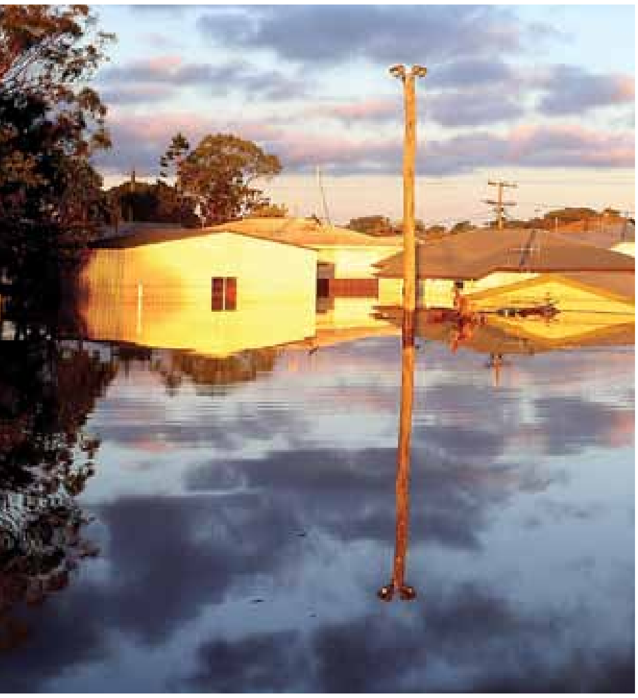
Deloitte Access Economics

Building our nation's resilience to natural disasters

Australian Business Roundtable for Disaster Resilience and Safer Communities

Deloitte.



About the Australian Business Roundtable for Disaster Resilience and Safer Communities

The *Australian Business Roundtable for Disaster Resilience and Safer Communities* was formed in December 2012 by the Chief Executive Officers of: Australian Red Cross, Insurance Australia Group, Investa Property Group, Munich Re, Optus and Westpac Group.

Following an unprecedented number of floods, storms and bushfires that have devastated life and property across Australia in recent years; Chief Executive Officers Mr Robert Tickner, Mr Mike Wilkins, Mr Scott MacDonald, Mr Heinrich Eder, Mr Kevin Russell and Mrs Gail Kelly created the Roundtable as all believe building resilient communities that can adapt to extreme weather events is of national importance.

Deloitte Access Economics was commissioned to prepare the following comprehensive paper in response to the call in the *Australian Government's National Strategy for Disaster Resilience* for greater collaboration between government, business and community to reduce Australia's vulnerability to natural disasters.

Bundaberg, Queensland January 2013

Contents

Glossary

Adaptation

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects. Adaptation can be carried out in response to (post-disaster) or in anticipation of (pre-disaster) changes in weather risks. It entails a process by which measures and behaviours to prevent, moderate, cope with and take advantage of the consequences of climate events are planned, enhanced, developed and implemented. (The World Bank, 2012) *This paper is focused on the '**pre-disaster**' component of adaptation.*

Benefit cost ratio

A benefit-cost ratio (BCR) is an indicator that attempts to summarize the overall value for money of a project or proposal. A BCR is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms. All benefits and costs should be expressed in discounted present values.

Disaster risk reduction

The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events. (United Nations, 2009).

Emergency Management

Emergency management has four areas of focus: prevention, preparedness, response and recovery (Australian Government – Attorney General's Department, 2011a). *This paper is focused on the **prevention** aspects of the emergency management approach.*

Mitigation

Measures taken in advance of a disaster aimed at decreasing or eliminating its impact on society and environment. (Council of Australian Governments, 2011) *[In climate change terminology, mitigation refers to actions to address the causes of climate change. This generally involves actions to reduce anthropogenic emissions of greenhouse gases that may contribute to the warming of the atmosphere. This is **not** the definition of mitigation used in this paper.]*

Preparedness

To protect our people, assets, infrastructure and institutions from disaster events; and to establish, train and exercise arrangements to respond to, and recover from a disaster event. (Prosser & Peters, 2010).

Prevention

To hinder, deter and mitigate disasters, while maintaining readiness to deal with disaster events. (Prosser & Peters, 2010).

Recovery

To return national and community life to normal as quickly as possible after a disaster event, through the restoration of social, economic, physical and environmental wellbeing. (Prosser & Peters, 2010).

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. (United Nations, 2009) *This paper is focused on the component of resilience that deals with 'resisting' or **actions taken in advance of a disaster** to reduce the impact of hazards.*

Response

To respond rapidly and decisively to a disaster event and manage its immediate consequences. (Prosser & Peters, 2010).

Acronyms

ABCB	Australian Building Codes Board
ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AGDRP	Australian Government Disaster Recovery Payment
ANZEMC	Australian New Zealand Emergency Management Committee
AWE	Average Weekly Earnings
BCA	Building Code of Australia
BCR	Benefit-Cost Ratio
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BTE	Bureau of Transport Economics
CBA	Cost Benefit Analysis
CCS	Civil Contingencies Secretariat
COAG	Council of Australian Governments
CPI	Consumer Price Index
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAE	Deloitte Access Economics
DIRS	Disaster Income Recovery Subsidy
DRR	Disaster Risk Reduction
EIA	Economic Impact Assessment
EIS	Economic Impact Statement
EMA	Emergency Management Australia
ERA	Economic Regulation Authority of Western Australia
EU	European Union
FEMA	Federal Emergency Management Authority
FIMA	Federal Insurance and Mitigation Administration
G-NAF	Geocoded National Address File
HFA	Hyogo Framework for Action
HM	Her Majesty's

HMA	Hazard Mitigation Assistance
IAG	Insurance Australia Group
ICA	Insurance Council of Australia
IMF	International Monetary Fund
IRR	Internal Rate of Return
LGA	Local Government Area
NCC	National Construction Code
NCCARF	National Climate Change Adaptation Research Facility
NDRRA	Natural Disaster Relief and Recovery Arrangements
NFRIP	National Flood Risk Information Project
NIAC	National Insurance Affordability Council
NPA-NDR	National Partnership Agreement on Natural Disaster Resilience
NPV	Net Present Value
NSDR	National Strategy for Disaster Resilience
NYS OEM	New York State Office of Emergency Management
OBPR	The Office of Best Practice Regulation
OECD	Organisation for Economic Co-operation and Development
PC	Productivity Commission
PHD	Personal Hardship and Distress
PMF	Probable Maximum Flood
PSMA	Public Sector Mapping Agencies
RIS	Regulatory Impact Statement
SCCC	Select Council on Climate Change
SCPEM	Standing Council on Police and Emergency Management
SEQ	South East Queensland
UN	United Nations
UNISDR	United Nations International Strategy for Disaster Reduction
UNDP	United Nations Development Program
VSL	Value of Statistical Life

Executive Summary

The financial and emotional burden of natural disasters in Australia has been great and the costs of extreme weather events continue to rise

Protecting lives and property is an enduring issue for all Australians and the opportunity remains to develop a national, long-term preventative approach to managing natural disasters and protecting our communities.

Over the last four years, natural disasters around Australia including the Black Saturday bushfires in Victoria, Cyclone Yasi in Northern Queensland, and widespread flooding across Queensland, Victoria, Tasmania and NSW have claimed more than 200 lives and directly affected hundreds of thousands of people.

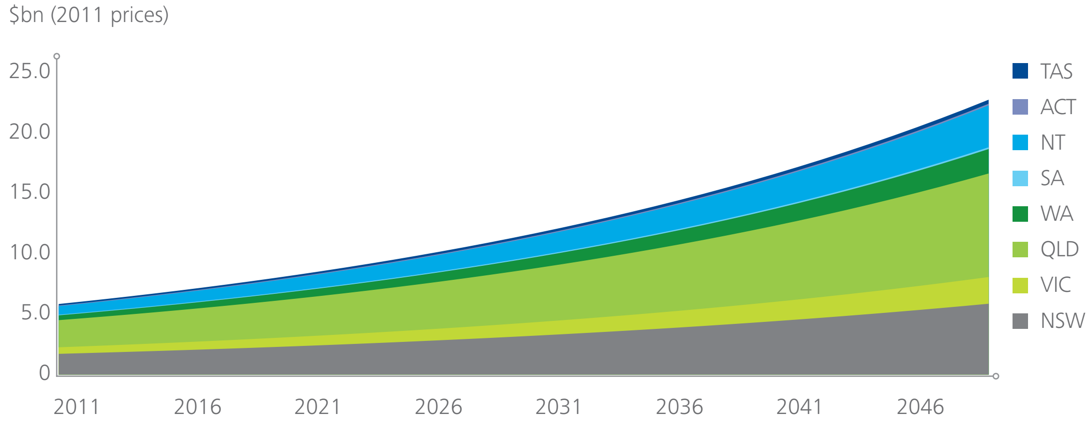
In 2012 alone, the total economic cost of natural disasters in Australia is estimated to have exceeded $6 billion. Further, these costs are expected to double by 2030 and to rise to an average of $23 billion per year by 2050, even without any consideration of the potential impact of climate change (Chart i).

Each year an estimated $560 million is spent on post-disaster relief and recovery by the Australian Government compared with an estimated consistent annual expenditure of $50 million[1] on pre-disaster resilience: a ratio of more than $10 post-disaster for every $1 spent pre-disaster[1].

These material social and economic costs have, understandably, generated considerable discussion on how we might reduce our vulnerabilities to natural disaster threats. As recognised in the National Strategy for Disaster Resilience (NSDR), the task of building more resilient communities is complex and requires greater collaboration between government, business and community.

In response, the *Australian Business Roundtable for Disaster Resilience and Safer Communities* was formed with the aim of working constructively with governments by contributing expertise, research and resources to address the challenge.

Chart i: Forecast of total economic cost of natural disasters: 2011 – 2050



Source: Deloitte Access Economics (2013)

1 The Australian Government Budget 2013-2014, handed down on 14 May 2013, allocated $50 million per year over two years to reduce flood risk.

"His Excellency, however, still cherishes the hope that the calamities which have befallen the settlers will produce at least the good effect of stimulating them to the highly expedient and indispensable measure of proceeding to establish their future residences in the townships allotted for the preservation of themselves, their families and their property"

Governor General Lachlan Macquarie, Government and General Orders, Government House, Sydney, Wednesday 5th March. 1817. Civil Department

The research outlined in this paper demonstrates that the opportunity exists for Australia to design a more sustainable and comprehensive national approach to making communities safer and more resilient.

It shows that the budgetary impact of responding to and recovering from natural disasters could potentially be significantly reduced through carefully considered and directed investment in pre-disaster resilience.

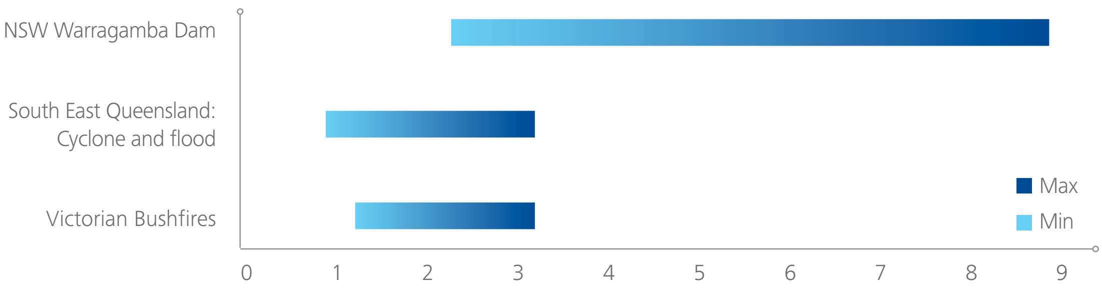
For example, an annual program of Australian Government expenditure on pre-disaster resilience of $250 million at the national level has the potential to generate budget savings of $12.2 billion for all levels of government (including $9.8 billion for the Australian Government) and would reduce natural disaster costs by more than 50% by 2050.

While different resilience measures show a wide range of benefit-cost ratios (BCRs) (see Chart ii below), investments that target high-risk locations using appropriate combinations of infrastructure, policy and procedure carry the highest BCRs.

As demonstrated in the case studies contained within this paper, cost effective action can be taken[2]:

- A program focussing on building more resilient new houses in high cyclone risk areas of South-East Queensland would reduce the risk of cyclone-related damage for these houses by around two thirds, and generate a BCR of up to three. Existing houses can be particularly challenging to retrofit but the BCR approaches one in high risk areas
- Raising the Warragamba Dam wall by 23 metres would reduce annualised average flood costs by around three quarters, and generate a BCR of between 2.2 and 8.5. This would result in a reduction in the present value of flood costs between 2013 and 2050 from $4.1 billion to $1.1 billion, a saving of some $3.0 billion
- Building more resilient housing in high risk bushfire areas generates a BCR of around 1.4; improved vegetation management a BCR of around 1.3, and undergrounding electricity wires results in a BCR of up to 3.1.

Chart ii: Case Studies – Ranges of Benefit-Cost Ratios of specific resilience measures



Source: Deloitte Access Economics, (2013)

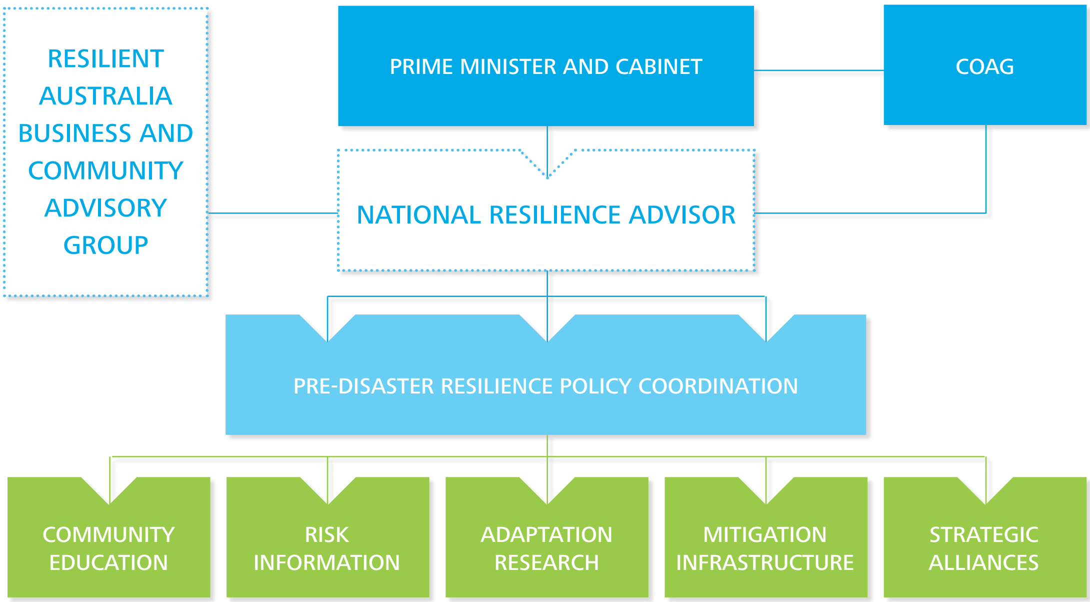
2 In each case, the estimated BCRs have been based on data and information drawn from existing studies as well as data provided by Roundtable members. As with all government investment decisions, detailed analysis utilising the latest engineering and technical data should be conducted along with comprehensive impact assessment to assess the full extent of possible environmental effects.

These case studies represent only a small selection of the natural disaster risks present in Australia but they highlight the need for a new approach to tackle the most complex challenges:

- Prioritisation of mitigation and investment options based on appropriate economic value and risk assessment. This includes finding mechanisms that allow key investment decisions to be taken at a localised level, often property by property. Those decisions can be supported by government through the provision of information and incentives and by the private sector through price signals that reflect the risks involved
- Higher quality planning standards required of local government, to ensure no further development is allowed in areas of unacceptable risk and that building standards reflect the need to protect property, as well as lives
- An increased effort to co-ordinate and update existing data, natural resource mapping and assessments that may exist across government departments needs to be prioritised and integrated into land use planning. This will enable the government to provide a more informed and consolidated approach to planning decisions and land management
- Commitment to recurrent funding of education and awareness programs aimed at helping people to adapt to living with the threat of disaster to promote long term behavioural change (e.g. along similar lines to road accident prevention campaigns).

The research presented highlights the opportunity to develop a national, long-term approach to managing natural disasters, through a co-ordinated and collaborative response. Importantly, the policy response to building our nation's resilience to natural disasters must **focus on prevention.**

Figure i: Building a more resilient Australia



PRINCIPLE: CENTRAL GOVERNMENT FOCUS WITH STRONG SUPPORT FROM BUSINESS TO ADDRESS THE COORDINATION CHALLENGE

Recommendations

This paper offers three key recommendations:

1 **Improve co-ordination of pre-disaster resilience by appointing a National Resilience Advisor and establishing a Business and Community Advisory Group.**

Developing resilient communities should be elevated to the centre of government decision-making to deliver effective and efficient coordination of activities across all levels of government, business, communities and individuals. This should be directly supported by a Business and Community Advisory Group to help facilitate a more co-ordinated response and to ensure that business and the not-for-profit sector are represented at the highest levels of policy development and decision-making.

2 **Commit to long term annual consolidated funding for pre-disaster resilience.**

All levels of government – led by the National Resilience Advisor – should commit to consolidating current outlays on mitigation and to funding a long-term program which significantly boosts investment in mitigation infrastructure and activity.

Critical to this success will be support for the consolidation of existing information and commissioning of additional data where needed. This will assist in the development and implementation of effective local responses by governments, businesses and the community.

3 **Identify and prioritise pre-disaster investment activities that deliver a positive net impact on future budget outlays.**

A program of mitigation activity should be developed based on cost-benefit analysis that demonstrates a clear positive outcome from investing in pre-disaster resilience measures.

Prioritisation of these activities should be informed by analysis of research, information and data sets allowing key investment decisions to be taken at all levels, including government incentives and price signals from the private sector.

Conclusion

The Australian Business Roundtable for Disaster Resilience and Safer Communities formed to contribute to the national discussion on how Australia might reduce its vulnerabilty to natural disasters. This paper fills an important information gap, both here in Australia, and internationally, on the potential outcome of mitigation activities at an aggregate, or national, level.

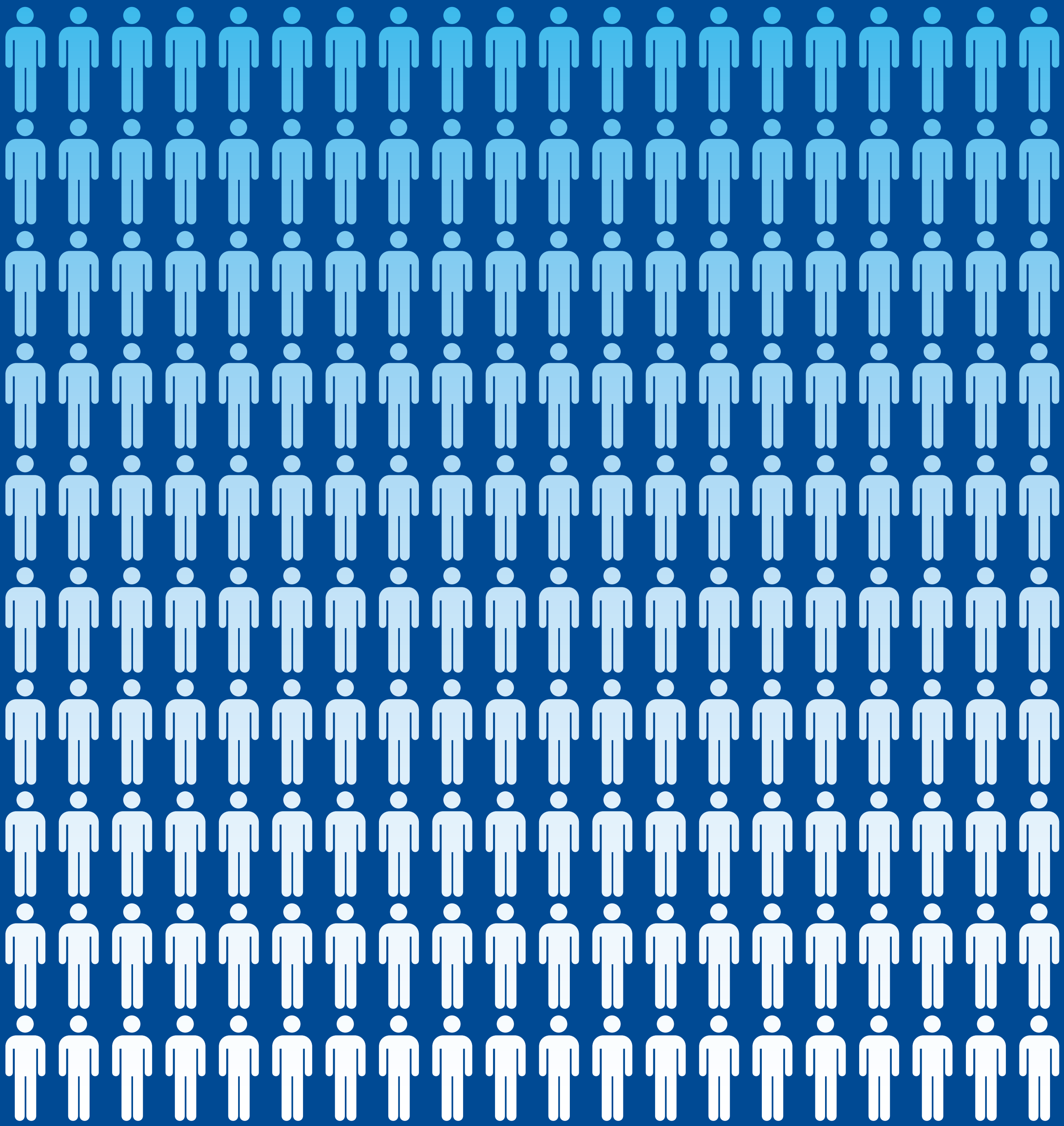
The paper outlines a new approach for effective and prioritised pre-disaster investments across the country and highlights the importance of integrated information and activity across government, business and community.

By pursuing the paper's key recommendations, economic costs can be materially reduced, as well as relieving long term pressures on government budgets.

More importantly, a safer Australia can be created through building resilience against the trauma and loss of life that all too frequently confronts many of our communities when a natural disaster strikes.

Brisbane River Flood Map, Queensland 2012

2009–2011



200 LIVES LOST

AND MANY THOUSANDS OF PEOPLE AFFECTED

1. Introduction

Key Points

- The financial and emotional burden of natural disasters in Australia is large and set to rise. As recognised in the National Strategy for Disaster Resilience, building more resilient communities is complex and challenging, but possible to achieve
- This paper focuses on pre-disaster resilience measures to resist the impacts of natural disasters rather than measures during and in the aftermath of disaster
- The greatest benefit from disaster resilience measures but arguably the biggest coordination challenge involves existing residential buildings (retrofit, compliance and relocation).

The financial and emotional burden of natural disasters in Australia has been great and the cost of extreme weather events has continued to increase over time. Protecting lives and property is an enduring issue for all Australians and the opportunity remains to develop a national, long-term approach to managing natural disasters and protecting our communities.

Australia is exposed to a broad range of natural disasters including storms, cyclones, floods, bushfires and earthquakes. Over the period from 1967 to 2012, Australia experienced on average, at least four major natural disasters per year where the insured loss exceeded $10 million (Insurance Council of Australia, 2013). These disasters have caused widespread destruction, threatened human lives and homes, damaged the broader natural environment and impacted key infrastructure. In addition, there have been numerous smaller scale disasters with equally devastating local consequences.

Some of the worst natural disasters have occurred in the last few years, including the 2009 Black Saturday bushfires, which claimed numerous lives and destroyed homes in Victoria; Cyclone Yasi, which hit northern Queensland in February of 2011; and the widespread flooding across Queensland that same year. Over the three years 2009–2011, more than 200 lives were lost and hundreds of thousands of people were directly affected by natural disasters around Australia.

Evidence from climate change research suggests that some natural disasters can be expected to increase in incidence and severity in future years, with geographical changes in at-risk areas (Intergovernmental Panel on Climate Change, 2012).

The research presented in this paper, however, is based on the current incidence of natural disasters only, and does not reflect any expected increase or shift in the currently observed level and severity of natural disasters. The potential impacts of climate change will serve to make this research more compelling and strengthen the case for preparedness now.

What does a resilient community look like?

A resilient community is one which has procedures in place to minimise the impact of a disruptive event and to ensure that recovery is timely and effective. To be resilient is to be prepared but also dynamic, flexible and quick to respond.

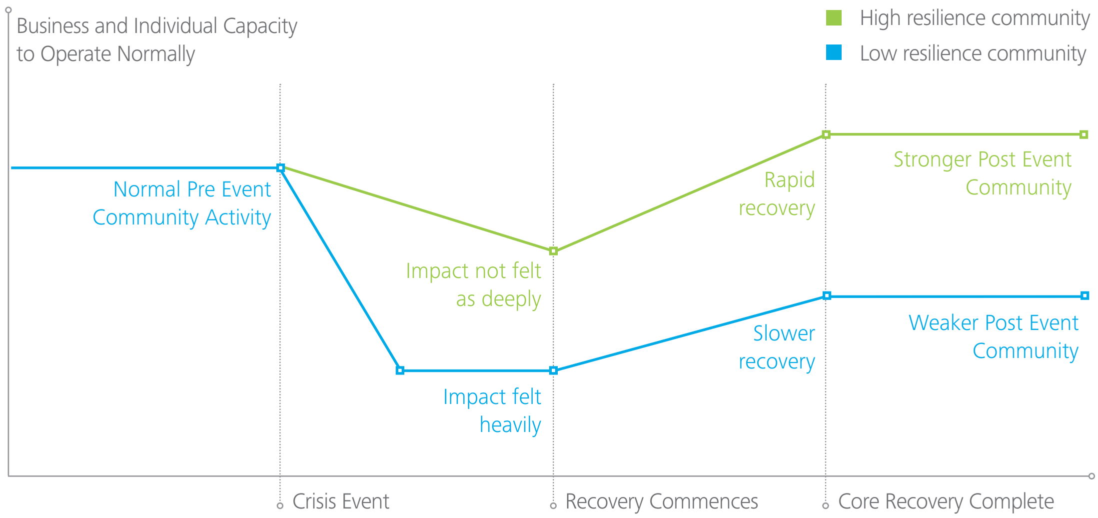
Figure 1.1 demonstrates the difference in capacity to operate normally following a disaster for a high and low resilience community. The focus of the research in this paper is on measures that can be taken before a natural disaster happens, or **pre-disaster** resilience, rather than relief and recovery from disasters.

The National Strategy for Disaster Resilience (NSDR) (Commonwealth of Australian Governments (COAG) 2011) is the core Australian Government policy which deals with the issue of natural disasters. The NSDR lays a clear pathway for what needs to be done. The strategy builds from the Council of Australian Governments (COAG) agreement in 2009 to adopt a whole-of-nation approach to disaster resilience and management. It recognises that a national, coordinated and cooperative effort is needed to enhance Australia's capacity to withstand and recover from emergencies and disasters. The strategy clearly acknowledges the roles of businesses, community organisations and individuals, as well as government.

The Australian Government approach to emergency management has four key focus areas which encapsulate the elements of prevention, preparedness, response and recovery. While each area is important, the focus of the research in this paper explores the pre-disaster aspects of resilience that fall under the notion of prevention.

Over the past five years there has been greater recognition of the need to build a more resilient Australia. In addition to the NSDR, this is also evident in a number of government programs, reports and inquiries. For example, in November 2012, the COAG Select Council on Climate Change (SCCC) adopted a document outlining the roles and responsibilities of different groups within Australia as a 'statement of common understanding' (SCCC, 2012).

Figure 1.1: Impact of high/low resilience community post crisis event



Source: Insurance Council of Australia (2008)

The responsibilities outlined by the SCCC, whilst specific to climate change, are also highly relevant to the case for natural disaster resilience. This paper aligns with the SCCC 'statement of common understanding' and seeks to explore how this might be implemented. Tackling the coordination challenges and alignment of incentives across all stakeholders is the key to unlocking a more resilient Australia.

The nature of the issues faced is laid out in **Appendix A.** This analysis points clearly to areas which deserve greater focus for government, business, communities and individuals. The analysis has an initial focus on 'hard adaptation' activities required. It then looks at what is necessary from a 'soft adaptation'[3] perspective to better understand the coordination issue to be addressed in developing a more resilient and safer community.

The critical role for government is to develop and share appropriate information and develop high-level awareness of risks. While planning reform and enhanced building codes are an important element of building resilience, they only affect new and renovated homes. The greatest impact of resilience measures but arguably the biggest coordination challenge, lies with existing residential buildings (retrofit, compliance and relocation). It is often more technically difficult and costly to retro-fit an existing property to be disaster resilient. Further, over time resilience measures may deteriorate (e.g. clearing vegetation around homes in bush fire risk areas) and so the property and surrounding environment must be appropriately maintained to ensure ongoing resilience. This is challenging as it requires sustained and consistent localised management.

