Executive Summary

No state or territory in Australia is immune to the impact of natural disasters. As well as having an enormous economic cost, natural disasters inflict a massive social cost on the community. Although disaster response, recovery and mitigation are reasonably developed in Australia, risk analysis, which provides the foundation for risk reduction, has received less attention.

As Australia's population and density of living continue to grow, so does the potential impact of a natural disaster on the Australian community. Increasing numbers of people, buildings and infrastructure assets are being exposed to natural hazards as the pressures for urban development extend into areas of higher risk.

This report provides an overview of the rapid onset natural hazards which impact on Australian communities, including tropical cyclone, flood, severe storm, bushfire, landslide, earthquake and tsunami events. Emphasis is placed on identifying risk analysis requirements for these hazards and the phenomena that they cause, with a particular focus on likelihood and consequence.

The gaps in information required to more rigorously analyse risk from natural hazards are identified, with emphasis placed on those which are research related. Also included is an overview of the roles played by government and non-government agencies, groups and individuals in the management of natural hazards.

Impact of Natural Disasters

Natural disasters have a significant economic, social, environmental and political impact on the community. While some of the impact of natural disasters can be mitigated, the risk cannot be completely eliminated.

Distribution

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 tide). 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).

The impact associated with hazards also varies and can range from frequent moderate impacts (e.g. bushfire) through to rare but potentially catastrophic impacts (e.g. earthquake). Some hazards may occur suddenly (e.g. rockfall), while in the case of others the threat may be identified in advance and a warning provided (e.g. flood).

The future distribution of some natural hazards may also be affected by climate change.

Role of communities

While Australia's growing economy and technological advances may assist in managing disasters, they also make communities more vulnerable to the potential impacts of hazards.

This occurs through the increase in numbers and concentration of people and other assets exposed to hazards, and the greater reliance on infrastructure such as power and water supplies.

A hazard develops into a disaster when it has a widespread or concentrated negative impact on people. Therefore, communities can play a key role in both creating and mitigating 'natural' disasters. The preparedness of a community for a natural hazard can reduce the impact of an event and allow for more rapid recovery. Therefore, a key to reducing the overall risk of natural disasters is for those who play a role in the management of natural disasters to work closely with the wider community.

Cost

The average annual cost of natural disasters in Australia is estimated at $1.14 billion (over the period from 1967 to 1999), although the actual cost incurred varies greatly from year to year (BTE 2001). Only natural disasters with an estimated total cost greater than or equal to $10 million were considered.

Tropical cyclones, floods, severe storms and bushfires have had by far the greatest impact historically in Australia. However, a single event, such as a moderate-sized earthquake in Sydney, could fundamentally change this picture of natural hazards.

Consequently, it is critical to quantify the potential impacts of a full range of small through to extreme events in order to fully understand the risks from natural hazards. It is also important to consider the potential impacts of climate change on future risk. The study of prehistoric impacts of natural hazards can also be useful in extending historical knowledge for application today.

An economic framework is often used to calculate the cost of natural disasters. However, the difficulty of measuring the actual impact of a natural disaster on the community continues to be a major challenge, because of the complexities in assessing loss.

Intangible losses, such as the destruction of personal memorabilia and the effects of post-disaster stress, are particularly difficult to measure. Though insured losses are the most easily captured, they represent only a small proportion of total loss. These complexities need to be kept in mind when measuring and communicating the concept of 'impact'.

Role of policy

Government policy determines the future development of Australia and the wellbeing of people living within Australia's borders. Therefore, policy plays a fundamental role in influencing the impact of natural disasters, particularly in areas such as land use planning, construction standards and emergency management. Creating closer links between policy, research and practice is central to reducing the impact of natural disasters.

Risk Analysis

A good understanding of the risk of natural disasters is vital to minimise their potential impact. The systematic process used to understand and assess the level of risk is called 'risk analysis', and provides essential inputs to planning emergency management response and prioritising resources for sound mitigation practice.

