



Australian Government

Australian
Climate
Service

Real Economy Technical Report

A technical report for the
National Climate Risk
Assessment

September 2025



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About the Australian Climate Service

The Australian Climate Service is a partnership between the Bureau of Meteorology, CSIRO, the Australian Bureau of Statistics and Geoscience Australia.



Executive summary

Australia's first National Climate Risk Assessment (the National Assessment), delivered by the Australian Climate Service, provides a foundational understanding of how climate change is reshaping the systems Australians rely on. It identifies and analyses risks across eight key functional systems, using a robust framework grounded in the Intergovernmental Panel on Climate Change (IPCC) approach. These systems represent interconnected domains—such as health, infrastructure, ecosystems, and the economy—where climate impacts can cascade and compound.

This technical report focuses on the Economy, Trade and Finance system, and specifically on one of the 11 nationally significant risks selected by the Australian Government for deeper analysis following the first pass of the National Assessment. That risk relates to the 'real economy' – the part of the economy concerned with the production and consumption of goods and services, rather than financial markets. The real economy is exposed to both acute and chronic climate impacts, including potential financial system shocks, and is deeply interconnected with other systems such as infrastructure, primary industries, and communities.

The approach used for this priority risk included a national literature review, supplemented by targeted analysis and interviews across key exposed industries. The work was guided by a policy and economy reference group.

It is not possible to quantify the full impact of climate change on the Australian economy. However, the literature, and modelling by The Treasury (Commonwealth of Australia, 2023), quantifies the impacts on some key drivers of economic growth, including capital assets, infrastructure and the built environment, household financial stability and demand, supply chains, health and access to labour and primary industries and productivity.

This assessment finds that most if not all of the drivers of the economy will be eroded by the changing climate. Impacts include:

- reduced business productivity through disruption to operations, supply chains, capital assets, premises, critical infrastructure and workforce availability
- increasing insurance affordability stress, which has implications for access to credit, asset prices, and broader financial resilience
- increased construction labour and materials costs due to physical climate impacts to assets, and potential impact to other discretionary spending or investment
- increasing pressures on the productivity of primary and outdoor industries and their communities from the changing climate and impacts in related sectors

The National Assessment identified strong interactions between risks to the economy, trade and finance system and impacts in other key systems such as primary industries and food, and defence and national security, creating the potential for cascading and compounding risk to the economy from chronic and acute climate events. The literature highlights that climate risk is a systemic risk—meaning it can affect entire systems rather than isolated sectors. As Stern (2023) notes, financial markets often struggle to assess such complex, interconnected risks. Because of this, climate risks may be underestimated or mispriced, leading to financial instability or crises when those risks materialise.

The scope of the National Assessment is limited to domestic risk, however this assessment notes that the Australian economy is affected not only by the domestic impact of climate change on its businesses, infrastructure and resources, but also indirectly through international trade with the rest of the world. Climate change impacts on our regional neighbours and trading partners are likely to have significant impacts on trade. This has not been assessed in this report but is noted as a gap.

As climate change continues to reshape our society, environment, and ecosystems, consideration of its widespread and interconnected impacts should be embedded into all future planning and decision-making processes to build resilience and adapt.

Key insights

1. The Australian economy is already experiencing the impacts of climate change through the direct and indirect effects of increasingly frequent extreme events, including tropical cyclones, floods, bushfires, droughts, and heat waves. The cost of disasters is projected to escalate and severe and extreme weather events have broad impacts, including disruptions to supply chains, reduced agricultural productivity, destruction of homes, damage to businesses, and increased insurance costs.
2. Outdoor-exposed industries, especially agriculture, tourism, mining, and construction, are particularly susceptible to physical climate risks due to their close connection to the land on which these activities occur, and their reliance on outdoor workers as extreme heat events are projected to increase.
3. Households are already experiencing the impacts of the changing climate through the cost of recovery after extreme events, impacts on supply chains, increased health costs, increased costs of goods and services impacted by severe weather and increased insurance costs. Cascading risks could also result in impacts to house prices and household wealth.
4. Impacts to finance, insurance and banking are exposed through multiple pathways including impacts on revenue, changes in sectoral economic activity and re-valuation impacts on some assets. There is potential for impacts to cascade through the economy, increasing the risk of climate-driven financial crises.
5. The changing climate is likely to have global and regional impacts that will be felt by Australia, but which have not been fully evaluated and are challenging to quantify. Impacts on supply chains and markets may be affected by changing climates or from regional instability driven by rising sea levels and increasingly frequent climate-driven disasters.
6. The overall impact on the Australian economy is difficult to quantify. Most economic modelling projects that the Australian real Gross Domestic Product (GDP) will continue to increase, with the 2023 Intergenerational Report projecting it will grow by 2.2% per year over the next 40 years (Commonwealth of Australia, 2023). Advice from the Economy and Policy Reference Group (for the National Climate Risk Assessment) was that forecasts of economic growth do not capture many likely impacts of the changing climate, such as the impacts of sea level rise, the loss of natural and cultural assets, the potential for cascading or compounding impacts, or the international transmission of impacts. Top-down analysis by Bilal and Kanzig (2024) (for example) shows that a 1°C rise in global temperature causes global GDP to decline by up to 12%.

7. Risks to the economy, trade and finance system interact strongly with other systems such as infrastructure, food, and national security. These interactions create the potential for cascading and compounding impacts from chronic and acute climate events.
8. Climate change may overwhelm existing governance structures, leading to maladaptive responses and reduced capacity to manage risk. There is a growing need to strengthen institutional resilience and decision-making processes to avoid social tipping points and maintain economic stability.
9. Climate-driven increases in insurance premiums are intensifying affordability stress for households and businesses, particularly in high-risk regions. Rising underinsurance and insurer withdrawal from some markets pose risks to financial stability, access to credit, and household wealth.

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Acknowledgements

The Australian Climate Service (ACS) is a partnership that brings together expertise from the Bureau of Meteorology, CSIRO, the Australian Bureau of Statistics (ABS) and Geoscience Australia to bring the Australian Government's extensive climate and natural hazard information into a single national view.

This report was developed by the Australian Climate Service, with collaboration and support from the Department of Climate change, Energy, the Environment and Water (DCCEEW).

The ACS gratefully acknowledges the contributions of:

- Judith Landsberg (ACS), Angela Maharaj (ACS/DCCEEW), Trent Lind (ACS/ABS), Alice Burgess (ACS) and Francine Machin (ACS) for contributing to this report
- Jan Drienko, Jiao Wang, Dominic Thorn, Evelyn Yong and Sharanjit Paddam from Finity Consulting for expert interviews, literature reviews and economic impact modelling
- Annette Hirsh, Tayanah O'Donnell and team from Deloitte for socio-economic scenario development, and economic and land-use projections
- The Economy and Policy Reference Group for their advice and technical review of the report: Freya Carlton (Treasury), Ivan Chan (Australian Prudential Regulation Authority), Mark Edwards (Geoscience Australia), Nigel Evans (Department of the Prime Minister and Cabinet), Stephen Howes (Australian National University), Toomas Mirlieb (Climate Change Authority), Johathon Khoo (ABS), Tom Kompas (University of Melbourne and National Climate Risk Assessment Expert Advisory Committee) and Mark Lawrence (University of Adelaide).

We also thank the stakeholders and community representatives who participated in consultations, workshops, and interviews. Their insights have been invaluable in shaping the findings and recommendations presented in this report.

1 Introduction

The Australian Climate Service (ACS) has delivered Australia's first National Climate Risk Assessment (the National Assessment). This assessment aims to help governments, industry, and communities prepare for, adapt to, and mitigate the risks associated with a more challenging climate.

Climate change poses a significant societal challenge with wide-reaching implications for all Australians. The frequency of climate hazards is increasing, and their severity, and the characteristics of extreme events are likely to change with accelerating consequences (Australian Climate Service, 2025b).

The escalating risks, impacts, and associated losses require preparation, proactive management, and strategic investment in adaptation and resilience. To safeguard our society, communities, and economy, we urgently need to understand and, where possible, mitigate these effects. The National Assessment recognises that long-term and enduring transition to a global low-carbon economy is required to lower the future risk of economic impacts from permanent and unadaptable levels of climate change.

The analysis from the National Assessment will inform national priorities for climate adaptation and resilience actions through the National Adaptation Plan, providing a framework for broader public and private assessments of climate risks.

1.1. Purpose and context

The National Assessment considers risks in systems. Each system can be described as a natural grouping of elements that interact closely and where decisions are strongly intertwined. These systems are a fundamental construct in the National Assessment conceptually representing a national view of systems Australians value that are threatened by climate change and encompassing various sectors, industries, domains, and elements at risk (Figure 1). Understanding the risks to and resilience of these systems in the changing climate will help keep them working sustainably.

Changes to any one aspect of Australia's climate will not exist in isolation. Rather, impacts in one area or system may cause cascading and compounding impacts in other areas and systems. A systemic view allows for analysis of how risks and impacts in one system contribute to or have the potential to mitigate risks in different systems. An integrated perspective provides a strong foundation for adaptation planning, supporting consideration of how adaptation can mitigate risk across systems, or conversely, where there is potential for action in one system to increase vulnerability or have an impact in another system.

Understanding how climate risks evolve over time is also important. Risks are not static; rather, they unfold in sequences, accumulate, and interact with both existing vulnerabilities and the outcomes of past decisions. The impacts of a single event may not be fully realised in the moment but can intensify over time. For example, investment in infrastructure that is not climate-adapted may not appear consequential until a series of extreme weather events exposes the vulnerabilities. Similarly, climate-informed decisions made today, such as land use changes or infrastructure development

that considers how the climate is changing, can reduce future risk and impacts by reducing exposure.



Figure 1: Australia's 8 key functional systems (Australian Climate Service, 2025e)

1.2. Climate risk framing

The National Assessment uses 3 time periods to assess the change in climate risk (Figure 2: Projected global warming levels used for each time horizon in the National Assessment (Australian Climate Service, 2025e)). These use 20-year ranges for the climate projections, centred on 2020, 2050 and 2090. The 2050 and 2090 time horizons are chosen for their relevance to various planning cycles and policy frameworks as well as their ability to provide actionable insights for both short-term and long-term decision-making. Socioeconomic and built environment risk assessments where possible use point in time projections for 2050 and 2090.

Climate projections based on global warming levels (GWL) describe the expected warming and impacts on land and oceans that Australia is likely to experience when the world reaches particular levels of global warming, compared to the pre-industrial era, and are in line with the latest IPCC [Sixth Assessment Report](#) (Table 2) and means that analysis is to some extent emissions pathway independent and is policy relevant. A higher GWL means a greater chance of extreme events.

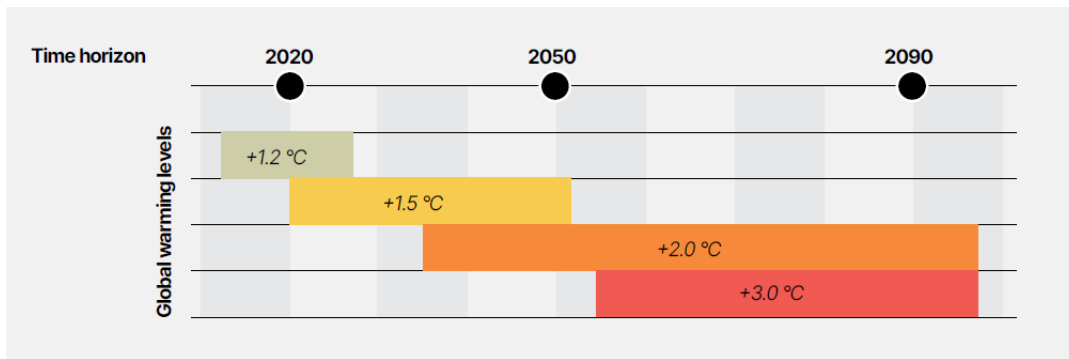


Figure 2: Projected global warming levels used for each time horizon in the National Assessment (Australian Climate Service, 2025e)

Time periods and corresponding global warming levels over the 20-years allow for natural variability in the climate and warming and are compared with the pre-industrial baseline (1850-1900). Modelled socio-economic changes (e.g., population) were based on the point in time at the centre of the time span, i.e., 2020, 2050, and 2090. Sea level rise projections use timeframes rather than global warming levels, as this process is slower and natural variability is small compared to the overall projected change.

GWLs represent globally averaged surface temperatures over both ocean and land and thus, the temperatures felt in Australia may be higher than the GWL. Therefore, using GWL1.5 does not mean that risks are being assessed when Australia reaches 1.5°C, but rather the expected warming that will be felt in Australia based on when global warming reaches 1.5°C.

2 The economy, trade and finance system

The economy, trade, and finance system in Australia is a complex network that governs how resources and capital are allocated for the production, distribution, and consumption of goods and services. It includes how work is conducted, and the institutional arrangements that guide economic activities and trade networks at all levels. The system also includes interconnected financial markets, import and export markets, the labour market, and the production, distribution and consumption of goods and services. A healthy economy depends on critical infrastructure, including transportation, utilities, and communication networks. Supply chains ensure the efficient flow of raw materials, goods, and services from producers to consumers. Government finances and capacities provide foundational support for public services and infrastructure, directly influencing economic conditions. Individual and household budgets play a key role in driving demand within the economy, affecting production and service delivery.

Trade supports economic growth by facilitating the efficient exchange of goods and services with other countries. Australia's trade relationships are essential for maintaining and deepening existing markets and gaining access to new markets and resources, as well as for domestic production and employment. International trade arrangements and treaties provide a framework that facilitates the efficient flow of raw materials and finished products across borders and investor confidence to finance those flows. Governance and decision-making institutions provide the regulatory framework that facilitates transparency and stability in trade agreements, maintaining investor confidence.

The impact of climate change on international trade and supply routes is noted but not quantified in this report as it was outside the scope of the National Assessment. Australia's trading partners and Pacific neighbours are likely to experience significant social and economic impacts as the climate changes, and therefore it should be noted that the international transmission of risk could significantly alter the magnitude of risk assessed in this report.

Finance includes the interconnected investment (equity), credit (debt) and insurance markets, domestic financial institutions, and international financial systems. Domestic financial institutions, including banks, credit unions, insurers, and investment funds, and markets, including stock and capital markets, enable the efficient allocation of capital, including liquidity which facilitates economic growth.

The health of the economy is heavily interconnected with other National Assessment systems (Australian Climate Service, 2025d) (Figure 3) and multiple drivers of the economy are being eroded as the climate changes. Physical impacts are likely to reduce the productivity of agriculture, cause damage to cities and communities, disrupt production and supply chains leading to higher prices for goods and services with increased cost-of-living pressures on households across the country (Steffen et al., 2019). These impacts and risks are likely to interact and compound across the economy, trade and finance system in ways that are hard to predict and not well understood.

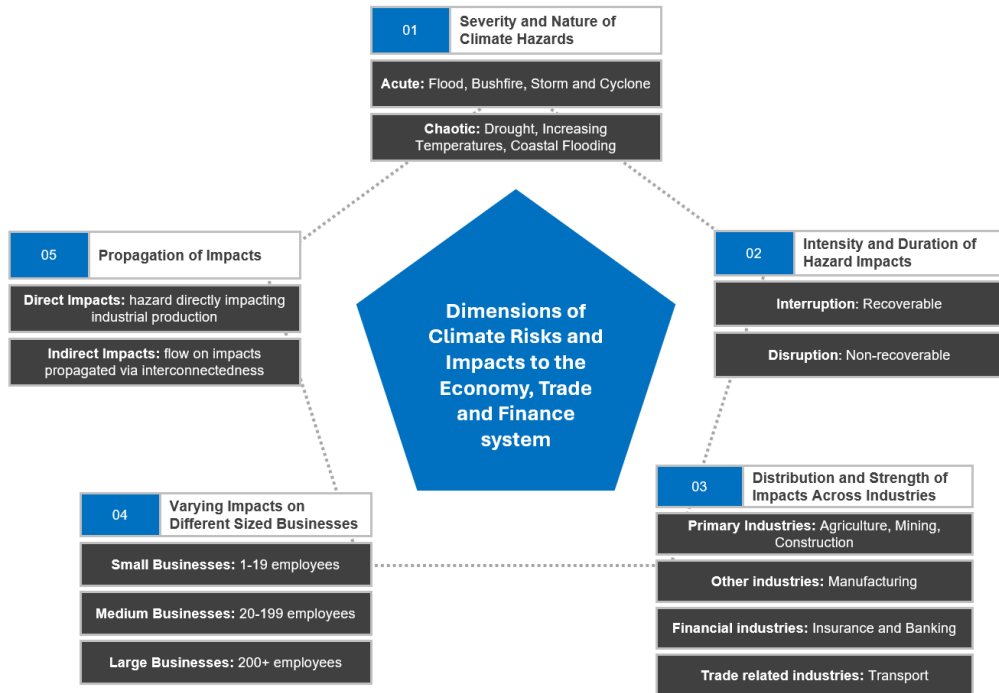


Figure 3: Climate risk mapping framework for the economy, trade and finance system. Source: Finity, 2024

3 National Assessment methodology

The assessment of risks to the economy, trade, and finance system is based on literature reviews¹, some quantitative analysis, and qualitative analyses conducted through expert elicitation and stakeholder consultations. This work included:

- development of socio-economic scenarios
- development of land use change projections (Appendix B)
- projections of Government spending on disaster relief (analysis conducted by Treasury).

The work of the National Assessment also provided an understanding of the interconnections between systems and how impacts in other systems may increase risk to the economy, trade and finance system.

This report presents a national synthesis of climate risk assessments and related outputs developed by consultancies, academic institutions, and research organisations. It is neither an exhaustive list nor are the different analyses necessarily consistent as it draws on work that used multiple different approaches and datasets, including climate projections. While not exhaustive or methodologically uniform, the synthesis offers a comprehensive overview of risk impacts for the economy, trade and finance system and provides an early signal of emerging national climate risks.

The analysis was guided by an expert reference group comprising representatives from The Treasury, the Climate Change Authority, Australian Prudential Regulation Authority, the National Assessment Expert Advisory Committee and Melbourne University. Each of the representatives were consulted in their relevant area of expertise.

3.1 Nationally significant and priority risks

The first pass of the National Assessment (DCCEEW, 2024), released in March 2024, provided a consolidated understanding of Australia's nationally significant risks. The full National Assessment identified 63 nationally significant climate risks including risks to Aboriginal and Torres Strait Islander people with 5 risks directly relevant to the economy, trade and finance system (Table 1).

¹ The literature scan from the First Pass of the National Climate Risk Assessment is reported in full in CSIRO's National Climate Risk Assessment Stage 1 Rapid Literature Scan (Lin, Barnett, Toze, et al., 2024).

Table 1: Nationally significant risks from the changing climate to the economy, trade and finance system (DCCEEW, 2024).

Topic	Risk statement	Risk description
Governments' finances and capacities	Risks to governments' finances and capacities that decrease revenue, increase expenditure and increase demands for government involvement	<p>Climate-related impacts affect government revenues, investments, and expenditures, with consequences for the capacity to govern.</p> <p>Decreased revenue may result from decreased taxes and levies, such as from lower property values in flood-affected areas. Increased construction and repair costs for public property and infrastructure due to extreme events may result in increased government expenditure. Increases in healthcare costs from climate-related impacts may increase costs and pose delivery challenges. The costs of emergency response and recovery during and after natural disasters may increase.</p> <p>Increased expenditure on climate-related recovery may reduce the ability of government to invest in sustainable economic development. This may limit our ability to fund climate adaptation and to transition to a less carbon-intensive economy to mitigate future climate change.</p> <p>Rapidly changing economic, social and environmental systems, including increased demand for government assistance and involvement may increase pressure on governments and governance systems to similarly adapt and respond to support disaster management rapidly, increasing the risks of maladaptation.</p>
Australian economy	Risks to the Australian economy from international climate-related impacts that result in changing biosecurity risks, decreased tourism and agricultural exports and macroeconomic shocks, affecting Australia's international trade and competitiveness	<p>International climate-related risks and opportunities, similar to those identified for Australia, may affect international trade, trading partners and the international trade system, affecting Australia's relative competitiveness in international markets, the ability to import and export goods and services, trade balances, and withstand macroeconomic shocks of international origins.</p> <p>This also includes risks to Australia from the management of climate change risks internationally, such as trade implications of climate-driven biosecurity risks, decreased tourism due to hazards, risks to agricultural exports, due to domestic and global climate change impacts, and changes or disruptions to the global trade system and supply chains.</p> <p>Australia may benefit from new export opportunities as a result from climate change and shift in energy systems, particularly in renewable energy and critical minerals.</p>

Topic	Risk statement	Risk description
Individual and household budgets	Risks to individual and household budgets (such as incomes, savings, and expenditure) that exacerbate inequality and social or economic disruption and reduce the adaptive capacity of individuals and households	<p>Domestic and international climate-related impacts may result in an increase in the cost of living with flow-on impacts to economic equality and opportunities that exacerbate inequality and social or economic disruption and disadvantage. This includes risks that increase household costs, such as increased insurance costs, and risks that affect the distribution of costs and benefits across the economy and the population, with differential impacts across geographic regions and socio-economic demographics (e.g., climate-driven impacts on access to health services that exacerbate existing inequalities).</p> <p>Increases in construction and repair costs of private property after natural disasters may impact household wealth and finances. Population displacement due to natural disasters or climate-related impacts may disrupt industries and employment markets. The adaptive capacity of individuals and households may decrease as a result of climate-related impacts on wealth, incomes and purchasing power, such as decreased property values in hazard affected regions, increased insurance costs and inflated prices of goods and services from shocks to production.</p>
Financial system	Risks to the financial system from climate-driven impacts on financial institutions and markets that adversely affect public and private finances and decrease economic resilience	<p>Climate-related impacts pose risks to the financial system such as from, increased loan losses for banks and other lenders, and asset price write-downs for investors including superannuation funds. Macroeconomic shocks may be felt in Australia and internationally from hazards such as bushfires, flooding, or sea level rise. This includes risks from difficult to quantify climate change and economic impacts, shocks, and tipping points that are challenging to plan for adequately.</p> <p>Financial instability adversely affects the flow of funds between savers and investors, with potential consequences such as asset price shocks and reduced confidence in the financial system and economy. Financial system responses to climate change, including increased insurance premiums or reduced insurance availability, can have adverse impacts on households and businesses.</p>

Topic	Risk statement	Risk description
Production and consumption of goods and services	Risks to the production and consumption of goods and services in climate-exposed sectors of the economy that affect workplace productivity, essential services and ecosystem services	<p>Climate-related impacts on the relationship between people and the environment affect basic economic activity, including the production and consumption of private and public goods. Climate change can also adversely affect services provided by public goods, such as tourism, recreation, community, and social events. Access to workplaces could also be affected by climate-related impacts, such as high temperatures or natural disasters.</p> <p>National and regional economies can also be affected by climate-driven impacts on industries that rely on the provision of ecosystem services from the environment, such as agriculture and tourism.</p> <p>The supply of climate-exposed essential services, such as water, energy, telecommunication, and transport may be physically affected by the impacts of climate change or by price fluctuations, supply constraints and disruptions with subsequent flow-on impacts to all other economic activities that rely on these services as basic inputs.</p> <p>Climate-related impacts that increase costs and reduce investments may affect our ability to transition to a decarbonised economy at the national and regional levels.</p>

As part of the first pass of the National Assessment the following priority risk within the economy, trade and finance system was selected by the Australian Government for further analysis and is the focus of this report:

Risks to the real economy from acute and chronic climate change impacts, including from climate-related financial system shocks or volatility

This is described as:

The real economy is the part of a country's economy that produces and uses goods and services, rather than the part that consists of financial services such as banks and stock markets (Figure 4). This priority risk is assessed and evaluated around the plausible worst-case scenario depicted in the risk statement and focuses on the observed and anticipated impacts and consequences to the real economy from direct or indirect economic impacts for at-risk communities.

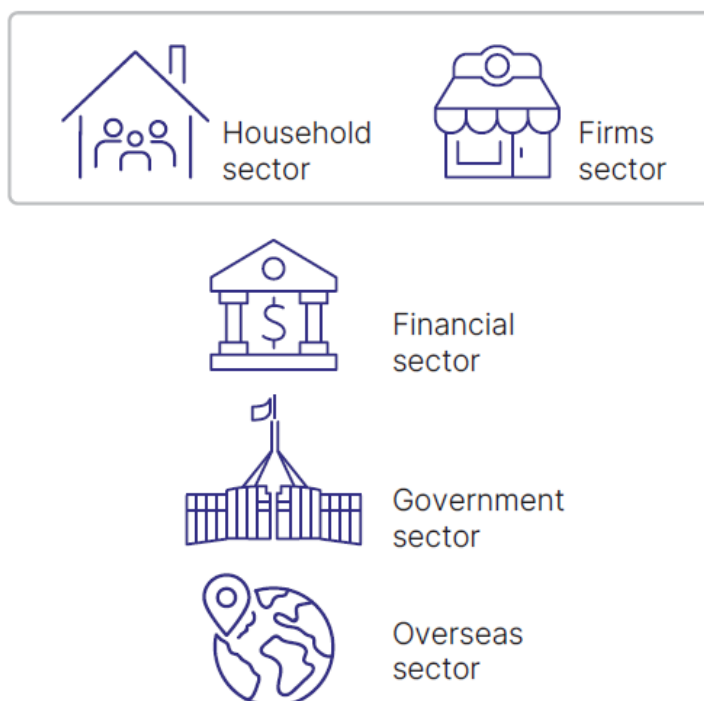


Figure 4: Reserve Bank of Australia view of the economy, with the 'real economy' outlined in grey box (Australian Climate Service, 2025e).

Many parts of the real economy are exposed to physical climate risks, both directly due to exposure to extreme weather (e.g. agriculture, outdoor labour, mining) and indirectly due to cascading impacts that flow through the economy or society (e.g. impacts on property prices, energy availability or supply chain disruptions) (Lawrence et al., 2022).

4 Understanding climate risk

The National Assessment uses the IPCC definition of climate risk (Figure 5), where risk is driven by the interaction of climate **hazards** with **exposed** and **vulnerable** elements. When considering how risk changes over time, it is also important to consider how the **response** to the risk is changing, as actions in one system can increase or mitigate risk in other systems.

