Progress made with early warning systems in Australia since 2005

Neil Dufty summarises the findings of detailed research in early warning systems and outlines possible improvements.

ABOUT THE AUTHOR

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Early warning systems defined

Early warning can be defined as:

'the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.' (ISDR 2006, p. 2)

Early warning systems detect impending disaster, give that information to people at risk, and enable those in danger to make decisions and take action (Mileti 1999). The objective of people-centred early warning systems is to empower individuals and communities threatened by hazards to act in sufficient time and in appropriate manners so as to reduce the possibility of personal injury, loss of life, damage to property and the environment, and loss of livelihoods (ISDR 2006).

According to the Second International Conference on Early Warnings (UNISDR 2003), there are four parts of an effective early warning system:

1. Risk knowledge—knowledge of the relevant hazards and of the vulnerabilities of people and societies to these hazards.
2. Monitoring and warning service—the technical capacity to monitor hazard precursors, to forecast the hazard evolution, and to issue warnings.
3. Dissemination and communication—the dissemination of understandable warnings, and prior preparedness information, to those at risk.
4. Response capability—knowledge, plans and capacities for timely and appropriate action by authorities and those at risk.

A weakness or failure in any one part could result in failure of the whole system (ISDR 2006, p. 2).

Hazards in Australia

Australia is prone to a range of natural hazards including bushfires, floods, droughts, severe storms, tropical cyclones, heatwaves, earthquakes and landslides. As shown in Table 1, there are also several non-natural hazards that Australia is exposed to.

While some natural hazards have the potential to occur anywhere in Australia (e.g. severe storm), many occur only in reasonably well-defined regions (e.g. tropical cyclone) and are confined by topography (e.g. storm surge). Similarly, some natural hazards have the potential to occur at any time of year (e.g. tsunami) while others are often seasonal (e.g. thunderstorm) (Middelmann ed. 2007).

In recent years, there have been several significant disasters in Australia including the 2009 Black Saturday bushfires in Victoria and the 2011 floods in Queensland and Victoria. There is evidence to show that the number and intensity of weather-related disasters will increase in the future due to anthropogenic climate change (Steffen, Hughes & Perkins 2014, CSIRO & Australian Bureau of Meteorology 2014).

Early warning systems in Australia

Some hazards may occur suddenly (e.g. earthquake) while others may be identified in advance and a warning provided (e.g. flood, bushfire, cyclones). Early warning systems have therefore been developed in Australia particularly for those hazards where there is an opportunity for warnings to have (or may have) the greatest impacts. Under Australia's constitutional arrangements, State and Territory emergency management legislation identifies control agencies and guides early warning practices. The control agencies are responsible for delivering warnings to the public.

The Australian Government provides national leadership around emergency warning activity, contributing to a whole-of-nation, resilience-based approach to preventing, preparing for, responding to, and recovering from disasters (Attorney-General's

Table 1: Main Australian hazards.

Natural	Technological	Human-caused
Resulting from acts of nature	Involves accidents of failures and structures	Caused by intentional actions of an adversary
• Bushfire • Cyclone • Drought • Earthquake • Epidemic • Flood • Heatwave • Storm • Tsunami	• Aeroplane crash • Dam/levee failure • Hazardous materials release • Power failure • Radiological release • Train derailment • Urban conflagration	• Civil disturbance • Cyber incidents • Sabotage • School violence • Terrorist acts

Department 2013). This includes assisting States and Territories to enhance their warning capabilities (e.g. the national telephone-based emergency warning system, Emergency Alert) and developing resource material, such as *Emergency Warnings: Choosing your Words* (Attorney-General's Department 2008a).

Under the authority of the *Meteorology Act 1955*, the Bureau of Meteorology (BOM) disseminates warnings, watches and advises on weather events such as severe thunderstorms, fire weather, coastal hazards, high winds, flood and tropical cyclone warnings and, in collaboration with Geoscience Australia, tsunami warnings. A significant number of warnings issued for natural hazards in Australia are issued by the BOM.

Communities and individuals also have responsibilities including preparing themselves for emergencies that might affect them and taking appropriate action in response to emergency warnings. According to the Australian Government:

> *'A key element in building the disaster resilience of Australian communities is that individuals, households and businesses should be prepared and have action plans for emergencies that might affect them. Preparation and planning at the individual, household and community levels supports informed decision making.'*
> (Attorney-General's Department 2013, pp. 5–6)

Broadcast media plays an important role in emergencies, both in disseminating and collecting information about an incident. Codes of practice ensure that broadcasters have well-established procedures in place to enable, in consultation with emergency services organisations, the timely and tailored broadcast of warnings and information to the public during an emergency.

In October 2008, the then Ministerial Council for Police and Emergency Management – Emergency Management (MCPEM–EM) endorsed 12 National

Emergency Warning Principles[1]. The principles (Attorney-General's Department 2008b) provide a framework that guides public warning activities. A number of States and Territories have developed their own protocols that reference these principles.

