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Decision-making and evacuation planning for flood risk management in the Netherlands

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A traditional view of decision-making for evacuation planning is that, given an uncertain threat, there is a deterministic way of defining the best decision. In other words, there is a linear relation between threat, decision, and execution consequences. Alternatives and the impact of uncertainties are not taken into account. This study considers the 'top strategic decision-making' for mass evacuation owing to flooding in the Netherlands. It reveals that the top strategic decision-making process itself is probabilistic because of the decision-makers involved and their crisis managers (as advisers). The paper concludes that deterministic planning is not sufficient, and it recommends probabilistic planning that considers uncertainties in the decision-making process itself as well as other uncertainties, such as forecasts, citizens responses, and the capacity of infrastructure. This results in less optimistic, but more realistic, strategies and a need to pay attention to alternative strategies.

Keywords: decision-making, evacuation, flood risk, the Netherlands

Introduction

Evacuation is a potential measure to reduce loss of life in a time of disaster or threat of disaster. People, animals, and goods that can be moved might be saved, but it can be costly in terms of time, money, and credibility (Bourque et al., 2006). Evacuation is a potential measure to address the risk of flooding. When a delay occurs, not everyone can reach the desired destination in time (Urbina and Wolshon, 2003; Barendregt et al., 2005; Jonkman, 2007; Kolen and Helsloot, 2012). The response to Hurricane Katrina in New Orleans, Louisiana, United States, in 2005 demonstrated that people and some movable items of property might be saved, but goods will be affected by flooding, and economic processes will come to a halt (Vrijling, 2009). The cost of an evacuation in the case of a hurricane in the US can exceed USD one million per mile of the coast because of commerce, productivity, and direct losses (Wolshon et al., 2005). With regard to credibility, this involves addressing concerns about the quality and sources of information, the discrepancy between timely warnings and later but more accurate warnings (Dow and Cutter, 2000), and the impact of false alarms (Gruntfest and Carsell, 2000).

Floods often are described as the most deadly of all natural disasters (Alexander, 1993). The mortality rate for different kinds of flooding has been shown to be related

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to the time available for the implementation of measures (Jonkman and Kelman, 2005). Furthermore, its relationship with lead time is highlighted in research conducted after other kinds of disasters, such as earthquakes (see, for example, Alexander, 2004).

This paper focuses on large-scale flooding caused by extreme water levels on rivers (rain, snow) and storm surges in tidal areas. The expected lead team for these events is relatively long compared to flash floods. The research shows that, owing to uncertainties in forecasting, different geotechnical mechanisms of failure of levees, and different hydraulic conditions, multiple events can happen. For example, extreme events as worst credible events (ten Brinke et al., 2010) can occur as can smaller events when the hydraulic load is much less. Furthermore, the lead time can vary between days and unforeseen events (Barendregt et al., 2005; Jonkman, 2007). By taking these uncertainties into account (as a part of reality), a raft of flood scenarios for emergency management can be defined that represents all possible situations (Kolen et al., 2011).

Human interventions can reduce the consequences of a flood. When people leave the potentially exposed area or move to relatively safe places, such as shelters on high ground, they are less vulnerable to a flood. In addition, traffic management and mass communication campaigns can be implemented in the case of a threat to maximise the possibility of mass evacuation. These human interventions require decisions by citizens and authorities—all of which are based primarily on information about a possible threat, the expected consequences of the threat, and the anticipated outcomes of emergency measures. Authorities can influence the 'physical environment' that creates boundary conditions for a later response and increases the effectiveness of emergency measures. This paper uses the term 'transition phase' to characterise this period.

The central issue for authorities (as well as for the general public) is how and when to respond to large-scale flooding. A previous evacuation with or without a flood, a missed call (Gruntfest and Carsell, 2000; Grothmann and Reusswig, 2006), or other circumstances in society (as depicted in the survey presented in this paper) might influence future credibility and response and hence loss of life. However, other evidence suggests that this relation is less important (Baker, 1991; Lindell, Lu, and Prater, 2005). According to Kunreuther et al. (2002), this is because people fail to learn from the past. For low frequency events, as in the Netherlands, one can question whether learning is relevant for citizens because the length of the return period for such events might be far greater than a lifetime. For authorities, though, learning is relevant and explicit attention is needed as citizens in a democratic society expect public leaders to introduce responsible measures based on available information and knowledge in a crisis (Boin et al., 2005). Research shows that exercises and training to stimulate the correct response have to be based on plausible scenarios (Alexander, 2000). These scenarios and possible responses have to be recognised and accepted within the realm of planning.

The decision-making process for mass evacuation is influenced by great uncertainties and consequences. Research following Hurricane Katrina, for instance, assessed whether or not the earlier involvement of national organisations would have lessened

the impacts (Parker et al., 2009). More insight is needed, therefore, into the effectiveness of different strategies for mass evacuation and the mechanism governing how (and when) to decide on a specific strategy based on the probability of flooding, available time, the characteristics of different areas, and the effect of uncertainties (Kolen and Helsloot, 2012).

Objective and overview

Almost all of the literature (see below) focuses on the relationship between available time and required time for evacuation. This relation is used to define the moment at which to call for an evacuation; planning documents that support decision-making are based mainly on deterministic assumptions about a linear relation between threat/decision/execution, which is applied to all possible events. Almost never addressed is the role of the decision-making process itself in strategy choice and the moment of decision-making and the impact on evacuation planning. Owing to the effect of ambiguity and current risk perception, a deterministic approach to decision-making processes might not result in minimisation of loss of life or social consequences.

This paper focuses on the impact of ambiguity and uncertainties in decision-making on mass evacuation strategies in the event of flood risk. This is called 'top strategic decision-making' and it centres on preventive or vertical evacuation and the moment at which to initiate such a strategy. The literature review below shows that evacuation planning for flooding concentrates on preventive evacuation because this is the best-case strategy. In a best-case strategy optimistic assumptions are used to define the threat and all operational measures. There is no attention to other evacuation strategies even though they might be more effective in reducing potential loss of life. A better understanding of the role of the decision-maker and the crisis manager in the decision-making process in relation to evacuation strategy choices can result in more realistic evacuation planning and improve the effectiveness of evacuation. Consequently, this study concentrated on the:

- concept of top strategic decision-making and the transition phase;
- primary information for top strategic decision-making for evacuation;
- key factors in the decision-making process that affect strategy choices; and
- willingness to act according to the decision made.

The results are discussed within the context of evacuation planning.

