Economic costs of natural disasters in Australia

by Neil Gentle, Sharyn Kierce and Alistair Nitz, Bureau of Transport Economics[1], Department of Transport and Regional Services

Introduction

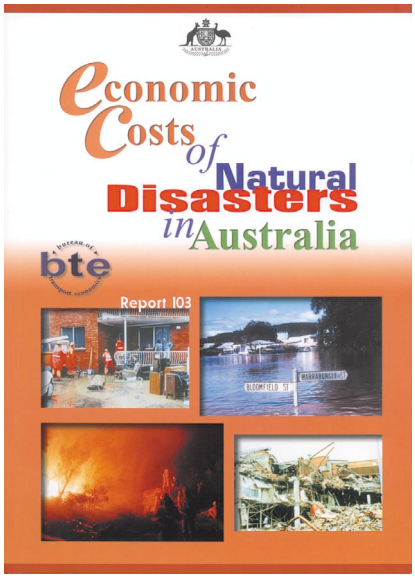
The risk of natural disasters forms a backdrop to our everyday lives. Depending on where we live, floods, bushfires, cyclones and earthquakes are threats to both property and lives. Over time, communities have developed organised responses to the threats posed by natural disasters. Although preparation and response measures can mitigate their effects, natural disasters continue to occur and cause severe damage.

This article summarises the findings of a recently released report by the Bureau of Transport Economics, which examined the economic costs of natural disasters in Australia for the 1967 to 1999 period. The Bureau also brought together work by others on loss estimation methods to develop a consistent framework for use in estimating the future costs associated with natural disasters.

Although scientific understanding of natural disasters in Australia is of a high order, very little work has been undertaken on the economic effects of disasters. The report arose out of a need to put the value of mitigation expenditure on a sounder footing than had previously been the case. In response to the need for better cost information, a working group (the Disaster Mitigation Research Working Group, chaired by the Department of Transport and Regional Services) was established to oversee the project. The working group comprised representatives from Commonwealth, State and Territory, and Local Governments, the Insurance Council of Australia and the New Zealand Government. The research was endorsed by the National Emergency Management Committee (NEMC).

The objectives of the project were to establish the costs of natural disasters in Australia over time, to examine the trends in these costs and to develop a model for estimating the costs of future disasters. The research is part of a longer-term project to look at mitigation measures in more detail.

The term 'natural disaster' covers a wide variety of disaster types. For the purposes of the project, a natural disaster was classified as any emergency defined by the Commonwealth for the purposes of the Natural Disaster Relief Arrangements (NDRA). As a result of this classification, the analysis was limited to floods, storms (including hailstorms), cyclones, tsunami, storm surges, bushfires and earthquakes. Landslides were also included, as they are in the NDRA when they are consequential to an eligible event.



A report by the Bureau of Transport Economics that sheds new light on the costs to the Australian community of natural disasters.

The focus of the study was national economic costs. A national approach was necessary to achieve the project's objectives. A local or regional approach may be more appropriate for an assessment of individual disaster mitigation measures. An economic, rather than financial, approach was chosen because economic analysis is concerned with the broader social effects of a disaster on the whole community. A financial analysis is concerned with the financial impact of a disaster on individuals and enterprises affected.

The impact of a disaster can be devastating for businesses and communities directly affected. However, economic analysis has a national perspective, rather than a local one, in order to develop an Australia-wide view of the cost of disasters. One consequence of a natural disaster might be that private or public enterprises lose business to competitors. Although the loss of business is a financial loss for the disaster-affected enterprise or locality, it is an economic loss only if the national economy is affected. Loss of business to a competitor within Australia is not an economic cost of the disaster, but a loss of business to a foreign competitor is. It should be noted that if there are additional costs incurred by the use of an alternative supplier, such as increased labour or transport costs, then these additional costs are economic costs of the disaster, as resources are consumed that could be used for alternative uses (Thompson & Handmer 1996, pp. 22-24). Further discussion on this complex issue can be found in the report.

