Warning of Catastrophe: the Way Forward

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More than anything else, the catastrophic earthquake and tsunami of December 26th 2004 taught us that an effective early warning system is a critical element in any package of measures designed to limit the impact of natural hazards and reduce the risk of disasters. At the very least, the existence of an effective tsunami warning system in the Indian Ocean would have provided coastal communities in Thailand, southern India and Sri Lanka with around two hours warning, slashing the estimated 300,000 death toll by at least a third. Combined with a programme of education focusing on tsunami risk, many thousands of lives could also have been saved in Indonesia, even though inhabitants of the worst affected parts of Sumatra would have had little more than 30 minutes to reach safety.

But what exactly is an early warning system (EWS)? Various definitions exist and the term means different things to different people. To seismologists, an EWS is a radio-based technology that provides several to a few tens of seconds warning, *after* an earthquake has happened, that seismic waves are on their way. This short, but vital, respite can permit – for example – the automatic shutting off of gas supplies, the switching on of hospital generators, and the opening of fire and ambulance station doors.

To most people in the hazard and risk science business, however, the term early warning relates to a longer-term forecast or prediction that provides information about a hazard *before* it happens. Even this definition, however, fosters debate and disagreement. Does early warning relate to the identification of the potential for a particular hazard at a specific location, but without accompanying knowledge about when the hazard will be realised, or is it more specific? For example, a probabilistic prediction about a volcanic eruption two days ahead based upon monitoring data. In fact, both can be considered to be early warnings and both have a part to play in reducing the likelihood of a hazard translating itself into a disaster.

In relation to geological hazards, such as earthquakes, volcanic eruptions, tsunamis and landslides, the ideal EWS would comprise a number of different elements designed to provide information and warnings about future hazards at a range of time-scales.

Threat identification: The first element involves identifying potential threats capable of impinging upon the country or region in question. Such an exercise would pinpoint, for example, "seismic gaps", where major earthquakes are known to be due (northern Sumatra constituted such a gap prior to December 26th 2004), and explosive volcanoes where geological surveys or the historical record have revealed the potential for another eruption soon. This largely qualitative or, at best, semi-quantitative analysis, however, would not provide any clear guidance on the likely timing of the next earthquake or volcanic eruption.

Probabilistic forecasting: The second element of the ideal EWS would zero in on those threats regarded as most serious. A combination of more detailed surveys of past activity and contemporary monitoring would be used to develop probabilistic forecasts of the timing and scale of the hazard under study. Current examples of such forecasts include a 62 per cent probability of an earthquake of magnitude 6.7 or greater striking the San Francisco Bay region by 2032, and a 32 per cent chance of a large earthquake affecting Istanbul in the next decade. Figures like this can work wonders in terms of focusing attention on disaster preparedness and the whole area of disaster risk reduction. The particularly worrying forecast for Istanbul, for example, has prompted a major initiative to ensure that critical facilities such as schools, hospitals and emergency response centres are able to withstand the expected levels of ground shaking.

Monitoring: The third element of an ideal geological hazard EWS would be an effective monitoring system designed to provide a short-term warning of the hazard in question. No earthquake has ever been successfully predicted, but recognised precursors, such as the occurrence of foreshocks, changes in water levels in wells, or increased emissions of radon gas may provide foreknowledge of an imminent event. Monitoring ground surface deformation, which often accompanies the strain increase that precedes a large earthquake, can be accurately and precisely measured using the global positioning system. Determining whether or not a submarine earthquake will trigger a tsunami is not an exact science, but once formed tsunami travelling in deep water can be detected using a system of ocean floor sensors such as those that have operated in the Pacific Ocean since 1964. No volcano erupts without precursory signs, notably swarms of small earthquakes and swelling of the surface as magma makes its way upwards. Consequently, the timing of the start of an eruption can be predicted a few days ahead, allowing time for evacuation and other preparatory measures. The science is still not sufficiently advanced, however, to predict the size or duration of an eruption or the timing of the climactic phase, when most destruction occurs. The monitoring of unstable terrain can be undertaken using the global positioning system, which is capable of detecting accelerations in movement that often precede the formation of a landslide, again allowing time for evacuation and some remedial measures.

The tripartite framework described above constitutes the scientific component of an EWS. While essential, the science component on its own, however, is unlikely to save lives. The ideal geological EWS must incorporate a second hazard management component that is concerned with effective warning dissemination, appropriate public education, and risk reduction. It is now planned to have a tsunami warning system up and running in the Indian Ocean by sometime in 2006, comprising a network of ocean bed sensors capable of detecting tsunamis formed by submarine earthquakes. As in the Pacific, these will be connected by cable to floating buoys that will send warnings via satellite to emergency authorities in the countries at risk. In terms of limiting loss of life, however, such a warning will be worthless unless procedures are already in place to ensure its dissemination rapidly, widely and unambiguously to threatened coastal communities, who have been educated sufficiently about tsunamis to know how to respond. Similarly, without risk reduction measures such as encouraging the growth of protective mangroves and coastal forests, ensuring that properties are set back from the seafront, and designing and constructing buildings better to withstand the impact of tsunamis, the level of damage and destruction will remain very high.

Only when the scientific and hazard management components are in place, and interlocking seamlessly, is any geological EWS likely to achieve maximum effectiveness. This is a goal towards which we can work, but it is one that is likely to take a considerable time to accomplish in many parts of the world. Development of such a system, in many countries, is likely to be hindered by a plethora of factors, including a lack of political will, focus on other priorities, insufficient funding, inadequate technical or scientific skills, and poorly developed institutional responsibilities and capabilities in the hazard management field. In many cases, putting together an integrated EWS along the lines outlined is likely to be dependent, to a large degree, on help and support from international agencies such as the UN and the European Commission Humanitarian Office (ECHO), appropriate departments of developed world national governments, such as DfID, and aid organisations such as the IFRC (International Federation of Red Cross and Red Crescent Societies). The problem is that many of these bodies focus on reacting to natural disasters rather than preparing for them. ECHO, for example, spends around 50 times more responding to humanitarian crises than it does anticipating them.

In a progressively more crowded world in which ever larger numbers of vulnerable people are increasingly exposed to geological hazards, the establishment of effective early warning systems must be embraced if we are not to experience a repeat of the Indian Ocean tsunami tragedy – or worse. The development of such systems should not, however, be undertaken in isolation, but should form part of a compendium of measures designed to foster a pro-active approach in which preparedness to prevent disaster takes precedence over response and recovery.

The pivotal role for effective natural hazard early warning systems in minimising the impacts of natural hazards was emphasised in the recent report of the UK Government's Natural Hazard Working Group* established by the PM in the aftermath of the tsunami. The key recommendation of the report, which recently received the support of the G8 meeting at Gleneagles, was the establishment of an International Science Panel for Natural Hazard Assessment to address the threat of potential natural hazards likely to have high global or regional impact. This would provide the critical first element of a global EWS by identifying geophysical threats capable of affecting more than one state, highlighting those of greatest concern and validating forecasts and predictions about their timing. The Panel, if it comes to fruition, will also play a role in fostering a pro-active approach to tackling natural hazards, which – it is to be hoped – will help to bring about a sea-change in disaster risk reduction.

*The role of science in physical natural hazard assessment. Report to the UK Government by the Natural Hazard Working Group. June 2005. DTI. 42pp. Online at: http://www.ost.gov.uk/policy/bodies/nhwg/index.htm