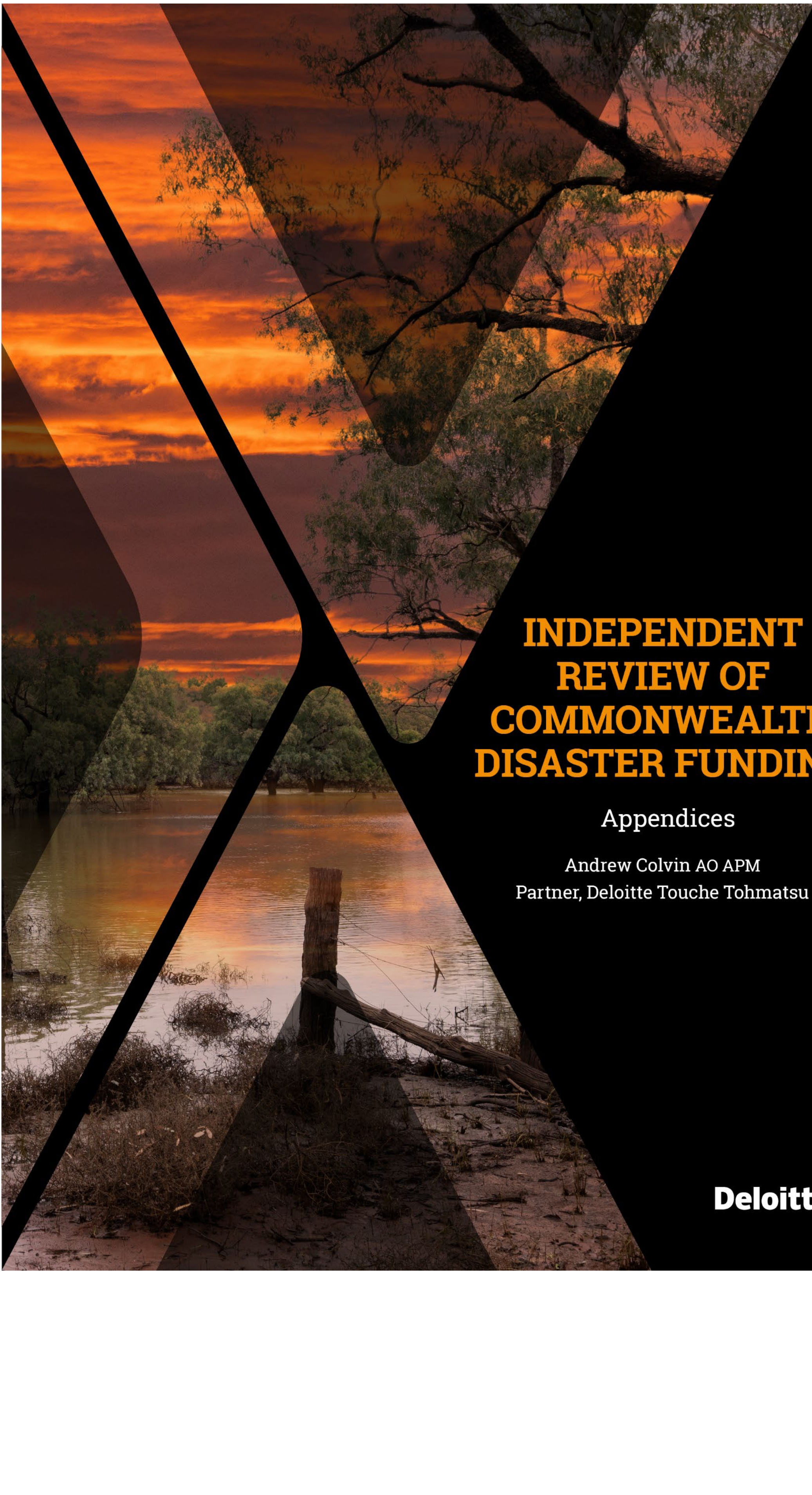

INDEPENDENT REVIEW OF COMMONWEALTH DISASTER FUNDING

Appendices

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Foreword

The following Appendices have been constructed as a companion to the Independent Review of Commonwealth Disaster Funding (the Review). The Review examined the Commonwealth's natural disaster funding arrangements to identify areas of reform which would enable a scalable, sustainable, effective, equitable, transparent and accessible system. These Appendices outline the methodologies and data used by the Independent Reviewer and the supporting teams to reach these outcomes.

Appendix A outlines the Terms of Reference for the Review, as established by the Minister for Emergency Management, which guided the actions of the Independent Reviewer and his support teams.

Appendices B through G outline the methods, data sources and principles which guided the various streams of work within the Review. These included both quantitative and qualitative research methods.

Appendix B provides a holistic narrative for the Review's process, including explanations of the various workstreams and their objectives. These workstreams are then further detailed in the following appendices.

Appendix C explains the lines of enquiry which were developed to support the Review's analysis of disaster management and funding arrangements, notably in the stakeholder engagement and research and insights streams.

Appendix D provides an outline of the works undertaken in the stakeholder engagement workstream. It dictates the methodology and sources used, as well as presenting findings and references. This stream includes First Nations engagements, public submissions to the Review, the local government survey and the range of other engagement activities which were conducted on a more targeted basis. These include one-on-one interviews and focus groups.

Appendix E describes the research and insights workstream – which undertook a systematic literature review, grey literature review and comparative case study and comparative analysis of the current state and leading practice. This Appendix provides the methodology and rationale for each of these components, as well as presenting their sources and findings.

Appendices F and G explain the two quantitative analysis workstreams: the financial and economic modelling and analysis workstream, and the climate scenario and analysis modelling workstream. Both appendices provide detail on the methodologies for the various types of analysis conducted, present their findings and provide a list of sources and references.

Contents

Appendix A: Terms of Reference

This appendix presents the Terms of Reference underpinning the Review.

Objective

The review will consider how Commonwealth arrangements for disaster funding can be optimised to support a system that is fit-for-purpose to support wellbeing, national productivity, prosperity and economic security and maintains state, territory and local government roles and responsibilities in the context of the projected increase in natural disasters over the coming decades.

Context

Disasters cost the Australian economy $38 billion per year (on average). The severity, intensity and frequency of natural disasters is expected to increase, putting further strain on Australia's relief, response and recovery capabilities. By 2060, the cost of disasters could rise to at least $73 billion per year (Deloitte 2021).

Managing the risks of, and responding to disasters, including the provision of relief and recovery assistance to disaster affected communities, is primarily the responsibility of state and territory governments (states). However, these events can often result in significant and overwhelming costs to the states, which impact on and exceed their capacity to cope. In these instances, the Australian Government supports and complements state disaster arrangements. Through this role, the Australian Government has an opportunity to provide incentives to the states to more effectively manage risks to reduce the impact and overall costs of disasters.

It is timely to consider how Commonwealth, state and local disaster funding should support a system that is fit-for-scale for the transformation needed to build resilience to the types of extreme events Australia is projected to experience due to climate change over the coming decades. As well as ensuring the current system can respond to our increasing natural disaster risk in the future, there is a need to capitalise on existing response and recovery funding and harness opportunities for increased investment from all sectors to reduce risk and make disaster-affected communities more resilient to future natural disasters.

The Commonwealth has a leadership role in ensuring all governments, the private and not-for-profit sectors are working together to make Australian communities safer in the face of growing natural disaster risk.

Matters to be considered by the Review.

The review is to consider and report on:

- The Commonwealth arrangements for funding disaster risk reduction, preparedness, response and recovery and identify the areas of reform required to ensure they support a system that is scalable, sustainable, effective, equitable, transparent and accessible.
- Options to embed resilience and risk reduction into response and recovery funding and how the Commonwealth can incentivise states and territories to better manage risks and mitigate recovery costs.
- Options within Commonwealth, states and local governments (including cost sharing) to encourage greater investment in disaster risk reduction and resilience to help constrain growing disaster recovery costs.
- Areas of further work (outside of the scope of the review) that would help to enhance Australia's overall disaster risk reduction, recovery and response efforts, including through the private sector.

This will include an examination of:

- Australia's funding environment, in the context of the multiple natural disasters over the last three years and the projected escalating costs of recovery due to the likely increase of natural disasters.
- Areas of duplication/gaps/opportunities to streamline funding to align with best practice.
- Processes, protocols and guidelines (e.g., funding activations, evidence and eligibility criteria, audit requirements).
- Commonwealth investments in other portfolios (as determined by the Review) which deliver disaster resilience outcomes and how transparency and reporting can be improved to provide a more complete and accurate picture of Commonwealth investment.

The review should also have regard to:

- The role, responsibilities and capacity of the Commonwealth, states, and local governments (including cost sharing).

The review will look specifically at Commonwealth funding but may consider other disaster funding where relevant to the objectives of the review.

Process

The review will address the Terms of Reference through analysis of outcomes from any current and forthcoming reviews, existing bodies of evidence and any consultation to date in relation to the following, but not limited to:

- Disaster Recovery Funding Arrangements,
- Australian Government Disaster Recovery Payment,
- Disaster Recovery Allowance,
- Existing and emerging NEMA administered program funding,
- Existing and emerging program funding administered by other Commonwealth Agencies,
- Disaster and resilience funding programs cost-shared with and administered by states and territories and local government, and
- Other disaster or resilience funding programs the Review considers relevant.

The review will consult across the Australian Government, with states and territories and local government and with representatives from the business, industry and not-for-profit sectors.

Governance

- The Prime Minister is responsible for agreeing the Terms of Reference for the Review.
- The Minister for Emergency Management (the Minister) is responsible for:
    - appointing an Independent Reviewer, based on advice from NEMA in consultation with central agencies.
    - promoting engagement with key stakeholders, including the states, by writing to the National Emergency Management Ministers Meeting (NEMMM) about the review
    - guiding direction of the review.
    - bringing forward updates to Government.
- The Independent Reviewer is responsible for:
    - conducting the review.
    - consulting with key stakeholders including states.

    - providing updates to the NEMMM and the Australia-New Zealand Emergency Management Committee (ANZEMC), through the Minister, and other Ministerial Committees as required.
    - providing updates to the Inter-Departmental Committee and seeking advice as required from the group.
    - delivering a progress, interim and final report to the Minister.
- ANZEMC/NEMMM – will receive regular progress reports and support as requested. Where needed, reports will be provided to other national Ministerial Meetings.
- The Inter-Departmental Committee (IDC) will:
    - be chaired by NEMA's Coordinator General, with officials (Band 2 SES) from impacted agencies (NEMA to determine the membership).
    - provide oversight and delivery of the review.
    - review the Terms of Reference, Project Plan and Stakeholder Consultation Plan.
- The Review Secretariat will:
    - be established within NEMA to support the Independent Reviewer with policy and stakeholder advice (the secretariat may include secondees from other departments)
    - project manage the review.
    - coordinate with other parts of government, including coordinating the IDC.
- An external consultancy will be engaged to support the work of the Independent Reviewer, provide surge capacity to the Review Taskforce and undertake other relevant activities as determined by the Review Taskforce.

Timeframe

The review is likely to take up to 18 months, with a progress report due in March 2023, an interim report due in September 2023 and a final report due in April 2024.

Appendix B: Methodological approach to the Review

The purpose of *Appendix A* is to provide an overview of the methodological approach taken by the Independent Reviewer and supporting Deloitte team – in collaboration with the NEMA Review Taskforce – to execute this Review.

The Terms of Reference for the Review (*Appendix B*) are systemic in nature, which informed the selection of a mixed-methods approach. While method "workstreams" were used to organise a comprehensive approach to answering the Terms of Reference, execution of the methods, analysis and synthesis of findings was connected throughout to ensure the work was multi-disciplinary and the findings integrative. In addition to the methods executed by the Deloitte team and the NEMA Review Taskforce, the Independent Reviewer used the Terms of Reference throughout to guide his own activities and direct evidence gathering at his discretion.

The method streams were the following. An overview of the approach taken by each of these workstreams is provided in the sub-sections of *Appendix A* below.

- Stakeholder engagement:
    - Public submissions collected through the NEMA website and other channels,
    - Focus groups with a cross-section of relevant sectors and interests,
    - Interviews with senior officials in Commonwealth, state, territory, private sector, and international entities,
    - An online survey extended to all Australian local governments, and
    - First Nations people and communities.
- Research and insights:
    - Systematic academic literature review,
    - Review of grey literature,
    - Comparative case study review and comparative analysis,
    - A funding pathway desktop review, and
    - Legislative and policy analysis.
- Financial and economic modelling and analysis:
    - Historic and committed financial analysis of Commonwealth administered funding,
    - Forecast baseline for total cost of natural disasters and Commonwealth funding estimate in 2050,
    - Policy options assessment, and

    - Multi-criteria analysis of policy options.
- Climate scenario analysis and modelling:
    - Climate scenario analysis, and
    - Providing climate overlay for economic modelling of future costs.

All workstreams structured their work according to two devices: tranches and lines of enquiry.

Tranches

Tranches (or phases) organised the process of evidence gathering, synthesis, and analysis over the course of the Review.

The first and second tranches supported the broader objectives of the Review, including identifying whether the funding environment adequately serves its purpose from the perspective of a diverse range of stakeholders, as well as exploring opportunities to align Commonwealth arrangements.

Tranche 1

The objective of tranche 1 was to gather an initial picture of the current state of disaster funding in Australia and forward-planning for the rest of the Review. This included gathering information and data while undertaking detailed planning for subsequent phases of evidence gathering. The lines of enquiry were devised from the Terms of Reference. The Independent Reviewer was introduced to critical state, territory, and Commonwealth stakeholders and the first stakeholder engagement plan was drafted.

Led by the NEMA Review Taskforce, the Commonwealth compiled the Disaster Resilience Funding Dataset (Funding Dataset) through consultations with relevant Commonwealth departments and agencies. The funding dataset formed the basis for subsequent analysis of Commonwealth investment in disaster. The associated deliverable was the Progress Report, which provided a 'state of the system' perspective and served as the basis for narrowing areas for further enquiry, as deemed relevant by the Independent Reviewer.

Tranche 2

The objective of tranche 2 was to assess the effectiveness of current Commonwealth funding arrangements. This included gathering a greater depth of evidence associated with the issues of importance, identified by the Independent Reviewer. The associated deliverable for tranche 2 was the Interim Report.

To gather quantitative perspectives on the totality of Commonwealth funding for disaster, the financial and economic modelling and analysis workstream analysed historic data on Commonwealth administered funding. They also identified case studies of initiatives undertaken across the disaster continuum, provided by stakeholders, to build a model for executing future policy modelling. Research included a systematic academic literature review, grey literature review, comparative case study review and comparative analysis, funding pathway desktop review, a legislative and policy analysis and other ad-hoc and mapping activities required. In addition to informing the Independent Reviewer, the findings from research activities informed design of stakeholder engagement agendas and issues or ideas for discussion.

Stakeholder engagement in tranche 2, involved 32, two-hour online focus groups. Each contained between six to thirty-five participants. These focus groups were held with:

- Representatives from every state and territory government,
- Local government associations in every state and territory to represent the views of their members, supported with a small selection of local government case studies which had experience using Commonwealth funding arrangements, selected with the NEMA Review Taskforce,
- Private sector, industry peak bodies and companies for sectors directly impacted or playing a role in disaster management, and
- Community organisations, not-for-profits, and peak bodies.