Defining a disaster is a difficult and somewhat controversial task. Storm damage to a few houses may be disastrous for the households involved, but from a national perspective is unlikely to be thought of as a disaster. However, designating just how many properties must be damaged or lives lost before an event constitutes a disaster is necessarily subjective and mostly arbitrary. As our focus is the national economic cost of disasters, we believe the use of a $10 million total cost threshold (excluding the costs of deaths and injuries) to define a disaster captures significant natural hazard events from an economic cost viewpoint. The implications of this choice of threshold are discussed in detail in the report, but it is important to note that a $10 million total cost threshold means that, depending on the disaster type, events with insurance costs of just a few million dollars are included in the analysis. We believe the use of this threshold does not substantially affect the conclusions reached.

Notes

1. The Bureau of Transport Economics (BTE) is a division of the Commonwealth Department of Transport and Regional Services. The BTE conducts applied economic research related to both transport and regional service issues.

Availability of data

Australian data used for the historical analysis were derived from a database maintained by Emergency Management Australia (EMA).

Although we consider the EMA database to be the best currently available in Australia for purposes of the project, it has limitations.

- The heavy reliance on media reports limits the accuracy of the database.
- Some of the earlier events that occurred in Australia, especially smaller ones, are not likely to have been recorded, as they were not reported in the media.
- The method of estimating total costs as multiples of insurance costs can lead to significant inaccuracies.
- Cost estimates contained in the database were found to have not been properly indexed to 1998 dollars. However, the low inflation levels experienced over the past three to four years would have had little impact on the cost estimates.

Although the EMA database contains records dating back to the 1800s, it is only since 1967 that reliable insurance data, on which the most reliable cost estimates in the database are based, became readily available.

Therefore, records of events prior to 1967 were not included in the analysis. However, care is still required, as events early in the study period may not have been reported and recorded in the database.

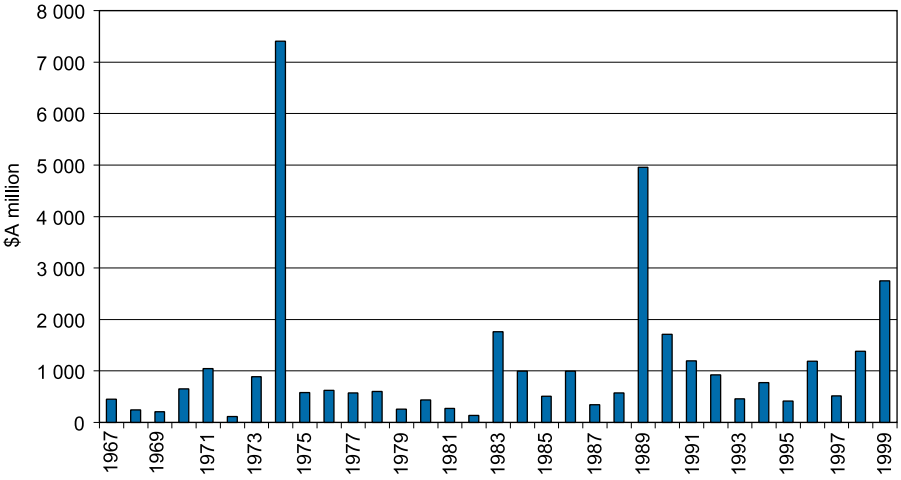


Figure 1: Annual total cost of disasters in Australia, 1967–1999 Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