The challenges for the Dutch decision-maker

The people of the Netherlands live in a delta that is largely below sea level. Historically, the country has concentrated principally on flood prevention, resulting in a flood defence system with the highest safety standards in the world. This paper examines flooding in the Netherlands caused by extreme discharges from rivers and/or storm

surges. Forecasting models and early warnings are used to alert crisis organisations and citizens to the need to implement protective measures. However, the time available for evacuation based on forecast and failure mechanisms and the time needed for decision-making are uncertain (Barendregt et al., 2005). Flooding, as a natural hazard, can happen under many different scenarios (ten Brinke et al., 2010; Kolen et al., 2011).

Preparing for flood disasters on a national scale means preparing for extreme—but very unlikely—events (ten Brinke et al., 2010) that involve multiple decision-makers. Critical (forecasted) water levels in the Netherlands that could initiate a decision-making process are foreseen to occur less than once in a lifetime (Ministry of Transport, Public Works, and Water Management, 2008). Hence, the Dutch lack frequent experience of these events as well as other comparable threats with a short lead time in which to initiate a mass evacuation. Most relevant is the evacuation of some 250,000 persons in 1995 owing to the level of river waters. The main reason to select preventive evacuation in 1995 was the message from the water boards that they could not guarantee any longer the strength of the dikes (van Duin et al., 1995). In the days and hours before this announcement, there was a sense of urgency among the authorities and members of the general public because of the rising water levels in the rivers. Subsequently, discussions took place about the need for mandatory evacuation (Meurs, 1996).

An evaluation of the water safety policy in 2004 showed that the Netherlands is not prepared for extreme flooding (RIVM, 2004; see also ten Brinke, Bannink, and Ligtvoet, 2008a). As a result, the Government of the Netherlands (Ministry of the Interior and Kingdom Relations and Ministry of Transport, Public Works, and Water Management, 2005, 2006) sought to address the need for improved preparation. National (BZK, 2007; Kolen et al., 2007; Kolen, Vermeulen, and van Bokkum, 2008; LOCC, 2008; Ministry of Transport, Public Works, and Water Management, 2008; Wegh, 2008) and regional (Brabant, Veiligheidsregio Midden- en West-Brabant, 2008; Hulpverleningsregio Haaglanden, 2008; Veiligheidsregio Zeeland, 2008; TMO, 2009b) authorities prepared emergency plans for flood prevention and large-scale preventive evacuation. Drafts and first-generation plans were tested in a nationwide exercise entitled 'Waterproef' between 3 and 7 November 2008 (TMO, 2009b). The Government of the Netherlands (Ministry of the Interior and Kingdom Relations and Ministry of Transport, Public Works, and Water Management, 2009) concluded that, owing to this planning, research, and testing, the country was better prepared for flooding, although improvements still could be made, such as in evacuation planning.

A complete preventive evacuation of large coastal areas generally is not possible. Road capacity is not appropriate for a preventive evacuation within a realistic early warning time frame. The provinces of North and South Holland, the most valuable part of the Netherlands in terms of economic processes, need the most time for preventive evacuation. Other provinces, such as Zeeland, require less time because they are less populated. In most circumstances, however, they still need more than

one day. Other evacuation strategies are highlighted in planning documents as possible alternatives strategy, but they are not (yet) taken into account. A preventive evacuation owing to river flooding in polder areas takes less time than one for coastal flooding in highly populated areas, such as the province of South Holland, and forecasts of water levels are more uncertain in the case of a storm surge than in relation to high discharges on rivers. In general, these areas can evacuate in time, although exceptions can manifest themselves because of unexpected events.

Earlier research by the authors (Kolen and Helsloot, 2012) underlined the need to consider three alternative strategies:

- **Preventive evacuation:** the organisation and movement of people from a potentially exposed area to a safe location outside of this area before the start of a flood.
- **Vertical evacuation:** the organisation and movement of people inside the area under threat to shelters or safe havens before the start of a flood.
- **Shelter in place (or hide):** the organisation and movement of people to the upper levels of residential buildings at the location before the start of a flood.

In addition to preventive evacuation, safe havens, shelters, vertical evacuation, and support to augment the self-reliance of citizens should be taken into account in order to reduce loss of life and the impacts of evacuation (Haynes et al., 2009b; Kolen and Helsloot, 2012; Kolen et al., 2013). Decision-makers, though, have to make choices about evacuation strategy. These are only relevant when they can be implemented before people in the threatened area initiate an evacuation on their own. Research shows that an increase in the time available for evacuation is more critical for its effectiveness than further improvements in how organisations connect their planning, how people behave during an evacuation, or how infrastructure is used during an evacuation (Kolen et al., 2013).

The challenge facing decision-makers is how to deal with the positive (reduction in loss of life in a flood) and negative (economic and social disruption) consequences of evacuation, which are related to the uncertainty of a flood and the time available. The size of a flood (for example, 20 per cent of the Netherlands might be flooded in one event), the magnitude of the evacuation, and the possible autonomous response of the public increase complexity.

To gain more insight into the decision-making process and the role of decision-makers and crisis managers during an evacuation, this paper evaluates the 'Waterproef' large-scale exercise of 2008. In addition, a survey of all 431 Dutch mayors and 95 international crisis managers who advise decision-makers was conducted between January and March 2010.

The study focused on the situation in the Netherlands for two key reasons:

- complete preventive evacuation is not always possible so there is a need to consider different evacuation strategies; and
- the magnitude of the threat in the Netherlands means that a large number of local and national decision-makers and crisis managers are involved.

Dutch mayors of municipalities are responsible for emergency planning in their community and safety region. When their communities are under threat they have a role to play in the evacuation decision-making process, or they can be confronted by the consequences of evacuation in their community or safety region or the decisions of the national authorities.

The 95 crisis managers who participated in the survey all have a role in crisis centres and inform and advise decision-makers. The survey of crisis managers took place during the visiting programme of the international exercise 'EU Floodex' on 23–24 September 2009. All respondents were given some background information on mass evacuation in the Netherlands and a description of the different types of evacuation described in this paper. Furthermore, it was assumed that all respondents were aware of the possibility of flood risk (because of their involvement in the exercise and their profession).

The research endeavour aimed to gain more insight into the impact of decision-makers and crisis managers. Although one can question whether decision-makers in the Netherlands will respond to a crisis in the same way as they answered the questions in the survey, the results are important for emergency planning since they clarify the way in which they think.

Experience and knowledge of decision-making for flood-related mass evacuation in the Netherlands is scarce. Flooding is a (very) low-frequency event in the country, and the public perception is limited (Terpstra, 2009). However, authorities have paid increasing attention to the consequences of flooding since Hurricane Katrina in the US in August 2005 (ten Brinke, Bannink, and Ligtvoet, 2008a).

Future preparation for mass evacuation (such as emergency planning, exercises, and research) could challenge the results of the survey. Moreover, according to the literature, a lack of knowledge of heuristics and biases in dealing with uncertainties in these situations can influence the decision-making processes negatively (Tversky and Kahneman, 1974). Nevertheless, the survey serves to reveal the current perceptions of decision-makers and crisis managers of mass evacuation in the Netherlands. For emergency planning, this range of perceptions is particularly important.