Focus groups were accompanied by the dissemination of a structured online survey to all Australian local governments, devised in response to a high level of interest from the local government sector to input to the Review. Public submissions were submitted through the NEMA website by answering five questions on specific areas of interest to the Review. The Independent Reviewer undertook interviews as he required.

Tranche 3

The objective of tranche 3 was to continue and finalise analyses, and to develop, socialise and finalise recommendations which addressed the Terms of Reference.

Representatives from Commonwealth departments and agencies were engaged to provide their perspectives and to reflect on perspectives provided from other stakeholders in tranche 2. Financial and economic analysis of historic Commonwealth administered disaster funding was socialised with Commonwealth and state and territory stakeholders as part of this process.

Additional engagement was also undertaken to address gaps identified from tranche 2 by the Independent Reviewer. A targeted selection of peak bodies, representing higher-risk cohorts, were also engaged to ensure perspectives of vulnerability were appropriately and adequately represented. The Review considered higher-risk cohorts to be groups of people who were at a greater risk of being affected by natural disasters on a short-, medium- and long-term basis, due to socioeconomic, cultural and systemic factors. This included but was not limited to, First Nations peoples, people with a disability, women and children, the LGBTQ+ community, culturally and linguistically diverse communities and people from low socioeconomic communities.

First Nations engagement, led by Professor Deen Sanders, was undertaken in tranche 3 to allow for as much time as possible following the Referendum on the Voice to Parliament. This engagement was accompanied and informed by a review of disaster management and funding literature written by, or in respect to, Aboriginal and Torres Strait Islander peoples. Five virtual workshops were held with a range of community members from across Australia including one with the National Indigenous Australians Agency (NIAA); the process for these engagements followed a blended methodology of storytelling, yarning and appreciative inquiry, following a relational methodology for transferring Indigenous knowledge.

Climate scenario analysis was conducted and used to project possible future costs of disasters in Australia under several scenarios. Future cost modelling was undertaken and policy modelling – including associated cost implications – was developed for three policy options (*Appendix F, Section 1.2*).

The Deloitte team supported the Independent Reviewer in recommendation design – including devising a multi-criteria analysis for a long list of recommendations – and socialisation with a selection of critical stakeholders through small Chatham House focus groups and interviews. Additional research was undertaken on an ad-hoc basis to support stakeholder engagement, recommendation design, and other requirements of the Independent Reviewer. The deliverables for tranche 3 were a Consultation Draft and this Final Report.

Lines of enquiry

Lines of enquiry created a consistent and structured set of research questions that ensured each Term of Reference was answered using the appropriate methods and level of detail through the progression of tranches. While each line has been created to develop particular insights, often they are interrelated.

There are seven lines of enquiry which each have a set of sub-questions pertaining to the relevant tranche. The complete list of sub-questions and the progression of lines of enquiry across tranches can be found in *Appendix C*.

The foundations of each line of enquiry can be understood as follows:

1. *Funding Landscape:* How current funding from any source can be understood nationally and in aggregate (landscape level), what is funded and the gaps, what funding is trying to achieve and how it should be designed in the future.

2. *Funding Principles:* What principles should underpin the Commonwealth's approach to disaster funding to support a scalable, sustainable, effective, equitable, transparent and accessible system?
3. *Funding Roles:* How levels of government, private and non-government bodies and individuals consider their current responsibilities in respect to disaster, in a system of actors and what the future state of responsibilities and roles should be.
4. *Funding Types and Pathways:* What are the funding measures and mechanisms within the national funding landscape, are they effective and achieving their intent?
5. *Funding Progression (economic):* How the funding environment has responded to natural disasters since 2018, future projected costs, and how the Commonwealth might better manage these projected costs.
6. *Funding Resilience and Risk Reduction:* The Commonwealth's approach to funding resilience and risk reduction and how could this be optimised.
7. *Funding Incentives:* What incentives could align funding processes between Commonwealth, state, territory, local government and non-government actors?

Figure 1 illustrates, at a high level, how each of the workstreams engaged with each line of enquiry. It should be noted that while this figure depicts each workstream independently, in practice, the work and outputs informed one another.

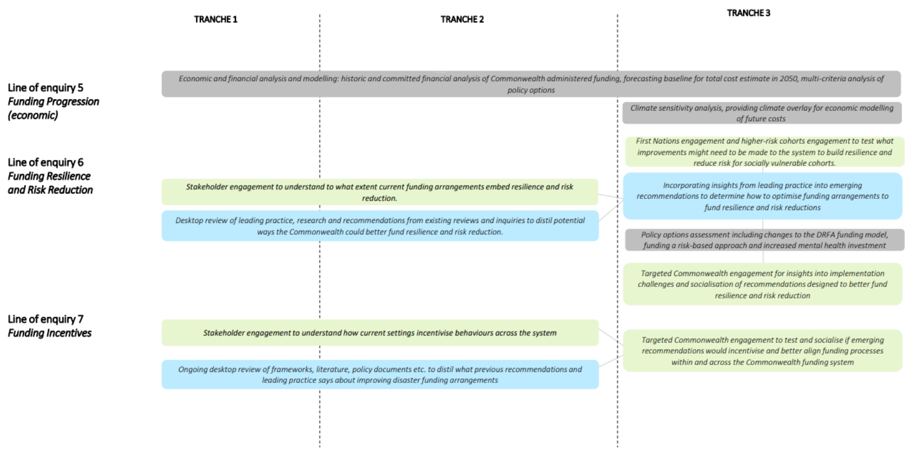
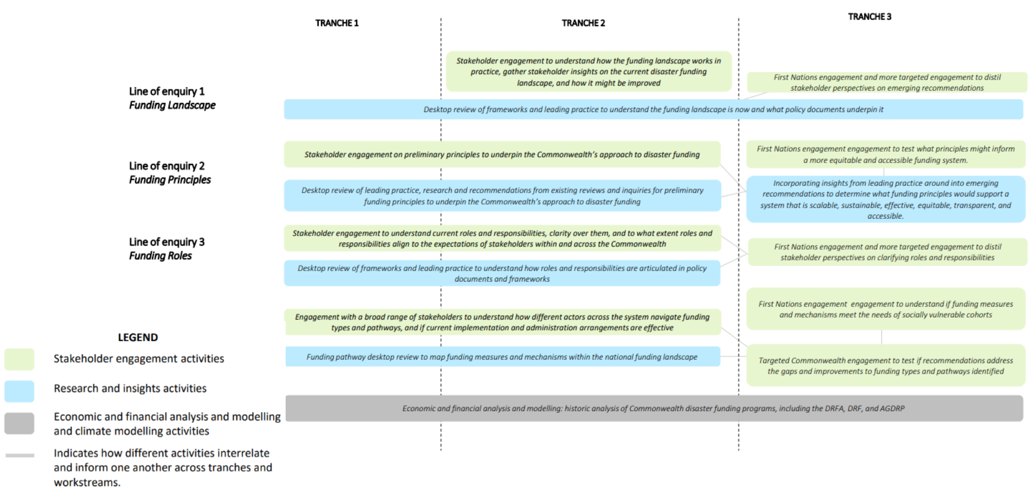


Figure 1. Overview of workstream activities across tranches mapped against lines of enquiry



The following sections present a more detailed overview of the approach of each of workstream, noting that the full methodology, findings, sources, and references are provided in *Appendices D to G*.

1. Stakeholder engagement

The detailed methodology, findings, sources and references associated with stakeholder engagement are in *Appendix D*.

Questions and agendas for all engagement were designed in reference to the lines, and sub-lines, of enquiry to create structure and consistency across methods and to ensure the inputs were relevant to the Terms of Reference. They also incorporated issues, ideas, and requests from other workstreams of the Review.

The purpose of these engagements included collecting different perspectives about challenges articulated in the Terms of Reference, characterising the disaster funding system using multiple viewpoints, gathering input on possible solutions and technical information. Stakeholder engagement involved a mix of methods over the course of the Review to create the opportunity for stakeholders across sectors, interests and geographies to contribute.

The public submissions process, in addition to the Review accepting unsolicited submissions, opened the opportunity for any Australian or entity to contribute. Five short-answer questions (*Appendix D, Section 2.2*) were designed collaboratively by the NEMA

Review Taskforce and Deloitte team to direct contributions and make the process simple to engage with.

A broad cross-section of stakeholders from across sectors, interests and geographies were invited to contribute through direct engagement via focus groups and interviews. Given the broad relevance of disaster to businesses, governments and communities, the Review devised a structured approach for selecting invitees to focus groups and interviews, which is detailed in *Appendix D*. Focus groups were chosen as the predominant method of engagement, as they provide an opportunity to bring together several stakeholders and allow participants to interact, react, and create socially informed inputs. Focus groups balance the ability to gather direct inputs from individuals (less possible in methods with larger participation such as town halls) while facilitating engagement with more stakeholders at once than one-on-one methods such as interviews. Interviews were undertaken by the Independent Reviewer and other senior Deloitte staff as required, where discussions likely contained sensitive material or required deep and detailed exploration of an issue. Finally, an online survey was distributed to every Australian local government to invite their contributions in a structured format. This method was chosen to enable participants to engage at a time that suited them and provided sufficient limitation in the scope of questions to direct their responses.

Local government survey responses, public submissions and focus group content were analysed using the same deductive thematic coding approach to ensure consistency and enable comparison of findings across methods. These activities were complemented by First Nations engagements and literature review. For further information, see *Appendix D*.

To socialise the emerging recommendations smaller Chatham House focus groups were undertaken by the Independent Reviewer in the final stages of the Review, with the narrower purpose of socialising early drafts of recommendations. These groups were divided into private sector entities, community organisations and not-for-profits, and the local government sector. As these were devised for the purposes of feedback and socialisation, contributions were not recorded or analysed. Commonwealth, state and territory governments were engaged closer to the release of the Final Report by the Independent Reviewer once recommendations were in a mature state.

2. Research and insights

The detailed methodology, findings, sources, and references associated with research and insights are in *Appendix E*.

The Deloitte team and NEMA Review Taskforce conducted a thorough literature review to discern best practices within the disaster management sector. The objective was to pinpoint areas of duplication, identify gaps and explore opportunities for alignment with these practices. This review comprised three stages: a systematic examination of academic literature pertaining to disaster management best practices; a review of relevant scientific articles, policies, and reports from Australia (referred to as grey literature); and an international comparative case study of approaches.

The synthesis of academic, grey literature and comparative case study findings formed a comprehensive analysis that informed the Review, offering insights into current theories and practices employed within Australia and the international disaster management sphere. To guide the systematic academic literature review, two primary exploratory themes were utilised: leading practice and administration of funding. These themes aligned with three questions from the Independent Review's lines of enquiry, shaping the identification and analysis of literature.

The systematic academic literature review yielded a final list of 38 priority papers, from which key themes were synthesised and analysed. The initial scan of grey literature identified 100 documents, which were categorised into three groups based on their discussion of leading practice and principles, as well as administration of funding. This exercise led to the prioritisation of 26 pieces of grey literature for synthesis and analysis.

The international comparative case study focused on four countries – the United States of America, Canada, New Zealand and Japan – examining their disaster management arrangements, principles, funding administration, and lessons learnt. A preliminary review identified between 10 to 20 documents per country for further analysis. Summarised reports from each country, along with recent academic literature reviews, formed the basis of the comparative analysis.

In tranche 3, leveraging insights from tranches 1 and 2, a comparative analysis of the current state of disaster funding against leading practices in Australia and internationally was conducted. This analysis explored four topics: disaster planning, advancing financial investment in disaster resilience and risk reduction, public-private partnerships and outcomes-based decision making. Thematic coding and iterative prioritisation of dominant themes from the literature review guided the selection and analysis of additional academic literature, facilitating a comprehensive comparison between leading practices and the Australian context.

Throughout the Review process, this activity encompassed the creation of case notes and document summaries derived from relevant reviews and reports which are listed in *Figure 2*. These encompassed both publicly accessible and confidential materials. Upon receiving a report or document, its analysis occurred to extract relevant content that could enrich the body of evidence for the Review. Subsequently, a case note summary was prepared for integration into the Review.

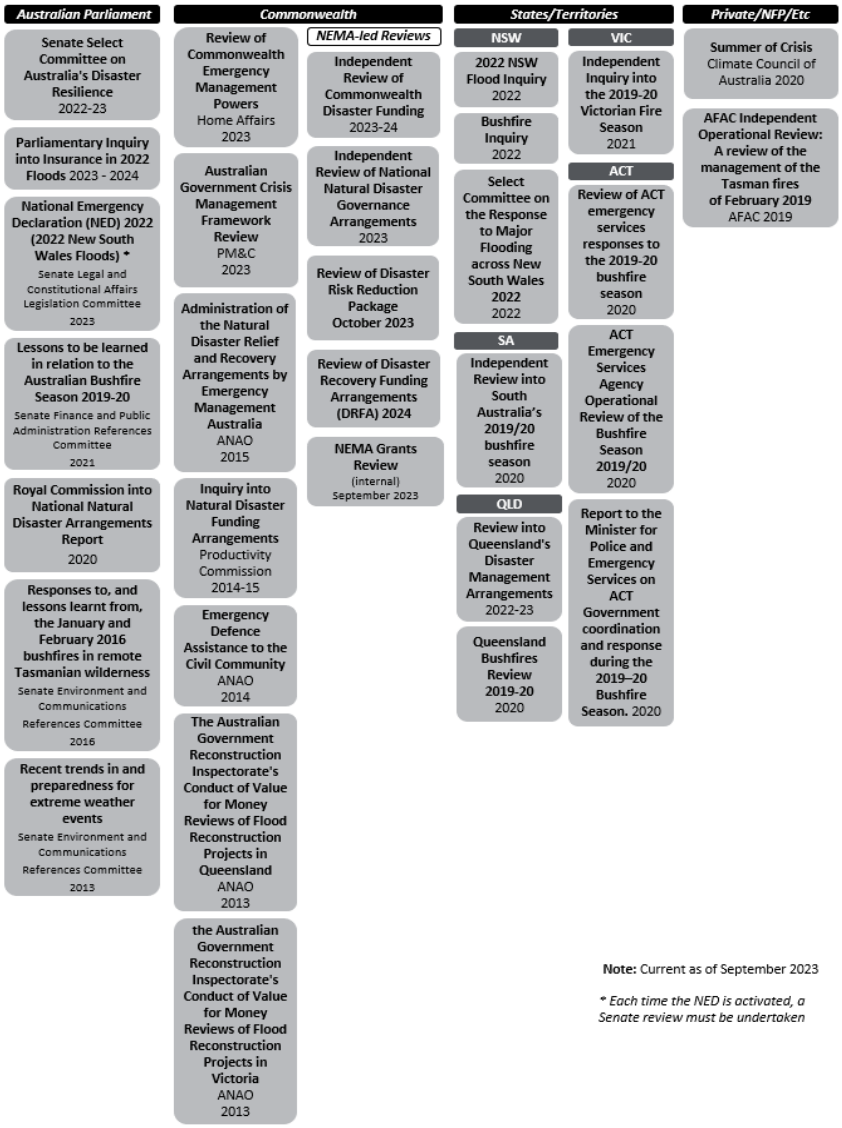


Figure 2. Overview of previous reviews and inquiries

Created June 2023

3. Financial and economic modelling and analysis

The detailed methodology, findings, sources and references associated with financial and economic modelling and analysis are in *Appendix F*.