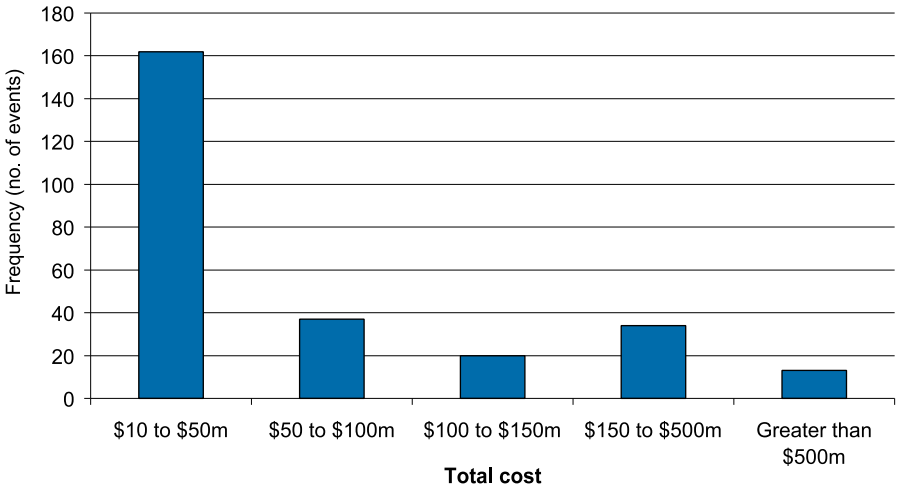


Figure 2: distribution of disasters by cost, 1967–1999 Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

Key findings

The key findings of the report with respect to both historical and future analysis are listed below.

Disaster costs

- Natural disasters (with a total cost per event over $10 million) cost the Australian community $37.8 billion (including the costs of deaths and injuries) in 1999 prices over the period 1967 to 1999.
- The average annual cost of these disasters between 1967 and 1999 was $1.14 billion (including the costs of deaths and injuries). This translates to approximately $85 per person per year.
- Estimated average costs were $1.3 million for a fatality, $317,000 for a serious injury and $10,600 for a minor injury. The estimated total cost of deaths and injuries during the period 1967 to 1999 was $1.4 billion at an average cost of $41 million per year.
- The average annual cost is strongly influenced by three extreme events—Cyclone Tracy (1974), the Newcastle earthquake (1989) and the Sydney hailstorm (1999). If the costs of these three events are removed from the calculations, the average annual cost declines to $860 million. This may be a better estimate of the costs of disasters that can be expected in a year in which extreme events do not occur.
- The annual cost of disasters is highly variable *figure 1*, standard deviation $1.5 billion). The annual cost in years in which extreme events do not occur can be as high as $2.7 billion in 1999 prices. In years in which extreme events occur, the total cost can be much higher. As a result, it is not possible to assess whether the annual cost is increasing or decreasing over time.
- There is no evidence in the data that the total cost of smaller and more frequent events (less than $10 million total cost) exceeds the total cost of large rarer events. For a selection of sample years, these smaller events are estimated to have accounted for an average of 9 per cent of total economic costs of disasters.

Numbers of disasters

- There have been 265 natural disasters costing more than $10 million each during the period 1967 to 1999.
- The total cost of most disasters is between $10 and $50 million. *Figure 2* shows that more costly events are much less common. Despite the large number of events in the $10 to $50 million range, the sum of total costs of these events remains small (around 10 per cent of total cost) in comparison to the cost of the infrequent extreme events. (Again, it is worth bearing in mind that many smaller disasters go unrecorded).
- There is some evidence that the annual number of events considered to be disasters is increasing *figure 3*) due partly to better reporting in recent years and possibly to increasing population in vulnerable areas.