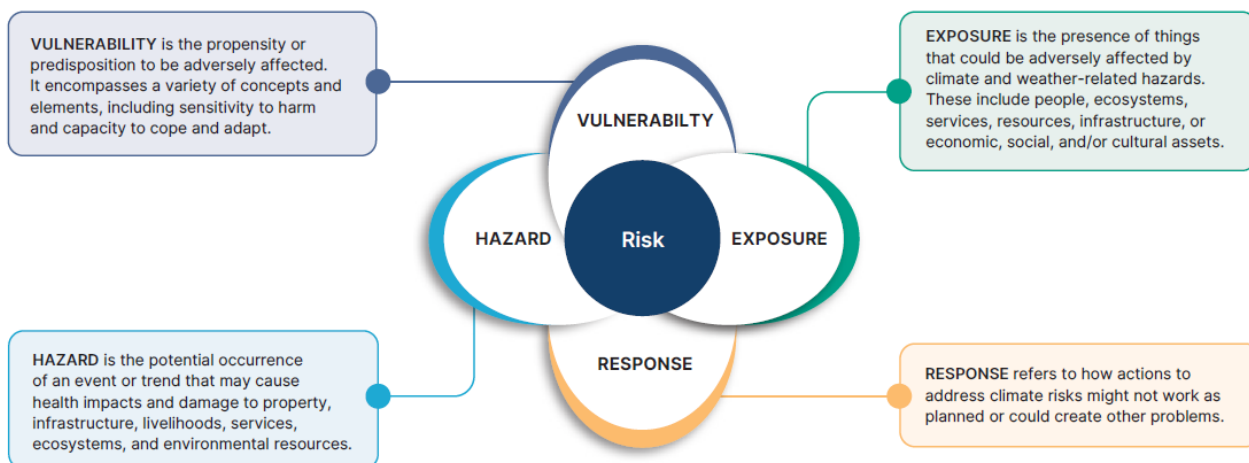


Figure 5: Determinants of climate risk adapted from the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2022a) and Simpson et al. (2021)

Understanding climate risk in the economy, trade and finance system requires a structured approach to assessing how hazards interact with exposure, vulnerability, and response. This chapter draws on the IPCC risk framework and is organised into four key components:

- **Hazards** – the changing nature of Australia’s climate and the priority hazards identified for this system.
- **Exposure** – the elements of the economy that are physically or systemically exposed to climate hazards.
- **Vulnerability** – the characteristics that make certain industries, regions or communities more susceptible to harm.
- **Response** – the actions taken to reduce or manage risk, including adaptation measures and governance considerations.

4.1 Changes to Australia's climate and hazards

Australia’s climate is changing, with significant impacts on communities, infrastructure and ecosystems. Bushfires, floods, heatwaves, tropical cyclones, storms and other hazards are changing in frequency, severity and complexity, posing challenges to how we live, work and interact with our environment.

The National Assessment uses 4 different time horizons to assess the change in risk. It considers the current climate and 3 different global warming scenarios that are likely to be reached by the mid-

term (2050) and long-term (2090) horizons, according to the latest international climate science. To account for natural variability in the climate, average climate projections were used across 20-year timeframes.

Some of the evidence cited in the report uses alternative climate change scenarios, for example, Shared Socioeconomic Pathways (SSPs) or Representative Concentration Pathways (RCPs). Best estimates for global warming for SSPs and RCPs are provided by the IPCC (Table 2).

Table 2: Changes in global surface temperature for 20-year time periods and five scenarios. 'SSP' describes the socio-economic trends underlying the scenario and final number refers to the Representative Concentration Pathway (RCP). Source: (IPCC, 2021)

Scenario	Near-term, 2021-2040		Mid-term, 2041-2060		Long term, 2081-2100	
	Best estimate °C	Very likely range (°C)	Best estimate °C	Very likely range (°C)	Best estimate °C	Very likely range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

Australia’s Future Climate and Hazards Report (ACS, 2025) provides the foundational climate science underpinning this risk analysis. It outlines projected changes to key climate variables—temperature, rainfall, and sea level rise—and identifies the characteristics of the ten priority hazards of the National Assessment. These hazards are expected to change in frequency, intensity and spatial distribution over time, with many occurring in combination or affecting new locations (Figure 6).

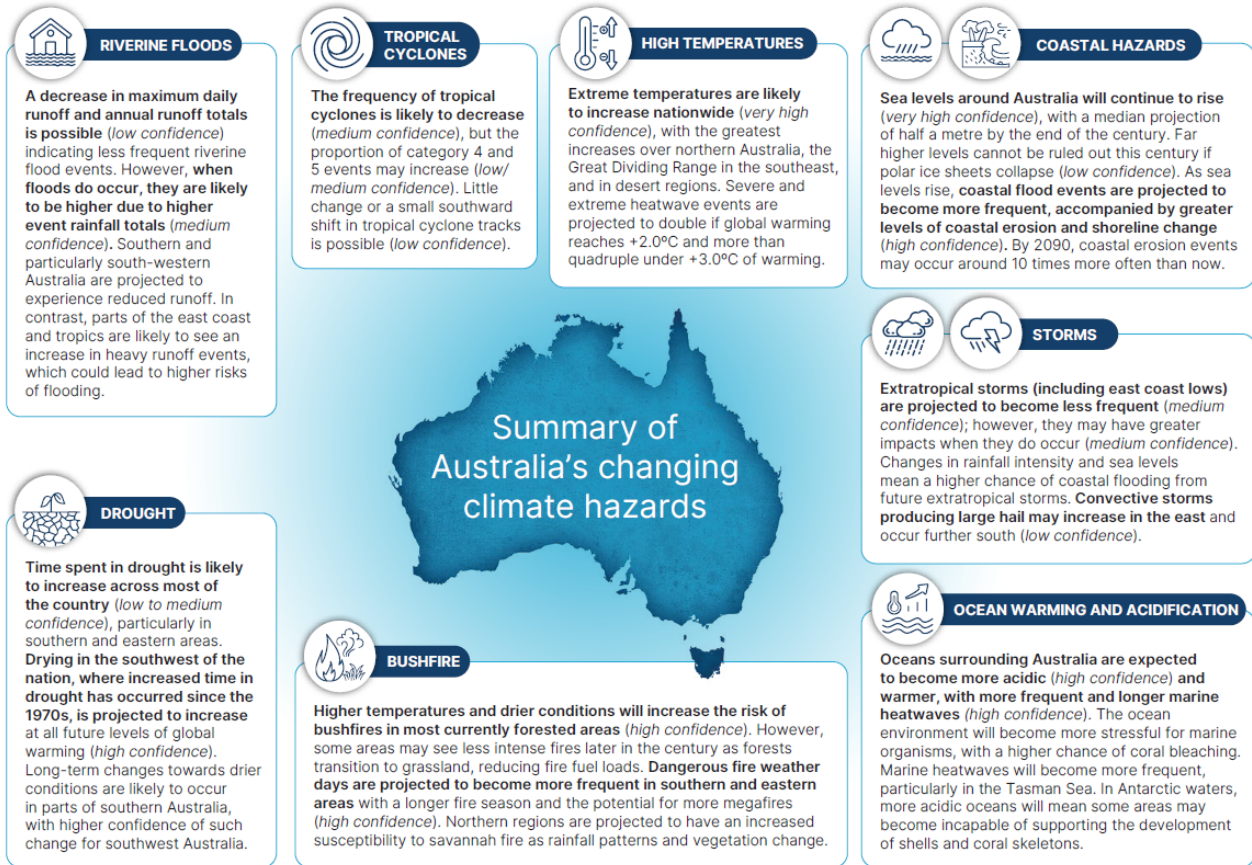


Figure 6: Changes to the priority hazards identified as part of the National Assessment. Source: (Australian Climate Service, 2025c)

The priority hazards that affect the economy, trade and finance system were determined in the first pass of the National Assessment (Table 3).

Table 3: Degree of risk to the system by hazard (white = low; yellow = medium; red = high)

Hazard	Risk 2050	Risk 2090	Examples of historical impacts
Bushfires, grassfires and air pollution	Red	Red	<p>The most devastating bushfire event recorded in Australian history was the 2019-2020 Black Summer bushfires. New South Wales (NSW) losses included over 2.5 million hectares of conservation land, 750,000 hectares of forests and plantations and 559,000 hectares of farmland.</p> <p>Major consequences of the bushfires resulted in a loss of 29,600 jobs, loss of \$10.2bn in real GDP and \$6.1bn in lost household consumption (Wittwer & Waschik, 2021).</p> <p>International tourist bookings were reduced by 10-20% during the Black Summer bushfires, estimated to cost the industry \$4.5b by the end of the year (Carruthers, 2020). Reiner et al. (2024) estimated that 7,300 jobs in tourism were lost due to the Black Summer Bushfires</p>
Tropical cyclones	Red	Red	<p>In 2017, Severe Tropical Cyclone Debbie crossed the Queensland coast causing widespread destruction, with isolated rainfalls of 400mm and wind gusts of up to 265km per hour. Impacts included more than \$800 million in damage to essential public infrastructure as well as some \$450 million damage to the agriculture industry and more than \$150 million in losses to the tourism industry (Queensland Government, 2017).</p>
Changes in temperatures including extremes	Yellow	Red	<p>Heatwaves are responsible for more deaths than any other type of natural disaster in Australia. During heatwaves, there are generally more hospital admissions for mental health issues, workplace accidents or injuries and power outages. Deloitte (2017) estimates that heatwaves in Australia have caused 509 deaths between 1987 and 2016 and affected over 4.5 million people.</p> <p>AEMO (2020) report higher incidence of power outages during heatwaves. Xiang et al. (2014) identified a 6.2% increase in worker compensation claims in Adelaide during heatwaves.</p> <p>If global temperatures were to increase by up to 3°C or over 4°C, Australia's total labour productivity levels could decrease by 0.2 to 0.8 per cent by 2063. This is a significant economic cost, reducing economic output over this period by between \$135 billion and \$423 billion in today's dollars (Commonwealth of Australia, 2023).</p>
Coastal and estuarine flooding and shoreline change	Yellow	Red	<p>Yu et al. (2020) and Williams et al. (2020) highlight increases in demand for emergency services during flooding with conditions that make it much more difficult for fire, police and ambulance services to be available at the appropriate time</p> <p>ACC (2020) reported 25% of 2019 Townsville flood impacted households did not have home insurance.</p> <p>Steffen et al. (2019) estimates 27,000-35,000km of roads and rail worth \$51-67 billion are exposed to coastal risk, while 120 ports, 5 power stations, 258 police, fire and ambulance stations, 75 hospitals and 44 water and waste facilities all at risk within 200m of the coast and are at risk from rising seas</p>

Hazard	Risk 2050	Risk 2090	Examples of historical impacts
Drought and changes in aridity			<p>The Millennium Drought in Southeast Australia was associated with increased psychological health problems (Nicholls et al., 2006) has been linked to a 15% increase in male suicides (Steffen et al., 2019).</p> <p>King et al. (2017) identified severely reduced crop yields during the Millennium Drought. During the Millennium Drought in southeast Australia, agriculture's contribution to Australia's GDP fell 16%(van Dijk et al., 2013). In the worst hit regions, its estimated 6000 jobs were lost between 2006-2009.</p> <p>Between 2002 and 2010, severe droughts were estimated to have led to an 18% reduction in agricultural total factor productivity (Sheng & Xu, 2019). Already, severe droughts such as the 2002-03 and 1994-95 droughts, have reduced Australia's gross domestic product by about 1% (Productivity Commission, 2005)</p> <p>Drought costs the northern Australian agricultural industry approximately 19% of output per year, which may fall as low as 10% and rise as high as 40% depending on drought-affected properties (Tran et al., 2016).</p>
Riverine and flash flooding			<p>The Australian Institute for Disaster Resilience (n.d.) reports that following the 2010-11 Queensland floods, an estimated 28,000 homes were in need of rebuilding, approximately 3,572 businesses were inundated and the mining, agriculture and tourism sectors experienced an estimated \$4 billion in losses. Nineteen thousand kilometres of road were damaged, and 3 ports significantly affected. Over 28% of the Queensland rail network was left displaced. The Insurance Council of Australia estimates the 2011 damage at \$2.38 billion.</p>
Compound severe events			<p>Disruptions in business activity from severe events include the disruptions caused by road closures, typically result in significant losses to businesses and lost days of production or service provision (Queensland Department of Agriculture and Fisheries, 2023).</p> <p>The Colvin Review (2024) reports \$9.2 billion in Disaster Recovery Funding Arrangements (DRFA) payments over the period 2018-19 to 2022-23 (Colvin, 2024).</p> <p>Gao (2024) identified that extreme weather events can trigger political-economic risk through lost incomes, welfare, profits, and lead to climate migration and conflict.</p>

4.2 Exposure

Exposure refers to the elements of the economy, society and infrastructure that are situated in harm's way and therefore susceptible to climate hazards. In the economy, trade and finance system, exposure is shaped by the location, nature and interconnectedness of assets, industries, people and institutions. This section outlines the major exposure themes that influence climate risk in this system:

- Critical industries such as agriculture, mining, construction and tourism that are physically exposed to climate hazards.
- Businesses and supply chains that rely on climate-sensitive inputs or infrastructure vulnerable to disruption.
- Coastal housing stock and infrastructure at risk from sea level rise, flooding and erosion.
- Finance and markets exposed to asset devaluation, volatility and cascading economic impacts.
- Government resources that are increasingly drawn into recovery and reconstruction efforts.
- International trade and finance systems exposed to global climate shocks and supply chain disruptions.
- Outdoor workers who face direct health and safety risks from extreme heat and weather.
- People and households exposed to rising costs, reduced access to insurance and financial stress.

Many important drivers of the economy are directly or indirectly exposed to climate risk. Business premises can be directly exposed to natural hazards, this applies to both acute events, such as floods, but also the chronic exposure to changing climate conditions, such as rising temperatures, for enterprises which are largely conducted outdoors such as construction, mining, tourism or agriculture (Figure 7).

Other economic drivers that are exposed to climate hazards include road and rail networks that are essential for supply chains to transport goods and facilitate productivity. When a major supply chain route is blocked, the movement of goods may be prevented, or the costs of moving goods increase. For businesses, this can mean increased costs to move products in or out of communities, and for people, this can mean higher prices for essential goods and services.

Value of Agricultural Commodities Produced (LGA)

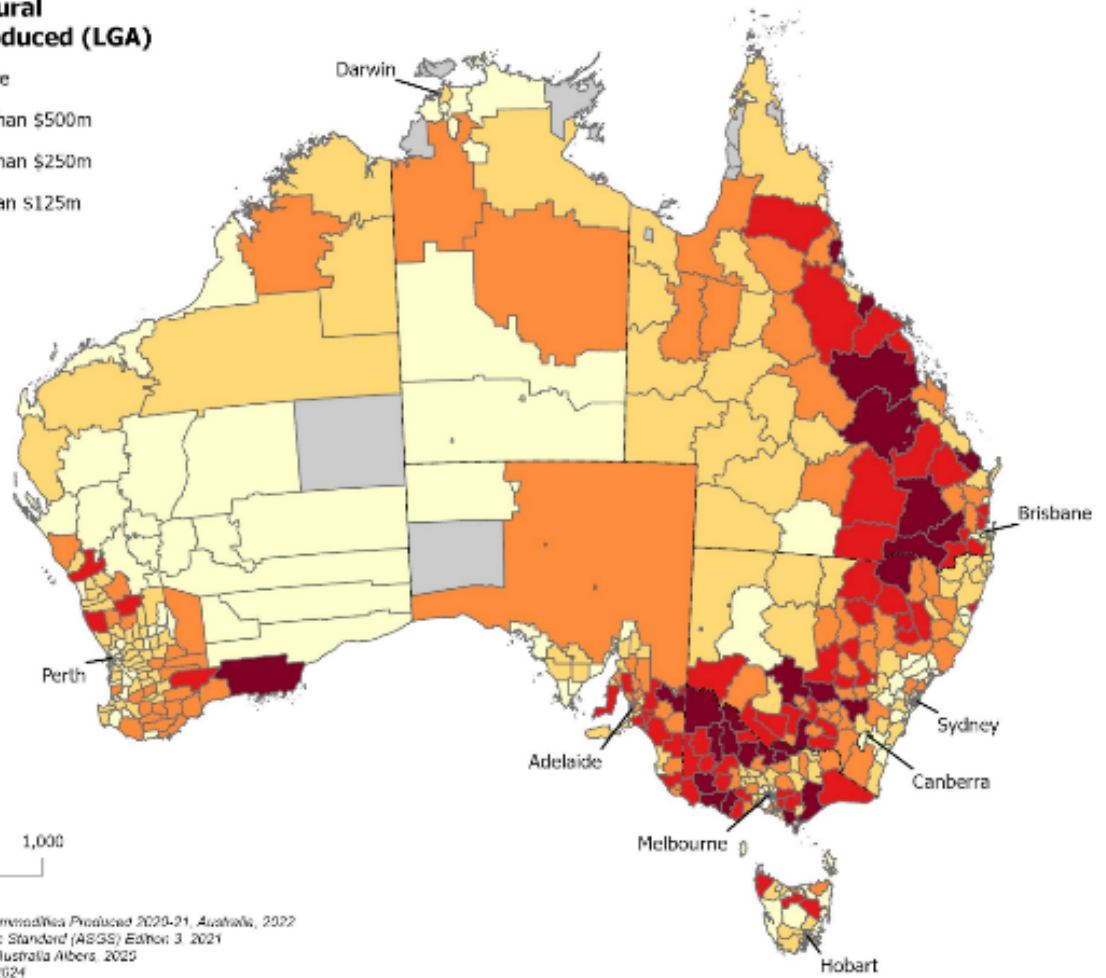


Figure 7: Australian Bureau of Statistics (2022) 'Value of agricultural commodities produced 2020-21, Australia'. Accessed 2025

Coastal locations are exposed to sea level rise and therefore to increasing coastal hazards such as flooding, damage from tropical cyclones and erosion. Most businesses are located in Australia's coastal capital cities and along the east coast, as well as in populous regional cities such as Toowoomba, Tamworth, and Mildura (Figure 8).

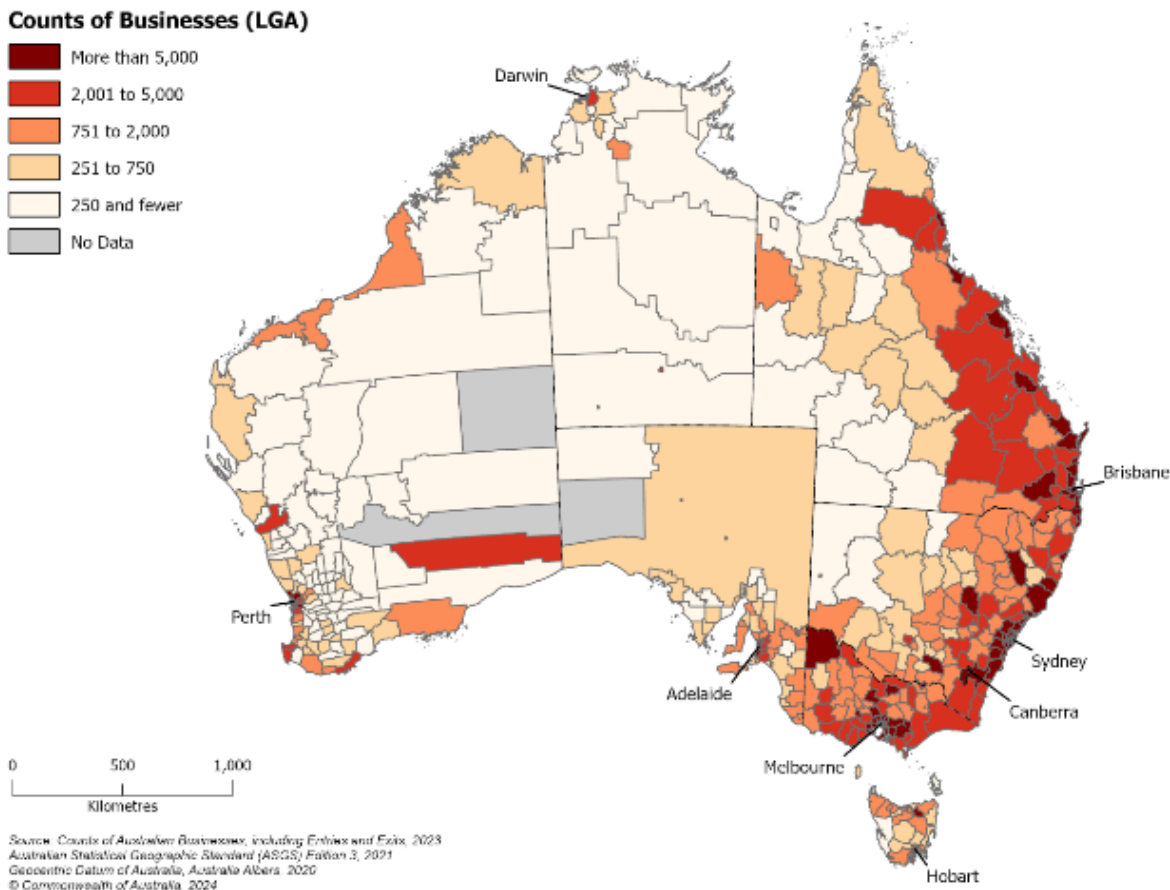


Figure 8: Australia On Bureau of Statistics (2022) 'Counts of Australian Businesses'. Accessed 2025

Indirect impacts may be experienced by the finance sector through multiple pathways, including increased cost of operations, increased risk as assets used as collateral may be re-valued in high risk areas and impacts on revenue as businesses' ability to repay loans are impacted (Kearns, 2022).

Finally, the wealth and income of households, as well as the financial well-being of communities, can be exposed to flow-on effects from impacts on businesses and the finance and insurance sectors, as well as acute impacts on supply chains and services.

Deloitte developed three scenarios for the National Assessment (Figure 9) for use in identifying exposure to and impacts from climate change. These describe distinct but plausible futures for Australia that consider varying socioeconomic contexts and the potential role of climate damages under different levels of global warming (see Breakout Box 1 and Appendix A). These scenarios are based upon the Shared Socioeconomic Pathways (SSPs) that underpin the IPCC Sixth Assessment Report (IPCC, 2022a). By combining these with hazard projections into different scenarios, analysts involved in the National Assessment explored a range of possible outcomes and identified the scale of risks under various conditions.

BREAKOUT BOX 1: Future socioeconomic scenarios

Analysis by Deloitte commissioned by the Australian Climate Service as part of the National Assessment provided scenarios for future population and economic exposure (see Appendix A). This analysis included national and regional forecasts for metrics such as population, real economic output, dwelling completions, household disposable income and gross value-added by industry.

Over the longer-term, the analysis identified that the pace of economic growth is expected to gradually slow across all scenarios due to demographic ageing and the associated decline in the labour force participation rate. Three scenarios were developed:

- The **moderate shift scenario** assumes low population and productivity growth, depicting a future trajectory that aligns with a moderate global greenhouse gas emissions scenario (SSP2-4.5). In this scenario, the global mean temperature is projected to rise by more than 2°C above pre-industrial levels by 2100.
- The **balanced outlook scenario** assumes moderate population and productivity growth, depicting a future trajectory that aligns with a relatively low global greenhouse gas emissions scenario (SSP1-2.6). In this scenario, the rise in global mean temperature relative to the pre-industrial period is limited to less than 2°C by 2100.
- The **accelerated momentum scenario** assumes high population and productivity growth, depicting a future trajectory that aligns with a moderate global greenhouse gas emissions scenario (SSP2-4.5). In this scenario, the global mean temperature is projected to rise by more than 2°C above pre-industrial levels by 2100.

Moderate shift	Balanced outlook	Accelerated momentum
Over the periods to 2050 and 2090, average annual growth is projected to be 1.5% and 1.2%, respectively.	Over the periods to 2050 and 2090, average annual growth is projected to be 2.1% and 1.9%, respectively.	Over the periods to 2050 and 2090, average annual growth is projected to be 2.6% and 2.5%, respectively.
Income is projected to grow more than 1.5 times by 2050, and more than 2.6 times by 2090, relative to 2023.	Income is projected to grow more than 1.8 times by 2050, and more than 4.4 times by 2090, relative to 2023.	Income is projected to grow more than 2.1 times by 2050, and more than 6.6 times by 2090, relative to 2023.
By 2050, the population is projected to be 34.5 million and to grow to 43 million by 2090.	By 2050, the population is projected to be 36.7 million and to grow to 50.6 million by 2090.	By 2050, the population is projected to be 39.2 million and grow to 58.8 million by 2090.
Urban areas expand by 24% by 2050 and by 39.8% by 2090.	Urban areas expand by 17.1% by 2050 and by 21.7% by 2090.	Urban areas expand by 39.8% between 2030 and 2090.
By 2090, agricultural activity covers more land, with 1.1% growth in cropping activities by 2050 and 12% growth by 2090. Grazing activities see only minimal changes.	By 2050, cropping activity expands by 7.1%, which slows to 4.6% expansion by 2090; both managed rangeland grazing activities decrease marginally.	By 2090, agricultural activity covers more land, with 1.1% growth in cropping activities by 2050 and 12% growth by 2090. Grazing activities see only minimal changes.
Deforestation of 0.9% by 2050 and 2.6% by 2090 occurs outside of protected areas.	Deforestation of 1.6% by 2050 and 2.4% by 2090 occurs outside of protected areas.	Deforestation of 0.9% by 2050 and 2.6% by 2090 occurs outside of protected areas.

Figure 9: Three plausible future socioeconomic and land-use scenarios tailored to the Australian context.

The scenarios illustrate how land use (including the built environment) and socioeconomic conditions are expected to continue changing through to 2090. Each scenario presents a distinct but plausible future for Australia, offering valuable insights for long-term planning. (Source: Deloitte for the National Assessment).

4.3 Vulnerability

Vulnerability refers to the characteristics of systems, communities and assets that influence their susceptibility to harm from climate hazards. In the economy, trade and finance system, vulnerability is shaped by financial resilience, infrastructure condition, institutional capacity and social equity. Understanding vulnerability is critical to identifying where targeted responses can reduce risk. Key factors that contribute to vulnerability and amplify climate risk in this system include:

- Ageing or unadapted infrastructure that is not designed for future climate conditions.
- High household debt that limits financial flexibility and recovery capacity.
- Volatile and interconnected financial markets that can transmit shocks rapidly across sectors.
- Land-use planning that has not adequately accounted for climate risks or future hazard exposure.
- Unaffordable or inaccessible insurance, increasing financial vulnerability for households and businesses.
- Reliance on climate-sensitive industries, such as agriculture and tourism, which are exposed to multiple hazards.
- Resource-limited communities with constrained capacity to prepare for, respond to or recover from climate impacts.
- Dependence on global markets, which may be disrupted by climate-related shocks and cascading risks.

Some industries are more vulnerable to climate hazards than others. Mining, construction, agriculture, power generation, transmission, and certain service occupations such as emergency response are vulnerable to reduced labour productivity as a result of higher temperatures (Commonwealth of Australia, 2023). Agricultural industry is particularly vulnerable to the impacts of drought due to its reliance on natural resources (Department of Agriculture Fisheries and Forestry, 2023). Fisheries are vulnerable to changes in population and distribution of key species as a response to marine warming (Darbyshire et al., 2025). Local Government Areas with a large proportion of agricultural output are, therefore, potentially more economically vulnerable when a drought or other hazards such as bushfires or floods occur.

The vulnerability of businesses is also driven by reliance on supply chains. A lack of redundancy in the supply chain network can drive risk where a single hazardous event can have significant economic impacts if it disrupts a key route. This occurred in 2022-2023 summer when a flood destroyed a bridge and damaged roads on the Great Northern Highway in Western Australia, this cut off a key freight route, increasing the costs of transportation of essential goods into rural communities and exports out from local businesses (O'Connor, Sinclair, & Mitsopoulos, 2023).

