

Chapter Two: Impact of Natural Disasters



*A burnt out fire truck on Warragamba Avenue following the fire storm in Duffy, Australian Capital Territory, January 2003
Photo courtesy: The Canberra Times/Richard Briggs.*

Impact of Natural Disasters

Natural hazards have impacted on people since humans first walked on the earth. They have influenced, shaped and modified human behaviour, changing the way people live with and respond to the environment. In Australia alone, billions of dollars have been spent in trying to mitigate or prevent, prepare for, respond to and recover from natural disasters. Moreover, natural disasters have resulted in enormous intangible losses, causing grief through the loss of life and personal possessions.

A range of measures are used to illustrate the potential or actual impact of natural disasters. Examples include the probability or frequency of occurrence of a hazard, the number of people killed or injured, or the number of buildings damaged and the extent of that damage. An economic cost may be assigned, taking into account any of a number of measures. An economic cost, however, does not adequately portray the sense of enormous social loss that results from disaster.



Banana crops destroyed by Cyclone Larry near Innisfail, Queensland, March 2006

Photo courtesy: Geoscience Australia.

Destruction of the curator's residence in the Botanical Gardens by a flood in Brisbane, Queensland, February 1893

Photo courtesy: John Oxley Library/123308/Poul Poulsen.

Damage to railway tracks resulting from an earthquake in Meckering, Western Australia, October 1968

Photo courtesy: Geoscience Australia.

Road damage caused by a slow moving landslide at Pleasant Hills, North Tasmania

Photo courtesy: Geoscience Australia/captured in 1996.

This chapter provides an insight into aspects of natural disasters in Australia, including their distribution and the influence of communities. The socioeconomic impact of natural disasters in Australia is described, as well as the role of policy in influencing the impacts of natural disasters. The primary information sources used throughout the report are also highlighted.

Natural Hazard Phenomena and their Potential Effects

Natural hazards have the potential to cause a number of primary and secondary phenomena. The secondary phenomena produced by a natural hazard vary with event, as does their severity.

Tropical cyclones bring strong winds and heavy rains which cause secondary hazards such as flood, storm tide, landslide and water pollution. Flood inundates areas, which in turn may lead to landslide, erosion, water quality deterioration or turbidity, as well as sediment deposition. Severe storms range from isolated thunderstorms to intense low-pressure systems producing phenomena such as severe winds, heavy rain, lightning, flood, storm tide, hail and coastal erosion.

Secondary effects of bushfires include water pollution, erosion and reduced water catchment yield. A landslide may block a watercourse, leading to flooding and debris flows upstream. Earthquakes may also bring fire, flood, water pollution, landslide, tsunami and soil liquefaction, which can be as devastating as the primary hazard.

Each of these phenomena may produce physical, social and economic effects (Institution of Civil Engineers 1995). Physical effects on the built infrastructure may involve structural and non-structural damage and/or progressive infrastructure deterioration. They may also result in the release of hazardous materials such as chemicals which are usually stored in a safe

environment. Social effects may include fatalities, injuries, homelessness or loss of income; or secondary effects such as psychological impact, disease or loss of social cohesion.

Economic effects may include business disruption; disruption to the supply of power, water and telecommunications; and the cost of response and relief operations. Secondary economic impacts, such as insurance losses and rising premiums, loss of investor confidence, and costs of providing welfare and medical assistance, may also result (Institution of Civil Engineers 1995).

However, a natural hazard is not inherently negative, as hazards produce a disaster only when they impact adversely on communities. Natural hazards can bring positive environmental and social benefits. Bushfires, for example, can stimulate growth and regenerate forest ecology, as the heat from fire is required for some seeds to germinate (Luke and McArthur 1977). Floodplains are picturesque places for recreational activity and floods can bring welcome relief for people and ecosystems suffering from prolonged drought.

Primary Information Sources used for Measuring Natural Disaster Impact

There are several sources of information which can be used to estimate the impact of natural disasters. The report *Economic Costs of Natural Disasters in Australia* (BTE 2001) is the main source referred to within this report for the estimated cost of disasters. Other primary information sources referred to include the Emergency Management Australia (EMA) Disasters Database (EMA 2007), the Insurance Council of Australia (ICA) Catastrophe List (ICA 2007), and Australian Government data on the Natural Disaster Relief and Recovery Arrangements (NDRRA) (DOTARS 2007a).



*Red Cross volunteers helping with disaster relief, Victoria, 1986
Photo courtesy: Emergency Management Australia.*

The socioeconomic cost estimates throughout this report are indicative only. Each source, and its limitations for the purpose of this report, is briefly described below. These summaries emphasise the difficulties of estimating the cost of natural disasters.

Economic Costs of Natural Disasters in Australia Report

The *Economic Costs of Natural Disasters in Australia* report (BTE 2001) was based on information from EMA Track (now the EMA Disasters Database) for the period from 1967 to 1999. In developing estimates of economic cost, insurance data from the ICA, as well as information from the media and published reports on disasters, were incorporated. Only natural disasters in Australia with an estimated total cost greater than or equal to \$10 million (excluding costs associated with deaths and injuries) were considered. Both tangible and intangible costs were considered where the data were available. Estimates are usually given in 1998 dollar values. Details on the limitations in the completeness and accuracy of data used are provided in the report.

Emergency Management Australia's Disasters Database

The EMA Disasters Database is the main Australian Government database containing information on injuries, fatalities and costs of

natural, technological and human-caused events. For inclusion in the database, disasters must have resulted in three or more deaths, 20 injuries or illnesses, and/or losses of \$10 million or more.

Cost estimates are intended to include both insured and uninsured losses. Insured losses are sourced from the database maintained by the ICA. Uninsured losses are derived from a number of sources and relate to costs of repair and replacement to private property, public buildings, assets and records, and damaged infrastructure. Each cost estimate is stated in dollar values of the year in which the disaster occurred (EMA 2007).

Insurance Council of Australia's Catastrophe List

The Catastrophe List (or database) maintained by the ICA contains data on insured natural disasters since 1967. The database includes events which are likely to cost \$10 million or more, or events declared a disaster by an appropriate government authority irrespective of the loss sustained. Insured losses are original costs incurred at the time of the event.

The ICA database records insured losses for an event by aggregating the losses from the following categories: residential (property, contents, vehicle); commercial (property, contents, vehicle, plant and equipment, interruption); rural (fencing, plant and equipment, crop); marine;

aviation; and engineering and construction. The database is updated following each disaster event, though it can take up to 12 months for the full insured cost, particularly the commercial component, to be known.

Natural Disaster Relief and Recovery Arrangements Data

The NDRRA are administered by DOTARS on behalf of the Australian Government. Financial assistance is provided to eligible Australian states and territories following natural disasters.

Relief measures provided under the NDRRA include grants for relief of personal hardship and distress; concessional interest rate loans to primary producers, small businesses, voluntary non-profit bodies and individuals in need; restoration or replacement of essential public assets; and provision of counselling. In severe events, a community recovery package which includes a community recovery fund and clean-up grants for small businesses and primary producers may also be made available, subject to the approval of the Prime Minister (DOTARS 2007b).

Limitations of Data and Information Sources

The intended purposes of each data source must be considered when looking at the information they provide. Of the four mentioned above, only the NDRRA and ICA resources are confined to data obtained directly from the original source.

The data on NDRRA are limited to providing estimates on the Australian Government's NDRRA expenditure following natural disaster events. NDRRA data do not include expenditure from other government sources, such as state and territory and local government contributions. They also do not include other Australian Government expenditure such as the Australian Government Disaster Recovery Payments administered by Centrelink.

The database maintained by the ICA provides information on insured losses. It records a large proportion of costs associated with those disasters which are covered as part of all insurance policies, such as earthquake. It provides limited information for those hazards for which very few companies offer insurance. Consequently, losses for flood, tsunami, storm tide and landslide are greatly underestimated, as the provision of insurance for those hazards has been very limited.

Additionally, not everyone has insurance. Therefore, insured losses, particularly the contents component, represent only a proportion of the actual losses experienced by a community. The uptake of residential contents insurance is about 72%, although the rate varies considerably between owner-occupiers and renters. Building insurance is much more widespread, with an uptake in the Australian community for owner-occupied residential dwellings at 96% (Tooth and Barker 2007).