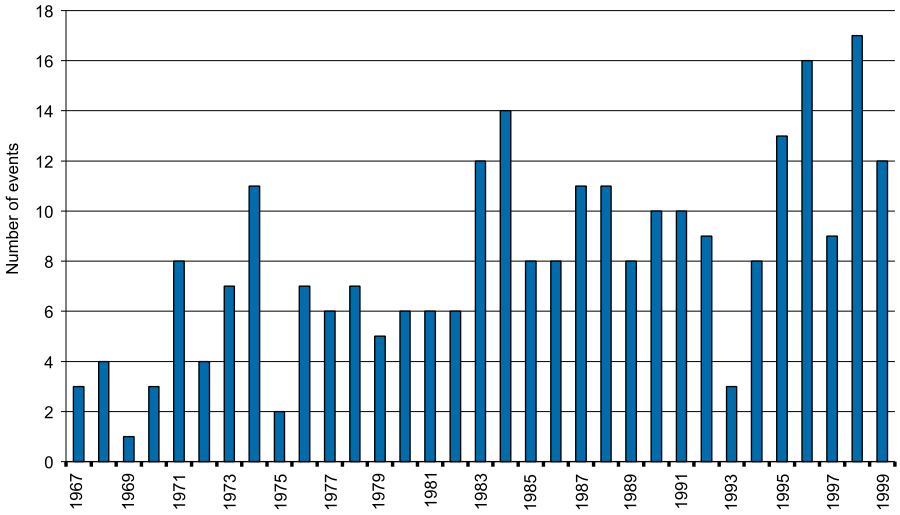


Figure 3: Number of natural disasters in Australia, 1967–1999 Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

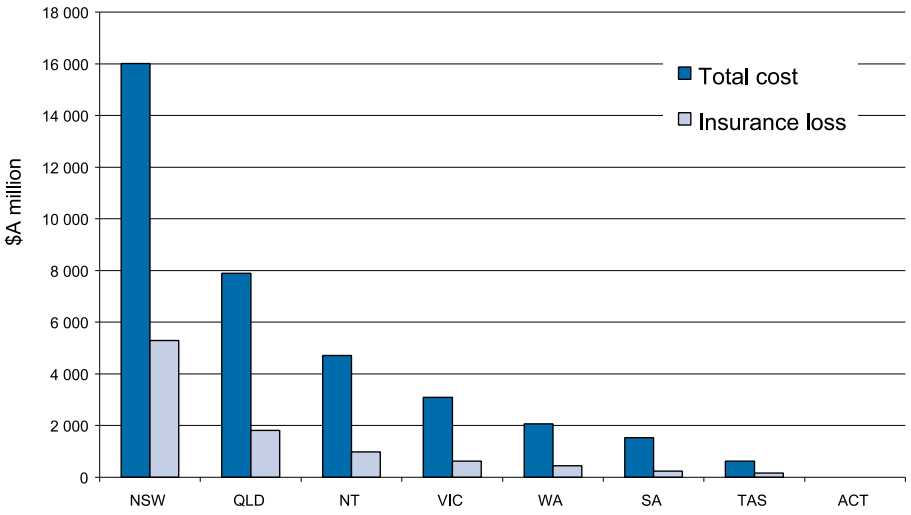


Figure 4: Disaster costs by State and Territory in Australia, 1967–1999 Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

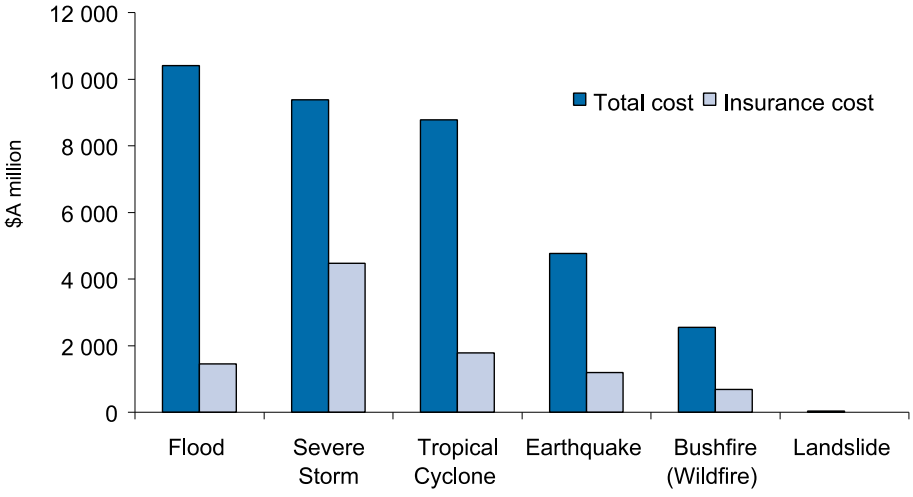


Figure 5: Total and insurance costs by disaster type, 1967–1999 Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

