measures (and involvement) than opposing peer feedback (that is feedback that questioned the advice in the news article). Apparently, when in doubt about how to act to mitigate risk, the tone of peer feedback on social media is important for one's decision making.

4.1.7 Role of news media in defining human responses to crises

In this final case we discuss the role of the news media. This case is not an example of one of the four risk communication approaches in particular. Rather that news media can be regarded as a (highly) influencing factor in each of these approaches, as they reflect on the norms, values and behaviour of people and organisations in relation to risks, incidents and crises. People may be influenced not only by how information about the actual risks is framed, but also by how different frames concerning reactions and behaviours to risks and dangers are put forward in media articles and reports after critical events. The role of media in contributing to erroneous beliefs and myths about human behaviour in stressful situations has been discussed for some decades in the social science literature, culminating in a number of critical analyses of the reporting of reactions to Hurricane Katrina in 2005 (Tierney et al, 2006). More recent work has further demonstrated how subtle and implicit framing can define the portrayal of human reactions, potentially influencing the expectations and evaluations of both the public in general and risk and crisis professionals in particular. In an analysis of media reporting from six different crisis events affecting Swedish society, including natural disasters, antagonistic threats and diffuse threats, Nilsson et al. (2016) identified three dynamic interrelated processes simultaneously at work in framing public reactions.

The first process, that of identification, concerned individuals and groups that were referred to as affected, and in what context. For example, in the natural disaster events, some groups were described as vulnerable and affected by serious losses in terms of economic value of forestry, while others with less tangible losses were barely mentioned. The second process refers to characterisation of how different individuals and groups reacted and coped with the situation. In this process certain characteristics tended to be attributed collectively to groups among the public, creating ingroups and outgroups. This pattern was particularly evident in the case of antagonistic events (one case concerned street shootings in a major city), separating the fear reactions of law-abiding citizens from those of victimised groups with suggested criminal links.

News media reports play a very important role in effective communication and support public needs in stressful situations.

Finally, evaluation processes that provided signals could be identified, sometimes quite subtle, as to which reactions and behaviours could be considered as expected, accepted or stigmatised. For example, the choice of certain words or references could suggest that individuals are either reacting logically, are not reacting sufficiently responsibly or are overreacting. Such suggestions indirectly communicate expectations and evaluations of correct or incorrect behaviour. Thus, for example in the case of the influenza A (H1N1) pandemic and the issue of vaccination, quite subtle semantics could reflect evaluations of who reacted sensibly (and got vaccinated) and who did not. Interestingly, these evaluations were somewhat reversed when cases of narcolepsy were linked to the vaccination campaign, leading to a new and somewhat different media debate (Scott and Enander, 2016). Taken together, these findings demonstrate a need to examine critically frames which may distort a realistic view of public needs and reactions when faced with risks, thus leading to ineffective communication and support.

4.1.8 Conclusions and key messages

In this chapter we presented different approaches to risk communication and acceptance of risk communication and addressed a number of socio-psychological concepts that have been shown to influence people's perceptions, attitudes and behaviour in the face of a wide variety of risks. Based on the pillars of the Disaster Risk Management Knowledge Centre, we conclude with the following three key messages.

Partnership

For a number of years now, a broad shift has been taking place throughout Europe (and beyond), characterised on one side by 'a right to know' and on the other side by a stronger focus on 'individual responsibility' of citizens to be prepared for incidents and disasters. Risk communication that is based on one-way media campaigns alone, telling people how to prepare, is hardly effective. In terms of partnerships, engaging in a dialogue with local communities to understand the historical and local contexts is an important basis for future risk communication that focuses on stimulating resilient behaviour.

Knowledge

Sound knowledge of the effects of communication messages based on communication experiments and tests is indispensable for delivering effective communication. In addition, there are many best practices available that have been identified by EU projects, such as Tactic and CapHazNet, that may offer inspiration.

Innovation

In some cases a more fundamental approach may be needed to set up and monitor communication effects and improve communication practice. This is especially important where it concerns innovative methods such as the use of new communication tools (e.g. WEA), complex topics (e.g. flood evacuation strategies), activities that cause great societal unrest (e.g. CO2 storage) or where norms and values are at stake (e.g. stigmatisation in media reports). In such cases, profound insight from communication research can be useful to support further decision-making.

4.2 Decision-making under uncertainty

***Tina Comes**, Anouck Adrot, Caroline Rizza*

4.2.1 Technology innovation: promise and reality for decision-makers

For more than a decade now, information has been recognised as a form of aid (IFRC, 2005). Uncertainty has been largely related to the lack of predictability of some major events or stakes, or a lack of data (Argote, 1982). To overcome this uncertainty, the traditional decision support paradigms suggest collecting more information. Therefore, decision-makers have focused on gathering and analysing more and more data about potentially disaster-affected areas (Comfort, 2007; Wybo and Lonka, 2003).

In parallel, progress in engineering continues to promise connectivity, broader bandwidth and unknown computational power to all (Gao et al., 2011; Meier, 2014). The use of social media that first gained prominence in the 2010 Haiti earthquake has become 'main stream' in the response to Typhoon Haiyan in 2013 (Butler, 2013). Technology-driven data sources such as GPSs, radio frequency-based identification tracking, remote sensing, satellite imagery or drones enable real-time monitoring (Comes and Van de Walle, 2016). Biometric identification technologies are increasingly used as tools for refugee management (Jacobsen, 2015) and relief provision shifts towards virtual distributions through digital payment systems or 'mobile money' (Sandvik et al., 2014). However, the more decision-making depends on (big) data the more challenging it becomes to manage and analyse:

- In a fragmented and 'post-factual' society, information coming from heterogeneous sources and actors is likely to be contradictory — and recent elections, from Brexit to the United States in 2016, highlight that (mis-)information becomes a commodity which is a source of influence and power.
- Volatility — the pace of change in data and public opinion is unprecedented, drastically reducing the time available for strategic policy decisions (Noveck, 2015).
- Because of the ever-more complex socio-technical interdependencies, the implications of decisions cannot be clearly assessed any more (Comes et al., 2011).

Technology has enabled new forms of data collection and participation. It has introduced a new layer of complexity in decision- and policymaking. Technologies are enabling but never the end-solution.

Besides a lack of information, uncertainty can also stem from a lack of understanding of the actual information (as opposed to rumours) and the impact of a decision on complex systems; as a result, decision-makers are not even aware of what is uncertain (Taleb, 2007). From this perspective, some authors have strongly advocated a renewed perspective of decision-making strategies (Makridakis and Taleb, 2009). The need for new participatory approaches to making decisions in the Big data era has been equally recognised by the European Commission under the Citizen Science theme (EC, 2013) as well as central humanitarian actors such as the International Federation of Red Cross and Red Crescent Societies with its 2013 World Disasters Report, which explicitly focused on technology and the future of humanitarian action (IFRC, 2013), and a series of reports by the United Nations Office for the Coordination of Humanitarian Affairs, Humanitarianism in the Network Age (OCHA ,2012), and the implications of Big data (Whipkey and Verity, 2015).

The uncertainties related to this new decision space will be unpacked in this subchapter. Since decision-making under uncertainty is important in crisis and disaster risk management, this chapter covers both domains, making distinctions whenever necessary.

We first discuss in Chapter 4.2.2 the standard paradigms of rational choice, emphasising new types of uncertainty that decision-makers are confronted with; this view entails that power relations are an important driver of uncertainty. We discuss power as a hidden dimension, introducing behavioural uncertainty in Chapter 4.2.3. Power relations can also introduce legal and ethical dilemmas, particularly when it is about collecting, analysing and sharing uncertain information by using technology; such dilemmas are reviewed in Chapter 4.2.4. We conclude with a taxonomy of decision approaches and processes to manage uncertainty in Chapter 4.2.5 as well as a discussion and recommendations for science and policymaking.

4.2.2 Uncertainty undermining the paradigm of rational choice

The standard paradigm of decision-making under uncertainty suggests that uncertainties are due to inherent randomness in an event, such as throwing a coin. Such uncertainties can be best captured by probabilities. To this end, scientists or citizens collect and evaluate data, which are translated into a model. For instance, the chances of a flood, storm or earthquake affecting a community is typically given by the frequency of the occurrence of such events over a certain period, for example a 100-year flood. Data to predict such a flood include rainfall or changes in temperature upstream. Standard decision support tools assume that a crisis evolves from a chaotic beginning into a steady state that follows patterns which can be identified. Therefore it is sufficient to collect comparable data to retrieve the patterns.

However, this implies that data are comparable and standardised and were collected following a series of specific methods. Applying expected utility theory (French et al., 2009), i.e. recommending the decision that leads to the highest expected value, also means that the recommendations lead to the best outcome over a series of (repeated, similar) events.

Disater risk management deals with highly uncertain situations. Such uncertainties can be best captured with probabilistic approaches. Decision-making under uncertainty requires the understanding of the underlying uncertainties and assumptions within the probabilistic models or the data.

In addition, the variety of the data collected and analysed today ranges from sensor measurements to social media information or radio conversations (Comes, 2011). Each of these types of data is fraught with different types of uncertainty or error: while sensors can malfunction or fail, human judgement is typically ambiguous, subjective and highly contextualised (Palen et al., 2010). As such, new approaches that help policymakers consolidate the different types of uncertainty inherent to the heterogeneous data need to be developed.

In addition, the potential impact of a flood, for instance in terms of damage to infrastructure, is much harder to predict than the event itself. Behavioural issues need to be considered; for example where will people turn for help and how will they support each other? The use of smart phones in the refugee crisis, allowing refugees to navigate their way across European borders, for instance, has caught many organisations and governments by surprise (Comes and Van der Walle, 2015).

Despite these complexities, under the time pressure of (looming) disasters and crises, often simple and straightforward recommendations are sought for their ease of communication (Renn, 2008). Since disasters are low-probability events, however, such models can be misleading, particularly if there is 'blind trust' in a prediction or model (French and Niculae, 2005) — and no room to reflect upon the underlying uncertainties and assumptions within the model or the data.

4.2.3 Decision-making contexts and new sources of uncertainty

Three major contexts for decision-making in disaster risk reduction have emerged with the push for increasing digitalization. Creating information does not require specific education and background any more. By relying on open software tools anyone can create a map, dashboard or analysis, opening opportunities for participation and engagement.