A level of underinsurance also exists. While the level has yet to be quantified, underinsurance is likely to be greatest during times of inflation or real estate boom, when the value of properties and contents increases rapidly. It is therefore believed that insured loss significantly understates actual losses.

All of the information sources have thresholds which must be reached before an event is included. The cut-off threshold is usually \$10 million, or a number of deaths or injuries, per event. Therefore, natural hazards which occur regularly throughout Australia but rarely meet this threshold, such as landslide, are under-represented.

Distribution of Natural Disasters

The distribution of natural disasters in Australia varies both spatially (i.e. in space or location) and temporally (i.e. in time). The future distribution

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

Spatial distribution of natural disasters is influenced by region and by topography. Hazards and disasters also vary in the size of the geographical area affected. Temporal distribution is influenced through factors such as frequency of occurrence, speed of onset and event duration, and seasonal weather conditions.

Spatial Distribution

While earthquakes and severe storms have the potential to occur anywhere in Australia, many of Australia's natural hazards occur only in reasonably well-defined regions. For example, tropical cyclones generally occur only in the northern, tropical regions of Australia. Similarly, riverine flooding is generally limited to low-lying areas adjacent to water courses.

Topography also plays an important role in the occurrence or impact of tsunami, storm tide, tropical cyclone, bushfire and landslide. The onshore impact of storm tide is limited to lower lying coastal areas. Similarly, the shape of the ocean floor and coastal topography play a large role in the behaviour and onshore impact of tsunami. Bushfire spreads faster when travelling up-slope. The wind speed from tropical cyclones or severe storms increases in areas of high relief. Landslides are common in hillside areas, although in some circumstances they occur on shallow slopes.

Generally speaking, the larger the area affected by a hazard event the greater the number of people or communities that are likely to experience loss or disruption. For example, the Black Friday bushfires in 1939 burned 1.6 million hectares across four states and the Australian Capital Territory and resulted in 84 fatalities (EMA 2007). Similarly, a tsunami might have successive impacts on an entire state's coastline as waves continued to travel away from the tsunami's source.

Such a broad impact can make an event very difficult to effectively mitigate and respond to. However, these catastrophic but generally rare events must be considered in any comprehensive risk analysis.

The hazard impact may also be localised but cause loss of life and widespread disruption. For example, on average, lightning strikes kill between three and four people (Coates and others 1993) and result in over a hundred injuries (Courtney and Middelmann 2005) each year.

Significant damage to electrical appliances and communications equipment from lightning strikes is also common. For example, the *West Australian* of 25 January 1999 states that lightning strikes during an electrical storm in January 1999 resulted in more than 10,000 Perth residents reporting phone damage, with some having to wait up to 10 days to be reconnected. The cost to a major telecommunications company was estimated to exceed \$1 million.

Lightning strikes are also a major ignition source for bushfires, with devastating impacts. During a single day in January 2003, lightning strikes started 87 fires in eastern Victoria (DSE 2007). The devastating Canberra bushfires of January 2003 were also started by lightning strikes.

Similarly, tornadoes occur in small localised areas but are intense and often have devastating effects. In 1918, three tornadoes occurred in the Melbourne suburb of Brighton. Though the tornadoes lasted only about two minutes, they destroyed or severely damaged buildings and caused two fatalities and many injuries (BoM 2007).

Temporal Distribution

The impact of natural disasters also has a temporal or time element. For example, the time of day or night at which a hazard occurs affects the scale and nature of a disaster, particularly in terms of mobile elements such as people and

vehicles. A disaster which strikes in a residential area during the day is likely to have a lower death toll than a similar disaster that occurs during the night when people are at home sleeping.

Across a much larger time scale, increased population growth and urbanisation can influence the magnitude of a disaster. The temporal distribution of disasters in terms of their frequency of occurrence, speed of onset and event duration, and in terms of seasonal weather conditions, is described below.

Frequency of occurrence

Records of past events highlight the devastating impacts caused by natural disasters. They can also provide an insight into what may be expected in the future. Emergency managers often prioritise their mitigation and planning to focus on hazards which have regularly impacted on their community's history. Consequently, Australian communities are often better prepared in areas where particular events occur fairly frequently, such as floods in Lismore in New South Wales or bushfires in the Mount Lofty Ranges in South Australia.

However, many of the natural hazard events which affect Australia occur irregularly and have unexpected and devastating impacts on communities. One such event was the 1989 earthquake in Newcastle, New South Wales. In general terms, the lower the recurrence interval of hazards the less adequate the technologies and practices to control or mitigate them tend to be. An important part of risk analysis is to

consider 'what if' scenarios in order to assess the risk for types of events which have not occurred, including those with the potential to be severely damaging.

Speed of onset and event duration

Some natural hazards, such as tropical cyclone, flood and tsunami, can often be detected hours or days before they impact upon a community. Other hazards, such as earthquake, can impact suddenly and without warning.

In catchments where the topography is relatively flat, such as in central Australia, floodwaters may be slow moving and shallow, but spread over thousands of square kilometres. A flood warning may be issued up to several months in advance, providing ample time for flood mitigation measures to be implemented downstream. However, in steep catchments, with often deeper water travelling at high velocities, warning time may be only a few hours, adding to the resulting impact.

The opportunity for emergency services to activate an emergency response plan and for residents to react to a warning is important, because it influences disaster losses. The Australian Tsunami Warning System provides approximately 90 minutes warning prior to a tsunami reaching the Australian coastline. Although short, this warning time provides emergency services with an opportunity to reduce the loss of life and damage caused by the event.



Lightning in Wollemi National Park, New South Wales, January 2007
Photo courtesy: Will Barton Photography.



A flood in Lismore, New South Wales, May 1963
Photo courtesy: NSW SES.



A grassland fire in the Bethungra Hills near Junee, New South Wales, January 2006
Photo courtesy: Will Barton Photography.

The length of time for which a natural hazard affects a specific place or region is also different for each hazard type. For example, in 1999 Sydney experienced Australia's most expensive insured natural disaster event. A supercell thunderstorm took 20 minutes to pass and produced the largest hailstones ever recorded in the Sydney region, while the entire storm lasted about five hours.

In contrast, a devastating earthquake may last for only tens of seconds. However, aftershocks may occur for days or weeks after the main event. Though landslides frequently occur suddenly, for example, as a rock fall, they may also be slower moving. Floods can inundate an area for weeks, though inundation of only a few days or hours is more typical. A grassland fire may run out of fuel within a few hours, while a forest fire may burn for many weeks.

Seasonal weather conditions

Earthquake and tsunami events have the potential to occur at anytime of the year. In contrast, bushfire, tropical cyclone and severe storm events are often seasonal. For example, the official tropical cyclone season in the Australian region runs from 1 November to 30 April (BoM 2007). This enables media advertising campaigns aimed at raising the community's awareness to target the lead-up of each tropical cyclone or bushfire season.

Bushfires tend to occur only where there are sufficient fuel loads and conditions for fire spread. These conditions are highly correlated to seasonal weather conditions, which affect the growth and drying out of vegetation. Climate variations across Australia mean that at any time of the year there is some part of the continent that is prone to bushfires, with the country's different weather patterns reflected in varied fire seasons. In southern Australia most fires occur during summer and autumn, while for northern Australia the fire season is winter and spring. The peak danger period for New South Wales and southern Queensland is spring and early summer (BoM 2007).

Potential Influence of Climate Change

Climate change will potentially affect the impact of some natural disasters, changing both their spatial and temporal distribution. The Fourth Assessment Report by the Intergovernmental Panel on Climate Change (Solomon and others 2007) indicates a likely increase in bushfires in southern and eastern Australia. The same report suggests an increase in the severity and frequency of storms and coastal flooding by 2050. The development of real estate in coastal areas affected by rising sea levels will exacerbate risk.



Crews work at repelling a fire as it burns over the Brindabellas and into the suburb of Gordon, Australian Capital Territory, January 2003 Photo courtesy: The Canberra Times.