What is also well recognised is the importance of ground-up involvement and empowerment of communities in understanding the unique risks that they face in their particular circumstances. The concept of social capital is one that is difficult to measure from an economic perspective but is a critical attribute of a resilient Australia.

3 'Hard' adaptation measures usually imply the use of specific technologies and actions involving capital goods, such as levees, seawalls and reinforced buildings, whereas 'soft' adaptation measures focus on information, capacity building, policy and strategy development, and institutional arrangements.

Resilience and social capital

Social capital refers to networks of formal and informal organisations, combined with strong community leadership, which can be drawn on in times of need. It has been shown to save lives, encourage the sharing of information and resources, provide a basis for the planning and implementation of tasks and ensure appropriate self-advocacy on the basis of need. Social capital can be invested in and drawn on in times of need.

The concept of social capital has been incorporated in the Red Cross' Emergency REDiPlan – a community education program which helps people prepare for, respond to and recover from natural disasters.

Source: Australian Red Cross (2013)

The attention to, and progress on, resilience issues is not unique to Australia. International action in this area is explored in **Appendix B.**

For example, Australia is an active participate in the UNISDR program, the Hyogo Framework for Action (HFA) (2005–2015). The Hyogo framework, adopted in 2005, aims to substantially reduce losses from natural disasters by 2015. More recently, in April 2013, the European Commission announced a package to advance action on adaptation to climate change in the European Union (EU). This package sets out a framework and mechanisms for taking the EU's preparedness for current and future climate impacts to a new level. This framework points clearly to the need for better informed decision-making to address gaps in knowledge about adaptation and the need to collate, build and share that adaptation knowledge.

Structure of this paper

This paper is set out as follows:

Chapter 2: Quantifies and forecasts total economic costs of natural disasters in Australia and considers the budget implications of these costs.

Chapter 3: Considers the current roles and responsibilities in disaster management in Australia.

Chapter 4: Provides three case studies which indicate how carefully coordinated pre-disaster investment has the potential to reduce future economic costs of disasters.

Chapter 5: Provides recommendations for future action in the area of pre-disaster resilience.

Supporting information is provided in six Appendices:

Appendix A: Sets out the structure of the problem to provide a clearer view on where the greatest problems lie and what the potential roles for all stakeholders could be.

Appendix B: Looks at some key overseas examples (the Netherlands, US and the UK) to explore how they are dealing with similar issues and to draw lessons for Australia.

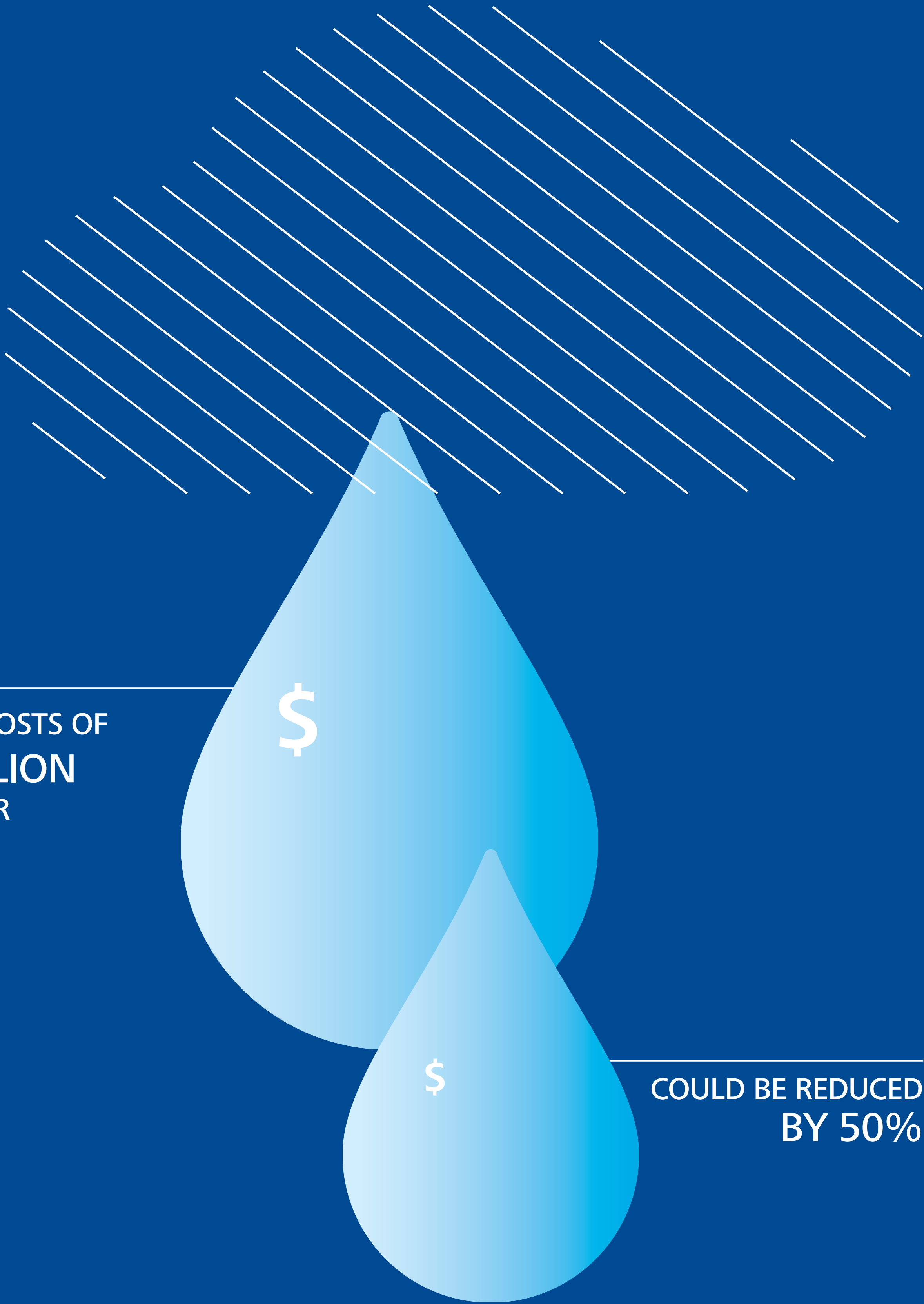
Appendix C: Provides the methodology for forecasting natural disaster costs.

Appendix D: Highlights relevant recommendations from the recent Productivity Commission report into Climate Change Adaptation, along with the responses from the Australian Government.

Appendix E: Outlines the cost-benefit methodology used for the case studies.

Appendix F: Provides a detailed Benefit-Cost Handbook for Local Governments.

2050



BY 2050 COSTS OF
$23 BILLION
EACH YEAR

COULD BE REDUCED
BY 50%

2. The costs of natural disasters

Key Points

- Without action, the forecast annual cost in real terms of natural disasters (across government, business and communities) in Australia is expected to reach $23 billion by 2050
- Despite the significant impact this will have on Australian Government relief and recovery payments, the forward estimates of the Federal Budget make no allowance for expected natural disaster expenditure
- Full consideration needs to be given to the virtuous budget impact of outlays on disaster resilience – funding prioritised for pre-disaster mitigation activities now will reduce public money spent on post-disaster recovery in the future
- The future cost of natural disaster relief and recovery could be reduced by 50% by 2050.

Australia is exposed to both frequent and large natural disasters that have the potential to destroy private property and essential infrastructure, causing problems for government, businesses and communities. Even without factoring in any findings from climate change research, there is clear evidence that the costs of natural disasters have risen materially over time. It is likely, therefore, that the forecast costs presented here are conservative.

2.1 Historic economic costs of natural disasters

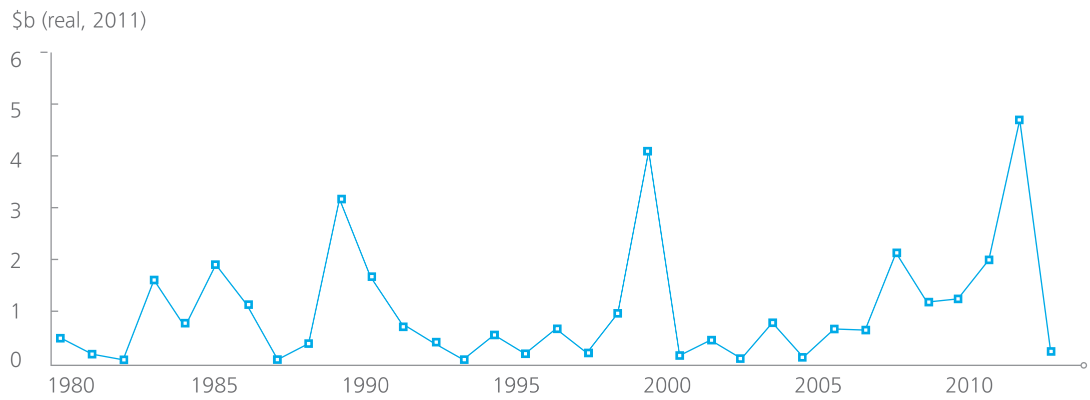
The costs of natural disasters throughout Australian history are substantial. Between 2000 and 2012 alone, the insured losses (borne by insurers) totalled $16.1 billion, an average of over $1.2 billion per year.

These costs vary significantly from year to year. Chart 2.1 illustrates the movements in total annual insured costs due to natural disasters from 1980 to 2012.

There are three major peaks – in 1989, 1999 and 2011. These years mark some of the worst natural disasters in Australia's recent history, although there have been other years with similarly large costs (such as 1974). Table 2.1 presents a costing of the extreme events that occurred in these years, and provides some indication of the growth in insured losses over time.

- In 1989, Newcastle was struck by a magnitude 5.6 earthquake. It took the lives of 13 people and caused extensive damage to property and infrastructure
- In April 1999, an intense hailstorm hit the eastern and inner suburbs of Sydney, damaging properties, vehicles and aircraft
- Of the last 30 years, 2011 was the most costly in terms of real annual insured losses due to the Queensland floods and Tropical Cyclone Yasi.

Chart 2.1: Insured costs of natural disasters, 1980–2012



Source: Insurance Council of Australia (2013)

Table 2.1: Real insured costs of extreme disaster events ($m, 2011 prices)

	1989		1999		2011
Melbourne Floods and Storm	$74	South East Queensland Floods and Storm	$7	Queensland Floods	$2,388
Cyclone Aivu	$138	Cyclone Rona	$14	Victorian Floods	$126
Ballarat Hailstorm	$81	Moora Floods	$12	Cyclone Yasi	$1,412
Newcastle Earthquake	$3,240	Cyclone Vance	$108	Melbourne Storms	$488
		Sydney Hailstorm	$4,296	Perth Bushfires	$35
		Wollongong Floods and Storm	$11	Margaret River Bushfires	$53
		Sydney Storm	$89	Melbourne Storms	$729
		Victorian Floods and Storm	$23		
All Events	**$3,533**	**All Events**	**$4,560**	**All Events**	**$5,231**

Source: Insurance Council of Australia (2013)

Insured losses represent only a proportion of the total economic costs of natural disasters. Total economic costs incorporate broader social losses related to uninsured property and infrastructure, emergency response and intangible costs such as death, injury, relocation and stress.

As total economic costs are borne by many parties (including individuals, communities, businesses, all levels of government and insurers), they can be difficult to measure. Research conducted by the Bureau of Transport Economics (BTE) in 2001 attempted to estimate the total economic costs borne by Australians due to natural disasters. Using data from disaster events which occurred between 1967 and 1999, and restricting the analysis to cases where the total estimated cost exceeded $10 million, it was found that total economic costs were between two and five times greater than insured costs alone for most natural disasters.

It is, however, important to realise that the total costs of rare but extremely severe incidents can be much greater than these annual averages.

There is indication of an increase in economic costs over time, particularly since 2005. This trend in natural disaster costs is largely attributable to demographic and environmental factors (Risk Frontiers, 2011). In particular, the size and density of Australia's major cities has increased, due to a combination of population growth, and domestic and international migration. Critically, significant net migration has been recorded in northerly, coastal and city fringe disaster prone regions (Department of Immigration and Citizenship, 2011).

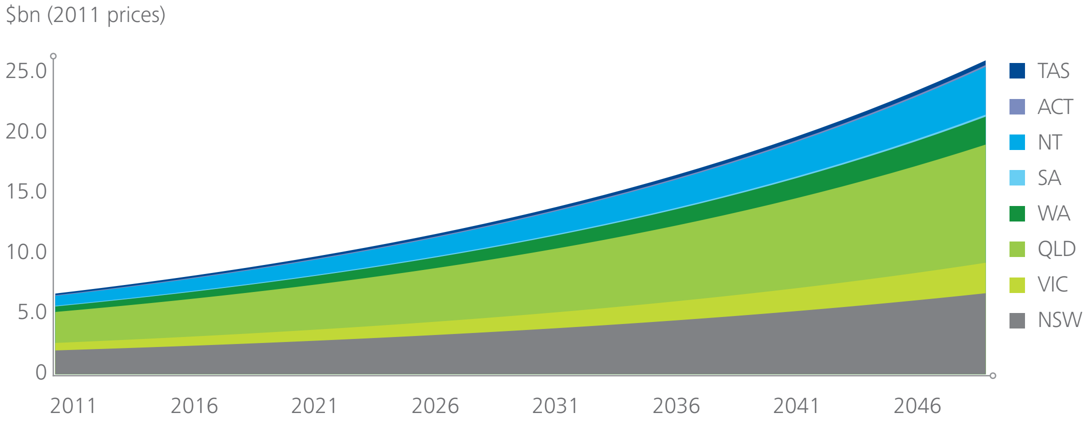
This pattern of migration has seen an increase in population density, supporting infrastructure and increasing value of assets in these areas. In addition, strong economic growth has led to the accumulation of higher value assets, increasing the economic risks posed by natural disasters. Combined, these factors have seen an increase in the exposure of Australia's economy to natural disaster risks and an increase in the costs of these disasters when they occur.

2.2 Forecasts of disaster costs in Australia

Using data on the incidence of past natural disasters in Australia (ICA, 2013), forecasts have been developed of the likely future costs of natural disasters. The process undertaken to generate these forecasts is described in **Appendix C.**

The forecasts presented capture three separate measures of expense: insured costs, total economic costs, and costs incurred by governments. As described earlier, insured costs represent the payouts made by insurance companies in response to eligible policy claims. To these costs must be added broader social costs which would not otherwise have been incurred had a disaster not taken place. The final additional costs relate to the likely financial obligations of local, state and federal Governments.

Chart 2.2: Forecast total economic cost of natural disasters: 2011 – 2050



Source: Deloitte Access Economics (2013)

At present, the total economic costs of natural disasters in Australia are estimated to average around $6.3 billion per year[4]. In real terms, this total is forecast to grow by 3.5% annually. This is primarily due to the likely impact of further population growth, concentrated infrastructure density, and the effect of internal migration to particularly vulnerable regions. With this growth rate, the annual total economic cost of natural disasters in Australia is expected to double by 2030 and reach $23 billion in real terms by 2050 (Chart 2.2).

2.3 Post-disaster relief and recovery expenditure

Relief and recovery financial assistance programs assist individuals and communities recover from a natural disaster and are an important aspect of disaster management. In recent years there has been a rising trend in disaster recovery expenditure by all levels of government against the increased intensity of events and corresponding number of people affected.

A range of on-the-ground relief and recovery programs put in place after disasters have developed over time. Currently a cost-sharing approach exists between the jurisdictions and the Australian Government to help manage individual and community recovery costs following large natural disasters.

4 These forecasts do not factor in any potential increased risk resulting from climate change. More detail on the modelling approach is provided in Appendix C.

2.3.1 Natural Disaster Relief and Recovery Arrangements and other payments

The State/Territories and Australian Government's cost-sharing system is largely composed of the Natural Disaster Relief and Recovery Arrangements (NDRRA). The NDRRA is a framework for the Australian Government to provide financial assistance to the states in the aftermath of natural disasters and it sets out the levels and conditions for this funding to be provided.

The NDRRA consists of:

- Assistance to individuals in the form of Personal Hardship and Distress payments (PHD)
- Assistance to communities, in the form of reimbursement of 50% to 75% of State and Territory expenditure on measures such as restoration or replacement of essential public infrastructure and concessional interest rate loans to small businesses, primary producers, voluntary non-profit bodies and needy individuals.

The Australian Government Disaster Recovery Payment (AGDRP) is a one-off payment to Australian residents affected by a major disaster in Australia or overseas. Ex-gratia payments provide one-off financial assistance to those adversely affected by a major disaster to help meet their basic, immediate needs.

Table 2.3: Estimated timing of NDRRA cash payments ($m) for past disasters (2013–14 budget)

	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Total
2012–13	289.1	–	0.7	52.6	–	7.2	–	16.3	365.9
2013–14	223	98.9	1,641.70	47.1	3.7	16.9	–	–	2,031.30
2014–15	2.9	0.1	2,909.10	0.1	–	–	–	–	2,912.30
2015–16		0.1	860.6	–	–	–	–	–	860.6
Total	**515.0**	**99.1**	**5,412.1**	**99.8**	**3.7**	**24.1**	**0.0**	**16.3**	**6,170.1**

Source: 2013–2014 Australian Government Budget (The Commonwealth of Australia, 2013)

Payments of almost $67 million in 2011–12 were made under the AGDRP and ex-gratia programs. A majority of this was from the AGDRP program for floods in New South Wales, Victoria and Queensland in early 2012. Disaster Income Recovery Subsidy (DIRS) assists employees, small businesses and farmers who can demonstrate a loss as a result of a natural disaster.

2.3.2 Implications for the Australian Government Budget

The cost implications for the Australian Government of the recent natural disasters in Australia are set out in Table 2.2. This table presents the cash payments to be made to the States in relation to past disasters under the National Disaster Relief and Recovery Arrangements (NDRRA). These figures are drawn from the 2013–14 Budget. While the payment of $365.9 million due to be made in the current financial year alone seems significant, this is only a proportion of the $3 billion payment made in 2011–12, and the payments of over $2 billion to be made in 2013–14 and 2014–15.

These forward estimates do not make a clear allowance for the costs of potential future natural disaster payments, and are simply defined as the present value of expected future payments. It is likely, these expected future payments are based on liabilities due from the ongoing recovery of past disasters and do not account for costs related to future events.

There is an opportunity to minimise future expenses by proactively developing best-practice resilience measures.

Based on historical averages, total annual costs to governments of natural disasters are expected to be around $700 million per year in real terms. This estimate is derived from the natural disaster costs estimated above and an assessment of historical data.

Historical data indicates that the Australian and state governments collectively face around 11% of the total economic costs of natural disasters. **It is estimated that 80% of this government expenditure is outlaid by the Australian Government.**

Considering the increase in natural disaster costs forecast over the period to 2050, it is anticipated that governments will eventually face an annual cost of around $2.3 billion in real terms (up from $700 million).

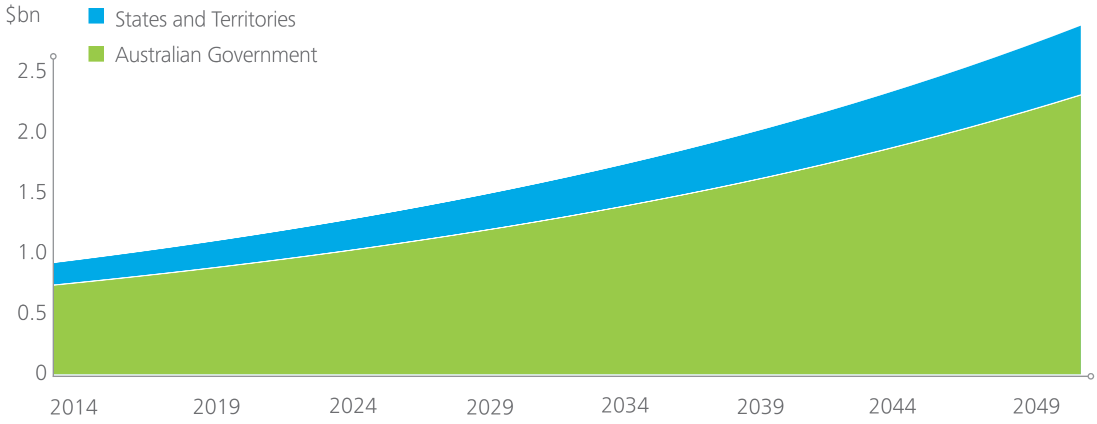
The projected trend over time is shown in Chart 2.3.

This analysis of government outlays is based solely on expenditure which falls under the NDRRA. Essentially, it encompasses most core natural disaster response programs from all levels of government, including emergency response, personal hardship support and reconstruction of infrastructure. It is important to note that this estimate does not capture the range of small, dispersed natural-disaster-related programs which sit outside the NDRRA. For instance, the funding of more resilient roads may fall under transport/infrastructure-related departments but is closely related to natural disasters.

Other measures have been taken to fund disaster recovery activity. Following the Queensland floods, the Australian Government was faced with undertaking an unprecedented infrastructure rebuilding program.

In response to significant costs associated with this rebuild, the Australian Government introduced a temporary flood and cyclone reconstruction levy (flood levy), which applied during the 2011–12 financial year only. To rebuild Queensland, the total expected costs for the Australian Government were estimated to be around $5.6 billion.

Chart 2.3: Forecast annual cost to governments of natural disasters: 2011 – 2050



Source: Deloitte Access Economics (2013)

At the time, Treasury estimated that the levy would raise around $1.8 billion over the 2011–12 year. This represented only one third of the total rebuilding costs. Hence, a further $2.8 billion was reprioritised through spending cuts and a further $1 billion in infrastructure reprioritisation to help fund the rebuild[5].

Clearly these measures were necessary to ensure the provision of critical services to communities affected. However, it may be seen as a more reactive, rather than sustainable, approach.

2.4 Summary

The expected future costs of natural disasters highlight the need for governments to invest further in resilience measures. As the government does not currently account for future disaster costs in the forward estimates, it is difficult to recognise the true cost advantages of building resilience.

A simple cost-benefit analysis demonstrates how government funds would be saved in the long run by bringing forward expenditure on natural disaster recovery and placing a greater level of investment in pre-disaster resilience measures.

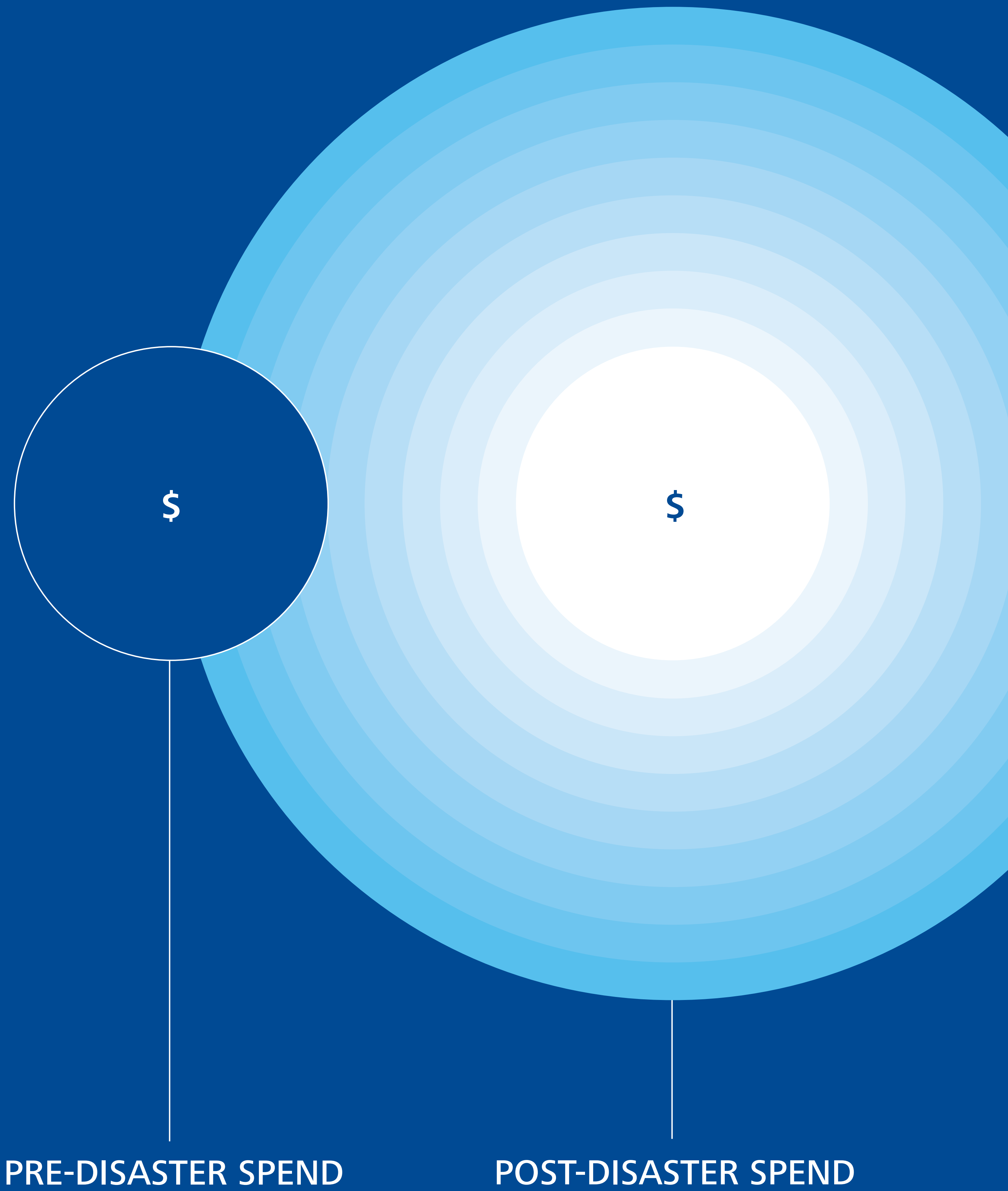
Assume, for example, that carefully targeted programs of resilience expenditure in the order of $250 m per annum achieved an overall Benefit-Cost Ratio (BCR) of around 1.25. This implies that this program of expenditure would incur costs in the order of $5.3 billion over the period to 2050 (present value terms) but would generate budget savings in the order of $12.2 billion for all levels of government (or $9.8 billion when looking at the Australian Government budget only).

If successfully implemented, this intervention could see Australian and state government expenditure on natural disaster response, fall by more than 50% by 2050.

The case studies examined in Chapter 4 illustrate opportunities to deliver a program of pre-disaster resilience that generates an average BCR of at least 1.25. Combined with the virtuous budget impact of this spending, the case for greater prioritised investment in pre-disaster mitigation activities seems clear.

5 The levy was payable by individuals whose taxable income was more than $50,000 during the financial year, with some exemptions. To fund the unexpected expenditure the Government cut green programs including the Green Car Innovation Fund, the Cleaner Car Rebate Scheme and other programs.

1:10 ratio



3. Roles and responsibilities in disaster management

Key Points

- Disaster management in Australia involves a complex range of stakeholders and activities
- There have been a number of reviews and inquiries undertaken at the federal and state government levels producing a wealth of information and insight into specific disaster events
- However, implementing recommendations related to pre-disaster resilience has been slow
- While some funding has been provided for pre-disaster resilience, the ratio of pre-disaster resilience funding to funding during and following disasters is low.

3.1 Recent inquiries and reviews

The prevailing principles of disaster management in Australia (prevention, preparedness, response and recovery) are evolving. Recent inquiries and reviews have highlighted the vital role of resilience in disaster management planning.

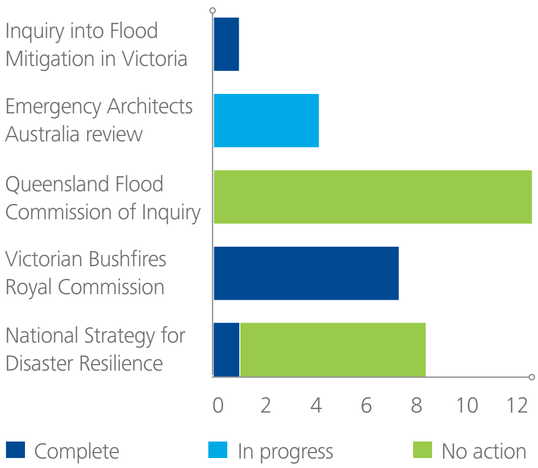
Since 2009 there have been a number of Inquiries/Reviews related to Natural Disasters, including:

- The Victorian Bushfires Royal Commission
- The Queensland Floods Commission of Inquiry
- The Australian Government's Natural Disaster Insurance Review
- Productivity Commission Inquiry into Regulatory and Policy Barriers to Effective Climate Change Adaptation
- Treasury Consultation Paper Reforming Flood Insurance: Clearing the Waters
- The Australian Government's Consultation Paper, Reforming flood insurance: A proposal to improve availability and transparency
- The Federal Parliamentary Inquiry into the operation of the insurance industry during disaster events
- The Federal Parliamentary Inquiry into Residential Strata Title Insurance
- Australian Government Actuary Report On Investigation into Strata Title Insurance Price Rises in North Queensland
- Senate Inquiry into Extreme Weather Frequency and Preparedness.