Businesses may also be vulnerable based on their size with medium, small, and micro enterprises often more vulnerable to climate impacts because they cannot absorb significant losses as well as larger businesses. It therefore follows that employees of medium, small, and micro businesses may

also be more economically vulnerable to climate hazards. Local Government Areas where micro-businesses (businesses which typically have fewer than 6 employees) comprise more than 95% of all businesses include Wandering (Western Australia), Central Darling (NSW) and Flinders (Tasmania).

Lack of economic diversity can contribute to a region's economic vulnerability (see Breakout Box 2). A more diverse region is less reliant on single parts of the economy and, therefore, has a greater likelihood of withstanding market shocks (United Nations Framework Convention on Climate Change (UNFCCC), 2016).

BREAKOUT BOX 2: Industry of Employment Diversity Index (beta)

The ACS has developed the Industry of Employment Diversity Index (beta) ($IEDI_{\beta}$) to measure one aspect of economic vulnerability. $IEDI_{\beta}$ provides a nationally consistent measure of the diversity of sources of employment in a Local Government Area (LGA). Reliance on a few industries is likely to make an LGA more vulnerable, as the impacts of climate change and natural hazards on these industries will affect the LGA's economy more significantly than those of LGAs with a more diversified industry base, which may be better equipped to absorb these shocks. Scores for $IEDI_{\beta}$ compare each LGA to the national composition of industries, with higher scores indicating that the mix of industries is more similar to the national level and, therefore, more economically diverse.

The $IEDI_{\beta}$ shows that (Figure 10):

- The east coast of Australia and capital city regions have relatively high employment diversity.
- Inland rural and remote regions have relatively low employment diversity.
- In regions with low employment diversity, the most common industries of employment are mining, agriculture, forestry and fishing.

The $IEDI_{\beta}$ is a beta index, and the concepts, methodology and indicators will continue to be further refined and developed. This will be guided by ongoing consultation and feedback from stakeholders and subject matter experts.

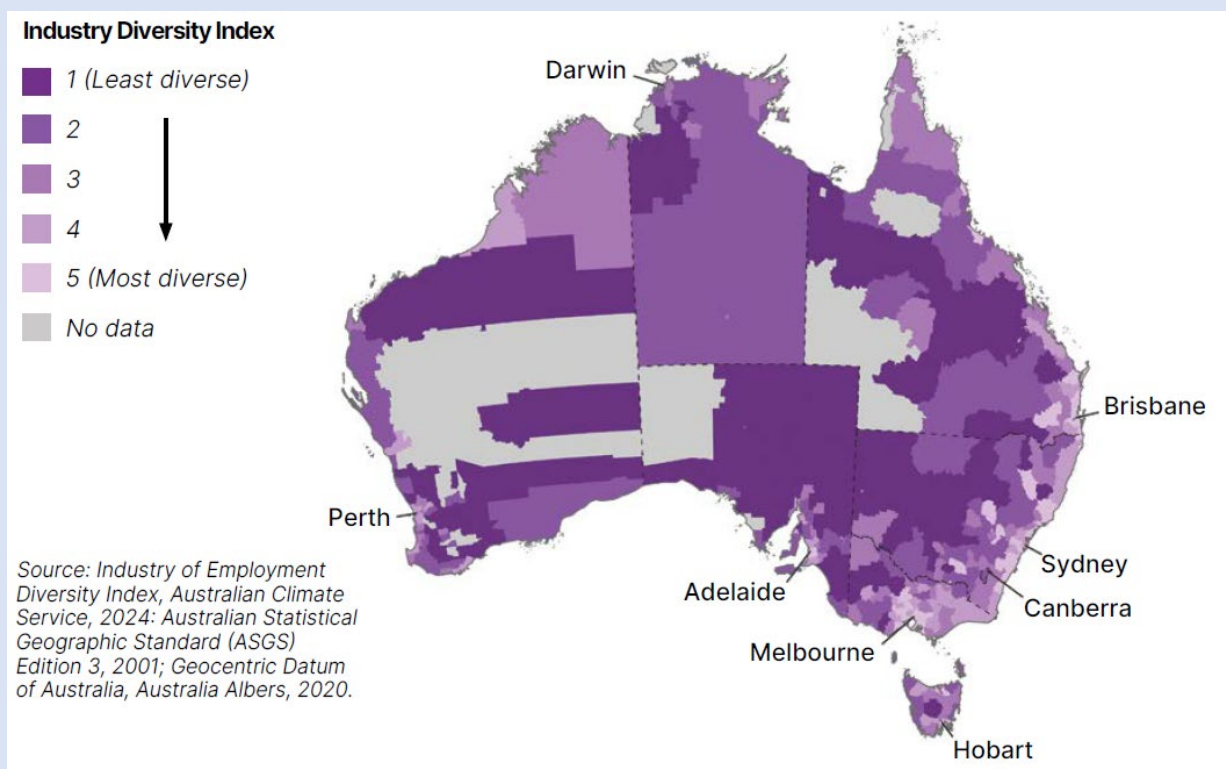


Figure 10: Industry of Employment Diversity $IEDI_{\beta}$.

The index uses 2021 Census employment data, using the information of residents living in each LGA and the industries in which they work. The colour indicates how vulnerable a community is expected to be – dark purple represents LGAs with least employment diversity, while pale purple represents the greatest diversity. Some LGAs were excluded from the analysis for having too small a population or too few employed persons – these areas are greyed out.

4.4 Response

Response in the economic domain refers to actions taken to reduce or share risk. Response actions could include:

- climate risk mapping of hazard location and severity, and public climate risk disclosure
- financial response options such as reinsurance pools, insurance subsidies, insurance tax cuts, change to regulatory capital requirements, price controls and a public insurer of last resort
- planning changes such as land use rezoning, change to building standards, structural improvements subsidies and land buybacks or large-scale managed retreat
- infrastructure changes such as flood levies, fire breaks, dams, sponge cities, hardening infrastructure and natural defences.

However, over time, these responses could be maladaptive, for example, if subsidies for recover grants encourage households and businesses to remain in locations with high hazard exposure this will compound climate risk over time.

Unplanned responses can also increase or decrease exposure. Australians are tending to move to live in coastal areas, which increases exposure to coastal hazards (DITRDCA, 2022). Climate-sensitive rezoning of land use could result in fewer buildings in high-risk areas and, therefore, lower exposure to climate related risks over time. Climate-sensitive building codes may also reduce vulnerability and, thus, economic risk.

Successful response in the economic domain will need to be supported by governance structures and processes that help to identify and validate complex climate change risks, generate innovative adaptation options that consider risk interactions, anticipate and avoid response risks, accelerate positive adaptation action, and track and adjust to outcomes (Rickards et al., 2025). The National Adaptation Plan will set a framework for mainstreaming adaptation action and driving private sector investment.

5 The economic impacts of climate change

This chapter examines the systemic and cascading impacts of climate change on Australia's real economy, drawing on evidence from literature, scenario-based projections, and expert insights. It is structured to provide a clear understanding of the drivers of risk, the pathways through which impacts occur, and the implications for households, businesses, and financial systems. Specifically, it covers:

- Climate risk framing and context – how hazards, exposure, vulnerability, and response interact to shape economic risk.
- Climate-sensitive industries – including agriculture, mining, construction, and tourism, and their susceptibility to chronic and acute hazards.
- Impacts on the built environment and critical infrastructure – with a focus on housing, supply chains, and energy systems.
- Direct impacts from severe and extreme hazards – particularly considering short term costs responding to disaster events.
- Direct and indirect financial impacts – including pressures on banking, insurance, and markets, and the potential for cascading financial crises.
- Implications for households and communities – including affordability, inequality, and risks to Aboriginal and Torres Strait Islander peoples.
- Implications of ecosystem changes for the economy – pressures to the underpinning environment and the roles it plays in primary industries, communities, ecosystem services and flow on risks.
- Governance and adaptation responses – highlighting current measures, gaps, and opportunities to reduce vulnerability and build resilience.

5.1 Climate risk framing and context

Contributors to the World Economic Forum's (2025) Global Risks Report 2025 identified environmental or climate-change related risks as the top four global risks in the next 10 years (Figure 11).

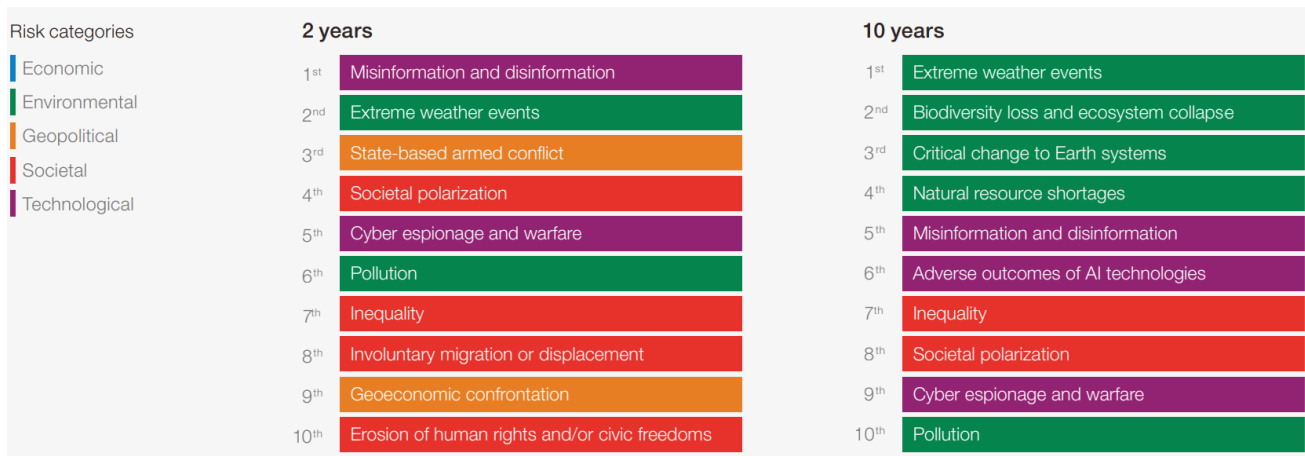


Figure 11: Global risks ranked by severity over the short and long term. Source: World Economic Forum Global Risks Perception Survey 2024-2025

Climate change threatens many drivers of economic growth. Examples of impacts include: reduced labour productivity from extreme heat, especially for outdoor work, and the recovery demands from the increasing frequency of extreme weather events; the destruction or disruption of physical capital; erosion of natural resources from impacts on primary industries; and challenges to trade and investment as climate impacts are felt by our regional neighbours and trading partners. Climate change impacts on the economy will also be felt through second and third order impacts (Figure 12).

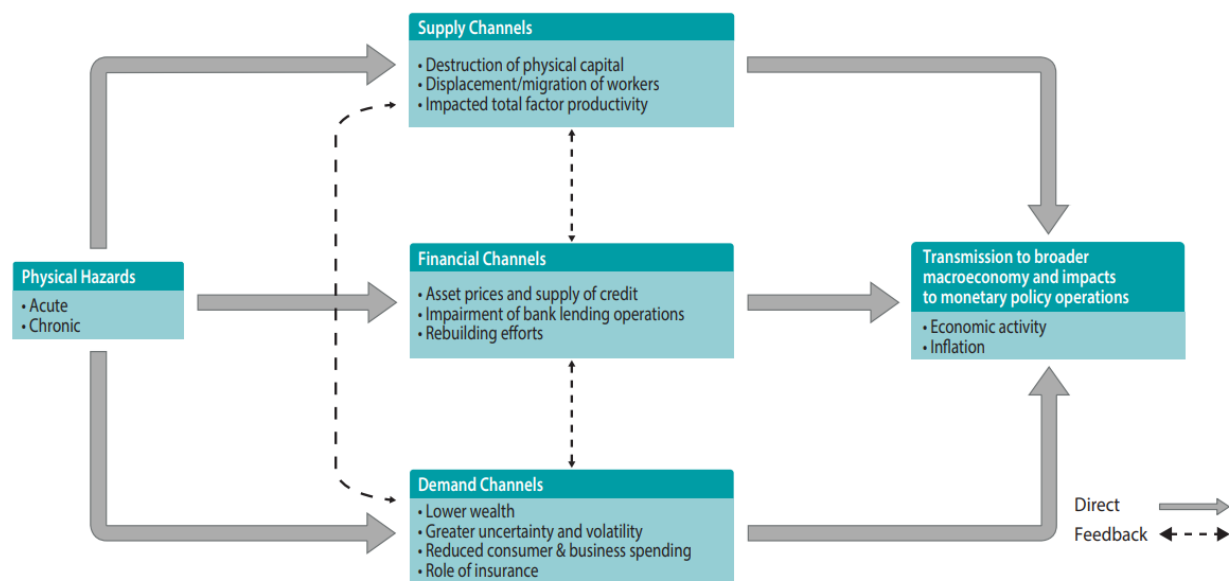


Figure 12: Flow chart of potential channels or mechanisms for risk to the economy. Source: (Network for Greening the Financial System (NGFS), 2024)

The overall impact of climate change on the Australian economy is difficult to quantify. Economic modelling of climate risks and impacts is generally conservative, considering known relationships and changes in average conditions.

Modelling using Computable General Equilibrium (CGE) or other 'whole of economy' models relies on a quantifiable understanding of the relationships between parts of the economy and external drivers, including climate drivers. Kompas et al. (2018) estimate long-run Australian GDP losses

from heat stress impacts on agricultural and labour productivity at 1.08% per annum under the 3°C global warming scenario and up to 1.6% in the 4°C scenarios. However, it should be noted that damage functions used in this model do not include other climate related impacts such as from sea level rise, loss of biodiversity, bushfires and floods.

Fernando, Liu, and McKibbin (2024) studied the magnitude of change in risk premia due to physical climate risk. According to the study, physical climate risks are projected to cause significant losses under two climate scenarios. Depending on regions, real GDP losses range from 0.3% to 2% per year by 2050 under SSP 1-2.6 and from 1.3% to 9% under SSP 2-4.5. This equates to global cumulative real GDP losses, relative to the baseline scenario of no effects of future GDP performance, (in 2018 \$US) from 2021 to 2050 that range from \$35.77 trillion under SSP 1-2.6 to \$93.93 trillion under SSP 2-4.5.

Recent studies utilising damage functions found that a 1°C increase in global mean temperature could reduce global GDP by 12%, and if global mean temperatures reach +3°C GWL this would result in "precipitous declines in output, capital and consumption that exceed 50% by 2100" (Bilal & Kanzig, 2024).

Economic modelling generally considers changes to the median. The most common scenarios used SSP 1-2.6 which delivers a best estimate of global warming of 1.7°C (1.3 to 2.2) by 2050 and 1.8°C (1.3 to 2.4) by 2090 while for SSP 2-4.5 global warming best estimates are 2.0°C by 2050 (1.5 to 2.5) and 2.7°C (2.1 to 3.5) by 2090 (IPCC, 2021). There is a body of research that emphasises the need for economic analysis to consider the deep uncertainty associated with climate change to better understand the potential macroeconomic consequences (Weitzman, 2012; Weitzman, 2014; Weitzman & Wagner, 2015). There are several ways in which the impacts from climate change could be much higher than generally considered. First, scenarios of high global emissions remain plausible, even if they are unlikely. Second, the global warming response to emissions is often described by the median or likely (>66% chance) confidence interval of achieving a certain temperature outcome, meaning that risks from 'tails' (e.g. <5% or >95% confidence interval) may be left unexplored. Third, the climate response to a given warming level could be at the high end of the plausible range in terms of change to extreme events (including unprecedented or record-shattering 'Grey and Black Swan' events), and the potential for triggering abrupt, non-linear geo-physical changes (climate tipping points).

Failing to account for 'tail risk', where the probability of extreme climate outcomes is small but non-negligible, and the potential damages are enormous, may be leading to systematic under-estimation of the possible economic impacts of the changing climate (Barro, 2013).

While the full dynamic response of the Australian economy to national and global climate change impacts is not fully understood, even for low-to-moderate-scenario future changes, many of the mechanisms for impacts can be identified. These include decreased economic productivity in the short term, increased mortality, increased heat stress and the potential for climate shocks to reduce not only short-term consumption but also future expected consumption growth (Bansal, Ochoa, & Kiku, 2016).

Some impacts on the economy, trade and finance can originate from less expected sources, for example the impacts of disease and pests, as the Australian environment is very susceptible to biosecurity risks. Increasing temperatures and wet weather create conditions conducive to the easier spread of pests and diseases across industries, along supply chains as well as across seasons and regions that would traditionally be more separated.

The primary mechanisms for economic impacts from climate change are discussed below.

5.2 Climate sensitive industries

Businesses with a workforce that operates primarily outdoors are highly exposed to risks from the changing climate, both from chronic changes and acute events.

Increases in heat, particularly across northern Australia, are projected with high confidence as the climate changes (Australian Climate Service, 2025b). This is likely to affect sectors with high proportions of outdoor workers, including agriculture, construction, manufacturing, and mining (NSW Treasury, 2021). NSW Treasury (2021) calculated that by 2061 between 700,000 (GWL +3.0°C) and 2.7 million (>GWL +3.0°C) additional days of work are projected to be lost each year in agriculture, construction, manufacturing and mining due to the higher frequency and intensity of heatwaves. A study for the city of Perth projects that by 2070, manual labour will be hazardous to perform 15–26 days per year, compared with 1 day per year at present for acclimatised individuals (Zhang et al., 2018).

The flow-on effects of this could be significant for labour-based work and are likely to affect the broader economy. Unpleasant working conditions outdoors and extreme climate events could push workers into other industries, creating labour shortages. Impediments to workforce stability and productivity may impact regional employment markets (Australian Climate Service, 2025e). For example, 6,000 jobs were lost at the height of the Millennium Drought (van Dijk et al., 2013), and it's estimated that over 7,000 jobs were lost due to the Black Summer bushfires (Reiner et al., 2024). Attracting new workers to areas affected by extreme weather and climate change, or those where natural disasters have occurred, will become increasingly difficult. These industries are characterised by a large number of relatively small family-owned businesses, they often operate on thin profit margins and lack the resources to implement significant changes in their operations. Reduced productivity and reduced employment opportunities in communities dependent on these industries may threaten the economic viability of regional and remote communities.

The 2023 Intergenerational Report shows that, in the absence of adaptation measures, increased heat stress could reduce labour productivity by 0.2-0.8% by 2063 (global warming levels up to 3°C). This would reduce economic output by \$135-423 billion in today's dollars over the 40 years to 2063. Limiting warming to 2°C could avoid \$155 billion cumulative losses to GDP over the 40 years to 2063 by reducing this impact, relative to the 3°C scenario (Commonwealth of Australia, 2023).

5.2.1 Primary industry – agriculture

Primary industry production is dependent on a suitable workforce, a reasonably stable environment and appropriate markets. Climate change is expected to directly affect agricultural production through changes in rainfall patterns, runoff and temperatures (NSW Treasury, 2021; Rickards, 2012). Chronic changes, such as rising temperatures and altered precipitation patterns, can affect the suitability of crop types and growing seasons and impact livestock health (Lieferring, Newton, Vibart, & Li, 2016; Arnell & Freeman, 2021). In addition, extreme weather events such as droughts or storms can severely reduce crop yields (e.g. King et al. (2017)).

Changes in climate since 2000 (relative to 1950-1999 climate) have reduced annual broadacre farm profits by 22%, around \$18,600 per farm (Hughes et al., 2019). This represents an average annual loss in revenue (gross value of production) for the cropping industry of \$1.1 billion, based on production levels from 2015-16 to 2017-18 (Hughes, Lu, Soh, & Lawson, 2022). Drought costs the

northern Australian agricultural industry approximately 19% of output per year, although the range of impacts may be as low as 10% and rise as high as 40% depending on drought-affected properties (Tran et al., 2016). By 2061, lost production in agriculture due to pastoral and growing conditions is estimated to be between \$750 million and \$1.5 billion (in real 2019-20 dollars), depending on the climate scenario (Hughes, Lu, Soh, & Lawson, 2022).

Examples of modelled losses for specific crops or regions include:

- The Intergenerational Report (2023) estimated that crop yields could be about 1% lower by 2063 in a scenario where global temperature increases are limited to 3°C by 2100, and up to 4% lower in an exceeding 4°C temperature increase world.
- An increase in growing season temperature of 1°C is expected to result in a 9% decrease in the average price of grapes (Puga et al., 2022).
- By 2050, extreme events related to climate change are projected to halve the agricultural output of the irrigated areas of the Murray–Darling Basin. The Basin covers much of New South Wales (NSW) and currently accounts for 50% of Australia’s irrigated agrarian production by value (NSW Government, 2025b)
- Australian wheat yields are projected to decline by up to 30% in southwest Australia and 15% in southern Australia by 2050 (Lawrence et al., 2022).
- According to the OECD (2015), crop yield declines in Australia and New Zealand range from 30% or more for oilseeds, 10-15% for fruits, vegetables, and other grains, and 10% for plant fibres under an RCP8.5-like scenario.
- The average number of heat stress days for livestock is projected to increase by 12-15 days by 2025 and by 31-42 days per year by 2050, compared to the period from 1970 to 2000. However, some have noted that impacts may be more severe in other parts of the world, making Australia’s produce more competitive (OECD, 2015).
- The risk of heat stress in cattle increases from southern to northern Australia and is greater for European beef and dairy breeds. All regions will experience a greater number of days classified as heat stress conditions for European beef breed and dairy cattle, with 1.4 to 5.4 million km² of Australia experiencing this heat stress load for at least 150 days per year (Darbyshire et al., 2025).
- Droughts are projected to become more severe across Australia as a whole due to climate change and increased rainfall variability. By 2061, it is projected that climate change impacts on pastoral and agricultural conditions could lead to annual average production losses of between \$750 million and \$1.5 billion (NSW Government, 2025b).
- Hughes et al. (2019) found negative impacts on broadacre farming across all states and territories (except the Northern Territory) due to drought. As an example, in the cropping sector, profits were reduced, on average, by 35% for a typical cropping farm under severe drought conditions.

Steffen et al. (2019) calculated the direct and indirect impacts that climate change is likely to have on regional production, transportation, food retailing, food prices, and economic as well as social outcomes. According to the analysis, the impacts of heat on agricultural and labour productivity would amount to \$19 billion per year by 2030 and \$211 billion by 2050, with a cumulative loss in wealth projected to reach \$4.2 trillion by 2100. These estimates do not account for losses from extreme events such as riverine flooding, bushfires, storms, or tropical cyclones.

Climate risks to the agriculture sector can reduce the viability of rural communities and negatively affect social structures (Figure 13). Rural communities often have older populations and lower incomes, and where this is the case will have lower adaptive capacity and are likely to be disproportionately affected by climate impacts (Lawrence, et al., 2022).

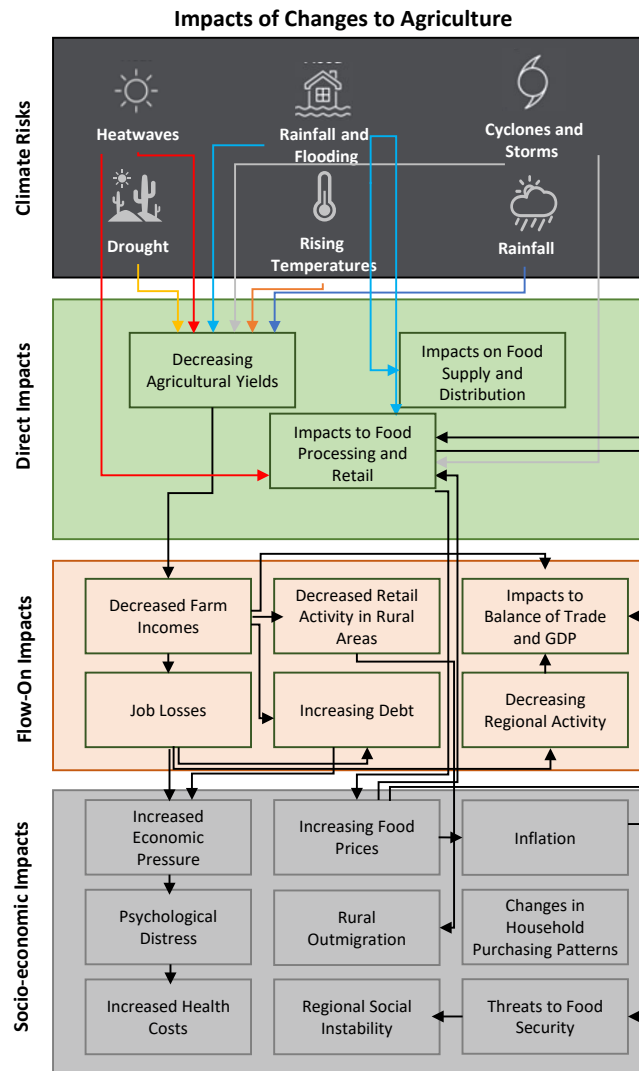


Figure 13: Map of potential impacts of climate risks on Agricultural activity and impacts on socioeconomic outcomes. Source: Finity, 2024

BREAKOUT BOX 3: Global impacts of water and heat stress on food security

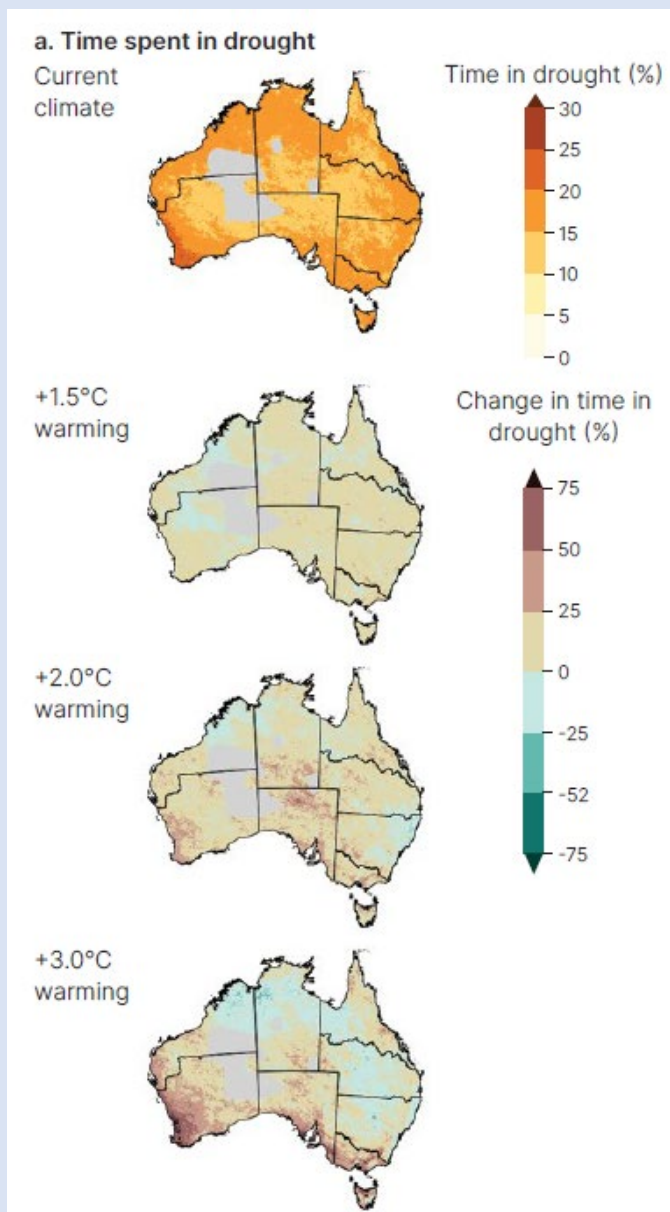


Figure 14: Time spent in drought for the current climate (+1.2°C above the preindustrial average) and the change at each future global warming level (+1.5°C, +2.0°C and +3.0°C) compared with the current climate. (Australian Climate Service, 2025b)

Agriculture accounts for 70% of total water withdrawals and supplies 40% of the global calories consumed by humans. Kompas, Che, and Grafton (2024) employed a large-scale computational global climate and trade model to project the impacts of water and heat stress on global food supply and food security through to 2050. The study employed three climate scenarios: SSP2-4.5, SSP2-8.5, and SSP3-8.5, and defined projected population increases. Global food production is estimated to decline by 6%, 10%, and 14% by 2050 under the three climate scenarios. The number of people with severe food insecurity is projected to increase by 556 million, 935 million, and 1.36 billion by 2050 compared to the baseline. The African continent is identified as the most threatened due to the projected increases in Africa’s population by 2050, followed by the Middle East, South Asia, and Central America. Future climate changes exacerbate adverse impacts on agricultural productivity and yields, and the uncertainty of future water availability intensifies water stress in many regions, including China, India, Pakistan, and the United States.