For hazards such as tropical cyclone and storm tide, Australia is likely to suffer from less frequent but more extreme events in the future (Meehl and others 2007). This suggests that when an event does occur in a populated area the impact is likely to be severe. The potential influence of climate change for tropical cyclone, flood, severe storm, bushfire and landslide is described in more detail in the relevant hazard chapters.

Influence of Communities on Natural Hazards

A key distinction exists between what is termed a 'hazard' and what is referred to as a 'disaster'. For example, Twigg states (2001, p. 2):

'We are concerned about natural hazards because they might lead to disasters. A disaster is the impact of a hazard on a community/society—usually defined as an event that overwhelms that community/society's capacity to cope.'

Humans therefore play a key role in creating 'natural' disasters. Blaikie and others state (1994, p. 3):

'The crucial point about understanding why disasters occur is that it is not only natural events that cause them. They are also the product of the social, political, and economic environment (as distinct from the natural environment) because of the way it structures the lives of different groups of people.'

A disaster may effect a largely urban environment, cause damage to an agricultural region, or both. Cyclone *Tracy* in 1974 caused devastation because it hit the city of Darwin. Had the tropical cyclone passed just 60 kilometres to the south, the impact would have been significantly less. More recently, Cyclone *Larry* in 2006 caused widespread devastation to agricultural crops and a number of towns in north Queensland.

The effects of urbanisation and increasing population growth and density, most notable in the big cities and coastal regions, have led

to greater demand for and concentration of infrastructure and a higher potential exposure to natural hazards. Therefore, it is not surprising that in Australia the majority of deaths from natural hazards are concentrated in Australia's southeast, where a large proportion of the population is located (Blong 2005).

Combined with increasing wealth and materialism, the socioeconomic cost of a natural disaster today would typically be much greater than the cost of an event of the same magnitude and geographical extent that occurred at an earlier moment in history.

For example, since the massive development on the Hawkesbury–Nepean river floodplain in New South Wales, the catchment has fortunately not experienced a flood disaster. However, historical records reveal that large floods have occurred, the most severe of which was the devastating flood of 1867. Another example is the Glenorchy landslide of 1872, which caused the largest and most damaging debris flow recorded in Tasmania since European settlement (Mazengarb and others 2007). Were similar events to be repeated today, the impact on the now densely built or developing areas nearby would be severe.

Any mitigation measures implemented in the intervening periods may help to reduce the impact of some of the more frequently recurring events. Engineering and town planning professions have long been involved in flood mitigation, for example, through the construction of levees and land use planning controls. These methods, coupled with the implementation of effective warning systems, have resulted in a dramatic reduction in the loss of life from floods in Australia over the past 200 years.

Australia has also incorporated structural design standards for wind and earthquake into the building code (AS 4055:2006; AS/NZS 1170.2:2002; AS 1170.4:1993). The success

of the wind-loading standard in mitigating wind damage was demonstrated in the impact of Cyclone *Larry* in March 2006, for example (Edwards and others 2007).

While the past can be used as an indicator of what may happen in the future, disasters will happen in areas where there is no memory or experience of them. This may be because the hazard has never arisen in the area before. This is particularly true for rarer, but potentially catastrophic, hazards such as earthquake and tsunami.

For example, three earthquakes with a Richter magnitude greater than 6 occurred in a single day in 1988 near Tennant Creek, Northern Territory. The region was previously thought to have had virtually no seismic activity (Bowman 1992). It is now classified as having a high hazard level, and provides an example of a hazard map which changed significantly after a large event. It illustrates how unreliable hazard maps can be if they are based on inadequate sampling of data.

Socioeconomic Cost of Natural Disasters

The cost of natural disasters in Australia and worldwide varies greatly from year to year (BTE 2001; ICA 2007; Walker 2005). Some years are punctuated by extreme, highly damaging disasters with large social and economic costs, while in other years fewer and/or less damaging events are experienced.

Insurance companies, governments, businesses and charities often absorb a large proportion of the cost following a disaster and are effective mechanisms for spreading the cost beyond those immediately affected. It can be concluded that the costs of natural disasters are eventually passed on to individual consumers and tax payers. Mechanisms need to be developed in order for these costs to be adequately factored into economic cost estimates for a better understanding of the cost of natural disasters to Australian communities.

A disaster will affect various parts of the community in different ways. For example, disasters have a greater financial impact on people of lower socioeconomic status (Blaikie and others 1994; Dwyer and others 2004). Although a household on a lower income may spend less in total terms than a wealthier household, they are likely to spend a higher proportion of their income on recovery (Institution of Civil Engineers 1995). Households on lower incomes are also less likely to have purchased insurance (Tooth and Barker 2007). Therefore, disasters may impose a greater social impact on those with lower incomes. Similarly, a small business is likely to feel the impact of a disaster much more than a multimillion dollar company.

While a single cost is typically assigned to a disaster, the composition of that cost should always be considered. Some questions for consideration may include: What direct costs are considered and how are these costs calculated? Have indirect tangible costs been considered and, if so, which ones? Has loss of life been considered and, if so, how?

Framework for Calculating Losses

A range of tangible and intangible measures are used to estimate disaster losses. Tangible measures are relatively easy to assign a loss to: for example, the loss of a car. Intangible measures, however, are much more complex and variable. The loss of cultural icons and personal memorabilia, for example, will affect people differently.

Tangible and intangible measures are generally described in terms of direct and indirect costs. Direct costs are the consequence of the initial disaster event and will be felt immediately, for example, through the loss of a life or destruction of a house. Examples of indirect losses are the costs of goods or services which, as a result of a disaster, are not produced or provided, and the inconvenience and stress imposed on people.

An economic framework is often employed to capture the measures used in calculating costs arising from natural disasters. A framework which portrays different types of losses arising from a natural disaster is shown in Figure 2.1, developed using Smith and others (1995) and SCARM (2000) as a reference tool.

An economic framework incorporates concepts such as the costs of a small business that has burnt down or the number of houses that have been destroyed. The framework attempts to capture those costs and any benefits which result from the flow-on effects of the disaster. Following the Canberra bushfires in 2003, for example, construction costs increased due to the high demand for builders and materials. In the example of a small business being destroyed, the

framework would try to capture the cost of the salaries that the employees of the small business ceased to receive when the business was lost.

The measure most frequently used to calculate damage is direct tangible cost. This includes costs associated with replacing, rebuilding or repairing items which have been damaged or destroyed, and is often calculated through insurance costs. Clean up costs are also considered direct tangible costs.

Indirect tangible costs may include financial elements, such as accommodation costs and lost revenue, and the loss of opportunity through disruption of public services. Business continuity is also a significant component of indirect costs. For example, when the supply of agricultural

