At what cost? Mapping where natural perils impact on economic growth and communities

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GLOSSARY

ABS	Australian Bureau of Statistics
GDP	Gross Domestic Product
ICA	Insurance Council of Australia. The representative body of the general insurance industry in Australia
iLEAD	Insurance Council of Australia's Low-resolution Exposure Address Dataset
IER	Index of Economic Resources, a SEIFA index which measures a community's access to economic resources
LGA	Local Government Area, as defined by the ABS. May differ from current local government boundaries
SEIFA	Socio-Economic Indexes for Areas. ABS measures of economic and social advantage and disadvantage

EXECUTIVE SUMMARY

Australia is at growing risk from a range of natural disasters including tropical cyclones, bushfires, storms and floods. If unmanaged, these risks will significantly impact our resource and knowledge-led economy, and damage homes, businesses and infrastructure and put lives at risk.

Since settlement, a number of options have been taken on an ad hoc basis to try to manage the impacts of natural disasters including: relocating the population from heavily-exposed areas; implementing land-use planning strategies to direct growth to lower risk areas; and constructing levees and dams to minimise the impact of flooding yet without a consistent, long-term, national approach, large parts of the country, including the most populated or economically valuable, remain exposed to natural perils.

At what cost? Mapping where natural perils impact economic growth and communities is the first time the population data and economic activity of all Local Government Areas (LGAs) across the nation have been overlaid with natural perils risk levels provided by the Insurance Council of Australia (ICA) and IAG. The aim of this report, and its accompanying interactive maps and data files, is to highlight the locations at the greatest risk of natural perils and demonstrate how this risk intersects with economic activity and the communities' capacity to respond to disasters.

The analysis found:

- Areas of key economic importance at high to extreme risk include large parts of our mining industry and knowledge economy hubs in the major Central Business Districts (CBDs).
- $326.6 billion worth of GDP (20.3 per cent of the Australian economy) and 3.9 million people (17.3 per cent of the population) are in LGAs with a high to extreme risk of tropical cyclone. Recent tropical cyclones have significantly impacted on mineral and agricultural production.
- 28.4 per cent of GDP ($425.5 billion) and 24.9 per cent of the population (5.5 million people) are living in LGAs with high to extreme flood risk. The 2011 Queensland floods illustrated the disruption to the region's economic activity and highlighted how a community's economic capacity impacts its ability to respond and rebuild following natural disasters.
- Parts of the Melbourne CBD, and its 450,000 workers, are at very high risk of flood. Flooding has impacted on the transport network in the Melbourne CBD several times recently causing economic disruption.
- The 500,000 workers in the Sydney CBD have experienced transport disruptions caused by storms in recent years.
- LGAs with high and extreme risk of bushfire generated $175 billion (10.8 per cent) of GDP and are home to 2.2 million people (9.2 per cent of the population).
- LGAs with high and extreme risk of earthquakes generate $853 billion, or 52.5 per cent, of our nation's GDP and house 58 per cent of our population.

At what cost? highlights that not only is economic activity at risk but the high cost to human life. As our population increases, governments will face more pressure to release low-cost land in higher risk areas, putting more lives in danger. Development of this land should be informed by accurate data on natural perils risks and accompanied by appropriate mitigation measures to minimise the risks.

The report identified the Queensland LGAs of Brisbane, the Gold Coast, Townsville and Moreton Bay as containing communities deemed to be at high to extreme risk of tropical cyclones, storms and floods. Despite this risk, the population in these areas increased by more than 450,000 people between 2001 and 2015. In Victoria, 17.5 per cent of the population live in LGAs which contain communities at high to extreme risk of bushfire.

The report identified that some communities at risk may not have the economic resources required to independently prepare for and recover from natural disasters. For example, Moree Plains in New South Wales and Bundaberg in Queensland are at risk of flooding yet are low on the Australian Bureau of Statistics Socio-Economic Index for Areas: Index of Economic Resources. Economic resilience, together with high levels of social capital, translates to greater resilience to natural disasters.

Hepburn, Central Goldfields and Hindmarsh in Victoria are at high risk of bushfire yet low on economic resources which may undermine their ability to prepare for and recover after a disaster. As a result, the economic burden will primarily fall on government and these communities may take longer to recover and rebuild. This has large implications on future planning and decision making.

Recent economic analysis has highlighted that successive governments have overinvested in post-disaster reconstruction and underinvested in mitigation that would limit the impact of natural disasters on our economy and communities. As a general rule, one dollar spent on mitigation can save at least two dollars in recovery costs. The Australian Government spend on mitigation measures is equivalent to three per cent of what it spends on post-

disaster efforts. The rebalance of this spending allocation is a national priority: investment in mitigation strategies reduces the cost of reconstruction and safeguards our communities.

A safer future does not just depend on Government. Individuals and communities also have what the Royal Commission into Victoria's bushfires called a 'shared responsibility'. While all levels of government should take steps to improve protective infrastructure, emergency management, land use planning and building regulations, individuals and businesses need to be educated and empowered to take more responsibility for their own safety.

Without heightened awareness, appropriate information and a co-ordinated, long-term approach to managing risks, individuals, businesses and government will remain exposed and our future economic strength and stability will be at risk.

Black Saturday bushfires, Victoria, 2009

1 INTRODUCTION

Natural perils, such as bushfires, floods, storms and tropical cyclones, are part of the Australian experience. Indigenous Australians understood the uniqueness of the environment and managed the risks of these natural perils. In the post-colonial era these lessons were not understood or applied. For example, traditional owners used fire as a land management tool but settlers feared bushfires and sought to suppress them to protect life and property.

As the impact of natural perils on European settlement became apparent, Governments introduced methods to manage these risks such as hazard mitigation infrastructure, land use planning controls and construction standards to better withstand weather conditions. However, many options were implemented on an ad hoc basis without an overarching plan to ensure the most at risk locations were protected. As a consequence, many areas in Australia remain exposed to natural perils and the population living in these places is projected to increase.

If inadequately managed, these natural perils will damage houses, businesses and infrastructure. While individual property owners can take steps to protect their properties and assets, there is a need for a coordinated and collective approach by all levels of government to improve community resilience. This is especially important in areas at high risk of natural perils and in areas of high economic activity.

Table 1 indicates the scale (as measured by insurance loss) of the various natural perils. Between 1970 and 2013, 27 per cent of insurance losses were caused by storm. Hail (21 per cent, largely driven by the 1999 Sydney hail storm), tropical cyclone (18 per cent) and flood (18 per cent) were the next largest perils. Earthquake losses are mostly attributable to the Newcastle earthquake of 1989. The level of insurance loss across the country varies by type of peril. For example, Queensland has been highly impacted by flood and tropical cyclones, while bushfire has greatly impacted Victoria.

Ensuring areas with the highest level of economic activity are protected from natural perils by wise infrastructure investments and mitigation measures will help to maintain

TABLE 1. INSURANCE LOSSES BY NATURAL PERILS, 1970-2013[1]

State	Bushfire	Tropical cyclone	Flood	Storm	Hail	Earthquake	Total
NSW	527	36	965	2,747	4,856	1,657	10,788
VIC	1,650		400	2,439	294		4,783
QLD		3,329	3,630	1,376	949		9,283
SA	189			47	92		327
WA	96	486	24	1,232		15	1,852
TAS	100		51	34	86		271
NT		1,529	123				1,652
ACT	440						440
Australia	3,002	5,380	5,193	7,875	6,277	1,672	29,396
Share of Total	10%	18%	18%	27%	21%	6%	100%

Source: Productivity Commission (2014)

[1]In 2011 dollars

economic growth. This requires government to understand the distribution of economic activity and the risk of natural perils. Understanding the capacity of communities to deal with risk is also an important consideration for government.

At what cost? sourced natural perils data from the ICA and IAG. The ICA's Low-resolution Exposure Address Dataset (iLEAD) provides a simple exposure score at 13.5 million Australian addresses describing, proxy exposures to various natural perils. IAG contributed additional flood data for a more complete picture of risk exposure.

The natural perils examined in this report are defined events such as tropical cyclones, bushfires, floods, storms and earthquakes. The list could also include, heatwaves and coastal erosion among others. However, these perils are a slow onset or gradual process rather than defined events with a quantifiable loss and they do not result in the same scale of economic loss and disruption.

A number of recent reports have focused on natural perils costs, funding arrangements and land use planning. Some of these include:

- The Australian Business Roundtable for Disaster Resilience & Safer Communities commissioned Deloitte Access Economics to prepare:
  - *Building our Nation's Resilience to Natural Disasters* White Paper, June 2013
  - *Building an Open Platform for Natural Disaster Resilience Decisions*, July 2014
  - *The Economic Cost of the Social Impact of Natural Disasters*, March 2016
  - *Building Resilient Infrastructure,* March 2016
- Productivity Commission Inquiry Report, *Natural Disaster Funding Arrangements*, Dec 2014
- The Australian Government, the Treasury, *Northern Australia Insurance Premiums Taskforce Report*, Nov 2015
- Global Access Partners Taskforce, *The North, Agriculture and the Environment*, March 2016
- Planning Institute Australia, *National Land Use Planning Guidelines for Disaster Resilient Communities*, 2016

These reports, highlighted the risk of natural perils nationally, however they tended to focus on insurable and economic loss, as opposed to loss of economic activity.

This report, and its interactive maps and data files, identifies the LGAs with the greatest risk. They are identified because of their high natural perils risk rating, their high level of GDP, their capacity to deal with natural perils or, most importantly, due to an overlap of two or more of these factors.

These tools can offer value to government, individuals, communities and businesses in several ways.

Governments
The analysis demonstrates the places where natural perils intersect with high GDP and builds a case for more proportionate spending on disaster mitigation. This information can help governments decide where to invest, to minimise the impact on the Australian economy.

Individuals and communities
The interactive map can be used by residents to better understand their exposure to natural perils so they can better protect themselves, their family and their property.

Businesses
Information on peril risk can help businesses be better positioned to minimise interruption from the loss or delay of income due to a natural disaster.

