The contribution of disaster management to integrated flood risk management strategies: lessons learned from the Netherlands

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45. The contribution of disaster management to integrated flood risk management strategies: lessons learned from the Netherlands

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EXTENDED ABSTRACT

An integrated flood risk management (IFRM) strategy consist of a comprehensive set of measures to reduce the risk: protective measures (to reduce the probability of a flood), and land use planning and disaster management (to reduce the consequences of a flood. In the Netherlands this is called a 'multiple layer safety approach', other countries refer to 'multiple lines of defence'. In the development of IFRM strategies one of the main challenges is to define the contribution of disaster management to the reduction of risk, especially when experience with floods is rare and flood awareness is limited.

In the Netherlands since January 2017 new legal flood protection standards apply for all primary flood defenses. The tolerable probability of failure of each flood defense is partly based on the individual risk of drowning from a flood, a cost benefit analyses and group risk (Van Alphen 2016). Historic floods, especially of 1995, show that evacuation is a realistic phenomenon, can be enhanced by early warning and emergency preparation. Therefore the effectiveness of preventive evacuation (expressed as 'evacuation fraction') was taken into account in the development of the new flood protection standards. The evacuation fraction describes the expected number of people in a threatened area that can leave the threatened area prior to a dike breach. With large effectiveness (i.e. a large evacuation fraction) the number of inhabitants remaining in the threatened area is reduced, and so does the potential loss of life which is defined using the model of Jonkman (2007). In this paper we discuss Dutch experiences with the estimation of the evacuation fraction and the validation of these results by disaster management authorities for the use in risk analyses.

Estimation of the evacuation fraction

For the Dutch situation the evacuation fraction is defined for areas that are threatened during the same event of possible large scale flooding, which are assumed to be independent (e.g. floods from a coastal storm surge vs floods from high river discharge, see Figure 1). For each situation specific highways are flooded and not available for evacuation (as for example the Afsluitdijk). The independent evacuation areas are described in Table 1.

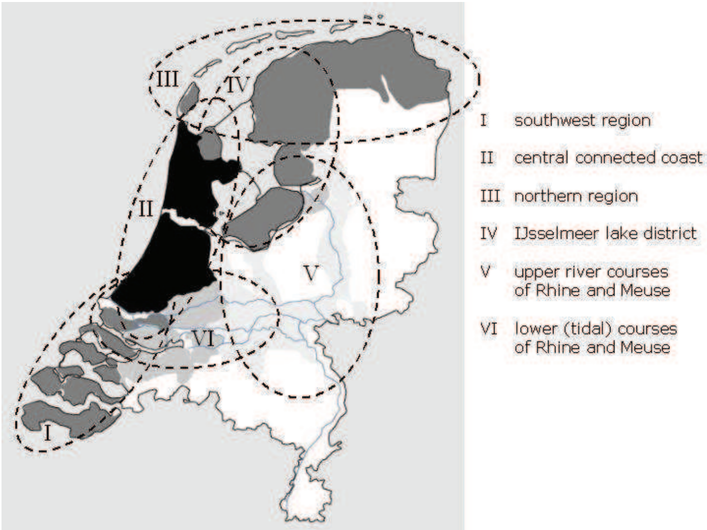

Figure 1: Areas threatened during the same event in case of extreme river discharge or storm surge (ten Brinke et al 2010)

The evacuation fraction is calculated using event trees taking into account the number of people that can evacuate within a range of time intervals available (Kolen 2013). The probability distribution (see Table 1) of the available time (AT) for evacuation is defined at Delphi sessions taking early warning processes and disaster management documents and procedures into account. For storm surges related events it has been taken into account that the 24 hours prior to a dike breach are not available for evacuation because of extreme speed if wind.

Table 1: Probability distribution of available time (AT) for evacuation and evacuation capacity (EC) per area

	4 days		3 days		2 days		1 day		No time	
	EC	AT	EC	AT	EC	AT	EC	AT	EC	AT
Southwest region (I)-Zeeuws Vlaanderen (connected to Belgium)	nvt	nvt	nvt	nvt	75%	50%	0%	40%	0%	10%
Southwest region (I)	nvt	nvt	nvt	nvt	52%	50%	0%	40%	0%	10%
Central connected coast (II)	61%	5%	45%	10%	25%	30%	0%	45%	0%	10%
IJsselmeer lake district (east) (III)	nvt	nvt	nvt	nvt	78%	40%	60%	40%	0%	20%
IJsselmeer lake district (west) (III)	nvt	nvt	nvt	nvt	80%	40%	80%	40%	0%	20%
Northern region (IV)	78%	5%	71%	20%	47%	50%	0%	15%	0%	10%
Upper river course Meuse (V)	nvt	nvt	nvt	nvt	77%	50%	74%	40%	0%	10%

Upper river course Rhine (V)	nvt	nvt	79%	20%	77%	50%	67%	20%	0%	10%
lower tidal courses of river Rhine and Meuse (VI)	nvt	nvt	nvt	nvt	59%	20%	0%	50%	0%	30%