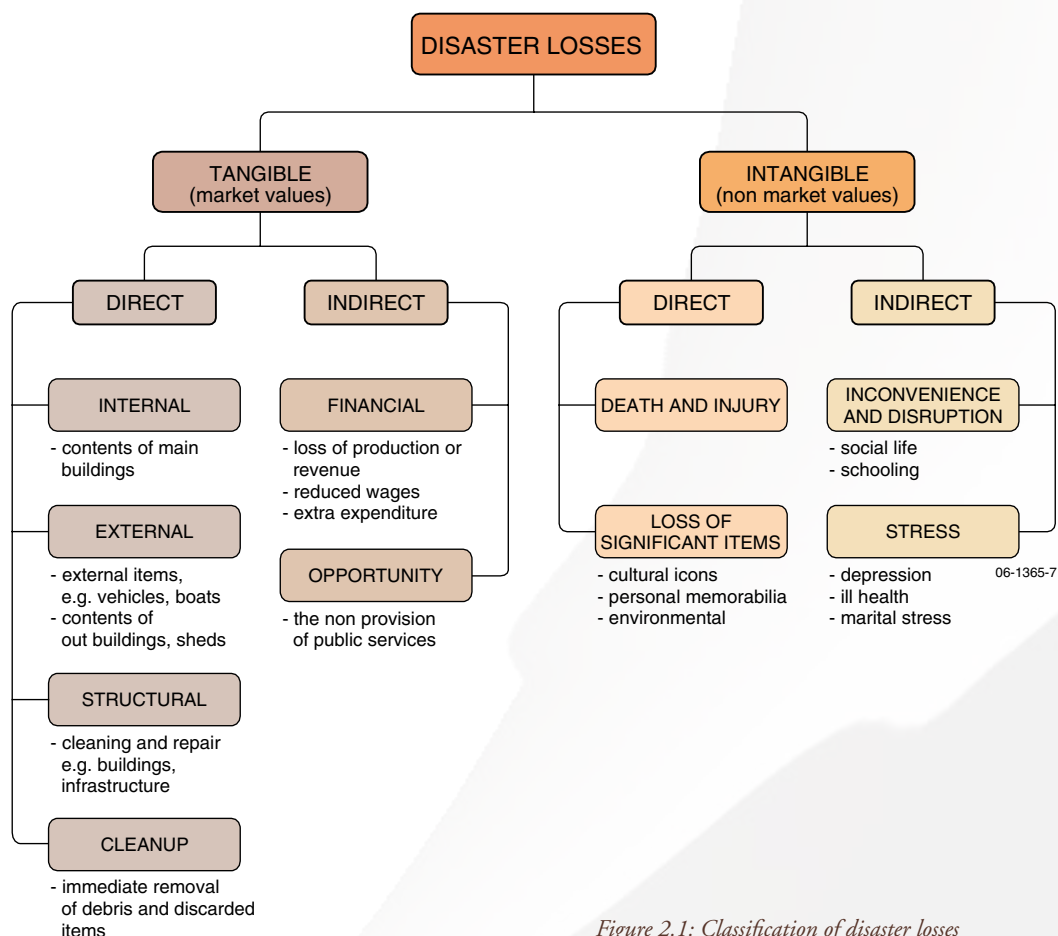


Figure 2.1: Classification of disaster losses

produce is affected by a disaster, the increased cost has implications reaching beyond the area immediately affected by the disaster. This was illustrated by the four-fold increase in the price of bananas across Australia that followed Cyclone *Larry* in 2006; prices returned to pre-disaster levels close to 12 months after the event (ABS 2007; ABS 2006a; ABS 2006b).

Tangible costs do not provide a complete picture of how extensive or devastating an event was, or the number of lives lost and the magnitude of social disruption caused. These losses are often described as intangible. Costs are sometimes assigned for intangible direct losses, such as loss of life and injury.

However, intangible indirect losses are very difficult to measure. The intangible impacts of a disaster, such as emotional trauma, may persist long after the event. The intangible impacts often remain even when recovery indicates that the tangible costs have ceased to be significant.

Economic Costs in Australia

The average annualised cost of natural disasters in Australia is estimated at \$1.14 billion and includes an estimate of the costs of deaths and injuries (BTE 2001). All other references to economic cost in this report excludes the cost of deaths and injuries.

An annual estimation of economic cost in the period from 1967 to 1999 is shown in Figure 2.2. Floods, severe storms and tropical cyclones are estimated to have caused the greatest economic losses during those 33 years, as shown in Figure 2.3.

Figure 2.4 shows the average proportional annual cost of disasters for each state and territory, while Figure 2.5 shows the proportional cost of each type of disaster for each Australian state and territory, for the same period. Almost half of the total economic cost of disasters was incurred in New South Wales; severe storms made the greatest contribution to cost.

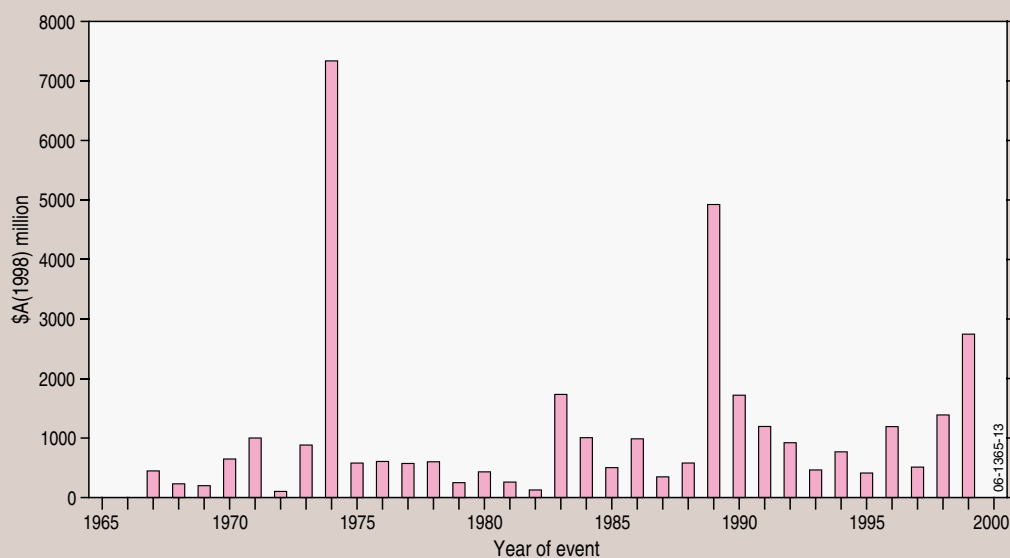


Figure 2.2: Annual total cost of natural disasters in Australia, 1967 to 1999
Source: BTE (2001), Figure 3.1.

During the same period, tropical cyclones dominated costs in the Northern Territory and Western Australia. Although Queensland suffered from the impact of many tropical cyclones during this period, tropical cyclones did not contribute a high proportion of cost to Queensland's total disaster expenditure.

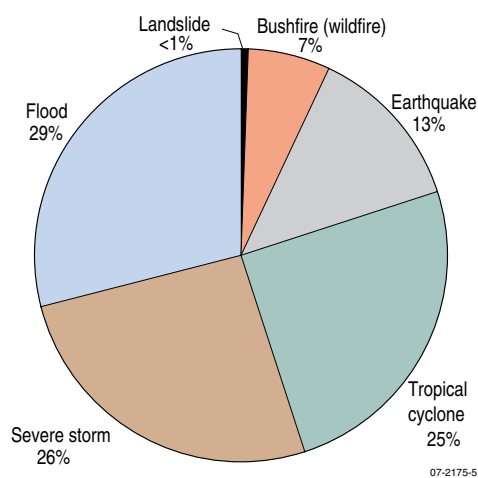


Figure 2.3: Average proportional annual cost of natural disasters, by type, 1967 to 1999
Source: Based on BTE (2001), Table 3.1.

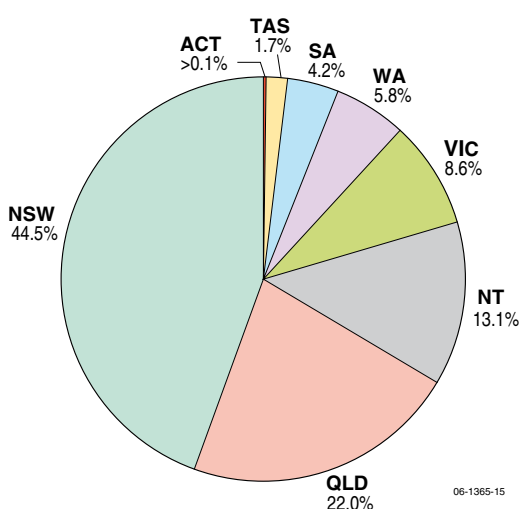


Figure 2.4: Average proportional annual cost of natural disasters by state/territory, 1967 to 1999
Source: Based on BTE (2001), Table 3.1.

This can be attributed to the relatively high contributions of other meteorological hazards, including flood, bushfire and severe storm.

Landslides occur regularly in Australia and, while the individual cost of each event is low, the cumulative costs to road and rail infrastructure and private property are high. The landslide in Thredbo, New South Wales, in 1997 was a notable exception, as a single event with very high costs. Historically, the impact of tsunami has been minimal, and that hazard is not included in the BTE (2001) data.

Single large events profoundly affect the total cost of natural disasters. This is particularly evident when comparing the number of events to the total cost. For example, Cyclone *Tracy* in 1974 dominates disaster costs in the Northern Territory. The Newcastle earthquake in 1989 has been the major contributor to the total cost of earthquakes in Australia, at 94%, and a significant contributor to disaster costs in New South Wales, at 29%. The Sydney hailstorm in 1999 contributed significantly to the cost of severe storms in New South Wales, causing damage estimated at \$2.2 billion. The Ash Wednesday bushfires in 1983 were the major contributor to the total cost of bushfires during the 33-year period (BTE 2001).