1.1 Considerations when reviewing this report

The risk data used in this report is built on complex scientific models. The scientific terms may not equate to descriptions of events used in everyday language. For example, people may use the term flood to describe a range of events which are technically different, such as a riverine flood, storm surge or storm water inundation.

Interactive maps and data files
This report is accompanied by a set of interactive maps and data files which give a more comprehensive understanding of natural perils risks and its intersection with GDP and a community's economic resources. The maps show the different perils risk exposure by LGA and the user can overlay GDP and economic data to gain greater insight into the potential impact on economic and social well-being.

Spatial aggregation of perils risks
The data shows the average risk levels of each property within an LGA. In each LGA it is possible that for some natural perils, the risk level would vary significantly. For example, for flooding, properties along a waterway would likely have a higher risk rating than other parts of the LGA which are on higher ground. Floods do not affect regions uniformly and can damage the same area repeatedly while not affecting properties very close by. Similarly, properties along the urban fringe would likely have a higher risk of bushfires than properties in built up areas.

Averaging of risk means that the LGA data is not directly comparable with other measures of risk for individual properties. This is due to the ICA's dataset being used for research and analysis on insurance affordability, mitigation priorities and perils data gap closure activities. It is not suitable for underwriting applications and may not reflect premiums charged by insurers[2].

The nature of risk and impact
Even if the risk of a natural peril is low, severe events can still occur. For example, South Australia is not at extreme risk of storm, but recently had a one in 50-year storm.

The risk of a natural peril occurring is different to the impact. The risk rating is a function of the likelihood of an adverse event occurring based on a range of environmental factors, for example, the proximity of a property to a flood prone river.

Cronulla Beach, New South Wales, June 2016

The actual impact of the natural perils relates to the scale of the event and mitigating factors such as: land use planning and building codes; where properties are located; building standards; and the protective infrastructure, such as levees, which can mitigate the impact. As such, the risk of being impacted by a natural perils can be mitigated by planning, protective infrastructure and building standards.

The level of possible mitigation varies according to the type of natural peril. For instance, infrastructure can be built to deal with heavy rain or flood but a similar infrastructure solution is not available for bushfires.

Comparing risk levels between natural perils
The risk ratings by LGA are useful in comparing LGAs for the same peril (e.g. comparing flood risk between two LGAs), however, the risk ratings for the various natural perils are not comparable to each other. That is, the risk or potential impact of earthquake in an extreme risk LGA is not the same as an extreme risk for bushfires.

Index of Economic Resources
The Australian Bureau of Statistics Socioeconomic Index for Areas: Index of Economic Resources has been used to understand the economic resources communities can use after a natural disaster. This measure does not account for the underlying resilience or social capital (community cooperation and networks) of the community within the LGA. The level of resilience and social capital are important factors in the community's ability to deal with natural disasters.

[2] For more information see: http://www.icadataglobe.com/ilead/

2 OVERVIEW

Gross Domestic Product[3] (GDP) and population of the LGAs for each of the natural perils risk levels is presented in Table 2. It shows $326.6 billion worth of GDP generated in 2014-15 (20.3 per cent of Australia's total GDP) was located in LGAs at high ($169.6 billion), very high ($104.1 billion) or extreme ($52.8 billion) risk of tropical cyclones. The population living in these LGAs is 3.9 million people (17.3 per cent of the population).

Table 3 summarises the GDP, population and average risk rating[4] for the metropolitan area of each capital city and for the regional section of each state and territory. Key points are:

- Sydney is Australia's largest city with a population of almost five million and GDP of $378 billion. On average, Sydney has a high risk of floods relative to other regions, due to extensive development in the floodplains of the Hawkesbury, Georges and Cooks rivers and their various tributaries.
- On average, regional Victoria has high risk of flood and bushfire due to the many communities in floodplains and close to vegetation.
- On average, Brisbane has a high risk of flood due to extensive urbanisation of the Brisbane River, Pine River and coastal creek floodplains.
- Northern Australia (including north-west Western Australia, coastal Northern Territory and North Queensland) has a very high to extreme exposure to tropical cyclones, as evidenced by tropical cyclones Larry, Yasi and Tracy.

LGAs with high, very high and extreme risk of bushfire generated $174.7 billion (10.8 per cent) of GDP and are home to 2.2 million people. A quarter of Australia's population live in LGAs with high, very high or extreme risk of flooding - areas that generate 28 percent of the natural GDP.

The risk of extreme weather events in these areas presents a significant threat to the national economy and to the people of Australia. Government, businesses and households must be aware of their exposure and take steps to manage the impacts of these natural perils.

The remainder of this report looks at the various natural perils risks and how they relate to the economic resources of the population and the economic activity of businesses. It also highlights the key implications for governments, business, individuals and communities.

TABLE 2. GDP, POPULATION AND PERILS RISKS[5][6]

		No Exposure	Low	Medium	High	Very High	Extreme
Tropical Cyclone	**GDP ($B)**	1,170.8	63.6	47.2	169.6	104.1	52.8
	Population (M)	17.3	1.0	0.5	1.7	1.6	0.6
Bushfire	**GDP ($B)**	378.1	841.3	216.3	132.5	37.9	4.3
	Population (M)	3.2	13.6	4.0	1.7	0.4	0.0
Flood	**GDP ($B)**	19.8	-	746.6	654.9	195.1	8.1
	Population (M)	1.0	-	106.5	90.7	31.0	1.0
Storm	**GDP ($B)**	394.8	279.6	397.2	405.1	20.4	-
	Population (M)	4.8	4.8	6.8	5.0	0.5	-
Earthquake	**GDP ($B)**	-	-	723.9	452.4	417.9	13.9
	Population (M)	-	-	110.7	56.6	59.3	1.0

Source: SGS (2016) based on ICA iLEAD data and ABS Regional Population Growth, (Cat. No. 3218)
Peril risk ratings are averages that should be treated with caution as they can combine areas with a diverse risk profile. For example regional Western Australia includes areas very high tropical cyclone risks, averaged with areas with no tropical cyclone risk, resulting in an overall low rating.

[3]Gross Domestic Product (GDP) refers to Australia, Gross State Product (GSP) refers to a State, while Gross City Product (GCP) refers to a city's metropolitan area and Gross Regional Product (GRP) refers to a particular region. In this paper, all different measures are referred to as Gross Domestic Product (GDP).
[4]Based on the land area weighted average for Local Government Areas.
[5] LGAs with no data are excluded.
[6] Risk ratings can be compared between regions, but not between perils. For example, earthquake ratings reflect the risk of a very infrequent event impacting a lot of people, where flood ratings reflect the risk of a more frequent event with direct impacts to less people.

TABLE 3. REGIONAL[7] GDP, POPULATION 2014-15 AND NATURAL PERILS RISKS[8]

Region	GDP ($Billion)	Population (million)	Tropical cyclone	Flood	Storm	Bushfire	Earthquake
Sydney	$378.0	$4.9	No Exposure	High	Medium	Medium	Very High
Regional NSW	$128.9	$2.7	Low	Medium	Medium	Low	Medium
Melbourne	$284.8	$4.5	No Exposure	Medium	Medium	Medium	Very High
Regional Victoria	$70.8	$1.4	No Exposure	High	Medium	High	High
Brisbane	$155.4	$2.3	High	High	Medium	Medium	High
Regional QLD	$144.9	$2.5	Medium	Medium	Medium	Low	Medium
Adelaide	$74.0	$1.3	No Exposure	Low	Medium	High	Very High
Regional SA	$24.5	$0.4	No Exposure	Low	Medium	Medium	High
Perth	$154.6	$2.0	Low	Medium	Low	Medium	Medium
Regional WA	$121.7	$0.6	Low	Low	Medium	High	High
Greater Hobart	$14.2	$0.2	No Exposure	Medium	Medium	Medium	Medium
Rest of Tas.	$25.4	$0.3	No Exposure	High	Medium	Medium	Low
Greater Darwin	$7.5	$0.1	Extreme	No Exposure	Extreme	Low	Medium
Rest of NT	$22.4	$0.1	Medium	Low	High	Medium	Medium
Australian Capital Territory	$34.9	$0.4	No Exposure	No Exposure	Medium	Low	Very High

Source: SGS (2016) based on ICA iLEAD data, ABS Regional Population Growth, (Cat. No. 3218) and SGS Australia Cities Accounts (2015)
Peril risk ratings are averages that should be treated with caution as they can combine areas with a diverse risk profile. For example regional Western Australia includes areas very high tropical cyclone risks, averaged with areas with no tropical cyclone risk, resulting in an overall low rating.

[7] Based on a weighted average risk for all LGAs within the region. The total land area of the LGA was used as the weight.
[8] Risk ratings can be compared between regions, but not between perils. For example, earthquake ratings reflect the risk of a very infrequent event impacting a lot of people, where flood ratings reflect the risk of a more frequent event with direct impacts to less people.