- Participatory and community-based approaches emphasise novel possibilities of engagement and can empower local communities through joint planning and crowdsourcing (Edwards, 2009; Norris et al., 2008). An example is a citizen science approach to flood protection, where communities themselves were involved in research from scratch and were thus better informed in decision-making (Wehn et al., 2015). Uncertainty here is related to the fragmentation of voices, the subjectivity of data and the volatility of public opinions:

- Increasing automation and dominance of technology-driven approaches refer to the integration of information into decision practices through pervasive information technology (IT). Using satellite imagery, drones and artificial intelligence for damage assessment after an earthquake or a forest fire is just one of many examples. While data-driven approaches sometimes suggest the increase in objectivity, they are often far from complete and digital shades persist. For instance, social media analyses that rely exclusively on Twitter neglect the fact that Twitter users are hardly a representative sample of the population. At the same time, commercial proprietary algorithms and software (such as those used by big search machines like Google and Facebook) are certainly not neutral, and uncertainty persists about how data are analysed.

- Virtual collaborations in networks of experts and volunteers include, for instance, 'crisis mappers' that help local communities map out assets such as hospitals or schools. The use of local implementing partners, combined with virtual elements, has led to increasing centralised coordination and remote management, particularly when access is difficult (McDonald, 2016; Comes and Van de Walle, 2015). Uncertainty stems from the fact that decisions are made removed from the context. A mapper in Oslo or Brussels may not know what is most important to fight fires in Greece or Portugal. Decisions and policies designed in capitals are often political in nature. They are related to power structures, negotiations and standards that neglect the specifics of local context. New movements such as the Global Parliament of Mayors (n.d.) argue that because of such uncertainties, even strategic and policy decisions must be made at city (or local) level.

Expertise is not limited to policy-makers and scientists any more. Decision-making under uncertainty needs to respect new contexts, environments and shifted power structures.

To deal with these emerging decision-making contexts, policymakers, responders and scientists are expected to abide by given professional standards and norms such as emergency plans, risk management and resilience

frameworks and good academic practice. Maybe most prominent are the humanitarian principles, which include humanity, impartiality, neutrality and independence (OCHA, 2010). However, through readily available software, new grassroots initiatives and volunteers that do not subscribe to any standard or code of conduct can produce the same types of information products, maps or analysis — without quality assurance. For instance, the easy use of Ushahidi or Google Maps contributes to the coexistence of similar maps with conflicting information, which can aggravate uncertainty. Moreover, algorithms that structure data collection and analysis underlying these products are often proprietary and not transparent. Having lost the exclusivity to create information, scientists should therefore ensure that their approach to data collection and modelling is transparent and matches the purpose of the specific situation and context.

At the same time, uncertainty related to professional products that are designed to support decisions leave way for interpretation and 'spinning' of any information into a favourable direction, introducing motivational biases (Montibeller and von Winterfeldt, 2015). One important aspect of such decisions are power relations between actors and organisations.

4.2.4 Decision-making under uncertainty as a power relation

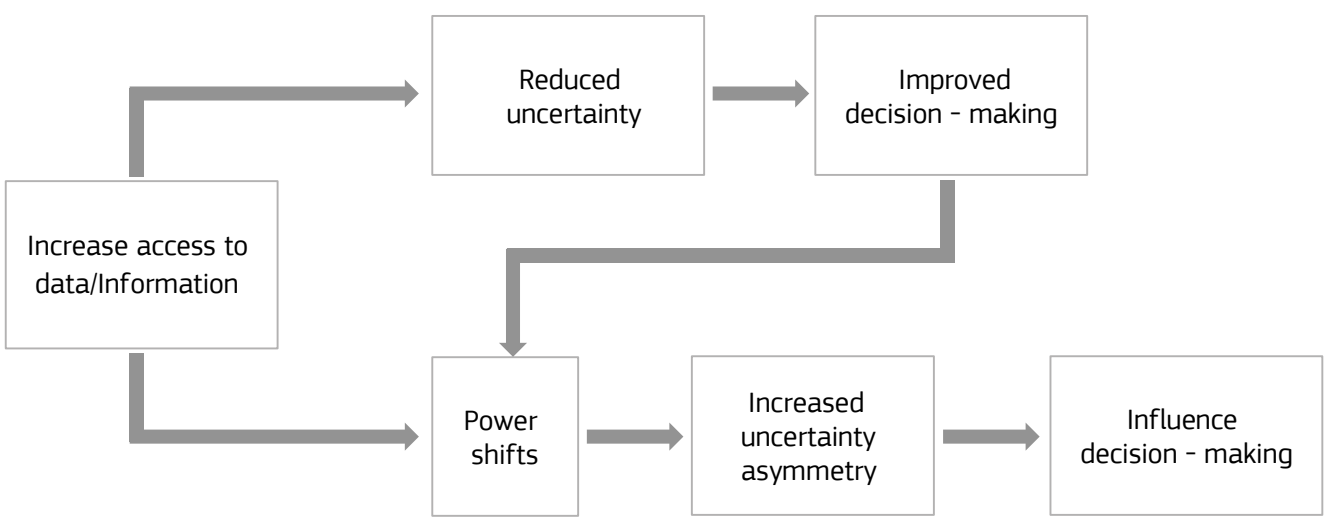
Uncertainty, information and power are intricately related concepts. As outlined in the previous chapter, decision-makers and scientists need to revise standards and practices that have emerged with increased information access. Likewise, decision-makers need to fully consider power dynamics in their approach to uncertainty and adapt their practices.

In practice, power can be defined as the extent to which an entity can guide or frame another entity's actions. Entities can be individuals, groups, organisations (companies, non-profit organisations, communities, governments, etc.) and groups of organisations (consortia, alliances, partnerships, networks, etc.). Power is thus key to understanding how collective action emerges and evolves (Prus, 1999).

Power fuels on 'an intent or capacity on the part of one person or one group to influence, control, dominate, persuade, manipulate or otherwise affect the behaviour, experience or situations of some target' (Prus, 1995, cited by Hall, 1997). Information and knowledge are essential to power: to influence, control, dominate, persuade and manipulate others, one needs to know more (Crozier and Friedberg, 1977). Thus, one can strive to maintain asymmetrical levels of information access and uncertainty to

FIGURE 4.4

Power, information access, decision-making with uncertainty
Source: courtesy of authors



gain power over the others. Reciprocally, power shifts affect the level of uncertainty that concern the various actors involved in disaster risk.

Power is a driver of information creation and sharing, which biases seemingly objective data adding a layer of uncertainty to decision-making.

Various cases illustrate how disastrous the effect of power on uncertainty can be. In the aftermath of 2008 Cyclone Nargis, the Burmese junta feared losing its power because of the arrival of foreign aid. It significantly retained information by imposing a media ban. By struggling to control information, the Burmese junta prevented the relief actors from collecting information. Uncertainty about humanitarian needs increased at the expense of the population (Pan et al., 2012).

Criticism arose and was directed towards the overwhelming power of the international humanitarian apparatus in the aftermath of the 2010 Haiti earthquake. The government's infrastructures collapsed and international non-governmental organisations (NGOs) quickly took over, centralising information and allocating resources without sharing information. The local government remained blinded by uncertainty and compelled to rely extensively on international aid. Such asymmetry led to a vicious circle: priorities shifted to the import of western governance standards, which impeded the country's response to the 2010 outbreak of cholera (Biquet, 2013).

While thus being an important driver of uncertainty in decisions (Hart, 1993), power is often mixed up with the surrounding notions (Comfort, 2007). This is, at least in part, because the impact of power is hard to capture. Power relations can shift quickly through interactions and in changing circumstances (Hall, 1997). In addition, power is invisible and 'silent' (Brown et al., 2010) and cannot be bound to a single event, fact or process.

To address this issue, decision-makers need to be aware of uncertainty and information asymmetry in disaster risk. First, decision-makers should understand the implications of a lack of power on uncertainty (Chapter 4.2.4.1). Second, they ought to identify benefits from genuine information collection (Chapter 4.2.4.2.). Finally, they should consider the implications of information on uncertainty and power in a holistic way (Chapter 4.2.4.3. and 4.2.4.4.). Figure 4.4 provides a representation of how power and information affect decisions.

4.2.4.1 Power as a necessary but insufficient condition to reduce uncertainty

Because power affects communication and coordination patterns, a structural lack of power confronts decision-makers with extreme uncertainty when disaster strikes. Baumgartner and co-authors (cited by Hall 1997) highlight how power influences communication: when an incident strikes, access to information within a group of individuals depends on the underlying power relations. The most powerful actors can radically restrict the number of actors involved in making the decision (Smart and Vertinsky, 1977). The humanitarian example of the 2010 Haiti earthquake illustrates how a lack of power results in high uncertainty and low participation when it comes to decision-making.

To nuance this point, one needs to remember that power, while increasing centrality in decision-making, does not suffice to reduce uncertainty. The 1962 Cuban Missile Crisis vividly illustrates this assertion: powerful actors can centralise information to legitimately influence decision-making in spite of intense uncertainty (Guttieri et al., 1995).

4.2.4.2 Reliable information from other entities an entity can reduce uncertainty and establish power

From an operational perspective, organisations expect information access to reduce uncertainty and support insightful decision-making. The reliability of the decisions made can then significantly influence performance, thereby increasing decision-makers' power in the longer term. Note that 'good' decisions are mandatory; massive data collection alone does not increase a decision-maker's power.
For example, during the 2003 European heat wave, some French hospital

directors relied on their friendships to collect information about potential incidents in emergency rooms. By doing so, they got reliable alerts from the hospitals and triggered and communicated emergency plans quickly enough to capture and mobilise physicians, nurses and other hospital personnel. In the aftermath of the crisis, experts applauded this initiative as well as the hospitals' reliability, thereby supporting the directors' long-term power and legitimacy within the French healthcare system (Adrot, 2010).

4.2.4.3 Information sharing reduces uncertainty asymmetry, thereby rebalancing power relationships and redefining decision-making constraints and modalities

Traditionally, command chains mobilise operational actors to collect information to reduce uncertainty and make decisions. However, information sharing is hardly reciprocal, and typically reporting chains are directed 'upwards' to centralised coordination structures (Turoff et al., 2004). In addition, internet and electricity blackouts and limited coverage can make local communities suffer from restricted access to information and intense uncertainty. In such settings, these local communities often rely on their direct perception, experience and networks instead of professional responders or official information (Comes et al., 2015a).

Interestingly, power relations between local and global communities can shift because of technological progress: increased use of smartphones, increased connectivity and open-source tools can catalyse access to data and information. Such access means that additional actors, such as virtual communities, can provide information and participate in operations and reduce uncertainty. For example, the opening of satellite views, through open-source platforms and communities (such as Open Street Map in the aftermath of the 2010 Haiti earthquake or even earlier in the aftermath of Hurricane Katrina), can compel actors with strong supremacy to admit the empowerment of local communities. In addition, the visibility of the virtual citizen community is improved (Palen et al., 2010). In the longer term, such visibility will strengthen these communities' participation in decision-making.