It is expected that, given the disasters that have occurred since 1999, such as the Canberra bushfires in 2003 and Cyclone *Larry* in 2006, the proportions in Figure 2.4 would differ considerably if they took into account more recent data, particularly for the Australian Capital Territory and Queensland.

Insured Losses and Australian Government Payments

Another source of information on the cost of natural disasters is the expenditure of the Australian Government through NDRRA. Funding is administered to eligible states and

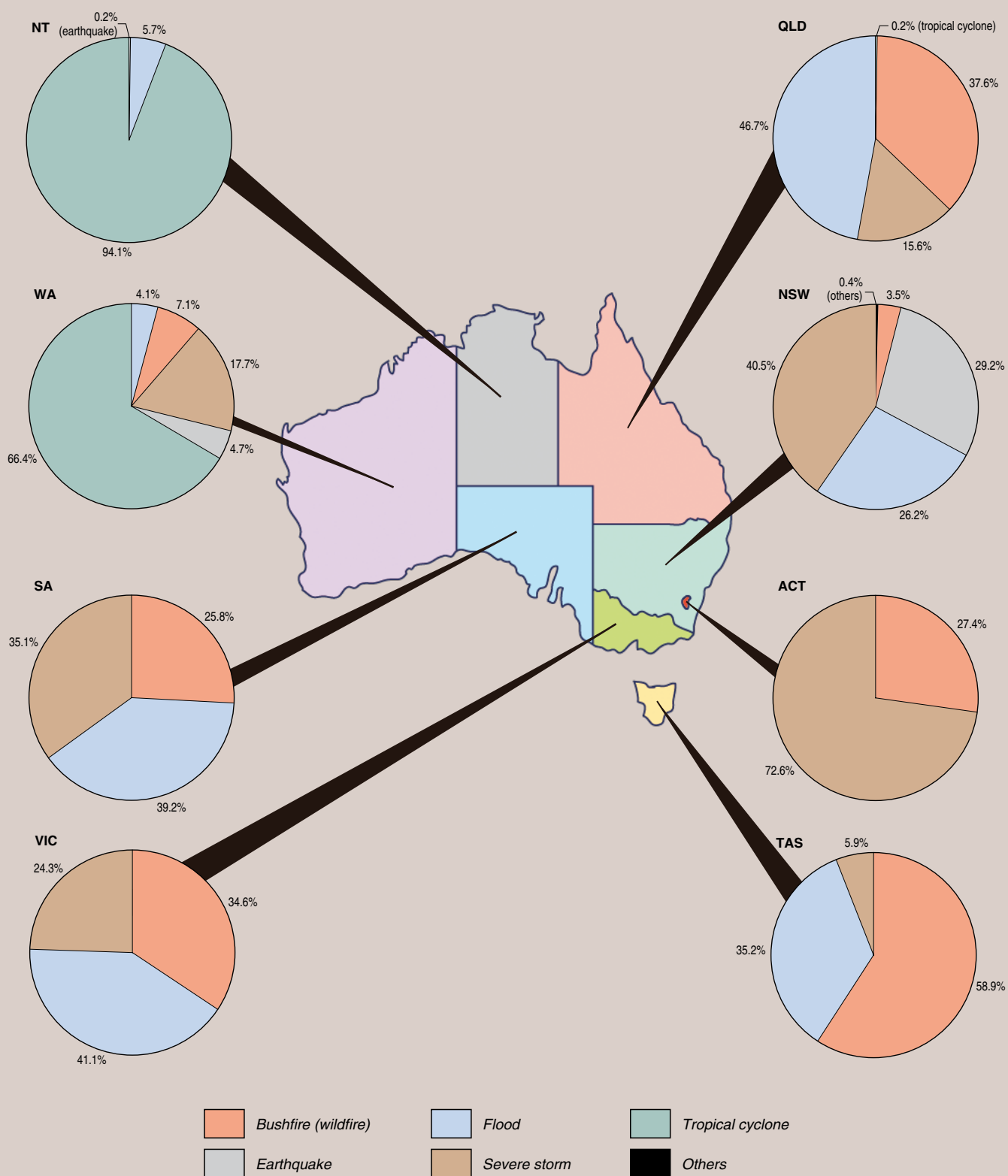


Figure 2.5: Average proportional annual cost of natural disasters in each state/territory, by type, 1967 to 1999
 Source: Based on BTE (2001), Figure 3.12.

territories, following a natural disaster, by DOTARS.

In Figure 2.6, the expenditure of NDRRA is compared with insured losses from the ICA Database of Catastrophes for the financial years from July 1994 to June 2006.

It is evident from Figure 2.6 that insurance payouts significantly exceeded NDRRA expenditure. The most notable example occurred in 1999 following the Sydney hailstorm. Because of the type of impact, the event was readily costed through insurance claims. This highlights the role that insurance can play in reducing government expenditure, though NDRRA is only one aspect of government expenditure on natural disasters. Nevertheless, insured losses are still only a small proportion of estimated total costs, as shown in Figure 2.7 for the period from 1967 to 1999.

This emphasises that estimating losses solely from one source may be misleading. The expenditure resulting from the devastation

caused by Cyclone *Larry* in 2006 is another example of the danger of using only one source to look at cost. An estimate of the total damage bill by a global reinsurance intermediary is \$1.4 billion (Guy Carpenter 2007). Estimates of insured losses are \$640 million (Guy Carpenter 2007) and \$540 million (ICA 2007), while the EMA Disaster Database estimates total losses at \$360 million (EMA 2007).

Building Damage

Meteorological hazards, including tropical cyclone, flood, severe storm and bushfire, accounted for 94% of total structural damage to buildings during the period from 1900 to 2003 (Blong 2005). More specifically, tropical cyclones contributed the greatest proportion of total building damage, at approximately 30%, as shown in Figure 2.8. Severe storms and floods contributed similar amounts to building damage. Severe storms included damage relating to wind gusts (excluding those associated with tropical cyclone), tornadoes and hailstones.

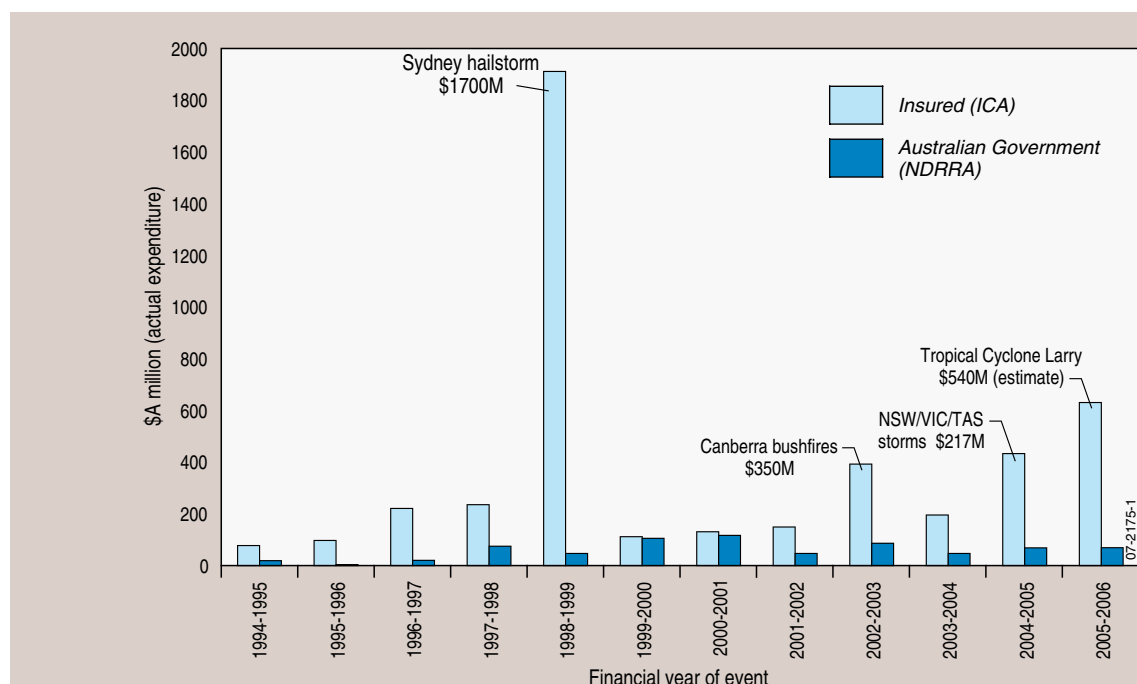


Figure 2.6: Actual expenditure following natural disasters in Australia

Note: NDRRA payments do not necessarily correspond with the year in which a disaster occurred, as the state governments occasionally delay seeking reimbursement.