3 WHERE NATURAL PERIL RISK IS LOCATED

3.1 Tropical cyclone

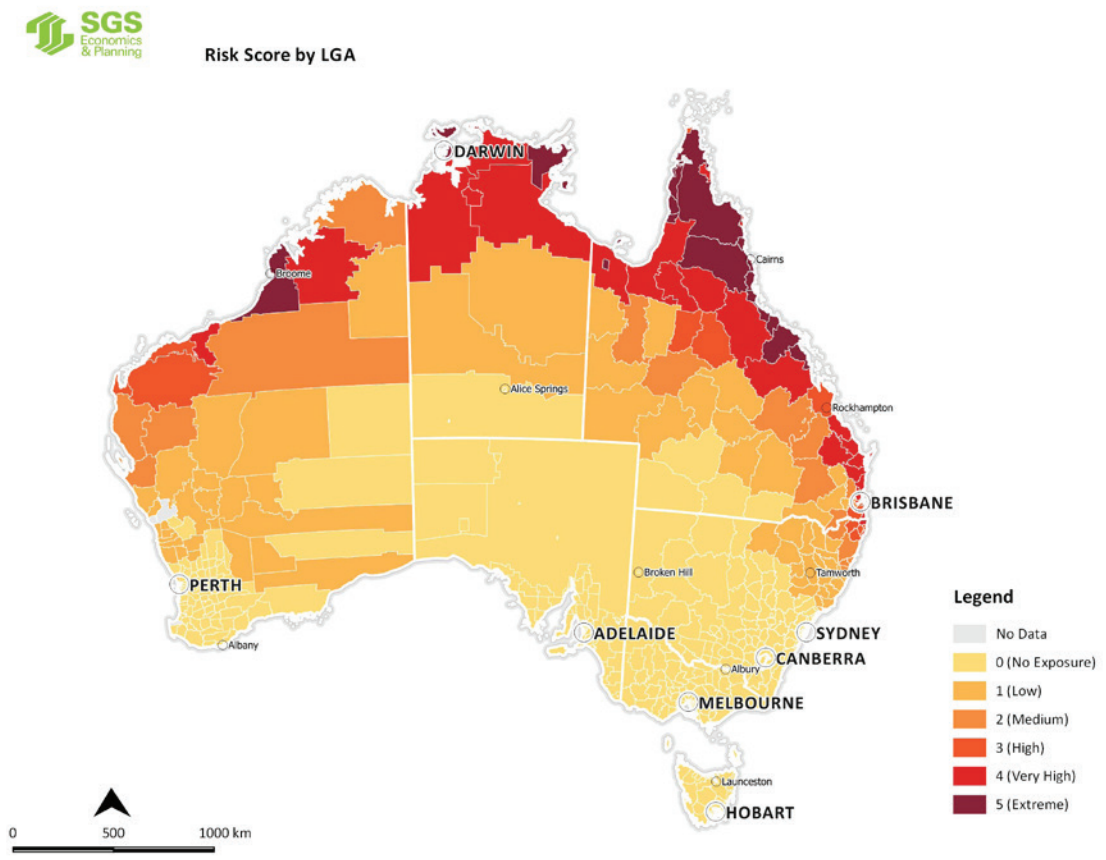
Figure 1 illustrates the risk of tropical cyclones across Australia. A rating of zero is the lowest risk and a rating of five is the highest.

Tropical cyclones are common in northern Australia. They form when a low pressure system intensifies over warm tropical waters, resulting in a rotating structure with a distinct 'eye', causing destructive winds of more than 200 km/h during a category five system. Their strength can be disastrous and their reach vast, with wind and intense rainfall able to extend hundreds of kilometres from the centre of the cyclone.

The tropical regions in the north of Australia are most affected, with areas rated as having very high or extreme risk concentrated in Queensland, the Northern Territory and north-west Western Australia. Tropical cyclones decay as they move inland, resulting in lower risk in inland areas of Australia.

Several major tropical cyclones have devastated northern Australia. Tropical Cyclone Tracy hit Darwin in 1974, killing 65 people and destroying most of Darwin. In North Queensland, Tropical Cyclone Yasi in 2011 caused $3.6 billion in damage. The Mackay tropical cyclone of 1918 saw 1,411 millimetres of rain fall in Mackay in three days, and caused the death of 30 people.

FIGURE 1. TROPICAL CYCLONE RISK

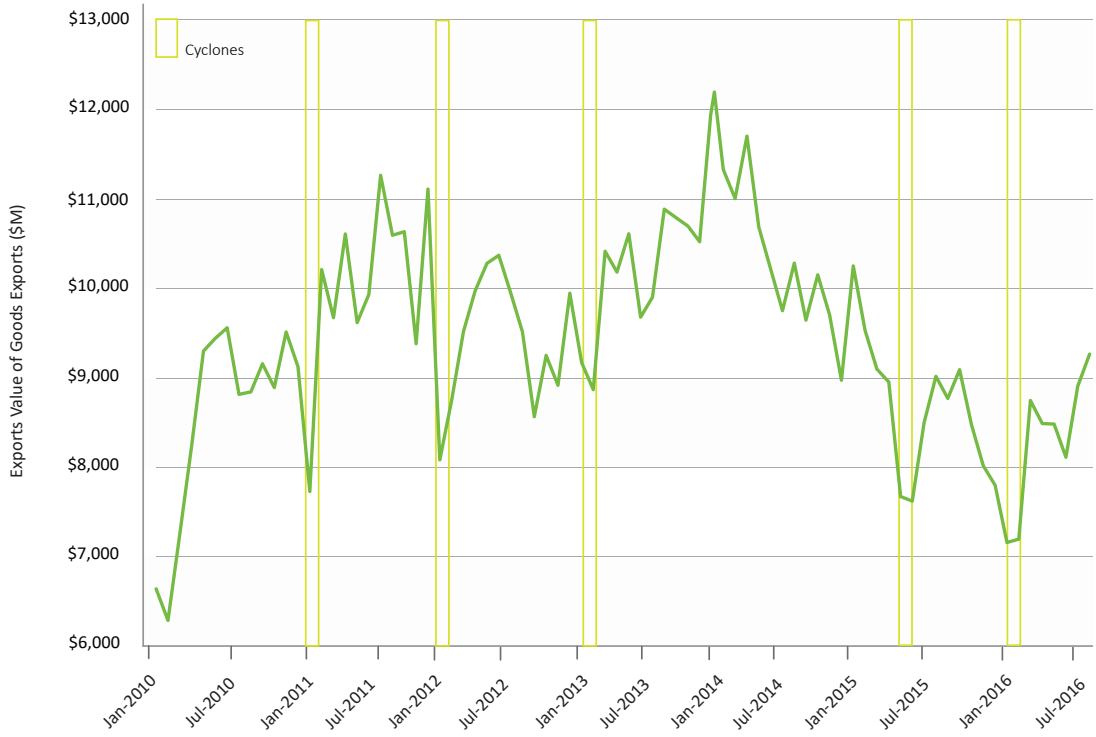


Source: SGS (2016) based on ICA iLEAD data

In 2014-15, 20.3 per cent of Australia's GDP, which is worth $326.6 billion, was in LGAs at high to extreme risk of disruption from tropical cyclones. GDP in these locations is increasing at 3.4 per cent per year (compared to the 2.4 per cent national average) driven by increased mining production.

Mines and export systems are able to recover quickly from tropical cyclones but they do delay exports, which in turn delays payment. This can slow economic growth in the short term and put pressure on government budgets.

FIGURE 2. WA MERCHANDISE EXPORTS ($M) & TROPICAL CYCLONE EVENTS



Source: ABS International Trade in Goods & Services, Australia, (Cat No. 5368.0) and BOM Severe Weather Events (2016)

Figure 2 presents merchandise exports from Western Australia over the past five years. Trends depicted in the chart are largely driven by iron ore exports from the Pilbara.

Records of selected tropical cyclones have been overlaid with the value of these exports. This illustrates that steep troughs in revenue have coincided with the export of tropical cyclones, as they have disrupted the production and export of iron ore in the region. Table 4 identifies the tropical cyclones in Western Australia between January 2010 and January 2016.

Tropical Cyclone Yasi damage, Queensland, 2011

[9] Includes all goods (e.g. wheat, iron ore, manufactured goods, fruit and vegetables)

TABLE 4. TROPICAL CYCLONES IN WESTERN AUSTRALIA (2010-2016)

Event	Date	Maximum category (0-5)
Stan	Jan 2016	2
Quang	Apr-May 2015	4
Olwyn	Mar 2015	3
Christine	Dec 2013 – Jan 2014	3
Alessia	Nov 2013	1
Rusty	Feb 2013	4
Peta	Jan 2013	1
Lua	Mar 2012	4
Iggy	Jan-Feb 2012	2
Heidi	Jan 2012	2
Carlos	Feb 2011	3
Bianca	Jan 2011	4
Magda	Jan 2010	3

Source: BOM Severe Weather Events (2016)

White Paper on Developing Northern Australia

The White Paper *Developing Northern Australia* produced by the Australian Government is focused on policies to increase the scale and breadth of economic activity and population living north of the Tropic of Capricorn.

Given the risk of natural perils in this part of the country, development should be risk appropriate, adapted to weather volatility, and combined with measures to increase community resilience.

3.2 Flood

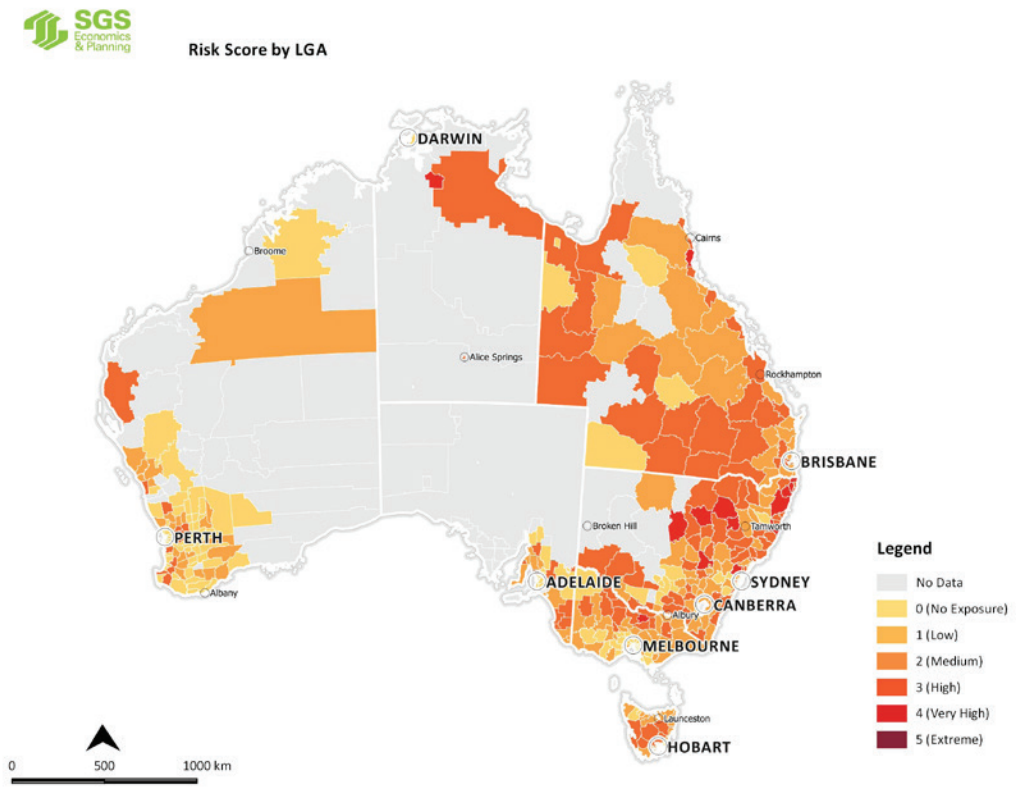
Figure 3 presents flood[10] risk data showing the average risk level within each LGA. It is important to note that these are relative average risk levels between communities and the level of flood risk varies within each LGA. Only around five per cent of properties in Australia are at clear risk of flooding (Allianz Australia Insurance, 2014), and even the most flood-prone communities includes many properties with no flood risk.