4.2.4.4 A holistic approach to power highlights bigger challenges related to decision-making and uncertainty

Even though information access can contribute to increasing one's power at the response stage, one should keep the side effects in mind. From an institutional perspective, increased competition for information to gain power can result in opportunistic or fuzzy behaviour with respect to information. This, in turn, can negatively affect relationships between local or other professional actors at the expense of the population that has potentially been affected by a disaster. For instance, during the 9/11 response, a large spectrum of actors (citizens and local non-profit organisations in search of institutional visibility) urged on the crisis response stage, providing non-exploitable data and creating confusion, which slowed coordination down (Dawes et al., 2004).

In addition, NGOs can tend to exploit information as an opportunity to gain legitimacy and visibility. Such a tendency is not new. In 1994 Eng and Parker observed how local Mississippi communities shifted their efforts from social interactions to developing legitimacy towards their partners. However, we believe that digitisation can potentially lead to an opportunistic use of information and we therefore call scholars and practitioners to consider the ethical and legal implications of technology-based decisions as a burning issue.

4.2.5 The ethical and legal implications of technology-based decisions

The power implications and uncertainties related to technology require a critical review of the ethical, legal and social issues (ELSI). For instance, how to engage with citizens through social media or how to share information between different agencies and information systems in line with data protection laws remains a current issue. Consequently, designing and developing technologies and practices which address such issues becomes essential.

4.2.5.1 Pandora's Box? Uncertainty related to unintended consequences of informationalisation

We have previously highlighted that behavioural issues, particularly when reinforced by social media platforms, increase complexity and uncertainty in decision-making. Rather than relying on compliance of the population ('keep calm and carry on'), citizen and volunteer groups today emerge and organise, leading to 'unintended consequences'.

Specifically, the case of the 2011 Vancouver riots (Rizza et al., 2014) highlights risks associated with citizen engagement crises through social media. The Vancouver Police Department asked Vancouverites to send their material and to help identify rioters. Feeling empowered by local authorities, citizens started a real manhunt, and some families had to leave the city. This case has pointed out: 1) the 'institutional unpreparedness' in dealing with a huge quantity of data, their quality and the new processes of inquiry they require; 2) the 'unintended do-it-yourself justice', i.e. the shift from supporting crisis managers to vigilantes when citizens overruled authorities and enforced justice on their own terms; 3) the 'unintended do-it-yourself society' supported by the potential of social media for prompting people to act. What happened in Vancouver challenged human rights and values such as fairness, justice, integrity, responsibility and accountability.

For the 2010 Eyjafjallajökull volcano eruptions, Watson and Finn (2014) discussed some of the privacy and ethical implications surrounding the use of social media. Social media allowed persons stranded in Europe to communicate, organise their travel, etc. as well as allowing the aviation industry to get information from its customers. At the same time, social media use led to privacy infringements and inequality. Indeed, over-focusing on social media could lead disaster risk managers to focus on those who produce a lot of data and, consequently, to down-prioritise those unequipped (for example foreign passengers) or unable to use ICTs (for example the elderly). Lastly, 'self-help' between citizens under the umbrella of resilience (i.e. a spontaneous peer-to-peer communication) should not become a way for corporate or public entities to neglect care responsibilities for those who have been impacted by a disaster.

Ethical and legal considerations have become essential in designing and developing technologies and practices which collect, analyse and communicate (uncertain) information and data.

Consequently, designers and practitioners in disaster risk need to consider the uncertainty related to unintended consequences of IT. This implies noticing, anticipating and knowing them.

4.2.5.2 Data protection and privacy concerns: how much uncertainty is needed?

Rizza, Büscher and Watson (2017, forthcoming) underline that (personal) data and information (sharing) constitute the core interest of ELSI concerns in the Big Data era, which makes mass surveillance possible. The collection and processing of data coming from different applications makes the boundary between decision support and control or surveillance fuzzy. For instance, the knowledge database created through such a monitoring system could reveal individuals' habits, routines or decisions and, consequently, infringes citizens' privacy. Big data has even been said to contribute to trapping particularly vulnerable populations in poverty by obstructing the possibility to get loans or access to good education (Waddell 2016). As such, the statistical likelihood that someone from a specific neighbourhood may not pay back a loan blocks individual opportunities. The collection and processing of personal data is also problematic because in crises it can erode basic rights such as freedoms of speech, associations and movement.

To balance the need to reduce uncertainty and collect data with ethical responsibility in scientific and technological developments, an ethic of co-responsibility should emerge (Schomberg, 2013). Research around ELSI aspects of IT also reveals opportunities: integrating IT into disaster risk management with an explicit commitment to ELSI considerations

will provide useful insights for a proactive approach to innovation (op. cit.).

Initiatives like 'privacy by design' or 'ethics by design' (European Commission, 2010) attempt to deal with current critiques of the lack of concern for ELSI in the development of new technologies (Rizza et al., 2011). Privacy impact assessments can ensure that technology for disaster risk reduction is developed to protect the interests of end users and stakeholders within the organisational and legal frameworks.

4.2.6 Decision-making under uncertainty: better than muddling through?

The context of decision- and policymaking has become complex. The very nature of the different uncertainties we discussed makes it largely impossible to use probabilities: the socio-technical uncertainties in disaster risk reduction are deep (Comes et al., 2013; Comes et al., 2011; Pruyt and Kwakkel, 2014). Already in the 1950s, Lindblom (1959) had described that decision-makers confronted with such uncertainty are 'muddling through'.
Participatory approaches to model design and scenario analysis have been advocated as a way ahead when the communities affected are clearly known (Comes et al., 2015b; Wright and Goodwin, 2009). Examples range from scenarios for water and flood management (Haasnoot et al. 2011) to urban planning and resource management (Vervoort et al., 2010), approaches that rely on connecting communities and policymakers in the preparedness phase. Scenarios are built in deliberative processes that capture expert knowledge, preferences and values of stakeholders (Kok et al., 2006; Vervoort et al., 2010). While those scenarios serve to establish plans and evaluate alternatives based on a common understanding, they are time consuming to update and adapt to new circumstances or information. As such, they are most useful in the preparedness phase, not in the least to help build networks and partnerships of trust (Comes, 2016b).

The opposing trend relies on artificial intelligence and data mining approaches that enable real-time analysis of data streams to be made. Automated algorithms and tools can be used to extract and illustrate large-scale patterns and trends in human behaviour, damage assessments and communication flows (Meier, 2014; Monaghan and Lycett, 2013; Whipkey and Verity, 2015). As such, they promise fast answers, which is particularly relevant in the heat of a response. It is, however, necessary to ask how such analyses influence human sense-making or possibly introduce biases (Wright and Goodwin, 2009). Particularly if analyses are run remotely and disconnected from the community, there is a series of typical errors that may mislead analyses or the interpretation of results (Comes, 2016a). In addition, the reliance on software, data and algorithms has been increasingly criticised for the lack of transparency and control that communities have over their own data (McDonald, 2016; Sandvik, 2013).

In between there is a large spectrum of semi-automated data collection efforts, semi-automated analyses and assessments that are run by scientists, policymakers from municipality to international level and an increasing amount of local and digital volunteers. With the global availability of technology, software and data, the creation of information products has been democratised. While in the past the design of a map or a dashboard required dedicated technical skills, today anyone can produce graphs, figures and maps. Examples of such volunteer efforts range from the response to Typhoon Haiyan in the Philippines in 2013 (Comes et al., 2015a; Westrope et al., 2014), the Ebola response (Landgren 2015) and the response to the refugee crisis in Europe in 2015 (Comes and Van de Walle, 2015; Talhouk et al., 2016).

Decision-making should reflect the specific context, constraints, needs and stakeholders associated to a decision, including the specific phase of the disaster risk management cycle.

Decisions differ in terms of information required, time scales, geographical scope and actors. The question, for instance, of where to set up a hospital has very different characteristics from general resource-allocation decisions. Both decisions are important but have very different requirements in terms of information granularity, timeliness

and updates. Addressing specific decision-makers needs or problems in the socio-technical context is, however, still not commonplace. We propose a decision-centric paradigm for information collection, processing and visualisation that focuses on specific information needs.

4.2.7 Conclusions and key messages

Partnership

Together, scientists, policymakers and communities need to agree on standards that reflect good processes and representations of uncertainties. Citizen science can be a way ahead to providing necessary training and education. In particular, we propose that cultural, social and professional specificities must be thoroughly taken into account in the settling of standards. Since information is always also a source of power, it is imperative to follow the principle of reciprocity — empowering the people who provide information to use it for their own good and strictly following the principles of responsible data and technology.

Knowledge

Given that no single paradigm predominates how decision- and policymakers use information, data and uncertainties drive power relations and introduce ethical and legal dilemmas. So far, standard analyses use, at best, probabilistic approaches to represent uncertainties, neglecting the socio-technical dimension of decision-making, problems of data gaps and consent. The reflections on uncertainties presented in this chapter draw from both practical experiences and theory. They are, however, not readily translated into concrete policy measures or decisions because there is first a need for innovation in science and policy.

Innovation

Researchers need to frame the problem they are studying, including the context and the purpose of a model, simulation or analysis. Assumptions and limitations need to be reflected in the design of decision support systems. When situations are complex and uncertain there is a tendency to simplify the problem and to exert control through limited consultations and conflict avoidance. However, models and recommendations must not oversimplify complex problems, which is a challenge given the call for 'easily understandable' solutions.

In addition, we call for the development of methods and approaches that consider the different types of uncertainty from operational decision-making to strategic policymaking. So far, there is no clear understanding of the processes, models and tools that enable institutions to use operational and real-time information to collaborate with citizens to manage disaster risk.

Besides the uncertainty inherent in the new data environment, uncertainty is also rooted in the role of power in decision-making and the lack of addressing the ethical and legal stakes caused by information use. We therefore advocate further research on the socio-technical dimension of uncertainty in decision-making by putting technical, social, organisational, ethical and legal dimensions of information into perspective.

Problems in disaster risk reduction are complex. As such, any model will necessarily reflect this complexity by various layers and levels of uncertainty that will need to be considered in the decision-making process. This means that deliberation processes and communication with stakeholders need to be carefully designed to reflect such uncertainties, even if there is a temptation to go with quick fixes or easy solutions. Error bars or margins of error should not be just a footnote, but rather should be openly discussed. In particular, critical tipping points need to be flagged, such as flood levels that cause a breach in a levee or top wind speeds that damage major infrastructures.

New participatory processes such as risk mapping are increasingly important. In the preparedness phase, they make it possible to establish networks and partnerships that people can rely on during the response. If such processes are also to work effectively in disaster response, decisions, processes and organisational structures need to be adapted to enable the uptake of information provided by communities. Such approaches can only work successfully, if connections are established prior to disasters.