These reviews and inquiries outline an extensive list of recommendations and suggested courses of action for the Australian Government, state and local governments, and communities. While some of the recommendations have already been accepted and implemented, many remain in the consultation and planning phases. This suggests that, while disaster resilience is placed high on the agenda for future action, the issues are challenging and take time to resolve. In particular, actions which require the coordination of communities, local governments, state and the Australian Governments are less likely to have been completed.

Chart 3.1 demonstrates that, while most of the recommendations of inquiries have been considered and many are in progress, a majority remain incomplete[6].

Chart 3.1: Reviews and Inquiries: recommendations yet to be completed



6 The recommendations highlighted in the above chart include those that are related to the case studies outlined in Chapter 4. The reviews that were included in this analysis are: National Strategy for Disaster Resilience, National Disaster Insurance Review, Victorian Bushfires Royal Commission, Queensland Flood Commission of Inquiry, Queensland Flood Relief – Emergency Architects Australia, Brisbane backflow prevention measures investigation, Inquiry into Flood Mitigation in Victoria, Cyclone Testing Station. The bulk of the recommendations included in the Reviews and Inquiries relate to improvements in dealing with the disaster response and disaster recovery matters, only some of the recommendations are directly related to resilience. The Emergency Architects Australia report was an independent submission to the Queensland Floods Commission of Inquiry. The recommendations included in Chart 3.1 pertain to structures in flood prone areas, which are difficult to implement.

3.2 Current policy framework

COAG plays an important role in coordinating government responses to both natural disasters and human-caused risks to personal and community safety. 'Responding to disasters' is an existing issue under the COAG agenda for National Security and Community Safety. In 2011 COAG endorsed the resilience-based approach to emergency management, the National Strategy for Disaster Resilience.

However, there are also elements of pre-disaster resilience that reside within all current COAG reform agendas. Along with NSDR, there is the National Disaster Resilience Framework, Critical Infrastructure Resilience Strategy, and the National Climate Change Adaptation Action Plan as well as bodies such as the Australia New Zealand Emergency Management Committee, Trusted Information Sharing Network, the Climate Commission and the newly created National Insurance Affordability Council.

The fact that the scope of pre-disaster resilience spreads across a number of different agendas demonstrates the current fragmented nature of pre-disaster resilience and therefore the need for a fresh, sustainable and comprehensive national approach.

Through the NSDR, the current policy framework has recognised that disaster resilience is a shared responsibility for individuals, households, businesses and communities, as well as for governments. As outlined in the first chapter, the roles and responsibilities of the key stakeholders have been clearly articulated by government[7]:

- Building resilience should be assigned to those most appropriate to respond to local conditions; this will favour local initiatives and private responsibility where resilience has no external effects on third parties. That is, private parties will continue to take responsibility for their own actions, assets, investments and risks.
- Governments should respond to market failures and regulatory failures that prevent effective and efficient natural disaster risk management, focusing on:
  - Providing best available information about risks to facilitate adaptation by the private sector and making information accessible and useable
  - Ensuring that regulations, markets and institutions promote effective private risk management
  - Managing risks to public goods/assetsand government service delivery
  - Taking account of disaster risk in policy and planning
  - Helping build capacity and resilience, where required, particularly to assist vulnerable individuals, groups, regions and communities.
- Decision-making should:
  - Be based on the best available research
  - Be cost-effective
  - Be regularly reviewed to meet changing circumstances
  - Enhance social inclusion.

Based on this approach, the remainder of this chapter outlines the roles and responsibilities of key stakeholders, focusing on the activities that they currently undertake.

7 In November 2012, the COAG Select Council on Climate Change (SCCC) developed a set of guiding principles for the roles and responsibilities of key stakeholders that in this instance have been applied to pre-disaster resilience for natural disasters.

The range and breadth of activities attests to the importance of resilience in the broader policy agenda

3.3 Australian Government

Figure 3.1 demonstrates the current spread of Australian Government resilience activities across departments and governmental bodies. The range and breadth of activities attests to the importance of resilience in the broader policy agenda.

Figure 3.1: The current Australian Government approach to resilience in Australia

The Attorney General's Department, with its responsibility for Emergency Management Policy, is the core Australian Government department relating to disaster resilience. The **Responding to Disasters** COAG agenda is administered through the Standing Council on Police and Emergency Management (SCPEM) and the Australian New Zealand Emergency Management Committee (ANZEMC).

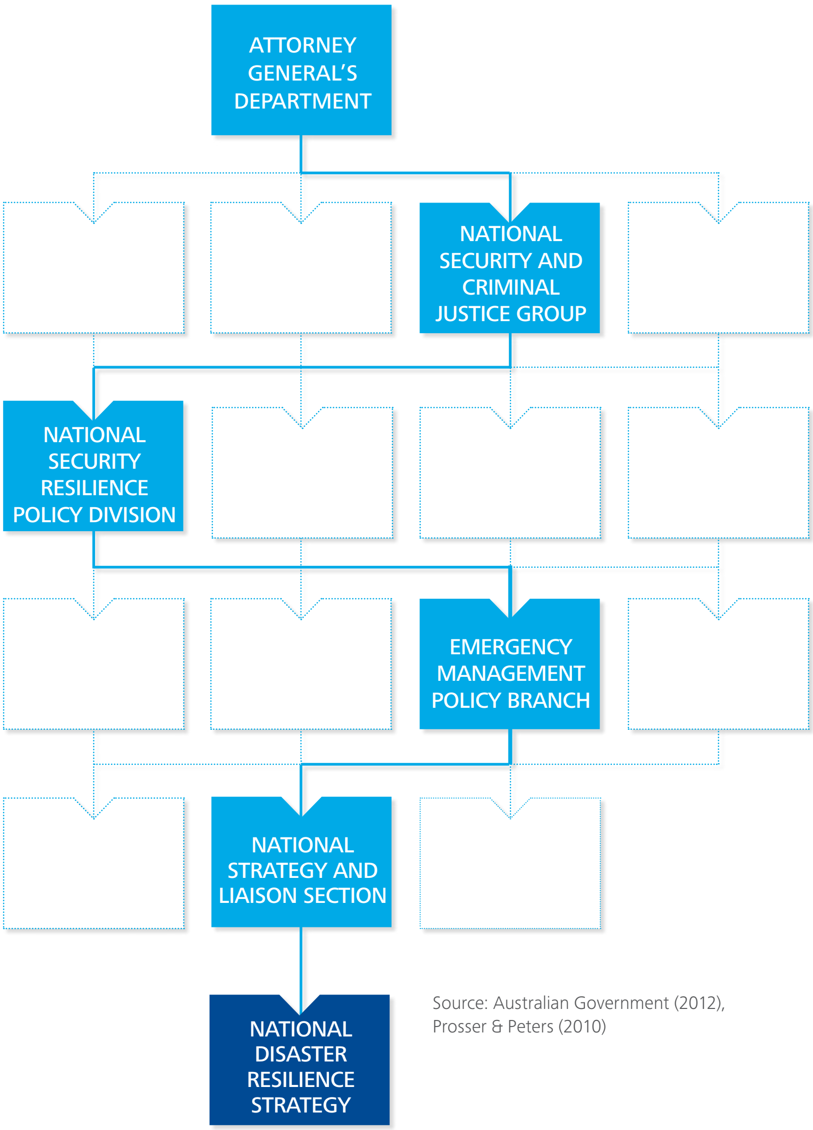
The ANZEMC meets twice yearly and reports to COAG through the Standing Council on Police and Emergency Management (SCPEM) whose focus is to:

- Promote a coordinated national response to law enforcement and emergency management issues
- Provide a framework for cooperation and shared strategic directions for the policing and emergency services of Australia and New Zealand
- Encourage and share best practice in police policy and operations, and in emergency management, across jurisdictions (Attorney General's Department, 2013).

Responsibility for driving the core strategy around disaster resilience – the NSDR – is housed in the Attorney General's Department, in the National Security Resilience Policy Division, Emergency Management Policy Branch, National Strategy and Liaison Section. The Division is responsible for policy, legislation, advice and programs related to developing resilience to all hazards, including the areas of critical infrastructure protection, electronic and identity security, and protective security policy.

Figure 3.2 illustrates this positioning of the NSDR within the Department.

Figure 3.2: Location of the National Disaster Resilience Strategy



Source: Australian Government (2012), Prosser & Peters (2010)

The Attorney General's Department's primary mechanism for pre-disaster resilience funding is the National Partnership Agreement on Natural Disaster Resilience (NPA–NDR)[8] administered in partnership with the states and territories. The program provides approximately $27 million per year to states and territories to fund disaster resilience programs (Australian Government – Attorney General's Department, 2011c). As the NPA–NDR is administered by the National Security Capability Development Division there is potential for further fragmentation of resilience policy and program delivery.

3.3.1 Natural Disaster Insurance Review/ National Insurance Affordability Council

Following the extreme weather events during the summer of 2010/11, the Natural Disaster Insurance Review was announced by the then Assistant Treasurer Bill Shorten. The review primarily focused on the availability and affordability of insurance offered by the private insurance market (Australian Government – Treasury, 2011). The review also addressed whether existing Australian and state government arrangements for natural disaster recovery and resilience require supplementation.

The proposal to establish a National Insurance Affordability Council (NIAC) is a recent outcome of this review (Australian Government – Department of Prime Minister and Cabinet, 2013). Although it is yet to receive Terms of Reference, the Council is expected to coordinate flood risk management and play a role in the collection of data and provision of mapping tools. It may also be involved in the identification of cost-effective mitigation investments. It is intended to broaden the program to include other natural disasters.

At least $100 million over two years will be directed towards mitigation projects, such as funding flood levees in at-risk areas. The agency will bypass the state and territory governments and accept funding requests directly from local councils and community groups across Australia. At present it is unclear how the Council will be structured, and how it will interact with other agencies such as Geoscience Australia. Nevertheless, it is anticipated that the Council will make important contributions to pre-disaster resilience on a national scale.

---

8 The NPA is an amalgamation of previous Australian Government programs, the Bushfire Mitigation Program, the Natural Disaster Mitigation Program and the National Emergency Volunteer Support Fund.

3.3.2 The Australian Building Codes Board

The development and management of building codes in Australia is undertaken at the national level by the Australian Building Codes Board (ABCB). Building standards in Australia are implemented and regulated at the state and territory level.

The role of building codes in increasing resilience

Building standards have undergone constant review, particularly after major natural disaster events and via research, to ensure adequate levels of safety and health are maintained for the community. Where the building standards proved to be inadequate, as identified in the wake of Cyclones Althea in 1971 and Tracy in 1974, they were subsequently upgraded. These improved standards for high-wind design were later demonstrated to be satisfactory as evidenced by the small number of building failures resulting from Cyclones Vance in 1999, Larry in 2006 and Yasi in 2011.

Recent changes to the regulatory regime show an ongoing commitment by Governments to improve the community's disaster resilience by modernising the Building Code of Australia (BCA). This has included the planned introduction of new National Construction Code (NCC) provisions to apply in flood hazard areas (Australian Building Codes Board, 2012). The new regulations took effect from May 2013. The Australian Building Codes Board has also recently finalised non-regulatory Handbooks on Community Bushfire Shelters and Building in Flood Prone Areas.

However, the benefits of changes to building codes need to be understood in the broader context. **Changes to building codes which apply to new residential buildings will affect only about 1.3% of the housing stock. It would take approximately 44 years for these changes to affect the housing stock as a whole** (Deloitte Access Economics, 2013 based on Australian Bureau of Statistics, 2010).

The difficulty of implementing changes to building codes as they affect existing housing is demonstrated in the recent Australian Government response to the Productivity Commission report (Australian Government, 2013). As described in **Appendix D**, it is particularly important to note that Recommendation 11.1 regarding mitigation for existing settlements was only 'noted' by the government. Although one of the hardest to implement, this is also one of the most important areas for resilience action.

In addition, building codes have tended to focus primarily on regulatory and engineering issues rather than economic considerations. This approach does not necessarily ensure that building codes maximise overall economic benefits.

3.3.3 Critical Infrastructure Planning

Natural disasters cause disruption to electricity networks, food and water supplies, health services, and communications systems. This compounds the costs of recovery for society, as limited access to these essential services inhibits the ability of communities to get back on track. Mitigation measures are necessary to minimise the impact of a disaster on these basic services.

The Critical Infrastructure Resilience Strategy, published in 2010, aims to reduce the exposure of Australian communities to risks posed by natural disasters. The strategy focuses on developing a process to improve resilience for physical facilities, supply chains, information technologies and communications networks, the loss of which would have significant impacts on the wellbeing of Australian communities (Australian Government – Attorney General's Department, 2010).

This approach is targeting ways to improve resilience, allowing for greater operational sustainability and business continuity in the aftermath of future disasters. For instance, infrastructure owners and operators are encouraged to participate in research projects through the Critical Infrastructure Program for Modelling and Analysis. This program captures interactions between critical infrastructure systems.

A comprehensive review of the effectiveness of the strategy is due in 2015. The Critical Infrastructure Resilience Strategy provides an example of how businesses, governments and communities have successfully worked together to build resilience. Further work is required to assist local councils, business, individuals and other interested stakeholders to achieve funding-assisted programs which will further drive investment into resilience infrastructure more broadly, particularly in residential areas.

> Work is needed to assist local councils, business and individuals to achieve funding-assisted programs which will drive resilience

3.3.4 Research into resilience

There are three main research bodies focused on pre-disaster resilience research: the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the National Climate Change Adaptation Research Facility (NCCARF) and the Bushfire Cooperative Research Centre (CRC). These are complemented by various universities focusing on resilience issues.

As Australia's national scientific agency, CSIRO undertakes research in relation to natural disasters. This plays a crucial role in supporting decisions into resilience investments. Specific examples of relevant activities include the use of 3D modelling techniques to simulate flood and storm surge behaviour, collection and analysis of bushfire data to target mitigation action, predicting the likelihood of disasters and associated financial losses to justify resilience investments and inform decision-making at the policy level.

Representatives from other national research bodies, including CSIRO and Geoscience Australia are actively involved with the NCCARF. Geoscience Australia also undertakes research into natural hazards and community safety including support for the National Work Program for Flood Mapping and operation of the Australian Tsunami Warning System and Sentinel bushfire monitoring system. Over the four years to 2015–16, enhancements of flood risk information will be allocated around $12.4 million.

Climate Adaptation National Research Flagship

In response to Australia's increasing vulnerability to natural disasters, the CSIRO established the Climate Adaptation Flagship in 2007.

The Flagship is a collaborative research partnership between the CSIRO, leading Australian scientists, research institutions and commercial companies, including the Bureau of Meteorology and the Australian Greenhouse Office. Its objective is to provide scientific information and expertise to enable the implementation of successful adaptation responses.

Upon establishment, it was granted $43.6 million to finance its first four years of operation. However, its funds are boosted from a number of sources on a project-by-project basis. For example, in 2010, the CSIRO Flagship Coastal Collaboration Cluster was launched, with $11 million assigned for the three-year project between a number of universities, the Climate Adaptation Flagship and the Wealth from Oceans Flagship. The purpose of the cluster was to collate and disperse knowledge to policy makers and planners in vulnerable coastal regions in a practical way.

Other important contributions of the Flagship fall within the key themes of 'pathways to adaptation', which relates to provision of accurate information, and 'sustainable cities and coasts', which focuses on the design of realistic adaptation solutions. In particular, the Flagship's series of working papers discuss vulnerabilities to natural disasters such as floods and cyclones.

Source: CSIRO (2013)

The NCCARF was established in 2008 as a partnership between the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education and Griffith University. Its role is to direct national research into the risks associated with climate change in an interdisciplinary manner.

The NCCARF is jointly funded by government and participating universities. The Australian Government is contributing $10 million, along with specific allowances under the Climate Change Adaptation Research Grants Program. However, the operations of the Facility expire in mid-2013. It has been proposed that the leadership of research be extended for another two years in the form of NCCARF2. It is estimated that this body will require government funding of $2 million annually, with an additional $1 million per year necessary to maintain the Adaptation Networks.

Specific research into bushfire hazards has also been undertaken by the Bushfire Cooperative Research Centre (Bushfire CRC), funded by the Australian Government's CRC Program since 2003. It concentrates its activities within three programs, aimed at understanding, communicating and managing risks.

In February this year, the Government announced that it would supply up to $47 million for the establishment of a new Bushfire and Natural Hazards Cooperative Research Centre. This organisation will lead further interdisciplinary research into the risks of floods, earthquakes, cyclones and tsunamis, as well as bushfires, to assist with policy and resource allocation decisions. With continued support, the Bushfire and Natural Hazards CRC will enable the application of pre-disaster measures for a variety of risks in a targeted, effective manner across the country.

3.4 State and territory governments

At the state and territory level, governments reinforce the national agenda on resilience matters, supporting the lead of the Australian Government and prioritising efforts on those resilience activities that will have the highest benefit within their jurisdictions. Whilst the overall approach needs to be consistent, the risks and responses will vary according to local conditions.

This proposed role should involve:

- Provision of local and regional science and information in a manner that is consistent with the rest of the country, and that also captures the risks of natural disasters at the regional level
- Implementing resilience measures to better protect public assets owned directly by the state/territory governments
- Working in conjunction with the Australian Government, and other states and territories, to protect assets that are located across borders
- Ensuring that resilience is adequately addressed in services such as emergency management, transport, land-use planning, environment, health services and public housing
- Establishing appropriate incentives, or regulatory requirements for resilience investment through legislation relating to state planning, property and environmental policies, such as building codes and engineering standards
- Supporting local governments with their role of promoting resilience at a community level.

In a number of instances, the implementation at the state level of the National Strategy for Disaster Resilience (NSDR) remains with departments largely responsible for Police and Emergency Management. It is important that resilience be raised in profile at the state and territory government level.

3.4.1 Land use planning

Land use planning is a key measure of resilience that is undertaken at the state level, and as such there are different principles applied across Australia. Appropriate planning prior to a natural disaster has the potential to significantly reduce the impact of natural disasters during and after an event. Careful consideration needs to be given to zoning land for residential or commercial use which is, or becomes, vulnerable to threats posed by natural disasters. Of particular concern is the ongoing use and development of land in areas that are continuously affected by natural disaster events.

Land use planning

State, territory and local governments should incorporate consideration of the impacts of weather volatility in land use planning decisions.

Land use planning regulation should: facilitate a risk management approach that promotes planning decisions that are robust across a range of climate change outcomes and are proportionate to the risks involved; moderate activities which retard adaptation by the community; and facilitate the provision of public goods.

Source: Productivity Commission (2012, p. 241)

In particular, a consistent framework for data collection and provision of regionally and locally relevant and accurate information is essential for land use planning and development decisions which promote effective pre-disaster resilience.

A national framework for data collection and management, established in consultation with the state and territories would be of assistance in implementing pre-disaster resilience in land development processes. Greater attention should be directed towards specifying how data will underpin planning outcomes, which modelling or mapping techniques should be used, and how these relate to zoning classifications.

3.5 Local government

Local governments are best placed to understand their localised circumstances and, provided they are equipped with the knowledge and skills required, can help to deliver the appropriately tailored resilience solution. On the frontline, local governments must cooperate effectively with members of the community; advise the states and territories on risk exposure; and work to implement suitable resilience measures in a timely and efficient manner. They are responsible for mobilising local resources and ensuring that households within their jurisdiction are well informed on how resilience relates to them.

Following consultation with local governments, it is clear that there is confusion as to where they can most appropriately apply for complementary funds in order to:

- Access information to prepare business cases and undertake community consultation
- Develop capabilities
- Appropriately and efficiently invest in mitigation activities.

Greater involvement of local governments during the planning stages of disaster resilience and improved access to better planning information will assist effective decision making to build resilient communities. Without clear guidelines on what data is available and how it should be used, the ability of local governments to promote pre-disaster resilience through land use planning and development will be reduced. Clear support for local government councillors and officials in understanding natural disasters risks, resilience adaptation options will support better decision making at the local level.

3.6 Businesses

Whilst governments have a responsibility to establish overarching policies and information to support resilience activities, business is best placed to develop market-based incentives to support resilience solutions.

Adding to the Guiding Principles generated by the Select Committee on Climate Change, business is well placed to assist government in the five key areas.

- **Education:** Developing public awareness and education campaigns
  Business has strong networks and a range of communication channels to provide tailored messages to individuals and communities to raise awareness at the local level.

- **Information:** Developing appropriate information sets
  Business has well developed information sets and can support government efforts to improve risk awareness and develop open platforms for risk information.

- **Adaptation Research:** Developing Best Practice
  Business expertise can support research efforts to develop best practice adaptation.

- **Pre-disaster resilience Infrastructure:** Supporting Incentives
  Business is well placed to develop and incorporate appropriate incentive structures into products and pricing to support efforts by governments to enhance resilience through public infrastructure.

- **Alliances:** Supporting business resilience and continuity
  Business has natural alliances through existing relationships and activities that are replicated at a local level.

3.7 Communities and individuals

Individuals are best placed to take responsibility for their own actions, assets, investments and risks. However, a socially responsible approach to building resilience would ensure that appropriate assistance is provided to particularly vulnerable individuals, groups, regions and communities[9].

Community and not-for-profit organisations are often the first responders in an emergency situation. It is these groups that are keenly aware of the disastrous impact that natural disasters can have on individuals and communities, and as such have been working with these groups to build resilience to natural disasters in Australia for a number of years.

Community action

In acknowledging the devastating impact that these events have had, community groups have developed innovative programs which focus on assisting individuals and communities prepare for natural disasters across Australia.

These include:

State Emergency Services: Throughout Australia, the State Emergency Services provide essential services during and after natural disasters. The State Emergency Services are also committed to assisting the community with building resilience to natural disasters in Australian communities. For example, the Victorian SES has developed a number of community education campaigns, such as FloodSafe, StormSafe and TsunamiSafe which help individuals and communities to prepare for natural disaster, while Queensland SES has developed 'Get Ready Guide' to help households prepare for floods and storm surge events.

Australian Red Cross: The Australian Red Cross undertakes a variety of community resilience activities. For example, Emergency REDiPlan is a national community education program run by Australian Red Cross. REDiPlan helps people prepare for, respond to, and recover from, emergencies. In the event of an emergency, individuals and communities are better able to respond to and manage their own recovery, thereby improving their overall wellbeing and reducing pressure on support services.

3.8 Summary

Australian, state and territory governments are increasingly engaging in resilience activities to reduce the impact of natural hazards on individuals, communities and businesses. There is a great deal of positive activity in this space across all stakeholders.

However, considering the current roles and responsibilities in pre-disaster resilience, activities and funding could be better coordinated across all sectors.

The main responsibility for driving the core resilience strategy rests in a traditional emergency management policy focus, while many other departments of the Australian Government have pre-disaster resilience responsibilities through COAG agendas and program delivery.

The development of the NSDR is to be commended as an important step in enhancing Australia's resilience. However, whilst ongoing coordination and integration of activities in terms of preparedness, response and recovery activities of emergency management will continue to be critical, it is apparent that a fresh approach to delivering a coordinated pre-disaster resilience investment across all stakeholders is required.

The Senate Inquiry into Climate Change adaptation illustrates the issue.

"Almost every single witness at this inquiry has said that what we need is a nationally coordinated response, and what I am seeing is not a nationally coordinated response at all." Senator Milne, 2013 (Senate Environment and Communications References Committee, 2013, p.65)

In addition to the NPA–NDR managed in the Attorney General's Department, there are a number of other funded programs and activities that sit in other Departments or funded bodies. The elements of this spending are set out in Table 3.1.

9 Information in this section draws on consultations undertaken with organisations in the References section

Table 3.1: Australian Government pre-disaster funding

Agency	Program	Funding
Attorney General's Department	National Emergency Management Projects Grant Program	$3.8 million in 2012–2013
Attorney General's Department	National Partnership Agreement on Natural Disaster Resilience	Around $27 million annually
Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education	Cooperative Research Centres Program – from 1 July 2013, the Program will support the Bushfire and Natural Hazards CRC.	$47 million over eight years*
CSIRO through the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education	National Climate Change Adaptation Research Facility	$43.6 million over four years.
Department of Resources, Energy and Tourism	Geoscience Australia – Flood information enhancements.	$12.4 million over four years**

* Contingent on further state and territory financial support

** Total funding for the Geoscience Australia in 2012–13 was $117.9 million.

The above demonstrates an apparent lack of co-ordination of the Australian Government spending on pre-disaster resilience. Whilst it is a difficult task to fully assess all the Australian Government funding spent on pre-disaster mitigation activities, a reasonable estimate of consistent annual expenditure based on available information is in the order of $50 million per annum. It is possible that this figure will increase, with the allocation of $50 million per year, for two years, to the new National Insurance Affordability Council and associated mitigation initiatives. However, the provision of this additional funding is conditional on contributions from state and territory governments. The amount that might be provided beyond the proposed two-year commitment is uncertain.

This estimated $50 million spent on pre-disaster resilience compares with the Australian Government expenditure on disaster relief and recovery of around $560 million per year, as outlined in Chapter 2. Hence, 10 times more is spent after a disaster than on building resilience beforehand. If this disparity is not addressed, the gap will widen as disaster bills increase.

'Broader emergency management arrangements may not be achieving the right balance between government expenditure on disaster prevention and expenditure on recovery. There appears to be an inadequate focus on preventing damages from natural disasters.'

Source: Productivity Commission (2012, p. 241)

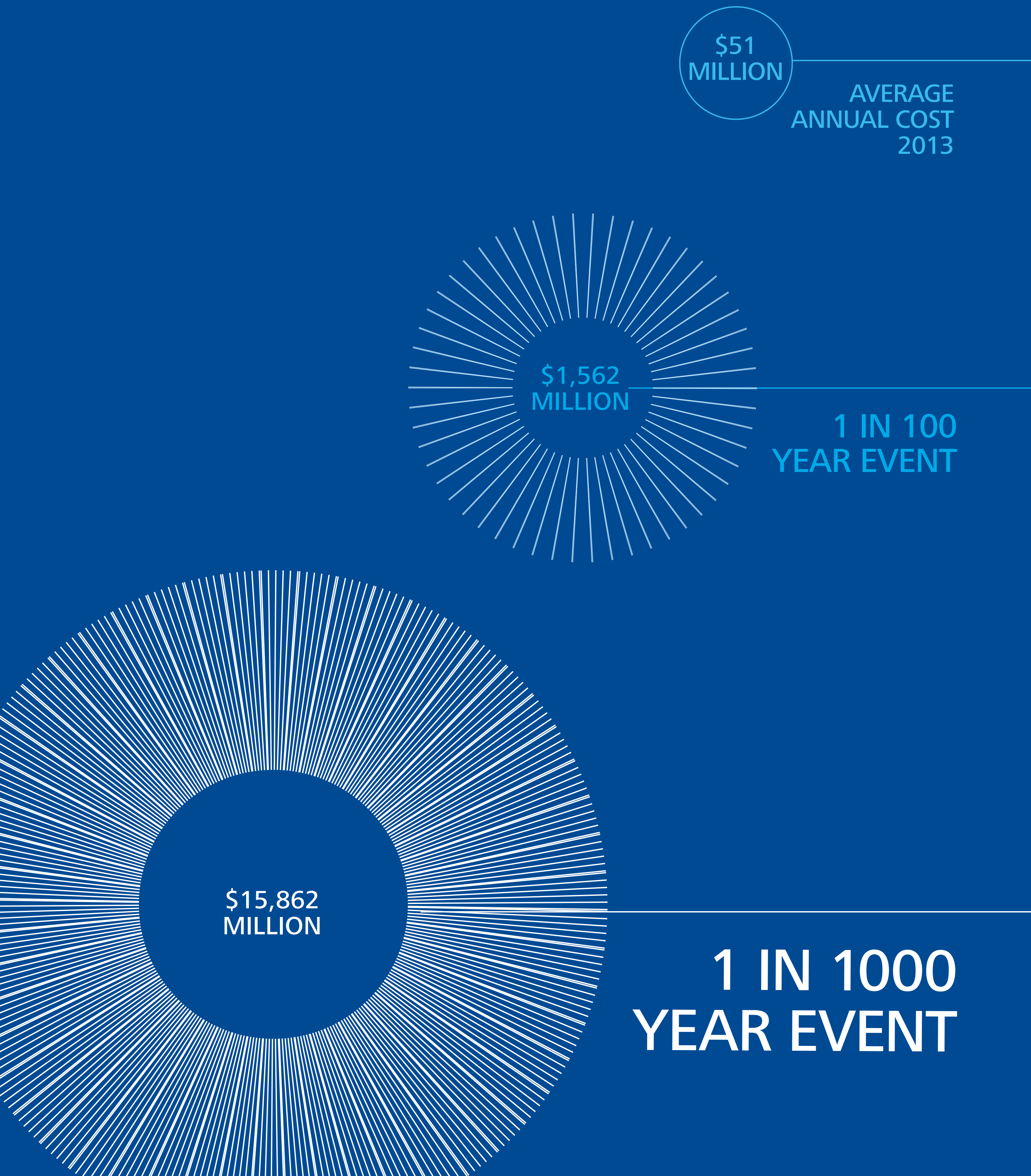
Based on the analysis provided in Chapter 2, there is a good case for greater expenditure on pre-disaster investment relative to post-disaster relief and recovery. Further, it is clear that greater emphases on activities directed at a nation-wide, co-ordinated approach to disaster resilience are likely to be more successful.