Literature review of different mass evacuation strategies

Much attention has been paid to preventive evacuation in the event of a possible flood, yet almost none has been devoted to other strategies. In New Orleans, for instance, 'a complete evacuation of the city has been the cornerstone of hurricane preparedness planning for the region' (Wolshon, 2006, p. 28). During Hurricane Katrina it was clear that not all citizens could, or wanted to, leave the area in time. Therefore 'shelters of last resort', such as the Ernest N. Morial Convention Center and the Mercedes-Benz Superdome, were opened (CNN, 2005). Post Katrina, New Orleans Mayor Ray Nagin declared that shelters of last resort would not be used again in the future (CNN, 2006). None were opened during Hurricane Gustav of August–September 2008. Those who did not leave the area in time arranged their own shelter, such as building on high areas (in the French Quarter).

Wolshon (2006, p. 28) describes hurricane-related evacuation in the US as an initiative to 'move people away from danger', but he notes that it might not be possible to evacuate everyone preventively. Hence, there is an implicit need for other strategies.

The need for strategies other than preventive evacuation has been addressed in contemporary literature. Following an analysis of 50-year flash-flooding in Australia, Haynes et al. (2009a, p. 9) concluded that: 'in cases where evacuation may lead to increased exposure to danger and a suitable refuge exists for suitable occupants, sheltering in place may be a better option'. In addition, they pointed out that: 'At the moment, the literature cannot unequivocally support one option over another, in part due to the fact that because evacuation is such a well-established emergency management strategy, literature about policy alternatives is relatively thin on the ground. What the literature does show is that neither strategy is without risk and more research is needed to guide decision-making by emergency managers. In the end, emergency managers and the people directly at risk need to be able to assess the relative risks of alternative strategies'.

Emergency planners in the Netherlands concentrate only on preventive evacuation (as illustrated by the Waterproef exercise) (TMO, 2009a). Jonkman (2007) mentions the possibility of vertical evacuation, but he focuses only on preventive evacuation. What is more, emergency planning for coastal areas of the provinces of North and South Holland assumes that coordination could solve the problems associated with the limited capacity of the infrastructure and restricted lead time. *The Coordination plan dikering area 14* states that: 'as long as there is no national operation evacuation plan a large scale preventive mass evacuation seems not possible in case of coastal flooding' (South-Holland, Province, et al., 2010, p. 24). Earlier research, however, reveals that, even in a perfect situation, a complete preventive evacuation is not possible (Barendregt et al., 2005; BZK, 2008b; Maaskant et al., 2009).

The success of an evacuation strategy depends on the relation between the time available and the time required to execute the strategy and emergency measures. Time available depends on a combination of availability of forecasts and their use by decision-makers and experts (van Zuilekom, van Maarseveen, and van der Doef, 2005; Jonkman, 2007; Kolen and Helsloot, 2012). Meanwhile, analyses show that the time required for an evacuation can be reduced by introducing several extra emergency measures, such as mass communication and traffic management. The time needed to evacuate the 'Islands of Zealand and South Holland' in the event of a possible storm surge, for example, can be decreased from a worst-case scenario of approximately 55 hours to some 25 hours. Although a complete preventive evacuation for the entire Dutch coast still remains impossible, national traffic management can lower the time needed to evacuate 50 per cent of the population by almost a full day (from 44 to 27 hours). A theoretical mathematical solution that optimises the use of roads and utilises the behaviour of people as a variable predicts that the time required can be reduced by up to 48 hours (Kolen and Helsloot, 2012). Furthermore, the contra-flow system of New Orleans shows that it is possible to decrease the time required for evacuation (DHS, 2006; Wolshon, 2006),

Other strategies, such as vertical evacuation, might result in less loss of life because shelters are relatively safe areas. By comparing lead and required time and determining loss of life in a preventive and vertical evacuation, it has been shown that a vertical evacuation in the coastal areas of the provinces of North and South Holland will result in less loss of life than a preventive evacuation, except in the very optimistic (best) case of an exceptional (very uncertain) lead time and a perfect logistical operation (Kolen et al., 2013). For other less-populated areas, whether a preventive or a vertical evacuation results in minimum of loss of life depends on the time available and the implemented measures (Kolen and Helsloot, 2012).

Case study: 'Waterproef'

Scope of the exercise

The Ministry of the Interior and Kingdom Relations, the Ministry of Transport, Public Works, and Water Management, and Taskforce Management Flooding organised 'Waterproef' between 3 and 7 November 2008. It was the first national exercise on flooding and mass evacuation and was held after a two-year programme of improvements for flood preparedness (TMO, 2009b). This study assesses the part of the exercise related to decision-making on evacuation during coastal flooding.[1]

Several national (crisis centres and Rijkswaterstaat) and regional (safety regions and water boards) organisations took part in the exercise. A public panel also participated, providing feedback on the communications of the authorities and the media (de Jong and Helsloot, 2010). Waterproef focused on the choice of decision-making strategy for evacuation four days before an expected dike failure and possible flood. A scenario was developed that described a possible storm surge that could cause large-scale flooding along the coast of the Netherlands—a best-case scenario was used to reduce complexity and to present preventive evacuation of coastal areas as a serious option. The development of the threat and of all decisions between the first warning (eight days before the possible flood) and the day of the exercise was described in a start document based on existing emergency planning (Kolen, Vermeulen, and van Bokkum, 2008). Decisions concerning evacuation were foreseen four days before the expected moment of failure of levees. During the exercise regional decision-makers called for an evacuation, but this was not supported at the national level.

Even though an exercise is a constructed situation and is not developed for scientific research, and it is so large that it cannot be controlled (Helsloot, Scholtes, and Warners, 2010), lessons can be learned that are applicable to top strategic decision-making for mass evacuation by taking its circumstances into account. An evaluation of the exercise offers a unique (because of the presence of observers) view of national crisis management.

Lessons learned during preparations for Waterproef

Waterproef illustrates the difficulties that decision-makers face in dealing with uncertainties and in employing an integrated approach. Three alternatives for mass evacuation presented to the national decision-makers sparked debate among them. This

resulted in a decision to implement a totally new strategy (not prepared in advance)—involving the evacuation of non-self-reliant individuals and the families of first responders; others had to wait—that delayed the preventive evacuation by at least a day. One can also question whether the decision made was realistic or even counterproductive.

At the same time, regional crisis centres advocated complete preventive evacuation because they were not aware of the other options. In addition, the decision-makers of one region decided to call for an evacuation on their own (based on their own risk perceptions and responsibilities), even though they were aware of the national decision-making process.