In the early stages of the Review, the modelling team analysed the Funding Dataset to provide quantitative evidence on the Commonwealth's historic contribution to disaster funding. The financial and economic modelling team focused on data visualisation and analysis to aid in comprehensively understanding the historical and committed expenditure across all facets of Australian Government disaster support, including preparation, recovery, and response efforts.

Tranche 3 involved revisiting and assessing the previous findings using updated data from the Disaster Resilience Funding and DRFA datasets provided by NEMA. The key objective of the remaining activities (listed below) was to establish a forecast baseline of the total cost of natural disasters and associated Commonwealth funding estimate in 2050. In summary, this was achieved by:

- Undertaking risk modelling to simulate the insured losses in a given year,
- Estimating the financial costs from the simulated insured losses, using ratios informed by the reference events,
- Deriving the social costs from the total financial costs, using ratios informed by a bottom-up analysis of the social cost of the reference events,
- Indexing the results to account for the change in the population, number and material value of dwellings in 2050,
- Overlaying the climate scenario outputs to arrive at the economic cost estimate for the RCP4.5 and RCP8.5 scenarios by jurisdiction by hazard, and
- Calculating the DRFA and other Commonwealth administered funding based on the average estimate excluding climate.

At the end of tranche 2, state and territory focus groups were conducted to present the Interim Report financial findings and distribute the data capture template, with the aim of obtaining relevant case studies to provide an evidence-based approach to the policy options assessment. Drawing on these submissions and a broader desktop analysis, a quantitative policy analysis was carried out on select policy recommendations (where quantifiable and based on the common themes of the shortlisted policy options). These included:

- Embedding betterment in the DRFA funding,
- Increasing resilience and risk reduction funding, and

- Increasing mental health support programs funding to reduce the social impact related to natural disasters.

Multi-criteria analysis was undertaken to shortlist the identified policy options long-list. Where relevant, quantitative financial and economic analysis was undertaken on the shortlisted options in tranche 3. Ahead of the Final Report submission, subsequent consultations with state and territory governments were conducted in tranche 3 to present the draft results of the financial and economic modelling and highlight the findings of the quantitative policy analysis.

4. Climate scenario analysis and modelling

The detailed methodology, findings, sources and references associated with the climate scenario analysis are in *Appendix G*. The methodology for how the climate modelling was then used in financial and economic modelling and analysis is in *Appendix F, Section 1.2*.

Deloitte's climate science team analysed the spatial variability across multiple climate projections for each Australian state and territory. This included consideration of socio-economic characteristics of the most highly exposed local government areas (LGAs). This analysis served as an overlay or input to be used by the financial and economic modelling and analysis workstream to model future costs associated with disaster under difference climate scenarios.

Appendix C: Lines of enquiry

This appendix presents the lines of enquiry. The Review explored 7 key lines of enquiry: *Funding Landscape, Funding Principles, Funding Roles, Funding Types and Pathways, Funding Progression (economic), Funding Resilience and Risk Reduction, and Funding Incentives.* The schematic below outlines how these lines developed iteratively across tranches with relevant sub-lines of enquiry for focused analysis.

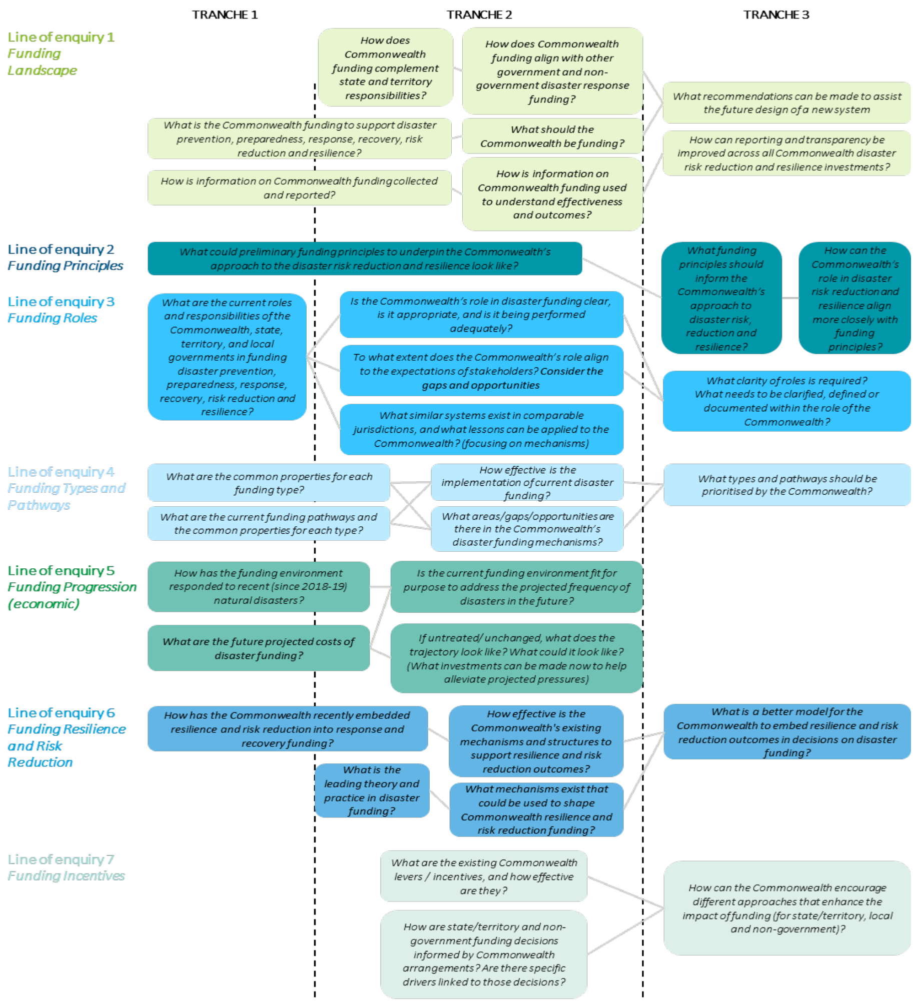


Figure 3. Overview of lines of enquiry with relevant sub-lines of enquiry for focused analysis

Appendix D: Stakeholder engagement workstream: methodology, findings, sources, and references

This appendix provides the methodology, findings, sources, and references associated with the stakeholder engagement workstream.

1. Methodology

The objectives of stakeholder engagement in this Review were to:

a) Understand the national disaster funding system – and Commonwealth funding as part of this national system – from the perspective of users, actors influencing system behaviour and outcomes, other funders, beneficiaries and Australian communities.
b) Gather information about what elements of current and historic funding arrangements are working well or not.
c) Garner inputs on possible solutions to problems identified in the Terms of Reference and by the Independent Reviewer.
d) Socialise draft and final recommendations to gather perspectives on feasibility, likely effectiveness and to increase the likelihood of their success should recommendations be accepted and implemented by the Australian Government.

To ensure consistency and thoroughness in stakeholder data collection, analysis and interpretation, a *Stakeholder Engagement Plan* (the Plan) was developed and used throughout the tranches. The Plan served as a common reference for all staff associated with the Review and was updated periodically to reflect changes to stakeholder engagement.

1.1. Methods

Public submissions

A public submissions process was facilitated through Deloitte and the NEMA Review Taskforce. Questions were designed collaboratively and were intended to be easy and fast to engage with, while capturing input relevant to the Review's Terms of Reference.

The submission process sought points of view from the public on the following five questions:

1. What experience have you had with Commonwealth disaster funding support?
2. How could Commonwealth funding support communities to reduce their disaster risk?
3. Please describe your understanding of Commonwealth disaster funding processes.
4. Are the funding roles of the Commonwealth, states and territories and local government, during disaster events clear?
5. Is there any further information you would like to provide?

A total of 224 contributions/submissions were received. One hundred and ninety four were received through NEMA's public submission process while a further 30 were sent to the Independent Reviewer directly. Public submissions were grouped as the following: individuals; state or territory government; local governments or regional association; not for profits, charities and philanthropies; private organisation and industry peak bodies and Commonwealth Government. A full list of public submissions received are located in *Appendix D, Section 3*.

Focus groups

Focus groups were chosen as the primary method for gathering qualitative information due to their ability to bring together several stakeholders to discuss, react and develop meaningful inputs about findings and concepts. They enabled the Review to both gather direct inputs from the individuals (less possible in methods with larger participation such as town halls) while facilitating engagement with multiple stakeholders simultaneously, which is less effective in an interview format.

Focus groups engaged with stakeholders across sectors, interests and geographies, which were organised into the following categories (see *Appendix D, Section 1.2*):

- State/territory governments,
- Local government associations, regional groupings and councils,
- Not-for-profits and community organisations,
- Private sector/industry peak bodies and entities,
- Commonwealth government departments and agencies.

Stakeholders from these categories were identified by Deloitte, in collaboration with the Independent Reviewer and the NEMA Review Taskforce and were mapped according to their perceived legitimacy, influence and urgency. Lists of stakeholders who attended each focus group are provided in *Appendix D, Section 3*.

Focus group agendas and questions were developed by mapping the broader lines of enquiry against each stakeholder category and designing questions to elicit answers to those questions. Each focus group had a tailored agenda based on the role or functions associated with the attendees. Minutes were captured during the focus groups by members of the Deloitte team and cleaned afterwards, supported by the Teams transcript and recording. Minutes were used to develop briefs for stakeholder categories and were thematically analysed using a codebook that contained themes relevant to the lines of enquiry and terms of reference.

Three focus groups, with a small selection of stakeholders who had already engaged with the Review, were undertaken in tranche 3 by the Independent Reviewer for the purpose of gathering reactions and feedback to early recommendation themes. These were organised according to private sector, not-for-profits and local government associations.

Local government survey

The local government survey was designed to enable wider engagement with local governments in a structured manner, as a supplementary engagement mechanism to focus groups. The survey was distributed via email to all Australian local governments via Qualtrics. Questions were designed to complement the focus group questions. The survey used a combination of question types to enable the collection of both quantitative and qualitative data, including open text, matrices and multiple choice.

Table 1 below outlines the question list from the local government survey. All questions were optional.

Table 1 List of local government survey questions

Q#	Question	Question Type
1	What state or territory do you live in?	Multiple choice (single answer)
2	Which local government area (LGA) are you in?	Open text
3	What is your role within local government? • Local government employee • Elected officials • Other	Multiple choice (as many as apply)
4	How has your region or organisation been involved in natural disasters in Australia? • I have a response or recovery role • I have a resilience role • I have a prevention or preparedness role • I have a risk reduction role • I have been affected by natural disaster • I have another role to do with disaster	Multiple choice (as many as apply)
5	Please describe your role in more detail	Open text
6	Has your organisation been directly involved in or engaged in Commonwealth funding? • Yes • No	Multiple choice (single answer)
7	What does your organisation see as the current role of Local Government before, during and after a disaster?	Open text

Q#	Question	Question Type
8	How well is the role of local government clearly articulated and/or understood by the following: • In state/territory frameworks and legislation • In Commonwealth frameworks and legislation • In the community • At the state/territory level • At the Commonwealth level	Choice matrix Scale: Not well at all to extremely well
9	What capacity does your organisation have to meet the following roles and responsibilities? • Community expectations • Sate/territory expectations • Commonwealth expectations • Your own understanding of your role	Choice matrix Scale: None at all to more than enough
10	Does your organisation have employees dedicated to disaster management and funding administration roles?	Open text
11	What gaps or shortcomings exist for meeting your organisation's role/s and responsibilities?	Open text
12	What roles could have dedicated employees?	Open text
13	How does the Commonwealth support, help, or hinder your organisation in doing your role? Does this support align with other government and non-government support?	Open text
14	What are your organisation's experiences with coordination and response frameworks, structures, or mechanisms put in place by any level of government?	Open text
15	In your organisation's experience, how effective are government coordination and response frameworks, structures and mechanisms? • Before disaster • During disaster • After disaster	Choice matrix Scale: Not effective at all to very effective
16	What Commonwealth support would help your organisation to meet your roles and responsibilities?	Open text
17	What are the funding and support mechanisms that your organisation has accessed?	Open text

Q#	Question	Question Type
18	Can you think of any non-financial supports that help your organisation to fulfil its role? For example, Commonwealth government policies that help to remove barriers to apply for support during a disaster	Open text
19	What challenges has your organisation experienced while accessing and using these supports? Examples include eligibility criteria, clarity and consistency of information, stakeholder awareness, grant disbursement, audit requirements.	Open text
20	What factors influence your organisation's decision to access these supports?	Open text
21	How suitable do you think Commonwealth supports are to address the increasing risk of natural disasters in the future? • Before disaster • During disaster • After disaster	Choice matrix Scale: Not at all suitable to very suitable
22	What aspects of Commonwealth support do you think should be improved?	Open text
23	Do you have any case studies of interactions with Commonwealth disaster funding that either: Worked well (e.g., expenditure that has facilitated long-term benefits through improving resilience or reducing risk), or Did not work well (e.g., frequent replacement of the same infrastructure or increasing social costs) • Yes • No	Multiple choice (single answer)
24	Please provide a short description of the case study	Open text
25	In what State/Territory did the case study originate?	Multiple choice (single answer)
26	What type of disaster does the case study relate to?	Multiple choice (single answer)
27	Where on the disaster continuum does the case study relate to?	Multiple choice (as many as apply)

Q#	Question	Question Type
28	What domain does the program relate to?	Multiple choice (as many as apply)
29	What were the costs for developing and implementing the initiative?	Open text
30	What was the timeframe for developing and implementing the initiative?	Open text
31	What were the costs for the ongoing operation of the initiative? How long does it take for the benefits to be realised post the implementation of the program?	Open text
32	Is the program effective at reducing the following: • Disaster likelihood • Disaster impact	Choice matrix Scale: Not effective at all to very effective
33	How confident is your organisation's assessment of the program's effectiveness at reducing the following: • Disaster likelihood • Disaster impact	Choice matrix Scale: A little confident to highly confident
34	Has your organisation participated in a focus group for this review?	Multiple choice (single answer)
35	Has your organisation participated in a focus group for this review?	Multiple choice (single answer)
36	Has your organisation participated in any other reviews related to natural disasters?	Multiple choice (single answer)
37	Has your organisation contributed a public submission to this review?	Multiple choice (single answer)

Interviews

In addition to the stakeholder engagement activities undertaken by the Deloitte team, the Independent Reviewer was responsible for limited discretionary stakeholder engagement which took the form of interviews. These included:

- Ad-hoc engagement with senior officials across the stakeholder categories, identified in the Deloitte engagement, to extract additional insights,
- Engagement with international counterparts to compare disaster funding systems and derive insights from other contexts. These included, for example, the Federal Emergency Management Agency in the United States, and

- Ministerial meetings to provide regular reporting to the Minister for Emergency Management and, upon request, ad hoc briefings with other Commonwealth ministers and parliamentarians.