'It is not clear if the current funding process underlying the NPA–NDR is the most appropriate way to support disaster mitigation. ...A better criterion would be to allocate national funding to projects where the biggest expected net benefit can be gained.'

Source: Productivity Commission (2012, p. 254)

The next chapter considers specific case studies to illustrate where opportunities for greater, targeted investment in pre-disaster resilience could result in an overall benefit to Australia.

Melbourne fringe benefits



4. Building the case for resilience – Australian examples

Key Points

There are practical resilience measures which would create net benefits for society:

- A program focussing on building more resilient new houses in high cyclone risk areas of South-East Queensland would reduce the risk of cyclone-related damage for these houses by around two thirds, and generate a BCR of up to 3. Existing houses are particularly challenging to retrofit but the BCR of retrofits approaches one in high risk areas
- Raising the Warragamba Dam wall by 23 metres would reduce annualised average flood costs by around three quarters, and generate a BCR of between 2.2 and 8.5. This would result in a reduction in the present value of flood costs between 2013 and 2050 from $4.1 billion to $1.1 billion, a saving of some $3.0 billion
- Building more resilient housing in high risk bushfire areas generates a BCR of around 1.4; improved vegetation management results in a BCR of around 1.3, and undergrounding electricity wires results in a BCR of around 3.1.

This chapter provides an indicative benefit-cost analysis of three areas in Australia exposed to different natural disaster risks. The areas chosen are South-East Queensland (tropical cyclone, and flood), NSW's Hawkesbury Nepean (riverine flooding) and the outskirts of Melbourne (bushfire).

The selection of the case studies was based on a number of attributes, including:

- **Populous:** areas where a significant number of people and property would be affected
- **Data rich:** readily available data
- **Influence on affordability:** the affordability or availability of insurance is being affected
- **Change is possible:** it is realistically possible to implement resilience measures
- **Weather variability:** future weather variability is likely to increase the risks.

For each case study, a range of options for building resilience is considered. The case studies demonstrate that there are practical approaches to building resilience which, with further research, could be tailored and implemented at a local level in a way which creates net benefits for society. Whilst these case studies demonstrate the potential benefits of pre-disaster resilience, they do not provide the detailed benefit-cost analysis that would be required for decision-making, including, for example, new or targeted engineering information.

The case studies are also heavily focussed on physical or hard approaches to resilience (such as building infrastructure or retrofitting existing buildings). These approaches to resilience are most amenable to quantitative benefit-cost analysis. This should not be taken as an indication that other 'soft' approaches to resilience (such as information and business continuity planning) do not create substantial benefits. Further, in implementing any of the resilience approaches suggested, a comprehensive impact study would need to be carried out.

A detailed description of the methodology used for these case studies is presented in **Appendix E.**

As costs related to natural disasters are highly variable, there are a number of ways to present them. The most basic is to look at the average annual cost. This shows the natural disaster costs that can be expected to occur in any given year and, over the long run, it should be expected that the average costs experienced approach this estimate. This average annual cost can also be summed over a number of years to give a total cost expected over that period.

The total can be considered in present value terms to assess the amount of money that would need to be put aside now to cover costs over the period. However, as the most disastrous events are rare, this approach can work to conceal the true extent of costs that would occur in a bad year. Extreme events are also important to consider as they are more likely to result in mass loss of life and destruction of communities and so are related to high levels of traumatic intangible costs.

To capture these extreme risks, the costs associated with extreme events can be individually estimated. For example, a one-in-100-year event has a 1% chance of occurring in any year while a one-in-1,000-year event has a 0.1% chance of occurring in any year. These events could, however, occur in the near future and could occur within a matter of years.

A final methodological consideration is that the expected natural disaster costs have been estimated separately for cyclone-related events and flood-related events. These results can be combined to form a picture of the total consequences of both events. Table 4.1 provides a summary of the costs of disasters in these areas today and into the future.

Table 4.1: Summary of estimated costs of natural disasters in case study regions

Measure of cost	South East Queensland	NSW	Victoria
		Hawkesbury-Nepean	Melbourne fringe
Average annual cost in 2013	322	102	51
Average annual cost in 2050	1,162	317	165
Total cost to 2050	25,889	7,218	3,727
Present value of total cost to 2050	14,387	4,051	2,087
1% Annual Exceedence Probability (EAP) (≈1 in 100 year event)	3,424#	2,205	1,562
0.1% AEP (≈1 in 1000 year event)	12,899#	10,723	15,862
0.01% AEP (≈1 in 10,000 year event)	40,487#	16,183	68,590

Cyclone only

Source: Deloitte Access Economics (2013)

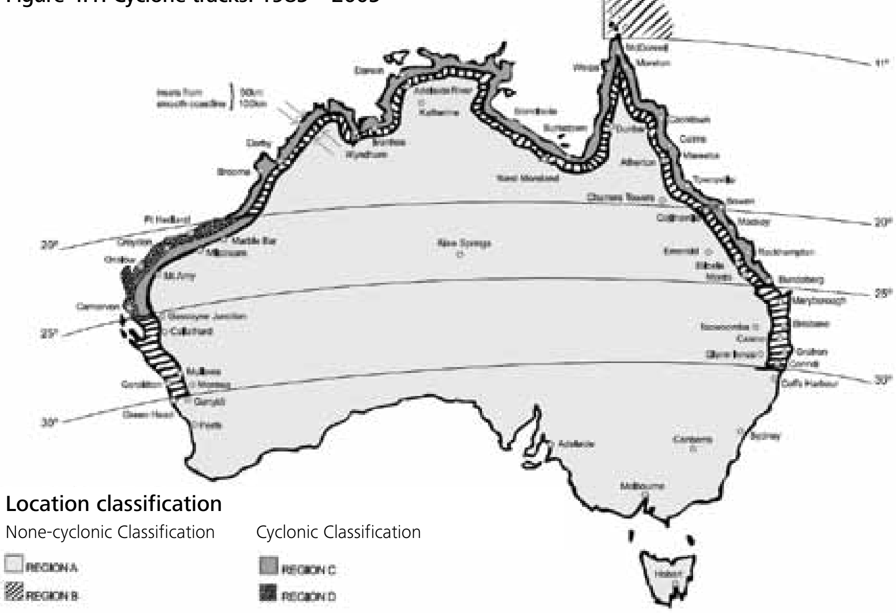
4.1 South-East Queensland – Cyclone and flood

4.1.1 The scenario

South-East Queensland is one of Australia's most disaster prone regions, facing significant risks from tropical cyclones and, in particular, flood. There are around 40,000 houses in the region which are exposed to high or medium flood risk[10].

South-East Queensland's population and economy have been growing strongly over the past few decades. This has led to a growth in both the quantity and value of assets located in the area. Much of this new population had, until recently, little experience of the cyclone and flood losses that have impacted the region historically.

Figure 4.1: Cyclone tracks: 1985 – 2005



Source: Stegbar, 2009, 'AS4055 wind loads for housing'. The above figure represents the broad wind risk regions in Australia; note refinements have been made in subsequent updates

10 High flood risk is here defined as being located below the 5% AEP level. Medium risk is defined as being located within the 1% flood level.

In the last few years, there has been some experience of extreme flooding events such as the events in Toowoomba, the Lockyer Valley, Ipswich and Brisbane. In addition, in early 2013, residents felt the effects of ex-Tropical Cyclone Oswald. However, South-East Queensland has not recently experienced a severe event that combines cyclonic winds with major floods.

Based upon historical tropical cyclone impacts near Brisbane, including the 1893 tropical cyclone that produced extreme river flooding of the Brisbane Rivers and the destructive 1954 Gold Coast tropical cyclone, it is apparent that this region could experience a Category 3 cyclone impact in the future with a combination of extreme river and flash flooding, a major storm surge and destructive winds.

Illustrating this potential, in 1967, Tropical Cyclone Dinah, a Category 3 cyclone, passed just east of the Brisbane coast but did not make landfall. A repeat of Tropical Cyclone Dinah which did cross the coast and pass directly over Brisbane and the Gold Coast would be something of a worse-case scenario – bringing extreme wind speeds, major flooding and material storm surge damage. With the majority of recent development in South-East Queensland having occurred on or near rivers and coastlines, the impact of this disaster would be catastrophic. Wind damage in Brisbane and the Gold Coast is estimated to be in the region of $8–14 billion in insured costs (Munich Re 2006). Insured flood costs would have to be added to this figure and could reach into the billions of dollars based on the $2.4bn of the 2011 floods and the $2.6bn of costs generated by the Brisbane River flooding of 1974. This level of insured losses could result in total economic costs of at least $27–42 billion.

For South-East Queensland, the average annual cost of cyclone and flood is currently estimated to be around $322 million in total economic value and is estimated to rise to around $1.2bn by 2050. Population growth together with increases in the value of property and assets in the region are the primary drivers of this inflation.

The total economic costs from cyclone and flood in the region are expected to be around $25.9 billion in the period to 2050, which has a present value of around $14.4 billion.

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs such as loss of life, injury and evacuation are also included.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important. For example, while the statistical value of life has been used a basis for assessing costs related to death and injury, this does not take into account longer term psychological consequences for survivors from the loss of property and memorabilia but more significantly the loss of family and friends.

Table 4.2: Estimated costs in South-East Queensland Case Study ($m 2011)

Measure of cost	Cyclone	Flood	Total
Average annual cost in 2013	160	164	322
Average annual cost in 2050	570	593	1,162
Total cost to 2050	12,685	13,204	25,889
Present value of total cost to 2050	7,050	7,338	14,387
1% AEP	3,424		
0.1% AEP	12,899		
0.01% AEP	40,487		

Source: Deloitte Access Economic analysis (2013)

Case study: The human side of natural disasters

As an auxiliary to government in humanitarian endeavours, Red Cross has a key role in supporting governments to respond to humanitarian crises. Through its work providing aid to those affected by natural disasters, it is able to bring a unique perspective to the personal side of natural disaster costs. In the case of the 2013 floods in South-East Queensland, the stories gathered by the Red Cross are particularly insightful as many individuals had been flooded out of their homes only a few years prior.

For example, the Red Cross interviewed residents of Ipswich in South-East Queensland following the floods. Like many others in Queensland, Ipswich residents had been similarly evacuated in 2011. Some of the natural disaster risks and costs of greatest concern to affected individuals included the:

- Speed at which flood waters can rise
- Destruction of a bridge connecting a victim's town to Ipswich
- Lack of basic supplies such as bread, milk and fuel
- Permanent damage done to carpets and flooring
- Loss of personal items with sentimental meaning.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the above estimates. These include:

Disruption to road, air, sea and rail services

In a minor event this may last only a few days while, in a major event, disruption could last for a number of months and destroy key transport infrastructure. This would affect local and international trade from industries including agriculture, consumer products, industrial manufactures and coal.

Utilities

For larger events (beyond the one-in-100 level), there is the potential for widespread loss of telecommunications and electricity services.

Water flow

For extreme events, there are risks associated with water flow such as the release of industrial chemicals into the water system; the backflow of stormwater drains into residential and commercial buildings; and damage to sewerage systems. Damage to sewerage can have serious longer term health effects as well as complicating the post-disaster recovery process.

Community cohesion

There are risks associated with disruption to communities and businesses. The time taken to rebuild what could amount to thousands of homes following the disaster could lead to communities dissolving or relocating. For businesses even a minor disaster increases the risks of closure while, in an extreme event, there is the possibility for a longer term decline in the riverside portion of the Brisbane CBD, particularly if businesses rebuild in a less disaster-prone location.

4.1.2 Pre-disaster resilience options

The pre-disaster resilience options focus on improving structures so that they are more resilient to wind and on changing planning regulations to reduce the number of houses in high flood risk areas.

Building more resilient houses

Analysis by the Cyclone Testing Station suggests that the most common risk to houses during a cyclone occurs once the building envelope (the physical separator between the interior and the exterior environments) has been penetrated. Once this occurs, the pressure differential between the house and its environment often results in the destruction of the house's roof structure. As a result, the Cyclone Testing Station has found that some of the most common sources of cyclone damage to houses consist of:

- Failure of fasteners
- Failure of rotten timbers
- Garage doors being blown in or out
- Roofs being blown away in whole or in part
- Doors and windows blown open
- Water ingress through the roof, doors, windows, vents, etc.
- Failure of attachments such as guttering, fascias and eaves
- Damage caused by falling trees.

This suggests that cyclone-related costs could be reduced by first increasing the resilience of the building's envelope by strengthening doors, roller-doors and windows. In high risk locations, resilience could be further developed by adding roof ties to a structure. Roof ties connect the roof structure to the core of the building, essentially linking the roof to the building's foundation.

Past experience from northern Queensland suggests that application of a more resilient building code in South-East Queensland could reduce the physical damage of a cyclone by around 55–66% (Risk Frontiers n.d.). This figure relies heavily on data gathered by the Cyclone Testing Station from actual loss experience in other parts of Queensland. It is, therefore, a good example of how improved research is able to help guide the development of resilience.

- **Improving planning**

Land use planning, as outlined in Chapter 3, is generally the responsibility of local government. The ability of local governments to assess the safety of a particular development is limited by the quality and availability of information. For example, the national rainfall map, as published in Australian Rainfall and Runoff underpins most of the nation's flood studies. It provides detailed information on design rainfalls of a wide range of frequencies, durations and intensities and is due to be updated in 2013, the first time since the late 1980s. More timely information could help eliminate high risk housing while, for existing structures, it may enable changes in zoning which encourage development of buildings (such as high-rises) which are less prone to cyclone and flood. This is a prime example of how better risk information is related to building resilience.

4.1.3 Benefits of pre-disaster resilience

- **Building more resilient houses**

Analysis of the benefits of building more resilient houses needs to take into account the mix of old and new houses. It is generally less costly to change standards for new houses than to retrofit existing houses. For example, research by Stewart and Wang (2011) suggests that, in South-East Queensland, building new houses to a more resilient cyclone standard could cost around $2,600–$6,500 per house while upgrades to existing housing could cost from $13,000–$52,000.

While retrofitting is more costly, it can generate significant, immediate reductions to natural disaster costs whereas changes to new houses can take a long time to result in large-scale savings.

The differential in costs between new and existing houses also highlights the fact that, in constructing new houses, it may be valuable to prepare the building for later additions that add resilience.

A further factor to take into consideration is the difference in cyclone risk within South-East Queensland. Exposure to cyclone risk is affected by factors such as the topography of the local neighbourhood and the design and location of nearby buildings. A straightforward approach to capture these local differences is to differentiate between foreshore property and inland property. Data in Stewart and Wang (2011) suggest that foreshore properties make up around 10% of houses in South-East Queensland but account for around 26% of insured damage during high wind events. This suggests that an intervention targeted closely on these high risk houses may be more beneficial than a broader program.

Taking into consideration the variability in both costs of more resilient housing and risks, the benefits of this type of mitigation are best expressed as a range of values, as shown in the following tables.

Table 4.4: More resilient housing: Benefits ($m NPV to 2050)

House type	Existing	New
Foreshore only (Benefits)	794.4	340.3
Inland only (Benefits)	2,302.9	986.7
All houses (Benefits)	3,097.3	1,327

Source: Deloitte Access Economics analysis (2013)

Table 4.3: More resilient housing: Costs ($m NPV to 2050)

House type	Existing			New		
Assumes:	Low	Med	High	Low	Med	High
Cost per house ($)	13,000	32,500	52,000	2,600	4,550	6,500
Foreshore only (Costs)	1,062.7	2,656.8	4,250.9	110.1	192.6	275.2
Inland only (Costs)	9,932.5	24,831.2	39,729.9	1,028.9	1,800.5	2,572.2
All houses (Costs)	10,995.2	27,488.0	43,980.8	1,139.0	1,993.2	2,847.4

Source: Deloitte Access Economics analysis (2013)

Table 4.5: More resilient housing: Benefit-Cost Ratio

House type	Existing			New		
Assumes:	Low	Med	High	Low	Med	High
Cost per house ($)	13,000	32,500	52,000	2,600	4,550	6,500
Foreshore only (BCR)	0.75	0.3	0.19	3.09	1.77	1.24
Inland only (BCR)	0.23	0.09	0.06	0.96	0.55	0.38
All houses (BCR)	0.28	0.11	0.07	1.17	0.67	0.47
All houses (Costs)	10,995.2	27,488	43,980.8	1,139	1,993.2	2,847.4

Source: Deloitte Access Economics analysis (2013)

Given past experience that more resilient buildings experience around 66% less wind-related damage following a cyclone, an intervention program focussed on new housing in foreshore areas could generate significant benefits over the full range of potential costs (with a BCR of 3.09–1.24).

There are a number of other interventions with BCRs close to one, including targeting of new houses in inland areas (when costs are low) and, if retrofitting could be achieved for slightly less than the range of costs reported in Stewart and Wang (2011), then a program targeting existing houses in foreshore areas could also be cost beneficial.

Improving planning

Assessment of the precise cost and benefits of improved planning is made difficult by the complexity of the process. That is, improved planning decisions can be made by simply implementing better procedures; a very low cost process. However, this requires better information for decision-makers, and this comes at a cost. Some indication of the scale of expenditure on improved information gathering can be seen in other recent government programs aimed at improving information related to natural disaster:

- Geoscience Australia Flood information enhancements has been allocated a budget of $12m for the period to 2016 which equates to $3m a year
- The Bushfire and Natural Hazards CRC has been granted a budget of $47m over eight years, equating to $5.9m a year
- The Bushfire Hazard Map project in Victoria received $13.8m.

The budget for these programs suggests that information gathering and dissemination can be achieved for a relatively low initial outlay. This can then be compared to the expected benefits of improved planning.

For example, if better planning resulted in 10% of high risk housing being redeveloped into more resilient forms the benefits over the period to 2050 are estimated to be around $52.4m in present value terms.

The above analysis demonstrates that there is an overall benefit from improving the resilience of houses. Further research is required into the most cost-effective methods of improving resilience, as well as an education and incentive program to encourage households to action these modifications. An example of the approach that could be taken is provided below.

Example

Minor modifications to improve the cyclone resilience of a new house in South-East Queensland could cost around $5000. There will be benefits for both the individual and government from undertaking this home improvement and so costs should be allocated accordingly.

A hypothetical cost sharing arrangement could include a combination of government grants (funded jointly by the Australian and Queensland Governments and upfront expenditure by the home owner).

Over time, insurance premiums would be expected to fall as the resilience measure reduces the risks of damage to the house and its contents. This means that, over time, the home owner may be able to recoup some of their upfront cost through reduced insurance premiums.

Local government's role could be the collection and dissemination of risk information and compliance monitoring, working in close collaboration with the relevant state government.

4.2 New South Wales – Flood

4.2.1 The scenario

The Hawkesbury-Nepean has been recognised as a major flood risk for the greater Sydney area since colonial times. This can be evidenced by flood peaks of 11.1m in 1992, 15m in 1961 (one-in-100-year flood levels), 19m in 1867 and 20m in 1788 (one-in-200-year flood levels).

In a repeat of historic large floods, heavy rainfall west of Sydney over a number of days would result in water flowing down the spillway and out of Warragamba Dam. The floodwaters would likely spread over large parts of Western Sydney and take days to drain away (due to the small pathways through which water can escape the basin – particularly around Wiseman's Ferry).

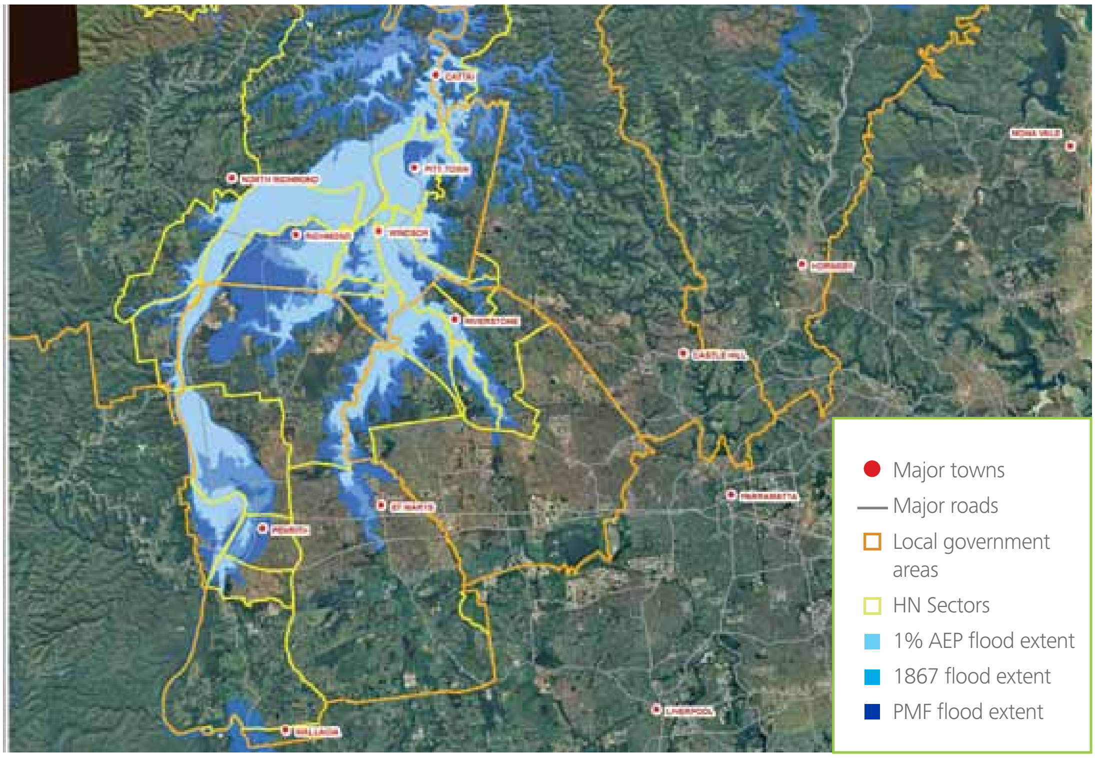
The scale of such an event today would result in the evacuation of around 60,000–90,000 people with an additional 20,000 people stranded for a number of days (as evacuation routes are cut off).

Those stranded would be stuck on ever-diminishing islands as flood waters continue to rise and cut off evacuation routes. In addition, around 1,000–3,000 businesses would be directly affected.

Intermittent steps have been taken to manage these risks with the earliest commands from Governor Lachlan Macquarie in 1817 regarding suitable locations for construction in the Hawkesbury-Nepean area. Building requirements have been an ongoing feature of resilience in the area – for example, since the mid–1990s, houses in Windsor must be built with a floor level high enough to survive a 17.3 metre flood, still insufficient for a one-in-200-year event.

Mitigation activity culminated in the construction of Warragamba Dam between 1948 and 1960, with the addition of a spillway in the 1990s to ensure the Dam's structural integrity during an extreme flood event. While the presence of Warragamba Dam can work to reduce natural disaster risks, it cannot eliminate them.

Figure 4.2: Extent of the probable maximum flood in the Hawkesbury-Nepean



Source: Ministry for Police and Emergency Services (2005)

4.2.2 Natural disaster risks

Noting the different ways to present natural disaster costs discussed at the beginning of this chapter, the Hawkesbury-Nepean area is currently estimated to be exposed to average annual flood costs of around $102 million in total economic value, increasing to around $317 million by 2050. This increase is primarily driven by growth in the value of property and assets in the area as well as increases in population. The total economic costs over the period to 2050 are expected to be around $7.2 billion in the period to 2050, which has a present value of around $4.1 billion (Table 4.6).

Table 4.6: Estimated costs in Hawkesbury-Nepean Case Study ($m 2011)

Measure of cost	Total economic cost
Average annual cost in 2013	102
Average annual cost in 2050	317
Total cost to 2050	7,218
Present value of total cost to 2050	4,051
1% AEP	2,205
0.1% AEP	10,723
Probable maximum flood	16,183

Source: Deloitte Access Economics analysis (2013)

These estimates bear comparison to those made in Molino Stewart (2012). For current natural disaster costs the estimates are quite similar; Molino Stewart estimate current average annual costs at $70.3m while we estimate costs at $95.6m. This difference can be attributed to different data sourced from Roundtable members on the number of houses in the area, flood levels and the effect of flood levels of house contents. Over time, however, the two estimates diverge. Although the annual costs are not reported in the Molino Stewart report, we estimate that their annual costs are around $80m by 2050 while our estimated annual cost is $317m. This represents different assumptions on the increase in house numbers, house value and population[11].

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs are also included such as costs related to loss of life, injury and evacuation.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the estimates. These include:

- **Disruption to road and rail services**

Once flood levels exceed the one-in-100-year level, significant damage and closure of the Victoria Bridge and Great Western Highway at Penrith is expected to have widespread consequences. Primarily this will affect the movement of people and goods by both road and rail from west of Penrith into Sydney. Many of Sydney's exports pass over this bridge, including coal from the western coalfields and agricultural products from west of the Great Dividing Range. In an extreme event, these services would be affected for around six months.

- **Utilities**

Many critical electricity and telecommunications connections also pass over the Nepean bridges. These include telecommunications and electricity, both of which would be affected in a similar way to road and rail services.

- **Water flow**

At the one-in-100-year level, there is likely to be discharge of sewerage into water systems around Richmond and at the one-in-1,000-year level, this is expected to extend to sewerage treatment plants around Penrith. Inundation of industrial areas would also likely be accompanied by chemical contamination of water.

11 Molino Stewart make a conservative assumption that natural disaster costs are likely to remain fairly stable over time while we predict an increase in costs in line with growth in the value of assets and population.

- **Community cohesion**

There are also risks associated with disruption to communities and businesses. In extreme events, there would be a need to evacuate 60,000–90,000 people, with an additional 20,000 people left stranded for a number of days as evacuation routes are cut off. In this extreme event, resettlement of evacuees may take a number of months with rebuilding continuing for a number of years. There are also estimated to be around 1,000–3,000 businesses affected in the area.

4.2.3 Pre-disaster resilience options

Approaches for building resilience to flooding in the Hawkesbury-Nepean have been a focus for the NSW government since the late 1980s. This concern led to the development of a thorough Economic Impact Statement (EIS) in the mid-90s. This EIS considered a broad range of resilience options including flood insurance, flood emergency planning, town planning, house raising, wall raising, flood resistant buildings, levees, deflection walls, dredging and river straightening.

The EIS found that the option with the highest BCR was raising the level of the dam wall by 23 metres. This EIS was updated in 1997 and was further reconsidered and updated by Infrastructure NSW in 2012. As part of the Infrastructure NSW process, Molino Stewart undertook a thorough review of the costs and benefits of raising the dam wall but did not attempt to re-assess the ranking of resilience options. This ongoing process is a good example of how risk information can be combined with adaptation research to provide insight into the benefits of pre-disaster resilience infrastructure.

More recently, government has also raised the possibility of increasing the height of the Warragamba Dam wall. On 28 February 2013, the Australian Government announced $50 million in federal funding to be used for flood protection in Western Sydney – funded as part of the National Insurance Affordability Council. This included a plan to raise the Dam wall by the identified 23 metres.

Our analysis builds from that undertaken over the past 20 years and primarily relies on the analysis of pre-disaster resilience options made in the Molino Stewart report (2012) focussing on raising the dam wall height by 23m. While this has traditionally been identified as the most cost-beneficial approach to building resilience in the Hawkesbury-Nepean, a number of factors should be kept in mind.

Importantly, before investing in construction of the Dam, it would be beneficial to re-do the EIS conducted in the mid-90s to ensure that the engineering and cost data are as accurate as possible and to factor in the construction of the desalination plant in Sydney. Having a reliable source of water in addition to Warragamba Dam should work to reduce costs as it takes pressure off the water volumes needed to be maintained in the dam. There are also a number of non-quantifiable costs associated with raising the Dam wall including potential consequences upriver such as increased flooding and inundation of bushland areas. A comprehensive impact assessment should therefore be prepared to assess the full extent of these environmental effects.

4.2.4 Benefits of pre-disaster resilience

Implementing the pre-disaster resilience measures outlined above would involve total construction costs of around $411m spread over five years. This has a present value of around $349m.