The evacuation capacity EC, the number of people that can evacuate as a function of time (see Table 1 for the EC over time per area) is estimated with traffic models taking several management strategies for evacuation into account:

- Reference: inhabitants are assumed to be free in choice regarding their method of evacuation;
- Nearest exit: evacuees are assumed to evacuate to the nearest exit, regardless of capacity and use of this exit;
- Advanced traffic management: evacuees are optimally divided over the available exit points, taking the capacity of these exit points into account;

Aa more detailed description about these evacuation management strategies is provided by Van Zuilekom et al (2005). The application of these management strategies for the Netherlands is described by Kolen (2012). As a result region specific evacuation scenarios are defined that describe the number of people that can leave the area as a function of time. Based on the possible strategies for evacuation the most pessimistic and optimistic scenario contributes each for 20% and the middle scenario for 60%. We also assume a non-response factor between 10% (river areas) and 20% (coastal areas) of the inhabitants.

Based on the available time and potential evacuation capacity scenario's the area specific evacuation fraction presents the statistical expected value (Figure 2). A bandwidth for uncertainty is due to e.g. limited knowledge about the effectiveness of preparations, human behavior of evacuees, limitations posed by extreme wind conditions).

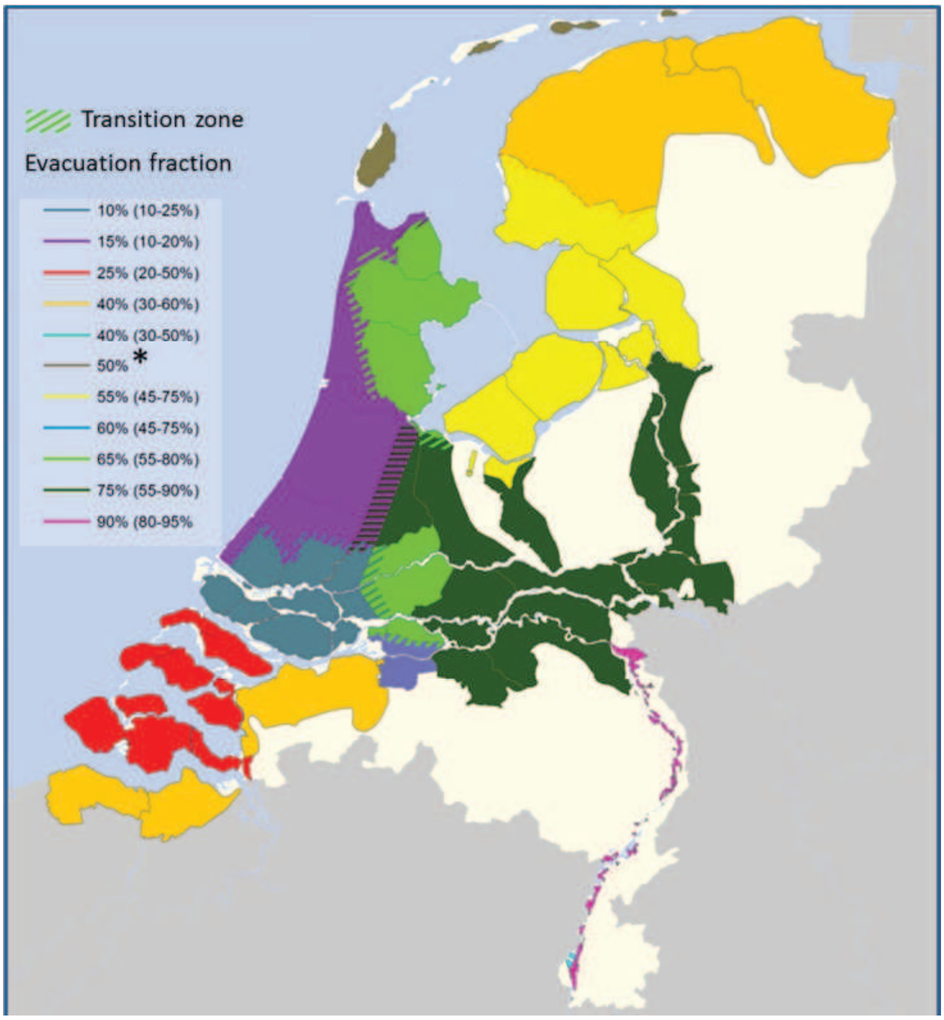

Figure 2: Evacuation fraction

Since disaster management authorities have little knowledge about the effectiveness of their preparation, the pessimistic margin of the evacuation fraction is used for the new flood protection standards. This was approved by the disaster management authorities.

Concluding remarks

The future challenge is improve the quality of the evacuation fraction estimates. The program 'Water and Evacuation' is aimed to increase flood awareness within the disaster management authorities and improve their preparation on evacuation as well as the communication to the public and private sector. Another initiative is to develop a new (international) database to collect empiric information for new flood- and evacuation events to develop a more detailed insight in the effectiveness of measures and improve loss of life and evacuation models (De Bruijn et al 2017). In this way it is expected that in 2020 uncertainties can be reduced and more accurate evacuation fractions can be estimated.

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