In Australia, the average time spent in drought is projected to increase under all future warming scenarios, with areas of southern Australia (Victoria, South Australia, Tasmania and southern Western Australia) likely to experience the highest increases (Figure 14).

Even though the economy produces more than enough food to sustain domestic consumption, the interconnection with global markets means that increases in international demand or reductions in supply are likely to result in price increases, which likely to be reflected in higher domestic prices.

Industry interviews – agriculture

Methodology for the interviews is documented in Appendix C.

Agricultural firms are active risk-takers, operating in more uncertain environments than most businesses in other industries; adapting to climate and weather changes is an integral part of daily agricultural operations. Agri-businesses are accustomed to variable outcomes from year to year, depending on seasonal harvest outcomes. However, the perception of interviewees is that the physical risks from climate change is exacerbating existing business risks (Figure 15).

1. Significant variations in rainfall
2. Water irrigation issues
3. Subsidies, drought preparedness and disaster recovery assistance
4. Technological change to increase efficiencies in adapting to climate changes
5. Co-dependence on regional communities and land management practices
6. Dynamic changes to land use
7. Pressures on input costs
8. Lead time to rebuilding herds and crop productions
9. Increasing variability of available exports
10. Commodity price variations impacting food prices

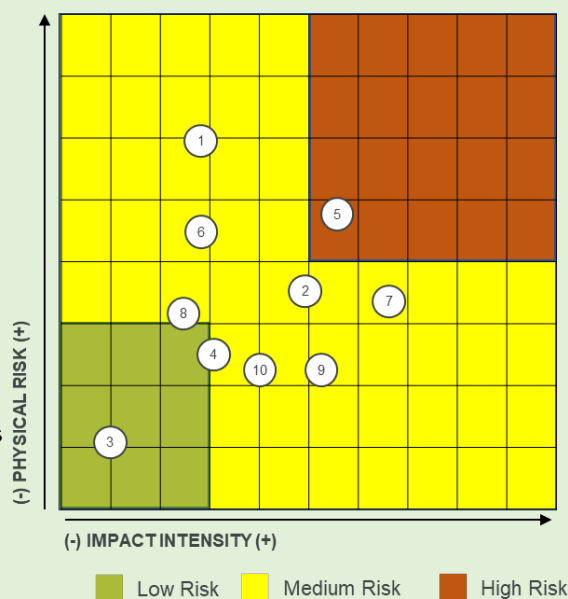


Figure 15: Agriculture industry relative risk map. Source: Finity, 2024

5.2.2 Primary industry – mining

Mining can be affected by droughts and other weather events. For example, a bauxite mine in Weipa, Queensland was disrupted by weather impacts in 2016, resulting in a 7% decrease in production compared to the previous year. Similarly, the 2010-2011 extreme weather resulted in 85% of Queensland's coal mines having restricted production or having to close entirely. Some mines needed months to recover (Australian Government, 2012).

Recently, Gao (2024) explored the economic impacts of physical risks and noted that physical risks cause losses in microeconomic output, including disruptions to supply chains and impacts on labour productivity. This research notes that these impacts, along with rising temperatures and other weather events, could create challenging conditions for mining worldwide, including exacerbating water scarcity. The paper found that for every degree of warming, mining productivity declines by 3%, but prolonged dry periods can lead to increased output.

Most mining companies are large and well-diversified businesses, supported by long-term contracts for their delivery. Larger mining companies diversify their climate risk by operating multiple mines for the same commodity in different locations. They also have sufficient scale of funding to compensate customers or purchase commodities from others to complete their delivery commitments.

Exploration is essential to for the ongoing health of the industry, and extreme weather risks are slowing down this effort. This work is usually carried out by junior mining businesses, these companies frequently take on very high levels of risk in their operations, often without access to flexible financing products to help deal with disruptions or additional capital requirements. If severe or extreme climate events threaten exploration plans or chronic changes threaten the ability to benefit from discovered deposits, future production schedules may be impacted, which in turn could increase the climate-related financial risks for large mining firms in the longer term.

Australia is one of the world's largest exporters of natural gas in the form of liquefied natural gas (LNG). Temperature increases impact liquification efficiency and increase off-gassing rates during transport, which in turn reduces the effective production of exported LNG.

International commodity prices can vary significantly over time, especially when disrupted by climate hazard impacts, influencing the revenue projections and values of mining operations. The values of projects can fluctuate significantly. These values influence the profitability of projects, with climate hazards adding additional risks in an already risky business. Increasing uncertainties in supply chains due to the potential for disruption from climate events affect both commodity exports and imports of critical goods and equipment.

Demand from manufacturing industries for critical rare earth minerals is expected to increase in the near future. The mining industry is well-positioned to capitalise on this demand.

Industry interviews – mining

The methodology for the interviews is documented in Appendix C.

Mining assets are particularly susceptible to climate hazards. Mining activity is vulnerable to disruptions due to floods, storms, and cyclones in the northern part of Australia. In addition, the supply of commodities is also susceptible to disruptions in transportation and at export terminals. Interviews with mining companies identified multiple routes for climate change to have introduced risk to mining productivity (Figure 16).

1. Production of mining commodities by large miners
2. Exploration for commodities by smaller miners
3. Future increases in domestic criticality of natural gas
4. Increased importance of critical mineral exports
5. Increasing export market uncertainty
6. Increasing supply chain risks of critical equipment

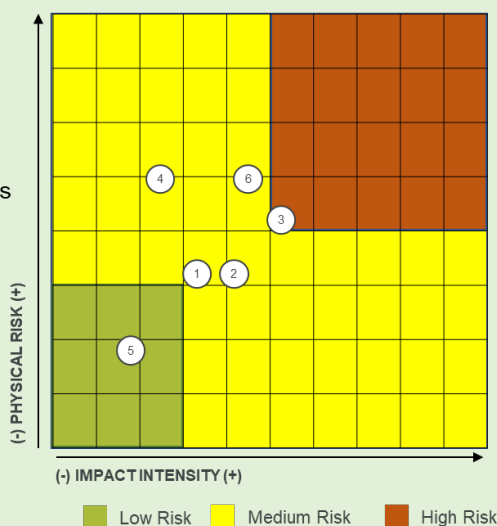


Figure 16: Mining industry relative risk map. Source: Finity, 2024

5.2.3 Tourism



Whitsunday Islands coral reef from the air. Credit: Helen Williams

Tourism in Australia is heavily reliant on outdoor attractions, it is, therefore, highly exposed to climate change. Possible impacts from the changing climate include the potential loss of iconic ecosystems and species, which would reduce the natural assets and biodiversity on which much of Australian tourism relies (Nicol et al., 2025). Most notably, the Great Barrier Reef, which generated \$6.4 billion (pre-COVID) of revenue for the Australian economy, has suffered repeated bleaching events (Great Barrier Reef Marine Park Authority, 2024; Henley et al., 2024). This has the potential to impact a large tourism sector in north Queensland. The Australian ski industry is also experiencing reductions in snow depth and season length (Olsson et al., 2025).

Mechanisms for climate change impacts on tourism include:

- Damage to attraction sites (example: Phillip Island, Victoria) (DCCEEW, n.d.)
- Reduced accessibility to locations (example: Kakadu Rainforest, Northern Territory) (Director of National Parks, 2010)
- Supply chain disruptions (example: Trans Australian Railway, Western Australia and South Australia) (ABC News, 2024)
- Adaptation costs (example: Great Barrier Reef, Queensland) (DCCEEW, 2024)
- Reputational damage (example: Blue Mountains, NSW) (Blue Mountains City Council, 2022)
- Increased health risks (example: Hervey Bay and K'gari Island, Queensland) (IUCN World Heritage Outlook, 2020)

The impact is not uniform and varies significantly by site type (natural or artificial) and category (beaches, vineyards, or rainforests). Queensland has the highest number of sites facing high

climate risks compared to other regions. Key tourism assets in Queensland are concentrated along the coastline, spanning the length of the state. Many airports are also coastal and can face significant impacts from storms, flooding, heat, and wind causing flight disruptions and damage to infrastructure. Consequently, natural disasters at or near these assets can have a severe impact on the visitor economy. The effect on local businesses can last for many years after the event.

The 2023 Intergenerational Report projects that tourism arrivals could decrease by more than 10% in a scenario where global temperature increases are limited to 3°C by 2100, and about 25% in an exceeding 4°C scenario (Commonwealth of Australia, 2023).

Loss of business revenues due to climate change can in turn lead to loss of government revenues (Hoegh-Guldberg et al., 2019). For example, the Great Barrier Reef is an economic, social and iconic asset worth AU\$56 billion (O'Mahoney et al., 2017).

Tourism employs one in 12 people in rural Australia (Tourism Australia, 2020), consequently, climate change impacts will be disproportionately large in rural areas, affecting the economic viability of some rural towns. The tourism sector is characterised by a large number of relatively small family-owned businesses that often operate on thin profit margins and lack the resources to implement significant changes in their operations and so these small businesses will disproportionately feel the impacts from climate change.

5.3 Built environment impacts

Much of Australia's housing stock and infrastructure has not been built to cope with rising temperatures and the increased severity of storm, drought, and bushfire events. The risks of extreme natural hazard events, such as bushfires, severe storms, floods, coastal erosion, and inundation of low-lying coastal areas, is increasing. The increased costs of repairs, insurance and maintenance will impose a financial burden on homeowners and other property owners. These will have cascading impacts and could result in reduced property values in high-risk areas. These growing financial burdens will have an indirect effect of reducing expenditure on other goods and services, impacting the economic wellbeing of Australian states and the nation as a whole.

By 2030, climate change and extreme weather are expected to reduce the value of the Australian property market by approximately \$571 billion (from 2019), however, costs resulting from climate change in the property sector are expected to be uneven (Steffen et al., 2019). Some properties are highly exposed to significant climate change threats such as flooding, bush fires and coastal inundation with increased costs impacting about 5-6% of properties (Steffen et al., 2019).

Local, state and federal governments are responsible for the construction, operation and maintenance of much of the infrastructure that enables assets and industry to function. Climate change is predicted to place significant pressure on existing infrastructure and increase the costs associated with constructing new infrastructure. Local governments will have concentrated impacts and are less able to manage revenue impacts than state and federal governments, while bearing the brunt of managing climate events.

Critical infrastructure assets and services are also at risk. The increase in rainfall variability and rising temperatures will lead to increased demands on water supplies; while water infrastructure may in turn be impacted by increased temperature and the increased frequency and severity of extreme events (Matic et al., 2025). Electricity infrastructure, roads, rail assets, airports, and shipping ports will cost more to maintain and repair as climate impacts intensify (Colvin et al., 2020).

Industry interviews – construction

The methodology for the interviews is documented in Appendix C.

The construction industry is facing increasing pressures, with higher demand for new construction and a more challenging operating environment, characterised by more unpredictable and severe weather, as well as higher temperatures that impact working conditions.

Following natural disasters and extreme weather events, the demand for construction materials increases sharply due to additional use resulting from repair and reconstruction activities, leading to price increases.

Construction during hot days is becoming more dangerous. Alternative approaches to mitigate this risk have been widely deployed in very hot countries, include varying the construction activity time to avoid the hottest part of the day and conducting activities at night. However, changes to work rest ratios and other measures can reduce productivity and conducting activities at night can generate additional risks.

Buildings are designed for an “expected climate regime” with many built to out-dated standards. In older buildings poor thermal performance leads to higher electricity demand for their cooling, while improving thermal efficiency of older buildings through retrofits can be slow and expensive potentially reducing the value of older properties due to the higher costs of use.

Using expert views gathered through interviews Finity mapped the risks described above into the physical risk and intensity of impacts dimensions (Figure 17).

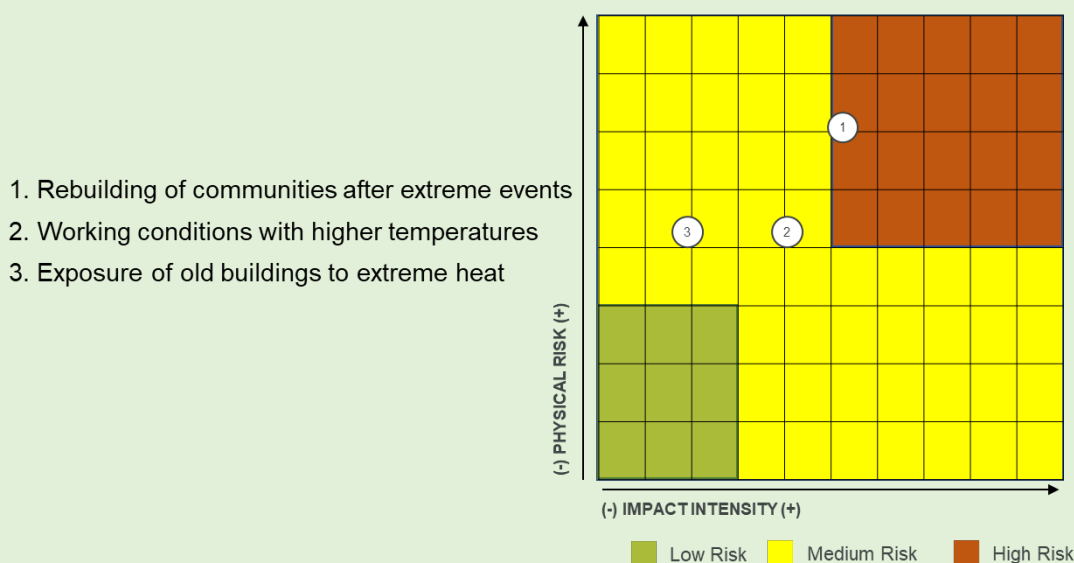


Figure 17: Construction industry relative risk map. Source: Finity, 2024

5.3.1 Coastal housing and the built environment

Property and land are exposed to loss and damage from sea-level rise and other coastal hazards (Australian Climate Service, 2025e). Sea levels will continue to rise even if greenhouse gas emissions are stabilised at current levels (Table 4), although they will rise more slowly at lower levels of global warming. Rising sea levels will exacerbate the impacts of coastal hazards such as storm surge, estuarine flooding and tropical cyclones (Figure 18).

If greenhouse gas emissions remain high, more than \$226 billion of commercial, industrial, road, rail and residential assets are at risk from sea level rise by 2100 (Steffen et al., 2019). The number of coastal assets at risk from the combined impact of inundation and shoreline recession is 5,800-8,600 commercial buildings, worth \$58-81 billion, and between 3,700 and 6,200 light industrial buildings, worth \$4.2-6.7 billion. Sea level rise presents a unique risk because it is not generally covered by private insurance contracts.

Major urban centres located along the coast, such as Sydney, Melbourne, Brisbane, Perth, and Adelaide, are particularly at risk from the impacts of climate change due to their dense populations, extensive infrastructure, and economic significance. Coastal suburbs and waterfront developments within these cities face risks from sea level rise, storm surges, and extreme weather events. Childcare, aged care, and education facilities are at risk in these locations, as are the services they provide, which are a critical component of social support for vulnerable segments of communities.

Australians continue to migrate to coastal areas with coastal cities growing faster than other areas (DITRDCA, 2022). This will tend to increase exposure to coastal hazards.

Kompas et al. (2022) estimated the economic impacts of coastal sea level rise and storm surge across regions and land use classifications in Victoria to be \$9.44 billion per year to 2040, \$14.77 billion per year to 2070, and \$23.66 billion per year to 2100 (in non-discounted values). This represents a reduction of 1.73%, 2.06%, and 2.68% of the Victorian Gross State Product (GSP) per year in 2040, 2070, and 2100, respectively. This work identified that approximately 151,000 current residential and commercial properties in Victoria, along with key infrastructure, will be at risk by 2100, with over 333,000 properties exposed to at least some damage from inundation, at a total market value of the property portfolio in Victoria showing a 3.7% loss in 2100 or (approximately) more than \$104 billion in current value. The study identified that actions that avoid \$1 of impact before 2040 are equivalent to avoiding \$4 in 2070 and \$10 in 2100. This study also noted the impacts on heritage properties and cultural and traditional values, but the economic value of these was not included.

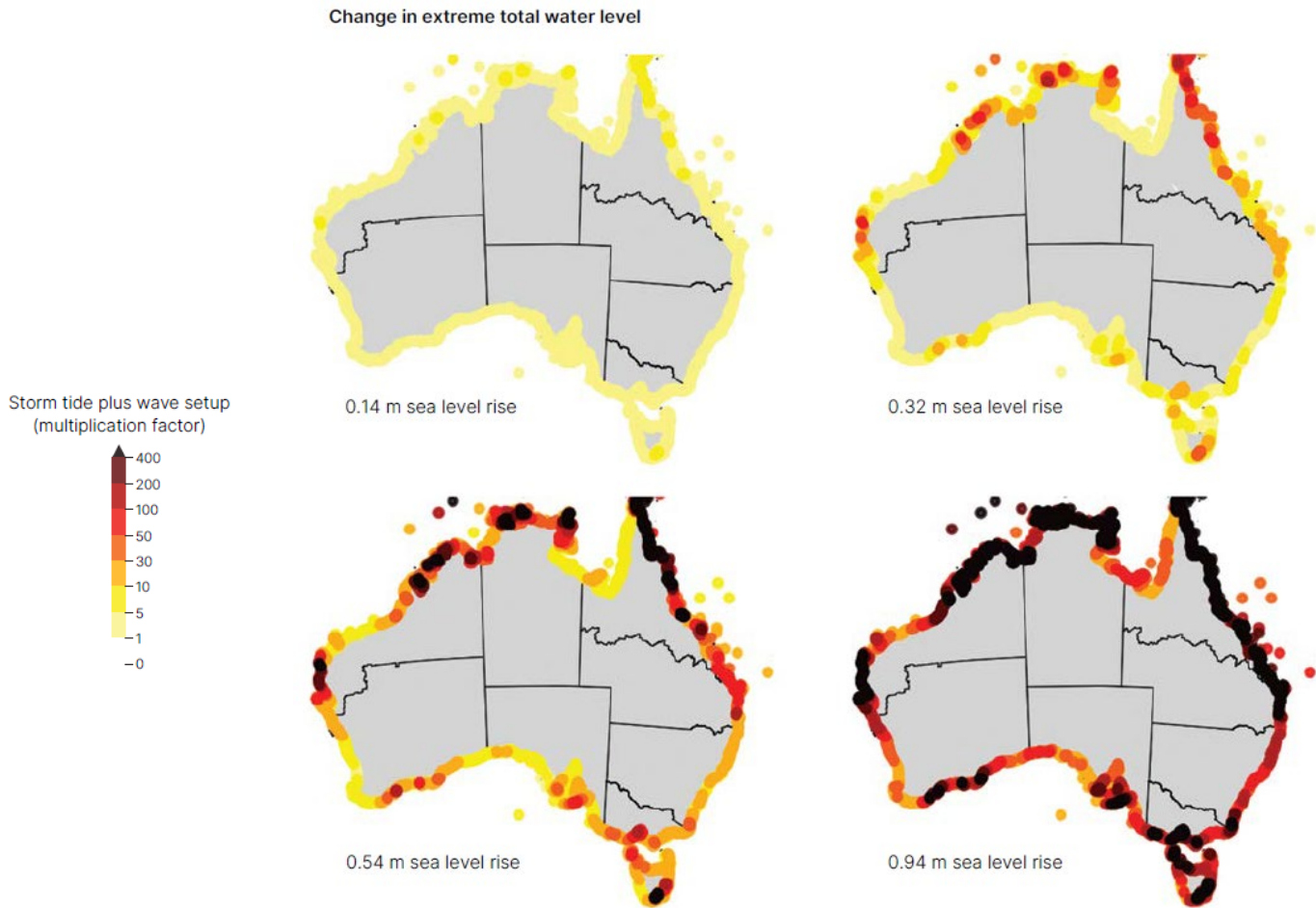





Figure 18: Regional changes in frequency of extreme water level for different sea level increments compared with current climate (Australian Climate Service, 2025b).

Table 4: Projected changes to sea level for different time frames and global warming levels relative to current climate. Circles indicate a confidence rating based on the direction of change. 3 circles = high confidence, 2 circles = medium confidence, 1 circle = low confidence (Australian Climate Service, 2025b).

		Current rise since 1880	Future change relative to current sea level			
			GWL +1.5/ +2.0°C at 2050	GWL +2.0°C at 2090	GWL +3.0°C at 2090	Planning benchmark
	Sea level rise	0.2m	+0.14m	+0.32m	+0.54m	+0.94m
	Frequency of coastal flooding	15 days	+24 days	+87 days	+193 days	+257 days
	Extreme water level frequency	x 1.0	x 2.0	x 5	x 14	x 101

CASE STUDY: Non-market value impacts from coastal sea level rise in the Kimberley Region



Mangroves growing in the water in Broome, Western Australia. Credit: Yellow Garnet Photography

The Kimberley Region of Western Australia is one of the highest-risk areas from sea level rise in Australia (Figure 18). Coastal ecosystems, such as those in the Kimberley Region, provide essential goods and services including carbon storage, coastal protection, improved water quality, and storm and erosion protection. Coastal ecosystems regulate the climate by influencing local temperature and humidity – this is by far the benefit with the highest non-market value they provide. Coastal erosion and flood control have the next largest non-market value.

Kompas et al. (2024) estimated the non-market value losses of the Kimberley’s coastal ecosystem and wetlands under the two climate scenarios, RCP4.5 and RCP8.5. The average annual non-market losses from sea level rise are estimated to be \$4.3 billion by 2050 and \$12.8 – \$16.5 billion by 2100 under the RCP8.5 climate scenario. This is equivalent to approximately 41.5% and 66.2% of the region’s current gross value product (GVP). The same study showed that rising seas could result in the permanent displacement of around 40,000 residents, including approximately 16,000 Indigenous residents.

5.3.2 Supply chains and transport

Transport networks, telecommunications, energy grids, water systems, and supply chains enable the efficient movement of people, goods, services, and information.

Steffen et al. (2019) estimate that 27,000-35,000 km of roads and rail worth \$51-67 billion are exposed to sea level rise and erosion. Additionally, there are 120 ports, five power stations, 258 police, fire, and ambulance stations, 75 hospitals, and 44 water and waste facilities, all within 200 meters of the coast. Many of these assets provide essential services which, if disrupted, could have significant negative impacts on local communities. This is particularly true in areas with lower adaptive capacity, such as older or lower socioeconomic communities.

As part of the National Assessment's work, three case studies were modelled based on identified supply chain vulnerabilities to illustrate the potential impact of future extreme weather events. The case studies used the footprint of historical events projected into a future climate (Higgins et al., 2025).

- A hypothetical major flood, based on the flooding across Victoria and NSW in October 2022 and covering a broad geographically dispersed area. The value of blocked freight would rise from \$4.9 billion in the current climate to \$9.3 billion in 2090. Health-related freight (e.g. medicines), although not the largest impacted sector in terms of volume, would have the most significant percentage increase in the value of freight blocked and requiring re-routing, suggesting this is a vulnerable commodity when considering extreme events.
- A severe tropical cyclone following the path of Tropical Cyclone Jasper. Direct impacts remain confined mainly to Queensland's north; however, greater shortages of food products would be experienced in major distribution centres across Australia, particularly impacting those products grown in northern Queensland, highlighting that local impacts can reverberate across the country.
- Disruption to the critical-east west supply corridor was modelled after the February 2022 flood event that cut access through Eyre and Stuart highways. Analysis based on a hypothetical more severe version of this event in 2090 resulted in an average detour increase of 730 km, but depending on severity this sometimes increased to over 3,000 km in 2090. The most impacted LGAs were Indigenous and remote communities. Increased length of detours in 2050 and 2090 for this case study is less likely to be absorbed by vehicle fleet capacity, leading to a significantly more extended recovery period, higher inventory depletion, and an expensive modal shift (e.g., air freight) in the case of priority commodities.

5.3.3 Electricity system

The electricity grid is not engineered for significant shocks that extreme weather events may bring. The increased frequency and severity of storms, bushfires, and floods pose significant threats to generation assets and the transmission grid (Figure 19). Additionally, the grid will need to support surges in demand during temperature and other weather extremes.



Figure 19: Electricity network infrastructure overlaid in orange Median number of days above 38°C. Left: GWL1.1; centre: GWL2; right: difference. Source: Australian Climate Service, 2023

Demand for electricity generation is expected to increase due to additional electrification, the growing hydrogen industry and a significant future fleet of electric vehicles. In addition, as the nation faces rising ambient temperatures there is likely to be an increase in electricity demand as homes and businesses use air conditioning to stay cool, which in turn increases the risk of power failures (Climate Change Authority, 2024). Global energy demand for space cooling is projected to increase by roughly 250% between 2010 and 2060 even without climate change, and by 330% if climate change is taken into account (International Energy Agency, 2022).

The energy system is exposed to fires, smoke, high winds, and rainfall, affecting both hydroelectricity and generator cooling. High temperatures (Figure 20) can also impact generation and distribution at times when demand is high (Lawrence, et al., 2022). Weather patterns and extreme events are already impacting the grid, as evidenced by the price spikes in June 2022 and the Victorian bushfires in 2009.