First Nations engagement

The First Nations engagements complemented the goals of the other stakeholder engagement activities, yet also served the following aims:

- A greater inclusion of First Nations perspectives in the review of Commonwealth arrangements for disaster funding, to ensure relevance,
- A deeper understanding of how Indigenous perspectives may be 'seen', connect and contribute to national disaster policies that creates opportunity for action, self-determination and protecting cultural knowledge, and
- Insights into the interconnectedness of environmental, cultural and community wellbeing and how to adapt traditional knowledge to the contemporary context.

The approach was uniquely tailored to the localised and cultural context of communities, with a focus on listening and learning how to embed local knowledge in disaster risk planning in Australia. Led by Professor Deen Sanders, the following four co-design principles guided these engagements (based on a synthesis of research into recognised success factors for community co-design):

- *Truth telling:* Sharing genuine experiences, histories and perspectives in culturally safe space to foster understanding and trust, while being open around how information will be used.
- *Two-way understanding*: Promoting mutual respect and knowledge exchange, recognising and valuing differences in cultural perspectives and ensuring both sides have equal voice and decision-making.
- *Reciprocity:* Acknowledging and honouring the contributions, knowledge and insights shared by providing fair and meaningful benefits in return (i.e., updates on how the Review may benefit communities).
- *Connecting knowledge systems:* Allowing Indigenous knowledge to meet mainstream perspectives and inform integrated national disaster policies that creates opportunity for action, self-determination and protecting cultural knowledge.

In addition to pursuing these targeted engagements with First Nations communities, the methodology also combined a high-level literature review, drawing from academic journals (particularly from Aboriginal and/or Torres Strait Islander researchers and academics), relevant and available public submissions, policy papers, media releases and published reports.

Articles were selected based on two major criteria: their relevancy to the subject matter (i.e., disaster risk reduction, emergency management, caring for Country, etc.) and their legitimacy (i.e., written by Indigenous people, peer and/or systemically reviewed, validated or provided by a recognised Aboriginal community-controlled organisation, etc.). Emerging themes were mapped to the individual lines of data pulled from these sources, which were then weighted and prioritised in terms of their reoccurrence (how many times that theme emerged) and their importance (evidence of impact for First Nations communities).

The literature review formed the bedrock upon which a thematic analysis was built, serving as the framework through which lived experiences shared during engagements were incorporated. Notes taken during the engagements provided an additional 'lived experience' lens, allowing the team to expand upon the thematic analysis. By intertwining scholarly findings with firsthand accounts, a comprehensive understanding of the nuances within the disaster funding system was attained. This synthesis facilitated the extraction of shared insights, which in turn informed and complemented the formulation of recommendations tailored to address the complexities inherent in the system of disaster funding.

For a full list of the participants and sources that informed the activities under the First Nations engagement, see *Appendix D, Section 3*.

1.2. Stakeholder identification

A full list of the stakeholders who engaged with the Review and the sources and references used to inform stakeholder engagement activities, can be found at *Appendix D, Section 3*.

The Review identified stakeholders using a defined process to ensure a robust and fair selection process was used. Stakeholders were chosen and prioritised throughout the Review according to their impact and legitimacy, as well as their influence and power. Below outlines stakeholders identified across the Reviews tranches.

Tranche 2

Stakeholders engaged included:

- State and territory governments, including central departments and agencies tasked with emergency management functions. The NEMA Review Taskforce provided Deloitte with a list of senior contacts in each state and territory government, who were then invited to nominate a staff member to organise attendees from across relevant departments and agencies. Focus groups engaged with each state and territory one-on-one to create a secure environment to discuss sensitivities.
- Local government sector contributors assembled to represent sectoral and lived experiences, as well as provide input on both the policy and operational aspects of

Commonwealth disaster funding arrangements. These were undertaken on a state or territory basis, and included:

  - Local government ‘case studies’, chosen by the NEMA Review Taskforce and Deloitte, which had direct experience of using Commonwealth disaster funding arrangements,
  - State- and territory-based associations, chosen to gather an aggregated perspective of their members on disaster funding and supports, as a means of accessing a large sample of local governments, and
  - Regional groups which are active.

- NEMA divisions and staff to understand the differences in perspective associated with strategic, policy, or operational work in different parts of the disaster continuum.
- Not-for-profits and charities, including emergency-specific organisations and those with a broader crisis relief remit. These included:
  - Social and health service providers,
  - Relief support providers,
  - Philanthropic organisations actively engaged in disaster, and
  - Interest or advocacy groups.
- Private sector peak bodies or large businesses in industries which had a critical role in respect to disaster. While peak bodies were preferred, to avoid any real or perceived influence of commercial interests, collecting some industries’ perspectives required direct engagement with large businesses due to their direct experience and/or market dominance. Sectors were chosen for:
  - Influencing the behaviour of individuals and/or the policy settings,
  - Providing critical services, and
  - Representing important businesses in affected communities.
- Research organisations and academia, including universities and disaster-focused research centres.

Tranche 3

Stakeholders engaged included:

- Ministers and senior officials in state and territory governments.
- Australian Government, including departments and agencies which were identified as having a role in disaster through:

    - Relevant policy and/or funding remit (e.g., NEMA, DCCEEW),
    - Strategic policy and finance (e.g., Department of Finance, Treasury, PM&C),
    - Contribute services or assets in the context of disaster policy and management (e.g., ACS),
    - Providing direct assistance to individuals in crisis (e.g., Services Australia), and
    - Contributing non-financial support (e.g., Defence).
- Peak bodies representing higher-risk cohorts (e.g., Children and Young People with Disability Australia, the Refugee Council of Australia).
- First Nations bodies and experts. NIAA was consulted and supported the Review in identifying stakeholders for engagement; through this process, over 100 First Nations organisations were contacted for input each of whom had strong interest or active involvement in disaster response, planning and management – however, of these, 85% did not respond.

Australian government focus groups were designed to bring together several like-departments and/or agencies based on their similar function in disaster (e.g., policy, funding, non-financial support) and portfolio similarities. This enabled appropriate tailoring of agendas and lines of questioning. Division of Commonwealth departments and agencies by focus group is in *Appendix D, Section 3*.

Throughout the Review

In addition to the above stakeholder categories the following stakeholders were engaged by the Independent Reviewer on an as-needed or upon-request basis:

- Committees (e.g., Australia-New Zealand Emergency Management Committee, Inter-Departmental Committee),
- Members of Parliament/Ministers (including their advisors and Offices),
- Commonwealth stakeholders, and
- Representatives from state, territory, and local governments.

1.3. Stakeholder data analysis

The following outlines further details on our analysis methodology against each of the featured stakeholder engagement activities, public submissions, focus groups and the local government survey.

Public submissions

The NEMA Review Taskforce hosted the submissions form on its webpage. The data cleaning and analysis of submissions was divided between NEMA and Deloitte, with a final analysis conducted by Deloitte, to ensure the approach and findings were appropriately integrated with wider stakeholder analysis.

The same approach taken for focus group minutes was applied to thematically analyse public submissions. The submissions were first tagged against the lines of enquiry that have guided the Review, with further analysis then conducted across all submissions to distil common themes. Submissions were also grouped into sectors; individuals; state or territory government; local government associations, local governments and regional grouping; not for profits and community organisations; private sector entities and industry peak bodies and Commonwealth Government.

Focus groups

Prior to the focus group sessions, the Deloitte team developed a thematic codebook to analyse the minutes (*Appendix D, Section 3)*. To identify overarching themes and sub-themes, the Deloitte team took an inductive approach – leveraging concepts from the Review's Terms of Reference and key themes from the Review's lines of enquiry. A concise description for each theme and sub-theme was developed to create consistency in use across the multiple Deloitte Team members working on analysis. Additionally, a deductive approach was applied to capture any new themes which arose that were not already in the codebook.

The Deloitte team utilised a phased process to analyse data collected during the focus groups. This involved transcribing minutes and preliminary analysis by identifying main themes discussed during the sessions. A brief of high-level themes and insights were then developed for communicating to the Independent Reviewer on a real-time basis. Using the codebook, the Deloitte team analysed the collated focus group minutes and thematically coded the discussion; using a spreadsheet for each subsequent theme mapped against stakeholders and the lines of enquiry, coded key insights were recorded. This approach allowed for data collected to be filtered across several variables and summarised across the lines of enquiry.

Following finalisation of stakeholder engagement, data from tranches 2 and 3 were combined into a whole-of-Review codebook to identify review-wide findings/attitudes according to themes associated with the lines of enquiry. In reviewing the stakeholder engagement data and noting duplication in several of the codebook themes across tranches 2 and 3, the whole-of-Review codebook was simplified to four themes: disaster continuum; roles and responsibilities; funding programs; and data and information. Findings were counted to develop a quantitative depiction of dominant attitudes or findings. An attitude was coded/counted for each instance that it was expressed in a focus group, as a means of anonymising the source of the attitude while indicating the amount of interest and sectoral or geographical context. Commonwealth departments and agencies were identified as their function, portfolio, and nature of influence in the disaster system is required to understand the meaning of their perspectives.

Local government survey

The responses to the survey were analysed by theme using the same codebook categories used for focus group minutes and public submissions to ensure consistency. The codebook themes were entered into Qualtrics to maintain analytic consistency between the survey and focus groups. Sentiment analysis was then run using Qualtrics and where required, checked and corrected manually.

2. Findings

2.1. Focus groups

The table below presents a non-exhaustive summary of the dominant findings and themes which emerged through focus groups. To de-identify entities, the finding was counted (frequency) on each occasion the topic was discussed by members of a focus group.

See *Appendix D, section 3. Sources and references* for a full list of focus group participants.