The combined impact of all decisions on an evacuation (in terms of a reduction in loss of life or risk) has not been defined in planning and was not addressed during the exercise. Consequently, they were not taken into account in the study. The decision-making process was dominated by perceptions and expectations regarding the effectiveness of an evacuation and the cooperation of others.

Waterproef also showed that the personal opinions of crisis managers vary strongly and are influenced by available information over time. Analysis of the development of top strategic decision-making, as recorded in the starting document, which was the input for the exercise, reveals substantial differences in when and how to inform others. Although this starting document (BZK and VenW, 2008) was based on available emergency planning, several crisis managers still questioned the point at which to inform decision-makers and when to call for certain emergency measures. This produced several extreme opinions, such as 'directly after the detection of a possible storm surge' up to the 'moment to call for a mass evacuation'. Arguments presented included 'decision-makers are too busy and not willing to spend time', 'it is not serious enough', 'media pressure will force them to meet directly', and 'because of the lack of resources and the possible consequences'. The matter has a serious political dimension because the most logical move, 'to wait and see', can become a dramatic decision, as less time is available for evacuation, resulting in greater loss of life.

Top strategic decision-making: key factors and parameters

The concept and the transition phase

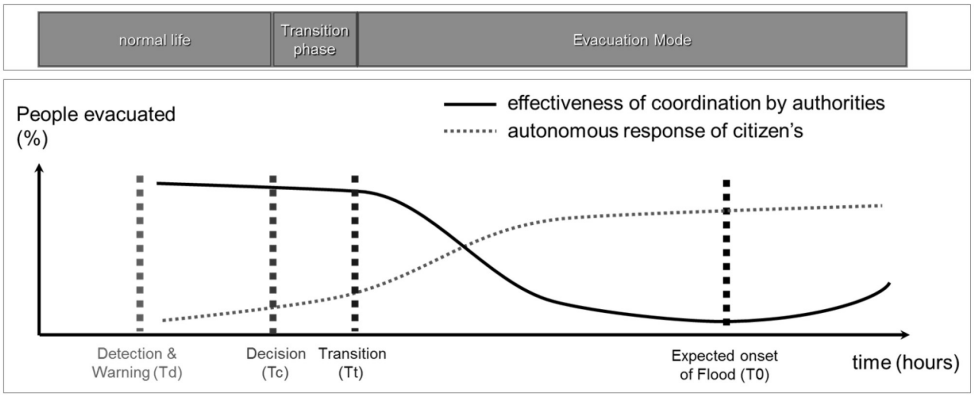
Top strategic decision-making for mass evacuation deals with (i) when to initiate an evacuation and (ii) the type of evacuation (preventive, vertical evacuation, use of shelters, and the creation of optimal (or better) circumstances for evacuation). The top strategic decision-maker is at the apex of the decision-making tree—the Ministerial Policy Team vis-à-vis flooding in the Netherlands. Top strategic decision-makers will be confronted automatically with many choices, great uncertainties, and myriad consequences in all circumstances. Uncertainties occur, for example, in predicting flooding (size and probability of occurrence) (ten Brinke et al., 2010; Kolen et al., 2011), the effectiveness of emergency measures (Kolen and Helsloot, 2012), and the responses of other stakeholders (local authorities, first responders, and citizens).

When forecasts become clearer and uncertainties decline (see Figure 1), people and decision-makers start to act. The autonomous response of citizens can lead to overload or the inefficient use of road capacity and available equipment and can place limitations on authorities in implementing further mitigating measures. Several models describe the possible responses of citizens to a natural hazard based on the interaction of environmental, individual, and social processes (Lindell and Perry, 1992; Sorensen, 2000; Grothmann and Reusswig, 2006; Kolen et al., 2013). It is known that not all people act directly after receiving a flood warning and that it takes time before people start to evacuate (Lindell et al., 2002). Since floods do not respect administrative boundaries multiple decision-makers are involved. The autonomous response of these decision-makers can result in counterproductive measures as well as the less optimal use of available resources and infrastructure.

Emergency measures have to be implemented before the combined consequences of the autonomous responses of others (citizens, organisations) create boundary conditions for evacuation. The impact of these 'top strategic decisions' depends on the possibility of establishing circumstances that facilitate a future response by citizens and several stakeholders. Rasmussen, Brehmer, and Leplat (1991) describe this process as reflective decision-making: the decision has to be made in relation to the decisions of others. These top strategic decisions have to be made based on information on forecasts and scenarios for evacuation and before people start to act. These decisions involve a transition from normal life to a mass evacuation mode. This period is called the transition phase (see Figure 1). Future decisions are made during an operation in the context of the evacuation mode.

During the top strategic decision-making phase, one can already speak of a 'crisis'. This is defined as the moment when policymakers experience 'a serious threat to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstance necessitates making vital decisions' (Rosenthal, Charles, and Hart, 1989, p. 10). Preparations for a future mass evacuation have the objective of transporting as many people, animals, and movable goods to the

Figure 1. Conceptual illustration of the transition phase for top strategic decision-making



Source: authors.

safest possible place before the event (in this case, a flood). In addition to flooding, which is considered to be a national crisis in the Netherlands (Helsloot and Scholtens, 2007), and hurricanes in the US (Cole, 2008; Parker et al., 2009), mass evacuation itself also has to be seen as a crisis.

To reduce the consequences of a possible flood, decision-makers can opt to initiate another crisis: the evacuation itself. An example is a 'shadow evacuation' (a non-authorised evacuation), as seen in the US during a chlorine spill in Graniteville, South Carolina (Mitchell, Cutter, and Edmonds, 2007), and during Hurricane Rita in Houston, Texas (DHS, 2006), in 2005.

The transition phase reveals the role of top strategic decision-making for mass evacuation: to create the conditions needed for the taking of other decisions and for the implementation of emergency measures in the near future by authorities, emergency services, and citizens. The following are examples of top strategic decisions with regard to communication policy and operational measures:

- Communicate with the public about the risk, the impacts, possible emergency measures, and uncertainties.
- Take policy decisions to influence other authorities. Warn the relevant national and regional authorities (if not warned already). Define the go/no-go decision and strategy for evacuation (preventive, vertical, shelter in place, or a combination). Inform other authorities about the risks and consequences (and timelines) of the threat, as well as about possible emergency measures, the impact of uncertainties, how to call for assistance, juridical arrangements, and international agreements.
- Implement operational emergency measures to adapt the environment, including implementing national traffic management, identifying the availability of routes, assigning regions that will offer public shelters, and prioritising the use of limited available (national) resources.