Flooding can cause disruption to agricultural and mineral production and to urban transport systems. Public transport systems in Sydney, Melbourne and Brisbane have all experienced delayed services due to heavy rains in recent years. Heavy rainfall also impacts road networks via reduced speeds and increased accident rates. This does not significantly damage the infrastructure but disrupts economic activity in the short term.

Twenty four hours of disruption to transport networks in a Sydney or Melbourne CBD, could reduce GDP by $30 million[11], much of which could not be recovered.

[10]Flooding is defined as the covering of normally dry land by water that has escaped or been released from the normal confines of any natural watercourse or any reservoir, canal, or dam. Flash flooding is considered a by-product of a storm and is not included in the risk ratings.
[11]SGS calculations based on a high level assessment of the industry productivity per worker, ability to work from home for each industry category during a flood and journey to work patterns.

FIGURE 3. FLOOD RISK



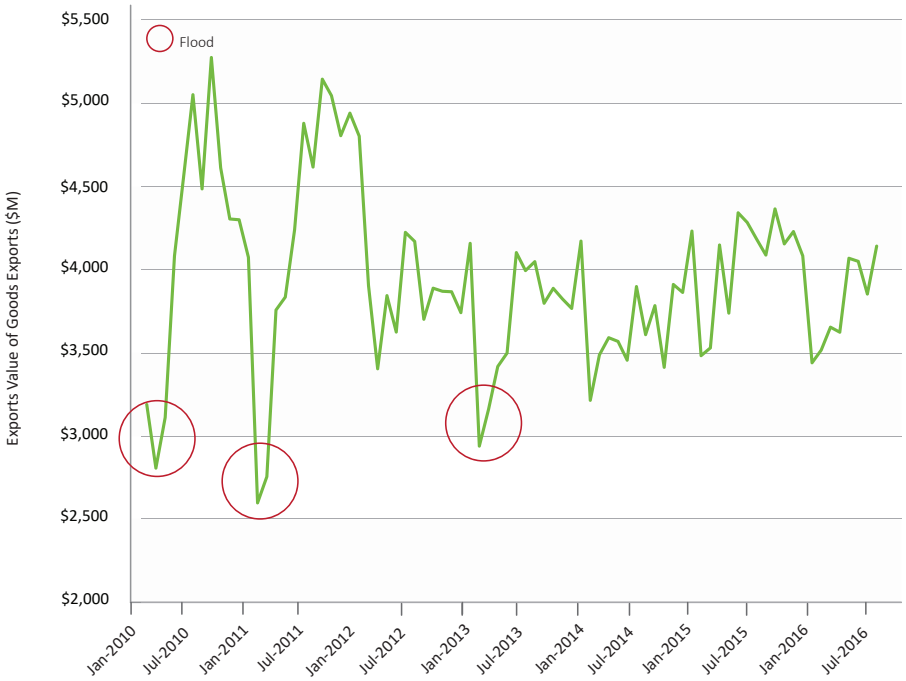
Source: SGS (2016) based on IAG data

Extreme flooding affects exports in a similar way to tropical cyclones, causing trade delays and slowing economic growth. A significant degree of Queensland exports come from coal and Liquefied Natural Gas (LNG). Largely sourced from the Bowen Basin, this industry is exposed to flood risk.

The combined effects of flooding and Tropical Cyclone Yasi in December 2010 to January 2011 had disastrous consequences for Queensland's economy. To support businesses and rebuild public infrastructure, the Government spent almost $7 billion (Queensland Government, 2011). A Temporary Flood and Cyclone Reconstruction Levy was raised by the Commonwealth to help fund the reconstruction. This event illustrates that the amount spent on reconstruction and rebuilding could be lessened by strategic pre-disaster mitigation investment.

Figure 4 presents merchandise exports from Queensland over the past six years, with extreme flooding events circled in red. It shows Queensland experienced significant declines in exports after flood events.

FIGURE 4. QUEENSLAND MERCHANDISE EXPORTS



Source: ABS International Trade in Goods and Services, Australia, Cat no. 5368.0 (2016); BOM 'Severe Weather Events (2016)

Case Study: Warragamba Dam

A study commissioned by Infrastructure NSW (Molino Stewart, 2012) showed that if a one in 1,000 year flood occurred in the Hawkesbury Nepean Valley it would cause $8 billion in damage. This event could potentially place more than 40,000 people at risk, completely destroy 6,500 homes and flood 14,000 homes. The flooding would disrupt the Main Western rail line affecting both Blue Mountains passengers and state coal exports for up to six months.

In 2012, Infrastructure NSW recommended lifting the Warragamba Dam wall by 20 plus metres, at a cost of $500 millon, to mitigate against such a flood. This would protect the economy and the people of western Sydney. Infrastructure NSW recommended this project happen within five years. While in June 2016 $58 million was allocated to the first phase of the project, West Sydney still remains at risk of a major flood event.

The effects of flooding on agriculture are significant. For some commodities, extreme rainfall affects quality not quantity but this is not the case for fruit and vegetables which suffered significant losses in 2010-11. This can have implications in subsequent too seasons. Some crops will continue to have reduced output, while increased soil moisture may provide better conditions for other crops to thrive.

Food shortages caused by heavy rains can impact the national Consumer Price Index. Following heavy rains and flooding in Queensland in 2009 the Reserve Bank of Australia (2011) noted that the headline inflation in the March Quarter of 2009 was up a quarter of a percentage point as a result.

3.3 Storm

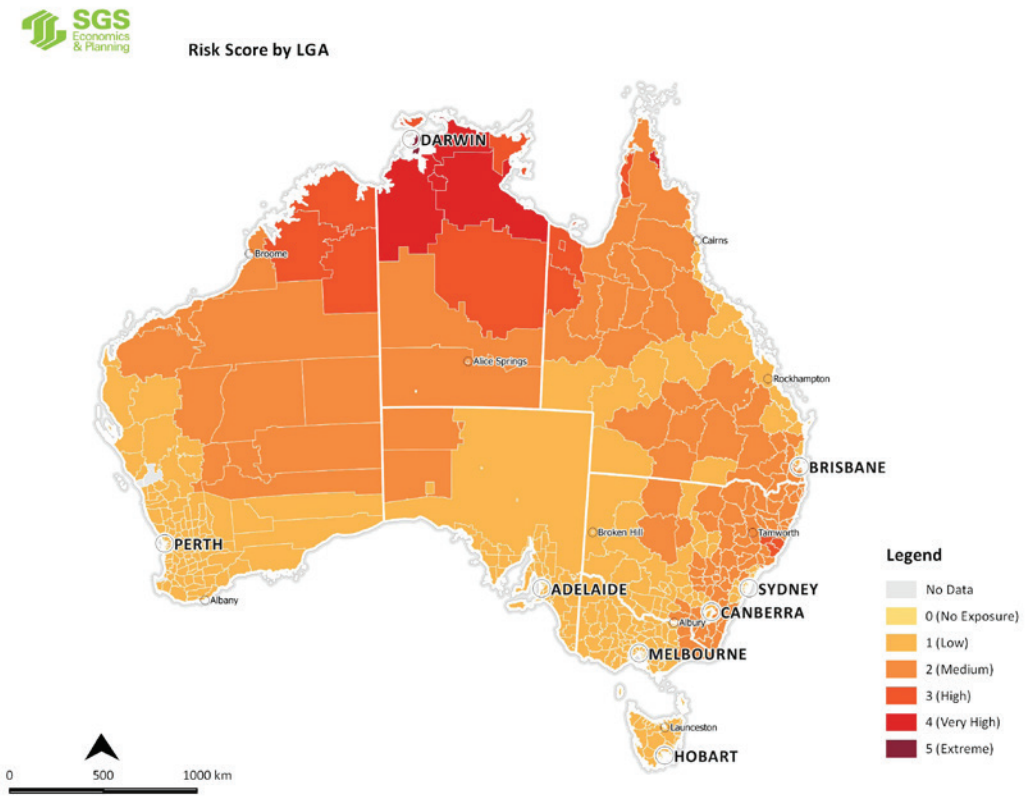
Storms are the most common natural peril and can happen anywhere in Australia. Severe storms can produce heavy rain, hail, strong gales and flash flooding[12]. The risk of a severe storm is shown in Figure 5, illustrating that Darwin has a very high risk as parts of New South Wales.

The iLEAD storm dataset is focused on measuring events where the vertically integrated water level is above a certain level. The risk of other storm events (not meeting this definition) are not captured in Figure 5. This highlights a limitation with the iLead data. Data is collected on events with the potential to create insurable losses (for example, where assets are damaged) but not for events which create economic disruption (for example, where transport failures stop people getting to work).

Collecting data on how these natural perils specifically impact economic disruption should be pursued. Extreme rainfall can have many impacts, including flooding, crop and infrastructure damage, and delays in extracting and transporting mineral products.

Storms can impact agricultural and mineral production and urban transport systems. As identified in Section 3.2, public transport systems in Sydney, Melbourne and Brisbane have experienced delayed services due to heavy rains. Heavy rainfall also impacts the road network via reduced speeds and more accidents. This does not significantly damage the infrastructure but disrupts short term economic activity.