Table 2 Dominant attitudes/perspectives from stakeholder engagement.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Disaster continuum – *before (preparedness, mitigation)*	To enhance disaster response, it is crucial to improve coordination among NGOs, local, state and Commonwealth entities before any event occurs. Collaborative planning with state governments has proven to be the most effective approach.	9	TAS State Government, QLD State Government, NSW State Government, NT Local Government, QLD Local Government, NSW Northern Rivers, Blue Mountains and Hawkesbury, QLD Local Government, VIC Local Government, Social Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The advantage of a preparedness and resilience policy that is not tied to specific events is its flexibility and adaptability to changing circumstances, unlike policies that are driven by specific events or disasters.	9	DCCEEW, DAFF, CSIRO, Department of Employment and Workplace Relations, Department of Industry, Science and Resources, Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, NSW State Government, Construction Sector, Social Services Sector.
	There is a need to enhance preparedness by engaging private sector actors, small businesses and individuals.	9	DAFF, CSIRO, TAS State Government, SA Local Government, QLD Local Government, Farming and Primary Producers Sector, Crisis Response Sector, Health Services Sector, Environment Sector.
	Forecasting and modelling are essential for the Commonwealth to support others in their preparedness efforts.	7	DCCEEW, Department Industry, Science and Resources, Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, Australian Climate Service, Services Australia, TAS State Government, SA State Government.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The lack of market agreements leads to high costs for the Commonwealth when contracting with industry for disaster support, causing confusion.	3	Construction Sector, Logistics Sector, Crisis Response Sector.
Disaster continuum – *during (response)*	Local and state governments often struggle to perform regular tasks (BAU) due to their focus on disaster response and limited resources.	4	TAS State Government, SA State Government, SA Local Government, Central West and South Coast NSW Local Government.
	There is a growing expectation within communities for swift and comprehensive support during disasters.	3	Department of Social Services, VIC State Government, NSW State Government.
	Improvements are needed in coordinating, collaborating and learning from post-disaster responses across all actors involved in the system.	5	DCCEEW, CSIRO, Energy & Telecommunications Sector, Construction Sector, Philanthropies Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Disaster continuum – *after (relief, recovery)*	The lasting mental health impacts of disasters extend beyond the duration typically considered in funding allocations.	6	Services Australia, Department of Health and Aged Care, SA Local Government, Higher-Risk Cohorts (Peak Bodies) Sector, Farming and Primary Producer Sector, Social Services Sector
	Small businesses and individual workers play a crucial role in recovery efforts but often do not receive adequate support or policy attention, leading to gaps in assistance.	8	DCCEEW, Department of Employment and Workplace Relations, Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, Department of Industry, Science and Resources, Small Business Sector, Banking and Financial Services Sector, Philanthropies Sector.
	Funding allocation across the disaster continuum is unbalanced, with a disproportionate emphasis on recovery efforts.	4	Department of Infrastructure, Small Business Sector, Insurance Sector, Environment Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Disaster continuum – *always (resilience, risk reduction)*	There is confusion resultant of ambiguous responsibilities, poor communication, and inadequate interdepartmental planning within the Commonwealth's disaster spectrum. This convolution hampers the effectiveness of the Commonwealth's interventions. Additionally, the absence of an overarching narrative leads to delays and further confusion.	9	NEMA, PM&C, Australian Bureau of Agricultural and Resource Economics, Department of Social Services, Australian Climate Service, National Indigenous Australians Agency, Services Australia, TAS State Government, Health Services Sector.
	Urban understanding of community can often result in rural communities' needs not being met. Resilience is believed to be greater in urban than regional areas and should be accounted for.	3	Department Infrastructure, Transport, Regional Development, Communications, and the Arts, Social Services Sector, Farming & Primary Producers Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Resilience needs to be embedded into recovery.	8	Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, Bureau of Meteorology, Department of Defence, SA State Government, Energy & Telecommunications Sector, Insurance Sector, Environment Sector, Logistics Sector.
	Social resilience and recovery requires greater investment.	5	Department of Social Services, Department of Health and Aged Care, VIC State Government, Social Services Sector, Banking and Financial Services Sector.
	There are varying definitions of key terms such as "disaster" and "resilience" across the country, convoluting appropriate intervention.	3	Department of Health and Aged Care, DCCEEW, ACT State Government.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Climate change is a driver of uncertainty and pressure on the disaster system and must be treated as a root cause of change.	4	DCCEEW, Murray-Darling Basin Authority, Australian Climate Service, VIC State Government.
Roles – *Commonwealth and State/ Territory*	While roles and responsibilities are clearly articulated in agreements, legislation and policies, in practice, there is a lack of clarity between the Commonwealth's role and the roles of states and territories. This exists to varying degrees across the disaster continuum.	16	DCCEEW, Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, Australian Bureau of Agricultural and Resource Economics, NEMA, Department of Social Services, Department of Health and Aged Care, National Indigenous Australians Agency, PM&C, Department of Home Affairs, Department of Finance, NT State Government, NSW State Government, NT Local Government, WA Local Government, Small Business Sector, Philanthropies Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Risk of duplication across roles, between states and the Commonwealth, has emerged. Stakeholders argue that this has led to confusion, unnecessary restrictions, and a lack of targeted funding and coordination.	6	Department of Social Services, TAS State Government, VIC State Government, NSW State Government, Research and Academia Sector, Philanthropies Sector.
	There is a shared role for the Commonwealth and states to play in ensuring equity of support to local governments.	5	NEMA, SA Local Government, WA Local Government, TAS Local Government, Research and Academia Sector.
Roles – *State/ Territory and local*	While roles and responsibilities for emergency situations are clearly stipulated in legislation and frameworks, many local governments believe that this is not always reflected in practice.	8	QLD State Government, WA State Government, VIC State Government, Northern Rivers, Blue Mountains and Hawkesbury, Central West and South Coast NSW Local Government, NT Local Government, VIC Local Government, TAS Local Government.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Local governments play a large role in response and recovery. There is a need for appropriate capability and capacity support from state governments to local governments to fulfil certain roles in disaster recovery.	9	QLD State Government, WA State Government, VIC State Government, NSW State Government, Central West and South Coast NSW Local Government, SA Local Government, WA Local Government, VIC Local Government, Environment Sector.
Roles – *Commonwealth and local*	There should be a bottom-up approach to disaster funding, informed at a local level and supported by state and Commonwealth expenditure due to intimate local knowledge.	13	VIC State Government, QLD State Government, NSW State Government, WA State Government, WA Local Government, VIC Local Government, Research and Academia Sector, Environment Sector, Insurance Sector, Crisis Response Sector, Farming and Primary Producers Sector, Banking and Financial Services Sector, Energy & Telecommunications Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The role of local governments in response and recovery has shifted due to increasing community expectations and demands. However, they are often not appropriately resourced and require additional support to meet increasing responsibilities.	8	Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, NSW State Government, NSW Hunter Valley Region, Central West and South Coast NSW Local Government, QLD Local Governments, Banking and Financial Services Sector, Environment Sector, Construction Sector.
	The absence of a direct link between the Commonwealth and local governments can complicate funding and response efforts.	4	Department of Health and Aged Care, NT State Government, WA Local Government, Environment Sector.
Roles – *Not-for-profit and community*	Volunteer numbers are declining, highlighting the need for the Commonwealth and state governments to support not-for-profit organisations and community organisations in training and increasing volunteer numbers.	5	Department of Defence, NSW State Government, Central West and South Coast NSW Local Government, Philanthropies Sector, Food and Groceries Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Not-for-profit initiatives and government support needs to be strategically aligned and better planned.	3	NSW State Government, NSW Hunter Valley Region, Central West and South Coast Local Government.
	Industry groups and not-for-profit organisations play a key role in preparation and resilience.	4	Farming and Primary Producers sector, Small Business Sector, Food and Groceries Sector, Health Services Sector.
	Not-for-profit organisations can serve as a crucial relationship manager in bridging the gap between different levels of government, sectors, and communities.	3	Farming and Primary Producers Sector, Crisis Response Sector, Social Services Sector.
	Not-for-profit organisations and philanthropies are often running at over-capacity and require additional support.	4	SA State Government, Research and Academia Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Social Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Roles – *private sector and industry*	Small businesses play an essential role in social and economic recovery. This is particularly evident in rural communities where industry recovery is synonymous with community recovery.	5	NSW State Government, Central West and South Coast NSW Local Government, Small Business Sector, Construction Sector, Farming and Primary Producers Sector.
	The private sector and non-governmental organisations play pivotal roles in the recovery and response phases. They work alongside community partners to leverage available funding and resources and they liaise with state governments during the response. Clarifying their roles would enable these organisations to contribute more effectively to the planning and preparedness phases.	7	TAS Local Government, Banking and Financial Services Sector, Food and Groceries Sector, Energy & Telecommunications Sector, Logistics Sector, Crisis Response Sector, Social Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	To leverage the role the private sector could play in providing data, improved and better coordinated partnerships with government are needed.	6	Australian Bureau of Agricultural and Resource Economics, QLD State Government, NSW Hunter Valley Region, Philanthropies Sector, Food and Groceries Sector, Insurance Sector.
Roles – *collaboration and coordination*	There is a need to develop clear and sustainable partnerships and channels for collaboration prior to disaster events to enable governments, not-for-profit organisations, community organisations and the private sector to fully leverage their contributions.	20	QLD State Government, SA Government, VIC State Government, TAS State Government, NSW Northern Rivers & Blue Mountains region Local Governments, WA Local Governments, TAS Local Governments, QLD Local Governments, Research sector orgs, Environment Sector, Banking and Financial Services Sector, Food and Groceries Sector, Energy & Telecommunications Sector, Construction Sector, Logistics Sector, Insurance Sector, Social Services Sector, Health Services Sector, Small Business Sector, Crisis Response Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	There is a need for the Commonwealth to take on more of a coordinating role across the system, taking federal leadership and clearly delineating roles and responsibilities to drive a more proactive approach to disaster arrangements.	14	Department of Infrastructure, Transport, Regional Development, Communications, and the Arts, DCCEEW, Department of Employment and Workplace Relations, NEMA, WA State Government, VIC State Government, NSW State Government, QLD Local Governments, WA Local Governments, Philanthropies Sector, Telecommunications Sector, Logistics Sector, Crisis Response Sector, Social Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Disaster funding and response is not well coordinated at a Commonwealth, or inter-jurisdictional level, often relying on formal and informal relationships rather than clear structures.	13	Department of Social Services, Department of Health, National Indigenous Australians Agency, TAS State Government, SA State, Government, NSW Hunter Valley Region, NT Local Government, WA Local Government, VIC Local Government, Higher-Risk Cohorts (Peak-Bodies) Sector, Construction Sector, Telecommunications Sector, Crisis Response Sector.
Funding programs – *Funding landscape, system, and design*	Short-term grants undermine organisations' ability to retain staff for the duration of a project and beyond. There is a need to move beyond pilot programs and secure long-term funding for initiatives that demonstrate tangible benefits.	12	SA State Government, WA State Government, VIC State Government, QLD Local Government, NSW Hunter Valley Region, Central West and South Coast NSW Local Government, TAS Local Government, Social Services Sector, Health Services Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Philanthropies Sector, Research and Academia Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The funding timelines across the disaster continuum need restructuring. While immediate relief efforts require rapid funding, the recovery and resilience phases extend far beyond two years and are often not adequately funded.	10	VIC State Government, NSW Hunter Valley Region, Central West and South Coast NSW Local Government, SA Local Government, Banking and Financial Services Sector, Insurance Sector, Social Services Sector, Higher-risk Cohorts (Peak Bodies) Sector, Philanthropies Sector, Research and Academia Sector.
	State-based administration of Commonwealth programs is not well coordinated. Administering DRFA applications through state and territory governments, while requiring all stakeholders to compete for the same funding, puts applications on an uneven playing field.	7	SA State Government, WA Local Government, SA Local Government, TAS Local Government, Social Services Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Research and Academia Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Application, auditing and reporting across Commonwealth disaster funding programs (NEMA and beyond) need to be harmonised and streamlined to reduce duplication and conflicts and to measure more meaningful outcomes consistently nationwide.	6	NEMA, QLD State Government, WA State Government, TAS State Government, NSW Hunter Valley Region, Banking and Financial services Sector.
	The number of funding streams is confusing. Sequencing of DRFA and other Commonwealth payments is not well coordinated which creates confusion for communities and state and territory governments.	8	DCCEEW, Services Australia, Department of Social Services, NT State Government, SA State Government, Small Business Sector, Banking and Financial Sector Social Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Grant writing assistance is sought by those with little experience. Grants can be won by those stakeholders which are adept at writing a well-crafted application but can miss those with effective suggestions but lack grant experience.	7	NEMA, SA Local Government, Crisis Response Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Philanthropies Sector, Environment Sector, Research and Academia Sector.
	Funding for planning needs to occur prior to disaster, considering existing planning done to satisfy complex legal requirements, in an inclusive and collaborative fashion.	7	VIC State Government, Northern Rivers, Blue Mountains and Hawkesbury, NSW Hunter Valley Region, Central West and South Coast NSW Local Government, QLD Local Government, VIC Local Government, Energy & Telecommunications Sector.
	The nature of competitive grant programs obstructs collaboration and resilience and leads to duplication.	7	NT State Government, VIC State Government, WA Government, NSW Hunter Valley Region, Crisis Response Sector, Philanthropies Sector, Research and Academia Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	DRF, DRFA and all Commonwealth funding needs to be allocated not only to the resilience of built assets, but to better facilitate support of social, economic and environmental needs.	5	QLD State Government, Social Services Sector, Philanthropies Sector, Construction Sector, Research and Academia Sector.
	Funding not-for-profit initiatives can be problematic where there is no accountability or long-term plan for their maintenance. Assets often then become the de-facto responsibility of the local government.	4	Central West and South Coast NSW Local Government, QLD Local Government, TAS Local Government, Banking and Financial Services Sector.
Funding programs - *DRFA*	Audit and reporting requirements, including evidence collection during and after disaster, are overly burdensome – particularly for small, rural and regional stakeholders. Auditing of projects and requests for evidence can continue for years.	11	SA State Government, VIC State Government, NT State Government, NSW State Government, Northern Rivers, Blue Mountains and Hawkesbury, NSW Hunter Valley Region, SA Local Government, WA Local Government, VIC Local Government, TAS Local Government, Research and Academia Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Timelines for applications are not always realistic. Rapid applications are not feasible when impact assessment are difficult and timely to produce, or when staff are filling multiple roles in the community immediately following a disaster (or when there are sequential disasters).	7	SA State Government, VIC State Government, NT State Government, NSW State Government, NSW Hunter Valley Region, QLD Local Government Farming and Primary Producers Sector.
	Reimbursement basis and like-for-like replacements are a source of significant financial risk as it can take years to process. Upfront funding to undertake assessments and applications would be welcomed.	7	NEMA, SA State Government, Northern Rivers, Blue Mountains and Hawkesbury, Central West and South Coast NSW Local Government, VIC Local Government, TAS Local Government, SA Local Government.
	Inconsistency in how the DRFA is applied by jurisdictions and accessed across state and territories, leads to confusion and uneven access and outcomes.	5	NEMA, Services Australia, NSW Northern Rivers & Blue Mountains Region Local Government, SA Local Government, Logistics Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The clarity and consistency of eligible expenditure decisions is lacking, leading to confusion. The criteria for eligibility are narrow, while the guidelines are broad, creating inconsistencies. To improve this, eligibility and guidelines should be simplified, harmonised across jurisdictions and potentially made more prescriptive. This would provide clarity to users and expedite assessment by NEMA.	8	NEMA, SA Government, VIC State Government, NSW Northern Rivers & Blue Mountains Region Local Government, QLD Local Government, WA Local Government, VIC Local Government, TAS Local Government.
	Assessment and release of funds in the immediate relief phase and in respect to betterment, takes too long and need to be simplified.	6	QLD State Government, Northern Rivers, Blue Mountains and Hawkesbury, Central-West and South Coast NSW, QLD Local Government, Social Services Sector, Health Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	Navigating all the categories and bureaucracy of the DRFA is complex and requires dedicated staffing. Category D (exceptional packages) are particularly complex to administer, navigate and understand.	5	QLD State Government, TAS State Government, SA Government, VIC State Government, NT State Government.
	Requiring the use of consultants, contractors and hire of assets is expensive and can hold up works when local governments in the same region require their services and are all funded by DRFA or other grants programs.	8	NT State Government, NSW State Government, NSW Northern, Blue Mountains and Hawkesbury, NSW Hunter Valley Region Local Government, SA Local Government, WA Local Government, VIC Local Government, TAS Local Government.
Data and information – *general*	Improved data sharing, planning arrangements and collaborative efforts can support better risk-based funding. In some jurisdictions, initiatives are underway to meet this need.	8	VIC State Government, SA Government, TAS State Government, WA Local Government, Research and Academia Sector, Philanthropies Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Logistics Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Data and information - *gaps*	There is not just a need for 'more' data but rather for localised, real-time information that is combined in a coherent format and is easily usable for different stakeholders.	12	CSIRO, Australian Bureau of Statistics, VIC State Government, Environment Sector, Philanthropies Sector, Social Services Sector, Energy & Telecommunications Sector, Farming and Primary Producers Sector, TAS Local Government, SA Local Government, Central West and South Coast NSW Local Government, NSW Hunter Valley Region.
	There are significant data gaps on the people who are impacted by disaster, including their demographics and wellbeing as a result of the disaster, measured over time.	6	Australian Bureau of Statistics, TAS Local Government, VIC Local Government, SA Local Government, Central-West and South Coast NSW Local Government, Health Services Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Data and information - *sharing*	There is a need for ongoing processes for data sharing to be developed and streamlined so that information provided during and post disasters can inform pre-disaster planning decision-making. There are existing processes and datasets within the Commonwealth that can be leveraged to enable this need.	23	NEMA, Bureau of Meteorology, Australian Climate Service, NSW State Government, VIC State Government, WA State Government, TAS State Government, TAS Local Government, VIC Local Government, WA Local Government, SA Local Government, QLD Local Government, Central West and South Coast NSW Local Government, NSW Hunter Valley Region, Environment Sector, Health Services Sector, Social Services Sector, Logistics Sector, Insurance Sector, Energy & Telecommunications Sector, Food and Groceries Sector, Banking and Financial Services Sector, Farming and Primary Producers Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
	The Commonwealth has a role in coordinating data sharing across sectors and jurisdictions and creating greater consistency across the system. This would be beneficial to stakeholders across the system who experience different data sharing and management regulations.	16	Department of Defence, Bureau of Infrastructure and Transport Research Economics, NEMA, Australian Bureau of Agricultural and Resource Economics, TAS Local Government, VIC Local Government, WA Local Government, SA Local Government, NT Local Government, QLD Local Government, Central West and South Coast NSW Local Government, NSW Hunter Valley Region, Higher-Risk Cohorts (Peak Bodies), Crisis Response Sector, Energy & Telecommunications Sector, Farming and Primary Producers Sector.

Theme/ cluster	Attitude/ perspective	Frequency	Focus groups in which this attitude was discussed
Data and information - *management*	There is a need for better data management practices to enable the Commonwealth better oversight over efforts and initiatives within and across the system. This view would in turn support knowledge sharing and continuous improvement across the system.	6	Australian Climate Service, NT Local Government, QLD Local Government, Research and Academia Sector, Higher-Risk Cohorts (Peak Bodies) Sector, Logistics Sector.
Data and information – *public communication, awareness, and education*	The need for investment into improved public data and information and communication channels is well recognised by a range of stakeholders.	6	DCCEEW, NSW State Government, VIC State Government, Health Services Sector, Banking and Financial Services Sector, Small Business Sector.
	Having centralised and consistent information accessible to the community during a disaster situation is invaluable for an effective response and recovery process.	4	Murray-Darling Basin Authority, QLD Local Government, Energy & Telecommunications Sector, Small Business Sector.

2.2. Public submissions

Public submissions were analysed and mapped against the lines of enquiry. Several themes emerged through this analysis, including:

- The desire for national standards and consistency,
- Resilience and risk reduction as a national priority,
- Clarity of roles, funding and processes,
- Perverse outcomes and barriers to funding, and
- Capacity and coordination.

The submissions highlighted consistent themes across sectors and locations, which are presented below.

Desire for national standards and consistency

A recurring theme throughout the submissions was the concept of national standards or consistency. Many submissions advanced the idea that the Commonwealth should provide national standards or a consistent framework to which they can plan and align in disaster management. This was particularly evident in the concept of consistent guidelines for funding processes. A key issue highlighted in most of the submissions was the inconsistency in funding arrangements, with the interpretation of guidelines and decisions being noted as a key concern and cause for confusion across sectors. A national standard or guideline was proposed to reduce both the perception of and actual occurrences of differing eligibility and approvals across states, territories and administering agencies.