Scope and purpose

In the context of this report, the risk analysis process enables the likelihood and consequences of natural hazard events to be assessed. Risk is analysed by considering the combined effects of likelihood and consequence that produce disasters. Assessing likelihood involves assessing the frequency or probability of natural hazard events. Consequences are examined by collecting information on the elements likely to be exposed to the impact of the hazard phenomenon, such as buildings, infrastructure and people, and gathering information on their vulnerability to a particular hazard.

The purpose of the risk analysis is to describe the risk through an objective and consistent process, the results of which can be described either qualitatively or quantitatively. The level of quantification depends on the level of rigour and accuracy required for the application of the results. For example, whereas a qualitative ranking of hazard risks may be adequate for a general understanding of risk to the community, a much more rigorous and quantitative analysis would be required for input to the design of critical infrastructure.

Necessity for good data

A good understanding of hazard, exposure and vulnerability is fundamental in any rigorous analysis of the risk posed by natural hazards, as the assessment of risk is only as good as the data used.

Knowledge of the elements likely to be exposed to the impact of the hazard phenomena is vital in determining the potential impact or consequence of any hazard on a community or society. This includes information on the people, buildings and infrastructure potentially exposed to a hazard impact. Such data are fundamental to any analysis of risk, regardless of the hazard.

Although a basic analysis of risk may simply look at what elements are exposed to a hazard event, an understanding of the vulnerability of these elements is vital for a more rigorous analysis of risk. This may include information such as building type and construction, or a community's wealth, health and access to key facilities or services.

Data collection is a long-term investment which requires the ongoing support of all levels of government, the private sector and the community. Where the data are inadequate, the ability to analyse and effectively reduce the impact of natural hazards is severely limited.

Management of Natural Hazards

All levels of government, non-government groups and the community play a role in managing the impact of natural disasters.

Government agencies

The Australian Government plays an important role in:

- developing national strategic disaster management policy
- providing warnings and alerts to the community, for some meteorological and geological hazards
- undertaking nationally significant scientific research
- providing support in emergency management awareness, training and education
- providing states and territories with financial and/or operational support for natural disaster mitigation, response and recovery.

State and territory governments have primary responsibility for natural disaster management in their jurisdictions, including developing appropriate policies and strategies, warning systems, awareness and education, and response and recovery; and providing support and direction in natural disaster management for local governments and remote Indigenous communities.

A bushfire in the Blue Mountains, New South Wales, November 1968
Photo courtesy: Bureau of Meteorology.

Local governments generally lead the development of disaster risk assessments and emergency management plans, and the implementation of mitigation measures within their jurisdictions. However, the extent to which this is done varies from hazard to hazard and between states and territories. Local governments play a key role in increasing community awareness and preparedness for hazard impacts, issuing local warnings and managing impacts in their jurisdictions.

Non-government agencies

A large number of professional bodies, coordinating groups and industry bodies play an advocacy role in the management of natural hazards. There is a mix of informal and formal groups, with some functioning at a national level while others are state-based or locally based. The engineering profession plays a large role in mitigation, through Engineers Australia and Standards Australia.

Research into natural hazards and their impact is undertaken at many Australian universities. Numerous consulting companies are involved in developing risk assessment and disaster management plans on behalf of government and non-government agencies.

The media and the community

The media play a vital role in delivering warnings to the community and in raising the community's awareness of natural hazards in general.

Volunteers play an important role in managing the impacts of natural hazards, particularly through the state emergency services and rural fire services.

Members of the general community have a basic responsibility to be aware of the risk natural hazards pose to them, and to maintain their properties to minimise vulnerability. Ideally, individuals should know what to do during a natural hazard event; at a minimum, they should at least have adequate knowledge to understand the advice of the relevant authorities during an event.

Overview of Hazards

The following pages provide an overview of the hazards covered in the report: tropical cyclone, flood, severe storm, bushfire, landslide, earthquake and tsunami.