Participatory processes and new governance structures should empower local communities in guiding disaster risk management and reducing uncertainty. However, this implies collective awareness of how power shapes decision-making. Power is a system-wide dynamic that can impact uncertainty for all.

4.3 Last mile communication

***Irina Stanciugelu**, Aurel Bilanici, Ian Cameron*

4.3.1 Introduction: disaster risk management and information and communications technology

Disaster risk management (DRM) is undergoing noteworthy changes, reflecting the emergence of a globalised system of DRM with technological, organisational, and institutional capacities enhancing DRM's ability as a unit in near real time across the globe (Jensen et al., 2015).

ICT is enabling better communications, remote sensing, monitoring networks, warning systems and modelling and geospatial technologies. Various ICT tools such as geographic information systems (GIS) and global positioning systems (GPS) can allow organisations to receive satellite information and produce accurate location information about the affected areas, which can be further linked with socioeconomic, demographic and needs assessment information (Hu and Kapucu, 2014). There are diverse emergency management information systems such as E-Team, Web EOC, SharePoint that make it easier to gather, process and disseminate information, which helps emergency managers make informed decisions (Carver and Turoff, 2007).

Incident management systems can inform disaster response teams with real-time information about the incident and available resources and can help emergency management organisations coordinate efforts (Iannella and Henricksen, 2007). Innovative means, such as citizen observatories enabled by ICTs (e.g. sensor technologies and social media), have the potential to provide new ways of participation (When et al., 2015) whilst at the same time generating relevant information and promoting demand-driven policy responses (Holden, 2006; Rojas-Caldenas and Corona Zambrano, 2008).

Despite the significant advantages of ICT, unequal ICT adoption within and between countries becomes a DRM limitation. As an example, the uneven distribution of warnings in the 2004 Indian Ocean tsunami resulted in many thousands of avoidable deaths.

Various ICTs are used in disaster risk management to help organisations process and share real-time information. Other functions of ICT are to establish different communication channels, to engage with stakeholders and to coordinate among a large number of agencies.

During Hurricane Katrina in 2005 the inadequate monitoring of infrastructure and failed warning systems led to hundreds of avoidable deaths. Also, the different level of adoption of ICT tends to affect the more vulnerable populations disproportionately. More generally referred to as the 'digital divide,' this tends to exacerbate economic differences (Jensen et al., 2015).

In this chapter, we focus on the main changes that ICT brings in DRM. The next chatper present what constitutes an effective early warning system (EWS) (Chapter 4.3.2 and 4.3.3) and investigate requirements for and recommendations on community linkages and community empowerment within the chain of an EWS (Chapter 4.3.4 and 4.3.5). Chapter 4.3.6 and 4.3.7 present the opportunities that ICT technologies and social media provide for engaging citizens in the emergency management and how the new digital technologies could be used to close the last mile communication gap. We conclude with some general remarks (Chapter 4.3.8).

4.3.2 'Last mile' communication and development of early warning systems (EWS)

The notion of the 'last mile' has been popularised in countries of the Indian Ocean in relation to tsunami EWS development (Thomalla and Larsen, 2010). Even so, 'last mile' has been understood differently: 'last mile' as a challenge for rural communities to access media and address this by supplementing traditional media channels for warning dissemination with additional technologies (LIRNE Asia, 2008); 'last mile' as the capacity of the community to take action in response to a received warning and that supports the development of the capacities of local institutions (Singh Bedi, 2006).

Early warning systems are designed to analyse the risks of vulnerable communities, carry out the task of monitoring environmental variables, issue warnings and ensure that appropriate response capabilities are in place.

The Hyogo Framework for Action 2005-2015, which was adopted at the 2005 World Conference on Disaster Risk Reduction, recognises early warning as an effective tool to reduce vulnerabilities, save lives and help protect livelihoods as well as to improve preparedness and response to natural hazards.

The Hyogo framework takes on the perspective of the 'last mile' in stressing that disaster risk reduction (DRR) must be 'underpinned by a more proactive approach to informing, motivating and involving people in all aspects of DRR in their own local communities' through multi-stakeholder and cross-sectoral partnerships (UN/ISDR, 2005). The diversity in interpretations of the notion of 'last mile' hints at the complexities associated with the links between DRM and ICT, the development of national and regional EWSs and the advent of social media in crisis management.

Early warning is defined as 'the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response' (UNISDR, 2004). EWS defines a technological infrastructure that can assist in carrying out these tasks. However, the EWS needs to go beyond this infrastructure by taking account of how risks are understood and providing information for warning messages (Horita et al., 2016). EWS has four interlocking elements (Grasso, 2012):

- risk knowledge — to understand the risks (hazards and vulnerabilities) and priorities at a given level;
- monitoring — to stay up to date on how the risks and vulnerabilities change through time;
- response capability — so that each level (pre-season mitigation activities, evacuation or duck-and-cover reflexes) is able to reduce risk once trends are spotted and announced;
- warning communication — to prepare monitoring information into actionable messages understood by those that need them.
- In addition to the four elements, there are a number of cross-cutting issues that are critical to the development and sustainability of effective EWS; these include:
- effective governance and institutional arrangements;
- a multihazard approach to early warning;

- involvement of local communities;
- consideration of gender perspective, vulnerable populations and cultural diversity.

The most common view of EWS comprises a 'warning chain', a linear set of connections from observations through warning generation and transmitter to users. In the meteorological community, the term 'end-to-end' warning system is often used (Basher, 2005). The end-to-end concept aims to make forecasts and warnings more relevant and useable to end users. Such linear models are top-down and expert driven. They neglect the likely impact of the hazard and how warnings are communicated and responded to.

4.3.3 Effective early warning systems and warning communication

An effective EWS needs an effective communication system. Early warning communication systems are made up of the following two main components:

- The communication infrastructure hardware that must be reliable and robust, especially during natural disasters; many communication tools are currently available for warning dissemination such as cellular phone text messaging, email, radio, TV and web services. It is essential to assure the redundancy of communication systems, while emergency power supplies and back-up systems are critical in order to avoid the collapse of communication systems after disasters occur (Grasso, 2012). In addition, in order to ensure reliable and effective operations and to avoid network congestion, frequencies and channels must be reserved and dedicated to disaster relief operations.

- The warning messages: a critical element to influence the perception of risk and public behaviour is how the warning information is structured and what it contains. Generally, warning message content represents a source's assessment of the existence and seriousness of a threat as well as what the public should do to protect themselves (Lindell and Perry, 2004). A message delivered during a critical situation should contain:
  - hazard — short description of the physical characteristics of the hazard (nature and magnitude);
  - location — if possible, a certain position of the area affected by the hazard;
  - time (slow onset — occurring time, time estimated to reach the area; rapid onset — occurring time, rapid development);
  - guidance — the appropriate course of action necessary to prevent death or injury, providing protective action recommendations, including options for those unable to comply with recommended measures (e.g. evacuation orders);
  - pertinent details that should be included in messages; i.e. where to find shelter and the location of recovery supplies or aid stations that may not be obvious to the recipients of the warning.

Communication and dissemination systems should be tailored to the needs of individual communities (e.g. radio or television for those with access and sirens, remote disposals, warning flags or messenger runners for remote communities). Messages should incorporate the understanding of the values, concerns and interests of those who will need to take action.

Recent studies (Sellnow et al., 2015) have underlined the importance of using instructional messages (messages that take into account how people learn and the learning styles) during the response phase. The messages must include elements that not only explain the information, but also give its relevance (proximity, timeliness and personal impact) and motivate receivers to realise the value/utility of the message content and action (specific behavioural directions) that specify exactly what receivers are to do for self-protection.

A frequent problem is the weak link between the technical capacity to issue the warning and the local communities' capacity to respond effectively to the formal systems of warning (Basher, 2005). As such, it is important to recognise that these activities

cannot be undertaken or directed by a single organisation, but require the coordinated participation of many different types of organisations that are committed at community level. National platforms for disaster reduction, stakeholder roundtables or interdepartmental committees should be empowered or established to organise the required coordination. The core technical agencies can play a key role by demanding the establishment of such mechanisms and supporting them with specialised technical information.

4.3.4 People-centred approach to early warning

To respond to these needs, the EWS has grown from a 'techno-centric only' paradigm to a 'people-centric' one where the 'end-to-end' and 'multihazard' components and their procedural norms start to bind together (Adger, 2000; UN, 2015). This new global move is led by the World Meteorological Organisation (WMO) which adopts a service delivery approach that should be making early warning information available and ensure the information is timely, reliable, dependable, usable, expandable, sustainable, responsive, authentic and credible (Ahmed, 2015). The WMO argues (WMO, 2014) for service-oriented actions that start from:

- user engagement and developing partnerships;
- evaluation of user needs and decisions;
- linking service development and delivery to user needs;
- evaluation and monitoring of services, performance and outcomes;
- sustained improved service delivery;
- development of skills needed to sustain service delivery;
- sharing of best practices and knowledge with others.

People-centred early warnings need to be clearly understood by people, easily and readily accessible to people; and timely: tied to response actions to be taken by people before, during and after the event.

The people-centred approach to early warning is promoted by the Hyogo Framework for Action, and focuses on how communities must understand threats in order to deal with them. Communities must be active receivers of information and be engaged in monitoring and such to facilitate the adoption of protective actions (Grasso, 2012). The 'people-centred' characteristic requires many systematic approaches and diverse activities spanning the four elements of EWS described above, such as (Basher, 2005):

- identifying target populations (especially the vulnerable and disadvantaged);
- interacting with target populations to determine needs;
- involving communities in exploring and mapping their risks and planning their responses;
- fostering the development by communities of monitoring and warning systems for local risks;
- generating public information tailored to target groups and making innovative use of the media and education systems;
- establishing people-focused benchmarks and performance standards for technical warning services;
- developing formal mechanisms for public representatives to monitor and oversee warning system design;
- using surveys to measure public awareness and satisfaction;
- creating monuments, publications, annual events and other anchors of public memory and learning;
- providing training on social factors for technical experts, authorities and communicators who operate the warning system;
- conducting research on factors that enhance or impede human understanding of and response to warnings;
- providing exercises and simulations to enable people to experience and practice warning interpretation and responses.

4.3.5 Effective early warning systems: lessons learned at community practice level

The International Federation of Red Cross and Red Crescent Societies (2012) has published an overview of successful practices from the field for the disaster risk reduction/manage-

ment practitioners interested in EWS.

To be effective, warnings must have not only a sound scientific and technical basis, but also a strong focus on the people exposed to risk. Developing working relationships with partners, such as emergency managers and the media, and involving stakeholders in the development and review of the warning system is essential.