Resilience and risk reduction should be a national priority

A dominant theme from across submissions that there is a desire for risk reduction and resilience to be a priority for the Commonwealth, with increased funding and focus in this area. Numerous submissions argued that the current state of the Commonwealth system created disincentives for investing in resilience and that this was a key area requiring reform, especially considering the projected increases in natural disasters and their associated costs. Various options were suggested for achieving this, with one significant proposal being the incorporation of betterment into funding arrangements like the DRFA, albeit as an optional decision. This approach would not only shift the focus towards resilient-based outcomes but also empower the funding recipient to decide how and where the betterment occurs, tailoring it to the specific needs of their community or area.

Clarity of roles, funding, and processes

The submissions have highlighted that there is a varied understanding and clarity regarding roles and responsibilities across the Commonwealth and among stakeholders. Some submissions argued that roles were clear, but this perception often depended on the position of the person making the submission (i.e., if they were employed and trained in disaster management). In contrast, those less directly involved in disaster management argued that roles were unclear, not delineated and created confusion. This confusion also extended to the funding processes, where the amount of funding, various applications, evidence requirements, timelines and delays often created confusion and compounding issues that meant support was not received efficiently or adequately. Other themes commonly discussed was the desire for clarity around funding types, eligibility and the process for applying for funding. This need for clarity was apparent across multiple sectors and organisations, from the individual level up to government organisations and agencies.

Perverse outcomes and barriers to funding

Not for profits and charities/philanthropies stated that existing mechanisms create a significant administrative burden, which can erode their organisational funding and require staff to be redirected from essential services to complete applications. This often resulted in applications being abandoned due to constraints. Delays and administrative issues also created other problems. Some examples provided were:

- Services in NSW and QLD communities affected by the 2022 floods did not receive allocated disaster funding until June 2023.
- Centres in WA are yet to receive funding to support communities in the Kimberley affected by the January 2023 floods. The delay has impacted service delivery and the organisations' ability to retain staff long-term.

Local governments highlighted issues of perverse outcomes and disincentives. This included the Commonwealth's focus on response and recovery, which is perceived to influence states and territories to follow suit, leading to a lack of investment in resilience. Budget cycles not aligning with Commonwealth funding cycles and challenging administration processes (timelines, auditing, etc.) compounded to create disincentives for local governments to apply for funding. They would be unable to meet the often-required co-contribution and stringent auditing requirements due to capacity issues. States and territories also noted that perverse outcomes were an issue, as administering agencies could implement their own guidelines on Commonwealth funding, without disclosing them. This created confusion when applications were rejected with little to no information explaining the decision-making process, leading to a level of distrust and discouragement from applying for funding in some submissions.

Capacity and coordination

Capacity was a recurrent theme throughout the submissions, albeit with different nuances. For instance, local government and individual submissions noted struggles with capacity, citing economic constraints, resource limitations and inadequate training and education as factors hindering their ability to respond to disasters and seek funding from the

Commonwealth. In contrast, non-government organisations and the private sector argued that they possessed untapped capacity that the Commonwealth could utilise to aid in disaster management. They viewed this as a key opportunity for the Commonwealth to collaborate with these organisations, using their resources to address capacity issues and fill gaps in the system through funding. This underscored a shared desire across sectors for improved coordination and communication. All sectors expressed willingness to assist in disaster management; and a collaborative and coordinated system would enable each sector to play a role in meeting the needs of Australians and responding to disasters more effectively.

2.3. Local government survey

Participation

A total of 156 individual responses were received from Australian local governments. Based on those who did provide their demographic data, 82 local government organisations responded, representing 15% of Australian local governments.

Rate of survey participation by state or territory was the following:

- 17% of NSW local governments,
- 21% of QLD local governments,
- 4% of SA local governments,
- 21% of Tasmanian local governments,
- 14% of Victorian local governments, and
- 15% of WA local governments.

No responses identified themselves as being from a Northern Territory local government. In Queensland and New South Wales, those who responded were mostly elected local government officials. For other jurisdictions, local government employees predominantly responded.

Eighty percent of respondents had been directly involved in Commonwealth disaster funding. Involvement across the disaster continuum was mainly in response and recovery at 24%. 20% of participants were also involved in resilience and prevention/preparedness.

Fifty percent of respondents had participated in other reviews. Eighty-six percent of respondents did not participate in a focus group, which indicates that the survey achieved its aim of reaching a wider range of local governments than occurred through other stakeholder engagement mechanisms.

Findings

Survey comments attested that most funding focus corresponded with response and relief. While improving the effectiveness and suitability of Commonwealth funding remains important, respondents believed that a shift to support for planning and implementation of resilience, risk reduction, prevention and preparation is required.

When asked what they consider to be their current role in disaster, 90% of local governments considered recovery a key component of their role, with around 70% considering the before and during stages important. By contrast, only 35% mentioned one or more of risk reduction, resilience and adaptation.

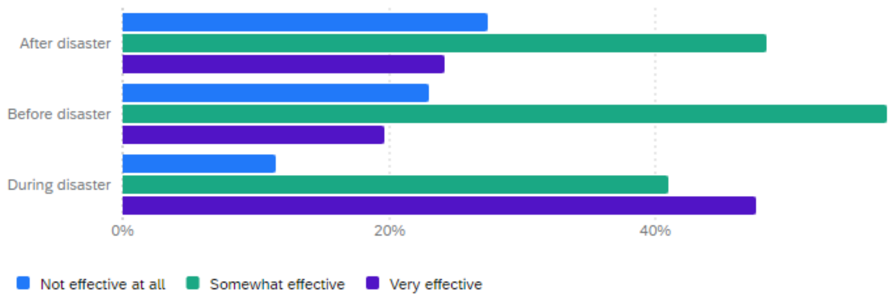
Local governments were often concerned with the speed with which they could rebuild assets following a disaster, with the speed of funding administration and application requirements being cited as reasons for slowed reconstruction. Local governments expressed in 79% of the responses which discussed the disaster continuum, that they needed greater non-financial supports after an event – typically in the form of trained personnel.

Figure 4 demonstrates how much local governments spoke about each stage of the continuum when discussing current Commonwealth supports. Seventy-eight percent of comments were about supports after disaster, with about half expressing negative sentiment across each theme. Forty-four percent discussed supports for risk reduction, resilience and adaption. This indicates that local governments see this as an important community need, but that it is not part of their current role, whether due to capacity, capability, or support.

Figure 4. Disaster continuum themes in current Commonwealth support

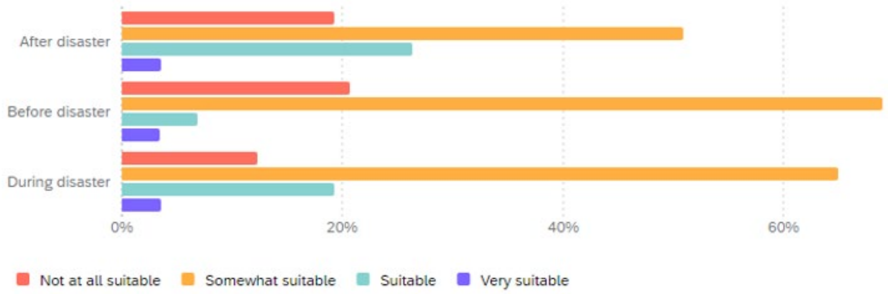
Participants were asked how effective government coordination and response frameworks, structures and mechanisms are in the current system. Participants expressed that support during a disaster is somewhat to very effective. Approximately 20-25% of participants believe that support after and before disaster is not at all effective.

Figure 5 Perceived effectiveness of current Commonwealth coordination and response



When asked how suitable they believe Commonwealth supports are to meet the needs of the system in the future, 10% of participants indicated that support before disaster was either suitable or very suitable, with 69% indicating somewhat suitable (*Figure 6*). Support after disaster was considered suitable or very suitable by 30% of respondents, somewhat suitable by 51%, and not at all suitable by 19%.

Figure 6 Perceived suitability of Commonwealth support for future events



When asked what they consider to be their current role in disaster, 92% of comments referenced responsibilities in relation to the built domain. In contrast, economic (8%), environmental (12%) and social (12%) domains were not seen as important responsibilities for local government. For those that did discuss economic, environmental and social domains, they did not specify what they do or what they might need.

Regarding the built domain, comments regarding assets when asked about roles and responsibilities of organisations focused on both quick responses to rebuilding infrastructure and to making it more resilient. Some responses expressed that greater access to technical experts when trying to build resilient infrastructure or to repair disaster damaged infrastructure would be beneficial.

In respect to the division of roles across governments, responses demonstrate quite different understandings across the country of how local governments perceive the roles of other governments and relevant legislation (*Figure 7*). When asked how well the role of local government is articulated and understood in legislation and by other actors, 23% of local governments believe that the community has a very good understanding of their role and 28% believe community has a moderate understanding.

Figure 7: Perception of how well the role of local government in disaster is understood.

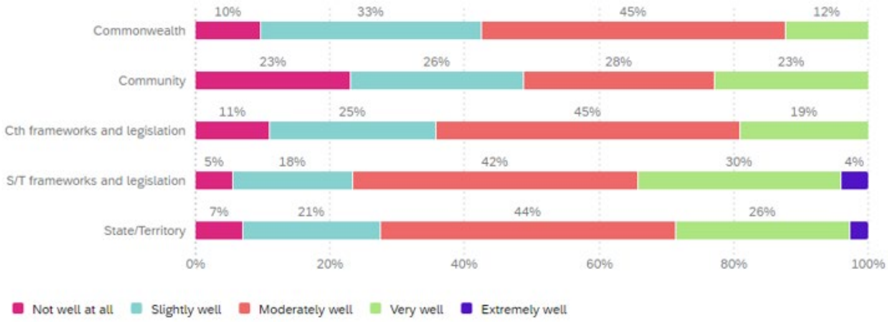
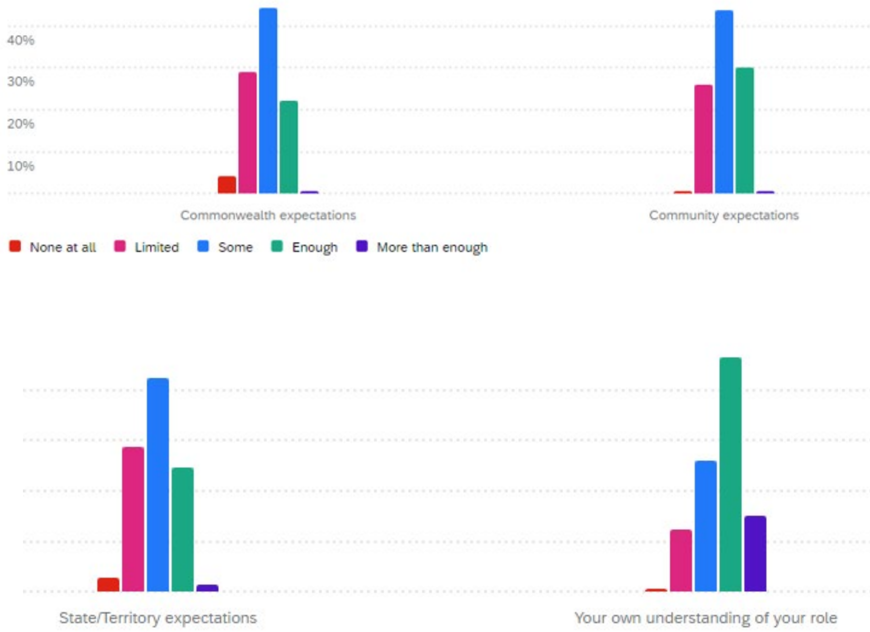


Figure 8 demonstrates the confidence of local governments in their capacity to meet expectations of their role. Forty-seven percent of local governments believe they have the capacity to meet their own understanding of their role. This indicates that they feel external expectations are higher than the actual requirements of their roles.

Figure 8: Local government perceptions of their capacity to meet roles, responsibilities, and expectations.



Several local governments highlighted that disaster management does not have a dedicated role in their organisation, rather it sits separately to normal operations, or as one part of an individual's role until a disaster strikes. Many of those who did have dedicated disaster management roles explained that this was not sustainable due to the short-term funding available and requirement for contractors rather than full time employees.

When asked about the role the Commonwealth had in supporting local governments, many expressed that the layer of bureaucracy through the Commonwealth to state government was a significant issue. Of the submissions which discussed the roles of states and territory governments, 22% of them did so positively.

Throughout the survey, there was less of an emphasis on the relationship with the Commonwealth as there was with the states/territories. Local governments felt that the high evidentiary requirements indicated a lack of trust in local government. There was a strong sentiment that local governments are expected to fill a significant role in disaster management but are not trusted by the Commonwealth to perform this role. Local governments saw Commonwealth funding as critically important for enabling their role.

Key funding programs discussed were the DRFA, Natural Disaster Relief and Recovery Arrangements (NDRA) and Financial Assistance Grants. When asked how the Commonwealth supports, helps, or hinders local government in their role and if the support aligns with other government and non-government support, 38% of comments overall were negative, 35% were neutral and 12% were mixed. Sentiment around the DRFA specifically was more varied, with 25% being positive comments, 12% very positive, 12% mixed and 38% negative.

When asked about the factors that influence local government decisions to access Commonwealth supports, respondents reiterated that capacity and capability are the main barriers for access. These included a lack of experience in council staff, financial constraints, the time taken away from BAU duties and the complexity of applications. Overall, responses expressed a desire for greater simplification of the DRFA eligibility criteria and application process, as an important way to provide non-financial supports, this included increasing communication across different jurisdictions.

2.4. First Nations engagements

The following 14 key themes present a high-level summary of the themes integrated from the engagements and literature review undertaken with First Nations peoples as part of this Review.

Table 3 Key themes from First Nations engagement.

Theme title	Theme description
1. A differing worldview of 'natural disasters'	First Nations' understanding of 'natural disasters' differs from the Western view that drives government policy and response. First Nations' people understand that 'disasters' will have complex causation and effect. Events will have scientific significance. They will also most certainly have human-induced environmental significance and a practical impact that generates human responsibility and obligation. Underpinning that will always be cultural significance – which helps explain those complex elements. Yet, there is still significant progress required to move this knowledge towards holding a valued place within Australian society. Without it, the consequence is profound, limiting the capacity to shift methodologies and change the paradigm of 'disaster recovery' and to benefit from a cultural inclusive response.
2. Positioning First Nations values at the centre of disaster resilience	The evolving impacts of climate change present unprecedented challenges for all communities. For Aboriginal and Torres Strait Islander communities, resilience is a product of place; expressed in song, story and cultural practice adapted to the land's patterns and cycles. Building resilience requires respecting and formally valuing traditional knowledge as a crucial tool for community structure and ongoing support. Investing in this directly, as well as funding programs of preparedness and resilience on an ongoing basis are vital for all community health, longevity and long-term outcomes. Furthermore, mainstream emergency management often turns first to the protection of human life and infrastructure, with awareness of and response to damage of biodiversity, Country and sacred sites coming later (if at all).