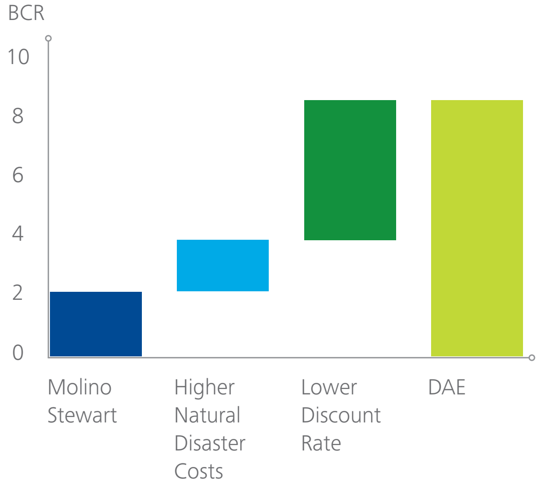
Raising the Dam wall reduces average flood costs by around 73%. This results in a reduction in the present value of flood costs between 2013 and 2050 from $4.1 billion to $1.1 billion, a saving of some $3.0 billion. This gives a benefit-cost ratio of 8.5 for raising the dam wall.

This ratio is far higher than that estimated in Molino Stewart (2012), which indicated a BCR of around 2.2. The reconciliation of the two results is illustrated in Chart 4.1.

The first cause of this deviation is the difference in natural disaster costs discussed above. In addition, Molino Stewart use a discount rate of 7% a year while this analysis uses a discount rate of 2.7% a year. This means that the benefits that are experienced far into the future are given more value in our analysis than in Molino Stewart's. A discount rate of 7% is the normal value required by the NSW government in assessing infrastructure projects while the discount rate of 2.7% a year is based on the long-term real Commonwealth bond rate and aligns with recommendations from the Australian Government Department of Finance. This lower rate is appropriate when assessing costs and benefits from a societal point of view (which is the aim of this paper).

If the discount rate in our analysis is adjusted to 7%, then the estimated benefit-cost ratio for raising the dam wall at Warragamba falls to 4.1. This suggests that around 70% of the difference in BCRs is attributable to the difference in discount rates while 30% is related to differences in the estimated natural disaster costs.

Chart 4.1: Reconciliation of BCR estimated by Molino Stewart and DAE



Source: Deloitte Access Economics analysis (2013)

The above analysis demonstrates that pre-disaster resilience action is cost beneficial for Australia. The process needs to be extended by a coordinated approach to consideration of pre-disaster resilience investment. Some key steps are set out below:

- The most effective measures for mitigating the identified risks need to be ascertained. For example, this may involve specific flood modelling to assess the effectiveness of raising levees or relocating electrical grid assets
- A strategy for implementing the measures in the previous step needs to be developed. Ideally, this should be done by an entity closer to the ground. For example, local government could develop a business case describing the benefits of a particular public asset project. A comprehensive impact assessment should also be prepared
- The strategies developed need to be assessed by an independent entity. For example, the Australian Government could assess submitted strategies in a process similar to that currently used by Infrastructure Australia. This results in a competitive prioritisation process to drive best practice pre-disaster resilience and also serves as a method for collecting and collating information and data to promote and communicate 'best practice' pre-disaster resilience options across the nation
- The costs for such projects need to be apportioned between different levels of government. The intention here is to preserve incentives for all parties by ensuring that they all have a financial commitment. An example of this would be the Australian, state and local governments funding a project at a ratio of 1:1:1.

Along the lines of Infrastructure Australia's competitive prioritisation of projects, the Australian Government announced on 28 February 2013 that it is setting up a new agency, the National Insurance Affordability Council, to approve investments in priority areas for flood pre-disaster resilience. At least $100 million over two years is expected to be injected into the Council, which will fund pre-disaster resilience works jointly with state and local governments by redirecting funds currently used to buy terrorism reinsurance.

This is a positive step forward but needs to be extended in funding and in focus from just flood pre-disaster resilience to an 'all hazards' approach. Greater incentivisation of state governments and local councils would align efforts and generate a greater flow of information and dissemination of best practice, and support local councils' capability development.

Moreover, business can play a role by sharing risk data and their analysis with local councils to demonstrate the value of pre-disaster resilience. Businesses can also work with communities to help in understanding the financial benefits of reduced risk to their properties resulting from the pre-disaster resilience infrastructure and in developing social and community based resilience (such as disaster management plans).

4.3 Victoria – Bushfires

4.3.1 The scenario

Victoria is heavily exposed to bushfire risk and has experienced a number of very large bushfire events.

Some of the largest bushfire events in Victoria's history include:

- Black Saturday in 2009 which burnt 4,500km^2 of land, killed 173 people, injured an additional 414 and destroyed 2029 homes
- Ash Wednesday in 1983 where 2,300 homes were destroyed and 75 people were killed
- Black Friday in 1939 which burnt 20,000km^2 and resulted in 71 fatalities
- Black Thursday in 1851 which burnt around 50,000km^2 and killed 12.

The largest potential loss caused by a bushfire in Victoria would be one that affects the populous greater Melbourne Metropolitan fringe area. This area is the focus of this scenario. In the worst case scenario considered in this case study, a wet spring encourages the growth of grass and is followed by a severe drought throughout summer.

This drought dries out the bushland surrounding Melbourne. A heatwave then hits Melbourne with a string of days registering maxima in the 40–45°C range. The heatwave is itself associated with a range of economic costs including disruptions to electricity supply, potential closure of buildings in the CBD and an increase in heat-related deaths.

On one of the hottest and windiest days a number of fires spring up around the outskirts of Melbourne. This could involve a fire starting somewhere within the north-west to north-east of the city. This fire could then be fanned by strong north-westerly or north-easterly flames and driven south towards the outskirts of Melbourne. The fires may then spread to housing near bushland and further into urban areas. This scenario would be similar to the Duffy fires in Canberra, which resulted in the loss of 200 houses, only on a much larger scale. In this scenario, the most heavily affected Local Government Areas (LGAs), on a risk weighted basis, are likely to be Nillumbik and Whittlesea. Both of these LGAs are located in Melbourne's far north.

Figure 4.3: Example of housing intermingled with Bushland in Nillumbik, Victoria

Source: Google Earth

4.3.2 Natural disaster risks

Noting the different ways to present natural disaster costs discussed at the beginning of this chapter, average annual bushfire risks in the Melbourne area are currently estimated to be around $51 million in total economic value, increasing to around $165 million by 2050. This increase is primarily driven by increases in the value of property and assets in the area as well as increases in population. The total economic costs over the period to 2050 are expected to be around $3.7 billion which has a present value of around $2.1 billion.

Table 4.7: Estimated costs in Victoria Case Study ($m 2011)

Measure of cost	Total economic cost
Average annual cost in 2013	51
Average annual cost in 2050	165
Total cost to 2050	3,727
Present value of total cost to 2050	2,087
1% AEP	1,562
0.1% AEP	15,862
0.01% AEP	68,590

Source: Deloitte Access Economics (2013)

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs are also included such as costs related to loss of life, injury and evacuation.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the above estimates. These include:

- **Utilities**

Depending on the precise path of the fire, above-ground services in the affected areas may be lost. In the case of electricity, this has the potential to affect broad areas of Melbourne in the rare event that critical transmission lines are destroyed. This would have flow-on effects for public transport networks and other infrastructure including schools and other public buildings.

Case study: The human side of natural disasters

Firefoxes Australia was consulted as part of the research undertaken for this paper. This organisation is a grassroots support group that formed in the Kinglake region of Victoria following the 2009 Black Saturday bushfires. The formation of Firefoxes Australia was a response to the unmet need of affected communities for a framework, forum and practical approach to rebuilding communities following a natural disaster.

Some of the critical experiences of those involved in the Black Saturday bushfires were that:

- The initial trauma of the event can last up to 10 years as the community recovers. Within this, the longer term psychological effects of natural disasters are poorly understood, with support focussed too strongly on those who have directly suffered loss rather than more broadly on those affected by the disaster
- There is a tension between the feeling of being lucky to survive and feeling loss over smaller things such as possessions, gardens and sentimental items
- At the moment, around four years after the fires, the community continues to feel effects of mental health issues, divisions between those who have been able to rebuild and those who have not, the consequences of insurance battles and the breakdown of families and friendships
- Rebuilding of housing and resettlement can take many years. Rebuilding is still an ongoing process in the Kinglake region, with only around 30% of houses rebuilt after two years. A particular cause of slow rebuilding that was noted is the difficulty in deciding whether to move on to another location or attempt to rebuild. Renters were particularly at risk of social dislocation from having to move out of the region, as landlords decide whether to rebuild the property or not.

Water

Again depending on the path of the fire, there is the possibility of contamination of drinking water supplies. This would occur if fires were to heavily affect the catchment area of dams in Melbourne. For example, the Cardinia Reservoir, Silvan Reservoir, Sugarloaf Reservoir and Yan Yean Reservoir all lie within areas of risk. Together, these reservoirs account for around 25% of Melbourne's water storage capacity. Widespread fire within a catchment results in the destruction of ground cover, allowing high levels of dirt to run into the dam, as well as the creation of large amounts of ash which flows into the dam.

4.3.3 Pre-disaster resilience options

Pre-disaster resilience options focus on improving processes, structures and infrastructure to reduce the creation and effect of flying embers, which are primarily responsible for the ignition of houses during bushfires.

Building more resilient houses

Past experience has shown that the 6% of houses located within 100m of bushland (71,000 properties in Melbourne) are responsible for around 87% of total housing losses during a bushfire. This has led to the development of specific housing standards for these bushfire-prone areas of Victoria. Depending on the specific risks of the location, the measures covered by these standards encompass:

- Sealing gaps in the building
- Sealing vents with mesh
- Installing a bushfire sprinkler system
- Replacing doors.

All of these changes in construction aim to reduce the chance of ember attack.

While these building codes are mandatory for new construction in bushfire-prone areas, they are only voluntary for existing properties. This is an area where community education about the benefits of retrofitting for disaster resilience could generate real benefits.

Vegetation management

While properties at serious risk from bushfires are normally located within 100m of a large area of bushland, 50% of all properties destroyed by bushfires are within 15m of bushland (Risk Frontiers 2010). This implies that frequent management of vegetation within a property could generate significant benefits, not only for that property but for its neighbours.

Strategic alliances between local communities, organisations such as the Country Fire Authority and local government, are best placed to implement such granular pre-disaster resilience options and monitor compliance.

Reducing ignition sources

Faults in either electricity transmission or distribution networks are a frequent cause of bushfires. Over the past 20 years they have been responsible for around 14% of the total area of land burnt by bushfires in Victoria (Weber n.d.) and the Victorian Bushfire Royal Commission found that five of the 15 fires it investigated were caused by electrical faults (Victorian Bushfires Royal Commission 2010). Burying wires underground would remove electricity transmission and distribution networks as a bushfire risk and is an example of an infrastructure-based response to developing resilience.

4.3.4 Benefits of pre-disaster resilience

Building more resilient houses

The upgrades required for houses in bushfire-prone areas were thoroughly costed for a range of fire hazards and house types by the Australian Building Codes Board (ABCB 2009). A weighted average of these cost estimates suggests an average cost of compliance of $14,931 per house (the weights take into account the distribution of risks within the 100m zone covered). This cost estimate is a total cost of compliance with fire standards and not an incremental cost of the new standards. This means that it can be interpreted as the cost of upgrades for both new and existing houses.

It does not, however, appear that there is any thorough analysis of the benefits of compliance with these standards in terms of reducing fire risk. The analysis undertaken by the ABCB concedes that, due to a lack of evidence, it 'is not possible to accurately assess the effectiveness of enhanced bushfire protection measures in reducing estimated annual damage costs'. We have therefore assumed a reduction in fire risk of 80% for houses complying with the new building code. Although this is an assumption it is in line with some evidence from bushfire losses in America which suggested that there was an 82% increase in the proportion of buildings surviving a bushfire when certain ember resilience measures were in place (Foote 1994).

Building more resilient houses in high risk areas of the Melbourne fringe would therefore cost around $1.04bn in net present value terms but would generate benefits of around $1.45bn in net present value terms over the period to 2050. This gives a benefit cost ratio of 1.4.

• Vegetation management

Based on costs of vegetation management experienced in the electricity industry, we have estimated that clearing a 5m area around a house could be achieved at a cost of $200 a year. We have also incorporated an hour and a half of monitoring and compliance costs per house. For the 71,000 houses in Melbourne, in the high risk area, this translates to a total cost of $15.3m a year, which equates to $467m in present value terms over the period to 2050.

As a 5m clearance around a house reduces total bushfire risks by 30%, this is expected to result in a reduction in average annual disaster costs of around $14.7m in 2013 (increasing to around $47.6m by 2050). This translates to a reduction in the present value of disaster costs by $603m in the period to 2050.

Overall this suggests that improved vegetation management has a benefit-cost ratio of around 1.3.

• Reducing ignition sources

The cost of burying electricity wires has been estimated at around $9,700 per house in an in-depth analysis undertaken by the Economic Regulation Authority of Western Australia (ERA). This suggests that the overall cost for the 71,000 high risk homes in Melbourne would be around $690m.

Burying these electricity wires would reduce the chances of ignition by around 14%, giving a present value of reduced disaster costs of around $292m in the period to 2050. This implies that burying electricity wires has a benefit-cost ratio of around 0.4.

However, our analysis only takes into account the benefits of burying electricity wires for natural disasters. The analysis undertaken by the ERA focussed on benefits for electricity companies (such as reduced maintenance) and society in general (such as less visual clutter and less severe vehicle accidents). ERA's analysis found that burying electricity wires had a benefit-cost ratio of around 2.7.

If natural disaster costs are added to this calculation, the estimated benefit-cost ratio increases to around 3.1, with the program generating around $2.1bn of benefits in the period to 2050.

This case study again illustrates the benefit of undertaking pre-disaster resilience activity. It highlights the need for greater coordination to ensure that the most effective activities are targeted.

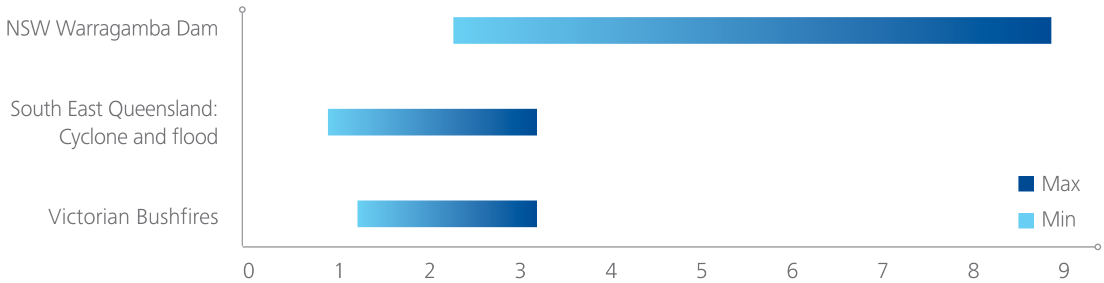
- Natural disaster risk needs to be mapped by location. For example, in the case of bushfires, the extent of the bush and fire load needs to be mapped in a manner that allows the determination of risk level in each house
- The most effective measures of mitigating the identified risks need to be ascertained. As an example, vegetation clearance may be determined to be the most appropriate solution to mitigating disaster risk
- Action on this front can be either compulsory or market-based. An on-the-ground compliance officer will be required to ensure that the property remains compliant, in this case potentially the rural fire service. Incentives can be either market-based (insurance discount) or mandated (legal requirement)
- Payment needs to be apportioned between the parties involved. In the example used, there is an immediate burden being placed on the compliance officer. To share the burden, it could be possible for governments to fully cover or subsidise the costs of the compliance officer.

Burying electricity wires generates around $2.1 billion of benefits to 2050

4.4 Summary

The case studies outlined above provide evidence of the economic benefits of building resilience[12]. While there is a large range of BCRs estimated (see Chart 4.2 below), it is important to note that investments in resilience which target high risk locations using appropriate combinations of infrastructure, policy and procedure have the potential to generate economic benefits.

Chart 4.2: Case Studies – Ranges – Benefit-Cost Ratio of specific resilience measures



Source: Deloitte Access Economics analysis (2013)

Whilst demonstrating that cost effective action can be taken, these case studies also highlight and point to some core elements of a reinvigorated agenda to build resilience:

- The estimated net benefits from upgrading the Warragamba Dam differ from those found in earlier studies in part because they have utilised detailed and current data provided by Roundtable members on the risks and costs of the Nepean River flooding. A national strategy to improve resilience needs to find ways to better coordinate relevant data held by all parts of government and business so that decisions can be made on the best available information
- The other two case studies point to the desirability of finding mechanisms that allows key investment decisions to be taken at a localised level, often property by property. The ranges shown for the BCRs for both cyclones and floods in SE Queensland and bushfires in high risk locations in Victoria reflect differences in whether the buildings are new or existing, and how risks and costs vary according to the precise location and type of building. For new buildings, the BCRs will tend to be towards the top of the ranges depicted in the chart and there will often be a clear case for requiring preventative action through building codes or planning for all new houses being considered in a region.
- In contrast, the BCRs for existing properties may be towards the lower end of the ranges shown. It will only be cost effective to invest in prevention in a subset of cases. Decisions taken by individual property owners will need to reflect the particular circumstances involved. Those decisions can be supported by government providing information and incentives and by the private sector providing price signals that reflect the risks involved. A coordinated approach across all parties will be needed for this to be effective.

These measures involve broader application of existing building codes, gathering better risk information, making better planning decisions and individuals taking responsibility for reducing risks around their own homes.

The case studies clearly point to the need for coordination across many parties, effective identification of both the risks and the resilience options as well as clear alignment of incentives to act.

The following chapter outlines recommendations for future actions in the area of pre-disaster resilience.

12 In each case, the estimated BCRs have been based on data and information drawn from existing studies as well as data provided by IAG and Munich Re. As with all government investment decisions, detailed analysis utilising the latest engineering and technical data should be conducted.

Estimated annual cost 2013

$63bn

FORECASTED TO GROW
BY 3.5% ANNUALLY

5. Recommendations

The three main recommendations

1. Improve coordination of pre-disaster resilience by appointing a National Resilience Advisor and establishing a Business and Community Advisory Group
2. Commit to long term annual consolidated funding for pre-disaster resilience
3. Identify and prioritise pre-disaster investment in resilience that delivers a positive net impact on future budgets.

A fresh, sustainable and comprehensive approach to pre-disaster resilience

The three main recommendations of this paper outline an approach that best facilitates the:

- Coordination of incentives of pre-disaster resilience activity across individuals, business and governments, as per the examples provided
- Strengthening of the decision-making framework and clarifying responsibilities among the three layers of government
- Establishing an appropriate funding model for pre-disaster resilience
- Strengthening the information framework by providing appropriate incentives to participate e.g. business, community organisations, state and local government
- Coordinating best practice research into effective pre-disaster resilience activities.

1 Improve coordination of pre-disaster resilience by appointing a National Resilience Advisor and establishing a Business and Community Advisory Group

Developing resilient communities should be elevated to the centre of government decision-making, a move necessary to deliver effective and efficient coordination of activities across all levels of government, business, communities and individuals. This should be directly supported by a Business and Community Advisory Group to help facilitate a more coordinated response and by ensuring that business and the not-for-profit sector are represented at the highest levels of policy development and decision-making.

To have a measurable impact on Australia's resilience, the coordination challenge is large and requires a nationally comprehensive approach. Many of the levers to drive this coordination challenge are in the hands of governments.

The issue of natural disaster resilience touches on all current COAG reform agendas. Given the range of cross-department activities, coupled with the large post-disaster relief and recovery costs to government at both the Australian and state level, a fresh approach to addressing the key challenges of building a more resilient Australia is warranted.

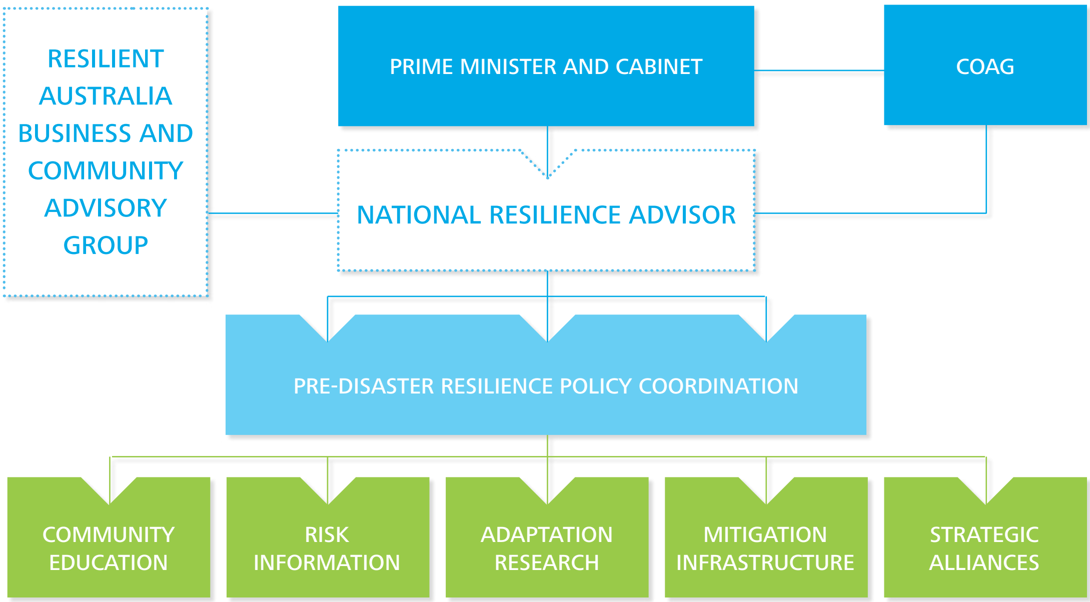
As discussed in Chapter 3, there are clear and agreed roles for government in the area of disaster resilience. Governments should respond to market and regulatory failures that prevent effective and efficient natural disaster risk management. As it stands, many decisions within the community and economy are made with limited awareness of the level of risk and even less knowledge of the effectiveness of available pre-disaster resilience actions. This is made more difficult by a lack of coordination between databases of information on both risk and pre-disaster resilience measures.

It is recommended that the development of resilient and safer communities must be brought together to the **centre of government** as a separate, but connected, policy issue relative to emergency management.

This can be achieved with the establishment of a **National Resilience Advisor** in the Department of Prime Minister and Cabinet to effectively drive the coordination required across government and to deliver faster progress on building a resilient Australia.

This recommendation is illustrated in Figure 5.1 and Figure 5.2 on the following pages.

Figure 5.1: Building a more resilient Australia



PRINCIPLE: CENTRAL GOVERNMENT FOCUS WITH STRONG SUPPORT FROM BUSINESS TO ADDRESS THE COORDINATION CHALLENGE

2 **Commit to long term annual consolidated funding for pre-disaster resilience**

All levels of government – led by the National Resilience Advisor – should commit to consolidating current outlays on mitigation and to funding a long-term program which significantly boosts investment in mitigation infrastructure and activity.

Critical to this success will be support for the consolidation of existing information and commissioning of additional data where needed. This will assist in the development and implementation of effective local responses by governments, businesses and the community.

3 **Identify and prioritise pre-disaster investment in resilience that delivers a positive net impact on future budget outlays**

It is also recommended that the fresh policy approach would develop a new set of **programs** that build on, consolidate or coordinate existing activity. While these programs will require upfront funding, they can be designed in such a way that the expected net present value of the overall costs to government will be reduced.

The design and funding of each of these programs should incorporate appropriate **incentives** to engage the relevant stakeholders including state government, local councils, business, communities and individuals.

The current programs and activities across government should be reviewed for effectiveness in driving alignment of incentives. Activities are often most effective and efficient when they are locally driven by motivated and engaged communities, individuals, businesses and local councils, with support from government on appropriate information, research and decision-making tools.
The fund should specifically target the hard problems of existing settlements: co-contributions for retrofitting, building levees and enforcing compliance are one means of securing alignment.

Figure 5.2 The coordination challenge – Building a more resilient Australia

Figure 5.3 Building a more resilient Australia – examples of incentive based programs

LOCAL GOVERNMENT INFRASTRUCTURE INCENTIVE PROGRAM

- PC recommendation 5.1 and 11.1
- Develop best practice
- Competitive prioritisation of mitigation funding
- Cost benefit guidelines
- Local government capability support.

RESILIENT RETROFIT INCENTIVE PROGRAM

- PC recommendation 5.1 and 11.1
- Work with ABCB and Building Ministers' Forum
- Develop a targeted retrofit program
- E.g. Sprinkler Systems in bush fire regions
- Develop compliance/ monitoring systems.

As noted in Chapter 4 in the NSW case study, the Local Government Infrastructure Incentive program could assess proposals in a process similar to that currently used by Infrastructure Australia. This results in a competitive prioritisation process to drive best practice pre-disaster resilience. It also serves as a method for collecting and collating information and data to promote and communicate 'best practice' pre-disaster resilience options across the nation. This would be an extension of the recently announced National Insurance Affordability Council approach.

Concluding comments:

The purpose of this paper is to contribute to the national discussion on how Australia might make decisions that help reduce vulnerabilities to natural disaster.

It outlines a new approach to making effective pre-disaster investments across the country. Combining data provided by the Roundtable members with publicly available information has resulted in a greater depth of analysis than has existed before. This demonstrates the value of integrating research and information across business and government for more effective decision making.

The paper demonstrates how the approach recommended can deliver materially reduced economic costs as well as relieving long-term pressures on government budgets. But even more importantly, this would reduce some of the trauma and loss of life that confronts many of our communities all too frequently.

The recommended approach would reduce some of the trauma and loss of life that confronts communities

References

Australian Building Codes Board, 2009, Final Regulatory Impact Statement for Decision, Proposal to Revise the Building Code of Australia requirements for Construction in Bushfire Prone Areas, RIS 2009–02, Canberra.

Australian Building Codes Board, 2013, Construction of Building in Flood Hazard Areas.

Australian Bureau of Statistics, 2010, Household and Family Projections, Australia, 2006 to 2031, Cat No. 3236.0.

Australian Emergency Management, 2013, Knowledge Hub.

Australian Government, 2012, Directory: Attorney General's Department.

Australian Government, 2013, Australian Government response to the Productivity Commission Report: Barriers to Effective Climate Change Adaptation.

Australian Government – Attorney General's Department, 2010, Critical Infrastructure Resilience Strategy, Barton.

Australian Government – Attorney General's Department, 2011a, Emergency Management Approaches.

Australian Government – Attorney General's Department, 2011b, Natural disasters relief and recovery arrangements.

Australian Government – Attorney General's Department, 2011c, National Partnership Agreement on Natural Disaster Resilience.

Australian Government – Attorney General's Department, 2013, Standing Council on Police and Emergency Management.

Australian Government – Department of Finance and Deregulation, 2012, Appendix G: Natural Disaster Relief and Recovery Arrangements (NDRRA) Review of States' (including Local Governments') Submissions – 29 August 2012.

Australian Government – Department of Finance and Deregulation, Office of Best Practice Regulation, 2012, Best Practice Regulation Guidance Note Value of Statistical Life.

Australian Government – Department of Prime Minister and Cabinet, 2013, Government to Increase Affordability of Insurance.

Australian Government – Geoscience Australia, 2012, Agency resources and planned performance.

Australian Government – Geoscience Australia, 2013, Historic Events – Earthquakes.

Australian Government – Treasury, 2011, National Disaster Insurance Review: Inquiry into flood insurance and related matters, Parkes.

Australian Red Cross, 2013, Australian Red Cross Public Submission to the Senate Standing Committee on Environment and Communications Inquiry into Recent trends in and preparedness for extreme weather events.

Bureau of Transport Economics, 2001, Economic Costs of Natural Disasters in Australia, Report 103, Canberra.

Council of Australian Governments, 2011, National Strategy for Disaster Resilience, Barton.

CSIRO, 2013, Climate Adaptation Flagship.

Deltacommissie, 2008, Working together with water: A living land builds for its future.

Economic Regulation Authority of Western Australia, 2011, Inquiry into State Underground Power Program Cost Benefit Study Final Report, Perth.

Emergency Architects Australia, 2011, Queensland Flood Relief, Final Report.

Foote, E.I.D. (1994), Structure survival on the 1990 Santa Barbara 'Paint' fire: A retrospective study of urban-wildland interface fire hazard mitigation factors. MS thesis, University of California at Berkeley

G20 & OECD, 2012, Disaster Risk Assessment and Risk Financing.

Gold Coast City Council Local Disaster Management Group, 2012, Gold Coast City Local Disaster Management Plan Version 6.0.

Healy A & Malhotra N, 2009, 'Myopic Voters and Natural Disaster Policy', American Political Science Review, 103:03.

Hensher DA, Rose JM, de Dios Ortúzar J, Rizzi LI, 2009, Estimating the willingness to pay and value of risk reduction for car occupants in the road environment, Transportation Research Part A 4, 692: 707.

Hugo G & Harris K, 2011, Population Distribution Effects of Migration in Australia, The University of Adelaide. Report for Department of Immigration and Citizenship.

References continued

Insurance Council of Australia, 2013, Historical Disaster Statistics.

Intergovernmental Panel on Climate Change, 2012, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the IPCC. Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner GK, Allen SK, Tignor M & Midgley PM (eds). Cambridge University Press, Cambridge, UK and New York, NY, USA.

International Monetary Fund, 2012, Natural Disasters Hitting More People, Becoming More Costly.