Source: Insured cost has been calculated using the ICA Database of Catastrophes (ICA 2007). Australian Government expenditure has been calculated from the NDRRA payments (DOTARS 2007b).

Figure 2.7: Total and insured costs by natural disaster type, 1967 to 1999
 Source: BTE (2001), Figure 3.13.

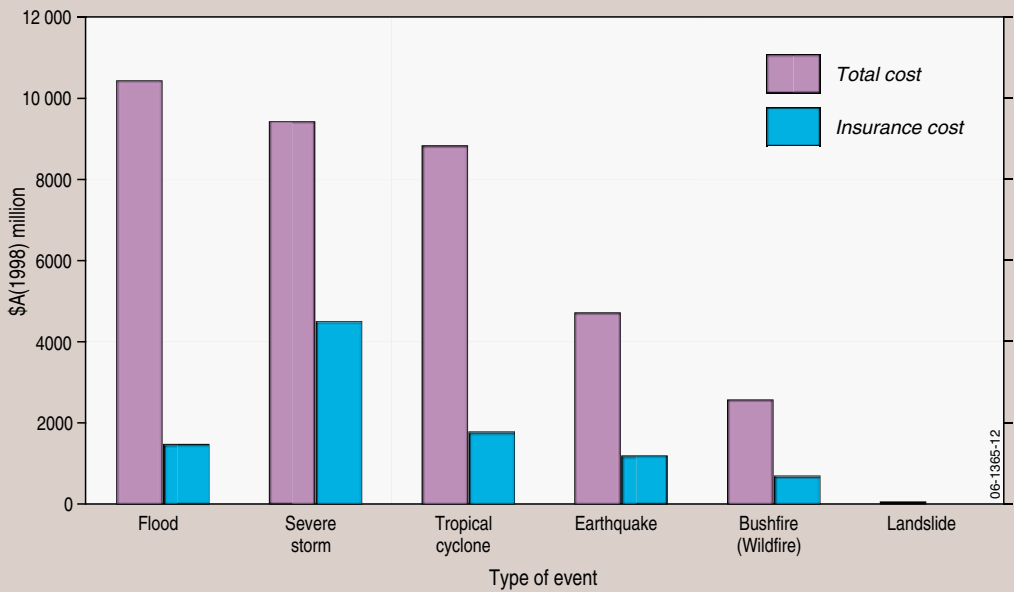


Figure 2.8: Proportion of total building damage caused by natural hazards, by type, 1900 to 2003
 Source: Blong (2005), Figure 4.

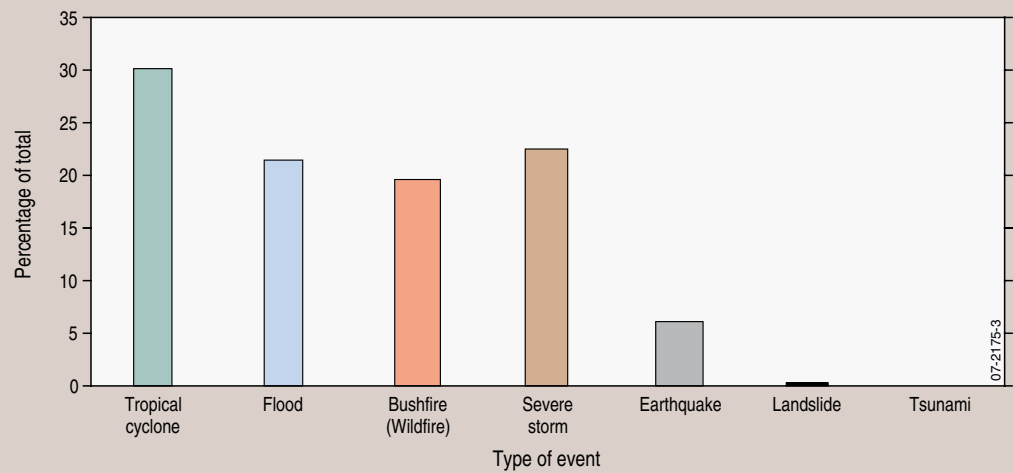
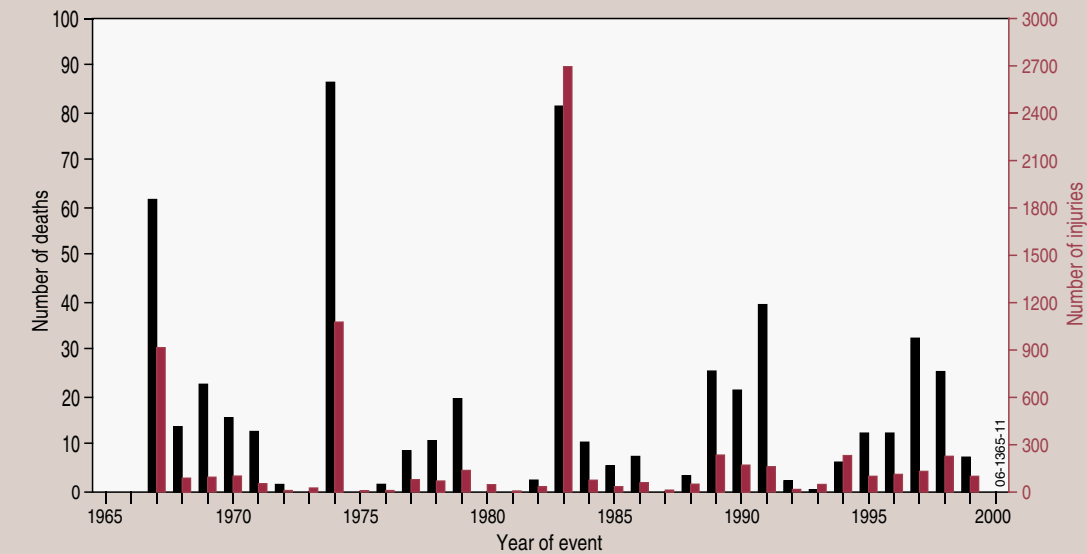


Figure 2.9: Number of natural disaster deaths and injuries, 1967 to 1999
 Source: Based on BTE (2001), Figures 3.28 and 3.29.



Past experience has shown that a single event which causes extensive building damage can significantly bias the total cost. For example, of the 1200 events included in Blong's calculations (Blong 2005), half of the total damage can be attributed to only 20 events.

Intangible Losses

The numbers of deaths and injuries arising from natural disasters in Australia varies considerably from year to year, as shown in Figure 2.9. Over the period from 1967 to 1999, 565 fatalities and more than 7000 injuries were recorded (BTE 2001).

The Ash Wednesday bushfires (1983), Cyclone *Tracy* (1974) and the Tasmanian bushfires (1967) contributed the largest number of natural disaster-related deaths and injuries in the 33-year period (BTE 2001). The Ash Wednesday bushfires in Victoria and South Australia had very high intangible costs, with 250,000 people affected. This included 75 fatalities, 2700 injuries and 9000 people made homeless. Cyclone *Tracy* resulted in slightly fewer fatalities, with 71 lives

lost. Fewer people were injured (650), and fewer people were affected overall (47,000), but many more were made homeless (41,000). The bushfires in Hobart in 1967 killed 62 people, injured 900 people, affected 35,000 people and made 7000 people homeless (EMA 2007).