FIGURE 5. STORM RISK



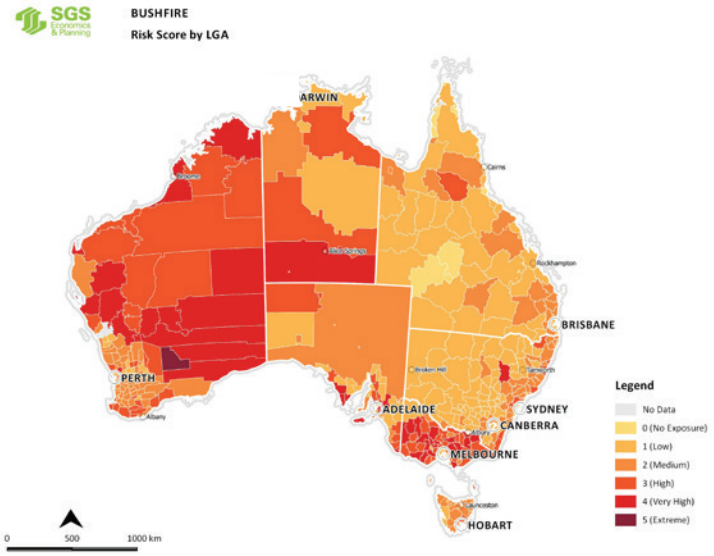
Source: SGS 2016 based on ICA iLEAD data

[12] Flash flooding is a short-term event that might cause disruption to transport and power networks

3.4 Bushfire

Bushfires are common in many parts of Australia, with ecosystems evolved to interact with, or depend on, fire to regenerate. Bushfires are destructive and often fatal. The speed, spread and intensity of a bushfire depends on factors including the type and dryness of vegetation, wind speed, temperature and humidity. Bushfire risk scores, calculated using proximity to combustible vegetation, have been applied across Australia and presented in Figure 6.

FIGURE 6. BUSHFIRE RISK



Source: SGS 2016 based on ICA iLEAD data

The data shows the average bushfire risk level for each LGA. However, the level of bushfire risk would vary within each LGA. For example, properties on the urban fringe would be at higher risk than more built-up areas in the same LGA.

Regional Western Australia and parts of New South Wales, Tasmania and Victoria are at high to extreme risk.

The deadliest bushfires in our recorded history have been: Black Saturday in Victoria in 2009 (173 people died); Black Friday in Victoria 1939 (71 people died); Black Tuesday in Tasmania in 1967 (62 people died) and Ash Wednesday in South Australia in 1983 (47 people died).

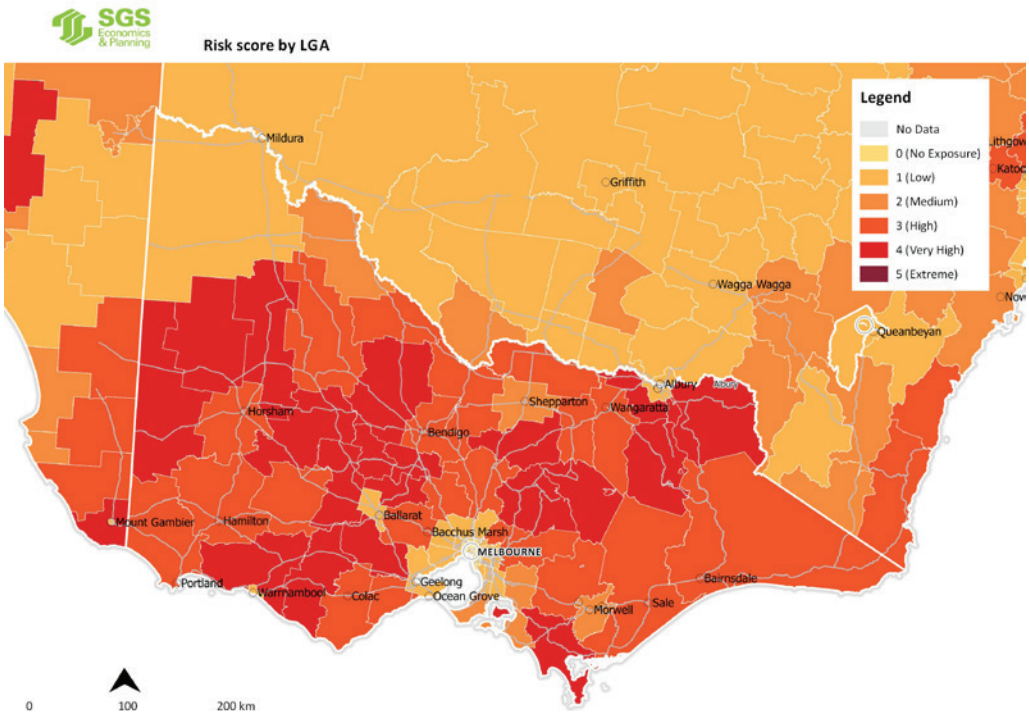
In Victoria, 17.5 per cent of the population live in LGAs at high to extreme risk of bushfire. While the metropolitan area of Melbourne has low risk, some regional areas of Victoria with high levels of planned growth are very vulnerable to bushfires (see Figure 7). For example, both the City of Bendigo, where the population is projected to increase by 26,000, or 25 per cent, between 2015 and 2031, and Mitchell Shire, where the population is projected to increase by 42,000, or 52 per cent, between 2015 and 2031 (DELWP, 2016), have a high bushfire risk.

2009 Black Saturday Bushfires

On 7 February 2009, Victoria suffered the worst bushfire in recorded history. 173 people died, 414 were injured and over 1.1 million acres of land was destroyed. The total cost of the losses was estimated at more than $4 billion (Royal Commission into Victoria's Bushfires, 2010). The Murrindindi Shire had the worst devastation after a firestorm wiped out townships including Marysville and Kinglake.

A Royal Commission examined all aspects of the government's bushfire strategy. It handed down 53 recommendations which focused on Victoria's bushfire safety policy, emergency and incident management, and planning and building regulations, including a call for a central point for mapping bushfire risk.

FIGURE 7. BUSHFIRE RISK VICTORIA



Source: SGS 2016 based on ICA iLEAD data

Black Saturday bushfires, Victoria, 2009

3.5 Earthquake

Australia is situated in the middle of a tectonic plate so it does not have frequent damaging earthquakes such as those occurring in countries at the boundaries of tectonic plates (for example, Japan, Indonesia, and New Zealand).[13] The 1989 Newcastle earthquake was an exception. While rare, earthquakes can cause a lot of damage. Figure 8 presents the average earthquake risk.

Small parts of Western Australia, South Australia, New South Wales and Victoria are at extreme risk of earthquakes relative to other parts of Australia, though the risk is relatively low compared to countries on tectonic plate boundaries.

1989 Newcastle Earthquake

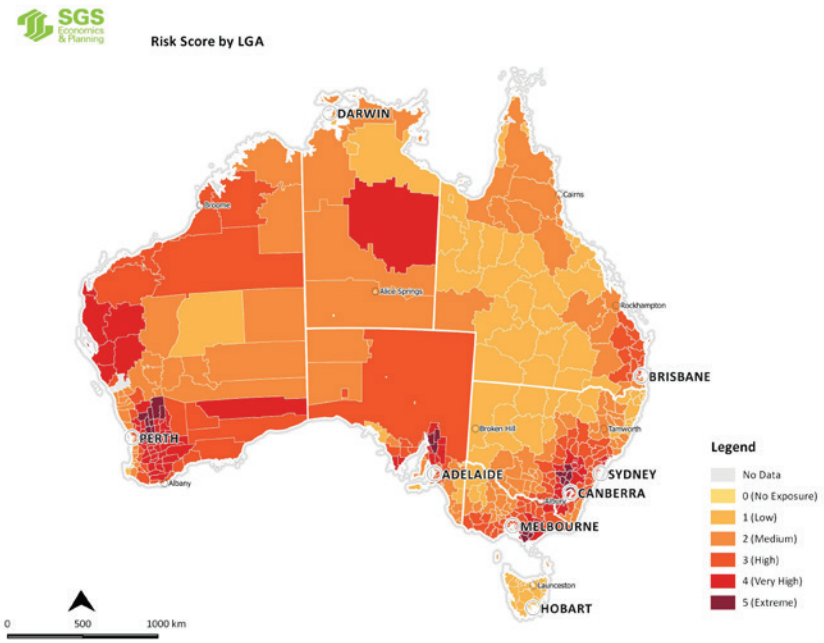
A magnitude 5.6 earthquake shook Newcastle on the 28th of December 1989.

The combination of older buildings, poor maintenance to deal with corrosive oceanic spray, brittle masonry and poor foundations resulted in the deaths of 13 people, injured 160 people and caused over $1.6 billion in insured losses. Around 50,000 buildings, including 40,000 homes, were affected leaving 1,000 people homeless.

This devastating event showed that, while the risk may be low, Australian communities are still vulnerable to death, injury and extensive property and infrastructure damage from earthquakes. This earthquake led to changes in building standards to improve resilience to future earthquakes.