International Hyogo Framework for Action

The ten-year *Hyogo Framework for Action* (HFA) came out of the World Conference held in Kobe, Hyogo, Japan in January 2005. The HFA is the first plan to explain, describe and detail the work that is required from all sectors and actors to reduce disaster losses. It was developed and agreed to by the many partners needed to reduce disaster risk — governments, international agencies, disaster experts and many others — bringing them to a common system of co-ordination.

In 2015 the HFA will be updated. The United Nations Office for Disaster Risk Reduction (UNISDR) issued a call for input papers as part of the development of its 2015 Global Assessment Report (GAR15). The GAR15 will be published prior to the World Conference on Disaster Risk Reduction in 2015, in which governments will adopt a successor framework to the HFA.

This paper is a summary of a more detailed input paper that addresses Research Area 4, Priority for Action 2 — Core Indicator 3 from the HFA:

> *Early warning systems are in place for all major hazards, with outreach to communities.*

It attempts to broadly evaluate the progress made with early warning systems used in Australia since the commencement of the HFA in 2005.

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1 National Emergency Management Principles at www.em.gov.au/Emergency-Warnings/Pages/Emergencywarningsguidelinesandprinciples.aspx.

Evaluation methodology

The National Emergency Warning Principles were used as a general evaluation framework to examine the progress made with early warning systems in Australia since 2005. However, international literature provided some additional measures and issues that were considered in the evaluation. For example, Parker and Neal (1990) identified approaches that should be considered in post-flood evaluation of flood forecasting and warning systems. This evaluation focussed on the main hazards for which early warning systems have been developed in Australia i.e. floods, bushfires, tropical cyclones and tsunamis.

The data for the qualitative evaluation was collected from a variety of sources including:

- consultations with emergency services agencies from Australian States and Territories. About half of these agencies responded to the request for data for this evaluation. They provided agency strategies, relevant reports, articles and papers

- post-disaster evaluations, including reports from royal commissions, government inquiries and after-action reviews, and

- between-event evaluations, conducted to gauge progress in particular improvements e.g. recommendations from a previous disaster inquiry.

Progress

The emergency management agencies consulted for this review all believed there had been considerable progress in early warning systems in Australia since 2005. Much of this progress had been triggered and guided by post-disaster reviews and inquiries such as the 2009 Victorian Bushfires Royal Commission, the Queensland Floods Commission of Inquiry and the Victorian Floods Review.

The progress identified included:

1. Forecasting and prediction. The BOM has upgraded its forecasts and warnings services. For example, in Queensland the number of locations across the State that obtain weather forecasts for seven days significantly increased after October 2013. The forecasts were presented as a combination of text and graphics. During 2014, services expanded further to include map-based graphical forecasts and the capability to generate a forecast for any location, including the coastal waters zones. The recently-launched MetEye™ provides access to maps of temperature, rainfall, winds and weather that are designed to make weather-based decision-making easier. In addition, rainfall information, including forecast probabilities of rain and average rainfall amounts, are issued for major centres across Queensland.

   The Bureau also provides predictions of the expected height of a river at a town or other important locations along a river, and the time this height is expected to be reached. This type of warning is normally the most useful in that it allows local emergency authorities and people in the flood-threatened area to determine the area and likely depth of the flooding. This type of warning can only be provided where there are specialised flood warning systems and where flood forecasting models have been developed. Progress has been made since 2005 in increasing the coverage of these warning systems and flood-forecasting models across Australia.

2. Intelligence. Emergency management agencies identified improvements in risk assessment and related GIS mapping as evidence of progress since 2005. With better understanding of the hazard risks and resultant emergency planning, agencies can provide more effective response and recovery.

3. Interoperability. There has been considerable improvement in emergency management agencies working together to prepare and disseminate warning messages. Provision of warnings is an important function of the Australasian Inter-Service Incident Management System (AIIMS). The widespread use of the system provides a structure for cross-agency co-operation during incident control.

   Progress with interoperability is also demonstrated by the integration of online warning and messaging into cross-agency alert websites. For example, Vic Emergency (http://emergency.vic.gov.au/map#now) is a single cross-hazard, cross-agency portal to communicate warnings across Victoria.

4. Public information officers. In those States and Territories that responded to the research, the role of the Public Information Officer in the Incident Control Centre (ICC) has been elevated to being directly responsible to the Incident Controller in the ICC. The public information officer and other public information staff have the role of preparing and disseminating warning messages during an emergency. According to the emergency agencies, direct involvement with the Incident Controller appears to provide more efficient and effective dissemination of warnings to the public.

5. Range of warning mechanisms. All levels of Australian government support a multi-modal approach to issuing emergency warnings. A multi-modal approach maximises the likelihood that as many people as possible will receive and comprehend a warning. These warning mechanisms range from traditional methods such as television and radio broadcasts, community meetings and sirens, to more modern methods, such as mobile telephone SMS messages and social networking posts (e.g. Facebook and Twitter). This makes it more likely that people will be in a position to take appropriate action to protect against loss of life, or injury, and to mitigate against damage to property (Attorney-General's Department 2013).