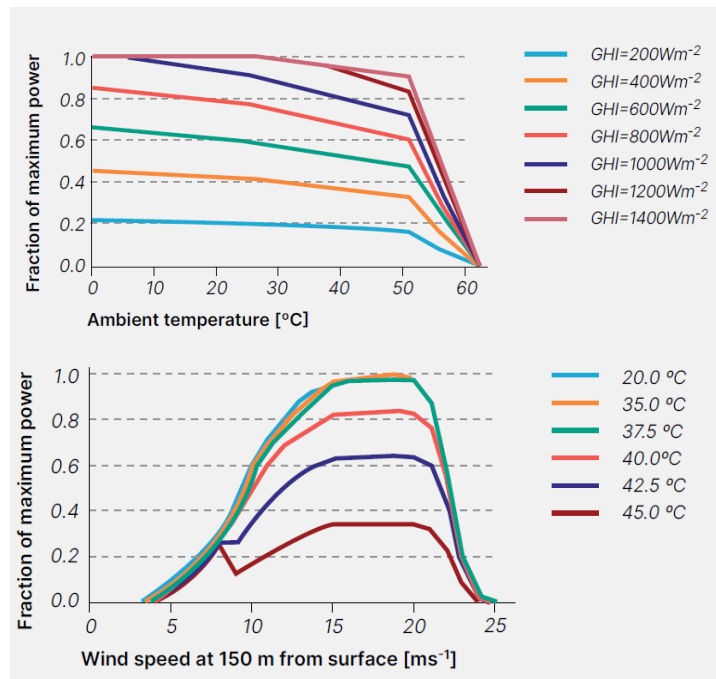


Figure 20: Influence of temperature on solar (top) and wind (bottom) generation outputs. (adapted from Huang et al., 2020)

5.4 Direct impact from severe and extreme hazards

Severe and extreme climate events can be highly disruptive and very costly to businesses. Short-term costs can be high. Immediately following the emergency response, work begins on restoring basic services, clearing debris, disposing of any hazardous waste, and assessing buildings to ensure they are safe to resume functioning. Temporary housing is typically required for evacuees and businesses activities may be disrupted (Charlesworth & Fien, 2024).

The destruction of physical capital stock by extreme events results in depreciation of capital, frequently to zero (Hallegatte, Jooste, & Mclsaac, 2022). These impacts vary across different asset types, such as infrastructure and non-infrastructure (Hallegatte, et al., 2022). For example, if heavy rainfall and flooding cause widespread pavement damage and scouring around bridges and culverts, the reduced availability of a few key roads or transport hubs can create significant disruptions to the transport system. Beyond the financial cost of repair, damaged roads also have substantial flow-on effects on the functioning of local, regional, and national economies, as roads and railways are essential infrastructure that enables trade.

Risk exposure analysis was conducted by Finity using their Finperils models to estimate the average annual cost of damage to residential, commercial and industrial assets (including private and public sector assets) for flood, bushfire, storm and tropical cyclone in 2024 and projections to 2050 and 2090 under a low-emissions and high-emissions IPCC scenario (SSP1-2.6/RCP2.6 and SSP5-8.5/RCP8.5 respectively) (Table 5).

For the built environment domain, the average annual losses (AAL) provides the expected (mean) annual cost of damage to a property by calculating the cost of rebuilding it (note: this is distinct from the market value of an asset and does not include the allowance for the value of the land). The costs are based on exposure and vulnerability estimates for a particular hazard by integrating the natural hazard density curve over all probabilities. It can also be referred to as Average Annual Damage (AAD).

Table 5: Projected average annual losses (AAL) by hazard by emissions scenario

Risk	Baseline	Low Emissions Scenario			High Emissions Scenario	
	2024	2050	2090	2050	2090	
Storm	\$ 5.160	\$ 5.216	\$ 5.269	\$ 5.073	\$ 5.005	
Flood	\$ 2.895	\$ 3.123	\$ 3.319	\$ 3.549	\$ 3.876	
Cyclone	\$ 1.900	\$ 2.432	\$ 2.508	\$ 3.077	\$ 4.959	
Bushfire	\$ 0.799	\$ 0.858	\$ 0.865	\$ 1.048	\$ 1.602	

In adjusting models, Finity follows the scientific guidelines of the Climate Measurement Standards Initiative (Climate-KIC Australia, 2020) and is consistent with the guidelines set out in the NSW Treasury Disaster Cost-Benefit Framework (NSW Treasury, 2023) and its definition of the AAL (or AAD).

The Colvin Review undertook financial and economic analysis to consider how a changing climate may contribute to the total economic cost, including both financial and social costs, of future disasters across each state and territory for floods, bushfires, storm surges and tropical cyclones under a moderate emissions scenario and a high emissions scenario between now and 2049-50 (Colvin, 2024). The Colvin Review projected disaster costs across each state and territory for flood, bushfire, storm, cyclone and hailstorm for a moderate emissions scenario may total an annual cost

of approximately \$40.3 billion by 2049-50 (median value) or up to \$200.62 billion at the 95th percentile (Figure 21) (Colvin, 2024). This modelling included both financial and social costs. Their estimates (Figure 21) are the P95 estimate of total economic cost for the financial year ending in 2050; that is, the value at which there is a 95 per cent chance, or level of confidence, that the actual cost will not exceed this amount, and therefore are likely to be an upper bound.

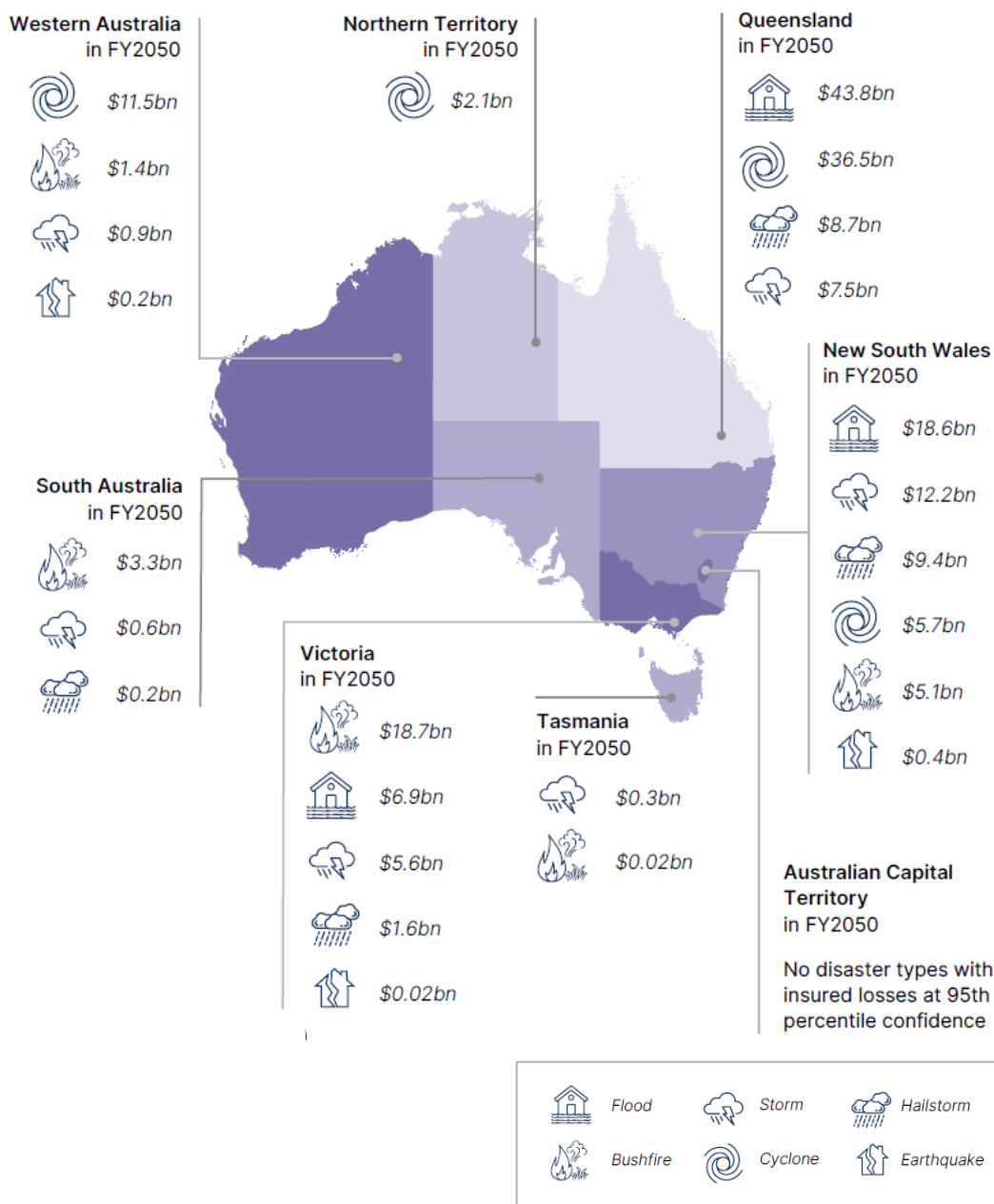


Figure 21: Total economic cost by hazard by jurisdiction (A\$ billion | Real 2023-24). 95th percentile estimates including the impact of climate change under a moderate emissions scenario for 2049-50. Source: adapted from The Colvin Review (Colvin, 2024) from ICA Historical Catastrophe dataset, 2023. ACT has only two events with associated insured losses recorded in the ICA dataset.

5.4.1 Impacts on government finances

Governments have a direct role in funding emergency response and recovery and the ability of governments to respond effectively and rapidly to extreme events is vital to maximising the impact of the support. Governments also provide disaster relief payments to individuals, loans and subsidies to businesses, and other funding that support local governments, businesses and households in their recovery processes. This investment minimises additional risks and reduces the likelihood of more costly support being required over a longer period.

However, financing these responses carries with it additional risks. Increased government expenditure triggered by extreme events has been linked to weakened government debt credit ratings (due to unexpected and substantial government expenditure impacting long-term government fiscal discipline); this may, in turn, increase the required rate of returns on investment in government debt (Marto, Papageorgiou, & Klyuev, 2017).

As part of the 2023 Intergenerational Report, Treasury modelled the expected change in future Commonwealth Disaster Recovery Funding Arrangements (DRFA) expenditure, relative to historic average DRFA expenditure (Commonwealth of Australia, 2023). For the National Assessment, The Treasury has extended this analysis to 2090 across three Representative Concentration Pathways (RCPs) – RCP 2.6, RCP 4.5 and RCP 8.5 for bushfires, tropical cyclones, floods, and storms. (All data and assumptions used are identical to those in the 2023 Intergenerational Report, Appendix A5 (Commonwealth of Australia, 2023)).

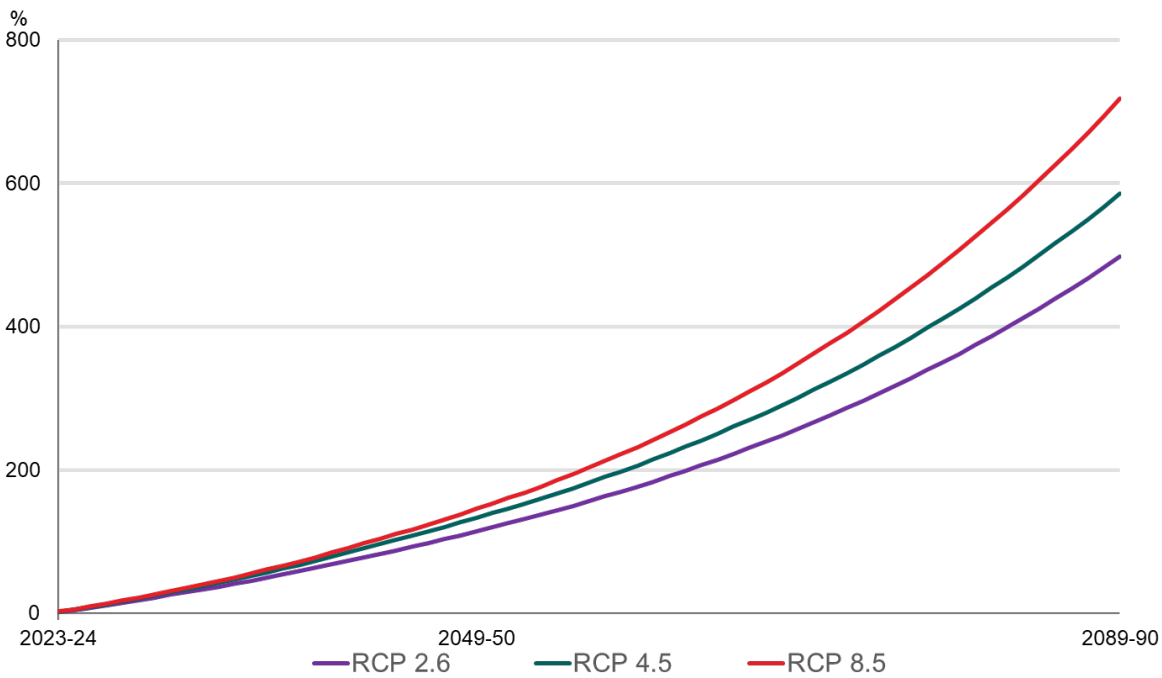


Figure 22: Expected increase in average annual Commonwealth DRFA expenditure from 2023-24 to 2089-90, total percentage change

The analysis shows that the fiscal costs to the government of natural disasters could increase significantly over time (Figure 22). In 2050, Commonwealth DRFA expenditure is projected to double (increase on average between 1.1 and 1.5) above 2023-2024 levels. By 2090, it is projected to increase by 5 to 7.2 times ².

These projections represent only a portion of natural disaster related expenditure and exclude State expenditure under the DRFA and non-DRFA expenditure by all levels of government. Beyond direct DRFA costs, there are other fiscal impacts, including increased payments through social security and transfer programs as well as foregone tax revenue due to lost employment and economic opportunities. This is in addition to other significant costs to repair physical infrastructure, health, social, and environmental impacts, as well as the unpaid labour typically deployed to support affected communities.

There are also other routes whereby climate change can have direct impacts on governments' budgets. For example, health services are likely to come under pressure due to the increase in heatwaves and other health effects of climate change (Beaty et al., 2025). These services will need to grow and adapt to meet the increasing demand (NSW Government, 2025a). This is also true for mental health services for affected communities, particularly those in agriculture and related industries (Berry et al., 2011).

Cross system risks related to disasters and emergency response are discussed further in Australia's National Assessment report (Australian Climate Service, 2025d) and in the National Disasters and Emergency Management Technical Report (Australian Climate Service, 2025f).

5.5 Finance, insurance and markets

Climate change is projected to have both direct and indirect financial impacts. Direct costs include rebuilding damaged or destroyed property while indirect consequences include changes to asset values with flow-on effects to personal wealth and financial institution portfolios, including superannuation funds.

5.5.1 Banking and finance

Banks and insurance companies are highly exposed to climate risks. Extreme climate events may interrupt bank operation, disrupting cash services, payment system, and financing, thereby hindering the functioning of the economy.

² Natural disaster expenditure is highly volatile, and current models have limitations in predicting natural disaster events. This analysis thus considers expected costs, not actual costs. Expected costs represent the average cost of a disaster event in any given year, while the actual costs represent the total cost incurred if a disaster event materialises. Actual costs will vary significantly year-on-year.

Banks are also exposed through their lending and underwriting of property, assets and businesses. This is particularly true for mortgage lending, which accounts for approximately two-thirds of major bank lending and business lending to the agricultural sector. Banks typically lend using a property's current value as collateral, however, international studies currently show little evidence that climate risk is being priced into property values (Bellrose et al., 2021). Household mortgage loans typically require insurance, therefore climate risks can also arise in portfolios when properties are inadequately insured.

Climate-related physical risk could negatively impact property prices (APRA, 2022; Kurian et al., 2023). For example, following the 2022 northern NSW and south-east Queensland floods, Mullumbimby recorded the most significant 12-month decline in property prices nationally, down 30.1%, equivalent to a \$432,000 decline in the median value. This was followed by south Lismore, where values decreased by 27% over the same period (CoreLogic (2023)). Steffen et al. (2019) also examined the impacts on the property market, finding that damage-related losses in property values could reach \$611 billion in 2050 and \$770 billion in 2100, noting that these impacts are very unevenly distributed.

The APRA Banking Climate Vulnerability Assessment (CVA) was conducted with Australia's five largest banks to assess the nature and extent of climate risks to financial institutions (APRA, 2022). It provided initial insights into the impacts of climate change's physical risks on banks and the security of the financial system. It identified that banks would face impacts to their ability to lend as a result of climate risk through declining asset values and increasing insurance costs. Under high-warming scenarios, upper estimates projected lending rate losses could increase by up to 3x the historical average by 2050. Some regions (e.g. parts of northern Australia) are more vulnerable than others to physical risks. Results from the CVA suggest that while "banks would continue their broad-based mortgage lending activities, the banks indicated that this stance was partly contingent on additional policy support for more at-risk regions" (APRA, 2022).

Climate impacts could be underestimated as climate scenario analysis and financial loss reporting is evolving and generally does not consider compounding climate damage and the potential for financial and economic system instability under higher warming scenarios. There are multiple feedback loops between the finance sector and the rest of the economy (Figure 23). However, there is a limited understanding of the relationships between direct and indirect impacts and how these can be transmitted through the financial system, which could trigger increasing volatility. As direct impacts increase in frequency and severity, the relationship between parts of the finance sector and the rest of the economy becomes more important.

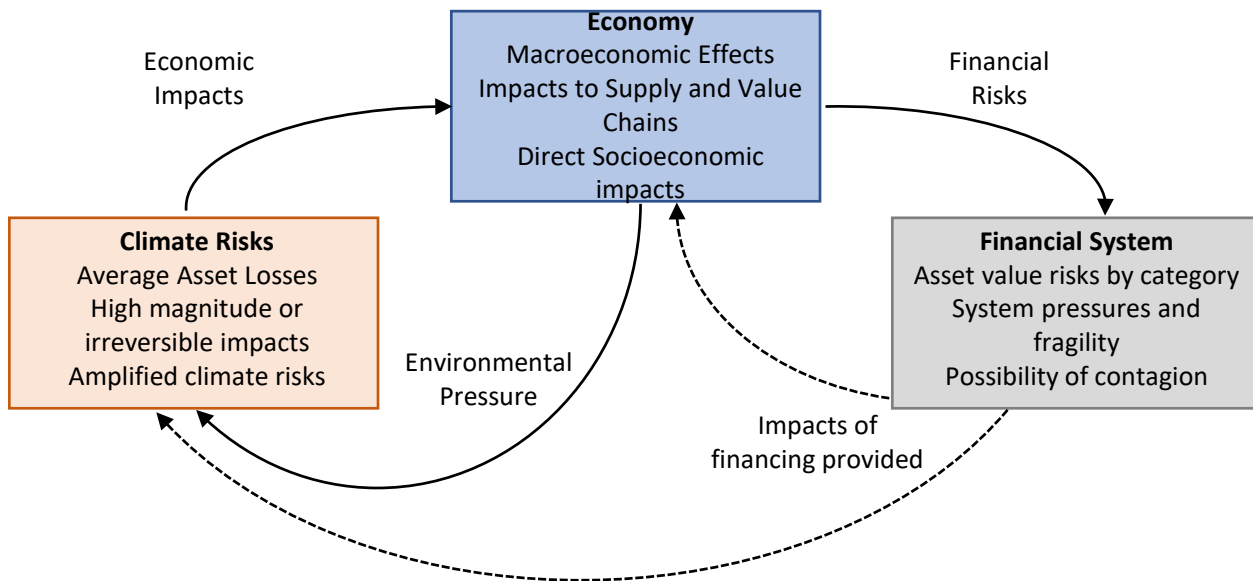


Figure 23: Potential economic-financial dynamics associated with climate risk. Source: Finity, 2024

Australia's 'Big Four' banks hold approximately \$1.7 trillion in mortgage loans, which represent 52% of their total Australian lending exposure. In 2021, the Australian Prudential Regulation Authority (APRA) released guidance for regulated entities (banks, insurers and superannuation trustees) to assist entities in complying with existing risk and governance standards, and to set out prudent practices in relation to climate risk management.

Industry interviews – finance

The methodology for the interviews is documented in Appendix C.

Using expert interviews, Finity identified significant risks to the finance industry.

Significant adjustments in asset values can happen after a natural disaster. Such adjustments need to be reflected in bank financial assets (loans) and can lead to unexpected changes in risks contained in portfolio values of those financial assets challenging financial stability.

Insurance is becoming increasingly critical, even as the availability and affordability of insurance coverage comes under increasing affordability pressures in certain geographies. Insurers may withdraw or significantly increase the price of specific cover as a response to understanding more about the potential damage which can be caused by a particular climate hazard in a particular area, or as a response to changes in the frequency and magnitude of the risk.

Disruptions in business activities due to climate and extreme weather events cause cashflow variability over time with businesses attempting to catch up on lost revenue or ceasing to continue to do business. Shocks to business revenues can be exacerbated due to disruption to payment systems, and high insurance claim volumes may cause delays in claims processing. This can be transmitted into the financial system via declines in cashflows and breaches of loan covenants or forced asset sales.

Potential increases in financing costs impact all businesses large, medium and small. Impacts to costs of financing and investing in resilience actions impact returns.

The risks described above were mapped onto the physical risk and intensity of impacts dimensions (Figure 24).

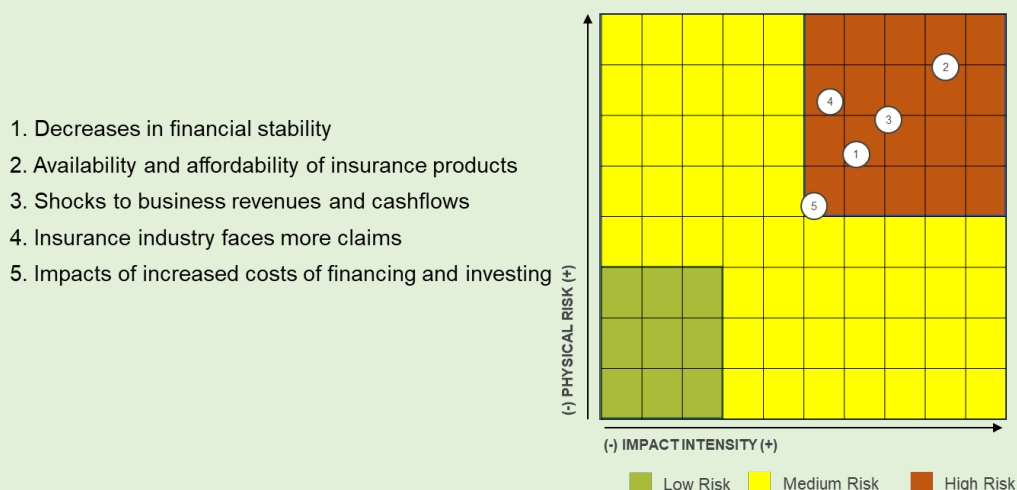


Figure 24: Finance relative risk map from interviews. Source: Finity, 2024

5.5.2 Insurance

Insurance allows individuals and households to financially manage their risk exposures by participating in a larger collective. By paying regular premiums, policyholders transfer their financial risk to the insurance company, which manages that risk by diversifying portfolios and by using reinsurance. However, climate change presents a challenge for insurance companies as severe and extreme events may become more frequent or change in severity, affecting magnitude of losses (Figure 25). Insured weather-related losses totalled \$13 billion between 2019 and 2022 across 11 catastrophes (ICA, 2022).

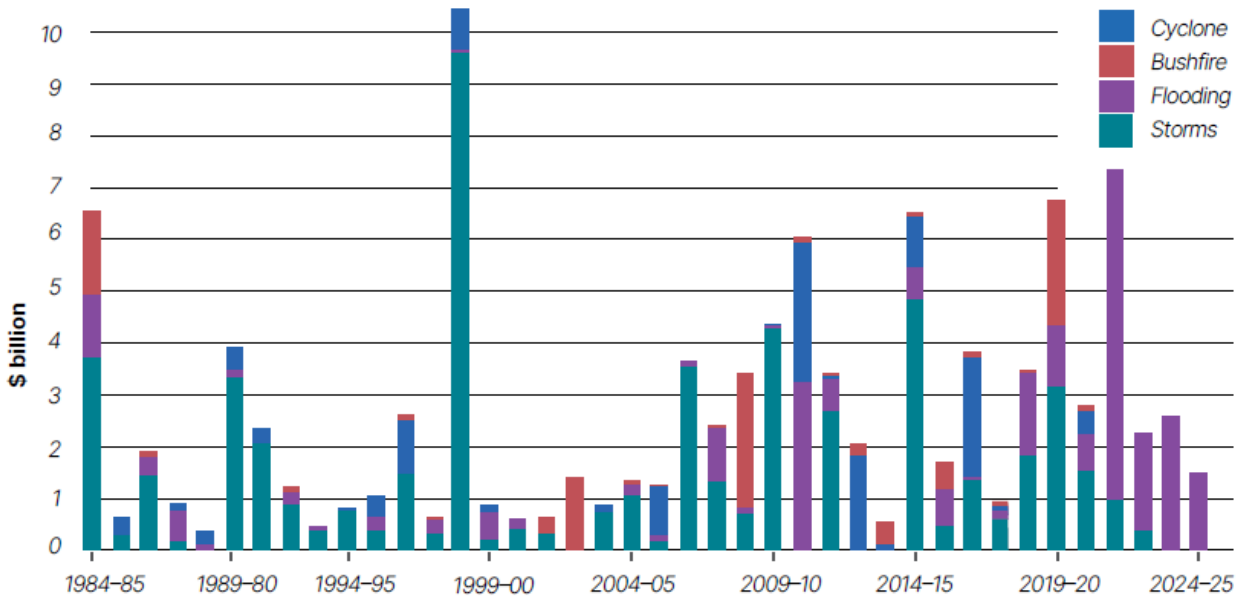


Figure 25: Normalised value of insured losses caused by natural disasters, 1982–83 to 2024–25. Impacts from non-climate-driven disasters, such as earthquakes and gas disruption, are excluded. (Source: Insurance Council of Australia, 2025)

Pressures on the affordability and availability of insurance coverage for at-risk communities are likely to intensify as severe and extreme events become more frequent or more severe. In its 2022 home insurance affordability report, the Actuaries Institute noted that the impact of climate change would be three times worse for households experiencing affordability stress compared to those not experiencing affordability stress (Actuaries Institute, 2022). Townsville, for example, has a median weekly household income of \$1,621, which is below the national average (Australian Bureau of Statistics, 2021); this economic vulnerability was evident in the 2019 Townsville floods, where, 10% of residents impacted had no insurance at all (ACCC, 2020).

Increases in insurance premiums in the future could decrease the affordability of full insurance coverage for households (ACCC, 2020; Vij et al., 2022), leading to underinsurance, or a 'protection gap'. Swiss Re estimates the protection gap in Australia for natural catastrophe losses for the decade 2014–23 at US\$12 billion, which is 33% of the estimated US\$37 billion cost of natural catastrophes over that period (Swiss Re Group, 2024). There is pronounced regional variation in the rate of non-insurance across Australia. While exact figures are unknown, it is estimated that the rate of residential buildings without insurance across northern Australia stands at about 20%, compared to a rate of approximately 11% for the rest of Australia (ACCC, 2020).

According to analysis by the Actuaries Institute (2024), over the year to March 2024, the proportion of "affordability-stressed" households – those facing insurance premiums equivalent to more than four weeks of gross household income – rose to 15% or 1.61 million households. This proportion continued to increase from 12% in 2023, up from 10% in 2022, with Queensland (24%), the Northern Territory (19%) and NSW (17%) facing the highest proportions of households under affordability stress (Paddam, Liu, Philip, Smith, & Nagarajan, 2024).