For evacuation planning, authorities in surrounding areas have an important part to play in supporting evacuation operations, such as traffic management, providing shelter, and delivering equipment and services (Wolshon, 2006; Ministry of Transport, Public Works, and Water Management, 2008; Wegh, 2008). Emergency planning (BZK, 2008a; Ministry of Transport, Public Works, and Water Management, 2008, 2009), research post evacuation (Jonkman, 2007; Kolen and Helsloot, 2012), experience of Hurricane Katrina (Parker et al., 2009), and exercises (TMO, 2009a) in the Netherlands indicate that proactive and direct involvement at the national level is necessary to increase the effectiveness of emergency measures following a national disaster.

The mass evacuation of Rivierenland in 1995 and the response to Hurricane Katrina in 2005 underscore the importance of and the difficulties associated with top strategic decision-making, including involving relevant partners in time and when to call for a preventive evacuation. During Katrina, some people did not want to evacuate because they hoped or they assumed that, as in the past, the hurricane would not hit their area (Parker et al., 2009). Earlier involvement at the national level, such as by the Federal Emergency Management Agency or the Red Cross, might have reduced

some of the consequences (Parker et al., 2009). The top strategic decision to involve the national level early in creating better conditions for a response was a lesson learned in New Orleans, as well as in the Netherlands (van Duin et al., 1995). During Hurricane Gustav of 2008, the national level made a concerted effort to be on top of the situation and to show its concern (Cole, 2008). Although this is not clear evidence of an increase in the effectiveness of top strategic decision-making, such action surely affects the perceptions of professionals and members of the general public. Another key factor that contributed to the Gustav response was recent experience of Katrina.

When time is limited, other strategies for mass evacuation, such as vertical evacuation and implementation of national traffic management (if implemented in time), might be more attractive (van Noortwijk and Barendregt, 2004; Wolshon, 2006; Jonkman, 2007). Whether to implement them is down to the decision-makers involved.

Primary information for top strategic decision-making for evacuation

The literature shows that, when relevant stakeholders have contact with one another, an optimal decision-making process can be implemented in which the right people work on the right objective at the right moment with the right information (Aldunate, Pena-Mora, and Robinson, 2005). One can question whether or not information can or will ever be completely available. At the moment the information is analysed, new information is, by definition, available because of the ongoing nature of the disaster or threat. It is also impossible to know whether all relevant information is available when taking the number of stakeholders (such as citizens, crisis centres, and first responders) into account.

In a Western society, some tasks of government are spread across several national and regional (semi-) governmental organisations; others are privatised. In normal day-to-day life, these organisations implement their own emergency measures based on their policies. The theory of 'Distributed Decision Making'—defined as the design and coordination of connected decisions (Schneeweiss, 2003)—describes the optimisation of multiple decisions in a situation involving multiple interests of organisations. The theory assumes that society is differentiated in such a way that a central body cannot control it via a hierarchical relation. The theory becomes more relevant when more stakeholders make decisions. Thus, decision-makers should take 'other decisions' into account so they do not frustrate other decisions.

In the case of the threat of flooding, time is available to share information and to discuss the decision-making process. Therefore, the theory of 'Natural Decision Making', which describes how people act in a disaster (Fjellman, 1976), applies only to top strategic decision-makers and their crisis managers. First responders are not confronted immediately with the need to act: during this phase, the flood has not occurred yet and evacuation has still to commence. Aside from top strategic decision-makers, no one else faces the consequences directly, so they are not required to make any immediate decisions. This might result in calls for further information gathering and in a delay in decision-making. Critical moments could pass, meaning that some emergency measures, such as a preventive evacuation, can no longer be introduced.

A major flood event, involving all stakeholders, as noted above, is a national crisis in the Netherlands (Helsloot and Scholtens, 2007; BZK, 2008c). In the best case, stakeholders in the dynamic organisation are completely aware of the available information and execute the (centrally) chosen strategy perfectly. However, decision-makers have to deal with imperfect and uncertain information and are confronted by the decisions of others. The key question is: what kind of information do they need during the transition phase? Another fundamental matter concerns the prioritising of sources of information (see Table 1).

The results show that the survey participants (mayors and crisis managers) all tend to prefer a risk-based approach, according most value to the probability, impact, and effectiveness of possible strategies. In addition, all placed great importance on expert advice. Public pressure and the economic and social consequences of decisions were considered to be less important. This means that decision-makers tend towards a rational approach and rely on experts for advice to support decision-making.

In a potential mass evacuation, however, one can conclude that the capacities of the emergency services are far outweighed by the population that needs to be served. Evacuation might reduce loss of life and the cost of lost movable goods, but it cannot decrease the expected damage to fixed goods, such as agricultural land and houses. Hence, authorities and emergency services have to prioritise and deal with limited resources.

Table 1. 'Determine the importance of each item to the decision-making process about mass evacuation on a scale of 1 to 5 (1 = no importance, 2 = less important, 3 = important 4 = very important 5 = most important)'

Parameter	Decision-makers		Crisis managers	
Response rate of decision-makers: 38% Response rate of crisis managers: 59%	Expected value	Standard deviation	Expected value	Standard deviation
Probability of flooding	4.2	0.8	3.9	0.8
Size of the threatened area	3.5	0.8	3.6	0.8
Time available until failure of defence system	4.0	0.7	4.1	0.7
Public pressure	2.9	0.6	2.9	0.7
Effectiveness of a strategy	3.8	0.8	3.8	0.8
Economic impact of an unnecessary evacuation	3.0	0.7	2.9	0.8
Social impact of an unnecessary evacuation	3.3	0.7	2.9	0.8
Accountability for decisions made	3.4	0.8	3.2	0.8
Required leadership	3.5	0.8	4.0	0.8
Expert advice	3.9	0.7	3.8	0.7

Hindsight permits an examination of the best decisions in a flood event or in a situation when a flood did not occur. The aftermath also influences public opinion on the response of decision-makers. Thus the second question in the survey focused on the parameters expected to be most important following an evacuation when a flood did or did not occur (see Table 2).

The results show that a reduction in loss of life is seen as a more important parameter than a decrease in damage. Evacuation happens more frequently than flooding in the Netherlands (HKV Consultants, 2010). In the case of an evacuation that is not followed by a flood event, more attention is paid to accountability of decision-makers and cooperation between authorities than when the flood does happen, although prevention of loss of life remains important (instead of prevention of damage).

Table 2. 'What are the 3 factors that contribute most to whether an evacuation decision was "right" in (1) a situation after a flood and (2) after a false alarm?'