Christchurch, New Zealand, 2011

FIGURE 8. EARTHQUAKE RISK



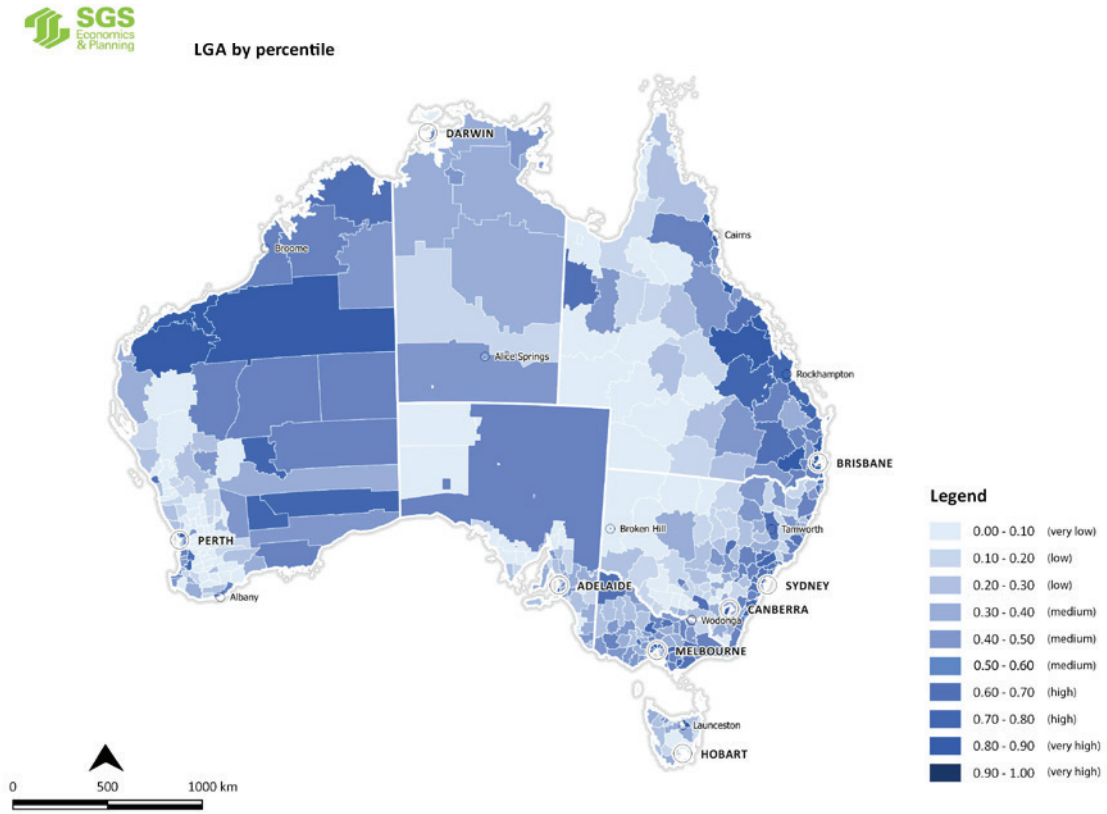
Source: SGS (2016) based on ICA iLEAD data

[13]Geoscience Australia shows all earthquakes for the previous seven days at http://www.ga.gov.au/earthquakes/

4 ECONOMIC ACTIVITY AND RISK

Australia's economy is most at risk from the impacts of natural perils in areas with high GDP. Figure 9 presents the GDP for each LGA. The economic contribution of mining areas (such as the Pilbara in Western Australia and the Bowen Basin in Queensland) can be clearly seen. However, as shown in Table 5, the bulk of Australia's economic activity happens in the major urban areas.

FIGURE 9. GROSS DOMESTIC PRODUCT



Source: SGS (2016) based on ICA iLEAD data

Table 5 presents a selection of LGAs with the highest economic production. The geographical size of the LGA can often determine the scale of economic production. For example, the Brisbane LGA covers the whole of metropolitan Brisbane, while the Sydney and Melbourne LGAs only cover the CBD.

Sydney, New South Wales 2015

TABLE 5. HIGH GDP LGA AND RISK[14]

LGA	State	2014-15 GDP	Share of GDP	Tropical cyclone	Flood	Storm	Bushfire	Earthquake
Brisbane	QLD	115,421	7.2%	High	High	Medium	Low	High
Sydney	NSW	112,681	7.0%	No Exposure	No Exposure	Low	No Exposure	High
Melbourne	VIC	84,629	5.3%	No Exposure	High	Low	No Exposure	High
Canberra	ACT	34,866	2.2%	No Exposure	Low	Low	Low	Very High
Perth	WA	33,340	2.1%	No Exposure	Low	Low	Low	Medium
Gold Coast	QLD	30,798	1.9%	Very High	Medium	Medium	Low	Medium
North Sydney	NSW	17,225	1.1%	No Exposure	No Exposure	Low	Low	High
Adelaide	SA	16,503	1.0%	No Exposure	No Exposure	Low	No Exposure	High
Parramatta	NSW	16,336	1.0%	No Exposure	Medium	Low	Low	High
East Pilbara	WA	16,294	1.0%	Medium	Medium	Medium	High	High
Ashburton	WA	15,063	0.9%	High	Low	Medium	High	High
Sunshine Coast	QLD	14,870	0.9%	Very High	Medium	Low	Medium	High
Ryde	NSW	14,765	0.9%	No Exposure	Low	Low	Low	High
Blacktown	NSW	13,833	0.9%	No Exposure	Medium	Low	Low	High
Moreton Bay	QLD	12,863	0.8%	Very High	Medium	Low	Low	High
Newcastle	NSW	12,698	0.8%	No Exposure	High	Low	Low	High
Roebourne	WA	12,223	0.8%	High	Low	Medium	High	High
Canning	WA	11,312	0.7%	No Exposure	No Exposure	Low	Low	Medium
Logan	QLD	10,953	0.7%	High	Medium	Medium	Low	Medium
Boroondara	VIC	10,904	0.7%	No Exposure	No Exposure	Low	No Exposure	High
Greater Geelong	VIC	10,079	0.6%	No Exposure	Medium	Low	Low	High

Source: SGS (2016) based on ICA iLEAD data and ABS Regional Population Growth, (Cat. No. 3218)
Peril risk ratings are averages that should be treated with caution as they can combine areas with a diverse risk profile. For example regional Western Australia includes areas very high tropical cyclone risks, averaged with areas with no tropical cyclone risk, resulting in an overall low rating.

[14] Risk ratings can be compared between regions, but not between perils. For example, earthquake ratings reflect the risk of a very infrequent event impacting a lot of people, where flood ratings reflect the risk of a more frequent event with direct impacts to less people.

The Melbourne CBD generated $84.6 billion in 2014-15 and is at extreme risk of flooding. The CBD flooded in 1998, 2004, 2008, 2010 and 2011 (State Emergency Service, no date). Public transport systems are heavily impacted by floods with the delayed or cancelled services making it difficult for people to get to and from work. Combined, the Sydney and Melbourne CBDs have one million workers who could potentially be affected by transport network failure.

Coastal communities in Queensland, including the Gold Coast, Townsville and Moreton Bay, are at high to extreme risk of combinations of tropical cyclones, floods and storms. Mining-focused LGAs in Western Australia, including Roebourne, East Pilbara and Port Headland, are at high risk too.

Adelaide, South Australia, 2016

2016 Adelaide blackout

In September 2016, a one in 50 year storm hit South Australia, knocking out power transmission for the state. Without power, Adelaide's public transport system could not function, the road network was severely disrupted and many businesses stopped trading. The electricity disruption caused the Port Pirie lead and zinc smelter to shut down for several weeks when the content of the smelter cooled and solidified.

In addition to business disruption, the event also put people's lives at risk. The Flinders Medical Centre's back-up generator failed forcing the transport of 17 intensive care patients to Flinders Private Hospital.

This event may have reduced the GDP of South Australia by as much as $200 million[15].

[15] SGS calculation based on the average GDP per day worked for South Australia and assuming that one day's of total production was lost.

5 POPULATION AND RISK

Several LGAs have high natural perils risks and growing populations. Growth in these locations, without adequate mitigation, will expose more people to risk.

Table 6 shows the 20 fastest growing LGAs in Australia between 2001 and 2015. The geographic size of the LGA can often determine the scale of population growth.

Queensland's coastal communities, such as Brisbane, the Gold Coast, Townsville and Moreton Bay have areas exposed to high to extreme risk of tropical cyclones and storms. Between 2001 and 2015 the population in these LGAs increased by more than 450,000.

Brisbane City Council residential buy-back scheme

Brisbane has experienced major floods in the past century. To mitigate the impacts, the Brisbane City Council purchased the residential properties at the highest risk of frequent flooding on a voluntary basis. The properties are used as open space and drainage easements and will not be redeveloped for residential use. This was in addition to improvements to land use planning and building controls, to ensure developments have less flood risk.[16]

Many high growth LGAs have people living in areas with a risk of flooding. Not all population growth occurs in parts of the LGA with extreme levels of risk as new housing developments tend not to be permitted in high flood risk areas. The impacts of flooding in newly developed locations can be mitigated via planning, appropriate building codes and investment in mitigation (see section 6.1)

Historically, development in high risk flood areas has not always been restricted. Options to minimise the impacts of flooding for existing properties include retrofitting, raising houses or, when a large number of properties are at risk, mitigation infrastructure. In some cases, where there are no mitigation solutions, relocation schemes may be considered, such as in Granthom after the 2011 floods.

With increasing population and pressure to release more land, the households at risk may increase if development is allowed in vulnerable locations. New development in high risk areas should be accompanied by levees, barrages, flood gates and improved drainage, to mitigate the impacts of floods. Promoting community resilience and household mitigation should also be encouraged.

Brisbane, Queensland 2010

It is important to ensure new buildings in at-risk areas can withstand weather events such as river and flash floods, tropical cyclones, hailstorms and bushfires. While building code standards are currently focused on protecting life and safety, there is scope to enhance them to also protect property. It should be acknowledged, however, that some land has an unacceptably high risk of tropical cyclones, severe thunderstorms, hailstorms, bushfires, flood and other risks and should not be zoned for residential or commercial use.