Lloyd's of London, 2013, 'Lloyd's supports unique flood solution in the Netherlands'.

Mechler R, 2005, Cost-benefit Analysis of Natural Disaster Risk Management in Developing Countries.

Ministry for Police and Emergency Services, 2005, Hawkesbury Nepean Flood Emergency Sub Plan.

Mogil, H. Michael, 2007, Extreme Weather: Understanding the Science of Hurricanes, Tornadoes, Floods, Heat Waves, Snow Storms, Global Warming and Other Atmospheric Disturbances.

Molino Stewart, 2012, Hawkesbury-Nepean Flood Damages Assessment: Final Report for Infrastructure New South Wales.

Multi-hazard Mitigation Council, 2005, Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities.

Munich Re, 2006, Topics Geo: Natural catastrophes 2006 Analyses, assessments, positions.

Munich Re, 2013, Natural catastrophes in 2012.

OECD, 2012, G20 ministers welcome OECD disaster risk assessment and financing framework.

Productivity Commission, 2012, Barriers to Effective Climate Change Adaptation, Report No. 59, Final Inquiry Report, Canberra.

Prosser B & Peters C, 2010, Directions in disaster resilience policy, The Australian Journal of Emergency Management, 25:3.

Queensland Floods Commission of Inquiry, 2012, Final Report.

Risk Frontiers, 2010, Bushfire Penetration into Urban Areas in Australia: A Spatial Analysis.

Risk Frontiers, n.d., Senate Standing Committee on Environment & Communications: Inquiry into Recent Trends in Preparedness for Extreme Weather Events.

Rose A, Porter K, Dash N, Bouabid J, Huyck C, Whitehead JC, Douglass Shaw W, Eguchi RT, Taylor C, McLane TR, Thomas Tobin L, Ganderton PT, Godschalk D, Kiremidjian AS, Tierney K, Taylor West C, 2007, 'Benefit-Cost Analysis of Federal Emergency Management Agency (FEMA) Hazard Mitigation Grants'.

Select Council on Climate Change, 2012, Roles and responsibilities for climate change adaptation in Australia.

Senate Environment and Communications References Committee, 2013, Inquiry into Extreme Weather Events, Canberra.

Stegbar, 2009, 'AS4055 wind loads for housing'.

Stewart MG & Wang X, 2011, Risk Assessment of Climate Adaptation Strategies for Extreme Wind Events in Queensland.

The Commonwealth of Australia 2012, Budget 2012-13, Paper No. 3, Part 2: Payments for Specific Purposes, Contingent Payments.

The Commonwealth of Australia 2013, Budget 2013-14, Part 2: Payments for Specific Purposes, Contingent Payments.

The Times of London, 2013, Insurers may be made to offer fixed-price flood cover.

The World Bank 2012, Adaptation Guidance Notes – Key Words and Definitions.

United Kingdom – Environment Agency, 2009, 'Investing for the future'.

United Kingdom – Cabinet Office, 2013, 'Improving the UK's ability to absorb, respond to, and recover from emergencies.'

United Nations, 2009, UNISDR Terminology and Disaster Risk Reduction, Geneva.

United Nations International Strategy for Disaster Reduction, 2013.

United Nations International Strategy for Disaster Reduction, 2013, Hyogo Framework for Action 2005–2015.

Victorian Bushfires Royal Commission, 2010, Final Report.

UNDP Maldives and Government of Maldives, 2009, 'Cost Benefit Study of Disaster Risk Mitigation Measures in Three Islands in the Maldives'.

Weber RO, n.d, Bushfire Ignition Probabilities and Spread.

Wegner C, Hussey K & Pittock J, 2013, 'Living with floods: key lessons from Australia and abroad, National Climate Change Adaptation Research Facility, Gold Coast.

Victorian Bushfires Royal Commission, 2010, Final Report.

Victorian Government, 2012, Inquiry into Flood Mitigation Infrastructure in Victoria.

Throughout this project we consulted with a large number of organisations. The feedback received during these consultations has been indispensable in putting this report together and we would like to thank all those who participated in the consultation process.

- Australian Red Cross
- CSIRO
- Cyclone Testing Station
- Firefoxes
- Gold Coast Council
- Insurance Australia Group
- Insurance Council of Australia
- Investa Property Group
- Molino Stewart
- Munich Re
- Optus
- Property Council of Australia
- The Australian Building Codes Board
- Volunteering Queensland
- Wagga Wagga City Council
- Westpac Group.

Coonabarabran, New South Wales January 2013

Bundaberg, Queensland February 2013

Brisbane, Queensland January 2011

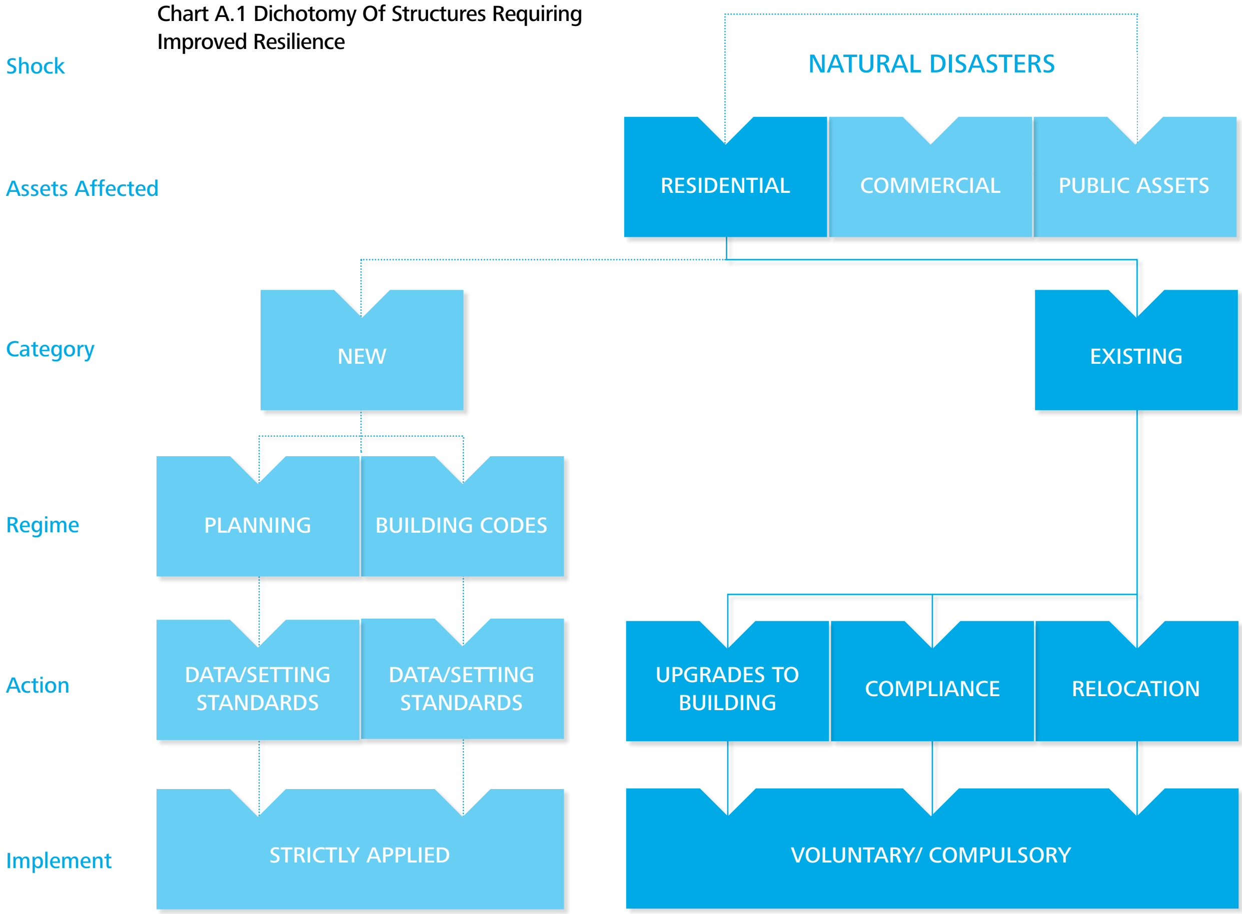
Appendix A: Resilience – the structure of the problem

This section lays out the structure of the problem to clearly point to areas which deserve greater focus of government, business, communities and individuals. The area of disaster resilience is complicated and the structured approach taken below provides an initial focus on 'hard adaptation'[13] activities required and then looks at what is necessary from a 'soft adaptation' perspective in order to better understand the coordination issue that needs to be addressed in developing a more resilient and safer community.

The categories of structures requiring resilience are presented in Chart A.1. We start by looking at the nature of the main assets affected by natural disasters namely: residential housing, commercial buildings and public assets (roads, bridges, parks, schools, etc).

We then take each of these asset classes in turn and consider separately both new and existing assets. This is an important consideration given that the appropriate pre-disaster resilience action and collaboration required are different between new and existing assets and hence impacts on the framing of policy recommendations.

Chart A.1 Dichotomy Of Structures Requiring Improved Resilience



13 'Hard' adaptation measures usually imply the use of specific technologies and actions involving capital goods, such as levees, seawalls and reinforced buildings, whereas 'soft' adaptation measures focus on information, capacity building, policy and strategy development, and institutional arrangements.

In this Appendix we focus on the residential category but the same analysis can be undertaken for commercial and public assets. Thus, the 'Residential housing' category in Chart A.1 is broken down to consider the implications for both new and existing properties and how the pre-disaster resilience activity will vary.

If we look at the existing residential asset category, consultations with industry and peak bodies have suggested that recent activity in improving planning and building codes in relation to disaster resilience is well in hand and is the subject of significant focus and attention.

> For example, on 30 January 2013, the Australian Building Codes Board (the Board) announced the decision to introduce new National Construction Code (NCC) provisions to apply in flood hazard areas as designated by state, territory or local governments (Australian Building Codes Board, 2012). The new requirements are designed to ensure the structural integrity of, and survival of utilities in, new residential buildings in designated flood hazard areas in all states and territories of Australia. This requirement found to increase construction costs by $216 million (present value over 10 years) with the benefits of ensuring structural integrity and survival of amenities estimated to be $352 million (present value over 10 years). Therefore, this option was found to have a net benefit to the community and has now been incorporated into the building codes (which are enforceable through the Local Council planning approvals process).

Considering each category in turn, we look to apply a standardised framework for analysis as set out in Chart A.2.

Chart A.2 Framework for analysis

Residential

> **Key Points**
>
> - Critical role for Government is to develop appropriate information that informs high level awareness of risks
> - The biggest coordination challenge but arguably the greatest impact is with existing residential buildings (retrofit, compliance and relocation)
> - Relocation options will be challenging for Governments but need to be considered in the appropriate circumstances.

Residential – new

Approximately 1.3% of the housing stock is built each year which makes standards for new residential construction a long-term method of introducing disaster resilience. At this rate of construction, a new building standard introduced today will take at most 44 years to cover 50% of the housing stock. While this time horizon might seem exceptionally long, the attractiveness of pursuing resilience in new homes is driven by the fact that it is both technically easier and more economical to improve resilience during the construction of a house as compared to retro-fitting a pre-existing home.

The proposed method of implementing disaster resilience in new homes is therefore through the improvement of Data and Standard Setting. We will analyse this method using the framework in Chart A.2.

- Natural disaster risk needs to be accurately mapped by location. For example, flood risk maps and detailed digital elevation maps needs to be made available that allow for modelling of flood risks in a manner that is specific enough to determine the risk for a given property
- The most effective measures for mitigating the identified risks need to be ascertained. For example, this may involve the CSIRO determining best practices for flood pre-disaster resilience given particular levels of risk. Insurers can also involve themselves at this stage by valuing the reduction in assets at risk brought about by these pre-disaster resilience efforts
- Action on this front can be mandated through the Building Codes and through conditions attached to planning approval. As an example, these standards could be included in the NCC or into the relevant State Development Code
- Payment in this case will fall on the constructing party, either the homeowner or developer.

Residential – existing

In any given year, existing residential buildings make up 98.7% of the housing stock and are thus a prominent target for the implementation of disaster resilience. Unfortunately, it is often technically difficult and very expensive to retro-fit an existing property to be disaster resilient.

However, three possible methods of improving resilience are proposed here:

- Upgrades to buildings
- Compliance
- Relocation.

Upgrades to buildings

One method of improving resilience in the housing stock is to consider specific upgrades to buildings. Again using the framework in Chart A.2:

- Natural disaster risks need to be accurately mapped by location (as for new residential buildings)
- The most effective measures for mitigating the identified risks need to be ascertained, again, through targeted research, including potentially building inspections and home audits, similar to energy efficiency or other 'improvement' processes for homes
- Action on this front can be market-based. Price signals can be communicated either through home valuation or through lowered insurance premiums. For example, the implementation of bush fire resilience upgrades to a home can both increase the value of the property when sold or mortgaged, as well as trigger a reduction in insurance premiums for the residents within it.

Example

A measure to improve cyclone resilience on existing homes by 50% could cost $25,000. There will be benefits for both the individual and government from undertaking this home improvement and so costs should be allocated accordingly.

Local government's role could be the collection and dissemination of risk information and compliance monitoring, working in close collaboration with the relevant state government.

Compliance

As well as upgrades, existing buildings need monitoring over time to ensure compliance with a required upkeep standard. Over time resilience measures may deteriorate (e.g. clearing vegetation around homes in bush fire risk areas) and so the property and surrounding environment must be appropriately maintained to ensure ongoing resilience.

Using the framework set out in Chart A.2:

- Natural disaster risk needs to be mapped by location. For example, in the case of bushfires, the extent of the bush and fire load, as well as local topography needs to be mapped in a manner that allows the determination of risk level in each house
- The most effective measures for mitigating the identified risks need to be ascertained. As an example, vegetation clearance may be determined to be the most appropriate solution to mitigating disaster risk

- Action on this front can be either compulsory or market-based. An on-the-ground compliance officer will be required to ensure that the property remains compliant although the officer could utilise aerial surveillance information to make this task more cost effective. Using the example of bushfires, a possible organisation that can ensure compliance would be the Rural Fire Service in the case of NSW. Incentives in this case can be either market-based (insurance discount) or mandated (legal requirement). The matter however is complicated by the fact that there are reputational costs associated with being the group that polices compliance. Furthermore, there may be a substantial monetary and time cost to checking properties in an area for compliance
- Payment in this case needs to be apportioned between the parties involved. In the example used, there is an immediate burden being placed on the compliance officer.

The appropriate pre-disaster resilience action is different for new and existing assets and hence impacts the framing of policy recommendations

Relocation

A third method of improving resilience is to relocate members of the community out of high-risk areas.

Using the framework set out in Chart A.2:

- Natural disaster risk needs to be accurately mapped by location
- The most effective measures for mitigating the identified risks needs to be ascertained. Critically though, relocation should be seen as a last resort, and only be applied when other methods of promoting resilience are deemed ineffective or inappropriate
- Action on this front can be either market-based or mandated. Market-based solutions would involve the use of voluntary buybacks to remove residents from homes that are most at risk. An extreme alternative would be to use compulsory acquisition laws to mandate the purchase of homes in highest-risk areas. Although extreme, compulsory acquisition has been used in the past in cases such as Sydney Airport where residents were provided with a sliding scale of noise reduction improvements depending on their distance from the flight path. Another example is Christchurch in New Zealand where, following the 2011 earthquake, certain areas have been designated 'red zone' prohibiting rebuilding of homes, with residents offered relocation to new subdivisions under their insurance
- Payment in this case needs to be apportioned between the parties involved. In this case, that would result in some measure of cost being balanced between the government and the residents being relocated. This could take the form of housing subsidies structured as an incentive to encourage residents to relocate.

Appendix B: Resilience international experience

International institutions

The number of people affected by natural disasters around the world has increased markedly over recent years. Over a two year period more than 450 million people were impacted by 700 natural disasters around the world. The cost of disasters has risen from an average of $20 billion each year during the 1990s to more than $100 billion each year by 2010–11. This dramatic increase is the result of the interaction between the rising number and increasing severity of events, with the concentration of people and infrastructure in high risk areas. Over the past few years of global economic instability, natural disasters have lowered economic growth and worsened fiscal balances (IMF, 2012).

In 2012 natural disasters cost US$160 billion. The majority of this was attributable to the United States. Losses in 2012 were significantly lower than in 2011 when natural disasters caused around US$400 billion worth of damage. The cost of damage caused by natural disasters in 2012 was around the 10 year average of US$165 billion.

Of greater significance is the number of people who lost their lives due to natural disasters. In 2012 alone, around 9,500 people died as a result of natural disasters (Munich Re, 2013).

There are a range of international frameworks that have been established which aim to reduce the impacts of natural disasters on communities, economies and the environment. These programs are primarily based around information sharing and disseminating guidance to national government and other interested stakeholders. In some circumstances financing is provided, particularly for developing countries facing high risk scenarios.

Established in 1999 the United Nations International Strategy for Disaster Reduction (UNISDR) has the primary goal of ensuring disaster risk reduction. The UNISDR coordinates disaster risk reduction and ensures that activities are aligned across the UN network. The UNISDR facilitates collaboration and information sharing amongst governments, international organisations and other stakeholders. The UNISDR organises a Global Platform for Disaster Risk Reduction every two years, this is a forum for exchanging information and builds awareness of disaster risk reduction (UNISDR, 2013).

Other programs include:

- PreventionWeb, a website for distributing information on disaster risk reduction
- Biennial Global Assessment Reports a global analysis of disaster risk (Productivity Commission, 2013).

The UNISDR program is premised on the strategic goals of the Hyogo Framework for Action (HFA) (2005-2015). The Hyogo framework, adopted in 2005, aims to substantially reduce losses from natural disasters by 2015. The framework outlines priorities to reduce losses from natural disasters and offers guidance and practical actions to achieving disaster risk reduction. PreventionWeb regularly publishes Hyogo Framework National Progress Reports. Australia's national report is prepared with the assistance of the Attorney General's department and outlines how Australia has committed to meeting the outcome of the framework.

The financial costs of natural disasters can exacerbate pre-existing social and economic conditions. Ensuring that economies are financially resilient is a key attribute to achieving national resilience to natural disasters. In recognising this in 2012 the OECD released a disaster risk assessment and financing framework. The methodological framework for disaster risk assessment and risk financing, is intended to help national finance ministries develop disaster risk management strategies, which focuses on disaster risk reduction and risk financing, rather than specific risk reduction policies (G20 & OECD, 2012). Key to this is the influence that strong financial management has in developing sound disaster risk management strategies. Australia has the potential to be a leader in these efforts.

Future activities could include:

- Developing a further understanding of budgeting for disasters, e.g. identifying, pricing and budgeting of contingent liabilities
- Considering mechanisms to enable sustained prevention and pre-disaster resilience investments (e.g. pre-disaster resilience funds), complementing the focus of the framework on the financial management of disaster losses
- Examining the potential impacts of disasters on financial infrastructure and systems, focusing on their sustainability and business continuity
- Building guidance and case studies for developing countries operating in extremely resource-scarce environments where people may be highly vulnerable to disasters and lack access to resources to mitigate impacts (OECD, 2012).

The International Monetary Fund (IMF) has emphasised the importance of a cooperative approach to building resilience to natural disasters. By providing financial support, policy support and risk management options the IMF helps national governments lay the foundation for economic recovery following disaster. The IMF achieves this by improving the coordination of multilateral institutions, bilateral donors, the authorities and civil society organisations which are intended to strengthen policy frameworks and improve resilience. There is however, considerable work to be done to improve donor coordination and international consultation which would focus on promoting donor assistance pre-disaster, that is funding for disaster risk reduction, which the IMF believes is likely to have a higher return than emergency assistance ex post (IMF, 2012). This action will strengthen disaster risk mitigation and build community resilience prior to disaster.

In recognising that adapting to climate change is one of the most fundamental challenges facing European territorial development, the European Commission has announced a package to advance action on adaptation to climate change in the European Union (EU). The strategy sets out a framework and mechanisms for taking the EU's preparedness for current and future climate impacts to a new level. The strategy is based around:

- **Promoting action by member states:** The EU Commission will encourage all member countries to adopt comprehensive adaptation strategies and will provide funding to assist members build their capacity to adapt
- **'Climate-proofing' action at EU level:** this will include promoting adaptation in vulnerable sectors as well as encouraging the use of insurance against natural and man-made disasters
- **Better informed decision-making:** the Commission will address information gaps and will continue to promote climate adaptation platform (Climate-ADAPT) as the 'one-stop shop' for adaptation information in Europe.

The Netherlands

Water management

More than 60% of the country and around two thirds of the population of the Netherlands is under sea level or at risk of flooding. The Dutch are keenly aware of the consequences of floods and the urgency to act to reduce the effects. Policies and programs, implemented at the national and local level, are focused on anticipating and minimising the effects of flooding.

Over the centuries the Dutch developed an elaborate system of levees designed to 'hold back' the water. Serious flooding in 1916 and again in 1953 highlighted that this policy was no longer appropriate. The decades long policy response to the 1953 flood was to implement a program of Delta Works. The program administered by the *Deltacommissie* focused on risk based approaches to flood protection which considered the probability and consequences of flooding (Deltacommissie, 2008). Specifically, the program guarded estuaries from storm surges, raised and strengthened levees, and included a program of floodplain management. The program cost around $13 billion over four decades.

Another series of serious flooding in 1993 and again in 1995 initiated a shift in policy away from flood control and towards making communities more resilient to floodwaters. The new policy emphasised a holistic approach to water management which identifies adaptation measures which consider water management issues more broadly including drought, flooding and water quality.

More recently The Deltacommissie focus is on building long-term resilience, through visionary, proactive and enabling policies (Wegner et at, 2012). Since 2007 the commitment to resilience has been most notable in the 'Room for Rivers' program. The 'Room for Rivers' program aims to ease flooding by giving waterways space to move and overflow, with pre-disaster resilience activities taking place at the municipality and national level. Each year the Dutch government spends around $1.3 billion on water control including the 'Room for Rivers' program, with local water boards, who have the rights to levy taxes from locals within the area, spending hundreds of millions more to maintain levees and canals (Statistics Netherlands, 2012).

There are many examples of a fragmented approach to water management in the Netherlands. The work of water management authorities is often limited to one part of the water system. While the Deltacommissie recognised the need for integrated and multi-functional land use projects, in practice there have been examples of a siloed approach to funding, the result of funding being directed only towards projects within a sector, instead of a whole of system approach. There are further conflicts within the system that are the result of issues between municipalities which are responsible for development planning and Water Boards some of which are incentivised to leave areas at risk of flooding undeveloped.

A fragmented approach to water management has the potential to cause irrevocable damage to those who are at risk. A coordinated response, which involves people at the local and national level, is necessary to ensure that communities are protected effectively.

Overall, the Dutch offer some practical examples for Australia of managing risks from floods including:

- The '*retain–store–drain*' and 'Room for the River' models could be implemented in Australia, these approaches would ensure that more land was allowed to flood by removing or setting back floodplain levees and would reduce the severity of flooding in affected areas
- There are advantages in the approach to land use where space is scarce, this strategy would provide an optimal outcome to stakeholders and encourage cost sharing of projects across jurisdictions.

The Dutch process of reviewing and preparing for natural disasters could also be implemented in Australia. Australia's review process has tended to be retrospective with a focus on past issues but this is not always effective in preparing for future disasters. The Dutch take a long term view, with a focus on future risks, when undertaking disaster reviews, Australia could benefit from having a similar approach to future reviews.

Insurance arrangements

Despite the improvements in flood protection over the last 60 years, flood risk in the Netherlands was generally considered uninsurable: most insurance companies in the Netherlands do not cover flood damage (Botzan W.J.W & van den Bergh J.C.J.M, 2006) and most of the country's homeowners do not have access to flood insurance. The Deltacommissie outlines the relationship between insurance and community resilience:

Lessons from the USA and the UK teach us that leaving responsibility to individuals does not always mean that they accept it … Flood protection often remains confined to local 'postage stamps' based on local cost-benefit considerations and so do not always form a consistent whole … Damage control and disaster management (and insurance) are better organised in countries with poorer levels of protection (and more frequent flooding). (Deltacommissie 2008).

The lack of private insurance has necessitated the Dutch government to provide compensation as an insurer of last resort. The Dutch government has recently attempted to stimulate the private insurance market by shifting risks to the private sector. However, private insurance coverage for floods remains limited.

In 2012, Neerlandse began offering flood insurance by assessing individual property owners, using a unique underwriting and risk assessment tool. The underwriting tool, which is available online for property owners to access, combines flood data from engineers with mapping technology to produce a risk assessment (Lloyds, 2013). Using this assessment a premium is determined for an individual property. This however, does not take into account resilience activities that individual property owners undertake. This does, however, demonstrate that insurance premiums which assess individual properties are possible.

The United States of America

Institutional arrangements

Like Australia, the United States of America faces threats from multiple natural disasters. In 2011 alone, President Obama issued 99 'major disaster declarations'[14]. Like Australia, the costs in the United States have been rising as a result of the increasing frequency and severity of events and the demographic shifts that are taking place. Significantly, some of the most expensive natural disasters in history have taken place in the United States within the last 10 years.

The Federal Emergency Management Authority (FEMA) is an agency within the Department of Homeland Security and is responsible for coordinating responses to natural disasters which overwhelm local authorities. This situation is similar to that found in Australia. In the United States preparedness and response to natural disasters are seen as part of responding to emergencies and disasters more broadly, both man-made and natural. Similar to the Attorney General's department in Australia the Department of Homeland Security is focused on national security as a primary concern. The policy outlined in section 5 suggests shifting the responsibility of responding to natural disasters to the Department of Prime Minister and Cabinet.

FEMA's Federal Insurance and Mitigation Administration (FIMA) is responsible for implementing a variety of programs which focus on:

- Analysing risk
- Reducing risk
- Insuring for flood risk.

FEMA also administers the Hazard Mitigation Assistance (HMA) grant programs which provide funding for activities that reduce disaster losses and protect life and property from future disaster damages. This program includes: Hazard Mitigation Grant Program; Pre-Disaster Mitigation; Flood Mitigation Assistance; Repetitive Flood Claims; and Severe Repetitive Loss.

14 Disaster relief is a local responsibility, however the Australian Government will become involved when disasters are so severe that state and local governments are unable to respond and recover without federal assistance. Federal involvement takes place after the President declares a 'major disaster' following a formal request by a state government. (Wenger, 2012).

Each state has a division of homeland security and emergency services and a Natural Hazard Mitigation Plans. The plans receive formal approval through FEMA, which allows states access to FEMA funding. For example, the New York State Office of Emergency Management (NYS OEM) is responsible for coordinating the activities of all the State's agencies to protect communities, and the environment from natural disasters and emergencies.

This includes offering assistance to local governments, voluntary organizations, and private industry with loss prevention, planning, technical support, and disaster recovery assistance.

Recently FEMA established the FEMA Think Tank. The Think Tank is intended to help FEMA understand best practice and to generate new ideas from the perspectives of the communities directly affected by natural disasters. The FEMA Think Tank brings together state and local governments and members of the public, including the private sector, the disability community, and the volunteer community.

The FEMA Think Tank has two main components:

- Online Forum which allows individuals to submit ideas, comment on others, and participate in conversations meant to generate solutions, about amongst other things mitigating against disaster.
- Monthly Conference Call Discussions: The Deputy Administrator Serino conducts monthly conference calls to discuss solutions and ideas that are generated by this online forum.

As recently as 6 February over 80 participants, including Secretary of Homeland Security, Janet Napolitano, participated in a Whole Community Discussion.

Funding

Over 2011 the Hazard Mitigation Assistance program provided $252 million for flood mitigation projects. In total over 2011, FEMA spent $2.9 billion on all activities which strengthened the United States ability to prevent, protect, respond to, recover from, and mitigate terrorist attacks, major disasters, and other emergencies (funding was for all natural and man-made disasters). Around $50 million of this was allocated to the National Pre-disaster Mitigation Fund. In contrast in 2011 alone, natural disasters caused around $14 billion worth of damage in the United States, far greater than the amount spent on resilience measures.

While it is not possible to say that resilience measures would have significantly reduced the costs of natural disasters, it is not unreasonable to expect that greater expenditure on mitigation activities prior to a disaster taking place, rather than expenditure after the fact is warranted.

There is some concern that voters value funding spent on recovery after an event, such as payments to individuals, rather than funding for mitigation activities prior to an event, such as funding for large scale community-wide projects, the benefits of which are not immediately recognised[15]. Specifically, Healy and Malhorta (2009) find that voters do not appear to value prevention measures at all. Direct payments may be contributing towards the imbalance between mitigation expenditure and recovery expenditure (Wegner, 2012).

Similar direct payments have been made in Australia following disasters. The Australian Government Disaster Recovery Payment was offered to all people affected by floods with payments totally $800 million. The value of having such a significant amount of funding spent after an event, rather than before, should be carefully considered. Specifically, Chapter 4 of this report recommends a higher quantum of funding be allocated to pre-disaster mitigation activities in order to reduce the cost of natural disasters to communities.