Parameter	Decision-makers				Crisis managers			
Response rate of decision-makers: 23% **Response rate of crisis managers: 48%**	Contribution to top three in case of a flood	Contribution to top three in case of a false alarm (no flood)	Contribution to top one after a flood	Contribution to top one in case of a false alarm (no flood)	Contribution to top three in case of a flood	Contribution to top three in case of a false alarm (no flood)	Contribution to top one after a flood	Contribution to top one in case of a false alarm (no flood)
Prevention of casualties (loss of life)	97%	47%	92%	40%	87%	48%	87%	44%
Prevention of damage	48%	31%	0%	3%	46%	26%	0%	0%
Availability of public shelters and care	63%	22%	1%	0%	48%	17%	0%	3%
Cooperation between authorities and emergency response units	24%	40%	0%	14%	28%	35%	6%	6%
Support of self-reliance	17%	13%	3%	3%	15%	13%	0%	3%
Accountability of authorities	21%	61%	2%	25%	24%	48%	6%	9%
Public perception	12%	47%	1%	6%	22%	41%	0%	16%
Perception of media	5%	31%	0%	6%	13%	52%	0%	16%
Impact of consequences of flooding outside the flood zone	12%	6%	0%	1%	17%	15%	0%	0%

Key factors in the decision-making process that affect strategy choices

By definition, top strategic decision-making for mass evacuation in the case of a threat of flooding is a low-frequency event for citizens and decision-makers. Most (developed) deltas in the world already have a combination of prevention and emergency management (based on available emergency management for other threats) that influences flood risk. Hence, a basic level of protection is already available.

Decision-makers also have to decide which information to use, and they have to assign a value to information (Boin et al., 2005). Decision-makers (in multiple teams) and crisis managers can provide simultaneously multiple frames of reference about a certain phenomenon. This is called 'ambiguity'. Some literature describes it as uncertainty (Dewulf et al., 2005, Brugnach et al., 2008), whereas other works state that ambiguity is not a part of uncertainty but is 'removed on the level of words by linguistic conventions' (Bedford and Cooke, 2001, p. 19). The risk of linguistic problems increases when risk perception or awareness is limited. Given the continuing struggle to raise awareness of flood risk management among decision-makers (ten Brinke et al., 2008b), and the low perception of risk among the general public (Terpstra, 2009), ambiguity might affect evacuation-related decision-making. Above all, these decision-makers are trained daily in a normal situation in how to take decisions on their own, and they focus on measures that are known and that are common to them. These measures, though, might be less effective in reducing loss of life in a flood and a mass evacuation. Because of ambiguity, therefore, it cannot be guaranteed that all decision-makers will execute a strategy as foreseen. In addition, it cannot be guaranteed that all relevant stakeholders will cooperate with the decision-making process. As a result measures can be counterproductive.

Table 3. 'What is the impact of an external issue on the outcome of the decision-making process for mass evacuation?'

Parameter	Decision-makers				Crisis managers			
Response rate of decision-makers: 30% Response rate of crisis managers: 59%	No effect	Delay in decision-making process	Speed up decision-making process	Change of strategy	No effect	Delay in decision-making process	Speed up decision-making process	Change of strategy
Large-scale flu	70%	7%	7%	16%	38%	21%	20%	21%
Pandemic flu	38%	13%	18%	32%	18%	14%	20%	48%
Animal diseases (such as foot-and-mouth disease)	41%	13%	11%	34%	30%	25%	25%	20%
Economic crisis	85%	7%	1%	7%	48%	34%	9%	9%
False alarm in previous year	49%	32%	3%	16%	27%	50%	13%	11%

Table 3 shows the impacts of external issues (such as events in the past or actual circumstances in society) on the chosen evacuation strategy of decision-makers. (Tables 4 and 5, moreover, highlight the influence of different perceptions of risk information by decision-makers and how they influence top strategic decision-making.) Table 3 clearly reveals that actual circumstances have a strong bearing on top strategic decision-making. Most of the circumstances presented in Table 3 cause a delay in decision-making, and so less time is available to execute an evacuation. These circumstances also result in the consideration of alternative strategies. The actual circumstances in a society cannot be gauged in advance in planning documents, meaning that decision-makers have to be able to take them into account in real time. Circumstances that affect human well-being and trust in the government (with regard to false alarms) seem to influence the decision-making process more than economic circumstances.

Table 4. 'In a situation when the forecast models show the first indications of a possible flood 4 days in advance and the time required for a successful preventive evacuation is approximately one day: When (1 = Certainly, 2 = Probably, 3 = Probably not, 4 = Not at all) should you decide to (A) start to develop several alternatives for evacuation for later decision-making, (B) advise the public to evacuate and (C) call for a mandatory evacuation?'

Parameter	Start planning process				Advised evacuation				Mandatory evacuation			
Response rate of decision-makers: 23% Response rate of crisis managers: 54%	Decision-makers		Crisis managers		Decision-makers		Crisis managers		Decision-makers		Crisis managers	
	Expected value	Standard deviation	Expected value	Standard deviation	Expected value	Standard deviation	Expected value	Standard deviation	Expected value	Standard deviation	Expected value	Standard deviation
Directly after first signals from forecast models	1.9	0.8	1.9	0.9	3.1	0.9	3.1	0.9	3.6	0.6	3.3	0.9
Later, when experts address the threat as 'serious'	1.7	1.0	1.7	0.8	2.4	0.9	2.1	0.7	2.8	1.0	2.6	0.8
Later, when public opinion addresses the threat as 'serious'	2.5	1.1	2.2	1.0	2.7	0.9	2.4	0.7	3.1	0.7	2.9	0.9
Later, when the risk increases to a low probability (10%)	2.4	1.2	2.4	1.1	2.8	0.8	2.6	0.8	3.1	0.7	3.0	0.8
Later, when the risk increases to an average probability (10%–25%)	2.2	1.1	2.1	1.0	2.3	0.9	2.2	0.9	2.7	0.8	2.5	0.8
Later, when the risk increases to a large probability (25%–50%)	2.0	1.2	1.7	1.1	1.7	0.8	1.7	0.9	1.9	0.9	2.0	0.8
Later, when the flood is almost certain (>50%)	1.9	1.2	2.0	1.3	1.3	0.7	1.6	1.0	1.4	0.8	1.6	1.0

Key factors in the decision-making process that affect strategy

Table 4 contains the survey results for when decision-makers and their crisis managers, given enough time, would start emergency planning for an evacuation and call for a mandatory or advised evacuation. An interesting outcome is that decision-makers tend to initiate emergency planning directly when information about a threat is available. This means that the warnings of experts should be presented to them and not be kept from them. Given the information, the decision-makers can decide to prepare (and how to prepare) for a possible nearby event (top strategic decision-making). Table 4 shows that decision-makers only call for an evacuation when the risk increases because of a rise in the probability of flooding. In addition, it reveals that planning, and therefore crisis management structures, are activated more quickly than evacuation decisions are made. In general, a mandatory evacuation requires a higher probability of flooding than an advised evacuation. 'Probability' influences the decision to call for an evacuation, yet it also depends strongly, or even more so, on

Table 5. 'What probability of flooding is necessary to be able to choose a certain type of evacuation in a situation 1.5 days before the possible flooding with the knowledge that 1 day is required at minimum?'