[16] For more information: https://www.brisbane.qld.gov.au/community/community-safety/disasters-emergencies/types-disasters/flooding/flood-policy-plans-projects/residential-property-buy-back-scheme

TABLE 6. HIGH POPULATION GROWTH LGA AND RISK[17]

LGA	State	Population growth 2001-2015	Tropical cyclone	Flood	Storm	Bushfire	Earthquake
Brisbane	QLD	194,000	High	High	Medium	Low	High
Gold Coast	QLD	119,000	Very High	Medium	Medium	Low	Medium
Moreton Bay	QLD	102,000	Very High	Medium	Low	Low	High
Wyndham	VIC	101,000	No Exposure	Medium	Low	Low	High
Wanneroo	WA	82,000	Low	Low	Low	Medium	Medium
Casey	VIC	78,000	No Exposure	No Exposure	Low	Low	Very High
Whittlesea	VIC	70,000	No Exposure	No Exposure	Low	Low	High
Blacktown	NSW	64,000	No Exposure	Medium	Low	Low	High
Canberra	ACT	59,000	No Exposure	Extreme	Low	Low	Very High
Melton	VIC	58,000	No Exposure	Low	Low	Low	High
Ipswich	QLD	56,000	Medium	High	Medium	Low	High
Logan	QLD	55,000	High	Medium	Medium	Low	Medium
Melbourne	VIC	53,000	No Exposure	High	Low	No Exposure	High
Sydney	NSW	47,000	No Exposure	No Exposure	Low	No Exposure	High
Rockingham	WA	46,000	No Exposure	No Exposure	Low	Low	Medium
Stirling	WA	46,000	No Exposure	Low	Low	Low	Medium
Hume	VIC	45,000	No Exposure	No Exposure	Low	Low	High
Parramatta	NSW	44,000	No Exposure	Medium	Low	Low	High
Swan	WA	40,000	No Exposure	Low	Low	Low	High
Townsville	QLD	39,000	Extreme	Medium	Low	Low	Low

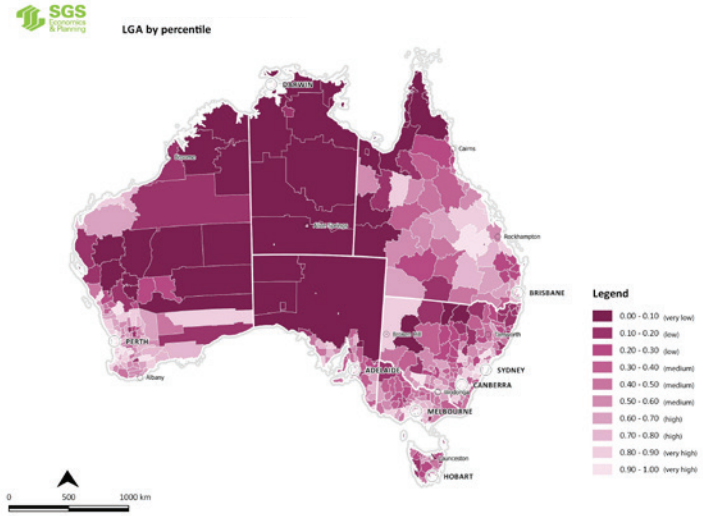
Source: SGS (2016) based on ICA iLEAD data and ABS Regional Population Growth, (Cat. No. 3218.0)
Peril risk ratings are averages that should be treated with caution as they can combine areas with a diverse risk profile. For example regional Western Australia includes areas very high tropical cyclone risks, averaged with areas with no tropical cyclone risk, resulting in an overall low rating.

[17] Risk ratings can be compared between regions, but not between perils. For example, earthquake ratings reflect the risk of a very infrequent event impacting a large number of people, where flood ratings reflect the risk of more frequent events with direct impacts to a smaller number of people.

In addition to the size of the population at risk, it is important to consider the community's ability to prepare for and deal with natural disasters. The ABS Socioeconomic Index for Areas (SEIFA) Index of Economic Resources (IER) has been used to understand the resources communities can use if a natural disaster happens.

The IER is derived from Census data such as low income, low educational attainment, high unemployment, and variables that broadly reflect access to economic resources.

FIGURE 10. INDEX OF ECONOMIC RESOURCES



Source: ABS Socioeconomic Index for Areas

Communities without economic resources may have limited means to independently prepare for and recover from natural disasters. These communities would be more reliant on government funds to recover.

The IER does not account for the underlying resilience or social capital in the LGA such as community cooperation and networks both important factors in a community's ability to cope with natural disasters.

Figure 10 presents the IER for Australia. LGAs with a score of 0.00-0.10 are communities with the lowest economic resources while those in the range 0.90-1.00 have the highest. Many rural LGAs have low economic resources and sparse populations.

Table 7 presents a selection of LGAs with a low IER. The State Decile[18] shows where a LGA sits amongst its peers across the state. While the average flood risk for each LGA should be treated with some caution, flooding is an issue for many LGAs with low IER, for example, Moree Plains and Bundaberg.

Case study: Moree Plains Shire

The Moree Plains Shire in north east New South Wales is a small community of about 14,000 people with a GDP of $750 million. Major floods occurred here in 2001, 2004, 2011 and 2012 (State Emergency Service, no date). The 2012 flood was the second largest flood on record, with 300 or more properties inundated and the road network of 2,700km affected. The 2012 flood led to an improved understanding of water flows and some small protective infrastructure investments (NSW Office of Environment and Heritage, 2012). These resulted in the Shire being better placed to deal with the heavy rains in 2016.

In regional Victoria there are a number of LGAs, including Hepburn, the Central Goldfields and Hindmarsh, with a high risk of bushfire and a low IER.

Additionally, Latrobe in Victoria has a low IER and is at extreme risk of earthquake.

[18] Decile is a method of splitting up a set of ranked data into ten equally large subsections.

TABLE 7. LOW ECONOMIC RESOURCES LGA AND RISK[19]

LGA	State	Index of Economic Resources State Decile	Population	Tropical cyclone	Flood	Storm	Bushfire	Earthquake
Moree Plains	NSW	1	14,053	Low	High	Medium	Low	Low
Fairfield	NSW	2	204,442	No Exposure	High	Low	Low	High
Wellington	NSW	1	9,073	No Exposure	High	Medium	Low	High
Hepburn	VIC	4	14,794	No Exposure	Low	Low	Very High	Medium
Central Goldfields	VIC	1	12,575	No Exposure	High	Low	Very High	Medium
Hindmarsh	VIC	3	5,494	No Exposure	High	Low	Very High	Low
Latrobe	VIC	1	73,548	No Exposure	Medium	Low	Medium	Extreme
Bundaberg	QLD	4	94,380	Very High	High	Low	Medium	High
Bunbury	WA	3	34,467	No Exposure	High	Low	Low	Low
East Pilbara	WA	2	12,197	Medium	Medium	Medium	High	High

Source: SGS (2016) based on ICA iLEAD data and ABS Socioeconomic Index for Areas (2011)
Peril risk ratings are averages that should be treated with caution as they can combine areas with a diverse risk profile. For example regional Western Australia includes areas very high tropical cyclone risks, averaged with areas with no tropical cyclone risk, resulting in an overall low rating.

[19] Risk ratings can be compared between regions, but not between perils. For example, earthquake ratings reflect the risk of a very infrequent event impacting a lot of people, where flood ratings reflect the risk of a more frequent event with direct impacts to less people.

6 WHAT THIS TELLS US

Previous analysis highlights the implications for government, individuals, businesses and communities when planning for natural peril risks. Some of these implications are summarised below where relevant to the analysis presented in this report.

Previous reports have highlighted the risk of natural perils nationally, but focused on insurable and economic losses, as opposed to loss of economic activity.

This report, and its interactive maps and data files, identifies the LGAs with the greatest risk and their economic activity and community resilience.

These tools can offer value to government, individuals, communities and businesses in a number of ways.

6.1 Implications for government

This report highlights the long term implications for Australia's earning capacity if investment in mitigation is not increased. More and more of Australia's economic activity is taking place in locations with high risk of natural perils. This means that economic activity and taxation revenue are at greater risk of disruption or delay.

There needs to be a greater focus on mitigation rather than post disaster reconstruction. The Productivity Commission Inquiry Report (2014) stated:

"Governments overinvest in post-disaster reconstruction and underinvest in mitigation that would limit the impact of natural disasters in the first place. As such, natural disaster costs have become a growing, unfunded liability for government" (pg.2).

Government spending is disproportionately skewed toward recovery efforts with current Australian Government spending on mitigation initiatives around three percent of what it spends on post-disaster recovery and reconstruction (Australian Business Roundtable for Disaster Resilience & Safer Communities, 2016). Yet investment in mitigation strategies reduces the cost of reconstruction. As a general rule, one dollar spent on mitigation can save at least two dollars in recovery costs (McClelland, 2011).

The key takeaway for government is that public funding can be better directed by targeting mitigation measures in places with the highest potential for social and economic loss.

By overlaying the areas exposed to the most extreme weather events with their economic activity and social vulnerability, the locations that stand to benefit the most can be identified.

The findings of this report are not intended to deter development but to guide future developments in a way that will safeguard community wellbeing and economic activity. The best way to mitigate risk will depend on the location and the type of risk.

In addition to protective infrastructure investments, appropriate land use planning, built form and building design is critical to help mitigate the risk of natural perils. Table 8 presents the influence that various planning can have on the impacts of natural perils. In some cases, land may have an unacceptable risk of natural perils and should not be zoned for residential or commercial use.

Local government should play a significant role, particularly in developing information and rallying communities to enhance their preparedness for natural disasters.