Less damaging events result in intangible losses which are significant to those affected, but are often not recognised in the same way as events declared as natural disasters. In a survey of primary producers undertaken by Geoscience Australia after Cyclone *Larry*, it was found that papaya growers had experienced similar crop losses caused by less intense cyclones on a number of prior occasions. Cyclone *Larry*, however, caused widespread devastation to many crop types. This enabled the papaya growers to receive financial assistance for the first time, as part of the Australian Government's cyclone relief package.

Meteorological hazards, including bushfire, flood, tropical cyclone and severe storm, accounted for 95% of fatalities during the 33-year period, as

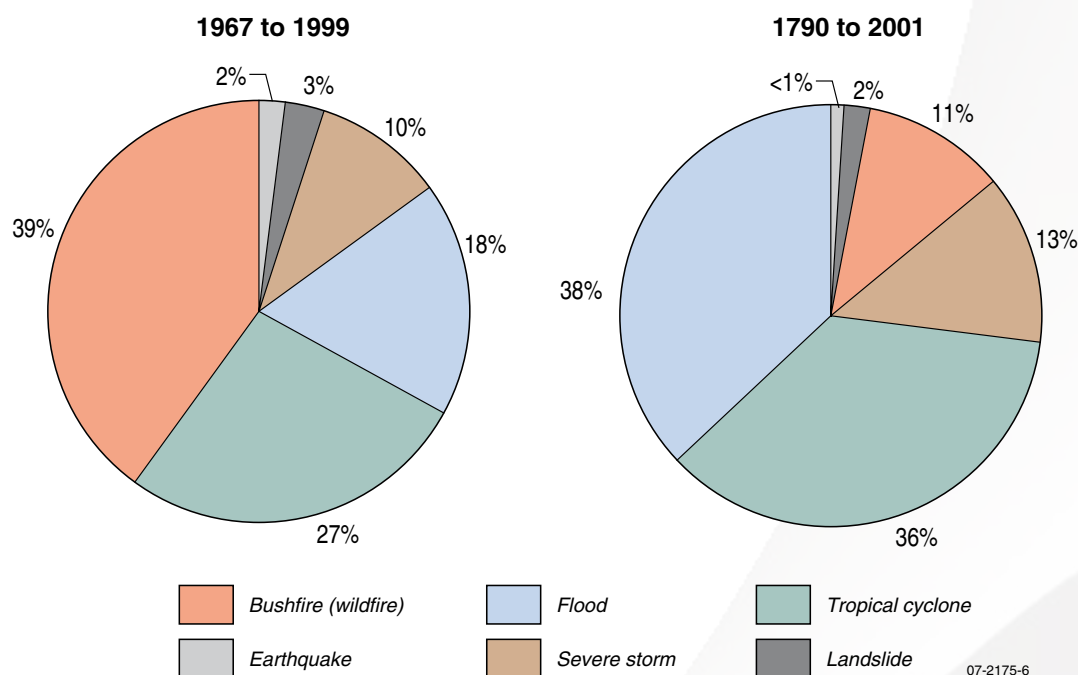


Figure 2.10: Proportion of fatalities caused by natural hazards, by type, 1969 to 1999 and 1790 to 2001
 Note: The date of the first recorded death varies: bushfire - 1850, flood - 1790, tropical cyclone - 1839, earthquake - 1902, severe storm - 1824 and landslide - 1842. Source: Based on BTE (2001), Table 3.2 and Blong (2005), Table 1.

shown in Figure 2.10, with bushfires contributing the most fatalities (BTE 2001). Figure 2.10 also shows that over a much longer period, from 1790 to 2001, flood-related fatalities surpassed the number of recorded deaths from bushfires and tropical cyclones (Blong 2005). The proportions of deaths arising from non-meteorological hazards remain very low in the second sample.

While the number of deaths and injuries is the primary measure of disaster impact in developing countries, an economic value is the primary measure used in Australia. The difference in measures used may be attributed to the decrease in fatality rates in Australia over the past two centuries, which allows economic costs to be considered as relatively significant. The decrease in the fatality rate due to natural disasters in Australia in the period from 1790 to 2001 is in the order of three magnitudes, as illustrated in Figure 2.11.

It is believed the decrease in natural disaster fatalities is testament to successful disaster mitigation strategies, particularly during the 1800s, which focused on reducing loss of life. These included improvements in warning systems, emergency

services, land use planning, communication, education and the development of building codes, and a greater understanding of the characteristics and impacts of natural hazards.

Evidence for Prehistoric Natural Hazard Impacts

The historical record from which Australian experience in disaster management is principally derived is largely limited to the period following the arrival of the first European settlers in 1788. However, natural hazards often leave evidence of their occurrence in a region's landscape. For example, large tsunamis can deposit massive layers of sand that can be preserved for millions of years and provide a significantly longer record of tsunami occurrence than recorded history.

Information on tsunami characteristics such as wave height, run-up and velocity can be acquired by studying the sediments, stratigraphy, size and distribution of deposits (Atwater and others 2005). If several tsunami deposits occur in stratigraphic sequence, dating of the deposits

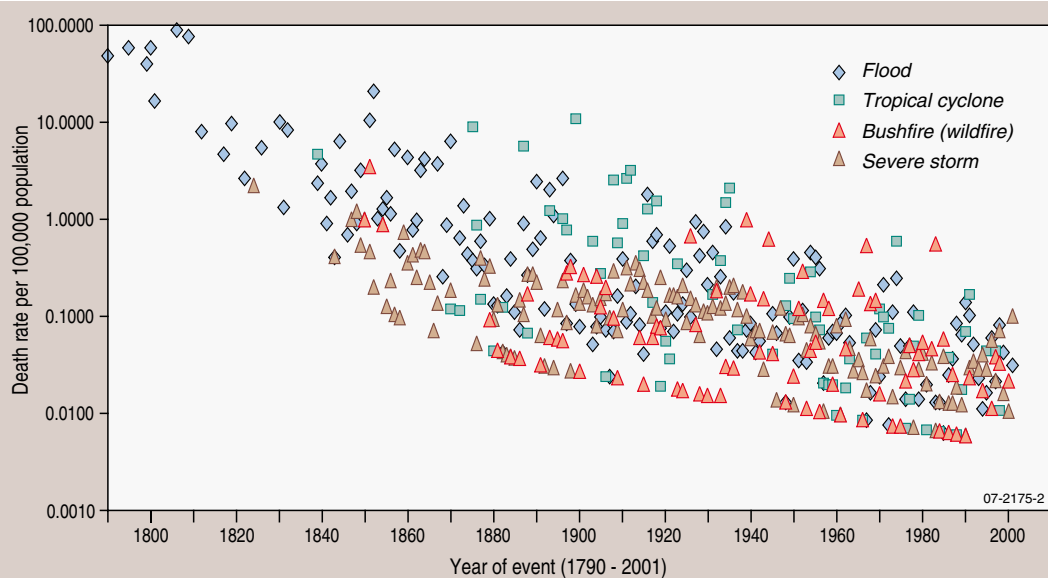


Figure 2.11: Fatalities caused by natural disasters per 100,000 population, 1790 to 2001
Source: Risk Frontiers cited in Blong (2005), Figure 2.

allows estimates of frequency (Cisternas and others 2005). Researchers have reported evidence thought to have been formed by large tsunamis along the Australian coastline (Bryant and Nott 2001; Switzer and others 2005); however, this work remains controversial (Felton and Crook 2003; Dominey-Howes 2007). These deposits suggest that past tsunamis were several orders of magnitude greater than any experienced in the historical period.

Evidence of prehistoric large earthquakes can also be found in the landscape, informing research on issues such as the spatial distribution of earthquake-prone regions, and the maximum likely magnitude and likelihood of recurrence of large events (Sandiford 2003; Clark and others in review-a; Clark and others in review-b). For example, the earthquake that occurred in Meckering, Western Australia, in 1968 produced a fault scarp 2 metres high and 37 kilometres long, which is still clearly visible. Two trenches excavated across the fault scarp revealed that a large earthquake had ruptured the same fault several hundred thousand years previously (GA 2007).

However, a preliminary analysis of data collected across Australia for traces of large prehistoric earthquakes suggests that large earthquakes are not restricted to the places where seismic activity is recorded today. The heights and lengths of many prehistoric fault scarps are much greater than those of the 1968 Meckering scarp, suggesting that earthquakes of much greater magnitude are possible almost anywhere across Australia (Clark 2007, written communication).