Regional findings

- New South Wales and Queensland accounted for 66 per cent of total disaster costs and 53 per cent of the total number of disasters over the period 1967 to 1999 (figure 4). The Northern Territory ranked third in terms of total disaster costs (13 per cent), followed by Victoria (9 per cent), Western Australia (6 per cent), South Australia (4 per cent), Tasmania (2 per cent) and the Australian Capital Territory (0.02 per cent). No events were recorded for Norfolk Island or the Indian Ocean Territories *(figure 4)*.
- Floods were the most costly of all disaster types, contributing $10.4 billion or 29 per cent to the total cost *figure 5*). Storms (26 per cent of total cost) and cyclones (24 per cent) caused similar levels of damage. Together, the combined cost of floods, storms and cyclones was almost 80 per cent of total disaster cost. They also accounted for 89 per cent of the total number of disasters. The cost of bushfires were a relatively small proportion of total disaster costs. However, bushfires are the most hazardous type of disaster in terms of deaths and injuries.

The two most costly hazard types for each State and Territory are:

- New South Wales (floods, storms)
- Queensland (floods, tropical cyclones)
- Victoria (floods, bushfires)
- Western Australia (tropical cyclones, storms)
- South Australia (floods, storms)
- Tasmania (bushfires, floods)
- Northern Territory (tropical cyclones, floods)
- Australian Capital Territory (bushfires, storms)

Table 1 gives the estimated average annual cost of natural disasters associated with the key findings. The average annual cost in the table (approximately $1.10 billion) is less than the $1.14 billion mentioned earlier because the costs of deaths and injuries are not included in the table.

Findings on methods of estimation

- There is considerable variation in the methods used to estimate past disaster costs, mostly in the estimation of indirect costs.
- The use of a consistent framework for estimating cost, based on that developed in the report, can provide a better basis for assessing mitigation proposals.
- There is no simple relationship between indirect and direct costs (defined below) of a disaster. Previous disaster reports indicate that, as a broad estimate, indirect costs are usually in the range of

Average Annual Cost ($ million)

State	Flood	Severe Storms	Cyclones	Earthquakes	Bushfires	Landslide	Total
NSW	128.4	195.8	0.5	141.2	16.8	1.2	484.1
QLD	111.7	37.3	89.8	0.0	0.4	0.0	239.2
NT	8.1	0.0	134.2	0.3	0.0	0.0	142.6
VIC	38.5	22.8	0.0	0.0	32.4	0.0	93.6
WA	2.6	11.1	41.6	3.0	4.5	0.0	62.7
SA	18.1	16.2	0.0	0.0	11.9	0.0	46.2
TAS	6.7	1.1	0.0	0.0	11.2	0.0	18.9
ACT	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Total	314.0	284.4	266.2	144.5	77.2	1.2	1087.5
Proportion of total (%)	28.9	26.2	24.5	13.3	7.1	0.1	100.0

Note Figures may not add to totals due to rounding.

Table 1: Average annual cost of natural disasters by State and Territory (excluding death and injury costs)
Source: BTE analysis of Emergency Management Australia (EMATrack) database (unpublished).

25 to 40 per cent of direct costs.

- There are very few methods for the adequate estimation of intangible costs and more research is needed in this area.

Framework for estimating costs

It was difficult to make a conclusive assessment of the trends in disaster costs due to limitations of the data. As a result, a framework for estimating the economic cost of natural disasters, which should facilitate future estimations of disaster costs, was developed. Although drawing heavily on flood literature, the framework should be suitable for use in determining the cost of all disaster types. Nevertheless, the unique character of each disaster means that the framework should only be used as a guide, rather than an exact model to determine the cost of any particular disaster.

The report includes a discussion of general principles that should be used in estimating costs. The key principles include exercising caution to avoid double counting of costs and ensuring the use appropriate economic values of assets.