It presents guiding principles that could build a strong foundation for the design or strengthen EWS at any level. We present here the guiding principles per EWS component and for the cross-cutting themes.

The guiding principles per EWS component

- **Risk knowledge:**
  - K-1: Although risk knowledge exercises may not lead to early warning, all early warning must be founded on risk knowledge;
  - K-2: Accept that a community's priorities may not be your own.
- **Monitoring**:
  - M-1: Passive receivers of information do not save lives;
  - M-2: Some communities will need to drive their EWS;
  - M-3: Public displays of monitoring can motivate communities;
  - M-4: When hazards evolve, so must their monitoring.
- **Response capability**:
  - R-1: In EWS, we respond to warnings, not to disasters;
  - R-2: Strive to organise robust no-regrets response actions;
  - R-3: Embed response options by annually updating contingency plans with links to funding;
  - R-4: Practice makes perfect: test drive your response actions.
- **Warning communication**:
  - C-1: Clearly delegate responsibility to alert or mediate;
  - C-2: Do not fall into the sophistication trap for warning devices;
  - C-3: Use staged warnings (levels and colours) in dissemination.

Cross cutting themes – guiding principles

- CCT-1: Integrate within DRR — EWS is not a stand-alone;
- CCT-2: Aim for synergy across levels: community, national and regional/global;
- CCT-3: Insist on multihazard EWS;
- CCT-4: Systematically include vulnerability;
- CCT-5: Design EWS components with multiple functions;
- CCT-6: Accommodate multiple timescales;
- CCT-7: Embrace multiple knowledge systems;
- CCT-8: Account for evolving risk and rising uncertainty;
- CCT-9: EWS without borders: target the full vulnerability and hazard-scape;
- CCT-10: Demand appropriate technology;
- CCT-11: Require redundancy in indicators and communication channels;
- CCT-12: Target and reach disadvantaged and vulnerable groups;
- CCT-13: Build partnership and individual engagement.

In the changing landscape of EWS, stakeholders should continue to practice a combination of the approaches to build people-centric, multihazard, end-to-end and service-oriented EWS. The key for success would rely on:

- continued proactive governance;
- mobilisation of resources and capacity development for delivering the services (from all four streams) to the countries;
- making provisions for integrating EWS into the overall disaster risk reduction measures, which would be essential for keeping future harm away and moving ahead to build resilience at the centre of all activities (Ahmed, 2015).

4.3.6 Social media and communities in disaster: connecting the 'last mile'

ICT in general and social media in particular are an integral part of many people's lives today, including during times of crisis. As the examples illustrate in the previous chapter, crisis management authorities in many countries are using the new technologies to increase public awareness and preparedness for disasters, to alert and warn the public and to optimise situational awareness when crises strike.

While traditional radio and TV news remain important venues for sending emergency messages and updates to the general public (Collins and Kapucu, 2008), the widely accessible internet and wireless technologies allow for more flexible methods of communication (Cutter et al., 2007; Kapucu, 2006a; National Research Council, 2007).

For example, a great tool for both emergency managers and the public is Google Crisis Response, which organises emergency alerts and news updates relating to a crisis and publishes the information on dedicated landing pages. It also provides opportunities for donation in collaboration with international agencies such as Unicef, International Medical Corp and local relief organisations. Google also builds and provides tools to help crisis responders and affected people communicate and stay informed, such as Google Person Finder, Google Maps, Google Fusion Tables and Google Crisis Maps. Mobile apps have been developed with different demands and create a new approach for risk communication. The SMS alert system is useful in some cases for delivering alerts in an emergency, and GPS-related mobile apps (location sensoring and hazard maps) help to locate people in potential danger; some applications are developed as pre-disaster warning devices (educational apps). One example for such alert apps is the Katwarn system in Germany, which is currently used by disaster management agencies in more than 60 counties to inform the population about all types of disasters; it is available for Android, iOS and Windows phone platforms. Other examples for disaster alert apps are NINA, a general purpose disaster alert app. also from Germany, and SAIP, an app. provided by the French Ministry of the Interior to provide the population with alerts on major crises (with a special focus on terrorism alerts) (Klafft and Reinhard, 2016).

Social media use a decentralised, collaborative and network-based communication approach that allows citizens to generate data and share information about a hazard event irrespective of its geographic location and temporal extent, contributing to a resilient community.

Across various studies of emergencies and disaster events, numerous positive and negative aspects of social media have been identified (Reuter and Spielhofer, 2016):

- Social media promote cross-platform accessibility and a constant flow of information. During the Haiti earthquake in 2010, Ushahidi (an open-source multimedia mapping platform) allowed near-real-time mapping of the impacted population, which helped volunteers with rescue and response operations. Just-in-time information could be provided on how to cope with developing situations. During Super Storm Sandy in 2012, FourSquare (a location-based social network site) provided location information about visitors, which helped emergency responders with evacuation. The Louisiana Bucket Brigade, a local environmental justice organisation active along the Gulf Coast of the United States, created the Oil Spill Crisis Map after the 2010 Deepwater Horizon oil spill to provide information about community experience and risk perception to help with emergency management (Kar, 2016).
- Moreover, social media provide a framework for the work of journalists and for public discussion and debate. The United Nations Office for Outer Space Affairs established the Space-based Information for Disaster management and Emergency Response (UN-Spider) in 2006 to help with disaster risk reduction through stakeholder participation (UN, 2006).

Negative aspects of social media include the sometimes 'chaotic' or disorganised work of volunteers and the need for quality assessment, as well as the possible increase of task complexity and uncertainty for emergency services (Reuter and Spielhofer, 2016).

Social media can be understood as communication services that employ interactive online ICT (often referred to as Web 2.0 technologies) to enable the exchange of user-generated content. The term 'social media' embraces blogs, micro-blogs, social bookmarking, social networking, forums, collaborative creation of documents (via wikis) and the sharing of audio, photographic and video files (Balana, 2012). Social media are highly interac-

tive 'digital tools that feature content users may generate, manipulate, or influence' (Giroux et al., 2013). In other words, social media encourage interaction and dialogue between users, creating an information space that is decentralised and devoid of hierarchy.

By providing community members with tools to engage in crisis preparedness, response and recovery, social media may have a role to play in building community resilience — a measure of a community's ability to respond to, withstand and recover from adverse situations (Dufty, 2012).

Most studies regarding social media use for emergencies focus on understanding how emergency response organisations adopt tools like social media and bring attention to members of the public as contributors and receivers in the emergency information arena. The 'crisis informatics' is the study of the social and technical (socio-technical) behaviours in emergency response, with a focus on the flows of information between the people and organisations involved. The approach attempts to account descriptively and theoretically for social behaviour that is made possible through technology (Hughes et al., 2009):

- Citizen reporting: the ability for people to report from on the ground during and after an event is analogue to ideas of citizens as 'sensors' — members of the public who detect, measure and report local emergency information — and as 'journalists' — members of the public who collect, report, analyse and disseminate news and information.

- Community-oriented computing: social media have been described as facilitating online communities where members share and seek information during times of crisis (Wang, 2010).

- Collective intelligence and distributed problem solving: social media have been shown to facilitate collective intelligence — where large, distributed groups of people solve complex problems (Vivacqua and Borges, 2010). Citizens may also provide geographically tagged localised and distributed reports — known as volunteered geographic information — of crisis events through social media. This geographic information can then be collated and mapped by volunteers who call themselves 'crisis mappers', using open-source mapping software such as Google Maps, OpenStreetMap or Ushahidi (Heipke, 2010).

- Contributions to situational awareness: an important contribution that social media offer in times of crisis is their potential to enhance situational awareness (Ireson, 2009).

The behaviours described above show ways to use social media in order to build community disaster resilience. These include (Dufty, 2012):

- developing social capital (e.g. networks, leadership and support systems) for disaster resilience-learning communities;
- informing others of the disaster risks in their community and discussing and planning what is being done to manage the risks and what they can do;
- engaging with others to help them prepare for a disaster;
- providing intelligence through 'crowdsourcing' to others (including emergency managers) before, during and after a disaster;
- communicating warnings and other information to communities during a disaster;
- providing support to people during and after a disaster;
- coordinating community response and recovery.

4.3.7 High tech/low tech communication and ethical challenges of social media

The London power outage of 2003 highlighted the importance of not relying on one single type of medium for warning and for informing the public (UK Cabinet Office, 2005) and reveals the vulnerability of social media networks to power outages, which in turn can leave healthy, affluent individuals in their mid twenties feeling very vulnerable. The guidance provided by the United Kingdom Civil Contingencies Secretariat to accompany the Civil Contingencies Act advises emergency responders to promote the use of resilient communication systems such as battery-operated or wind-up radios during emergencies as well as embracing social media platforms such as Twitter and Facebook to communicate during a crisis.

A woman in her late eighties, living alone in a small apartment with a meagre income from a state pension might appear vulnerable, but during the large-scale power outage in the

UK capital in 2003 she was able to heat a can of baked beans on a gas cooker and make a meal with some pasta, as well as share her experience with thousands of people through interactive media by using a landline telephone to call a BBC London local radio phone-in programme which was discussing the power outage.

Although social media will not replace traditional media in the foreseeable future, today many young people already heavily rely on social media to gain information, making this population hard to reach through established communication channels such as radio or television. Therefore, it is about striking a balance; social media tools are one of many communication tools to use.

By contrast, many well-paid workers in their mid twenties, who were employed in the main financial square mile of the City of London, might have been considered to be less vulnerable than the old woman, but the power outage exposed their lack of resilience — they could not use credit or debit cards to pay for food or drink due to the outage, they could not get any cash from ATMs and those that had cash could not buy provisions from supermarkets which were forced to close as their tills did not work. There were also additional security as well as health and safety concerns caused by the power outage (Civil Contingencies Act DVD, 2005). Wi-Fi networks were not available, denying internet access to the workers who commonly used email to organise their social life.

Those workers in their mid twenties who had a supply of ready-oven meals at home could not cook them as their microwave and electric ovens were not working and they could not travel further afield to areas with power because the London underground train system had stopped running and taxis, which were in great demand, would only accept cash payments (Civil Contingencies Act DVD 2005). With mobile phones lasting just a few hours before their batteries died or the back-up batteries at mobile phone masts lasting little more than 2 hours, the City workers in their mid twenties were revealed to be highly vulnerable and displayed little resilience as the power outage affected their service- and technology-reliant lifestyle (Civil Contingencies Act DVD, 2005).