Various techniques have been used to investigate cyclonic variability over thousands of years. Some include analysis of lake sediments (Liu and Fearn 2000), dune ridges (Nott and Hayne 2001), pollen types in coastal sediment cores (Elsner and others 1999) or overwash deposits (Liu and others 2001).

Evidence for ancient flood events can be found through the examination of river sediments. Debris found high above normal river levels may also provide evidence for large flood events prior to the written record (McCarthy and others 2006).

The much longer history provided by the geological record provides evidence for much larger events than those in the historical record. This highlights the possibility of Australia experiencing far more devastating impacts than those experienced in human memory.

The Role of Policy in Natural Disasters

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.

The Role of Government

The arrangements under the Australian Constitution (Commonwealth of Australia 1900) influence the management of natural hazards in Australia. That is, because emergency and disaster management is not addressed specifically in the Constitution, the states and territories have largely assumed responsibility for managing the impact of natural hazards (EMA 2000). The Australian Government guides and supports the states and territories in this role.

Local governments are often responsible for undertaking risk management and serving as the key point of contact for local emergency issues, because of their close ties to the community (EMA 2000). Further information on the roles and responsibilities of all levels of government is outlined in *Natural Disasters in Australia: Reforming Mitigation, Relief and Recovery Arrangements* (COAG 2004).

Disasters as Focusing Events

Natural disasters can influence changes in policy. Disasters have been described as ‘focusing events’ or ‘turning points’ in policy, and play an important part in setting agency agendas. The seriousness of the impact on a community and the extent to which that was recognised, rather than the size of the hazard, were found to be the key determining factors (Birkland 1997).

In Australia two examples stand out as focusing events in the management of natural disasters. The Brisbane floods in January 1974 led to the formation of the Natural Disasters Organisation (now EMA), and Cyclone *Tracy* in December 1974 cemented public resolve and political support for disaster planning (Walker 1999).

Political Will for Change

Political will and/or support is essential for change. Often, the optimal or preferred solution for managing natural hazards is not popular. For example, it is believed the reluctance by some governments to release flood maps stems partly from the fact that such a move would be unpopular with the real estate industry, developers and individual owners of flood-affected property, who fear that releasing such information would compromise the value of land (Yeo 2003). Similarly, Pelling states that (2003, p. 34):

‘inappropriate planning and legislation can exacerbate vulnerability. This is often an outcome of piecemeal approaches to development or inefficiencies in the administrative infrastructure.’

Figure 2.12 shows an example from the Launceston region in Tasmania, where houses built in inappropriate locations were subsequently destroyed by landslides. In this instance, the planning system was unaware of the potential hazards and there was inadequate geotechnical investigation prior

to development (Ezzy and Mazengarb 2007; Mazengarb 2007, written communication).

Information on natural hazards can often be seen as controversial or having the potential to cause panic if not adequately communicated. The development of appropriate policies and communication strategies to deal with sensitive situations is therefore essential. Equally important is instilling a culture of safety and local participation in the community. The recommendation by the Council of Australian Governments (COAG) (COAG 2004) to make all information on risk publicly available is one important step towards including the community in the solution to reducing risk.

Long-term, Apolitical Policy Development

Natural hazards are not confined by state or political boundaries. The actions of one local government can and do influence the potential impact of a natural hazard on neighbouring political areas. The construction of a dam or levee in one local government area, for example, may affect flood levels in other local government areas, depending on where they are located.

Policy relating to the management of natural hazards needs to be holistic (Twigg 2001), cross-jurisdictional and focused on achieving the best outcome for the whole Australian community. Arrangements, programs and policies within and between the different levels of government contribute to many effective natural disaster management relationships.

The cost of natural disasters can far outweigh the cost of preventative measures, in both economic and social terms. Investing in natural disaster risk reduction can be cost effective, as discussed by COAG (2004) and demonstrated for flood mitigation (BTRE 2002).



Figure 2.12: Orthophoto of Lawrence Vale, Tasmania, where over 40 houses were destroyed by landslide activity in the period from the 1950s to the 1970s

Source: Based on Ezzy and Mazengarb (2007), Figure 3.



*Volunteers from the Wollongong State Emergency Services unit, New South Wales
Photo courtesy: NSW SES.*

Reducing the risk of natural disasters requires the ability to correctly recognise emerging issues or problems. Two examples of emerging issues are demographic shifts to coastal regions in Australia, often known as the ‘sea change phenomena’, and the potential influence of climate change on meteorological hazards.

However, identifying and analysing risk are only parts of the process. The risk needs to be reduced to an acceptable level, by adopting risk evaluation and treatment strategies that ensure safer communities.

Incentives to Reduce Impact

The incentive for one level of government to minimise a natural hazard risk is reduced if another level of government pays for loss arising from the hazard (Environment Canada 2006). Therefore, policy should provide incentives for processes and practices to be implemented to help minimise risk.

Many mechanisms can be used by government and the insurance industry to help reduce risk. The provision of economic incentives and penalties such as grants, loans and taxes is one example (Institution of Civil Engineers 1995). The provision of resources, including professional expertise, is another.

Policy can be aimed at reducing risk on a large scale through land use planning and/

or development controls. At an individual householder level, the reduction of insurance premiums on the provision that steps have been taken to minimise the household’s risk might be an effective incentive.

A change in the NDRRA rules has had a big impact across Australian local governments. To be eligible for assistance, applicants are now required to demonstrate that mitigation measures have been adopted. Consequently, the majority of local government areas in Queensland and New South Wales have completed disaster risk management studies to demonstrate that they are actively attempting to mitigate their risks to be eligible for NDRRA (Granger 2007, written communication).

Link Between Research, Policy and Practitioners

Creating closer links between policy, research and practice is central to reducing the impact of natural disasters. Communication across these domains provides an appreciation, understanding and involvement across interrelated areas and is of high importance in reducing risk.

However, for science and research to effectively influence policy development, information must be clearly communicated to government in a timely and understandable manner. This is vital in ensuring scientific research reaches its

full potential and assists policy makers to make informed and relevant decisions using the best information available. As the Centre for European Flood Research observes (CRUE 2007, p. 7):

'If scientists really want to influence policy more, researchers need to become more visible, and clearer about the kind of changes they are aiming for, and are able to achieve.'

Practitioners need to communicate effectively to those whose role is to develop policy. Similarly, any policy which is developed needs to be coherent in whole-of-government terms. It is also vital that those involved in policy development seek the expertise of those working 'on the ground'. Researchers need to liaise with practitioners to find out what their needs are, and work toward developing relevant methodologies and techniques which can be easily applied and communicated to effectively inform policy makers.

Successful linking of policy and research requires an open, continuous dialogue. Where this relationship is effective and natural hazard impacts are minimised, the benefit is felt by politicians, policy makers, researchers, practitioners and the community.

Conclusion

Natural disasters have a significant economic, social, environmental and political impact on the community. While some of the impacts of natural disasters can be mitigated, the risk cannot be completely eliminated. Therefore, decisions regarding what risks are acceptable need to be made by those involved in managing natural hazard impacts.

Tropical cyclones, floods, severe storms and bushfires and the phenomena that they produce have had by far the greatest impact historically in Australia. However, a single event, such as a moderate earthquake in Sydney, could change the historical picture of natural hazards.

It is for this reason that modelling potential impacts for a full range of small through to extreme events, and considering the potential impacts of climate change, is important. The study of prehistoric impacts of natural hazards can be useful in extending the knowledge provided by historical records.

The socioeconomic cost and natural disaster policy, as much as the spatial and temporal distribution of both hazards and communities, need to be considered when managing the impact of natural disasters. A hazard develops into a disaster when it has a widespread or concentrated negative impact on people.

While Australia's growing economy and technological advances may assist in managing disasters, they also make communities more vulnerable to the potential impact of hazards. This occurs through the increase and concentration of the population and the built environment, and a greater reliance on infrastructure such as power and water supplies.

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 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 are only a small proportion of total losses.

These challenges need to be kept in mind when measuring and communicating 'impact'. A key to reducing the overall risk is for those who play a role in the management of natural hazards to work closely with the wider community, as well as with each other.