Theme title	Theme description
3. Embedding First Nations knowledge in disaster frameworks and policies	Incorporating local knowledge into all disaster management plans is crucial for the successful outcomes of all communities – Indigenous and non-Indigenous. First Nations' knowledge is a deeply informed, localised body of science that provides profound ecological insights, enabling effective prevention, prediction, preparation and resilience to natural hazards. In addition to the science of 'Country', the practical mechanisms of First Nations cultural and community practice means that solutions are understood and activated fast and effectively when it can inform and lead local decision making. Genuine consultation and an encouragement of collaborative research are vital for integrating Indigenous knowledge into modern disaster management approaches and developing effective risk reduction tools.
4. Improving outcomes by acknowledging systems design	Emergency response systems have been designed with Western frameworks of governance and risk at their centre, using language like 'coordination', 'centralisation', 'intervention' and 'risk reduction'. This approach emphasises action, but it also disconnects 'power' from place and diminishes both community and individual agency. There is evidence to suggest that the fundamental paradigm of Western governance – often associated with a deficit-based, decision-centralised approach – has overridden the deeply place based governance and socio-cultural-environmental adaptive capacities that Indigenous peoples traditionally used for risk management and response. Local Indigenous knowledge, grounded in reciprocal relationships with Country, ecological insights and kinship bonds, enhances the resilience of communities against natural disasters.

Theme title	Theme description
5. Enabling the meeting of two knowledge systems	The model of Western language, processes and structures in funding and legislation, particularly regarding access and eligibility, affects the nation's ability to prepare and respond more effectively to natural disasters. For First Nations people, their stories, wisdom, science and immense practical skillsets serve as essential tools for addressing disasters and complexities. Indigenous communities shared that, if enabled, they could have helped explain previous likely flooding consequences; the probable movement of water through the natural hydrology of the landscape, down to the practical strategies for road and access way building, alongside the same stories being shared about fire management disasters. A 'two worlds' approach should give equal value and weight to Western and Indigenous knowledge for sustainable development on local, national and global scales. This emerges as less of a matter of 'consultation', but as a genuine respecting and empowering of First Nations knowledge and leadership in the system as a whole.
6. Bias, racism, and exclusion	First Nations people have sought to be seen and respected as equal members of society, yet experiences of systemic bias, racism and exclusionary practices persist. Emergency management, as a field of work closely aligned to Country and place, could be a useful vehicle for respect to evolve. First Nations people aspire to contribute their expertise to disaster preparedness, planning, and response, but face exclusion from mainstream efforts, organisations and government agencies, which can extend to being overlooked for funding opportunities. A focus here should be placed on overcoming barriers to inclusion, increasing awareness of funding opportunities and ensuring equal recognition of Aboriginal community infrastructure.

Theme title	Theme description
7. Recognising ways of working, doing and being and First Nations governance	There are stories of successful disaster management and response across Australia, many of which are community and/or First Nations led. From food, shelter and even rapid response recovery in Lismore, to whole of recovery strategies across regions in the Fitzroy River Valley and Victoria, it was often First Nations community members who provided the leadership and knowledge necessary for the situation. These solutions were usually generated outside of the formal systems of emergency response governance. Indigenous people, particularly Elders and nominated community leaders, play crucial custodial, expert and leadership roles, maintaining social and environmental relations essential for community disaster response. Recognising, resourcing and supporting these governance structures is fundamental for fostering resilience in Indigenous communities and all community.
8. Understanding a multi-generational view of social and emotional wellbeing	First Nations people can be disproportionately impacted by natural disasters, both due to their connection to Country, as well as in terms of health, housing and the compounding of intergenerational trauma. First Nations culture understands intergenerational trauma and memory in direct and cumulative ways – because of a widely held multi-generational cultural responsibility and in many instances directly – because trauma is layered into the social and cultural determinants of health and opportunity. The resilience of First Nations lies in pattern thinking and 'recovery capitals' that emphasise long term thinking, including cultural, natural and kinship resources, as well as people, governance and community capability building. Funding that understands – and flows to – 'recovery capitals' would not only enhance social and emotional wellbeing, but also improve disaster management outcomes.

Theme title	Theme description
9. Supporting the power of kinship and drawing on community connection	Kinship and community systems are at the core of Indigenous community and knowledge holding practices and are central to the relational economy that drives community outcomes. Kinship is often misunderstood in the western framing as 'family'; rather, it is a layered and complex concept of relationship with all elements of the system (living and non-living, ancestral and future, human and non-human, personal and collective). At a profoundly practical level this deep connection centres around cultural relationships and generates networks of responsibility, mutual obligation and care that connect people and solutions – for food, shelter and family. Funding needs to be directed towards these relational networks to enable responsiveness, providing the essential structures for preparing, responding to and recovering from natural disasters within the community. Recognising and respecting these connections is vital for fostering two-way understanding and reciprocity in the relationships between governments and communities.
10. Elevating lore, culture and caring for Country	Cultural rights, interests and knowledge must be recognised within the funding system. Lore, which is deeply embedded in Country, provides a foundation for culture, people and community success – through story, responsibility, eldership, leadership and interconnected patterns of understanding. Knowledge of caring for Country is not restricted to 'bush fire and flood management' and extends into biodiversity and an inter-generational landscape, governance, leadership and whole system management. A widely shared First Nations' view is that existing funding models of disaster response and recovery come too late in the cycle to have beneficial effect on disaster management. Funding arrangements should prioritise caring for Country responsibilities and emphasise localisation, community-led, culturally informed design, noting that this may generate different approaches in different communities.

Theme title	Theme description
11. Place-based knowledge for both worlds	Agencies handling disaster funding must enhance their data capabilities and Indigenous capacity to overcome the cycle of excessive consultation, repeated requests and under-delivery. Establishing respectful processes for acquiring and building on advice is pivotal. Moving from an academic, extractive and 'disconnected from Country' approach, into a practical, local and programmatic one, ensures First Nations knowledge is valued and useful. Additionally, sharing relational-based examples of successful approaches, their mechanisms, beneficiaries and reasons, could contribute to an intersectional knowledge base that informs changes within and between systems. Planning a full system response for place that covers the entire spectrum of care, investment, response and recovery could provide a template that reflects the unique knowledge and needs of each community.
12. Delivering the right funding across the disaster continuum	Many Indigenous communities inhabit geographically extensive, regional, rural and remote areas where local government and even state jurisdictions may not align with First Nations boundaries. Resources are limited and challenges persist due to diseconomies of scale in these expansive regions. The administrative burden of applying for funding often fails to reflect the higher costs of service delivery in these areas. Funding allocation should account for the capacity, needs and risk of communities. Most importantly it should reflect that caring for Country and investing in prevention and response infrastructure as well as recovery capitals, need to occur before disaster strikes. Long-term, flexible funding and block funding models are perceived as critical solutions

Theme title	Theme description
13. Streamlining legislative complexity and safeguarding social and cultural values	The language of 'disaster' is intended to create an emergency response and trigger disaster management processes that often override other legislation. This Review heard evidence of emergency responses that overrode local cultural heritage and sacred site protections, family and domestic violence orders and out-of-home-care arrangements; some of which led to devastating loss of ancient knowledge, while others led to specific harms in social and emotional welfare. In many instances, the laws pertaining to emergency management are enforced by police, who often have a difficult relationship and a lack of trust from local community, further creating the risk of harm. Funding mechanisms need to encourage adjustment to localised decision making and legal power, as well as removing obstacles to the role that local cultural authority needs to play in prevention, response and recovery.
14. Improved navigation of funding structures	The current funding landscape – spanning multiple layers of government and multiple agencies of government and including programs from private, local and community avenues – means that it is highly challenging to understand and navigate. This can result in some funding pools being ignored, while others are overextended or used incorrectly. In all instances, communities carefully consider whether they can afford the process of applying for some grants or carry the burden of managing and reporting against others, noting also the cultural and linguistic differences that can present. To streamline the process, clear lines of responsibility between all relevant state and territory and Commonwealth government agencies are essential. Incorporating community input into the design and planning of funding models, at all levels of government and before disasters occur – is crucial for effective design, communication and responsiveness.

3. Sources and references

Focus group participants

Table 4 below outlines organisations, departments and agencies (organised by sector) of all stakeholders engaged throughout the Review through focus groups.

Table 4. Stakeholders engaged throughout the Review through focus groups.

Sector	Organisation
Food and Groceries	Aldi
	Australian Food & Grocery Council
	Bunnings
	Woolworths
Energy & Telecommunications	Australasian Convenience and Petroleum Marketers Association
	Energy Network Australia
	Evo Energy
	Origin Energy
Logistics	Australasian Railway Association
	Australian Logistics Council
	Australian Roads Research Board
	Australia Post
	Linfox
	National Transport Research Organisation
	Team Global Express
Environment	Climate Action Network Australia
	Climate Council
Health Services	Beyond Blue
	Gender and Disaster Australia
	National Disability Services
	People with Disability Australia
	Phoenix Australia

Sector	Organisation
Philanthropies	Minderoo Foundation
	Paul Ramsay Foundation
	Resilient Ready
Research and Academia	Australian Institute for Disaster Resilience
	Natural Hazards Research Australia
	University of Canberra
	Sydney University
Crisis Response	Drought Angels
	National Aerial Firefighting Centre
	Wildlife Information, Rescue and Education Services (WIRES)
Social Services	Anglicare
	Australian Red Cross
	Foodbank Australia
	Foundation for Rural & Regional Renewal
	Headspace
	Legal Aid NSW
	Legal Aid QLD
	Orange Sky Laundry
	Rural Aid
	St. Vincent De Paul
Banking and Financial Services	Australian Banking Association
	Bendigo & Adelaide Bank
Construction	Downer Group
	Planning Institute Australia
	Venetia

Sector	Organisation
Farming and Primary Producers	AgForce Queensland
	National Farmers Federation
	NSW Farmers
	Primary Producers SA
	Queensland Farmers' Federation
	Victorian Farmers Federation
Insurance	Allianz Suncorp
	Australian Prudential Regulation Authority
	Australian Securities and Investment Commission
	Insurance Australia Group
	Insurance Council of Australia
	QBE Insurance
	Royal Automobile Club of Queensland
Small Business	Australia Chamber of Commerce and Industry
	Australian Business Volunteers
	Business Council of Co-operatives and Mutuals
	Council of Small Business Organisations Australia
	Small Business and Family Enterprise Ombudsman
Higher-Risk Cohorts (Peak Bodies)	Australian Council of Social Service
	Carers Australia
	Diversity Australia
	Lifeline
	National Council of Single Mothers and their Children
	NSW Council of Social Service
	The Centre for Resilient and Inclusive Societies
	Victorian Council of Social Service

Sector	Organisation
State, Territory and Local Government	
NSW State Government	Department of Communities and Justice
	Infrastructure NSW
	NSW Department of Premier and Cabinet
	NSW Department of Primary Industries
	NSW Environment Protection Agency
	NSW Reconstruction Authority
	NSW Rural Assistance Authority
	NSW Treasury
	Public Works NSW
	Regional NSW
	Transport for NSW
NT State Government	NT Department of Infrastructure, Planning and Logistics
	NT Department of Territory Families, Housing and Communities
	NT Department of the Chief Minister and Cabinet
	NT Police, Fire and Emergency Services
QLD State Government	QLD Department of Premier and Cabinet
	QLD Department of Transport and Main Roads
	QLD Reconstruction Authority
	QLD Treasury
SA State Government	SA Department for Environment and Water
	SA Department of Primary Industries and Regions
	SA Department of the Premier and Cabinet
	SA Department of Treasury and Finance
	SA Fire and Emergency Services Commission
	South Australia Emergency Services
TAS State Government	TAS State Emergency Service

Sector	Organisation
VIC State Government	Department of Justice & Community Safety
	Emergency Management Victoria
	Emergency Recovery Victoria
	VIC Department of Agriculture
	VIC Department of Energy, Environment and Climate Action
	VIC Department of Families, Fairness and Housing
	VIC Department of Government Services
	VIC Department of Health
	VIC Department of Premier and Cabinet
	VIC Department of Transport and Planning
WA State Government	WA Department of Fire and Emergency Services
	WA Department of the Premier and Cabinet
ACT State Government	ACT Emergency Services Agency
	ACT Justice and Community Safety Directorate
Central West and South Coast NSW Local Government	Bega Valley Shire Council
	Central NSW Joint Organisation
	Central NSW Joint Organisation
	Cowra Shire Council
	Eurobodalla Shire Council
	Shoalhaven City Council
Municipal Association of Victoria and Regional Victoria Local Government	East Gippsland Shire Council
	Gippsland Regional Partnership
	Ovens Murray Regional Partnership
NSW Local Government	Central NSW Joint Organisation
	Hunter Joint Organisation
	Local Government Association of NSW

Sector	Organisation
NT Local Government	City of Darwin
	Local Government Association of the Northern Territory
	Organisation of Councils
QLD Local Government	Border Regional Organisation of Councils
	Central Queensland Regional Organisation of Councils
	Council of Mayors Southeast QLD
	Inverell Shire Council
	Local Government Association of Queensland
	Northwest Queensland Regional Organisation of Councils
	Southwest QLD Regional Organisation of Councils
	The Yellow Company
	Western Queensland Alliance of Councils
WA Local Government	Regional Capitals Alliance Kimberley Regional Group of Councils
	Shire of Cocos (Keeling) Islands
	Shire of Derby / West Kimberley
	Shire of Upper Gascoyne
	Western Australian Local Government Association
SA Local Government	Adelaide Hills Council
	Legatus
	Local Government Association of South Australia
	Mount Barker District Council
TAS Local Government	Glamorgan Spring Bay Council
	Hobart City Council
	Local Government Association Tasmania
	Tasman Council

Sector	Organisation
NSW Hunter Valley Region	Central NSW Joint Organisation
	Hunter Joint Organisation
	LGA NSW
Northern Rivers, Blue Mountains and Hawkesbury	Hawkesbury City Council
	Lismore City Council
	Penrith City Council
	Tweed Shire Council
Commonwealth Department / Agency	
Environment and Climate Policy	Commonwealth Scientific and Industrial Research Organisation
	Department of Agriculture, Fisheries and Forestry
	Department of Climate Change, Energy, the Environment and Water
	Murray Darling Basin Authority
Industry, Economic and Productivity Policy	Bureau of Infrastructure and Transport Research Economics
	Department of Employment and Workplace Relations
	Department of Industry, Science and Resources
	Department of Infrastructure, Transport, Regional Development, Communications, and the Arts
NEMA	NEMA (Data and Technology Branch, Community Engagement Branch, Policy and Design Branch, Recovery Branch)
Data and Science	Australian Bureau of Agricultural and Resource Economics
	Australian Bureau of Statistics
	Australian Climate Service
	Bureau of Meteorology
	Geoscience Australia

Sector	Organisation
Service Delivery	Department of Defence
	Department of Social Services
	Services Australia
Social and First Nations	Department of Education
	Department of Health and Aged Care
	National Indigenous Australians Agency
Strategic and Financial Policy	Department of Finance
	Department of Home Affairs
	Department of the Prime Minister and Cabinet
	Treasury

Codebook themes and subthemes

Table 5 provides the themes, codes and sub-codes used for thematic analysis of stakeholder engagement data.

Table 5. Themes, codes and their description as per the codebook used for analysis.