A study by the University of East London, carried out in 2010-2013, used gaming theory to predict social media use during a mass evacuation event in London and one of the main conclusions was that radio, especially BBC radio, was still regarded as one of the most trusted and reliable sources of information during an emergency (Preston, 2013).

Emergency managers normally have to walk a very thin line between actions that may be deemed excessive and any failure to respond adequately that could be considered as negligence (Alexander, 2014). Also, considering the vulnerable people, any system of disaster response or risk reduction that depends on social media for access to its services risks excluding those people who lack access to the technology. 'Computer illiteracy' is a form of disadvantage in a world that has become dependent on digital communication for many services. It is only partially compensated for by the fact that, by relaying information by word of mouth, other people will be able to help a disadvantaged individual cope.

Other ethical risks are associated with a largely unregulated internet-based system of public mass communication. The use of social media for malignant purposes could potentially include:

- attempts to persecute people or damage their reputations (Boggs and Edwards, 2010);
- attempts to spread malicious rumour;
- efforts to create violent protest;
- attempts to organise terrorist activities.

4.3.8 Conclusions and key messages

Partnership

In this changing landscape of ICT, EWS and advent of social media, the key for success in disaster risk management would rely on user engagement and developing partnerships for gradual evaluation and improvements. This process may comprise comprehensive provisioning of: (a) evaluation of user needs; (b) evaluation and

monitoring of actions, performance and outcomes; and (c) sharing of best practices and knowledge with others.

Knowledge

The opportunities and challenges that ICT and social media bring to development of disaster risk management foster a process that builds principles for action for communities of practice, creating a 'space of meaning' with theories for action, social change and instruments for implementation. Because each operational context is unique, stakeholders who aim to implement a policy or strategy have to learn their way into this implementation, often with a considerable need for innovation.

Innovation

This chapter presents some interesting and viable ways that disaster responders and people could rely on ICT and digital media to support their communities in times of disaster. In some cases, individual and community needs result in authority actions, moving toward the establishment of tangible resources that even endure over time. In other cases, ICT use might be ad hoc and temporary, resulting in the establishment of practices that prove useful to the community and can be used as tools for continuous adaptation and innovation.

4.4 Good practices and innovation in risk communication

***David Allen**, Eve Coles, Terhi Kankaanranta, Caroline Mcmullan, David Mobach, Alistair Norman, Tanja Perko, Kari Pylvas, Niek Wijngaards*

4.4.1 Introduction

In this chapter we deal with the thorny issue of innovations and 'best practices' in risk communication. Individual examples of best practice developed from both research and by enlightened practitioners (c.f. Coleman, 2013) are not difficult to find. Seeger (2006) identified the following ten 'best practices' in risk communication:

1. Process approaches and policy development for and responding to crisis are critical to success.
2. Pre-event planning, creating teams, fact-finding protocols, messaging and delivery are vital.
3. Partnerships with the public.
4. Listen to others' concerns.
5. Exhibit honesty, candor and openness.
6. Collaborate and coordinate with credible sources.
7. Meet the needs of the media and remain accessible.
8. Communicate with compassion, concern and empathy.
9. Accept uncertainty and ambiguity.
10. Provide messages of self-efficacy by issuing specific information telling people what they can do to reduce harm; these messages can help restore some sense of control over an uncertain and threatening situation (Seeger, 2006).

This was developed further by (Heath, 2006) who suggested two further best practices:

1. Realise that crisis response is a narrative and that you are telling a story.
2. Be committed and able to deliver on the promise to be the first and best source of information.

In the early 2000s these issues were seen as best practice and, given the relative paucity of research in this area, are easily identified. The complexity, scale and scope of both man-made and natural disasters now demand new types of response and have led to a blossoming of research and development activity to address these societal challenges. Equally, both the role of new technologies and new communication patterns have enabled new forms of practice to emerge. The best practice discussed by Seeger (2006) and Heath (2006) remains relevant but has now been embedded into processes and protocols discussed elsewhere in this chapter. We refer, therefore, to 'innovation' and 'emerging practice/improving practice' rather than 'best practice'.

Innovation can be described as the process of moving knowledge gained in research to the development of a physical product or changing the way things are done which can improve the quality of life. However, innovation and risk do not necessarily make good allies. Innovation by its nature suggests levels of uncertainty and risk (HM Government Office of Science, 2014); it is therefore unsurprising that different authors (Kasperson, 2014; Renn, 2014; Árvai, 2014; Pigdeon, 2014) have agreed that risk communication practices and processes have changed little over the last few years

(Kasperson, 2014). Furthermore, Pidgeon (2014) points out that increasingly complex, more frequent and costly disruptive events require scrutiny of both emerging technologies and changing risk identities in society to develop the strategic capacity to address these fundamental risk communication problems 'in appropriate methods for situating 'values' in public and stakeholder engagement and in fostering citizen deliberation for the wider public good'. However, by surveying the evidence from current research about what works, the relationship between public sector organisations and private citizens in fostering innovation in risk communication can be tested and its effectiveness determined (HM Government Office of Science, 2014).

Innovation has been categorised in a variety of different ways from process innovation, product or service innovation, governance innovation or conceptual innovation (De Vries et al., 2015). We focus on the following three aspects of innovation and improving practice in risk communication by identifying particular issues and areas of innovation which are challenging either for practice or areas of intense activity.

Firstly we deal with innovation and practice in the process of risk communication, focusing on one of the more significant areas of the former: new emergent approaches that reorientate practice around communities and new and evolving decentralised approaches. Secondly, we look at new communication patterns, emphasising the challenges of communicating with millennials and of cross-border communication. The third chapter of this chapter pays particular attention to technology infrastructure concerning innovations which allow rich media channels to be utilised. The final chapter discusses the challenges faced in embedding these innovations into practice.

4.4.2 Risk communication and citizen participation

Research indicates that messages need to be culturally adapted to different country settings. Investigated by the current EU BeSeCu project as well as by the EU E-COM@EU project, findings indicate that cultural differences extend from mere age differences to a national context with regard to the most popular social media tools and national norms for communication style and tone.

Governments (national, regional and local), emergency management (responder) organisations and other public service bodies are traditionally risk averse and mostly rely on communication methods that reflect a view that aims to align lay perceptions with expert views of severity (Árvai, 2014) rather than participatory models that recognise local citizen expertise and knowledge. Further, Höppneret al. (2012) suggest that within the current pan-European communication practices, knowledge on the (target-specific) suitability of different communication forms is rarely translated into the field. There has been, however, a recent paradigmatic shift in disaster risk management moving from a top-down focus to what has been termed a 'people-centred approach'. While this approach is still emergent and contested (Scolobiget et al., 2015), it has led to a range of innovative practices and approaches, such as the alignment of people-centred decentralised approaches. The development of digital technologies and social media platforms (e.g. the use of social media in the Haiti earthquake, the Queensland floods in Australia and Hurricane Sandy in the United States) has led to new ways of delivering better targeted, actionable risk information to diverse publics across multicultural, multiagency and multi-jurisdictional boundaries.

Communication needs to be culturally and context specific while it engages citizens "as sensors" and contributors in the unfolding "story".

Due to its popularity and collaborative, participatory, decentralised and accessible nature, social media allows information to pass quickly to multiple publics and organisations; thus extending the reach of emergency responder organisations, enhancing risk communication, improving situational awareness and furthermore providing traceable geographical and temporal data for monitoring disaster events in real time (OECD, 2012). Related research also indicates, however, that despite the shift from mass media to social media as a complementary platform and the several different identified uses and functions (preparedness, warning and informing, pre-

event signal detection, connecting communities, developing resilience and aiding recovery), social media is still emergent (Houston et al., 2015).

To address these issues there has been considerable investment by the EU through its seventh framework programme for research and technological development (FP7) and Horizon 2020 frameworks in risk communication research. An innovative, groundbreaking project — PetaJakarta.org — combines different sources of data and citizen participation to produce real-time intelligence-led information to create a shared situational awareness and to promote resilience (Holderness and Turpin, 2016).

PetaJakarta is an example of applying new concepts such as geosocial intelligence frameworks, and demonstrates an evolutionary process from passive spatial and temporal data mining techniques to 'big crowdsourcing'. Geosocial intelligence frameworks rely on a deep understanding of the information ecosystem within which social media platforms operate. The challenge in gathering 'intelligence' is to extract knowledge from the 'noise' generated by such platforms so that users, governments and other actors can make 'actionable decisions in a time-critical manner' (Holderness and Turpin, 2015). Four principles underlie such frameworks:

1. Reliable, free and open-source software that enables the gathering, sorting and displaying of useful disaster-related information.
2. 'Big crowdsourcing,' wherein users on a social media platform are actively encouraged to share information relevant to a given situation or anticipated scenario.
3. A participatory approach and co-management that values the peer-to-peer sharing of situational information within the same platform that is used by government agencies and first responders who can transparently monitor and cross-check the data being shared.
4. Open data, so that all users can inspect the software, review the system and develop complementary tools and technologies that further enhance resilience within the information ecosystem.

This 'people as sensors' paradigm (which echoes the work of Scolobig et al. 2015) was used by PetaJakarta to contact many more Twitter users than any human could hope to do and allowed the network of users to grow organically through linking to personal networks. The map used by both citizens and government agencies created a reciprocal communication interface between citizens, the PetaJakarta project and the government. By engaging with government civil defence agencies and noting their operating procedures, including interaction between Twitter accounts @petakjt and @BPBDJakarta to disseminate (retweet) key information, the project was seen as credible and legitimate by other government departments and the public. Major challenges for this project were:

- how to ensure the verification of very big crowdsourced data; and
- how to engage citizens to participate actively in sharing their data.

Verifying the data acquired from Twitter was of critical importance to the project. User-generated reports were cross-checked in a number of different ways: by cross-referencing data with tweets from the same location; Twitter feeds from government agencies; electronic media such as television reports and internet news sites; and by recognising active users who frequently tweet reliable information.

To engage as many citizen users as possible, a community inclusion strategy was designed to use concise, action-oriented messages such as 'See a flood. Tell Us' and also to adopt a user-centric approach by encouraging users to retweet any messages received from the project to their own personal networks. The big crowdsourcing element of the project was also emphasised by highlighted messages promoting the benefits of greater use of PetaJakarta such as 'The more people use PetaJakarta, the better the map will be' (Holderness and Turpin, 2015). The strategy sought to highlight the community resource element of the project by adopting a non-moralising, opt-in approach to include citizens as partners in the sharing of real-time information and situational awareness regarding flooding rather than just being the recipients of emergency or information messages.

The example of the PetaJakarta project demonstrates how innovative participatory, collaborative approaches can be extended to gather real-time information through the use of social media platforms and open-source software. Furthermore, the utility of the concept of a Geosocial intelligence framework appears to be transferable given the global nature of the social media platform and the availability of the open-source software, making the concept adaptable to the European context.