The current arrangements for emergency management in the United States demonstrate that governments are able to work with locals and businesses in communities to develop co-ordinated and appropriate responses to emergency management. However, what is also clear is that adequate funding for resilience measures, emergency response and recovery funding, is necessary to ensure the long term protection of communities.

The United Kingdom

Policy

Serious flooding, the Fuel Crisis in 2001 and the Foot-and-Mouth Disease outbreak in 2001 highlighted deficiencies in the United Kingdom's capacity to respond to disasters. As a result the Civil Contingencies Secretariat (CCS) was established in 2001. The CCS aims to improve the UK's preparedness for and response to disasters, both man-made and natural. Unlike Australia and the United States, in the UK the CCS sits within the Cabinet Office[16], and works with government departments and other key stakeholders.

The CCS has five objectives:

- Spotting trouble, assessing its nature and providing warning
- Being ready to respond
- Building greater resilience for the future
- Providing leadership and guidance to the resilience community
- Effective management.

Only two of these focus on activities prior to an event. Building greater resilience for the future covers activities which include delivery of resilience at the local and national level, as well as working with international organisations to build resilience capabilities. The CCS also aims to provide leadership and guidance to the resilience community; the Civil Contingencies Act is a key output of this objective. The Civil Contingencies Act is separated into two parts, local arrangements for civil protection and emergency powers. The former outlines the roles and responsibilities at a local level for emergency preparedness. The CCS is also currently working on developing a 'National Resilience Strategy'.

15 Other research has found that communities do value payments for mitigation activities. In a study of eight FEMA mitigation grants the National Institute of Building Sciences found that Interviewees in all communities thought the FEMA grants were important to reducing the communities risk to natural disasters and assisted in preventing future damage. Importantly, most of the people participating in the study felt that the grants provided additional benefits to their community than what could be readily measured.

16 The Cabinet Office supports the Prime Minister and Deputy Prime Minister.

Recent achievements in the area of disaster resilience of the CCS include:

- Establishing a national risk assessment process which, for the first time, takes a systematic and all-inclusive approach to risk analysis. The National Risk Register is designed to raise awareness of the risks faced by individuals and organisations, and importantly, encourages them to think about their own preparedness for disaster. This involves identifying risks over a five year period which assesses likelihood and impact and which forms the basis for decisions about disaster preparedness. After the risks are identified, the register then determines capability planning and funding arrangements
- Supporting the establishment of three new Resilience Emergency Divisions, these are managed by the Department of Communities and Local Government, and focus on facilitating communication between national and local government.

Severe flooding in the summer of 2007 pushed the issue of flood risk to the forefront of the policy debate in the United Kingdom. The Pitt Review undertaken in 2008 recommended immediate action from the UK government. Recommendations included restricting building in areas of high flood risk, and making flood risk assessments a mandatory part of Home Information Packs[17].

Currently the government does not have a complete understanding of expenditure on disaster preparedness in the UK. In the National progress report on the implementation of the Hyogo Framework for Action (2011–2013) released in March 2013, the ratio of budget allocation to risk reduction versus disaster relief was unknown. This is largely the result of the funding which is directed towards departments who are responsible for different risk, rather than one centralised agency.

Flooding and insurance

Almost three million homes in the United Kingdom face threat from floods. Flood risk insurance is currently provided under 'the Statement of Principles on the provision of flood insurance' as per the agreement between the Association of British Insurers and HM Government. The statement binds insurers to offer flood insurance to homes and small businesses where the risk of flooding is lower than a 1.3% AEP event (≈1 in 75 year) and where the property is already insured. For properties at a greater risk, insurance is available on the condition that flood defences are planned to be built to reduce the risk below that limit within five years.

Flood defence expenditure has been cut by 25% since 2010, while 294 schemes that should have received funding since then have yet to be started. As the Statement of Principles expired on July 1st 2013, the insurance industry wants to see more commitment from the government on spending on flood defences before it commits itself any further. The Department of Environment, Food and Rural Affairs has also intimated that if no settlement is reached between the insurance industry and the government, they would be willing to legislate in order to force insurers to provide flood insurance for those in high risk areas, at a fixed price.

17 Home Information Packs were a mandatory requirement, which were to be supplied by homeowners selling their homes. This has since been discontinued.

International cost benefit analysis

There is a paucity of available studies which examine the relative benefits of natural disaster resilience measures at an aggregate level. Primarily, the available evidence assesses the costs and benefits of individual resilience projects. Hence, this paper fills an important information gap, both in Australia and internationally, on the potential outcome of mitigation activities at an aggregate, or national, level.

Aggregate analysis

Rose et al., (2007), 'Benefit-Cost Analysis of Federal Emergency Management Agency (FEMA) Hazard Mitigation Grants' and Multi-hazard Mitigation Council 2005, 'Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities'.

- The report assessed the potential savings from FEMA hazard mitigation activities for earthquake, flood and wind hazards
- The overall results of the assessment indicate a benefit-cost ratio (BCR) of 4:1, that is, each dollar spent on hazard mitigation by FEMA provides around $4 of future benefits for the country
- There was variation across natural peril, with a ratio of 1.5:1 for earthquake mitigation, and 5.1:1 for flood mitigation
- A majority (95%) of the contribution to the net benefit ratio for floods was through an avoidance of losses to structures and contents, as a result of purchases (and demolitions) of homes in flood plains.

UNDP Maldives and Government of Maldives, 'Cost Benefit Study of Disaster Risk Mitigation Measures in Three Islands in the Maldives', 2009.

- CBA of three islands based on implementing risk management measures which would develop these into 'safer' islands
- Comparison between two scenarios: Hazards and their impacts on communities 'without' any Disaster Risk Reduction (DRR) measures, and the reduction in hazard impact 'with' DRR measures
- Findings are island specific, that is, they do not examine costs and benefits between islands, or on neighbouring islands
- Sensitivity analysis for each island was undertaken based on minimum hazard occurrence and maximum hazard occurrence
- Results varied from a Benefit-Cost Ratio (BCR) of 0.39 to 1.40 for Thinadhoo Island, a BCR of 0.28 to 1.0 for Viligili Island, and a BCR of 0.50 to 1.95 for Vilufushi Island.

UK Environment Agency 2009, 'Investing for the future'.

- Five investment scenarios were tested to assess how different levels of investment change the amount of flood and coastal mitigation measures
- Costs and benefits between 2011 and 2110 are assessed to analyse the long term results of investments
- Modelling includes the costs and benefits to manage coastal, tidal and river flooding and managing coastal erosion
- The Benefit Cost Ratio from different investment scenarios ranges from four to 11
- The net benefit to society, based on 100 year costs and benefits ranges from around £140 billion to more than £180 billion.

Individual project analysis

Mechler, R 'Cost-benefit Analysis of Natural Disaster Risk Management in Developing Countries', 2005.

This paper reviewed evidence of preventative disaster management measures that reduce or avoid impacts of natural disasters in developing countries.

Table B.1: Summary of evidence on net benefits of risk management projects

Project	Actual or potential benefits	Result
Hypothetical evaluation of benefits of retrofitting of a port in Dominica and school in Jamaica	Avoided reconstruction costs in one hurricane event	Benefit-cost ratio (BCR): 2.2–3.5
Appraisal of Argentinean Flood Protection Project. Construction of flood defence facilities and strengthening of national and provincial institutions for disaster management	Reduction in direct flood damages to homes, avoided expenses of evacuation and relocation	Internal rate of return (IRR): 20.4%
Research-oriented appraisal of integrated water management and flood protection scheme for Semarang, Indonesia	Reduction in direct and indirect economic impacts	BCR: 2.5
Ex-post evaluation of Rio Flood and Reconstruction and Prevention Project in Brazil. Construction of drainage infrastructure to break the cycle of periodic flooding	Annual benefits in terms of avoidance of residential property damages.	Internal rate of return (IRR): > 50%

Source: Mechler (2005)

Lessons for Australia

Experience with the full range of natural disasters makes Australia well placed to become a leader in developing safe and resilient communities. Currently disaster management encompasses the full range of emergencies, both natural and man-made. Australia can take a fresh approach by elevating the development of resilient and safer communities to the centre of government, as a separate issue to disaster management more broadly.

International experience demonstrates the importance of establishing an inclusive national framework for disaster management. Local on the ground activities should be supported through data sharing and information gathering facilitated at the national level by an organisation. This organisation should also coordinate activities across and between stakeholders to ensure alignment of a best practice approach all jurisdictions and stakeholders.

It is also clear that more funding for mitigation activities prior to disaster is needed, as part of this, Government needs to have a clear understanding of how much is spent on mitigation activities relative to relief expenditure.

Cost benefit analyses undertaken in similar developed countries demonstrate a clear positive outcome from investment in pre-disaster resilience measures, which are related to the analysis in Chapter 4. In particular, analysis of flood mitigation measures indicates significant benefits of investing in flood mitigation infrastructure. In the United Kingdom for each $1 invested in flood mitigation measures the benefits ranged from between $4 and $11, this was equivalent to savings of between £140 and £180. While in the United States the benefit cost ratio was around 5:1. These results are broadly similar to those obtained through the analysis undertaken for raising the Warragamba Dam wall (Chapter 4.2) which would reduce average flood costs by around 73%.

Appendix C: National forecasting methodology

The forecasts provided in Section 2 are based on the historical frequency and severity of natural disasters in Australia. The process applied to generate the forecasts of insured losses can be summarised into the following steps:

1. Data on natural disaster events was gathered from the Insurance Council of Australia's database of natural disasters (ICA, 2013)
2. For each state, the historical data was first used to identify the distribution of number of natural disaster events each year
3. For the forecast period the number of natural disaster events per year was then simulated from this historical distribution. This gave a total number of events to be simulated for each state for each year of the forecast period
4. Each natural disaster event was then simulated using a bootstrapping procedure. This involved randomly selecting a historical event from the ICA database and incorporating some additional random variation in severity of the event to represent tail risk not captured in historical data
5. The bootstrapping procedure was carried out 1000 times to provide a reliable estimate of both the distribution of natural disaster costs that could be expected as well as the average annual natural disaster cost in each state
6. The resulting simulated costs were then indexed to account for growth in the number of households and increases in the value of housing stock. This index was constructed from Australian Bureau of Statistics (ABS) population growth forecasts (ABS catalogue number 3236.0) as well as extrapolating trends in ABS data on housing value (ABS catalogue number 4102.0). It was assumed that growth rates for the value of housing in each state converged in the long run towards the national average.

To obtain predictions of total economic costs, the multipliers for different natural disaster types reported by the Bureau of Transport Economics (2001) were applied to the insured loss data. To ensure the relevance of these multipliers, they were checked against our estimates of the relationship between insured costs and total economic costs in Section 4.

In order to forecast the costs to government, the effects of historical disaster costs on the level of NDRRA expenditure was analysed. It was found that each dollar of insured natural disaster costs generally led to around 32c of Australian Government expenditure in the year following the natural disaster, 22c in the next year and 13c in the third year. The use of the funding rules set out in the NDRRA determination allowed for total government costs to be estimated and to be apportioned between the Australian Government and the states.

Appendix D: Productivity Commission Report

An important backdrop for the policy discussion is an understanding of the ***Productivity Commission Report into Climate Change Adaptation*** (or PC Report) and the Government's response to this (Productivity Commission, 2012 and Australian Government, 2013).

Specifically, the Government has agreed to consider whether, for example, Australian businesses and households are aware of the risks of climate change; have the decision-making tools to plan for climate change impacts such as extreme weather events in the face of uncertainty; and have the capacity and resources to translate awareness of climate change into action.

Further, the Government has agreed to consider policy reform for improving resilience and preparedness to natural disasters, particularly in areas where hazards are already high and where it is likely to deliver net benefits. The cost benefit analysis produced by the paper provides useful evidence to inform the focus of the Government's efforts.

It is important to note that recommendation 11.1 (below) regarding mitigation for existing settlements is only 'noted' by the Government. However, this is an area highlighted by the paper as the hardest but most important area for resilience action.

The key PC Report recommendations of relevance for the paper are:

Assessing reform options and identifying priority reforms

Recommendation 5.1

- Reforms to address barriers to effective climate change adaptation should be assessed on a case-by-case basis to determine whether they are likely to deliver net benefits to the community. This should include consideration of any risks to their implementation
- If there is a high degree of confidence that reforms will deliver net benefits, they should be implemented without delay
- If there is uncertainty about the net benefits of reform options, there could be a case for delaying implementation or adopting a flexible approach until decision makers have better information on the factors that affect their decisions, particularly if the up-front costs are large and the benefits are likely to be distant.

Australian Government response: Agreed in principle.

Information provision

Recommendation 7.1

The Australian Government initiative to improve the coordination and dissemination of flood-risk information should proceed in the most cost-effective way, be regularly updated and expanded over time to encompass other natural hazards. Guidelines to improve the quality and consistency of risk information should also be regularly updated and take climate change into account where feasible.

Australian Government response: Agreed.

Land-use planning

Recommendation 9.1

- As a priority, state and territory governments should ensure that land-use planning systems are sufficiently flexible to enable a risk management approach to incorporating climate change risks into planning decisions at the state, territory, regional and local government levels. Consideration should be given to:
  - Transparent and rigorous community consultation processes that enable an understanding of the community's acceptable level of risk for different types of land use
  - The timeframe of risks and the expected lifetime of proposed land use
  - The costs and benefits of land use.
- State and territory governments should provide appropriate guidance to local governments to implement these provisions in local government schemes.

Australian Government response: Agreed in principle.

Existing settlements

Recommendation 11.1

- The Council of Australian Governments should commission an independent public inquiry to develop an appropriate response to managing the risks of climate change to existing settlements. The inquiry should:
  - Explore, via extensive consultation with all levels of government and the community, in a variety of locations, the community's acceptable levels of risk for public and private assets
  - Identify the options available to manage climate change risks to these assets
  - Assess the benefits and costs of each option
  - Establish policy frameworks that can be applied by state, territory and local governments.
- State and territory governments should draw on the findings of the inquiry to:
  - Manage risks to their own assets
  - Clarify roles and responsibilities for managing climate risks for each level of government and the community
  - Provide appropriate support to local governments that face capacity constraints.

Australian Government response: Noted.

Mitigation for existing settlements is the hardest but most important area for resilience action

Appendix E: Cost benefit analysis methodology

The cost benefit analysis (CBA) undertaken in Section 4 essentially involves the comparison of two cases: a baseline case representing business-as-usual and a policy case where additional resilience measures are put in place. Total economic costs of natural disasters can be estimated under both of these cases. The differential in natural disaster costs can then be compared to the expenditure on resilience to determine the balance of costs of benefits for that particular resilience measure. In short, the process can be summarised as:

1. Estimate baseline natural disaster costs
2. Identify and cost a series of resilience measures
3. Re-estimate natural disaster costs
4. Compare costs of resilience to reduction in natural disaster costs.

The approach there has two data intensive components: estimating natural disaster costs and costing resilience measures.

Estimating natural disaster costs

Our approach for estimating natural disaster costs broadly follows the approach set out by the Bureau of Transport Economics (BTE, 2001) for estimating the total economic costs of a natural disaster. Under BTE's approach, the total economic costs of a natural disaster are broken down into four broad categories based on a combination of whether the costs are directly and indirectly caused by the natural disaster and whether the costs are tangible or intangible.

Considering each of the cost categories in order:

• Damage to buildings

This cost category also encompasses damage to other property such as motor vehicles and home contents. The approach taken to estimate these costs relied on data provided by Insurance Australia Group, MunichRe and Westpac. Insurance Australia Group was able to provide distributions of damage for assets insured with it in each of the case study regions. This allowed us to undertake modelling of both the average annual loss and the distribution of this loss over time. This Insurance Australia Group specific data was then scaled up to market wide insured losses by using MunichRe's data on total insured value in each of the case study regions. Insured value was then converted to total value by drawing on Westpac's data on total housing stock value in each of the case study regions.

• Damage to infrastructure

Damage to infrastructure focuses on damage to public infrastructure such as roads, transport networks, communication systems and the like. Expenditure on rebuilding public infrastructure following a natural disaster is covered by Category B of assistance provided under the NDRRA. A review of previous NDRRA expenditure and natural disasters indicated that:

- In Queensland, category B expenditure made up around 91% of total NDRRA expenditure on average
- In New South Wales, category B expenditure made up around 92% of total NDRRA expenditure on average
- In Victoria, category B expenditure made up around 47% of total NDRRA expenditure on average.

This information was drawn from a review conducted by the Department of Finance and Deregulation (2012). Total NDRRA expenditure was estimated based on an econometric analysis of historical expenditure – explained in more detail under 'emergency response costs'.

Table E.1: Economic costs of a natural disaster

	Direct	Indirect
Tangible	• Damage to buildings • Damage to infrastructure • Damage to crops and livestock.	• Emergency response costs • Household costs • Commercial costs • Loss of production.
Intangible	• Death • Injury • Personal items and memorabilia.	• Psychological • Inconvenience and stress.

Source: Bureau of Transport Economics (2001)

Damage to crops and livestock

In a slight departure from BTE (2001), the value of damage to crops and livestock wasn't estimated from building up individual costs components of agricultural production but, instead, drew on historical information on the value of agricultural production in the region from the ABS. ABS cat number 7503.0 contains detailed information on the value of agricultural production in Australia. This data was transformed to match the case study regions and provided the following estimates of annual agricultural production in each region:

- South East Queensland: $169m
- Melbourne fringe: $31m
- Hawkesbury-Nepean: $242m.

A proportion of this total value was assumed to be destroyed depending on the severity of the natural disaster. For example, if the modelled natural disaster was estimated to result in damages equivalent to half of the value of property, then half of the value of agricultural production was assumed to be lost.

Death and injury

Quantifying the costs of death and injury relied on two pieces of information. First, the value of statistical life was used to estimate the value of each life lost and injury incurred. According to the Office of Best Practice Regulation (OBPR) (2008): 'the value of statistical life is an estimate of the financial value society places on reducing the average number of deaths by one' and 'the value of statistical life (VSL) is most appropriately measured by estimating how much society is willing to pay to reduce the risk of death'. The VSL is a well established economic concept but there is a great deal of variability in estimates. For example:

- Updating the VSL used by BTE (2001) to today's dollars provides an estimate of $1.9m per death avoided
- Guidelines from OBRP based on a literature review recommend a value of $3.5m (OBPR 2008)
- Recent academic research identified a VSL in Australia of around $6m (Hensher et al 2009).

In our analysis, a VSL of $3.5m was used, in line with recommendations from OBPR. Values for serious injury ($853,000) and minor injury ($29,000) were drawn from BTE (2001) and updated to today's dollars using a CPI based adjustment. The adjustment factor was 1.46 based on comparing average CPI in 2011 to CPI in 1999.

The total number of injuries was estimated based on a historical analysis of natural disasters contained in the Emergency Management Australia (EMA) natural disaster database (EMA, 2013). This database contains information on the insured damage caused by natural disasters as well as the total number of deaths and injuries caused. This allows for a relationship to be established between insured costs, death and injury. For example for South East Queensland it was found that a quadratic relationship between insured costs, deaths and injuries was reasonable. This relationship implied, for example, that a $2.5bn insurance loss was associated with around 100 injuries and 17 deaths. Similar relationships were established for NSW and Victoria.

It was assumed that serious injuries made up 33% of total injuries and minor injuries made up 66% of total injuries.

Emergency response costs

Following the approach in BTE (2001), emergency response costs were estimated based on NDRRA payments. Expenditure under category A of the NDRRA covers emergency response costs. A review of historical NDRRA expenditures indicated that expenditure under Category C and D are insignificant when compared to Category A and B (Department of Finance and Deregulation, 2012). As a result, NDRRA expenditure on Category A was assumed to be the remainder of expenditure once category B expenditure was removed (this is described above under 'Damage to infrastructure').

However, it should be noted that NDRRA expenditure does not account for total government expenditure. Rather, NDRRA expenditure reflects the Australian Government's contribution to costs incurred by state governments. This contribution depends on the scale of expenditure made by the state government – higher levels of expenditure receive greater contributions from the Australian Government reaching a maximum of almost 75% of total costs for very large natural disasters. The rules set out in the NDRRA Determination can be used to convert Australian Government expenditure to total government expenditure (Attorney General's Department, 2012).

For example:

- For natural disasters occurring in Queensland, Australian Government expenditure was estimated to be around 89% of total government expenditure
- For natural disasters occurring in NSW, Australian Government expenditure was estimated to be around 45% of total Government expenditure
- For natural disasters occurring in Victoria, Australian Government expenditure was estimated to be around 48% of total Government expenditure.

Overall, Australian Government expenditure was estimated to be around 80% of total government expenditure.

A relationship was then established between this total government expenditure and the insured natural disaster costs in the Insurance Council of Australia database. Essentially, it was found that a $1 increase in the insured natural disaster costs leads to 60c of expenditure by all levels of government over the following four years.

This information allows for total government expenditure to be estimated for any level of insured natural disaster costs in each of the case study regions and for this total government expenditure to be attributed between Australian and state governments and between Category A and Category B of the NDRRA.

Commercial and household costs

The commercial and household costs to be estimated encompassed costs of clean-up for commercial premises and costs of clean-up and evacuation for household costs. The values for these costs were drawn directly from BTE (2001) and updated to 2011 dollars using the change in CPI. In particular the costs used were:

- Residential clean-up: $5,900 per house
- Commercial clean-up: $3,800 per premises
- Public Building clean-up: $15,000 per premises
- Evacuation: $77 for the first night and $38 for each subsequent night per person.

For evacuation it was assumed that there were 2.6 people per household (on average) based on the 2011 census results and that these people were evacuated for two days each, on average.

While reliable information on the distribution of evacuation time and how this relates to the nature and severity of a natural disaster was not available, the sensitivity of results were tested and changes in evacuation time did not significantly affect our findings.

To estimate the number of buildings affected, a similar approach was taken as for that used to estimate the extent of death and injury: historical data on insured losses and the number of properties affected were compared to identify average statistical relationships. This relationship was then used to estimate the number of buildings affected for any sized natural disaster.

Loss of production

In general, loss of production was not included in the CBA. Whether to include or exclude production largely comes down to a decision on the scope of the CBA. As the CBAs are essentially conducted at a national level, it is likely that production is able to shift from one location to another. That is: losses in production for a business in the disaster area are offset by gains in production for another business elsewhere in Australia. For example, a light manufacturer located in Brisbane may have to close their business for a week following a flood and so cannot supply their products to market. Users of their products would then seek out the next best alternative and purchase from its manufacturer– transferring their expenditure within the economy.

From a national perspective, it is only in rare cases where loss of production from natural disasters should be accounted for. This involves cases where imports or exports are affected or where unique production abilities are affected. For example, in the Hawkesbury-Nepean case study there is the potential that exports of Grain and Coal from NSW might be affected and the loss of these exports could be included in the CBA. We did not, however, include these costs in the CBA figures as diversion of exports of both coal and grain to other ports is possible. These potential costs were covered separately in a qualitative manner.

Personal items and memorabilia

Treated qualitatively and so did not enter the CBA.

Psychological, inconvenience and stress

Treated qualitatively and so did not enter the CBA.

Estimating resilience benefits and costs

The resilience benefits and costs are outlined in some detail in Section 4 but the inputs used are gathered below for convenience of reference

Table E.2: Resilience options – benefits and costs

Case study	Resilience measure	Data	Source
South East Queensland	**Housing**		
	Benefit:	66% reduction in damage.	Risk Frontiers (n.d.)
	Cost – retrofit	$13,000–52,000	Stewart and Wang (2011)
	Cost – new	$2,600–6,500 a house	Stewart and Wang (2011)
NSW	**Dam wall**		
	Benefit:	73% reduction in damage	Molino Stewart (2012)
	Cost	$337m	Molino Stewart (2012)
Victoria	**Housing**		
	Benefit:	87% of houses burnt are located within 100m of bushland No reliable information on effectiveness of ember proofing, assumed 80% rate of effectiveness	Risk Frontiers (2010)
	Cost	Average $14,931 a house	ABCB (2009)
	Vegetation management		
	Benefit:	5m clearance reduces total risk by 30%	Risk Frontiers (2010)
	Cost	$198 a year a house in vegetation management cost $17 in enforcement cost a year a house	Vegetation management costs estimated from data on expenditure on vegetation management by electricity distribution and transmission businesses. Data indicated average costs of 11c per m3 of management area. Enforcement cost based on half an hour of time at current AWE levels.
	Underground power lines		
	Benefit:	14% reduction in damage	Weber (n.d.)
	Cost	$9,685 a property	ERAWA (2011)

Appendix F: CBA Handbook

A rigorous and well executed Cost Benefit Analysis (CBA) is critically important in convincing State and Commonwealth Government Agencies of the benefits of a proposed resilience plan. A successful CBA can help with:

i. Securing funding

ii. Identifying the most beneficial resilience measure available

iii. Convincing local residents of the overall benefits of the project

iv. Understanding the range of costs and risks that could be incurred in completing the project.

While the CBAs undertaken in this report are more general than what would be required if a specific resilience measure was being implemented, they do follow a standard framework which can be generally applied. This handbook aims to be a brief guide to Local Governments for conducting CBAs relating to developing resilience to natural disasters. It does not necessarily provide the level of on-the-ground information that is required to carry out a reliable CBA, but seeks to outline an approach and data sources which may be useful.

Introduction to CBA

In the context of a policy intervention such as building resilience, the purpose of a CBA is to provide a structured approach to assessing whether or not the policy is likely to result in overall benefits to the economy. A CBA considers the economy in a broad way and should take into account non-monetary factors such as the environment, health and leisure time – the precise set of costs and benefits to be assessed as part of building resilience will be outlined later.

To carry out this economic assessment, a baseline representing business as usual is normally compared to a policy case where the proposed intervention takes place. By comparing outcomes in the baseline with those in the policy case we are able to reach a conclusion on the overall benefit of the proposed policy. There are various ways of measuring the overall net benefit of the project.

Other resources

CBA is an extremely common and long standing approach to assessing the benefits of a proposed policy. As such, there is a wealth of information available on how to undertake CBAs more generally. For example, most jurisdictions have CBA guidelines available from their Treasury, regulatory or Finance departments. These guidelines provide information on conceptual issues such as how to value life as well as practical issues, such as what discount rates should be used in what circumstances.

This type of general information will not be reproduced in this handbook. Rather, this handbook can be seen as an addendum to these general guides which seeks to provide specific information relevant to natural disaster resilience. Important guidelines from each jurisdiction are:

- Australian Government
  - Department of Finance and Deregulation: Introduction to Cost-Benefit Analysis and Alternative Evaluation Methodologies
  - Department of Finance and Deregulation: Handbook of Cost-Benefit Analysis
  - Department of Finance and Deregulation: Appendix E of the Best Practice Regulation Handbook
  - COAG: Appendix C of the COAG Best Practice Regulation Guide
  - Infrastructure Australia: Guidelines for making submissions
  - Infrastructure Australia: Regional Infrastructure Fund Guideline.

Table F.1: Common measures of benefit in a CBA

Measure	Calculation	Interpretation
Net present value (NPV)	Future flows of costs and benefits are brought to present value terms and netted	A value >0 implies net benefits
Benefit cost ratio (BCR)	The ratio of present value of benefits and present value of costs is calculated	A value >1 implies net benefits
Internal rate of return	The implicit return on initial investment is calculated.	IRR > alternative rate of return implies net benefits

- **Queensland**
  - Treasury: Project Assurance Framework – Cost Benefit Analysis
  - Environmental Protection Agency: Environmental Economic Evaluation.
- **NSW**
  - Treasury: NSW Government Guidelines for Economic Appraisal
  - NSW Department of Urban Affairs and Planning: Guideline for economic effects and evaluation in EIA.
- **ACT**
  - Treasury: Appendix C of Best Practice Guide for Preparing Regulatory Impact Statements.
- **Victoria**
  - Department of Treasury and Finance: Appendix C of the Victorian Guide to Regulation
  - Department of Transport: Guidelines for Cost-Benefit Analysis
- **South Australia**
  - Government of South Australia: Appendix G of the Better Regulation Handbook
  - Department of Treasury and Finance: Guidelines for the Evaluation of Public Sector Initiatives.
- **Western Australia**
  - Department of Treasury and Finance: Project Evaluation Guidelines.

CBA for natural disaster resilience

The guidelines listed above will provide a firm basis for conducting a CBA. The rest of this handbook provides guidance on how these general approaches can be refined into an analysis that is closely targeted at natural disasters and building resilience.

Overall approach

Conducting a CBA for building resilience to natural disasters is somewhat different to a standard CBA as it focuses almost entirely on costs.

The canonical CBA involves weighing up the initial costs of an investment against a stream of benefits flowing into the future. A good example of this is construction of a bridge to reduce travel time. Building the bridge requires an initial investment (the cost) but results in a permanent reduction in travel time for all those using the bridge (the benefits). In this case if the benefits in terms of reduced travel time outweigh the costs of building the bridge then the project creates net economic benefits.