Tropical Cyclone

Tropical cyclones develop over the warm oceans to Australia's north, including the Coral Sea and Indian Ocean. Tropical cyclones can bring destructive winds, heavy rain and coastal inundation through storm tide to many parts of Australia's western, northern and eastern coastlines.

Tropical cyclones have caused over 2100 fatalities in Australia since 1839 (Blong 2005). The average annual cost of tropical cyclones is estimated at $266 million (BTE 2001), accounting for 25% of the cost of natural disasters in Australia.

Current likelihood analysis methods involve using statistical or physical models to simulate many thousands of years of tropical cyclone events. These models rely heavily on the short historical record (spanning approximately 100 years) of observed tropical cyclones. Data on specifics such as the size, inner structure and decay rate of tropical cyclones after landfall are significant for determining likelihood but are poorly captured in the existing observational record.

The level of exposure of buildings and infrastructure can vary dramatically because of local terrain and topography effects and surrounding structures. The vulnerability of individual structures can be assessed using either of two methods: an engineering approach, or an assessment based on previously observed levels of damage for the type of structure.

The influence of climate change on tropical cyclone impacts is an area for further work. Suggested climate change impacts on tropical cyclones include increases in intensity and more southward tracks, exposing a greater proportion of the Australian community to this hazard.

At a fundamental level, the understanding of tropical cyclone behaviour and occurrence is limited and requires further research. A greater awareness of the vulnerability of residential structures and key infrastructure components to wind, rainfall and storm tide will improve quantitative risk assessments. Improved models of severe wind and storm surge hazard will provide town planners and emergency managers with fundamental information on community exposure to tropical cyclones.

Damage to flats at Nightcliff from Cyclone Tracy in Darwin, Northern Territory, December 1974
Photo courtesy: Bureau of Meteorology/Noel Stair.

Flood

Floods in Australia are predominately caused by heavy rainfall, with La Niña years experiencing more floods on average than El Niño years. Rainfall can cause both riverine floods and flash floods.

Records for flood deaths extend back further than those for any other hazard, with over 2300 fatalities since 1790 (Blong 2005). Floods have been estimated to contribute 29% of the average annual natural hazard damage in Australia, costing around $314 million each year, which makes flooding the most expensive natural disaster in Australia (BTE 2001).

Flood modelling is used to determine the likelihood of flooding for a given area. It involves two stages: estimating flood potential or probable flood flows (i.e. hydrologic analysis), and evaluating the flow of water through an area of interest (i.e. hydraulic analysis). Some of the data necessary include good rainfall and stream gauge measurements, cross-sectional data that capture the channel and floodplain geometry, and information on human and environmental features that influence flow behaviour.

The accuracy of the digital elevation data is often the greatest constraint for flood consequence modelling. While many factors contribute to flood damage, knowledge of the depth of flooding in buildings (i.e. over-floor depth) is a minimum data requirement. Information on the velocity and duration of inundation is also required for a more rigorous analysis of flood risk.

The influence of climate change on flood impacts is an area for further work, with existing climate change projections suggesting that average rainfall is likely to increase in the north of Australia and decrease in the south, with the intensity of rainfall likely to increase in many parts of the country. The increase in extreme rainfall intensity is likely to result in an increase in the intensity of floods.

Much more research is required to understand and manage the risks from flash flooding, which is likely to be a significant problem for most heavily urbanised areas of Australia. There are also areas for which no assessment of riverine flood risk exists, or where a more rigorous analysis of the risk may be warranted. Further work in the areas of flood vulnerability, post-disaster assessment and ways of making buildings more resistant to flooding are also important to minimise flood impacts.

Aerial view of the flooding in Lismore, New South Wales, June 2005
Photo courtesy: NSW SES/Phil Campbell.

Severe Storm

Severe storms (excluding tropical cyclones) can range from isolated thunderstorms to intense low-pressure systems (or synoptic storms). Thunderstorms may affect only a few square kilometres, while synoptic storms can cause damage over thousands of square kilometres. Severe thunderstorms affect all parts of the country, while synoptic storms pose a large threat to the southern states.