4.4.3 New communication patterns

This chapter looks into the use of social media and mobile technologies in the communication process with younger (millennial) demographics. Messages, urgency and level of planning change with the stage in the disaster cycle and planned versus reactive settings are highlighted. The place of such media in a wider set of media used in a range of disaster settings is examined and discussed, as are the opportunities to extend messages from traditional media to include, and take advantage of, newer forms of communication.

Eurostat statistics suggest that younger people are more likely, in Europe as elsewhere, to have access to more up-to-date smartphones as well as to information via tablets and gaming consoles. Furthermore, younger people are less likely to engage with traditional channels such as radio and broadcast media/print press and more likely to make use of social media such as Twitter, regarding this as a legitimate source of information, more than older citizens would (Bruns and Burgess, 2014).

Conflicting previous research (such as Austin et al. 2012) has implied that traditional media was preferred — at least a few years earlier —as a credible source of information, and similarly (according to Vihalemm et al. 2012), the trust in traditional media outlets has been seen to rest upon the belief that communication institutions have the proficiency to assess and estimate information to obtain an adequate overview of a situation and to calculate risks and make decisions when broadcasting.

Even though decreasingly, information is still sought through traditional mass media sources (namely from broadcasting companies), to some extent regarded as more credible sources of information. According to the findings of a survey of 1 034 citizens across 30 European countries, only 13 % of respondents perceived information on social media to be more accurate than that of traditional media channels. In fact, nearly half (44 %) of the respondents did not agree with this statement (Reuter and Spielhofer, 2016).

To this extent, there have been implications that — through its social, interactive, local, rapid, unfiltered and timely qualities as well as convenience and personal nature — social media serves as a medium leading towards providing relevant information (Posetti, 2012; Austin et al., 2012). This is also supported by the previously mentioned survey, showing that citizens perceive information provided on social media during emergencies as more accessible than information provided via more traditional media channels such as TV, radio or media websites (Reuter and Spielhofer, 2016). The change could be explained through media convergence; the interlocking of different types of media (text, audio and video) and content (news, popular culture, etc.) on online forums (and further on social media sharing) has improved and simplified access to any kind of information via smart devices that was previously sectored behind different media (television, radio and print press). Key social apps such as Facebook and WhatsApp also have a useful characteristic in that it is easy to share information, and the functionality of the apps make it clear which information is more recent or has updated other information; therefore, these apps facilitate the creation of shared situation (or information) awareness.

It is important to handle the transition from traditional media to social media, while fostering trust and reducing rumours and misinformation.

A key issue is that of engaging communities and citizens rather than purely disseminating messages. This was investigated comprehensively by the Public Empowerment Policies for Crisis Management (PEP), which suggested the integration of younger citizens in responsibilities for such communication to improve relevance and access to that demographic. A related effect is the low reliance of EU communities on self-help (POP ALERT project), with 'the authorities' being expected to lead efforts as well as be a source of information. POP-ALERT suggests that community resilience can (and should) be strengthened, and highlights social media and messaging as key tools in engaging younger demographics as well as in providing resources such as toolkits to support such development. This is further supported by Duffy (2012), who iden-

tifies the use of social media in such efforts to improve resilience and preparedness.

Once a disaster has occurred, the emphasis shifts from preparedness messages to messages designed to update and inform. There has been significant EU action to develop appropriate infrastructure, which allows connectivity and access to information during the course of a disaster that may have compromised such communication systems (IDIRA and PPDRTC, for example). For many people in such a situation, the priority becomes the ability to 'track' the disasters and gauge the likelihood of being affected. For example, residents in a flood area not yet affected by floodwater need to know whether they are in an area where they should stay put, prepare for the eventuality of evacuation or evacuate.

Another interesting notion is how the source and form of crisis information affects the public's information-seeking behaviour. Based on their study on such behaviour during crisis situations, Austin et al. (2012) suggest that people are more likely to use the same type of media to seek information as that from which they initially heard about the crisis. Their findings extend to the channel complementarity theory, which proposes that users of a medium that serves a particular functional need are also more likely to choose other media relevant to serving that particular function or need (Dutta-Bergman, 2006).

Similarly, previous research has established that the effectiveness of crisis communication is positively influenced when the social position of the communicator or the channel is 'close' to the recipients' everyday lives (Trumbo and McComas, 2008; Lachlan et al., 2007). Furthermore, the public's implicit or inherent presumptions regarding the source or channel of information may affect further information behaviour (e.g. seeking more information about threats or ignoring it) (Vihalemm et al., 2012). Bird et al. (2012), for example, highlight the use of Facebook groups — both official and community generated — in the Queensland floods in Australia. In this setting, the ability to trust the messages received is key and information is likely to be sought, particularly by younger people, from multiple channels in order to 'cross-reference' advice and information (EU public empowerment policies project). The issue of trustworthiness of messages also needs to be highlighted. Credible sources are needed to convey messages and should take advantage of the 'spotlight' period of public attention at the height of a disaster to ensure effective messages are disseminated. This issue of trust is specifically addressed by the E-COM@ EU project.

Post-incident preparedness messages can be continued and will have, for a period of time, a higher level of attention, especially with regard to the specific type of incident that has occurred, although, depending on the nature of the disaster, communication systems may be affected over a very short or an extended period of time (e.g. in the case of infrastructure damage after a flood or earthquake).

Cool et al. (2015) highlight the role of social media with younger citizens in post-disaster risk communication after Typhoon Haiyan in the Philippines as well as the lack of an infrastructure of social media use during the disaster itself. Yasuda et al. (2016) highlight the role of in-school projects in preparing younger citizens in the same setting, as do Schiavo et al. (2016) in a broader health-promotion context.

Communication with younger demographics shares one key issue with wider issues of communication; the requirement for a capable and resilient infrastructure to support communication. This is being addressed both as a technical issue (e.g. provision of resilient broadband —PPDRTC project) and through effective middleware to improve collaboration among message providers (e.g. Disaster and IDIRA). In terms of preparedness, such communication capability is available to many people (and arguably especially to younger people) for most of the time through 4G wireless networks, broadcast media and targeted project interventions.

Cyber security is also raised as a risk factor by projects including the EU public empowerment policies project, as is the quality of information sources feeding into messages — especially at the reaction stage; EU Proactive project being an example of a technical approach to this issue. The need to take a multidisciplinary and multichannel approach to communication rather than targeting specific groups — such as younger people — solely via a 'preferred' channel is highlighted by the EMBRACE project. Furthermore, studies related to crisis communication in real-life situations (e.g. Greater London area riots in 2011 and the swine flu epidemic in 2010) have highlighted the role of proactive and interactive methods of commu-

nication as well as timely reaction in both enabling trust and increasing communicational reach.

These studies emphasise the importance of interaction and participation in online communication rather than merely relying on one-way information dissemination. Prompt reaction and interaction can prove to be pivotal in avoiding a communicational void (especially from the public authorities) — and in preventing such a void from being filled by other actors — as well as in establishing dialogue and trust towards citizens, but also in increasing communicational reach through shares, likes and recommendations (Denef et al., 2013; Tirkkonen and Luoma-Aho 2011). A further risk issue in the use of social media — therefore disproportionately affecting younger citizens — is the potential (Alexander, 2014) for inaccurate information. Rumours, either naïve or malicious, can be rapidly and widely disseminated in advance of accurate information, and can potentially reduce its impact or fully eclipse it when it does come. For example, according to a study by Gupta et al. (2013), rumours and fake content covered 29 % of the most viral content on Twitter, while 51 % of the content was generic opinions and comments and only 20 % relayed true, factual information.

A recent study also found echo effects (i.e. the dissemination of older tweets with fake information) but also self-correcting mechanisms of social media communities when verifying and dispelling online rumours during crises (Jong and Dückers, 2016). There are also imbalances in national contexts; Mudhavanu et al. (2015), for example, highlighted the lack of involvement of younger citizens in disaster risk communication in Zimbabwe.

4.4.4 Technology Infrastructure

A key area for technological innovation in DRM relates to the social and technical challenges concerning personalisation while achieving a shared situational awareness among the emergency services and citizens. Shared situation awareness refers to information that is shared, including updates of the information among a group of people, for example as achieved by projects discussed above. Shared situational awareness is often defined for team performance (e.g. Cuevas et al., 2011), yet is also relevant in crisis management (e.g. Van De Ven et al., 2008; Wolbers and Boersma, 2013). Personalisation is directly related to cultural and contextual diversity in Europe, including multilingualism, the EU-wide mobility of its citizens and serving citizens experiencing a disability or requiring special needs (e.g. deafness, speech impairment, etc.). A number of EU FP7 and Horizon 2020 projects are currently addressing these aspects to enable rich(er) communication between emergency services and citizens, including bidirectional voice, real-time text, video and data: 'total conversation' with rich data (personal, medical and location data). A non-exhaustive overview can be found in the appendix.

Current communication means that rely mainly on voice calls via landlines or mobile phones as services for exceptional cases are only partially supported by SMS, email, fax and text relay. The advent of social apps and the wide availability of smart devices enable the implementation of a total conversation model that combines audio, real-time text, video and data-sharing to serve all citizens, including those experiencing a disability and requiring special needs. However, typical challenges encountered are related to standardisation and customisation: standardisation is necessary to ensure European-wide accessibility to emergency services, while customisation is necessary to allow the implementation of specific apps, products and services for specific audiences.

Another open challenge is multilingualism and multicultural personalisation (Stephens and Malone, 2009). Each European country (and beyond) hosts many citizens who do not speak the native language, including tourists, expats and immigrants, but also citizens who use sign language (i.e. due to speech or hearing impairments). During crises, effective and efficient communication is of utmost importance, and having control over the quality of translations of communications is also an applicable challenge to emergency services (Manso et al., 2016). The operators and first responders engaging in dialogue with citizens may need automated support in communicating effectively with citizens with different language proficiencies and cultural backgrounds (Manso et al., 2016). Projects such as NEXES, Insign and SignSpeak address the challenge of fostering communication with (national and international) sign language users.

Technical standardisation may be hampered or fostered by the current developments of regional and national 'emergency apps'. Examples of national apps with integration into the emergency services' systems and work processes include the BurgerNet app. (n.d.), the WhereAREU app. (n.d.), Greater Manchester Police app. (n.d.), and others. A possible disadvantage is a plethora of special-purpose apps that only function within a specific region. Other apps, such as the BurgerNet app., have functionality for cross-border cooperation and pave the way for standardisation efforts. An innovation investigated by the NEXES project is to provide standardisation to the 'back-end' of these apps through providing reusable libraries. This ensures flexibility by app. developers to build any desired app. with a harmonised integration with emergency services. An advantage of such an innovation is that, potentially, such apps can function everywhere in Europe and beyond.