Parameter	No opinion	1 (Very low probability: 1–5%)	2 (Low probability: 5–10%)	3 (Average probability: 20–30%)	4 (High probability: 30–40%)	5 (Very High probability: 40–50%)	6 (Almost certain: > 50%)	Expected value	Standard deviation
	Response rate of decision-makers: 28%								
A preventive evacuation, instead of a vertical evacuation or shelter in place?	1%	5%	8%	16%	19%	20%	31%	4.4	2.3
A vertical evacuation to a safe haven inside the threatened area, instead of a preventive evacuation or shelter in place?	2%	3%	11%	31%	20%	20%	13%	3.8	1.8
Shelter in place instead of other forms of evacuation	4%	37%	43%	7%	8%	0%	1%	1.9	0.9
	Response rate of crisis managers: 53%								
A preventive evacuation, instead of a vertical evacuation or shelter in place?	11%	7%	5%	25%	13%	13%	27%	4.1	2.6
A vertical evacuation to a safe haven inside the threatened area, instead of a preventive evacuation or shelter in place?	9%	0%	5%	13%	23%	34%	16%	4.5	1.2
Shelter in place instead of other forms of evacuation	14%	9%	14%	18%	13%	16%	16%	3.7	2.7

'expert advice' (and less on public opinion). Consequently, it is recommended that experts, as well as crisis managers, be included in decision-making.

In relation to the transition phase, this gives the decision-maker the opportunity to influence the people who have to evacuate. This can occur in three key ways: he/she can demonstrate involvement by activating planning, by recommending an evacuation when the risk increases, and by calling for a mandatory evacuation.

An extra element of uncertainty in the preparation for flooding and mass evacuation pertains to how decision-makers and crisis managers deal with risks and uncertainties. Table 5 presents the chosen strategy in relation to the probability of the occurrence of a disaster when just enough time is available for a preventive evacuation; other strategies (with a lower economic impact) could be considered as well, though. It illustrates clearly that the outcome and the speed of a decision-making process depends on the actual probability of flooding and the risk perception of those involved. Based on the same risk, decision-makers tend to choose a variety of strategies, such as preventive evacuation, vertical evacuation, or shelter in place. When more stakeholders on different levels are involved (plus decision-makers and crisis managers), this automatically creates a climate for time-consuming discussions or delayed or contradictory decisions. Thus, different timelines for decision-making have to be taken into account, as well as different strategies because of the possible behaviour of the decision-makers and the consequences of decisions.

Expectations of decision-makers to act as decided

Decision-makers and crisis managers were asked about their willingness to cooperate as a citizen with the chosen strategy and how they expected their neighbours to behave. Table 6 shows that approximately 25 per cent of respondents would not react to the evacuation call of the government. Expectations concerning the behaviour of neighbours were more pessimistic. Crisis managers assumed that 48 per cent of the people would not pursue the expected strategy of the government; decision-makers were less pessimistic, expecting 64 per cent of them to respond. The literature also

Table 6. 'How should you respond as a citizen, as a member of a family, to a call for evacuation by the authorities in a situation when the possibility to evacuate preventively exists but you are ordered to respond alternatively?'

Parameter	Decision-makers		Crisis managers	
Response rate of decision-makers: 29% Response rate of crisis managers: 59%	Yes	No	Yes	No
Delay moment of departure for preventive evacuation in favour of other strategies	77%	23%	75%	25%
Shelter in place and prepare yourself in your own house so other, more threatened people can evacuate preventively	76%	24%	79%	21%
How would your neighbour respond? Do you expect him to make the same choices as you and your family?	64%	36%	48%	52%

demonstrates that not all people act as advised by the government (the non-compliance rate). During Hurricane Katrina, for instance, some 20 per cent of the people did not leave the New Orleans area (Wolshon, 2006). Furthermore, the evacuation of the Rivierenland area in 1995 (van Duin et al., 1995; Meurs, 1996) did not lead to the removal of all people. Significant non-compliance rates are also known to exist for hurricanes in the US (between 35 and 64 per cent) (Lindell et al., 2002). Planning has to take into account, therefore, that not all people will comply with the chosen strategy. Realistic planning considers possible scenarios for people who do not comply with an evacuation instruction.

Discussion: how to structure evacuation planning to cope with the possible outcome of decision-making

Time span of the transition phase

During the transition phase the authorities can consider adapting the infrastructure, reallocating means and rescue workers, and informing the public. The created circumstance increase the later effectiveness of emergency measures. The time available for top strategic decision-making and the period of the transition phase cannot be defined in advance because such moments depend on the availability of forecasts and the speed of sense-making by decision-makers and the public and the capacity of the infrastructure. Hence, a delay in deciding to evacuate is also a decision with a potential major impact: emergency measures taken at a later stage could be less effective, not effective, or even counterproductive. Using the same line of argument, Boin et al. (2005) state that a non-decision is equal to a decision. Given the lead time for flooding and the slow onset of the event, the alternative strategy of 'delaying the decision' should be made explicit to decision-makers, and the consequences should be reviewed.

Owing to the different risk perceptions of decision-makers and crisis managers, the uncertainties, and the lack of time, the creation of better circumstances for decision-making is recommended. When the situation is considered directly as a national crisis and crisis management structures are activated to connect initiatives and to identify realistic measures, the performance rate of an evacuation increases.

The involvement of decision-makers and crisis managers

Another factor that might influence top strategic decision-making is the busy agendas of decision-makers and policymakers. This was highlighted before Waterproef in preparatory discussions about when to involve decision-makers. Following the detection and recognition of a low probability but high impact threat, experts have to be able to put the warning on the agenda to create the boundary conditions for the start of top strategic decision-making. Of course, this will clash directly with other issues; debates will arise about the need for the action. The uncertainty of the threat and low risk perception mean that there is a risk of delaying or ignoring the warning.

Accountability and the need for probabilistic preparation

Public leaders are expected to take care of citizens in liberal democracies (in contrast to non-democratic societies) (Boin et al., 2005). Although it is clear to all stakeholders that the capacities of the authorities are limited in the case of a mass event such as a flood (BZK, 2008b), the public expects to be warned and it expects emergency measures to be taken to reduce the possible impact. Emergency management, therefore, has to maximise the use of available means and infrastructure to prevent casualties, damage, and the capability to return to a normal situation (resilience). Emergency management has to be able to adapt the environment to an evacuation mode in time.