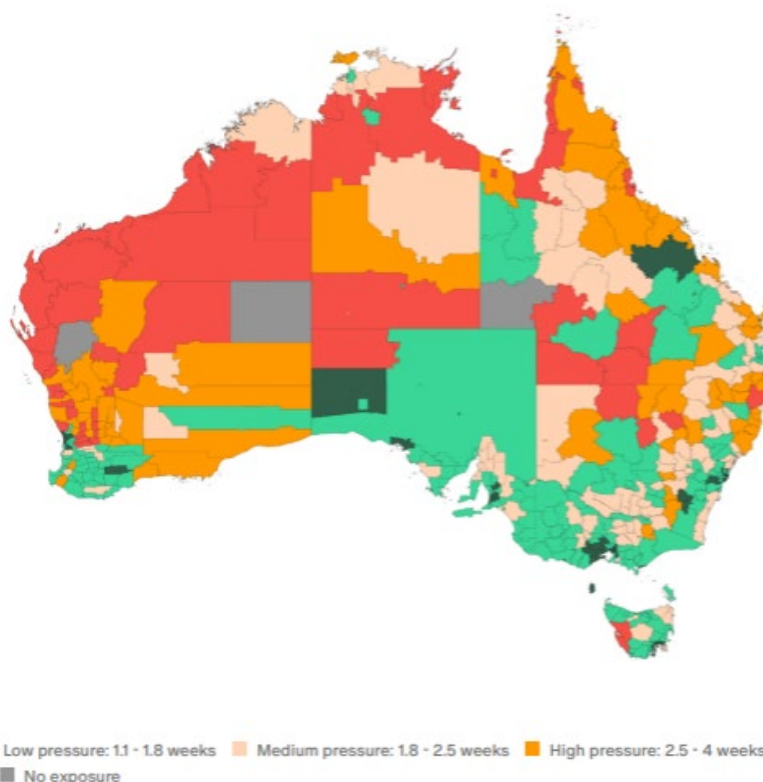


Figure 26: Median Australian Actuaries Home Insurance Affordability Index (AAHIA) by Local Government Area. Source: (Paddam, Liu, Philip et al., 2024)

Local Government Areas suffering from extreme home insurance affordability pressures are concentrated in regional Western Australia, the Northern Territory, southwest Queensland, and the Northern Rivers region of NSW (Figure 26). Metropolitan areas typically have lower peril risks and higher incomes. This means that the capital cities have lower affordability pressures on average. However, affordability pressure remains present in parts of the capital cities of Greater Sydney, Greater Melbourne, and Greater Perth, particularly on the outskirts of the city limits.

There is an increased risk of insurers withdrawing from the market in disaster prone areas, particularly for areas that are already the most vulnerable to climate-related disasters. Loss of insurance could lead to loss of access to finance with flow-on impacts on house prices and, ultimately, household financial well-being. The temporary refusal of insurance coverage after multiple and costly floods has already been felt in some areas, such as Roma (Suncorp Group, 2014) and has been reported in Lismore.

Some positive outcomes have been observed from adaptation investment. In Roma, Suncorp stated that the Queensland Government needed to mitigate flood risk before coverage could resume

(Suncorp Group, 2012). To address this the federal and Queensland government invested \$26.5 million in the Roma flood mitigation project, which including a 5.2-kilometer earthen levee, stage one was complete in 2015 (Maranoa Regional Council, n.d). The completion of the levee led to an average reduction in property insurance premiums of 45% by 2021–22 (Queensland Reconstruction Authority, 2022).

In response to these challenges, government interventions are being seen as an option to ensure access to insurance, particularly in high climate hazard risk regions. In Australia, the Tropical Cyclone Reinsurance Pool was established to reduce premiums for communities vulnerable to cyclones. The ACCC's fourth insurance monitoring report finds the government's cyclone reinsurance pool has moderated rises in insurance premiums for Australian households and small businesses facing medium to high risk of cyclones (ACCC, 2025). Consistent with its intent, the benefits of the pool have been more pronounced in the highest cyclone risk areas, with some policyholders receiving large premium reductions. But premiums remain very high for many consumers and are generally rising in most parts of the country (ACCC, 2025). Broader market pressures, like rising construction costs, continue to challenge insurance affordability.

5.5.3 International trade and finance

Detailed analysis of the transmission of risk to the Australian economy from global or regional climate-driven impacts is out of scope of the National Assessment. However, the economy is underpinned by integrated domestic and international supply chains. A constraint to availability anywhere in the global supply chain can interfere with the provision of critical goods for Australian businesses and communities. Studies of the transmission of risks through global supply chains is the focus of a growing body of contemporaneous work³.

Australia's export trade can be affected by climate impacts on trading partner countries, which could have impacts on the ability to exchange materials and goods with Australia (Steffen et al., 2019). Critical domestic port, road and rail assets support trade in fundamental ways and so impacts to trade caused by infrastructure disruption can be substantial. These coastal assets are vulnerable to many hazards including tropical cyclones, erosion, storm surge and flooding, all of which will be exacerbated by rising sea levels. In 2013-14, 48,000 Australian firms exported a total of \$330 billion of goods and services, accounting for 21% of GDP. Of these exports, 12% came from the climate-sensitive sectors of agriculture, forestry and fishing, and tourism, with tourism accounting for 84% of these climate-exposed exports (National Climate Change Adaptation Research Facility, 2016).

Commodity prices depend on relative demand and supply of specific products. Any disruptions including climate risk-related issues in either supply or demand of international products will have adverse pricing outcomes. The risk of uncertainty around price levels tends to deter trade and to move some trading into longer term contracts which some producers may find difficult to navigate.

³ For example: (Antras, Redding, & Rossi-Hansberg, 2023); (Cakmakli, Demiralp, Kalemli-Ozcan, Yesiltas, & Yildirim, 2020), (Cakmakli, Demiralp, Kalemli-Ozcan, Yesiltas, & Yildirim, 2021), (Eppinger, Felbermayr, Krebs, & Kukharsky, 2020), (George, Lakhani, & Puranam, 2020); (Sforza & Steininger, 2020).

This uncertainty around prices can reduce production levels, leading to further supply side disruptions.

Changing biosecurity risks also have the potential to affect Australia's international exports and competitiveness. Warmer temperatures provide an environment that enables easier and faster transmission of pathogens and pests to the vulnerable ecosystems (Darbyshire et al., 2025). This presents risk linked to domestic food security as well as food exports. This risk can damage trade relationships and reduce the value of Australian exports. Trade restrictions may be brought in to minimise new biosecurity risks that eventuate due to climate change (Carnegie et al., 2022; Kurian et al., 2023).

Impacts on the economy to and from international trade are likely to be material and therefore the assessment provided in this report is likely to underestimate the risk that climate change poses to the Australian economy, trade and finance system.

Industry interviews – impacts on trade

Methodology for the interviews is documented in Appendix C.

Trade risks are closely connected to the real economy. As a small open market economy, the ability to deliver exports and imports is fundamental to delivering orderly economic performance.

Using expert views gathered through interviews Finity mapped the risks described above into the physical risk and intensity of impacts dimensions (Figure 27).

1. Reliance on transport infrastructure
2. Increasing biosecurity risks
3. Commodity price uncertainty

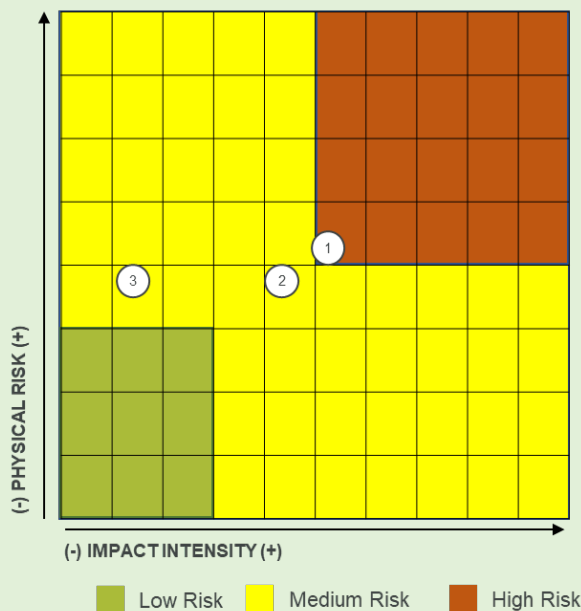


Figure 27: Trade relative risk map. Source: Finity, 2024

5.6 Cascades and financial crises

A financial crisis is typically triggered by a combination of systemic vulnerabilities and external shocks. Vulnerabilities can include poor risk management, concentration by asset or geography, over-confidence or weak regulatory oversight and high interconnectedness.

Interlinked factors such as asset depreciation and employment shocks can trigger or amplify financial crises through feedback loops that destabilises the economy. Due to the complementary nature of capital and labour in production, when capital is destroyed there could be concurrent shocks to employment (IMF, 2022). In addition, unavailability of workforce after extreme events due employee absenteeism while households address the immediate damage and secure their homes can reduce the availability of workforce when demand for workers is high. This means that businesses may find it difficult to recover quickly or at all and could adjust by permanently reducing the number of workers required, with ongoing impacts on local employment opportunities.

Local or regional impacts on productivity or employment can lead to erosion of social cohesion, and Steffen, et al. (2019) show bi-directionally that physical impacts leading to unaffordable insurance or decreasing property values may push people to leave certain areas leading to a shortage in labour and shut down of businesses, which exacerbates local economic stresses. Community impacts include impacts to individuals' mental health (Makwana, 2019) worsening of chronic diseases due to disruptions in supplies of critical medicines (Miller & Arquilla, 2012) or emergency and regular medical care. Disruptions in education for students (Hanushek & Woessmann, 2020) can cause longer term learning losses which could be difficult to recover.

Bellrose et al. (2021), for the Reserve Bank of Australia (RBA), looked at possible impacts on property value using Value at Risk (VaR), with the annual expected costs of climate related damage relative to replacement cost of dwellings as a key indicator of risk; VaR over 1% is considered high risk. Around 3.5% of homes in Australia were reported with VaR >1%; however, this proportion is projected to increase to 8% over the next 80 years. An estimated 0.4% change in VaR is considered to be roughly equivalent to a 10% decline in house prices (Figure 28) (Bellrose et al., 2021). However, the authors note that these risks are not evenly distributed and could emerge more rapidly if buyers factor in the increasing risk of climate change in some areas.

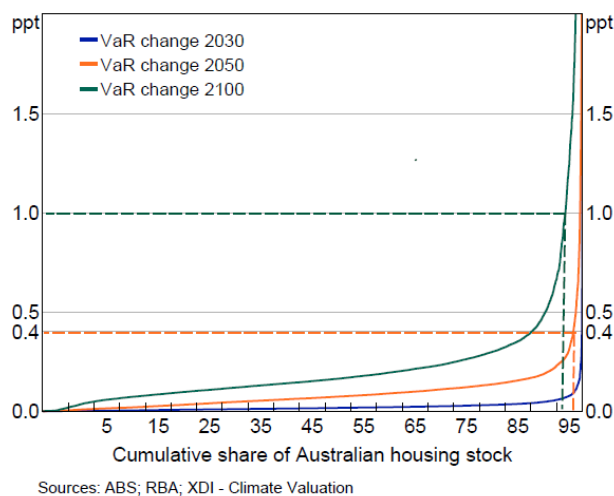


Figure 28: Projected increase in natural disaster costs as per cent of residential property value; by share of total housing for RCP 8.5. Source: Bellrose et al., 2021

The immediate impact of extreme events is likely to be reflected in both equity and corporate bond markets (Giglio, Maggiori, Rao, Stroebel, & Weber, 2021), however, Stern and Stiglitz (2023) note that "markets are poor at making risk assessments of complex and unknown factors" and that "climate risk is a systemic risk, and ... the market does not do well in assessing systemic risk". As the global financial crisis showed, credit defaults or loans based on expectations of future property value that proved to be incorrect can create systemic impacts across the economy, creating job losses and mass losses of wealth.

Cascading effects such as those outlined above can be exacerbated by credit risk from disruptions in household and business cashflows and additional unexpected expenses that reduce the ability of households and business to continue to repay their loans. These types of risks can mount very quickly and can translate into stability issues in financial markets (RBA, 2022).

Recent advances in research in this area include estimating the term structure of discount rates for businesses⁴, and real estate assets⁵ which shows the ways that different asset classes are exposed to climate risks. A central insight in (Giglio, Kelly, & Stroebel, 2020) considers the primary source of uncertainty as the future path of climate change, with a likely pattern of partial recovery of the economy following climate shocks.

Potential shocks and vulnerabilities identified by National Assessment workshop participants (Lin, Barnett, Bluhm, et al., 2024) for the time period up to 2050 include:

- The increasing vulnerability of the financial system to climate-related risks could lead to a run on the availability of capital, affecting investment and economic growth.
- Climate-related disruptions may cause export markets to diminish, impacting trade and economic stability.
- Rising climate risks could lead to a decline in land value, affecting property markets and the ability to raise capital.
- Inadequate preparation for workforce transitions in response to climate impacts could lead to mismanagement and social dislocation.
- Climate-related economic disruptions may lead to increased social division and corporate distrust, affecting overall societal cohesion.
- Climate-induced financial risks may not be uniformly distributed, potentially leading to uneven regional and local impacts on communities and industries.
- Inadequate climate policy could limit Australia's access to international capital markets, affecting economic growth and stability and failure to transition away from high-emission industries may result in the unmanaged loss of economically significant sectors.
- A failure to effectively transition may lead to a rapid and severe correction in international financial markets, potentially triggering a global economic downturn.

Impacts identified by workshop participants (Lin, Barnett, Bluhm, et al., 2024) for the 2050–2090

⁴ For example (van Binsbergen, Fernandez-Villaverde, Koijen, & Rubio-Ramirez, 2012) (van Binsbergen & Koijen, 2017) and (van Binsbergen, Hueskes, Koijen, & Vrugt, 2013).

⁵ For example (Giglio, Maggiori, Stroebel, & Weber, 2015) and (Giglio, Kelly, & Stroebel, 2020),

time period include:

- Climate-related disruptions may contribute to geopolitical conflicts and upheaval, isolating nations and impacting global stability.
- Environmental degradation may make investments in natural assets less appealing, affecting economic sustainability.
- Climate-induced challenges could lead to reduced returns on long-term infrastructure investments, impacting financial stability.
- Inadequate insurance coverage for major infrastructure projects may result in increased vulnerability and potential disrepair.
- Climate-induced disruptions may increase exposure to local markets, potentially reducing resilience to economic shocks.

An important aspect of financial risk from climate change is that an increase in volatility and adverse impacts on financial systems may lead to worse impacts for all the other systems. Climate-related impacts in other systems will have an impact on the financial system, but conversely a reduction in financial security would also have a negative impact on all other systems.

5.7 People and households

Impacts on household wealth and budgets and the cost of living can come through a variety of pathways, many of which have already been covered in this report. These include the potential for, increased cost of repairs and insurance, portfolio value declines, property value declines (APRA, 2022; Kurian et al., 2023), unemployment (Steffen et al., 2019) or higher costs of goods and services (Kotz et al., 2024) (Figure 29).



Figure 29: The impact of extreme events is increasingly seen on supermarket shelves. (Used with permission)

Households can experience damage to property or losses from an extreme event affecting their homes, motor vehicles and other property (ICA, 2023). In response, households often adjust their spending patterns, temporarily redirecting their spending towards replacing or repairing destroyed or damaged property and durable goods. While this change in consumption demand can temporarily increase retail activity in affected areas, the costs of goods, labour and financing may also rise.

Businesses that rely on natural environments, such as agriculture, tourism, and fisheries, often face prolonged recovery periods. Damage to the natural resource base, ecosystems, infrastructure, or supply chains can severely disrupt operations, especially for small businesses, leading to income losses and reduced employment. These effects flow through local economies, particularly in communities that depend heavily on these industries, compounding the financial strain on households.

The unavailability of workers for regular employment immediately following an event, reduces incomes, with households relying more on savings and income support. If losses are uninsured, households may face significant declines in overall wealth.

Disadvantaged individuals and households are particularly vulnerable. Factors such as lower income, insecure employment, limited education, poor housing, advanced age, and restricted access to services are likely to lead to more severe and long-lasting impacts for these households. These conditions also reduce coping capacity and the ability to invest in adaptation. People with pre-existing health conditions, the elderly, and people with disabilities are also more susceptible to the health impacts of extreme hazards such as floods and bushfires. The 2023 National Health and Climate Strategy identifies these and other population groups as disproportionately affected by

climate-related health risks, particularly in areas with limited health system capacity (Commonwealth of Australia, Department of Health and Aged Care, 2023).

In addition to financial and physical challenges, the mental health toll can be significant. Stress, anxiety, and trauma resulting from displacement, property loss, or the financial impacts affect mental health and wellbeing. For people in regional and remote areas, limited access to mental health services can further exacerbate these impacts, hindering recovery and resilience.

Investment in risk reduction is critical to reduce systemic vulnerabilities. In 2022 the Actuaries Institute recommended a range of measures to address home insurance affordability, including investments in resilience measures for individual homes, infrastructure projects to protect communities, improved building standards, and better land use and planning (Actuaries Institute, 2022). These measures are likely to have broader cost of living benefits by reducing overall climate risk.

5.7.1 Risks to Aboriginal and Torres Strait Islander peoples

Aboriginal and Torres Strait Islander peoples have a deep-rooted connection to the land, sea, and Country, which is central to their identity, culture, and spirituality. Climate change has the potential to drive disproportionate and unique impacts on Aboriginal and Torres Strait Islander peoples' ways of life, health and wellbeing, food and water security, and economic livelihoods. The Australian Climate Service has been collaborating with Aboriginal and Torres Strait Islander peoples to identify climate risks and potential impacts, including risks to economic participation for Aboriginal and Torres Strait Islander peoples and communities (Australian Climate Service, 2025a).

According to the Australian Bureau of Statistics (2023), 19% of the Aboriginal and Torres Strait Islander population lives in outer regional areas and a further 15.4% live in remote or very remote areas. These communities are particularly vulnerable to climate hazards due to their geographic isolation, limited infrastructure, and systemic disadvantage. They face heightened risks from extreme events such as heatwaves, floods, droughts and bushfires, which can disrupt essential services and supply chains.

Aboriginal and Torres Strait Islander communities have disproportionately limited access to the financial system (Weier et al., 2019). The changing climate could reduce economic participation for Aboriginal and Torres Strait Islander peoples through impacts on industries that are exposed to climate change, including tourism, commercial fishing and cultural and conservation sectors where place-based employment opportunities rely on the health of Country. There is also a risk of continuing constraints on economic participation and potential adverse impacts for Aboriginal and Torres Strait Islander peoples from a lack of adequate representation and resourcing in nature-related schemes, for example, the nature repair market and the Australian Carbon Credit Units (ACCU) scheme (Chubb et al., 2022).

Aboriginal and Torres Strait Islander consultations point to these compounding issues posing a significant risk to their ability to benefit from future market opportunities. The extensive Indigenous estate, Indigenous science and long history of sustainably living on Country puts Aboriginal and Torres Strait Islander peoples in an unparalleled position to contribute to successful adaptation to climate change. Internationally, the IPCC's work has increasingly acknowledged the significance of Indigenous peoples' knowledge systems in understanding and addressing climate change (IPCC, 2022a).

5.8 Impacts of ecosystem change

Ecosystems provide natural resources needed for production and provide inherent resilience against natural disasters. They are also important for water quality and security, mental health, tourism and Aboriginal and Torres Strait Islander Culture. But pressures on these resources from human activity and climate change is increasing the risk of ecosystem transition.

Natural ecosystem research as part of the National Assessment (Australian Climate Service, 2025d) identifies that significant change to Australia's eco-systems is highly likely with widespread, significant ecosystem compositional change predicted. At +3°C of global warming, species will be forced to move, adapt to the new conditions or die out, with 40 to 70% of native plant species exposed to climatic conditions that they do not currently experience.

Ecosystem impacts ("Biodiversity loss and ecosystem change") appears as the second highest global risk ranked by severity over the short and long term in the World Economic Forum Global Risks Perception Survey 2024-2025 (World Economic Forum, 2025). A study by Johnson et al. (2021) estimated the collapse of specific ecosystem services – wild pollinators, aquaculture, and forestry – will reduce global GDP permanently by 2.3% by 2030 annually. This may still be an underestimate as the analysis did not model further interactions between these ecosystem services.

Several recent studies attempt to link bio-physical tipping points to industry production impacts and economic changes they are likely to cause (e.g. Romanou et al., 2025). Ecosystem transition, the significant shift in the structure, function or composition of an eco-system in response to climate pressures, has feedback impacts on climate change if the ability to absorb atmospheric carbon and mitigate the impacts of increasing greenhouse gases is reduced. In addition, permanently losing or significantly changed ecosystems will permanently change industrial structures. For example, coral reef die-off, expected even under conservative scenarios, is likely to lead to substantial changes in tourism, reducing local industrial activity in the sector. Additionally, declines in pollinator abundance, the outbreak of pests, water quality impacts, and the emergence of new diseases are likely to reduce crop yields, and could lead to pandemics. These and other impacts will be felt in the economy via reduced food and energy security, ongoing damage to assets, and increased health risks that also reduce household productivity.

Significant uncertainties remain in the process of translating ecosystem transition into economic model shocks which can then be used to approximate the impacts on the economy and its parts.

5.9 Governance risk

Governance is about how society is organised to make decisions, pursue shared goals and manage risk. Governance plays a crucial role in economic regulation by providing the framework and mechanisms for effective oversight, accountability, and transparency in the management of economic activities. Good governance ensures that regulations are implemented fairly and efficiently, leading to better economic outcomes and public trust.

The nature and timeframe of climate-driven risks are difficult for many existing governance processes and structures to handle, and proliferating impacts are adding pressure (Rickards et al., 2025). The interactions between climate extremes and social, economic and environmental vulnerabilities can overwhelm existing management and institutional capacities (Shimizu & Clark, 2015). This can happen relatively directly, such as when an extreme event overwhelms services such as emergency management or health systems, or more indirectly as impacts aggregate and compound upon the national economy or social fabric (Collins et al., 2019).

As climate change risks escalate, governments are under increasing pressure to invest in adaptation at the same time as climate-related disasters and extreme weather events result in direct and indirect costs to governments through the cost of responding to a disaster, lost tax revenue, health and wellbeing issues, and the need for investing in climate mitigation (Gao, 2024). Compounding pressures from higher costs from disasters and lower economic activity can also lead to negative fiscal consequences, and credit rating agencies and other stakeholders are increasingly examining the relationship between climate change and sovereign bonds. Climate impacts, therefore, can erode government's ability to provide services, if funds are diverted towards recovery, and may not be available for innovation or other government priorities (Steffen et al., 2019).

There is therefore a need to consider risks to governance from climate change alongside physical climate impacts. Lawrence et al. (2022) cites the "inability of institutions and governance systems to manage climate risks" as a key risk for Australia and New Zealand. The potential impacts include hazard events overwhelming the capacity of institutions and governance systems to provide necessary policy and services to mitigate risks; the resulting reliance on short term, reactive approaches can lock in maladaptive outcomes (Rickards et al., 2025). Complexities such as jurisdictional boundaries, uncertainty, dynamism, complex risk ownership and long-term effects pose significant challenges for decision-making.

The complex interactions between climate change risks and governance may contribute to conditions for significant, non-linear changes in the social contract between governments and the population ('social tipping') (Rickards et al., 2025). Governance systems and structures are slow to change, and climate change could drive significant social changes that governance systems may not be monitoring or prepared to manage. Elements that can contribute to a social tipping point include social fragmentation, declining trust in authority / institutions and rising inequality. Social tipping, or even elements that drive social changes, are likely to make it harder for the institutions that support economic stability to function effectively.

6 Adaptation to mitigate climate risk

This chapter considers how Australia can adapt to reduce the economic risks of climate change, focusing on actions that strengthen resilience across systems and sectors. It examines the current adaptation landscape, identifies critical gaps, and highlights opportunities for investment and innovation. Specifically, it covers:

- Risk reporting environment – the evolving regulatory and disclosure frameworks shaping climate risk transparency and accountability.
- Investment to reduce vulnerability and exposure – measures to strengthen infrastructure, land use planning, and community resilience.
- Adaptation gaps – systemic and sectoral shortfalls that limit effective risk management and resilience building.
- Opportunities from climate change – potential benefits and innovation pathways that could emerge as Australia transitions to a low-carbon, climate-resilient economy.

The Australian Adaptation Stocktake (also known as the [Australian Adaptation Database](#)) has been established by the National Environmental Science Program Climate Systems Hub with additional support from the Australian Climate Service (Waters et al., 2025). This is a newly established database of over 670 publicly available examples of policies, plans, projects and actions specifically related to climate adaptation across local, state and national scales in Australia. This publicly accessible stocktake is the first of its kind in Australia and is currently the most comprehensive repository of information on adaptation policies, plans, projects and actions. At this stage of analysis these data should be read as an approximation of the extent of climate adaptation action across various criteria, however, consultation and input from key government agencies provides confidence that the database includes the most relevant entries at this point in time.

Adaptation actions are categorised by system and type (Figure 30). Eight per cent of total policies, plans and laws were identified as primarily addressing the economy, trade and finance system, and 5% of the total programs and projects. From a governance perspective, adaptation policies and plans can arguably be understood as progress towards adaptation: laws and regulations create mandates for change; policies create enabling environments for both government and non-government adaptation actors and planning is essential to facilitate adaptation at all scales. Adaptation programs and projects seek to enact tangible change in response to climate driven risks.

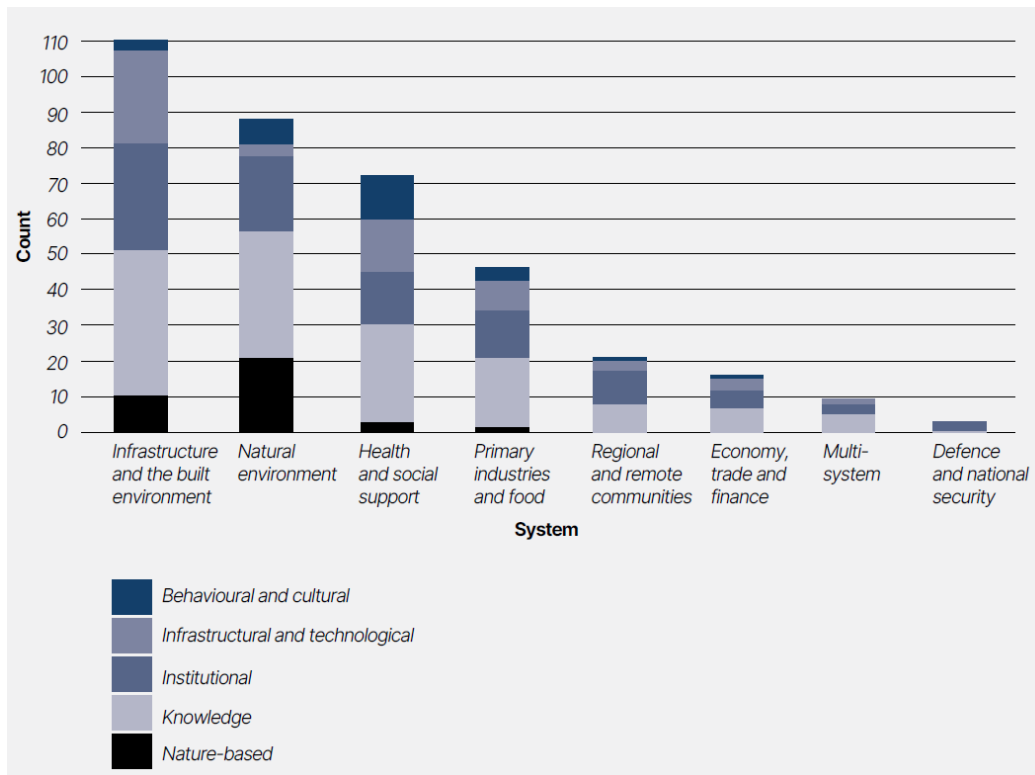


Figure 30: Comparison of adaptation actions by system, categorised by IPCC adaptation type. Source: (Waters et al., 2025)

It must be noted that there is little knowledge or monitoring and evaluation to understand the long-term effectiveness of adaptation in the system.