Enable communication between many parties through different (non-) digital media, securing proof of origin, tamper proof contents and discovery of updated information.

A social and technical challenge for emergency services is to engage in 'crowdsourcing': mobilising citizens to provide information on specific topics and/or engage in certain actions. However, both the advantages and disadvantages of crowdsourcing concern privacy, handling information from participants with malicious intent, detecting false positives, etc. Furthermore, participant motivation and engagement are of importance, especially when frequent updates of information from crowdsourcing are required (Liu, 2014).

Although general media coverage cannot, and likely should not, be restricted, communication with and by emergency services may need to become more focussed and targeted. A challenge for risk communication is to target specific risk communication to a specific audience, possibly deliberately excluding specific citizens, e.g. unaffected citizens (Manso et al., 2016).

Another challenge concerns the party that takes the initiative. Typically, citizens take the initiative by calling emergency services in an emergency. Emergency services, however, take the initiative prior to an incident/situation in providing information to (groups of) citizens. An innovation to be investigated in social and technical implications concerns how emergency services can contact a citizen, which could be a response of 'calling back' or when losing connectivity (Manso et al., 2016). Alternatively, there is the case of proactive communication: initiating communication before a hazardous situation unfolds. Unexpected communication by emergency services and other authorities towards citizens may raise issues regarding privacy.

Crisis informatics (Palen et al., 2007) is a documented phenomenon that illustrates how people in and out of the disaster go online through computers using Web 2.0 applications, cell phones and other personal devices to provide, seek and broker information in times of emergency.

For example, results found in Soteria indicate that citizens consider authorities' presence in social media as valuable and reassuring during emergency situations (Jäntti et al. 2016). This directly implies that trust is an important facet of risk communication (Coombs and Holladay 2014). Apart from social and political aspects of trust, a number of security considerations are of importance regarding the message(s) sent by certain (trustworthy) parties (Fruth and Nett, 2014; Tanenbaum and Van Steen, 2007):

- Non-repudiation: no message can be changed or tampered with; it is the original message with original author, source location and timestamp.
- Signed: any message can be traced to its author (the originating party).
- Relationships: any message explicitly refers to another message, including an annotation of the type of relationship, such as 'is an update of'.
- Distribution: any message can be shared and distributed, without changing the above properties.
- A challenge is to explore these technical considerations further so that messages sent by (authorised) parties can be received, inspected and shared by any recipient. Of importance is the ability to check for 'updates' and to have the built-in technical means to assure that citizens can be notified of updates in a timely fashion. Information-bound security approaches (Xylomenos et

al., 2014) may be of relevance.

A typical technological challenge during a crisis concerns the availability and reliability of communication networks. Numerous national and EU-funded projects (too many to list here) investigate new technologies and solutions for telecommunication infrastructures and network robustness. Nevertheless, it is prudent to assume that communication networks may be (temporarily) disabled, congested or unavailable during a crisis. Given this assumption, a challenge is to ensure that (a) information can be communicated to citizens and that (b) information can be inspected for authenticity and timeliness. The security considerations with regard to messages, formulated from the trust perspective, also apply to non-technical communication. Is it possible to deliver messages without using

BOX 4.1

Project overview (non-exhaustive)

- BeSeCu (Behavior, Security and Culture) project. Understanding culture in crisis behaviour.
- COMPOSITE project.Comparative police studies in the EU (www.composite-project.eu).
- DISASTER. Data Interoperability Solution At Stakeholders Emergency Reaction Novel methods to enhance cross-border emergency response (www.disaster-fp7.eu).
- E-COM@EU project. Effective communication in outbreak management (www.ecomeu.info).
- EMBRACE. Building Resilience Amongst Communities in Europe. (www.embrace-eu.org).
- HeERO 2 project. Harmonised eCALL European Pilot (www.heero-pilot.eu)
- IDIRA. Interoperability of Data and procedures In large-scale multinational disaster response actions. (http://www.idira.eu/).
- INSIGN. European Commission DG Justice and Consumers pilot project regarding improving communication between deaf and hard of hearing persons and the EU (www.eu-insign.eu; not online anymore)
- New information system for the national emergency response centre of Finland (http://www.112.fi/en/the_erc_reform/new_information_system)
- NEXES. NEXt generation Emergency Systems (www.nexes.eu, Manso et al., 2016)
- Online and mobile communications for crisis response and search and rescue actions (isar.i112.eu) (Flizikowski et al., 2014; Manso and Manso, 2012)
- Online and mobile communications for emergencies (soteria.i112.eu) (Jäntti et al., 2016)
- PEP project. EU Public Empowerment Policies for Crisis Management (www.crisiscommunication.fi/pep).
- POP ALERT project. Solutions to better prepare European citizens and authorities during large-scale crises.
- PPDRTC project. Public Protection and Disaster Relief — Transformation Centre. Roadmap to emergency communication (www.ppdr-tc.eu).
- PROACTIVE project. Terrorism detectors. (www.proactiveproject.eu).
- Project Slándáil, which aims to build and test a prototype system for managing disaster emergencies by fusing information available in different modalities in social media with due regard to ethical and factual data provenance (www.slandail.eu)
- REACH112. Responding to All Citizens needing Help (www.reach112.eu)
- REACT. Reaction to Emergency Alerts using voice and clustering technologies (www.react-ist.net; not online anymore)
- Software to understand sign languages (www.signspeak.eu)
- Use of new communications and social media to support citizens during crisis (www.projectathena.eu) (Gibson et al., 2015)

digital communication infrastructure, while retaining these trust-enhancing aspects? The challenge here lies in allowing citizens to distribute messages using various media, including but not limited to paper, photographs, photocopy, etc.

4.4.5 Conclusions and key messages

In this subchapter we have identified a number of areas of practice, many of which reinforce existing tenets of effective practice: communication is reciprocal and risk communication is about increasing the quality, timeliness and accuracy of situational awareness. We also point out the influence of technological innovations and current innovation challenges that lie in realising total conversation and crowdsourcing capabilities, personalisation for citizens, integration with emergency services, enhancing trust in (official) communication and standardisation with and beyond the EU. Research has indicated that many of the challenges related to information sharing during major incidents transcend technology issues (Allen, Karanasios and Norman 2014). These new innovative processes can, however, be seen as a double-edged sword, bringing not only benefits but also new risks and challenges. As Liegl et al. (2016) state, it is also important to note the importance of the consideration of ethical, legal and social issues (ELSI) related to these new innovations.

Partnership

Governments (national, regional and local), emergency management (responder) organisations and other public service bodies in disaster risk management are slowly shifting from communication methods that reflect a view that aims to align lay perceptions with expert views of severity to participatory models that recognise local citizen expertise and knowledge. A key issue is that of engaging communities and citizens rather than purely disseminating messages, that is, moving from a top-down focus to what has been termed a 'people-centred approach'. The development of digital technologies and social media platforms (e.g. the use of social media in the Haiti earthquake, the Queensland floods in Australia and Hurricane Sandy in the United States) has led to new ways of delivering better targeted, actionable risk information to diverse publics across multicultural, multiagency and multi-jurisdictional boundaries.

Knowledge

In this context, it is wise to consider the 'dark' or unexplored areas of research and practice in risk communication. In a recent structured literature review of research focusing on innovation within the public sector, De Vries et al. (2015) noted that only 7 % of the literature reviewed dealt with technological process innovation and that interorganisational innovations have not been thoroughly investigated. It is perhaps interesting that much of the work discussed here deals precisely with these areas: interorganisational innovations and technologically enabled process innovation. However, it is also telling that whilst the studies we have identified discuss the nuances of the technologies and processes to 'improve practice' or demonstrate 'innovations', they singularly fail to discuss the mechanisms by which the innovations are stabilised or grown in terms of institutionalisation, scope and function.

Innovation

The key challenges for innovation in disaster and risk communication lie not in the generation of innovative practices but in the implementation of mechanisms by which innovations and improving practice are diffused and moved from a state of emergence to wide-scale adoption. Rather than generating innovative approaches, we would suggest that embedding and diffusing innovations is the key area that both policy and practice must address.

Recommendations

The approach to communicating disaster risk in recent years has been shifted from a top-down, 'one size fits all' approach to a more democratic, engaged and inclusive one. It implies partnership between policymakers, practitioners and citizens of all backgrounds. In a society in which people have the opportunity to inform themselves about a wide variety of risks through various media channels, one-way media campaigns that tell people how to prepare, respond and recover from a disaster are not effective. Instead, engaging in a dialogue with local communities to understand the historical and local context is an important fundament for future risk communication that focuses on stimulating resilient behaviour:

- words used for risk communication should be inclusive and emphatic in order to contribute to effective communication and support and eventually to more resilient coping strategies of those affected by a disaster;
- since the people's response to disasters is influenced by past experiences and local cultures, risk communication should be based on the understanding of local risk perceptions and capacities.

Likewise, the practices of disaster and risk management should rely on a comprehensive approach to decision-making. Participatory models emphasising engagement with and empowering of local communities through joint preparation, planning and information crowdsourcing have emerged, enabled by increasing digitalisation. Those involved in risk communication should:

- realise that collecting, sharing and disseminating disaster information is not neutral, as it has an impact on how people perceive risks and deal with the consequences;
- bottom-up, people-centred and participatory processes need to be established to ensure collaborative and inclusive decision-making;
- make sure that the collection, analysing and modelling of crisis data is done in a transparent and ethical way to avoid privacy infringements, unauthorised dissemination of personal information, inequality and irresponsible behaviour.

ICTs play a vital role in risk communication. New communication tools and innovations, including social media, Wireless Emergency Alerts (WEA) and the use of mobile and online communication tools, might help people to find more relevant information on disaster risks. At the same time, innovation in risk communication should never be a goal in itself:

- it is critically important to invest in the implementation of mechanisms by which innovations can improve communication practices, including interorganisational collaboration;
- the communicator and/or the channel's social position should be as close as possible to the recipients' everyday lives as this will positively affect the

outcome of risk communication;

- using personalisation of risk communication that is related to cultural and contextual diversity is a key ingredient of a successful communication strategy;
- since critical information infrastructures can be affected by disasters (e.g. resulting in large-scale power blackouts), governments should invest in reliable, redundant and sustainable infrastructures, but at the same time take measurements to go beyond the infrastructure by investing in risk knowledge, monitoring and risk capacity and early warning systems.

The above efforts together will support a more balanced, inclusive and systematic approach to risk communication and will eventually lead to a more resilient European society that has to deal with increasing risks.

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Introduction

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