Of particular note is the Emergency Alert and use of social media platforms. Emergency Alert is the national telephone warning system used by emergency services to send voice messages to telephone landlines and text messages to mobile phones within a defined area related to possible or actual emergencies. It was established by the Australian Government in response to the Black Saturday bushfires of 2009.

The first widespread use of social media in an Australian disaster was by the Queensland Police Service in the Queensland floods in 2011. It provided an additional effective warning mechanism in this event (Bruns *et al.* 2012) and in subsequent emergencies across Australia.

6. The Standard Emergency Warning Signal (SEWS). In September 2004 the then Australian Emergency Management Committee (AEMC) supported a recommendation from the BOM that a set of clear, prescriptive and nationally-consistent guidelines for the use and application of SEWS should be developed. These guidelines provide direction and support to the State and Territory emergency management authorities. The States and Territories implement these guidelines as appropriate to their jurisdiction.

7. Principles and protocols. National documents such as the *National Emergency Warning Principles* (Attorney-General's Department 2008b) and the *Manual 21 Flood Warning* (Attorney-General's Department 2009) provide guidelines for early warning systems. Furthermore, several States have produced cross-hazard, cross-agency guidance documents such as the *Victorian Warning Protocol* (Victorian Government 2013). The protocol commenced in 2009 and provides emergency response agencies with co-ordinated and consistent direction on advice and/or warnings that inform Victorian communities of a potential or actual emergency event.

Future improvements

According to the responses from the Australian emergency agencies and major disaster reviews and inquiries, there are some aspects of early warning systems that can still be improved. These include:

1. Low levels of community preparedness. For tropical cyclones that occur reasonably regularly there appears to be relatively high levels of preparedness (King & Goudie 2006). For less frequent events such as flooding it appears that less than 20 per cent of people and businesses impacted have some kind of emergency plan that includes warnings (Molino Stewart 2009). More effective community education is recommended (Dufty 2008) to improve preparedness levels and adherence to early warnings.

2. Flash floods. Flash flooding in Australia is defined as flooding that occurs within six hours of the start of rain that causes it (Bureau of Meteorology 1996). The Victorian Floods Review (Victorian Government 2011) clarified the role of the BOM in providing flash flood warning services and the roles of government in the purchase, installation and maintenance of flash flood warning systems. The Review identified five core issues underpinning flash flood warning systems in Victoria:

   - The lack of definitive policy and direction on roles and responsibilities – the role of the BOM and other stakeholders in the delivery of forecasts and warnings of conditions likely to lead to flash flood events is not as clear as it needs to be.

   - Local government ability, in terms of financial and technical capacity, to establish, maintain and operate an effective flash flood warning system with regard to both technical and social aspects; unless there is active participation from local government, the framework breaks down.

   - The value of weather radar and timely local access to raw information on the likelihood of rainfall leading to flash flooding.

   - Awareness within the at-risk community that flash flooding is a credible risk and the circumstances that may give rise to an event.

   - Dissemination of meaningful and timely pre-scripted warning messages (that impart essential information in a way that is understandable and elicits appropriate responses) to those at risk from flash flooding.

3. Understanding response behaviours. There still appears to be public confusion and reticence, particularly about bushfire warnings and appropriate responses, even though the warning messaging is much clearer (in terms of evacuating early), and more relevant and tailored since the 2009 Black Saturday fires. Social research into community responses to bushfires in Western Australia in 2011 (Heath *et al.* 2011) found that:

   'Approximately one-half of all residents indicated that they either had no plan or that they wanted to wait and see how bad a fire was before taking any action. This result is quite concerning as the investigation into the Victorian bushfires of 2009 revealed that many bushfire related deaths occur after last-minute changes in plan.'
   (Heath *et al.* 2011, p. 2)

   Social research into the bushfires in NSW in January 2013 (Mackie, McLennan & Wright 2013) identified issues related to the effectiveness of bushfire warnings. The main findings included that few residents understood the implications of the different fire danger levels to their safety, and actions to take at each, apart from 'Catastrophic'.

Further work is being conducted by the Bushfire and Natural Hazards Cooperative Research Centre into the psychology of defending or evacuating once warnings are heard (e.g. McNeill *et al.* 2013).

4. Evaluation of early warning systems. The evaluation of early warning systems after emergencies and disasters is patchy (Dufty 2013). It is confined mainly to major inquiries and reviews for major disasters and agency after-action reviews. As cited in the findings, in some cases reports are commissioned to evaluate some aspects of early warning systems. Unfortunately, these evaluations are not consistently conducted after major emergencies and are not based on a standard set of indicators for the assessment of early warning system performance (Dufty 2013).

Conclusion

The research found that there has been considerable progress in Australian early warning systems over the past ten years. Progress particularly has been made in forecasting and prediction, intelligence systems, interoperability, and the increase in the range of available communication methods such as Emergency Alert and social media.

However, the research identified that further improvement could be made in some aspects of early warning systems such as raising low levels of community emergency preparedness in many Australian communities, designing effective flash flood warning systems, and understanding potential community response behaviours. Consistent evaluation of early warning systems – before and after emergencies – is also required.

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