Records for thunderstorm deaths extend back to 1824, with over 770 fatalities recorded in Australia since that time (Blong 2005). Severe storms have been estimated to cost Australia about $284 million each year (BTE 2001), representing 26% of the average annual cost of natural disasters in Australia.

Severe storms can cause a variety of phenomena, but the greatest impacts are generally a result of large hail, destructive winds (including tornadoes) and heavy rainfall. All of these hazards occur on local scales, meaning there are few direct meteorological observations available. The likelihood of these phenomena is commonly determined by modelling the likelihood of the atmospheric environments in which they occur.

Complete assessments of the consequences of severe storms are hampered by a lack of accurate damage models for phenomena unique to these events—for example, large hail. Consequences of other severe storm phenomena, including flooding and destructive winds, can be determined using damage models developed for those phenomena.

The influence of climate change on severe storms is an area for further work. Current research suggests climate change may cause a decrease in severe thunderstorm risk for southern Australia, but a marked increase in thunderstorm risk for the east coast. The tracks of severe synoptic storms are projected to move southward, with fewer but possibly more intense systems occurring along Australia's south coast.

Further work on understanding severe storm behaviour recurrence and impact will provide invaluable information on the appropriate standards of construction for buildings and infrastructure components required to minimise impacts. Quantitative vulnerability models for wind and hail damage for buildings (and other assets) will lead to better estimates of the overall impact from severe storms.

Isolated severe thunderstorm near Junee, New South Wales, November 2005
Photo courtesy: Will Barton Photography.

Bushfire

Bushfires in Australia originate from lightning and from accidental or deliberate ignition through human activity. Bushfires, including forest fires and grassland fires pose a threat in nearly all parts of the country, in different areas at different times of the year.

Since the first recorded death in 1850, there have been over 700 bushfire fatalities in Australia (Blong 2005). The estimated average annual cost of bushfires in Australia is $77 million (BTE 2001). Two iconic events, Ash Wednesday in 1983 and Black Tuesday in 1967, dominate house losses during the period considered; 1967 to 1999. While bushfires contribute only 7% of the cost of all major natural disasters in Australia, bushfires are the fourth most frequent disaster type.

Likelihood analysis for bushfire involves modelling the chance of arrival and the intensity of the bushfire. High-resolution digital elevation data, observations of fuel load and detailed information on weather conditions are required to adequately determine the level of hazard.

Aggregated probability models of house loss are commonly used to assess the impact of bushfires. The vulnerability of a building can be determined by analysing potential ignition points in combination with the likely ignition mechanisms, such as ember attack. Detailed cadastral information and high-resolution aerial photography are used to determine the exposure of structures to bushfire attack.

Current climate projections suggest that the risk of weather conducive to fire will increase across much of the country, which may result in increased bushfire impacts if fuel distribution and fuel types remain similar. Increased fire-weather risk could also reduce the opportunity for hazard reduction activities, further exacerbating the likely impact of bushfire.

Further research into bushfire behaviour is needed to quantify the impact of bushfire on the Australian community. Acquisition of the base datasets, such as topography and land use data, will also greatly advance the analysis of risk. Assessments of exposure and vulnerability to bushfires are also critical to a thorough assessment of the risk.

Aerial view of the devastation caused by the Ash Wednesday fires at Fairhaven, Aireys Inlet, Victoria, February 1983
Photo courtesy: Emergency Management Australia.

Landslide

Landslides in Australia are predominantly caused by an increase in pore water pressure from leaking infrastructure, or by intense or prolonged periods of rainfall. The three main types of landslide which occur in Australia are rockfall, debris flow and deep-seated landslide.

