The HuT

Building a safe haven
to cope with climate extremes

FACT SHEET #1

Designing early warning services

An effective warning system is a highly cost-effective way of reducing the risk from natural hazards. An effective warning system requires attention to the needs of the users and the capabilities of the producers. Users need information about the hazard, its expected impact and the actions they should take. Assembling this information and communicating it to the user may require contributions from experts in several organizations.

Key points

A warning system only has value if it leads to risk-reducing action.

In designing a warning system we must start by asking:

- Who is exposed and vulnerable?
- What protective actions can be taken?

Then we need to identify:

- What information do they need?
- How can it reach them?
- Who can produce it and how?

What is a warning system?

A warning system exists within a risk response environment, which may be represented by the warning cycle (Figure 1) adopted by the World Meteorological Organization for the Early Warnings for All initiative. Here we focus on production and communication of warnings, in the "Warning System" and "Early Action" parts of the cycle, and which operate in fast time when a hazardous event is forecast.

In designing a warning system, it is essential to consider the requirements and constraints of both users (those making decisions based on the information) and producers (those producing, analyzing and communicating the information). Perfect information is of no value if not acted on, but erroneous information that is acted on may have even worse consequences.

Process for designing a warning system?

Here we provide an example of designing an early warning system for a particularly challenging hazard-impact relationship in the UK. In reviewing the knowledge and preparedness parts of the warning cycle, a gap was identified in the provision of warnings of life-threatening hazards from intense thunderstorms. This gap exists in many countries, so the analysis described here may have broader applicability.

Current warnings of thunderstorms, in the UK, provide an early indication of the area and period of risk, enabling a degree of planning for travel and outdoor activities. However, they are not sufficiently precise to enable people to be protected from the threat to life due to rapid onset flooding from a specific thunderstorm.

To design an effective warning system, the following questions need to be addressed:

- Who is exposed and vulnerable?
- What action can they take to protect themselves and others?
- What information do they need to take this action?
- How can that information reach them?
- Who can produce that information and how?

At each step, there will be obstacles, so compromises must be reached that still provide value in reducing risk.

For rapid onset flooding, the warning production chain may consist of weather monitoring and forecasts; hydrological flood and inundation forecasts; exposure, vulnerability and impact assessment; warning construction and delivery, and warning response; each step receiving and adding value to information from the previous step.

Figure 1: Warning cycle as adopted by the WMO for the Early Warnings for All challenge.

UK example: warnings of intense rainfall from thunderstorms

Intense thunderstorms produce surface water flooding, flash flooding from minor watercourses and dangerous driving conditions on roads, which can lead to death and injury. Existing warnings enable some people to plan ahead to minimize their exposure, but the level of confidence is often insufficient at any specific location and time to justify high-cost responses. Escalation of the warning is needed to enable those most at risk to take protective action.

Not everyone is equally at risk from the effects of intense thunderstorms. People living, working, shopping, or travelling below ground (mainly in cities) and people undertaking outdoor activities near minor watercourses (mainly rural) as well as road users are the most vulnerable (Figure 2). These individuals need to know if intense rainfall and flooding, which could pose a threat to life, is imminent at their location. Having this information would enable these individuals to take protective actions such as moving away from or avoiding flood prone areas. Emergency managers or local flood wardens could also monitor and close-off these areas.

It is essential that information about how to stay safe reaches those at risk, wherever they might be (e.g. while travelling, underground or in a crowded place) at the right time for them to take protective action. The advice might need to be different for different groups of people.

In the UK, only the Emergency Alert System (EAS) can push warnings out to those at risk without pre-registration. EAS warnings are broadcast to all active smartphones within the range (typically a few kilometres) of specified transmitters. The message will be received by some people who are not at risk but not by those who have no phone or are unable to receive the signal. Use of this system should complement other warnings that enable people to be prepared and that reach people without smartphone access.

In the UK, the primary hazard associated with intense thunderstorms is rain accumulation – a meteorological problem. Depending on location and previous rain, some will soak into the ground. The rest will flow into drains and ditches or collect in low lying areas – a hydrological problem. Places where large volumes of water flow or collect may pose a threat or be an inconvenience – a public safety problem.

Figure 2: Heavy rain in London in 2021 led to flooding of basement flats up to the tops of the windows.

Thunderstorms are small and short-lived so a confident prediction of extreme convective rainfall is only possible for periods up to about an hour ahead. For this purpose, radar is the primary monitoring tool and the main forecasting method is storm cell tracking and extrapolation, supplemented by a range of information on weather conditions that might lead to intensification or decay.

The scale of land surface features that influences flooding can be as small as a few centimeters in the vertical. Such small variations are prone to rapid change. Fast modelling of these scales is not feasible, but the dominant water flow pathways and flood areas can be pre-computed using fixed topographic maps. The threat posed by the flood will depend on the exposure of the area affected, including property value and any infrastructure present. Identifying vulnerability requires knowledge of occupation, of the ease with which water can enter below ground spaces, including via the drains, and of the capacity of people to escape. Such information is difficult to access and is not currently available in real-time.

The concept being developed for the UK is shown in Figure 3. It focuses on exceedance, in the next hour, of 1:100-year return period rainfall accumulations over one, two and three hours, to a spatial precision of a few kilometres. The assessment will be made by an operational meteorologist in collaboration with a hydro-meteorologist, using radar-based cell-tracking overlaid on socio-economic mapping and incorporating their knowledge of the main variations in exposure and vulnerability through the day and week and from major public events. The warning message will be action-oriented and research is in progress with a wide range of stakeholders to identify risk-reducing actions. Given time pressure and since the primary uncertainty is in the rainfall, the warning will be initiated by the weather agency. However additional information may be required from flood and public safety agencies and it may be they who ultimately issue the warning.

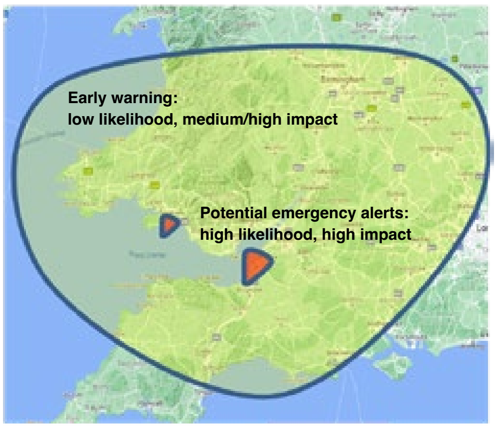

Figure 3: Comparison of area covered by existing warning (yellow) and proposed emergency alerts (red).

What is happening in The HuT

In The HuT many of the demonstrator projects are developing or improving warning systems with multiple users. A key part of these projects is making the connection between the needs of those who will receive and act on the warnings and the capabilities of those who will produce the warnings. This is especially important for those projects focused on multi-hazard warnings. Within The HuT, there is activity to improve aspects of anticipating hazards, for instance through improved nowcasting, and in assessing the impacts of hazards, for instance through incorporating time-varying exposure and vulnerability information.

References and Further Reading

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