Stakeholder elicitation conducted as part of the National Assessment noted that decisions in the economy, trade and finance system are highly interconnected to risk in other systems. While there are only a small number of examples primarily coded to this system, as Figure 30 shows, there is a strong connection to the infrastructure and the built environment system through secondary codes.

Given the systemic nature of climate impacts on the economy an effective adaptation measure is likely to be embedding climate considerations into existing planning and policy frameworks alongside financial forecasts.

Many studies⁶ assess the ability of economies to adapt to climate shocks and their ability to recover lost output and generally conclude that developed economies can adapt to and mitigate some of the lost output from decreased productivity. This does not mean that adaptation is possible across all sectors, with some industries, such as primary producers (agriculture, mining) expected to be hit harder in the short term and take longer to recover.

⁶ For example (Brohe & Greenstone, 2007), (Deschenes & Greenstone, 2011), (Desmet & Rossi-Hansberg, 2015), (Burke & Emerick, 2016) and (Barreca, Clay, Deschenes, Greenstone, & Shapiro, 2016).

6.1 Risk reporting environment

Australia's first mandatory climate-related financial disclosure regime came into effect on 1 January 2025, (Australian Government, 2024). This law requires entities (above a threshold) to report on the climate risks they face.

On 20 September the Australian Accounting Standards Board (2024) released Australian Sustainability Reporting Standards (AASB S2) which outline what is required for entities when reporting their material climate-related financial risks and opportunities faced by the entity as well as an assessment of the entity's resilience to climate-related changes using scenario analysis (Australian Accounting Standards Board, 2025).

The Australian Government has also committed to developing best practice climate-related transition planning guidance by the end of 2025. The voluntary guidance will encourage organisations to embed climate-related risks and opportunities into broader strategic decision-making. The guidance will also emphasise the importance of adaptation to address physical risks, as well as the opportunity to leverage insights and data from the National Assessment.

These reports will provide a significant source of information and data in the future, by firms, locations and industries they belong to. The reports are also expected to drive many changes in adaptation strategies and plans among individual businesses by identifying and highlighting risks which business may be ignoring or undervaluing. Climate-related financial risk disclosure for businesses and institutions will identify individual exposures but are unlikely to uncover systemic risks which could threaten the wider economy. This means the system level risks may not be captured and business alignment to reporting requirements may not be a useful measure of industry risk.

Industries such as electricity generation, insurance and banking, which are critical to the economy, are generally made up of large companies that have sufficient resources to focus on their business continuity planning activities and conduct climate risk assessments to identify climate-related risks and invest in practical mitigation and resilience-building activities. Entities that are exempt entirely from lodging climate risk reports includes small and medium-sized businesses and asset owners that fall below size thresholds, and those that do not report under the National Greenhouse Emissions Reporting scheme (which requires them to report on their greenhouse gas emissions, energy consumption and energy production). These entities are most at risk from climate impacts due to generally higher physical concentration of assets and premises and lower ability to cope with and recover from climate shocks.

6.2 Investment to reduce vulnerability and exposure

Reducing exposure or vulnerability to risk across multiple systems will help reduce economic impacts from climate change for drivers of economic growth. Business productivity is enabled by effective critical infrastructure, and can be affected by disruptions to supply chains, power supply and telecommunications. Reducing the exposure or vulnerability of these systems will reduce risk to business and communities from climate change.

The Actuaries Institute (2022) home insurance affordability report recommends a range of measures to address the cost of insurance, including investment in resilience measures for individual homes, investment in infrastructure projects to protect communities, improved building standards, and better land use and planning. The Insurance Council of Australia's (2023) Climate Change Roadmap provides similar recommendations, stating that: "For insurers to continue to provide insurance

coverage at affordable pricing, action is required to strengthen the resilience of our homes, businesses, and communities, shift our approach to what we build and where we build it and see Australia's economy transition to net zero."

Reducing stress in the natural environment through increased protection or connectivity of ecosystems and investing in increased water security will reduce the vulnerability of primary industries to climate change, as will supporting adaptation measures to protect outdoor workers from rising heat.

Resilient infrastructure design, and climate-informed land-use planning strategies can reduce exposure, especially in coastal cities. In some cases, the option to relocate high-risk communities should be considered. More broadly, informing communities about the level of risk in their area and providing education on how to understand climate information and make good choices about adaptation will distribute the responsibility and cost of resilience.

6.3 Adaptation gaps

Measures for addressing adaptation gaps may include: incentives for investment in managing climate risk; investing in circular economy technologies to reduce environmental impacts in manufacturing; developing a stronger understanding of how to manage institutional structures to encourage autonomous adaptation; and training and subsidies to redeploy people into new sectors or enterprises that are more likely to prosper in the new climate change scenarios.

Participants in the First Pass workshop (Lin, Barnett, Bluhm, et al., 2024) on the impacts of climate change on the economy noted that:

- Existing building codes and planning schemes were deemed insufficient to effectively address climate risks. This leaves infrastructure and property vulnerable to damage from extreme weather events.
- There is a lack of robust investment in research and development for climate adaptation strategies that may hamper the development of innovative and effective solutions.
- There is an absence of tailored financial products and incentives to inform adaptation efforts, which may discourage proactive measures to enhance resilience.
- There is a need for better information dissemination to homeowners and business owners regarding climate risks. This lack of awareness could hinder preparedness and adaptive actions.
- Fostering technological innovation in sectors particularly vulnerable to climate impacts is seen as crucial for developing adaptive solutions.

The importance of engaging stakeholders and communities in the adaptation process was emphasised for more effective and sustainable outcomes. For example, Aboriginal and Torres Strait Islander consultations highlighted that Aboriginal and Torres Strait Islander peoples have deep experience in effectively mitigating and adapting to the effects of a changing climate. Better resourcing of Aboriginal and Torres Strait Islander communities and organisations to lead, co-design and deliver training on Caring for Country practices in a changing climate would support natural environment adaptation. Aboriginal and Torres Strait Islander peoples can also benefit from future market opportunities including the benefits of partnerships with local Aboriginal Land Councils, universities, the Indigenous Rangers program and the Nature Repair Market.

Stern and Stiglitz in an important investigation in 2023 noted that "contrary to much of the conventional wisdom, taking stronger action on climate change may enhance economic growth even as conventionally measured, but even more so, in terms of societal well-being" (Stern & Stiglitz, 2023).

6.4 Opportunities from climate change

While the majority of the literature and this report focuses on the negative impacts of climate change on Australia's economy, there is significant uncertainty around future hazard trajectories and impacts.

It has been noted that there may be instances and regions that could benefit from a warming climate, for example through possible changing patterns of agricultural production (Puga et al., 2022). Australia is a nation that has already had to cope with severe weather conditions and a highly variable climate even before climate change started to have an impact. Australia's experience in building resilience to reduce the impacts of bushfires, floods and droughts could be a comparative advantage. For example, investing in knowledge and technologies to deal with these impacts may create opportunities to benefit from sharing this knowledge and technologies with other countries (Climate Change Authority, 2021).

Every aspect of our society is going to be changed by the changing climate. As the climate changes unexpected new economic opportunities will arise. Australia should monitor and actively encourage innovation as it occurs in response.

7 Limitations and future work

It is not possible to provide a single quantitative assessment of the economic impact of climate change in the National Assessment, due to uncertainty in the contributing factors and lack of fully integrated impact modelling.

Modelling by The Treasury and others (for example the economic scenarios developed by Deloitte and provided in Breakout Box 1 and Appendix A) project Australia's economic growth over the next 40 years to be slower than in the past 40 years but to continue to grow in real terms (Commonwealth of Australia, 2023). While these estimates and other economic projections are methodologically sound, it is acknowledged that there are structural limitations with these projections with regard to climate risk. Experts and emerging literature note that current projections of economic growth significantly underestimate climate change impacts to the financial system and the real economy, in particular, that they do not include key factors that are likely to reduce economic growth⁷ such as:

- The approaches do not include all externalities or unknowns with the impact of sea level rise and storm surge, and likelihood of reduced biodiversity and eco-system transition being two crucial variables ignored.
- Most analysis looks at changes in averages, however, the increase in the frequency, magnitude and duration of extreme events is likely to have the greatest effect on systems.
- The approaches do not cover other sources of change, including sociological changes, which is likely to be particularly problematic, especially at higher warming levels.
- Basic assumptions about how markets are likely to function as risks compound may be incorrect.

Work by The Treasury and others continues to build our understanding of the impacts of climate change, including integrating select physical climate risks. Further assessment of impacts including biodiversity loss and assessing the potential for transmission of international risk, are required.

Methods for valuing systemic failures, such as scenario analysis methods that consider extreme events, and stress tests of financial stability (Kurian et al., 2023), could help overcome concerns about the limitations of some financial methods that assume risks can be identified and are quantifiable using historical data (Department of Home Affairs, 2019).

While the full economic costs of the changing climate are not well understood then the economic benefits of adaptation to avoid these costs are hard to quantify. Assessments of the benefits, costs, and effectiveness of actions taken to reduce vulnerability and increase resilience to climate impacts could unlock investment in adaptation that will have broad and lasting benefits for societal health and well-being.

⁷ See commentary for example from (Stern & Stiglitz, 2023), (Neal et al., 2025), (Institute and Faculty of Actuaries, 2025), (Bilal and Kanzig, 2024).

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9 Appendices

Appendix A: A summary of socioeconomic and land use change in Australia

Prepared for the Australian Climate Service by Deloitte, July 2024

Climate and hazard projections, socioeconomic pathways, storylines and case studies are essential tools to understand how risks can change through time. By combining these into different scenarios, analysts involved in the National Assessment explored a range of possible outcomes and identified the scale of risks under various conditions. This approach helps to tease out key risks, trends and characteristics of these trends. It also provides valuable information for decision-makers to inform adaptive strategies, prioritise investments, and implement policies that build resilience.

Plausible future scenarios can support decision-makers to stress-test existing strategies and plans, helping leaders to explore how their operations might perform under different futures and to test the effectiveness of adaptation strategies. For example, a coastal city might use high global warming scenarios to evaluate flood risks and plan protective infrastructure, while a business might evaluate supply chain disruptions to inform long-term planning.

To enable effective analysis and integration, scenarios for climate and hazards as well as exposure and vulnerability scenarios were utilised across the National Assessment. Three scenarios were developed by Deloitte which describe distinct but plausible futures for Australia that consider varying socioeconomic contexts and the potential role of climate damages under different levels of global warming. These scenarios depict how land use, including the built environment, and socioeconomic circumstances may change from now until 2090. These scenarios are based upon the Shared Socioeconomic Pathways (SSPs) that underpin the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6). Inputs for the socioeconomic scenarios include economic assumptions, and outputs from Deloitte's population forecasting model and D.Climate damage functions. For the land use scenarios, inputs include information on present day land use for Australia and a consideration of current Australian Government policies to guide assumptions on urbanisation, agricultural activity, and minimal land disturbance to conservation and protected areas to limit land clearing and biodiversity loss.

⁸ Although the scenarios presented in this document go to 2090, the reference to global warming levels by 2100 refers to key attributes of the input datasets, specifically the SSP climate scenario outputs sourced from Global Climate Models used to calculate climate damages and global land use narratives.

⁹ Deforestation refers only to decreasing changes in tree cover outside of protected areas. It is assumed that protected areas will remain unchanged.

¹⁰ National estimates based on aggregating 10km gridded output

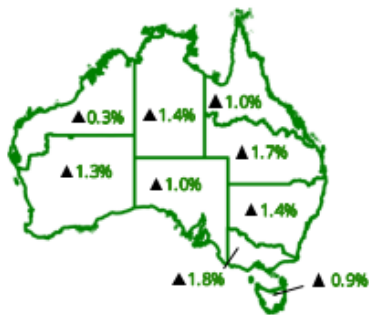
Moderate Shift | 2050

The Moderate Shift scenario is one that describes low population and productivity growth for Australia, depicting a future trajectory that aligns with a moderate global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the preindustrial period ranges from 2.1°C to 3.5°C by 2100⁸, according to global CMIP6 projections.

Moderate Shift is characterised by a slower average annual economic growth rate of 1.5% between now and 2050. All regions are projected to have lower positive growth rates relative to the other scenarios over the period. In line with a weaker profile for GDP and population growth relative to the other scenarios, household disposable income and real GDP per capita are also weaker. Under the Moderate Shift scenario, urban areas are projected to expand significantly (24%), which is notable given the slower population growth. Agricultural activity sees minimal change by 2050, with cropping activity and managed grazing expanding marginally (1.1% and 0.5% respectively), and rangelands decreasing marginally (-0.2%), suggesting only small transitions towards agriculture over this period. Deforestation⁹ occurs outside of protected areas at lower rates than other scenarios (-0.9%).

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **1.5%** per year over the next 27 years

Population is projected to grow by **7.8 million** between 2023 and 2050



6.0 million new dwellings to be constructed between 2023 and 2050

Real household disposable income is projected to grow by more than **1.5 times** between 2023 and 2050



Real GDP growth per capita is projected to rise by **0.5%** per year between 2023 and 2050

Forest area **declines by 0.9%** between 2023 and 2050



Urban areas expand by 24%, with **872.9 kha** of land transitioning to urban use between 2023 and 2050

Cropping activity uses **1.1% more land** by 2050



Managed pastures and intensive grazing uses **0.5% more land** by 2050

Rangeland grazing uses **0.2% less land** by 2050



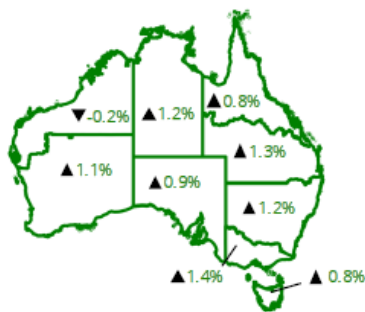
Moderate Shift | 2090

The Moderate Shift scenario is one that describes low population and productivity growth for Australia, depicting a future trajectory that aligns with a moderate global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the preindustrial period ranges from 2.1°C to 3.5°C by 2100⁸, according to global CMIP6 projections.

Moderate Shift is characterised by a slower average annual economic growth rate of 1.2% between now and 2090. All regions are projected to have lower positive growth rates relative to the other scenarios over the period. In line with a weaker profile for GDP and population growth relative to the other scenarios, household disposable income and real GDP per capita are also weaker. Under the Moderate Shift scenario, urban areas are projected to expand significantly (39.8%), which is notable given the slower population growth. Agricultural activity also expands to cover more land (however this excludes explicit consideration of agricultural productivity). Cropping activities expand (12%) disproportionately to the declines in grazing activity (managed pastures -0.9%; rangelands -1%), suggesting more land is transitioning towards cultivation. Deforestation⁹ occurs at similar rates to other scenarios.

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **1.2%** per year over the next 67 years

Population is projected to grow by **16.3 million** between 2023 and 2090



15.3 million new dwellings to be constructed between 2023 and 2090

Real household disposable income is projected to grow by more than **2.6 times** between 2023 and 2090



Real GDP growth per capita is projected to rise by **0.5%** per year between 2023 and 2090

Forest area **declines by 2.6%** between 2023 and 2090



Urban areas expand by 39.8%, with **1,444.1 kha** of land transitioning to urban use between 2023 and 2090

Cropping activity uses **12% more land** by 2090



Managed pastures and intensive grazing uses **0.9% less land** by 2090

Rangeland grazing uses **1% less land** by 2090



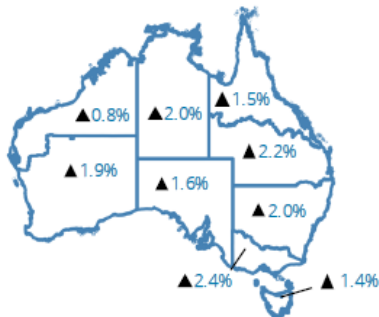
Balanced Outlook | 2050

The Balanced Outlook scenario considers moderate population and productivity growth, describing a future that aligns with a relatively low global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the pre-industrial period ranges from 1.3°C to 2.4°C by 2100⁸, according to global CMIP6 projections.

This scenario is the central scenario and is characterised by an average annual economic growth rate of 2.1% between now and 2050. All regions are projected to have positive growth rates, with Victoria and Queensland (south region) showing the strongest growth above the national average. Under the Balanced Outlook scenario, urban areas are projected to expand more slowly (17.1%) than in other scenarios. Expansion of crop areas sees greater change by 2050 (7.1%) compared to later in the century. Grazing activities see marginal decreases similar to other 2050 scenarios (managed pastures -0.7%; rangelands -0.3%). Deforestation⁹ outside of protected areas occurs at similar rates to other scenarios (-1.6%). Notably, due to opposing changes in land use across a large region, there are instances where total land use areas may appear to change only marginally.

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **2.1%** per year over the next 27 years

Population is projected to grow by **10.1 million** between 2023 and 2050



6.2 million new dwellings to be constructed between 2023 and 2050

Real household disposable income is projected to grow by more than **1.8 times** between 2023 and 2050



Real GDP growth per capita is projected to rise by **0.9%** per year between 2023 and 2050

Forest area **declines by 1.6%** between 2023 and 2050



Urban areas expand by 17.1%, with **612.4 kha** of land transitioning to urban use between 2023 and 2050

Cropping activity uses **7.1% more land** by 2050



Managed pastures and intensive grazing uses **0.7% less land** by 2050

Rangeland grazing uses **0.3% less land** by 2050



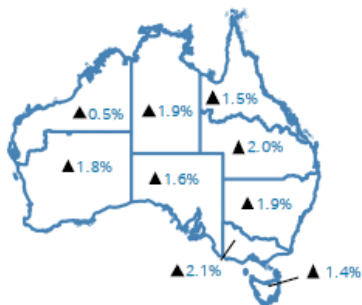
Balanced Outlook | 2090

The Balanced Outlook scenario considers moderate population and productivity growth, describing a future that aligns with a relatively low global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the pre-industrial period ranges from 1.3°C to 2.4°C by 2100⁸, according to global CMIP6 projections.

This scenario is the central scenario and is characterised by an average annual economic growth rate of 2.1% between now and 2050. All regions are projected to have positive growth rates, with Victoria and Queensland (South region) showing the strongest growth above the national average. Under the Balanced Outlook scenario, urban areas are projected to expand more slowly (17.1%) than in other scenarios. Expansion of crop areas sees greater change by 2050 (7.1%) compared to later in the century. Grazing activities see marginal decreases similar to other 2050 scenarios (managed pastures -0.7%; rangelands -0.3%). Deforestation⁹ outside of protected areas occurs at similar rates to other scenarios (-1.6%). Notably, due to opposing changes in land use across a large region, there are instances where total land use areas may appear to change only marginally.

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **1.9%** per year over the next 67 years

Forest area **declines by 2.4%** between 2023 and 2090



Urban areas expand by 21.7%, with **776.6 kha** of land transitioning to urban use between 2023 and 2090

Population is projected to grow by **23.9 million** between 2023 and 2090



Cropping activity uses **4.6% more land** by 2090



17 million new dwellings to be constructed between 2023 and 2090

Real household disposable income is projected to grow by more than **4.4 times** between 2023 and 2090



Managed pastures and intensive grazing uses **2.9% less land** by 2090

Rangeland grazing uses **0.6% less land** by 2090



Real GDP growth per capita is projected to rise by **1.0%** per year between 2023 and 2090

¹⁰At the levels of output use in

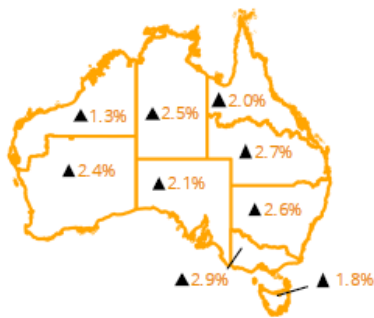
Accelerated Momentum | 2050

The Accelerated Momentum scenario corresponds to higher population and productivity growth and describes a future that aligns with a moderate global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the pre-industrial period ranges from 2.1°C to 3.5°C by 2100⁸, according to global CMIP6 projections.

Accelerated Momentum is characterised by a higher average annual economic growth rate of 2.6% between now and 2050. Under the Accelerated Momentum scenario, all regions have stronger economic growth relative to the other scenarios. In line with a stronger profile for GDP and population growth compared to the other scenarios, household disposable income and real GDP per capita are also stronger. Urban areas are projected to expand significantly (24%) by 2050. Agricultural activity sees minimal change by 2050, with cropping activity and managed grazing areas expanding marginally (1.1% and 0.5% respectively), and rangelands decreasing marginally (-0.2%), suggesting only small transitions towards agriculture over this period. Deforestation⁹ outside of protected areas occurs at similar rates to other scenarios.

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **2.6%** per year over the next 27 years

Forest area **declines by 0.9%** between 2023 and 2050



Urban areas expand by 24%, with **872.9 kha** of land transitioning to urban use between 2023 and 2050

Population is projected to grow by **12.4 million** between 2023 and 2050



Cropping activity uses **1.1% more land** by 2050



6.6 million new dwellings to be constructed between 2023 and 2050

Real household disposable income is projected to grow by more than **2.1 times** between 2023 and 2050



Managed pastures and intensive grazing uses **0.5% more land** by 2050



Real GDP growth per capita is projected to rise by **1.1%** per year between 2023 and 2050

Rangeland grazing uses **0.2% less land** by 2050



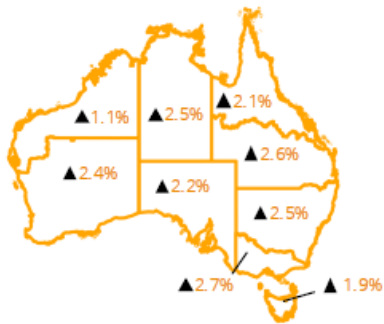
Accelerated Momentum | 2090

The Accelerated Momentum scenario corresponds to higher population and productivity growth and describes a future that aligns with a moderate global greenhouse gas emissions scenario. In this scenario, the rise in global mean temperature relative to the pre-industrial period ranges from 2.1°C to 3.5°C by 2100⁸, according to global CMIP6 projections.

Accelerated Momentum is characterised by a higher average annual economic growth rate of 2.5% between now and 2050. Under the Accelerated Momentum scenario, all regions have stronger economic growth relative to the other scenarios. In line with a stronger profile for GDP and population growth compared to the other scenarios, household disposable income and real GDP per capita are also stronger. Urban areas are projected to expand significantly (39.8%) by 2050. Agricultural activity also expands to cover more land: cropland expands (12%) disproportionately to the declines in grazing activity, suggesting more land is transitioning toward cultivation. Deforestation⁹ outside of protected areas occurs at similar rates to other scenarios.

Socioeconomic

Land use and built environment¹⁰



Average real economic growth of **2.5%** per year over the next 67 years

Forest area declines by **2.6%** between 2023 and 2090



Urban areas expand by 39.8%, with **1,444.1 kha** of land transitioning to urban use between 2023 and 2090

Population is projected to grow by **32.1 million** between 2023 and 2090



Cropping activity uses **12% more land** by 2090



18.8 million new dwellings to be constructed between 2023 and 2090

Real household disposable income is projected to grow by more than **6.6 times** between 2023 and 2090



Managed pastures and intensive grazing uses **0.9% less land** by 2090

Rangeland grazing uses **1% less land** by 2090



Real GDP growth per capita is projected to rise by **1.3%** per year between 2023 and 2090

levels by 2100 refers to key attributes of the input datasets, specifically the SSP climate scenario outputs sourced from Global Climate Models used to calculate climate damages and global land use narratives. ⁹Deforestation refers only to decreasing changes in tree cover outside of protected areas. It is assumed that non-protected areas will remain unharmed. ¹⁰National estimates based on

Scenario assumptions

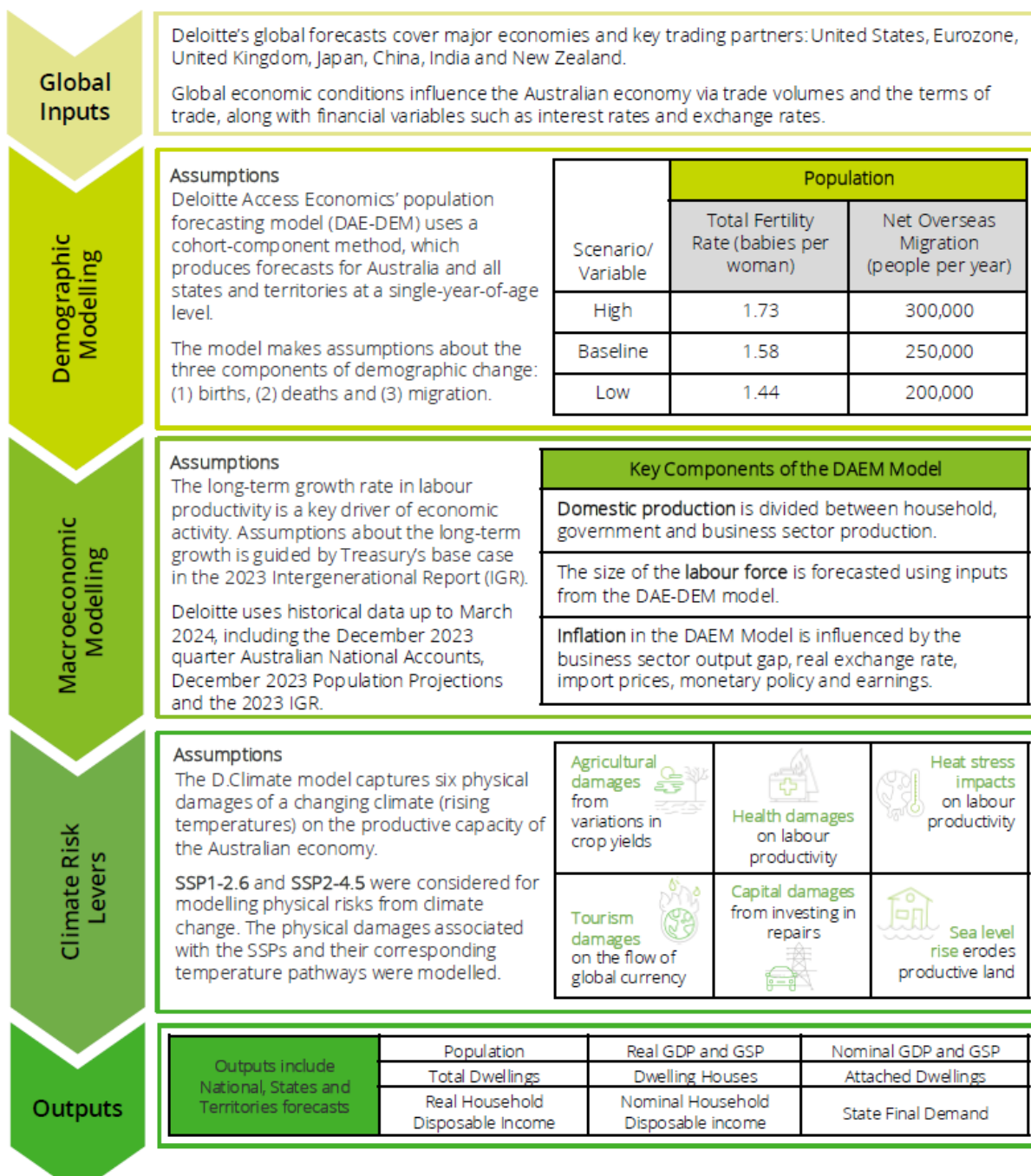
Scenario development consists of identifying the key drivers for Australia’s future development. Scenario metrics that underpin these drivers are assigned critical assumptions to guide how future conditions may evolve. In theory, there are countless future possibilities that could be used to construct insightful scenarios.