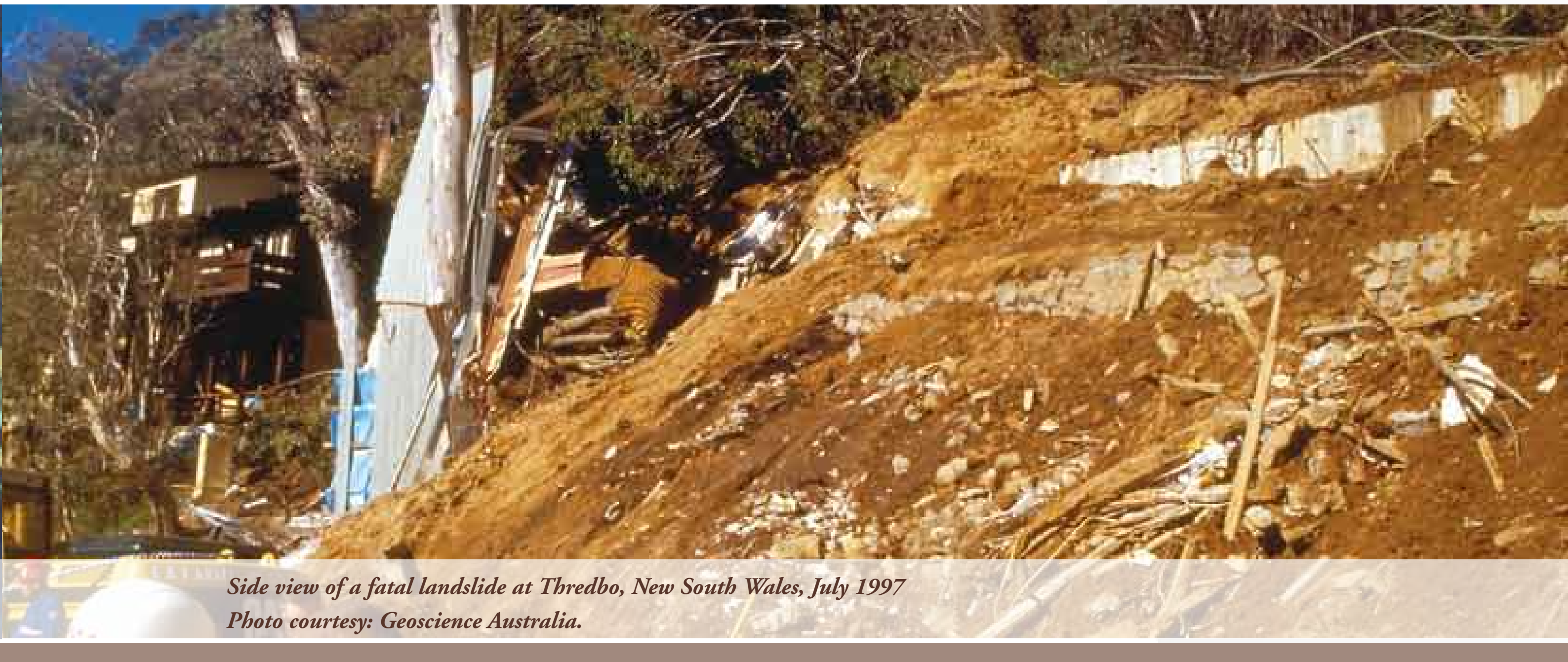
Since 1842 there have been approximately 84 known landslide events, collectively responsible for at least 107 fatalities (GA 2007). The economic cost of individual landslide events is typically much lower than the cost of other hazard events, with only one landslide event, the 1997 Thredbo landslide, achieving the damage threshold of $10 million used in calculating the impacts of severe events (BTE 2001).

Each type of landslide is governed by a different physical process and therefore needs to be analysed separately. Modelling likelihood involves determining the spatial and temporal probability of each landslide type. Some of the information necessary for effective modelling includes a good landslide inventory of historic events, an understanding of the source area and run-out path of landslide material, an understanding of the local site conditions, and data on the factors which trigger landslide.

Consequence analysis involves consideration up-slope, down-slope, laterally and in the run-out path of a landslide of the potential effects on elements such as buildings and people.