During the survey, decision-makers and crisis managers addressed the importance of the parameters of leadership and accountability in a false alarm and the importance of risk reduction in a flood. Leadership and accountability are also key drivers (in addition to probabilities, costs, and benefits) in the sphere of preparation. For the Netherlands, as well as parts of Australia and the US, the focus is on preventive evacuation, based on the assumption of a certain window of opportunity. Emergency planning focuses on one deterministic strategy based on a pre-defined event: using a chosen flood event, and after identifying the moment when measures to evacuate (all preventive) have been taken, and by whom, a timeline can be defined to connect all decisions at the strategic, tactical, and operational level by all stakeholders (including citizen response). This is deterministic planning, often based on best-case scenarios, which have a lead time that is sufficient to implement all measures. Other realistic events, such as a shorter lead time (Barendregt et al., 2005), a larger threatened area (ten Brinke et al., 2010), and disruptions in the decision-making process, are almost not foreseen in emergency preparation, yet they have to be taken into account. Thus, planning does not cover all possible strategies to minimise loss of life and damage.

Public leaders are also responsible, therefore, for realistic planning. The possible consequences of decisions, as well as uncertainties, should be considered. A leader has to initiate probabilistic planning instead of deterministic planning when uncertainties and ambiguity can result in different choices during top strategic decision-making to minimise the risk of loss of life and damage.

Owing to a lack of experience of all possible situations, preparations for mass evacuation should be based on relevant international knowledge and data. This can be combined with expertise in local characteristics to avoid the production of 'fantasy' documents.

Just as training and education are required to develop a culture of emergency management (Alexander et al., 2009), it is also important for the culture that training and education are realistic. When all decision-makers are trained and educated in preventative evacuation in best-case circumstances, other evacuation strategies, such as vertical evacuation, or even no evacuation, are unlikely because they are unknown to the decision-makers and their crisis managers. This is true even when these other strategies might result in less loss of life in a real-world situation.

The decision taken during Waterproef to delay the evacuation of self-reliant individuals while evacuating non-self-reliant individuals and the families of first responders could be seen as unrealistic planning because the effect was not considered. After the evacuation of 1995, it was concluded that a time-phased evacuation strategy of a threatened area (first this group, then the next) does not work in practice because most people will act primarily based on their own assessment (van Duin et al., 1995). The decision taken during Waterproef, combined with the press conference, in reality might be the signal to start a spontaneous evacuation directly. The result could be a preventive evacuation but without the support of mitigating emergency measures. One can question, therefore, whether the level of preparedness of decision-makers and organisations increased because they were not confronted by the consequences of their decision during the exercise.

The role of decision-makers, crisis managers, and experts

The survey shows that the crisis manager has almost the same perception as the decision-maker. Both support the need for experts to explain the threat and possible responses and strongly depend on them for decision-making. Some differences can be identified, though: decision-makers tend to accord more value to risk-based data (probabilities, consequences in terms of casualties and damage) combined with leadership, whereas crisis managers also attach importance to the perceptions of the public and the media. This might introduce extra elements to the decision-making process, increasing the likelihood of establishing meaning and framing and reducing the possibility of risk-based decision-making.

Many crisis teams from different authorities will be involved in a mass evacuation. It is recommended that the decision-making process be simplified to prevent loss of time owing to interference. Experts could advise decision-makers directly, whereas crisis managers could support this process and implement decisions. Their role is less to inform decision-makers and more to make things work.

Conclusions and recommendations

A traditional view of decision-making is that, given a probable but uncertain threat, there is a deterministic way of defining the best decision. This approach is not sufficient for mass evacuation due to potential flooding. Decision-making for mass evacuation cannot be seen as a deterministic process. Different timelines for decision-making have to be taken into account, as do different strategies. Owing to uncertainties, including the decision-making process itself, and ambiguity, a probabilistic approach (and the development of event trees) is required. This results in realistic planning. A probabilistic approach connects the measures of several stakeholders.

It is unrealistic to assume that all involved stakeholders (and local decision-makers in this network) will act in accordance with the strategy chosen by the top strategic decision-maker. In addition, the time needed for the decision-making process cannot

be determined in advance, and it depends on the involved decision-makers. That time is limited and it might exclude some evacuation strategies (as forms of preventive evacuation) or make them less effective, leading to an increase in loss of life or damage.

When ambiguity is considered as a linguistic problem it can be prevented. However, because of low risk perception, the struggle to keep decision-makers involved and the low frequency of event ambiguity have to be taken into account in emergency planning. These variables could influence the effectiveness of strategies or result in different strategies.

This does not mean that all deterministic planning documents are not realistic. Different strategies could be chosen based on the same information, depending on the decision-makers involved. In addition, local circumstances in a society also influence the decision-making process. When uncertainties are considered, one can conclude that a deterministic approach covers all possible events. As shown in the survey, though, the impact of uncertainties, including the role of decision-makers, necessitates a probabilistic approach to evacuation planning when the objective is to minimise loss of life and damage.

The Waterproef case study demonstrates a lack of attention to the consequences of top strategic decisions and the impact of evacuation on effectiveness and relations with other stakeholders. One can question, therefore, whether such exercises increase or decrease preparedness when no feedback is forthcoming about the comparison between the chosen strategy and actual or planned consequences.

Top strategic decision-making focuses on creating optimal conditions for a response by all stakeholders to a future threat. These emergency measures have to be implemented in the 'transition phase', to create boundary conditions for future responses.

To support top strategic decision-making, the situation has to be considered directly as a crisis, even in the case of a low probability threat. The top strategic decision-maker has to initiate crisis management mechanisms and involve other local decision-makers to enhance the possibility of connected planning. This is a top-down approach that differs from more classic ways of initiating crisis management mechanisms (using a bottom-up approach). When clear visual signals of nearby events are unavailable and public awareness is minimal, the decision has to be taken by decision-makers who are informed by experts. A delay in decision-making might be realistic, but it can also result in a less effective response.

The study shows that the most important information variables for top strategic decision-making on evacuation are the probability of flooding, the consequences in terms of loss of life and possible economic damage, and leadership and accountability. Accountability with regard to taking care of citizens when things go wrong is also one of the requirements of realistic evacuation planning in a democratic country. Preparations should aim to maximise available means and infrastructure to reduce the risk of loss of life and damage.

This research illustrates that crisis managers have almost the same perceptions as decision-makers. It is recommended that the decision-making process for a mass evacuation be simplified to prevent loss of time and to address properly risks, costs and

benefits, and uncertainties. It is suggested that experts be added directly to teams of decision-makers, whereas crisis managers should focus on supporting this process and implementing decisions.

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Endnotes

[1] For more background information, see the official evaluation of the exercise (Cappelleveen and Ven, 2009; TMO, 2009c) and the response of the Cabinet on flood preparedness (Ministry of the Interior and Kingdom Relations, 2009).

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