Classification of losses

Generally, the method used to estimate the cost of a natural disaster is to categorise the losses into tangible and intangible losses, which are further subdivided into direct and indirect losses. The BTE's approach (illustrated in *figure 5*) was to analyse the costs in three broad categories—tangible direct, tangible indirect and intangible (comprising the direct and indirect intangible cost). Direct costs, which are the easiest to classify, are losses that result from the physical destruction or damage to buildings, infrastructure, vehicles and crops.

Indirect costs, which are more difficult to estimate, are costs incurred as a consequence of the event occurring, but not due to the direct impact.

One area of contention is the cost of disruption to business. The cost of lost business is often included in the estimated cost of a disaster. The impact of a disaster can be devastating for businesses directly affected by that disaster, and local communities can suffer as a consequence. However, when examining the impact of the disaster from a national perspective, business disruption costs typically should not be included. This is because business disruption usually involves a transfer between producers, without a significant loss in national economic efficiency. There may be occasions when the transfer between producers involves additional costs, which would be a valid indirect cost of the disaster. Business disruption costs would be included if the event affected the nation's economy through an increase in the level of imports or a decrease in exports.

The intangible cost category attempts to capture all losses not considered as a direct or indirect tangible cost. Intangible costs are typically those for which no market exists.

These costs are difficult to estimate, as there is no systematic or agreed method available to measure them. The largest impact is normally found in the residential sector, which includes health effects, household disruption and loss of memorabilia.

Although presently available methods are generally poor at reliably estimating many intangible costs and benefits, they should not be ignored in assessing mitigation proposals.

The framework in the report provides information on appropriate methods for estimating costs and some approximate methods where more accurate (and more costly) methods may not be feasible. The suggested methods may not cover the full range of possibilities and should therefore be interpreted as a guide. *Tables 2* and *3* summarise our suggested approach to estimating natural disaster costs.

The tables illustrate the major points examined in the report. However, the categories are not intended to cover every conceivable cost category. Nor will every category apply to every disaster.