In contrast, a CBA looking at building natural disaster resilience considers the expected costs of natural disasters in a baseline case and the costs of natural disasters in a policy case. The difference between the two cases is created by expenditure on a resilience measure – another cost. The CBA is therefore weighing up the costs of investment in resilience compared to the reduction in natural disaster costs.

In a more stylised sense, the overall process of a natural disaster resilience CBA is to:

1. Estimate baseline natural disaster costs
2. Identify and cost a series of resilience measures
3. Re-estimate natural disaster costs
4. Compare costs of resilience to reduction in natural disaster costs.

Each of these steps will be considered in order.

Figure F.1: Overall CBA process

Estimate baseline natural disaster costs

The most important point to note here is that total economic costs of natural disasters are different from insured costs. Insured costs of natural disasters only capture the losses accruing to insured assets – they do not pick up uninsured assets or broader economic costs (such as emergency response costs and loss of life).

When conducting a CBA for a resilience measure the total economic costs are used, rather than insured costs.

The main source for how to estimate total economic costs of natural disasters is a report from the Bureau of Transport Economics (2001) 'Economic Costs of Natural Disasters in Australia' (BTE is now known as the Bureau of Infrastructure, Transport and Regional Economics). This source provides an overall framework which allows us to go through item by item to quantify costs and benefits where possible or consider effects qualitatively where quantification is not possible.

Under BTE's approach, the total economic costs of a natural disaster are broken down into four broad categories based on a combination of whether the costs are directly and indirectly caused by the natural disaster and whether the costs are tangible or intangible:

The total economic costs of a natural disaster can then be estimated by considering each of these cost categories in turn.

However, before considering each cost category it is also worth noting that BTE provide a set of general multipliers which can be used to turn insured losses into total economic losses. These multipliers may be useful to get an initial estimate of total economic costs before commencing a line by line estimation. Alternatively they could be used in initial analysis of resilience measures where a detailed estimate of total economic costs is not justified. The multipliers recommended by BTE are shown in the table below.

To apply these multipliers, the insured losses are simply multiplied by the multiplier. For example, if insured losses of a storm were estimated at \$1.5bn then total economic costs would be estimated at \$4.3bn (= \$1.5bn × 2.86).

Table F.3: Total economic cost multipliers

Natural disaster type	Multiplier
Storm	2.86
Cyclone	5
Flood	10
Earthquake	4
Fire	2.86
Hail	2.86

Source: BITRE (2001)

Table F.2: Economic costs of a natural disaster

	Direct	Indirect
Tangible	• Damage to buildings • Damage to infrastructure • Damage to crops and livestock.	• Emergency response costs • Household costs • Commercial costs • Loss of production.
Intangible	• Death • Injury • Personal items and memorabilia.	• Psychological • Inconvenience and stress.

Source: BTE (2001)

While these multipliers may be suitable for an initial or high level analysis, for a detailed CBA it is important to consider each cost category separately and build up a total picture of natural disaster costs. Each category in Table F.2 is considered in turn below. Most categories have a bottom-up and top-down approach outlined. The bottom-up approach is likely to provide more detail and a higher level of accuracy while, in some cases, the top-down approach may be the only approach available given data restrictions or may provide a level of analysis suitable to the current task. In a sense the top-down approaches below sit somewhere between the multipliers, shown above, and the bottom-up approach in terms of accuracy, reliability and detail.

Note on costs

Costs below are presented in 2011 dollars to align with the most up to date cost estimates included in the Insurance Council of Australia natural disaster database. Costs from BTE (2001) have been updated using a CPI adjustment.

• Damage to buildings

This cost category also encompasses damage to other property such as motor vehicles and home contents. When assessing these costs it is important to keep in mind that total asset losses are likely to be higher than insured losses as assets are, generally, underinsured.

These costs are likely to be the largest component of the costs of a natural disaster and it is therefore critical to develop good estimates in this area.

Assessing the extent of this damage requires information on:

- The natural disaster risks present in the area
- The value of assets in the area
- The relationship between the natural disaster risk and the value of assets that are damaged.

The task is, in essence, to model the presence of natural disaster risks and relate the risk to damage of assets. This can be done in a bottom-up way (looking at the nature of the risks and the presence of assets in the area) or in a top-down way (looking at historical probabilities of disaster and the associated loss).

Bottom-up

For example, bottom up modelling of flood risks could be done by considering the topography of the local area, the likely depth of flood waters, the location and floor heights of housing, the height of storage of goods within houses and the value of these assets. This could be combined to provide an annual average loss estimate as well as a probability distribution of this loss over time.

Bottom up modelling of this type is a complicated task and requires specific skills and experience. Some Councils have teams already established with the range of meteorological and actuarial skills required to undertake this modelling.

However, it is likely that external sources will need to be drawn on. As an initial source of external data, there are projects underway from the Commonwealth Government to centralise and disseminate available information on natural disasters. The prime example here is the National Flood Risk Information Project being undertaken by Geoscience Australia.

In addition, modelling of risks may require the use of external consultants or the use of State Government agencies. For example, CSIRO has capabilities in modelling flooding and bushfire events and the Bushfire CRC is developing a detailed bushfire model. There are also many models and data available from private consultancies such as AIR Worldwide's Australian models covering bushfire, cyclone and earthquake as well as PSMA's G-NAF database of housing locations in Australia.

Top-down

Modelling from a top-down perspective is far less data intensive but still requires the application of specific skills and techniques. A top-down perspective would mainly focus on the historical data on disasters in the local area and the damage that these disasters caused. For example, it might be found that an average year sees $20m of flood damage while, approximately, every 10 years there is damage exceeding $50m and every 50 years there is damage exceeding $100m. Good examples of this type of analysis can be found in research undertaken by Risk Frontiers, such as 'Australian Bushfire: Quantifying and Pricing the Risk to Residential Properties'.

While being easier to undertake, top-down modelling may miss some important features that bottom-up modelling can identify. These could include: increased risk from housing developments in new areas; or increased prevalence of natural disasters.

Output

The main output from this type of analysis is a table similar to the following:

Table F.4: Estimated risk to buildings, vehicles and contents

Approximate frequency of event	AEP (probability weighting)	Estimated loss ($m)
1 in 5 year	20%	5
1 in 10 year	10%	15
1 in 20 year	5%	30
1 in 50 year	2%	100
1 in 100 year	1%	200
1 in 500 year	0.2%	500
1 in 1000 year	0.1%	1,000
1 in 10,000 year	0.01%	4,000
Average annual		**10**

This table allows for an annual average loss to be used in the CBA as well as a distribution of this average annual loss to be used in risk assessments. Each of the following categories of cost can be added as an additional column to the table above.

Other output which could be generated from this modelling and which is required for further analysis is:

- Number of buildings damaged (residential, commercial and public)
- Number of buildings destroyed (residential, commercial and public)
- Number of people evacuated or made homeless
- Number of people killed
- Number of people injured
- Area of farmland affected.

• Damage to infrastructure

The damage to infrastructure category captures costs associated with assets not covered in the damage to buildings category. These are assets such as roads, electricity networks, sewerage, telecommunications networks and parks.

All of these assets have the same feature that they are large and concentrated in specific locations. Many of these assets will also be owned by governments and may not have information on their value readily available.

As with damage to buildings, damage to infrastructure can be estimated in a bottom-up or top-down way.

Bottom-up

The bottom up approach here is similar to the bottom up approach for estimating damage to buildings. It involves assessing the presence, type and location of infrastructure within the geographic area and modelling the risks of this infrastructure being damaged. For example, it may be found that there are 20km of highway within the area which would be inundated in a 5% AEP flood and 60km that would be inundated in a 1% AEP flood. This information can be used to calculate costs of reconstruction and can be added to the costs shown in Table F.4.

This approach is data intensive as it requires a knowledge of what infrastructure is present, its exposure to natural disaster risks, its resilience to natural disaster risks and the cost of reconstruction.

A good example of a bottom-up assessment of damage to infrastructure is contained in Molino Stewart's 2012 report on the Hawkesbury Nepean.

Top-down

Alternatively, a top down approach can be used. In this case the top down approach relies on the fact that most essential public infrastructure which is not captured in damage to buildings, falls under Category B of the NDRRA. Under the NDRRA, state governments apply to the Australian Government for re-imbursement of expenditure resulting from natural disasters. As part of this process, state governments must make submissions to the Australian Government. These submission can be used as a data source for the extent of damage to infrastructure caused by a natural disaster.

Gathering this information for a specific local government area would require the assistance of the State Government.

This data can be used to align infrastructure expenditure to past natural disaster events to gauge the relationship between natural disaster severity and expenditure on infrastructure.

As a rule of thumb, our historical analysis suggests that every dollar of insured losses results in the following expenditure by all levels of government on infrastructure:

Table F.5: Public infrastructure expenditure as proportion of insured costs

Expenditure per dollar of insured costs	
ACT	Historical data unreliable, maximum of 60c
NSW	20c
Victoria	19c
Queensland	15c
Western Australia	Historical data unreliable, maximum of 60c
South Australia	18c
Tasmania	32c
Northern Territory	15c
Total	**15c**

Source: BTE (2001) updated by Deloitte Access Economics

Additionally, our analysis of historical claims suggests that claims are made, on average, over the three years following the natural disaster with 48% made in the year following the natural disaster, 32% the year after that and 20% the year after that.

• Damage to crops and livestock

Assessment of costs related to crops and livestock can be done in a number of ways, each in varying levels of detail.

Bottom-up

If the natural disaster modelling undertaken for buildings also covers damage caused to agricultural areas then it is possible to build up a picture of total costs. This is done by accounting for the number (or value) of beasts, crops and infrastructure damaged. For example, ABARES' AGSurf database has information available on average area sown and average herd and flock size as well as data on average sale prices for farm outputs. These can be used to estimate a value of assets on farms in the area. This can then be combined with the following standard values from BTE (2001) for agricultural infrastructure to estimate the total value of agricultural assets.

Table F.6: Standard values for agricultural infrastructure

Item	Value
Fences ($/km)	7,300
Pasture ($/Ha)	
Dryland	
5-7days inundation	0
>7 days inundation	131
Irrigated	
5-7days inundation	44
>7 days inundation	539

Source: BTE (2001) updated by Deloitte Access Economics

Top-down

The top-down approach for valuing agricultural production is to consider the value of agricultural production lost due to natural disasters. As with the bottom-up approach, this requires some information about the severity of natural disasters in the area but relates this to aggregate agricultural production in the area, rather than the stock of agricultural assets in the area.

Table F.7: Standard values for livestock ($/head)

Item	Dairy	Beef	Sheep for wool production	Sheep for lamb production
Value	948	700	48	73
– High	816	598	39	66
– Average	671	496	34	51
– Low	87	87	12	12
Carcass disposal	948	700	48	73

Note: carcass disposal is added onto value to estimate total cost per head

Source: BTE (2001) updated by Deloitte Access Economics

For example, according to ABS cat number 7503.0, the Riverina region of NSW produces $1.8m of agricultural commodities each year. If the natural disaster modelling suggests that a flood will affect 5% of agricultural land every 10 years and 20% of land every 50 years then this translates to average losses of $90,000 every five years and $360,000 every 50 years. This calculation should also take into consideration seasonal patterns in agricultural production in the area. For example, if a flood occurs in a primarily wheat producing area during a time when many fields are fallow than losses would be expected to be far lower than the average value of production.

• Death and Injury

Estimating the costs of death and injury relies on two pieces of information. First, the number of people killed and injured is required. Second a dollar value for the value of death and injury is needed.

The first piece of information, the number of people killed and injured, should be sourced from the natural disaster modelling undertaken as part of the assessment of damage to buildings.

The second piece of information, the value of death and injury, relies on an economic concept called the value of statistical life. According to the OBPR (2008): 'the value of statistical life is an estimate of the financial value society places on reducing the average number of deaths by one' and 'the value of statistical life is most appropriately measured by estimating how much society is willing to pay to reduce the risk of death'. The VSL is a well established economic concept but there is a great deal of variability in estimates. For example:

- Updating the VSL used by BTE (2001) to today's dollars provides an estimate of $1.9m per death avoided
- Guidelines from OBPR based on a literature review recommend a value of $3.5m (OBPR 2008)
- Recent academic research identified a VSL in Australia of around $6m (Hensher et al 2009).

In general we recommend using a VSL of $3.5m in line with recommendations from OBPR. However, some jurisdictions may have their own recommendations for VSL and, if this exists, it should be used in preference to the OBPR recommendation.

Values for serious injury and minor injury can be inferred from the VSL. Recommendations from OBPR do not contain any VSL estimates and so we recommend using figures drawn from BTE (2001):

- Serious injury: $850,000
- Minor injury: $28,500.

BTE (2001) also recommends assuming a ratio between serious and minor injury of 1:2.

• Emergency response costs

Emergency response costs are estimated in roughly the same way as top-down approach to damage to infrastructure. Expenditure on emergency response falls under Category A of the NDRRA. Under the NDRRA, state governments apply to the Australian Government for re-imbursement of expenditure resulting from natural disasters. As part of this process, state governments must make submissions to the Australian Government. These submission can be used as a data source for the extent of damage to infrastructure caused by a natural disaster.

Gathering this information for a specific local government area would require the assistance of the State Government.

This data can be used to align emergency response costs to past natural disaster events to gauge the relationship between natural disaster severity and expenditure on infrastructure.

As a rule of thumb, our historical analysis suggests that every dollar of insured losses results in the following expenditure by all levels of government on infrastructure:

Table F.8: Emergency response expenditure as proportion of insured costs

	Expenditure per dollar of insured costs
ACT	Historical data unreliable, likely maximum of 4c
NSW	3c
Victoria	36c
Queensland	2c
Western Australia	Historical data unreliable, likely maximum of 4c
South Australia	18c
Tasmania	7c
Northern Territory	3c
Total	**4c**

Source: Deloitte Access Economics analysis

Additionally, our analysis of historical claims suggests that claims are made, on average, over the three years following the natural disaster with 48% made in the year following the natural disaster, 32% the year after that and 20% the year after that.

Commercial and household costs

Similar to death and injury estimating commercial and household costs relies on two pieces of information. First, the number of premises affects and, second, a dollar value for each premises.

The number of premises affected should be established in the natural disaster modelling undertaken as part of the assessment of damage to buildings.

Standard multipliers can then be used to convert the number of premises affected into a total cost. Based on BTE (2001) a reasonable set of multipliers to be used are set out in the table below. These are based on a combination of fixed and labour costs set out in more detail in BTE (2001).

In addition to these clean-up costs, evacuation costs should also be included. Again, BTE provides reasonable standard values for these:

Evacuation costs: $77 fixed cost and $38 for each additional night, per person.

Table F.9: Commercial and household clean-up costs per building

	$ per building
Residential	5,900
Commercial	3,800
Public	14,600

Source: BTE (2001) and Deloitte Access Economics

Loss of production

In general, loss of production is not included in a CBA looking at natural disaster costs.

However, whether to include or exclude production largely comes down to a decision on the scope of the CBA. It is generally good practice to consider the CBA in terms of the broader Australian economy; from this perspective it is likely that production is able to shift from one location to another. That is: losses in production for a business in the disaster area are offset by gains in production for another business elsewhere in Australia.

For example, a light manufacturer located in Brisbane may have to close their business for a week following a flood and so cannot supply their products to market. Users of their products would then seek out the next best alternative and purchase from its manufacturer – transferring their expenditure within the economy.

From a national perspective, it is only in rare cases where loss of production from natural disasters should be accounted for. This involves cases where imports or exports are affected or where unique production abilities are affected. For example, if there is the potential for exports of key commodities to be affected then the loss of these exports could be included in the CBA.

Personal items, memorabilia, psychological, inconvenience and stress

These costs, while important, are generally difficult to quantify and so are normally treated in a qualitative manner. A good approach is to develop case studies of individuals affected by previous natural disasters.

With this underlying modelling and associated valuations it is then possible to create an estimation of the extent of total economic costs of the natural disaster. The approach is, essentially, to extend Table F.4 adding a column for each disaster cost identified above. As a guide, the following page contains an example calculation (populated with dummy data) of total economic costs of a natural disaster (Table F.10).

The CBA can then move onto the second stage of the analysis: identify and estimating the benefits related to building resilience.

Table F.10: CBA Model Extract (1)

Standard Values

Fences ($/km)	7,300

Death ($ per person)	3,500,000

Pasture ($/Ha)		
Dryland	Dryland	Irrigated
5–7days inundation	0	44
>7 days inundation	131	539

Cleanup ($ per building)	
Commercial	5,900
Residential	3,800
Public	14,600

Evacuation	
Fixed cost per person	77
$ per night per person	38

	Value	Share
Major injury ($ per injury)	850,000	33%
Minor injury ($ per injury)	28,500	67%

Livestock ($/head)				
Item	Dairy	Beef	Sheep for wool production	Sheep for lamb production
Value	948	700	48	73
– High	816	598	39	66
– Average	671	496	34	51
– Low	87	87	12	12
Carcass disposal	948	700	48	73

Natural Disaster Modelling results

		Assets ($)				Agriculture				People				Buildings		
Frequency	Weighting	Damage to buildings ($m)	Damage to infrastructure	Hectares of farmland inundated	Fences destroyed (km)	Dairy (head)	Beef (head)	Sheep for wool production (head)	Sheep for lamb production (head)	Deaths	Injuries	Number evacuated	Nights evacuated	Commercial	Residential	Public
1 in 5 year	20%	5	1	10	100	28	65	71	40	1	7	101	253	4	34	1
1 in 10 year	10%	15	3	17	300	49	194	124	120	3	21	304	760	13	102	4
1 in 20 year	5%	30	6	22	500	63	323	160	201	5	35	506	1,235	21	169	6
1 in 50 year	2%	100	20	30	900	84	581	214	361	9	63	909	2,271	38	303	11
1 in 100 year	1%	200	40	35	1,200	97	775	247	481	12	84	1,212	3,030	50	404	15
1 in 500 year	0.20%	500	100	39	1,500	109	969	277	602	15	105	1,512	3,781	63	504	19
1 in 1000 year	0.10%	1,000	200	42	1,800	119	1,163	303	722	18	126	1,817	4,543	76	605	23
1 in 10,000 year	0.01%	4,000	800	46	2,100	129	1,357	327	842	21	147	2,118	5,294	88	706	26

Cost estimates ($m)

Frequency																Weighting	Total
1 in 5 year	20%	5.0	1.0	0.0	0.7	0.0	0.1	0.0	0.0	3.5	2.0	0.0	0.0	0.0	0.1	0.0	12.5
1 in 10 year	10%	15.0	3.0	0.0	2.2	0.1	0.2	0.0	0.0	10.5	5.9	0.0	0.0	0.1	0.4	0.1	37.5
1 in 20 year	5%	30.0	6.0	0.0	3.7	0.1	0.4	0.0	0.0	17.5	9.8	0.0	0.0	0.1	0.6	0.1	68.5
1 in 50 year	2%	100.0	20.0	0.0	6.6	0.1	0.7	0.0	0.0	31.5	17.7	0.1	0.1	0.2	1.2	0.2	178.4
1 in 100 year	1%	200.0	40.0	0.0	8.8	0.2	0.9	0.0	0.1	42.0	23.6	0.1	0.1	0.3	1.5	0.2	317.8
1 in 500 year	0.20%	500.0	100.0	0.0	11.0	0.2	1.2	0.0	0.1	52.5	29.5	0.1	0.1	0.4	1.9	0.3	697.2
1 in 1000 year	0.10%	1,000.0	200.0	0.0	13.1	0.2	1.4	0.0	0.1	63.0	35.4	0.1	0.2	0.4	2.3	0.3	1,316.6
1 in 10,000 year	0.01%	4,000.0	800.0	0.0	15.3	0.2	1.6	0.0	0.1	73.5	41.3	0.2	0.2	0.5	2.7	0.4	4,936.0
Average Annual		10.4	2.1	0.0	0.8	0.0	0.1	0.0	0.0	3.9	2.2	0.0	0.0	0.0	0.1	0.0	19.6

Identify and cost a series of resilience measures

After establishing the underlying economic costs of the natural disaster, the next stage of the CBA is related to the resilience measures. The tasks in this stage are to:

1. Identify resilience measures
2. Estimate the costs of the resilience measure.

Both of these steps are intimately related to the resilience measure that is being considered but some general principles can be set out.

• Identify resilience measures

The identification of resilience measures should, initially, seek to encompass a large range of potential policy responses. This broader set can then often be narrowed down to a smaller set of resilience options by a high level consideration of the likely costs and benefits of the option.

The broad set of resilience options should include relatively straightforward approaches such as infrastructure intervention as well as more subtle responses such as information gathering, changed planning, new approaches to compliance or development of community and social based approaches to resilience.

For example, an initial set of resilience options for addressing the flood risk in the Hawkesbury Nepean could include raising the height of the dam wall, river straightening, building levees, improving emergency response planning, changing the required floor height or construction materials of new houses or development of community plans for response to flooding.

From this broader set of resilience options, a smaller group of preferred options can then be looked into in more detail.

• Estimate the costs of the resilience measure

Working with a small group of preferred resilience measures (maybe only one) the next step is to estimate the costs of the measure. This should take into account not only the initial capital expenditure but any ongoing expenditure as well as other effects, such as destruction of environment, reduction in quality of living or shifting natural disaster effects onto neighbours.

The approach to estimating costs will vary significantly from resilience measure to resilience measure. For some basic resilience measures there may be good market data available. This could be the case where the resilience measure involves adding off the shelf products (such as stronger doors) to existing buildings.

In other cases a quantity surveyor may be able to provide estimates of the costs of the resilience measure or, in cases where costs are largely time based, estimates can be developed from the ground up and costed using average wage data. In cases of large, specific resilience measures (such as constructing a dam or levee), there is likely to be a need to commission original engineering analysis of project costs.

This stage of the analysis will allow an additional set of calculations to be added to the CBA. As a guide, Table F.11 contains an example calculation (populated with dummy data) of costs of a resilience measure.

With these pieces of information it is then possible to estimate the costs of the resilience measure (measured in net present value terms) and to then move into estimating the benefits of the resilience measure.

Estimate benefits of resilience and re-estimate natural disaster costs

The final stage of the analysis, Table F.12, is to re-estimate baseline natural disaster costs taking into consideration the reduction that is created by implementing the resilience measure.

This stage first requires estimating the benefits of resilience for each of the costs outlined in 'estimate baseline natural disaster costs' and then recalculating these costs after accounting for resilience benefits.

Taking an example from the paper, it was found that changing the building code for South East Queensland could be expected to reduce damage from a cyclone by around 66%. This figure was based on historical analysis of the performance of housing in northern Queensland that was built before and after the introduction of similar standards.

In practice, a figure like the 66% above is likely to either be sourced from historical analysis, simulation or by small scale experimentation. In our experience, historical analysis is the most likely source of data. Historical analysis normally takes the form of a research paper looking at trends in natural disaster costs. By comparing areas which differ in aspects of resilience (such as their building standards, their height above sea level, their distance from bushland or their urban surroundings) the benefits of resilience measures can be fairly easily measured – given that there is sufficient historical data to overcome the high degree of variability in natural disasters from year to year.

Table F.11: CBA Model Extract (2)

Resilience calculation

Discount rate	**7%**

Costs of resilience	
Initial cost ($m)	15
Year of construction	2015
Ongoing cost ($m/year)	0.25

Reduction in total natural disaster costs	20%

	Expenditure on resilience
Present Value	14.9
2013	0
2014	0
2015	15
2016	0.25
2017	0.25
2018	0.25
2019	0.25
2020	0.25
2021	0.25
2022	0.25
2023	0.25
2024	0.25
2025	0.25
2026	0.25
2027	0.25
2028	0.25
2029	0.25
2030	0.25
2031	0.25
2032	0.25
2033	0.25
2034	0.25
2035	0.25
2036	0.25
2037	0.25
2038	0.25
2039	0.25
2040	0.25
2041	0.25
2042	0.25
2043	0.25
2044	0.25
2045	0.25
2046	0.25
2047	0.25
2048	0.25
2049	0.25
2050	0.25

Modelling is an alternative approach to historical analysis and can be advantageous where good historical data is not available or where the underlying relationship between a natural disaster event and the resulting damage is well known. For example, modelling is particularly useful in flooding where the height of floods can be lowered within a model and the number of households no longer affected can be easily measured.

Small scale experimentation such as exposing scale model housing to various natural disaster risks can generate good data on the benefits of resilience measures which have not yet been implemented but is, in our experience, rare.

After establishing the likely benefits of resilience the task is largely a mechanical exercise of reducing estimated effects where appropriate. Taking up the cyclone example again, the reduction in damage to housing could realistically be applied to damage to residential and commercial buildings. A reduction in emergency response expenditure, clean-up costs, death, injury and evacuation would also be expected as fewer houses are damaged. However, a reduction in agricultural losses would not be expected to result from this resilience measure.

The task in this case would be to reduce damage to residential and commercial buildings, emergency response expenditure, clean-up costs, death, injury and evacuation costs by around 66% (there might be variability from 66% due the presence of fixed costs, for example).

Table F.12: CBA Model Extract (3)

Resilience calculation

Discount rate	7%

Costs of resilience	
Initial cost ($m)	15
Year of construction	2015
Ongoing cost ($m/year)	0.25

Reduction in total natural disaster costs	20%

	Expenditure on resilience
Present Value	14.9
2013	0
2014	0
2015	15
2016	0.25
2017	0.25
2018	0.25
2019	0.25
2020	0.25
2021	0.25
2022	0.25
2023	0.25
2024	0.25
2025	0.25
2026	0.25
2027	0.25
2028	0.25
2029	0.25
2030	0.25
2031	0.25
2032	0.25
2033	0.25
2034	0.25
2035	0.25
2036	0.25
2037	0.25
2038	0.25
2039	0.25
2040	0.25
2041	0.25
2042	0.25
2043	0.25
2044	0.25
2045	0.25
2046	0.25
2047	0.25
2048	0.25
2049	0.25
2050	0.25

	Baseline natural disaster costs	Reduced natural disaster costs
Present Value	745.9	596.8
2013	19.6	15.7
2014	19.6	15.7
2015	19.6	15.7
2016	19.6	15.7
2017	19.6	15.7
2018	19.6	15.7
2019	19.6	15.7
2020	19.6	15.7
2021	19.6	15.7
2022	19.6	15.7
2023	19.6	15.7
2024	19.6	15.7
2025	19.6	15.7
2026	19.6	15.7
2027	19.6	15.7
2028	19.6	15.7
2029	19.6	15.7
2030	19.6	15.7
2031	19.6	15.7
2032	19.6	15.7
2033	19.6	15.7
2034	19.6	15.7
2035	19.6	15.7
2036	19.6	15.7
2037	19.6	15.7
2038	19.6	15.7
2039	19.6	15.7
2040	19.6	15.7
2041	19.6	15.7
2042	19.6	15.7
2043	19.6	15.7
2044	19.6	15.7
2045	19.6	15.7
2046	19.6	15.7
2047	19.6	15.7
2048	19.6	15.7
2049	19.6	15.7
2050	19.6	15.7

Compare costs of resilience to reduction in natural disaster costs

The final stage of the analysis is purely mechanical. The difference in natural disaster costs under the baseline and in the case where resilience measures are put into place are compared to the costs of building resilience. This can be done using a number of measures but for natural disaster resilience the two most useful are to consider are net benefits and the benefit cost ratio:

Net benefits = Present value of Benefits-Present value of costs

$$\text{Benefits cost ratio} = \frac{\text{Present value of benefits}}{\text{Present value of costs}}$$

Using figures from the above example

$$\text{Present value of Benefits} = \text{Baseline natural disaster costs} - \text{Reduced natural disaster costs}$$
$$= 745.9 - 596.8 = 149.2$$

$$\text{Present value of costs} = 14.9$$
$$\text{Net benefits} = 149.2 - 14.9 = 134.3$$

$$\text{Benefit cost ratio} = \frac{149.2}{14.9} = 10.0$$

These can then be analysed using the decision rules outlined in Table F.1, which suggest that the modelled resilience measure creates significant economic benefits.

Summary

Conducting a cost benefit analysis for natural disaster resilience is not significantly different from other cost benefits analyses. As such, the starting point is to be familiar with the applicable guidelines documents. Following on from these, there are a number of specifics which can be added for natural disaster resilience.

The overall approach for natural disaster resilience is to estimate the economic costs of a natural disaster a baseline and under a policy of improved resilience. The difference in these costs can be compared to the costs of developing the resilience – this is the CBA.

The approach for estimating economic costs of a natural disaster is well established and is clearly outlined in BTE (2001). This handbook has provided an update and streamlined guide to the BTE report as well as presenting some various options for analysis depending on the level of detail required. If these steps are followed a CBA can be developed which will clearly show the expected costs and benefits of any resilience measure.

Limitation of our work

Contact us

Deloitte Access Economics
ACN: 149 633 116

Level 1
9 Sydney Avenue
Barton ACT 2600
PO Box 6334
Kingston ACT 2604 Australia

Tel: +61 2 6175 2000
Fax: +61 2 6175 2001

www.deloitteaccesseconomics

MCBD_SYD_06/13_048520