These scenarios were agreed upon through engagement with the ACS and relevant stakeholders. The scenarios are aligned with the population and productivity assumptions used by The Treasury in the Intergenerational Report (IGR). The global warming levels (GWLs) described within the National Assessment methodology report available from DCCEEW were also a consideration, namely the scenarios needed to align with 1.5°C, 2°C, and 3°C global warming which can be mapped to SSPs as described below.

Drivers	Variables	Assumption	Scenarios		
			Moderate Shift (Low)	Balanced Outlook (Baseline)	Accelerated Momentum (High)
Socioeconomic	Population	Total Fertility Rate (babies per woman)	1.44	1.58	1.73
		Net Overseas Migration (people per year)	200,000	250,000	300,000
	Productivity	Productivity Labour (productivity growth %)	0.9	1.2	1.5
	Climate Damages	Shared Socio-economic Pathways (SSPs)	SSP2-4.5	SSP1-2.6	SSP2-4.5
Land-use and built environment	Global Land Use Scenario	LUH2	SSP2-4.5	SSP1-2.6	SSP2-4.5
	GWL by 2100	CMIP6 models	2.1°C to 3.5°C (3.0°C)	1.3°C to 2.4°C (2.0°C)	2.1°C to 3.5°C (3.0°C)
		IAM models	2.6°C	1.8°C	2.6°C
	Urbanisation	Population Count	Expansion of built-up area is a function of population growth from socioeconomic scenario outputs		
	Land use narrative	LUH2	Decreased forest extent and increased cultivated land before 2050	Increased bioenergy use; forest restoration; reduced agricultural land	Decreased forest extent and increased cultivated land before 2050
	Land use regulation		Medium	Strong	Medium
	Land productivity	Incl. yield increases and livestock intensification	Medium	Rapid	Medium
	Environmental impact of food consumption	Incl. food demand and fertilizer use	Medium	Low	Medium
Environmental protection		All scenarios assumed that current conservation and protected areas remain unchanged.			

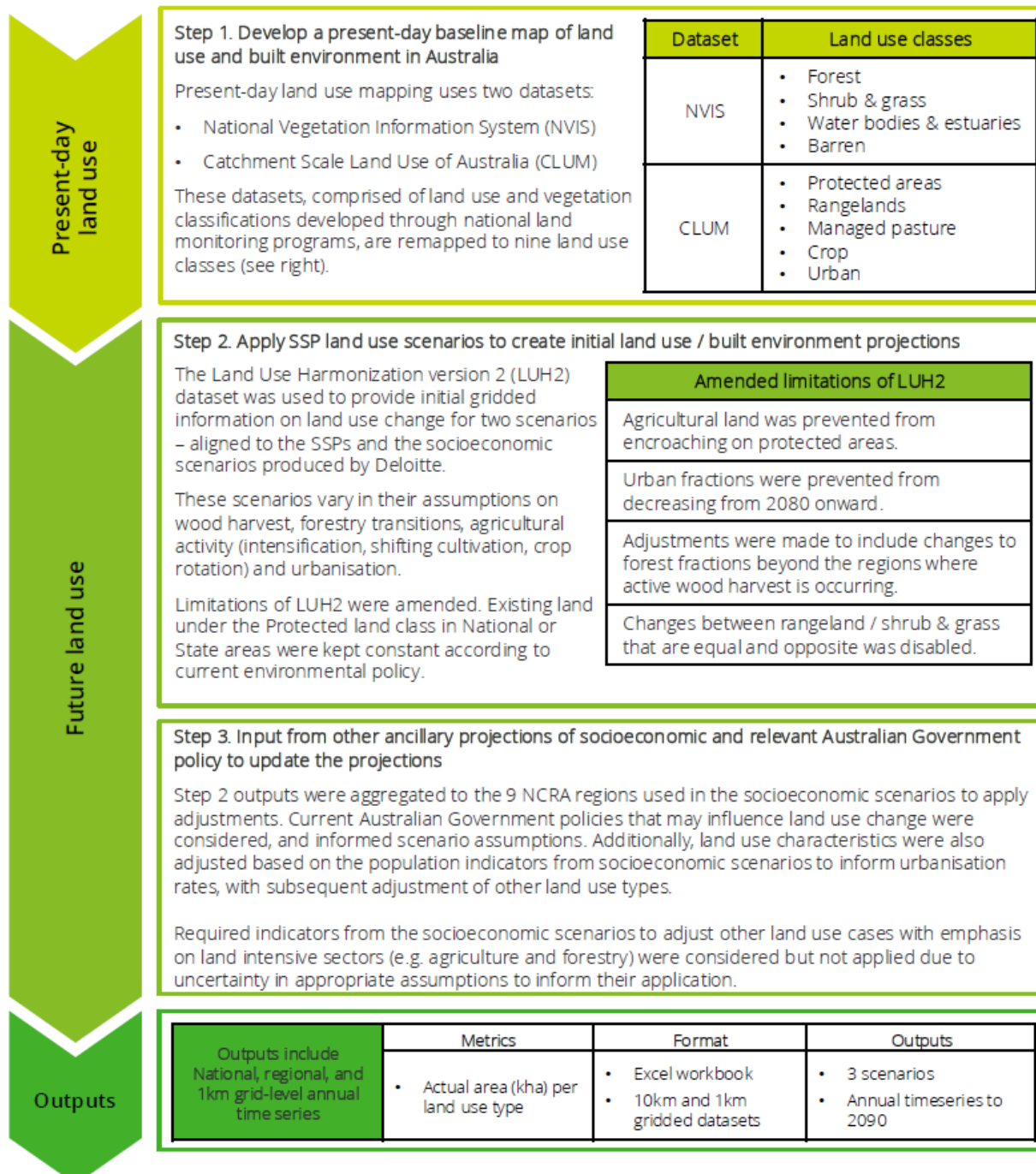
Socioeconomic scenario method

Deloitte’s approach to produce long term socioeconomic scenarios for the National Assessment involved leveraging a framework, similar to The Treasury’s 3Ps (Population, Participation and Productivity) approach. Deloitte’s framework defines the productive capacity of the Australian economy based on the key datasets and assumptions for each variable, whilst also accounting for climate change related physical damages to the Australian economy. The methodology involved a three-step modelling process, using the outputs of two supporting models – the Deloitte Access Economics Demographic Model (DAE-DEM) and D.Climate model – as inputs to the primary Deloitte Access Economics Macroeconomic Model (DAEM).



Land use and built environment scenario method

Long-term changes to land use and the built environment will inform the assessment of the National Assessment priority climate risks as these changes may influence future vulnerability to physical climate-related hazards. For this, Deloitte produced long-term projections that described changes in land use under different future scenarios. Deloitte’s approach involved developing a baseline map of present-day land use, before applying global land use scenarios to inform more granular information of land use change over different timeframes. These projections were then updated with inputs from the ancillary socioeconomic scenarios and guided by relevant policy.



Limitations and caveats

Socioeconomic Scenario Development

The methodology outlined for the development of the socioeconomic scenarios allows Deloitte to produce internally consistent long term socioeconomic scenarios at the national and state and territory levels. However, due to the accelerated timeframe, the approach does have limitations and some elements are excluded from the modelling framework. These include the following:

1. Potential trade effects of proposed industry policy such as the Inflation Reduction Act in the United States, or the Green Industrial Deal in the European Union are excluded.
2. Potential effects of international climate policy such as the EU Carbon Border Adjustment Mechanism (CBAM) are excluded from the modelling.
3. All transition risks to Australia from climate change, such as the risk of price fluctuations or the risk of stranded capital, are excluded from the modelling. Only a subset of climate damages incorporated into the D.Climate modelling framework are included.
4. It is assumed that physical risks impact economic activity by eroding growth in labour productivity as well as growth in exports of some commodities, such as agricultural commodities, and some services, such as those associated with tourism.

Land Use and Built Environment Scenario Development

The development of the land use and built environment scenarios may possess some limitations in how the land use scenarios can be applied in climate risk assessments. These limitations include:

1. Regional estimates and meaningful time series analysis are potentially affected by the compensating changes in increases and decreases as some land use types shift to new areas and due to the need to reconcile estimates to the same total land area of Australia.
2. The LUH2 dataset had a number of limitations, especially for the Australian context including expansion of agricultural activity into protected areas and forest cover changes limited to current forestry activities. Efforts have been employed to correct a number of these while the accelerated timeframe limited the ability to resolve others. Namely, blocking artefacts become apparent when comparing year to year changes in the land use types rather than the absolute values which is a feature of LUH2.
3. Ensuring land fractions sum to 1.0 in each grid cell necessitated a number of adjustments to limit counting land areas more than once. In this process, only land use fractions for Shrub & grass, Rangelands, Managed pasture, Crop and Forest were updated through this process after adjusting urban areas to align with the population growth of the socioeconomic scenarios. The updates were applied sequentially according to priority (as informed by policy assumptions).
4. The methodology applied to create 10km and 1km gridded land use scenarios for Australia, inherits many of the transitions of the main scenario input from LUH2. Therefore, land use transitions from LUH2 dominate over the adjustments applied to reconcile with metrics from the socioeconomic scenarios.
5. Some processes require more detailed modelling to enable an evaluation of the influence of sea level rise on land availability, vegetation productivity changes and distribution changes due to climate change and more complex urban categories. These influences have been excluded when developing the estimates provided within this dataset.

Appendix B: Natural and built domain scenarios

Prepared for the Australian Climate Service by Deloitte, July 2024

To inform the assessment of the priority climate-related risks identified by the National Climate Risk Assessment (National Assessment), it is necessary to consider how changes in land use and the built environment may influence future exposure and vulnerability to physical hazards associated with climate change. Global land use and built environment scenarios that align to leading practice exist, such as those which informed the findings of the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6). However, these scenarios are at the national level and given Australia's size and diverse climate, it is necessary to develop sub-national projections. The Australian Government's policy positions are likely to directly or indirectly influence future activities in agriculture, reforestation, and biodiversity conservation over time. There is, therefore, important to develop a new set of scenarios relevant to the Australian context, to enable a deeper characterisation of future risk, and to understand how the determinants of climate risk may change along with socioeconomic and land use factors.

Historical land use change in Australia is predominantly associated with agricultural intensification (DCCEEW, 2009). Policy changes and competing demands for land (e.g., urbanisation associated with population growth) are expected to influence future changes to the agriculture sector, including changes in land management practices and choices around commodity type (Williams, et al., 2021, p.64). Most of the Australian population reside in capital cities, wherein population growth is the primary driver for urbanisation (ABS, 2016). Most state and territory governments have policies that preference urban infill over urban sprawl – with this likely to influence the expansion of urban extent at the expense of other land uses. Environmental policy, such as the Australian Government commitment to protect and conserve 30% of Australian land by 2030 (DCCEEW, 2022), can further guide assumptions on future land use transitions. This includes protected areas and forested regions, which are important to reconcile with current policies and targets concerning greenhouse gas (GHG) emissions and the pursuit of a net zero economy.

The scenarios described in this report are informed by historical land use data. While historical data collection methods on land use are varied across Australia, the prevalence of land use data derived from remote sensing satellite imagery has recently allowed collection of more detailed data and more specific classifications. For example, the built environment can now be delineated into more specific types (e.g., commercial vs. residential), and on finer scales than previously available (Demuzere, et al., 2022). This can serve as a useful basis for understanding land use today. When considering future land use change, uncertainty exists and therefore the scenarios provide information on broader land use classes and fractional estimates rather than the detailed land use classifications that characterise current land use in Australia.

The SSPs depict five alternate futures where different socioeconomic circumstances are assumed and present challenges to climate adaptation and mitigation (O'Neill et al., 2014). For further information on the different SSPs, refer to Appendix A. The scenarios developed in this report are informed by two of the five SSPs, specifically SSP1-2.6 and SSP2-4.5, with key characteristics summarised in the table below. This selection was agreed with the Australian Climate Service.

The SSP1 pathway, corresponding to SSP1-2.6, describes a future with strong global socioeconomic development, supported by sustainable energy pathways. Under this scenario, it is assumed that income and living standards will rise globally over the century, and inequality will decline. Strong economic growth is projected to occur with more predominant consumptive changes

for multiple primary production sectors. This includes assumptions such as a reduced global demand for meat products. As nations develop, it is assumed that pollution controls will be enacted and GHG emissions will decline in the long-term.

The SSP2 pathway, corresponding to SSP2-4.5, denotes similar trends, but under conditions where changes are slower to occur. Under this scenario, consumption is expected to rely largely on non-renewable sources of energy, and resource-intensive livestock industries will flourish under moderate global population growth and wider global income inequality. Fossil fuel reliance is assumed to remain similar to present-day levels, consequently raising GHG emissions over time. Increasing mitigation efforts to reduce GHG emissions would occur at slower paces than under SSP1, with a notably greater lag between developed and developing countries.

	Land use change regulation	Land productivity growth	Environmental impact of food consumption	International trade
SSP1	Strong and effective regulation globally to avoid environmental trade-offs	Rapid growth in low-medium income countries, medium growth in high-income countries	Low growth in consumption, lesser demand for meat	Moderate, with connected markets and international cooperation
SSP2	Medium regulation, deforestation decreases only slowly	Medium rate of technological change	Material-heavy consumption, medium meat consumption	Moderate, with partially open globalised economy; delayed international climate cooperation

Future natural domain key results

The three scenarios produced throughout this process provided different potential futures of land use change in Australia.

Under both SSP2-4.5 (low and high) scenarios, more land overall is used for human-intensive purposes. Urban areas are projected to expand significantly, which is notable given the slower population growth. Agricultural activity is also projected to use more land, with declines in grazing land disproportionately small compared to the expansions in cropland. Due to the statistical downscaling approach taken, both scenarios show similar results for national estimates, with differences only becoming more apparent for smaller regions.

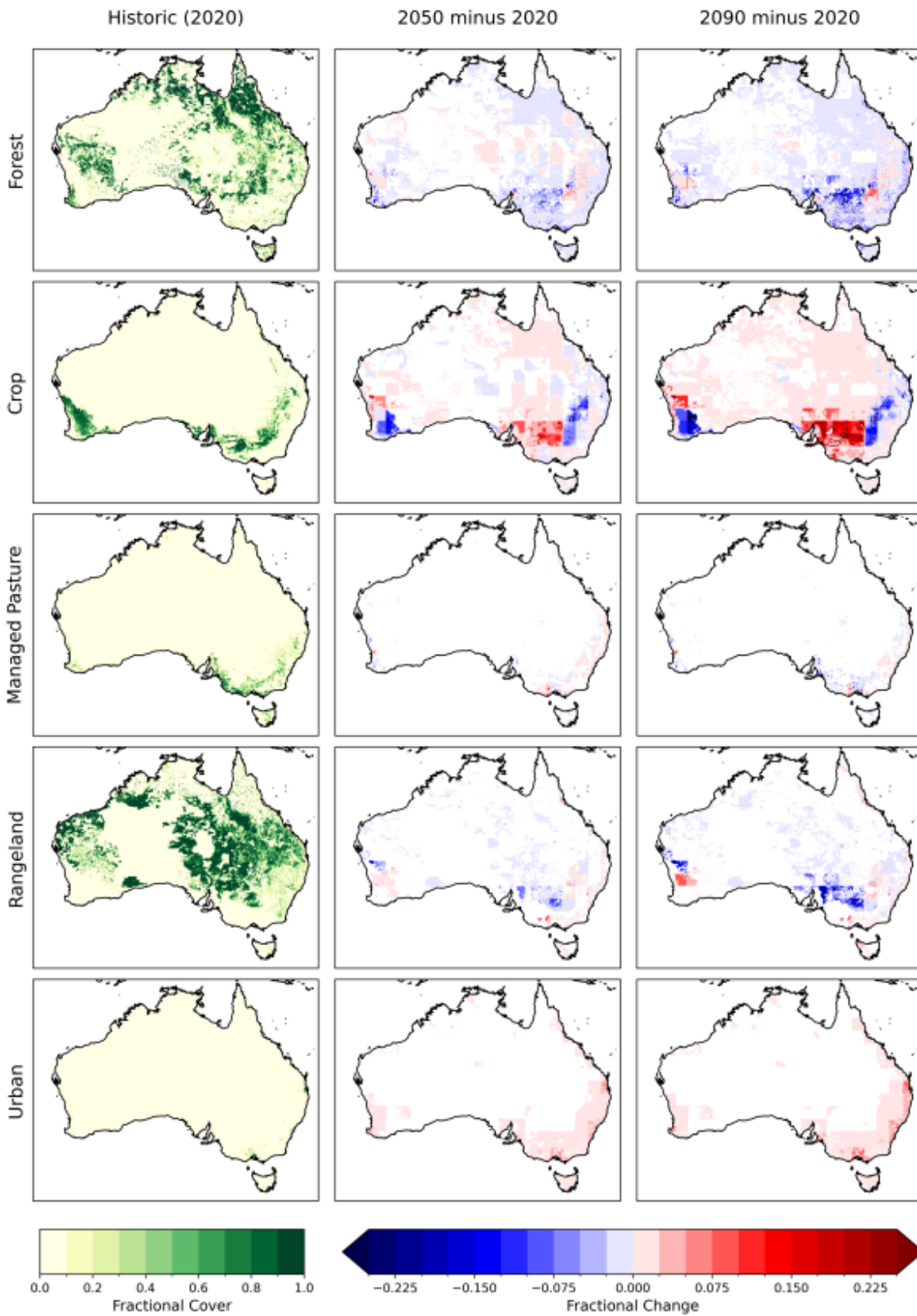
Under the SSP1-2.6 Base scenario, urban and cultivated areas are projected to expand slower than in other scenarios. Forest area declines (outside of protected areas) at roughly the same rate across all three scenarios. Due to opposing changes in land use across a large region, there are instances where total land use areas may appear to change only marginally.

More detailed results are provided in the Deloitte technical report to ACS.

Attribute	SSP1-2.6	SSP2-4.5
SSP narrative	Sustainability	Middle of the Road
Global warming level by 2100 - CMIP6 Models	1.3 to 2.4°C (2.0°C)	2.1°C to 3.5°C (3.0°C)
Global warming level by 2100 - SSP IAM Models	1.8°C	2.6°C
Global population by 2050	8.53 bn	9.17 bn
Global population by 2100	6.96 bn	9.03 bn
Land use narrative	<ul style="list-style-type: none"> Increased bioenergy use in combination with carbon capture and storage, avoided deforestation policy, and restoration of degraded forests to limit biodiversity loss. The combination of socioeconomic trends and climate policy results in substantial reductions in total agricultural land. At the same time, large areas are dedicated to bioenergy production, and forest extent increases. 	<ul style="list-style-type: none"> Initial decrease in forest extent out to 2050 with a subsequent increase from 2050 to 2100. Increase in cultivated areas at with some conversion of pasture areas for energy crops although at a lower rate than SSP1.
Urbanisation	Fast urbanisation in all countries with high income growth but aligned with sustainability aspirations.	Centralised urbanisation at moderate pace associated with moderate income growth.
Energy composition	<ul style="list-style-type: none"> Declining coal and oil ca. 2030 onwards, supplemented with some growth in gas over 2040 to 2070. Strong increase in renewables to 2050 with increase in bioenergy. 	<ul style="list-style-type: none"> Declining coal and oil ca. 2030 onwards, supplemented with growth in gas to 2070. Strong growth in renewables, particularly after 2050.

Future Change

(GWL by 2100: 2.1°C to 3.5°C)



Appendix C: Expert interviews

Prepared for the Australian Climate Service by Finity, August 2024

Consultations with key stakeholders across the ACS and relevant National Assessment working groups as well as other risk teams and representatives of DCCEE were conducted to identify subject matter experts to interview and capture their expert views.

Expert interviews focused on impacts of physical climate risks on the real economy, trade and finance system. The central question of the interview was “What are the expected impacts of current and future to 2050 and 2090 physical climate risks in the different parts of the real economy, trade and financial sectors of the overall economy?”

In addition to property losses, businesses and industries experience several different types of losses and impacts to their abilities to continue to provide goods and services to their customers as a result of climate events and natural disasters. Experts were asked about their views on the following categories of impacts:

1. **Production interruption:** when businesses are not able to produce goods and deliver services to their customers for any reason for any length of time it causes irreversible damage to business performance. It also frequently leads to businesses having to stand down employees or use productive worktime for other not productive activities. The costs of this risk are traditionally measured in terms of lost revenue. Lost production time which can be translated into lost revenue terms using average production per days, weeks or months.
2. **Costs of cleanup:** natural disasters and related damage requires clean up in terms of expenditure on services to help this process as well as dedicating the required hours, days, weeks or months required to bring facilities up to acceptable specifications to enable production to resume. Cleanup activities can also be performed by employees of the business in which case time is again diverted from production activities which can be measured by lost revenues.
3. **Capital destruction:** capital assets other than buildings may be damaged or even destroyed by impacts of natural disasters. These assets can include vehicles, specialised machinery and equipment used in the delivery of products and services. Loss of specialised often imported assets in particular could mean that businesses may experience longer suspensions in operations as such assets may take some time to be produced, delivered and installed. In addition, destruction of natural capital assets tied to specific production activities could lead to long recovery periods and even to permanent loss of production opportunities.
4. **Stock destruction:** Businesses frequently keep stockpiles of their products on premises to be able to satisfy sudden shocks in demand or to fulfill large or long-term orders to effectively manage their delivery contract obligations. These may be destroyed as a result of natural disasters and extreme weather events. This destruction is very costly because it involves destroying completed and sometimes already sold products which creates additional pressures on businesses to renew production as soon as possible to be able to deliver these.

5. **Supply chain delays:** in case of disrupted deliveries of inputs and outputs may have a similar impact to production interruptions. These impacts could also occur unexpectedly and to businesses that have not been directly impacted by disaster or extreme weather events when businesses that supply their products to the rest of the economy are impacted directly. These delays could be additional to supplies of capital assets discussed previously. Production revenues and time lost can be quantified in addition to opportunity costs of production.
6. **Facility recovery, reconstruction and rebuild:** varying levels of damage to buildings and assets drive the expenditure required for damage. Individual businesses and industries are exposed to these impacts in different ways depending on their locations, ability to move their operations and their business models. Some industries may not be impacted, some may be impacted temporarily until they find new premises, and some may require facilities to be rebuilt or reconstructed which may involve additional time depending on individual cash position and insurance cover.
7. **Capital recovery and reinvestment:** availability of investment capital and availability and affordability of insurance cover play an important role in the recovery process. Banks and investors may require higher level of returns due to higher risks of continuing business operations in the future. They account for additional risks when investing in businesses that are more susceptible to natural disasters and understand that such businesses could become constrained in the future. Insurers demand higher premiums from businesses previously impacted by extreme weather events as they also understand the increased likelihoods of these risks. Both investors and insurers should also understand that building in elements of resilience into the recovery process reduces future risks.

The second part of the interview focused on the severity of impacts described previously to enable interviewees to discern between recoverable and non-recoverable shocks to business and industrial operation as illustrated in Figure 31. This approach has been chosen in an attempt to create specification analogous to the system tipping points in other streams of the National Assessment. The two distinct questions that were used for this delineation were

- 1 What would be an impact to industry revenue of a temporary (recoverable) shock to industrial production? – to illustrate recovery where the no resilience actions required and the recovery would be sustainable
- 2 What would be an impact to industry revenue of a prolonged (non-recoverable) shock to industrial production? – to illustrate a recovery where additional actions are required including to prevent permanent future issues

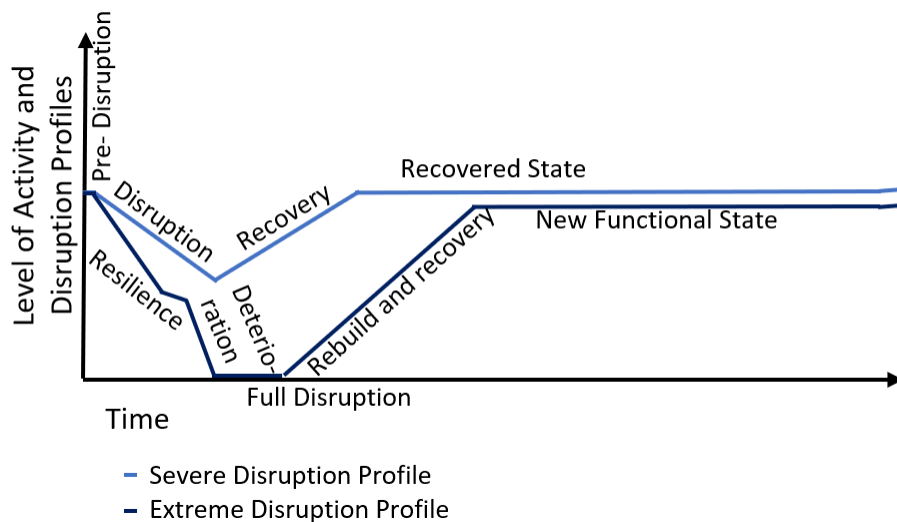


Figure 31: Recoverable interrupted and non-recoverable disrupted profiles. Source: Finity, 2024

Interviewees responded to this delineation of potential impacts with further clarification questions as not many considered these types of differences between idiosyncratic and systematic shocks to industry production previously.

Over 25 experts were interviewed including representatives of:

- Australian Bureau of Statistics
- Reserve Bank of Australia
- Australian Prudential Regulatory Authority (for insurance risks)
- Commonwealth Department of Climate Change, Energy, the Environment and Water
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Commonwealth Department of Industry, Science and Resources
- Australian Bureau of Agricultural and Resource Economics and Sciences
- National Emergency Management Authority
- Climate Change Authority
- Government of South Australia
- Government of Tasmania
- Government of Queensland
- Government of Australian Capital Territory
- University of Melbourne
- University of New South Wales
- Australian National University
- University of Adelaide
- Australian Energy Council
- Investor Group on Climate Change
- Ai Group

NOTE: experts were interviewed on their area of expertise, so not all experts contributed to all interviews.



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