TABLE 8. IMPACT OF PLANNING ACTION

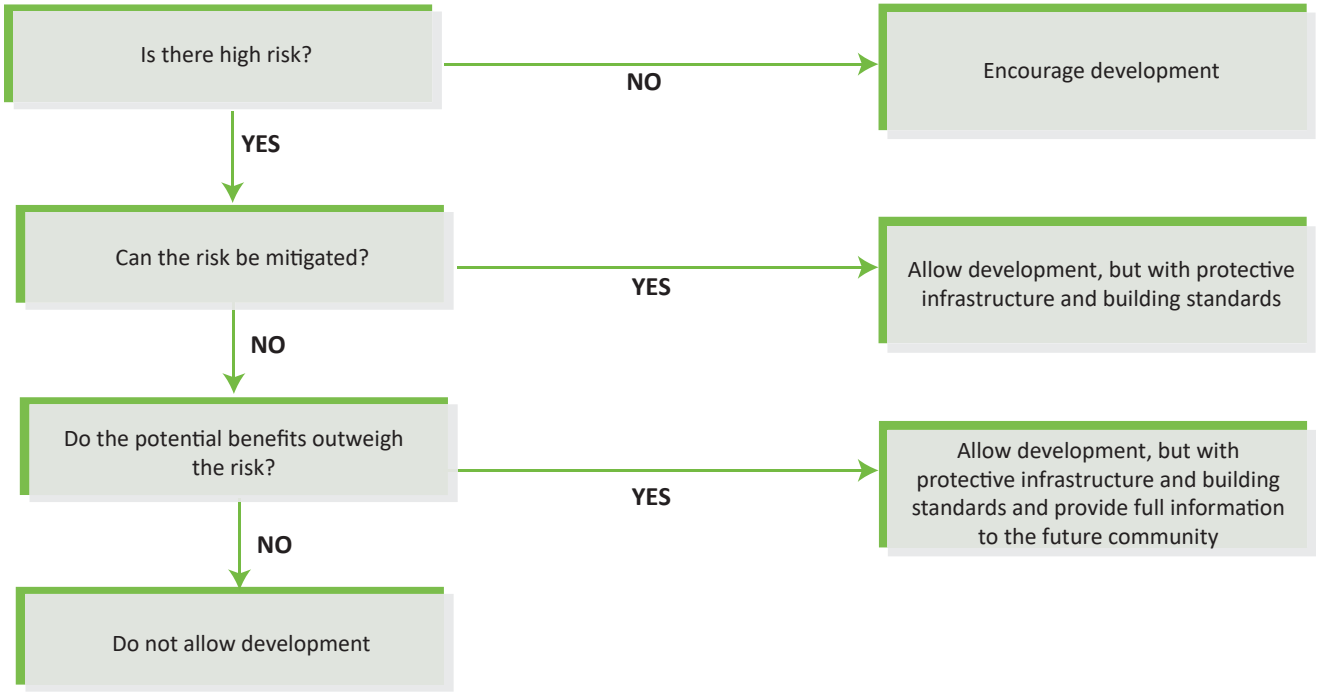
Peril	Land use zoning	Built form	Building standards
Bushfire	Strong	Strong	Strong
Earthquake	Strong	Strong	Strong
Flood	Strong	Strong	Strong
Tropical Cyclone	Limited	Moderate	Strong
Storm	Limited	Limited	Moderate

Source Based on Planning Institute Australia National Land Use Planning Guidelines for Disaster Resilient Communities (2016)

[15] The Commonwealth Government raises revenues in excess of its spending responsibilities, while state governments have insufficient revenue from their own sources to finance spending responsibilities

Figure 11 is an example of an investment decision tree governments could use to determine the location of development and mitigation.

FIGURE 11. SIMPLE EXAMPLE OF DECISION TREE



Source: SGS (2016)

Sydney, New South Wales, 2016

6.2 Implications for individuals and communities

The 2016 report *The Economic Cost of the Social Impact of Natural Disasters*, commissioned by the Australian Business Roundtable for Disaster Resilience & Safer Communities (Deloitte Access Economics, 2016), revealed the long lasting and far reaching social impacts of natural disasters on individuals and the community. In the face of natural perils all of these entities must work together to mitigate risk and deal with disasters.

The community's relationship to natural perils is unique to each area. The relationship is based on the risk of perils, settlement patterns, frequency, protective infrastructure, community economic resources and social capital.

The Royal Commission into Victoria's bushfires used the expression 'shared responsibility' to describe how the community should deal with, natural perils. It recommends state and local government improve protective, emergency management and advisory roles. In turn, communities, individuals, business and households need to take greater responsibility for their own safety and act on advice given to them before and during a bushfire.

The Productivity Commission Inquiry Report (2014) stated:

"There is some evidence that individuals may not have the capacity or willingness to properly assess, understand and treat natural disaster risks" (pg.29).

Better information will equip individuals with the knowledge to understand the options available. Improved awareness and understanding of the risk of natural perils will help individuals and businesses make more informed decisions.

It provides information to ensure their insurance coverage is appropriate too. This includes the natural perils they are insured for, and the amount they are insured for. Information on natural perils risks could also be used to develop household emergency plans.

This report can help individuals and businesses better understand the risks in their LGA. However, individuals must translate the information to their specific circumstances.

6.3 Implications for business

Natural perils can have wide ranging impacts on businesses by affecting stock, equipment, employees, customers and suppliers.

Small businesses, particularly, that suffer major loss due to a natural disaster, will be at greater risk of failure. It can take weeks or months to return a business to full operation after an event such as a fire or flood while expenses such as rent and wages need to keep being paid. An understanding of risk can encourage businesses to conduct a business impact analysis and develop a disaster recovery plan.

Many of the other implications for business are similar to those for households. That is, understanding the risks they face and assessing their insurance policies and emergency procedures.

The loss or delay of income, caused by a closure during a natural event or lower income from less customers is a particular issue for food service industries. There may also be increased expenses if a generator must be used if power is lost.

Warragamba Dam, New South Wales

Businesses must also consider if their workforce lives in high risk locations. What is the risk of a disaster preventing their employees reaching them? This can impact on customer satisfaction, particularly if the business is closed regularly due to employee absence.

There is also the issue of employee turnover. Events that impact the transport network may discourage workers from remaining with an employer. Businesses also need to understand the implications if their major suppliers or customers are in a high risk area.

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8 APPENDIX

8.1 Measuring natural peril risk

For this project SGS primarily used Insurance Council of Australia's Low-resolution Exposure Address Dataset, or iLEAD, for measures of natural peril risk.[20] Due to limitations in coverage of the iLEAD flood risk data, SGS used IAG's flood risk data.

iLEAD provides a simple exposure score at 13.5 million Australian addresses describing proxy exposures to various natural perils. It is important to note that risk bands are not comparable between natural perils. iLEAD is a dataset used by ICA for research and analysis on insurance affordability, mitigation priorities and natural peril data gap closure activities. It is not suitable for underwriting applications and may not reflect premiums charged by insurers.

The data sourced from iLEAD was in the form of anonymous addresses with a risk band and an LGA. SGS calculated averages for each risk for each LGA, filtering out addresses where the risk was unknown. As this method calculates an average risk for all recorded addresses in an LGA, there is some washing out of high risk areas within an LGA, especially for large LGAs.

The risk data is built on complex scientific models. The scientific terms may not equate to descriptions of events used in everyday language. For example, people may use the term flood to describe events which are technically different such as a riverine flood, storm surge or inundation. Further, the term tropical cyclone only covers a particular type of cyclonic event. Other cyclonic events can occur outside the tropics but are not captured here.

Tropical cyclone
The iLEAD Tropical Cyclone Average Return Interval attribute stratifies address level exposure according to the historical occurrence of cyclone events within 50km of the address, expressed as an Average Return Interval. Address level Average Return Interval data has been calculated through an intersect of the centroid of each Australian address with a 50km buffered polyline, with each polyline representing a cyclone track that has occurred in the last 100 years.

Storm
The iLEAD storm measure is based on historical storm data (at a postcode level) measuring vertically integrated water, combined with observational data to estimate the return interval of damaging hail.

Note, as this natural peril risk covers a particular type of meteorological storm event, other storm events are not captured.

Bushfire
The iLEAD Potential Bushfire Exposure attribute describes the exposure based upon distances from vegetation. It is not based on Bushfire Attack Level which requires a highly specific calculation based things including slope, orientation, and vegetation type.

Earthquake
The iLEAD Earthquake Damage Exposure attribute provides a proxy exposure to earthquake damage by referencing the spectral period zones referenced in the National Construction Code. The higher the spectral period for a zone, the higher the earthquake resilience required for designated buildings and infrastructure.

Flood
The IAG flood data risk ratings consider the average annual damage for each residential address in the LGA (including the 95% of addresses with no risk), averaged per LGA. These per-address assessments are based on approximately 590 collated sources of flood risk data including local and state government flood studies and historical flood extents, supplemented with bespoke flood hazard mapping prepared by hydrology consultants.

8.2 Measuring economic activity

The Australian Bureau of Statistics (ABS) Australian National Accounts: State Accounts (Cat. No. 5220.0) publication provides estimates of economic activity for each state and territory on an annual basis. Recent methodological advancements by the ABS have enabled SGS Economics and Planning (SGS) to develop estimates

[20] http://www.icadataglobe.com/ilead/

of economic activity for each major capital city, along with the regional balance of each state. These statistics provide improved insights into the relative economic performance of each of Australia's major capital cities (Sydney, Melbourne, Brisbane, Adelaide and Perth), the Northern Territory Tasmania and the Australian Capital Territory. For this project these estimates of GDP have been further disaggregated to LGA level.

8.3 SEIFA

Socio-Economic Indexes for Areas (SEIFA) is a product developed by the ABS that ranks areas in Australia according to relative socio-economic advantage and disadvantage, based on information from the Census. SEIFA 2011 is based on Census 2011 data, and consists of four indexes, each focussing on a different aspect of socio-economic advantage and disadvantage.

SGS used the Index of Economic Resources to indicate an area's access to economic resources. The Index of Economic Resources summarises variables relating to the financial aspects of relative socioeconomic advantage and disadvantage. These include high and low income, as well as variables that correlate to high or low wealth. Areas with higher scores have greater access to economic resources than areas with lower scores.

Areas with poor access to economic resources may have less capacity to respond following a natural disaster. Though, this measure doesn't account for the underlying resilience or social capital (community cooperation and networks) of a community; both important factors in a community's ability to deal with natural disasters.

8.4 Local Government Area

For this report SGS used LGA boundaries as defined by the ABS for the 2011 Census. These LGAs are an ABS approximation of official local government areas in 2011 as defined by each state and territory government.

Brisbane, Queensland, 2010

LGAs are not standardised in any way. Therefore, LGAs differ significantly in population, land use, and size. Care must be taken in comparing results between LGAs.

The LGA boundaries used for this report reflect those at the time of the 2011 Census, so local government boundaries today may differ now.

[21] More information on LGAs can be found at the ABS website http://www.abs.gov.au/ausstats/abs@.nsf/0/77214EF6765D0541CA2578D40012CF2E

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