Each disaster is unique. The analyst will

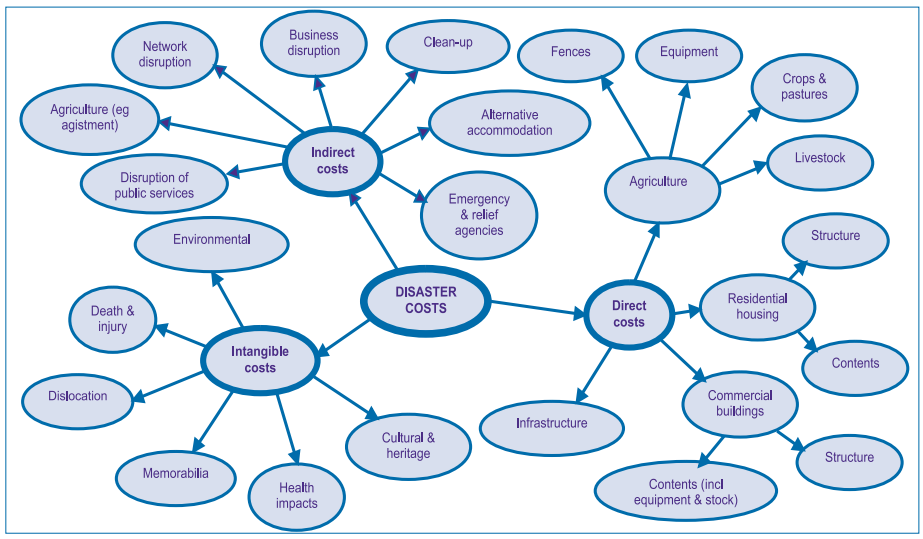


Figure 6: Outline of cost framework

Cost category	Estimation principle	Data sources
Direct costs		
Residential buildings – structures and contents[a]	Depreciated economic value	1. Survey 2. Stage-damage curves for floods 3. Adjusted insurance claims 4. $20 500 per flood damaged residential building (Read Sturgess & Associates 2000) 5. $23 200 per bushfire damaged building[b] (BTE estimate based on NSW Coroner (1994))
Commercial & industrial buildings – structures and contents	Depreciated economic value	1. Survey 2. Average unit cost based on floor area andsusceptibility to floods (Smith 1994) 3. Adjusted insurance claims
Public buildings – structures and contents	Depreciated economic value	1. Survey 2. Adjusted insurance claims
Infrastructure	Cost of restoration	1. NDRA 2. Unit costs (Read Sturgess & Associates 2000)
Crops	Market value less input costs avoided	1. Survey
Pastures	Cost of restoration	1. Survey 2. Average unit costs (Read Sturgess & Associates 2000)
Fences	Cost of repairs	1. Survey 2. Unit costs ($5000/km (Read Sturgess and Associates (2000))
Livestock	Market value	1. Survey 2. Representative values (Read Sturgess & Associates 2000).

a. Some methods give an estimate of potential flood damage. Actual damage is generally less than potential damage depending on the extent of warning given and the prior flood experience of the community.

b. The average bushfire damage estimate is only for damaged houses and does not include houses that are totally destroyed.

Table 2: Summary of disaster cost estimation—direct costs

Cost category	Estimation principle	Data sources
Indirect costs		
Business disruption	Loss of value added (usually not estimated if a national perspective is taken)	1. Survey
Loss of public services	Cost of provision	1. Service providers
Non-residential clean-up	Cost of materials plus opportunity cost of labour used	1. Survey 2. Smith et al. (1979, pp. 63-72) for commercial buildings 3. $10 000 for public buildings
Residential clean-up	Cost of materials plus opportunity cost of labour used	1. Survey 2. $330 per household for materials and AWE for household labour (20 person-days)[a]
Household alternative accommodation	Additional costs of accommodation plus any transport costs	1. Survey 2. $53 per person plus $26 per person-night
Agriculture	Costs such as fodder, agistment, loss of productivity due to pests	1. Survey
Transport networks	Increased vehicle operating costs. Value of time for delayed people and freight	1. Survey to estimate vehicle-hours of delay 2. Unit costs from table 4.8 in the report
Disaster response and relief	Marginal costs incurred by relevant agencies. Opportunity costs of volunteer labour.	1. NDRA 2. Survey of volunteer organisations
Intangible costs		
Fatalities	Human capital approach	$1.28 million (see appendix I of the BTE report)
Injuries	Human capital approach	$313 000 for a serious injury and $10 500 for a minor injury (see appendix I of the BTE report)
Health effects	Days of debilitation* AWE	1. Survey 2. Average proportion affected
Environmental damage, memorabilia & cultural heritage	Ideally one of: 1. Travel cost method valuation 2. Hedonic prices 3. Contingent valuation 4. Least cost alternative *Otherwise proportion of direct costs*	Survey if one of the analytic methods is used

a. There is considerable variation in material costs and clean-up times reported in the literature. The values suggested here are representative of the reported values.

Table 3: Summary of disaster cost estimation—indirect and intangible costs

need to decide on the basis of the nature of the event being investigated and the availability of data, which categories to include.

A comparison of estimates

Past disaster reports were also examined using the framework developed as a benchmark for the analysis. The Nyngan flood (1990), Lismore flood (1974), Cyclone Tracy (1974), Ash Wednesday Bushfires (1983) and the Edgecumbe (New Zealand) Earthquake (1988) were chosen because of the range of disaster types and their geographic distribution, and most importantly, the availability of adequate documentation.

In some cases, estimates (see *table 4*) were relatively close to past estimates (Nyngan, Lismore and Ash Wednesday). For others, the estimates differed widely (Cyclone Tracy and Edgecumbe). The main reason for differences between estimates was the lack of availability of indirect cost information and the different treatment of particular indirect costs, such as business disruption.

Next steps in disaster cost research

Although the cost framework developed provides some assistance in reviewing past studies, its main value is to provide a starting point for examination of the costs of future disasters. Its purpose was to provide a first step in attempting to develop a more consistent approach to measuring the cost of disasters in Australia. Historically, indirect costs—particularly intangible costs—have not been well documented and incorporated into estimates of disaster costs.