The influence of climate change on landslide impacts is an area for further work. Existing climate change projections suggest more frequent high-intensity rain, which may increase the frequency of some types of landslides.

Further research is also needed to understand and manage the risk from landslides to Australian communities. There are areas where landslide susceptibility mapping has not been conducted, and areas where a more rigorous analysis of the hazard and risk is required.



Side view of a fatal landslide at Thredbo, New South Wales, July 1997
Photo courtesy: Geoscience Australia.

Earthquake

Australia is in a relatively stable region which experiences few earthquakes large enough to cause damage in any given year. However, history clearly demonstrates that moderate-sized earthquakes have the potential to tragically affect Australian communities. Similarly, there is potential for much larger earthquakes to occur in urban areas, which could cause massive destruction and loss of life.

Earthquakes have been estimated to contribute 13% of the cost of natural disasters, at an annual average damage of $145 million (BTE 2001). However, the cost of earthquakes in Australia can be attributed almost entirely to the impact of a single earthquake—the Newcastle earthquake in 1989, which resulted in 13 fatalities (BTE 2001).

An understanding of earthquake risk requires an understanding of how frequent and how large earthquakes are likely to be in any particular region; how the ground shaking caused by the earthquake propagates; and how vulnerable communities and infrastructure are to the ground shaking. In practice this involves three key stages for assessing likelihood (i.e. earthquake source, ground motion and site response models) and two key stages for assessing consequence (i.e. exposure and vulnerability models).

By combining these models it is possible to quantify the risk, and to design structures to minimise the chance of catastrophic losses. To achieve this outcome requires high-quality seismic data; knowledge of the regional geological structures, including detailed near-surface geology; and comprehensive building and infrastructure inventories.

Because of the rarity of large earthquakes in Australia, there are several gaps in the fundamental data required for earthquake modelling. Further research is needed to identify active faults and their potential for releasing damaging earthquakes. Research is also needed to examine how soils in urban Australia will behave during earthquakes, as the manner in which near-surface soils respond to or amplify earthquake ground shaking has a dramatic effect on the resulting impact. Research into the performance of buildings and infrastructure exposed to earthquake shaking is also needed.

Damage following a devastating earthquake at Newcastle, New South Wales, December 1989
Photo courtesy: Emergency Management Australia.

Tsunami

Tsunamis occur rarely, but they are potentially very damaging. They are most often caused by earthquakes, but they can also be caused by landslides, volcanic eruptions or meteorite or comet impacts.

There is currently no estimate of the average cost to Australia from tsunami events. Anecdotal evidence from historic events suggests that the damage so far has been slight and restricted to marine and localised coastal areas. However, it is possible that Australia may be affected by large events in the future, which may cause much more widespread damage and fatalities.

Modelling the likelihood of a tsunami of a certain size reaching Australia involves two stages: modelling the likelihood of the source occurring in a location that could send a tsunami towards Australia, and modelling the propagation of the tsunami to the coast and any consequent inundation.

Modelling the source requires a good knowledge of the physical properties of possible sources (i.e. earthquake, landslide, volcano or meteorite/comet). Modelling the tsunami itself also requires a good knowledge of the bathymetry between the source and the coast. Once the tsunami reaches the coast, high-resolution digital elevation data of the potentially affected communities are also required.

To understand the consequence of a tsunami, information such as the height and velocity of the tsunami needs to be combined with knowledge of the structures and people within the area inundated, and how resistant the structures might be to the impact of the tsunami. The amount of warning time and the level of community awareness of the warning can also affect the consequences of a tsunami.

Since tsunamis happen so infrequently, it is not possible to use the historic record to accurately calculate the frequency of these events. To supplement the historic catalogue, evidence from prehistoric events and numerical modelling using high-resolution digital elevation data can be used. Accurately estimating the probability of events and the vulnerability of buildings and infrastructure are major areas for research.

Emergency treatment of survivors following a devastating tsunami in Aceh, Indonesia, December 2004
Photo courtesy: AusAID.

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