

Title: Improvement effectiveness of forecasting by better use of warnings and knowledge of uncertainties

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In case of threat for flooding caused by storm surge or extreme discharges on rivers multiple stakeholders are involved. The main driver behind the recognition of a threat and possible measures is a forecast of extreme water levels that might cause flooding. Information about the threat and consequences will come available for authorities by warnings and by (situation) reports of several crisis centres. In addition each person in this centre as well as the public is also influenced by information spread by media. Recent events show the growing impact of social media. International literature describes that information will only result in adequate and realistic measures if the threat and possible measures are understood (called sense making). In case of a threat for flooding the amount of involved stakeholders increases the complexity as well as the need to deal with uncertainties (about the possible flood, the consequences of measures). Multiple interpretations can be made by crisis managers, by decision makers and by the public resulting in different perceptions and decisions.

This article (including poster) discusses possible improvements in the use of forecasts related to the decision making processes. Therefore we focus on the role of alerts or early warning and information systems that can be used as support. Also we focus on the consequences when knowledge of uncertainty is made explicit in warnings in stead of implicit. We conclude that warnings should contain all possible events including a probability to create a dilemma for decision makers (as probability for different classes of water levels, probability of flooding or no flooding). Also we conclude that, after recognition of a possible threat, information about forecasts should be spread directly and automatically to public and all professionals as an alert. A warning (or no warning) is an extra element of information that can be added to the forecast in necessary. Finally we present a integration system developed by the program Flood Control 2015: Dashboard Water Safety. This is an umbrella system collecting information from several sources as forecasts, warning and alert but also a common picture of traffic and public perception for the actual situation and possible scenarios. The dashboard creates for professionals and public a better understanding of the actual situation and possible consequences. The decision making process can improve (quality and less time) because of the better common picture. These conclusions are further elaborated below.

Uncertainty as a dilemma for decision makers

In case of a threat for flooding uncertainty is often taken into account but implicit. For example the extreme water levels on the River Rhine in 1995 caused a threat for flooding. Finally the water boards informed decision makers that they 'could not stand for the strength of the dikes anymore'. Decision makers decided for mass evacuation using this statement of the water boards as an argument. With hindsight the dikes did not breach and discussion rose about the consequences of the evacuation and the impact of a false alarm [1]. The lack of capacity of dealing with uncertainties is also known from other Dutch national crisis exercises. Crisis centres are less capable to define information with a strategic advise (including options and consequences) for decision makers. Decision makers therefore tend to give their own interpretation to the situation that results in less optimal decisions [3].

International literature describes the consequences of false alarms: possible delay of decision making processes [2]. On the other hand a better understanding of heuristics and biases improves the decision making process in case of uncertainty [4]. In reality water boards can declare 100% safety for the strength of their dikes. On the other hand in case of extreme forecasted water levels failure of the dike is not 100% guaranteed (as was seen in 1995). For the example of 1995 it can be questioned what decisions if uncertainty was made explicit.

The presentation of information is related to the quality of decision making. When uncertainty is made explicit in warning or alert by presenting the probability for several classes of possible events. This will result in better information for decision makers (but also more difficult). An example is to present probability for classes of 1) certain flooding, 2) certainly no flooding and

4) a possible flooding. Decision makers will have to make a risk analyses about possible measures. Decision makers and crisis managers can add advices for measures to warnings.

Information is everywhere available: In case of a possible threat forecasts should be spread directly and automatically

In case of a threat each organization and person tries to gather and understand information. Measures are taken on their perception of the threat and consequences. This process is described in literature as sense making [5]. With the impact of social media and internet information is spread over the society very quickly. Information, also (very uncertain) forecasts are continuously available by public and crisis centres. Official and unofficial interpretations will be spread quickly. Information management changes from a pushing model to a pulling model that results in self synchronization of persons and crisis centres [6].

Knowing the process of sense making and accepting the impact of social media signals of a potential flood should be made available directly to public and crisis managers. A pro active role of authorities and a clear line of communication is expected to make the message more reliable [7]. This forecast should be combined by an interpretation of the forecast and consequences to support sense making. The first signals could be described as an early alert. In a later stadium, after risk analyses, warnings can be added. Authorities and public can use this alert to gather more information and prepare themselves, this could result in more available time for pre cautious measures and more effectiveness of measures.

An international comparisons shows lessons learned after Katrina in New Orleans. Improvements were made in the alarming scheme. The national level should be involved more early so national resources can be of a better use. This resulted in a better evacuation process during Gustav.

Use of different, connected, information systems for forecasting, warnings and a common picture

The program Flood Control 2015 is developing a Dashboard Water Safety. This dashboard gives a common picture about the actual situation of the threat, the society and possible consequences for the society. This picture can be designed for each role and for the public during implementation. Two important sources of input for the dashboard are information from hydrologists (forecasts) and crisis managers (warning or alert). Different systems with equal functions are available worldwide that can be used, in the program flood control is focused in FEWS en FLIWAS. These systems are below the umbrella of the 'Dashboard Water Safety'. By linking the processes of forecasting and warning as well as other processes (and their systems) the entire chain from measurement up to mitigation can be accessed by all users. This increases transparency and aids training roles in water- and disaster management. The decision making process will improve (in quality but also take less time) because of a more common perception of the threat and consequences and the accessibility of information.

The Delft-FEWS-system (**Flood Early Warning System**) is a modern data handling system that is specially developed for flood forecasting and time series management by hydrologists. The Delft-FEWS system is being used worldwide to perform flood forecasting and time series management. The British Environment Agency implemented the system in England and Wales, Scotland Environment Protection Agency (SEPA) uses it in Scotland. A nationwide roll-out is currently executed in the United States by Deltares and the US National Weather service. The Mekong River Commission uses it for their forecasts.

While managing a (provisional) flood situation, the availability of information is a key factor. FLIWAS, **Flood Information and Warning System**, supports the spreading of information and provides authorities, water managers and other involved parties with information. FLIWAS reads (predicted) water levels and visualizes them (in time-diagrams, long- and cross profiles). When water levels exceed these reference levels, the user is automatically warned and further informed as to which actions to perform (such actions having been incorporated into the FLIWAS-based calamity plan). Furthermore, FLIWAS also monitors the progress of the execution of needed measures and informs all relevant staff members of the occurring situation using fax, e-mail or sms.

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