As a consequence of these limitations, the conclusions derived from the data analysis must be interpreted as indicative or approximate only, and any conclusions drawn must be regarded as tentative. In the future, improved data collections and better methods of estimating costs should lead to more reliable results.

Obtaining a more accurate cost estimate would require a system for the consistent collection of disaster costs in the wake of a disaster occurring. The current short time series of available data means that it is very difficult to come to grips with any trends, while any changes to basic data parameters may have considerable implications for the future ability to analyse trends.

It is important that a strategy for handling this issue is devised if trends in natural disaster costs are to be reliably examined in the future.

The cost framework developed was cross-checked against several well-documented disasters which used differing approaches. The results were not strictly comparable.

As a result, the next step would be to test the cost framework outlined in the report in a variety of future disasters so that it can be refined to achieve greater agreement and consistency in costing Australian disasters.

The largest gap in the estimation of disaster costs is the inability to adequately estimate intangible costs. Evidence suggests that they are at least comparable with direct costs, and possibly much larger. Research is needed to develop reliable methods to overcome this gap.

There have been few extreme disaster events in Australia, so that the understanding of their costs is poor.

Knowledge of the potential cost of future extreme events can guide the development of measures to reduce their impact.

The Cities Project being implemented by the Australian Geological Survey Organisation in Queensland and Western Australia provides an excellent tool for analysing the vulnerability of communities to natural disasters.

Together with the models developed by the Cities Project of potential impacts of disasters on local communities, the methods presented in this report could provide a useful means of estimating the future costs of extreme events.

Finally, the costing of past events is not necessarily a reliable guide to the impacts of future events. More recent developments in technology and logistics can affect the scale of a disaster. For example, the greater reliance of some communities on sophisticated computer-controlled systems and just-in-time scheduling can increase the impact of natural disasters if these systems and facilities are disrupted.

Research is therefore needed on how these developments might affect the vulnerability of communities.

Disaster	Previous cost estimate	BTE cost estimate
Nyngan flood (1990)	$57.8 million	$46.4 million
Lismore flood (1974)	$89.4 million	$84.1 million
Cyclone Tracy (1974)	$4.2 billion	$1.97 billion
Ash Wednesday Bushfires (1983)	$975 million	$967 million
Edgecumbe (New Zealand) Earthquake (1988)[a]	$373 million	$357.7 million

a. Costs are in New Zealand 1987 prices

Table 4: comparison of past report estimates and bte estimates

References

Bureau of Transport Economics 2001, *Economic Costs of Natural Disasters in Australia*, Bureau of Transport Economics, Canberra.

NSW Coroner 1994, *New South Wales Bushfire Inquiry; Findings of the Coroner*, Sydney.

Read Sturgess & Associates 2000, *Rapid Appraisal Method (RAM) for Floodplain Management*, Department of Natural Resources and Environment, Melbourne.

Smith D.I. 1994, 'Flood damage estimation—A review of urban stage-damage curves and loss functions', *Water South Africa*, vol. 20, no. 3, July, pp. 231–238.

Smith D.I., Den Exter P., Dowling M.A., Jeliffe P.A., Munro R.G. and Martin W.C. 1979, *Flood Damage in the Richmond River Valley New South Wales: An Assessment of Tangible and Intangible Damages*, ANU Press for the Richmond Interdepartmental Committee, Canberra.

Thompson P. and Handmer J. 1996, *Economic Assessment of Disaster Mitigation: An Australian Guide*, Centre for Resource Environmental Studies, ANU and Flood Hazard Research Centre, Middlesex University for the Australian IDNDR Committee.

Author's contact details

For further information regarding the report please contact:
Sharyn Kierce
Bureau of Transport Economics
Department of Transport & Regional Services
GPO Box 501, Canberra ACT 2601
Phone: 02 6274 7176
Fax: 02 6274 6816
Email: Sharyn.Kierce@dotrs.gov.au

Copies of the report are available for purchase from Ausinfo: www.bte.gov.au