Overarching theme	Code level 2	Code level 3	Description
1. Disaster continuum	1.1 Before		Refers to the prevention and preparedness phases.
	1.2 During		Refers to the response and relief phase.
	1.3 After		Refers to the recovery phase.
	1.4 Always		Refers to risk reduction, resilience and adaptation building.

Overarching theme	Code level 2	Code level 3	Description
2. Domain	2.1 Social		Refers to the social systems, processes, attributes and elements of value which play a role in, and are affected by, disaster.
	2.2 Economic		Refers to the economic systems, processes, attributes and elements of value which play a role in, and are affected by, disaster.
	2.3 Environmental		Refers to the environmental and ecological systems, processes, attributes and elements of value which play a role in, and are affected by, disaster.
	2.4 Built		Refers to the built and infrastructural systems, processes, attributes and elements of value which play a role in, and are affected by, disaster.

Overarching theme	Code level 2	Code level 3	Description
3. Principles identified in the Terms of Reference	3.1 Scalable 3.2 Sustainable 3.3 Effective 3.4 Equitable 3.5 Transparent 3.6 Accessible		These codes refer to policy objectives for disaster funding which are specified in the Terms of Reference for the review. These should be used where a participant provides a perspective on what constitutes one of these objectives or characteristics. These should be considered, for the sake of stakeholder engagement, as subjective values that people have different views on.
4. Policy component/ stages	4.1 Policy problem definition		Refers to the way that a stakeholder conceptualises the problem which funding and policy needs to address.
	4.2 Policy design	4.2.1 Financial	Refers to financial instruments which can be/are used in disaster policy, e.g., grant programs, fee-for-service arrangements, funding programs.

Overarching theme	Code level 2	Code level 3	Description
		4.2.2 Non-financial	Refers to non-financial policy instruments which can be/are used in disaster policy, e.g., coordination, policy frameworks, on-the-ground resources, data provision.
		4.2.3 Response frameworks	Refers to policy instruments, systems and structures which provide decision support to governments/actors on how to respond to disasters as they occur and which services to deploy.
	4.3 Implementation	4.3.1 Eligibility criteria	Refers to the criteria by which an applicant is considered eligible to receive assistance.
		4.3.2 Guidelines	Refers to the guidelines which guide decision making on eligibility or applications for assistance.
		4.3.3 Stakeholder awareness	Refers to awareness of stakeholders or potential beneficiaries, of financial and non-financial assistance available (can be state or Commonwealth).

Overarching theme	Code level 2	Code level 3	Description
		4.3.4 Disbursement	Refers to mechanisms and processes by which financial assistance is distributed.
		4.3.5 Audit requirements	Refers to audit and reporting requirements which accompany provision of financial assistance.
		4.3.6 Funding governance	Refers to structures and processes which have been established to oversee the correct and appropriate application for, disbursement of, and reporting on financial assistance.
		4.3.7 Capability and capacity	Refers to the skills, abilities, and quantity of human and non-human capital to undertake the work of government.
		4.3.8 Time	Refers to the way timeframes and temporal constraints of systems, processes and government/non-government processes impact disaster risk reduction, recovery and resilience.

Overarching theme	Code level 2	Code level 3	Description
	4.4. Monitoring and evaluation		Refers to processes of evaluating the outcomes and impacts of a policy (financial or non-financial) in respect to policy objectives.
	4.5 Behaviours derived from policy settings		Refers to behaviours which emerge due to the influence of a policy.
	4.6 Political influence		Refers to influence of politicians or political apparatus on policy decisions.
5. Roles and responsibilities	5.1 Commonwealth and state		Refers to division of policy and practical responsibilities and roles between Commonwealth and state/territory governments.
	5.2 State and local		Refers to division of policy and practical responsibilities and roles between state/territory governments and local governments.
	5.3 Commonwealth and local		Refers to interactions and relationships between local governments and the Commonwealth government.

Overarching theme	Code level 2	Code level 3	Description
	5.4 NFPs	5.4.1 Social Services	Refers to work, interactions and issues associated with the social services sector.
		5.4.2 Health Services	Refers to work, interactions and issues associated with the health services sector.
	5.5 Private sector	5.5.1 Insurance	Refers to work, interactions and issues associated with the insurance sector.
		5.5.2 Telecommunications and Energy	Refers to work, interactions and issues associated with the telecommunications and energy sector
		5.5.3 Food and Grocery Sector	Refers to work, interactions and issues associated with the food and grocery sector
		5.5.4 Banking and Finance	Refers to work, interactions and issues associated with the banking and finance sector
	5.6 Collaboration and coordination		Refers to all issues associated with collaboration and coordination between any stakeholder in the system.

Overarching theme	Code level 2	Code level 3	Description
	5.7 Coordination		Refers to all the issues and channels associated with different levels of government determining responsibility and action within the system.
6. Commonwealth disaster funding	6.1 DRFA		Disaster Recovery Funding Arrangements
	6.2 DRF		Disaster Ready Fund
	6.3 AGDRP		Australian Government Disaster Recovery Payment
	6.4 DRRP		NPA Funding
	6.5 Event driven funding		Funding which was released to address specific events, for example, funding for the 2019 Monsoon Trough
	6.6 'Other' funding		Refers to non-disaster specific funding and all Commonwealth disaster funding programs which are not listed specifically, or in respect to qualities, elements and behaviours of the funding landscape.
	6.7 State or territory funding		Refers to funding arrangements and programs of state or territory governments.

Overarching theme	Code level 2	Code level 3	Description
7. Data and information	7.1 Data gaps		Refers to data or information gaps and needs.
	7.2 Data sharing		Refers to policies, operations, administration and complexities of sharing data.
	7.3 Reporting		Refers to the methods and processes which funding participants report their usage of, and need for funding
	7.4 Data accessibility		Refers to policies, operations, and administrative arrangements associated with accessing data.
	7.5 Data governance		Refers to all aspects of data governance including management systems.
	7.6 Education and awareness	7.6.1 Social media.	Refers to all issues associated with public education, access, use and awareness of data.
		7.6.2 Advertising programs	

Public submission participants

Table 6 details the entire list of public submissions. A total of 194 public submissions were submitted through NEMA's public submission process.

Table 6 List of public submissions.

This table only includes submissions made through NEMA's public submission process. Contributors could select whether they wanted their submission a) published, b) published with name, or c) not published. Those who did not want their submission published (option c) are not included. Individuals and entities named are those which explicitly opted for their name to be published with their submission; those who opted for their submission to be published but not with their name are anonymised.

State	Entity category	Name
NSW	State Government	NSW Department of Communities and Justice (Courts, Access to Justice and Regulatory Branch)
	Commonwealth Member of Parliament	Office of Sussan Ley MP
	Individual	Steve Block
		Barbara Pinning
		Pamela Green
		Phillip Skinner
		Mark Redding
		Heidi Chappelow
		Luke Barbagallo
		Nicole Luhrs
		Jesse Lees
		6 individuals opted to be anonymised.

State	Entity category	Name
	Local government	Central NSW Joint Organisation
		Uralla Shire Council
		Junee Shire Council
		Forbes Shire Council
		Sutherland Shire Council
		Wingecarribee Shire Council
		Lismore City Council
		Wollongong Shire Council
		Tweed Shire Council
		Canberra Region Joint Organisation
		City of Coffs Harbour
		MidCoast Council
		Eurobodalla Shire Council
		Hawkesbury Shire Council
		Camden Council
		Blue Mountains City Council
		Murray River Council
		Hunter Joint Organisation
		Port Macquarie-Hastings Council
		9 local governments opted to be anonymised.

State	Entity category	Name
	NFPs/Charities/Philanthropies	The Black Dog Institute
		Foodbank Australia
		Peppercorn Services (2 submissions received)
		Hawkesbury Blue Mountains Community Bushfire Alliance
		Royal Far West
		Regional Development Australia - Southern Inland Incorporated
		Australian Red Cross
		Rotary Australia World Community Service Ltd.
		Our Future Northern Rivers
		Southcoast Health and Sustainability Alliance
		Wentworth Healthcare Ltd
		Singleton Neighbourhood Centre
		Natural Hazards Research Australia
		Community Legal Centres NSW
		WIRES
		Relationships Australia (NSW)
		An Indigenous Health Organisation
		2 organisations opted to be anonymised.

State	Entity category	Name
	Private Organisations/Peak Bodies/Industries	Business Council of Co-operatives and Mutuals
		Destination Riverina Murray Ltd
		Independent Bushfire Group
		Ausgrid
		The Institute of Public Works Engineering Australasia (IPWEA) NSW & ACT Division
		MidCoast Disaster Recovery Providers Group
		New South Wales Council of Social Service
		Strata Community Association
QLD	State Government	Queensland Reconstruction Authority
	Individual	Benjamin Norris
	Local Government	Barcoo Shire Council
		Cook Shire Council
		Western Queensland Alliance of Councils (WQAC)
		City of Gold Coast
		Ipswich City Council
	NFPs/Charities/Philanthropies	Fortem Australia
		Healthy Land & Water
		Community Legal Centres Queensland
		Neighbourhood Centres Queensland

State	Entity category	Name
	Private Organisations/Peak Bodies/Industries	RACQ
		Public Safety Training and Response Group
		Queensland Farmers' Federation
		Australian Disaster Alliance/ 1300DISASTER
VIC	Individual	Helen Forbes-Mewett
		6 individuals opted to be anonymised.
	Local Government	Baw Baw Shire Council
		Golden Plains Shire Council
		Moorabool Shire Council
		Latrobe City Council
		Wimmera Emergency Management Resource Sharing Partnership
		Gannawarra Shire Council
		City of Greater Bendigo
		Macedon Ranges Shire Council
		Central Goldfields Shire Council
		Campaspe Shire Council
		South Gippsland Shire Council
		Hepburn Shire Council
		East Gippsland Shire Council
		Loddon Shire Council
		2 organisations opted to be anonymised.

State	Entity category	Name
	NFPs/Charities/Philanthropies	East Gippsland Community Foundation
		Gender and Disaster Australia
		Australian Breastfeeding Association
		Deakin University (2 submissions received)
		Foundation for Rural and Regional Renewal
		Fire to Flourish, Monash University
	Private Organisations/Peak Bodies/Industries	Resilient Ready
		CPA Australia
		Lighthouse Mental Health
		Sarsfield Community Association Inc.
WA	Individual	*2 individuals opted to be anonymised.*
	Local Government	Shire of Morawa
		Town of Port Hedland
		Shire of Victoria Plains
		Kimberley Regional Group of Local Governments
	Private Organisations/Peak Bodies/Industries	Western Australian Council of Social Service (WACOSS)
SA	Individual	*1 individual opted to be anonymised.*
	Local Government	City of Onkaparinga
		The Barossa Council

State	Entity category	Name
	NFPs/Charities/Philanthropies	Community Legal Centres (SA)
		Local Government Association of South Australia
		Australian Coastal Society Pty Ltd
		Volunteering SA&NT
TAS	Local Government	City of Hobart
	Private Organisations/Peak Bodies/Industries	Climate-KIC Australia, on behalf of the Resilient Futures Investment Roundtable
NT	Australian Government	Northern Australia Indigenous Reference Group
	Local Government	Central Desert Regional Council
		City of Darwin
		Local Government Association of the Northern Territory

Local government survey participants

Table 7 outlines which local government associations responded to the survey, their state or territory, as well as the number of respondents. Note, 156 responses were received in total; however, all questions were optional and 53 respondents did not disclose any location information.

Table 7. Local government survey participants.

State/ Territory	Local Government Association	Respondents
NSW	Warren Shire Council	1
	Hay	1
	Balranald	1
	MidCoast	1
	Fairfield	1

State/ Territory	Local Government Association	Respondents
NSW	Nambucca Valley Council	2
	Hornsby Shire Council	1
	Ballina	1
	Armidale Regional Council	1
	Glen Innes Severn	1
	Maitland	1
	Temora Shire Council	1
	Snowy Monaro Regional Council	1
	Richmond Valley	1
	Liverpool City Council	2
	Blayney	1
	Singleton Council	1
	Lismore City Council	3
	Gunnedah Shire Council	1
	Cabonne	1
	Mosman	1
	Peak Body - Local Government NSW	1
	Did not disclose	2
QLD	Longreach	1
	Livingstone	1
	Burdekin Shire Council	3
	Barcoo Shire Council	1
	Douglas Shire	1
	Ipswich	2
	Noosa Shire Council	2
	Cloncurry	1

State/ Territory	Local Government Association	Respondents
QLD	Boulia	1
	Cook	1
	City of Moreton Bay	1
	Somerset Regional Council	2
	Sunshine Coast	2
	Mackay	2
	Scenic Rim Regional	3
	Cairns Regional Council	1
	Did not disclose	2
SA	City of Tea Tree Gully	1
	Eyre Peninsula	1
	Alexandrina Council	1
TAS	Central Coast Council	1
	Kingborough	1
	Devonport	1
	Southern Midlands	1
	Meander Valley Council	1
	Break O'Day	1
VIC	Merri-bek City Council	1
	Maroondah	1
	Rural City of Wangaratta	1
	Brimbank	2
	Federation Council	1
	Municipal Association of Victoria	1
	Macedon Ranges Shire	2
	Murrindindi	2

State/ Territory	Local Government Association	Respondents
VIC	Frankston City	1
	Mildura	1
	Surf Coast Shire Council	1
	Did not disclose	1
WA	Shire of Wyndham East Kimberley	2
	Shire of Kent	1
	Carnarvon	1
	City of Kalamunda	1
	Shire of Carnamah	1
	Gnowangerup	1
	Cocos (Keeling) Islands	1
	City of Perth	1
	WALGA	1
	Shire of Exmouth	1
	Wagin	1
	Shire of East Pilbara	2
	City of Albany	1
	Shire of Corrigin	1
	The Shire of Serpentine Jarrahdale	1
	Port Hedland	1
	South West	1
	Morawa, perenjori yalgoo Murchison	1
	City of Cockburn	1
	Shire of Murray/Shire of Waroona	1
	Shire of Mundaring	2

First Nations engagement participants

Due to the small size of the organisations consulted during the First Nations engagement, to preserve the privacy of individual participants, the organisations' names have not been provided. 14 organisations, including the National Indigenous Australians Agency, were consulted. These groups were based across Australia and included organisations which worked in the following sectors: housing and homelessness, legal and Native Title, health services, family services, media and communications, land councils, disaster recovery and ranger services.

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Appendix E: Research and insights workstream: methodology, findings, sources and references

This appendix provides the methodology, findings, sources and references associated with the research and insights workstream.

1. Methodology

The section below outlines the detailed methodology for the activities undertaken as part of the research and insights workstream.

1.1. Methods

Systematic literature review

To guide the systematic academic literature review two primary exploratory themes were used – leading practice and administration of funding – to underpin our approach to literature identification. These align with three questions from the Independent Review lines of enquiry. Together these research questions guided the approach to identification and analysis of literature. The three line of enquiry questions relevant to this activity are:

1. What funding principles should inform the Commonwealth's approach to disaster risk, reduction and resilience? (Line of Enquiry 2).
2. What is the leading theory and practice in disaster funding? (Line of Enquiry 6).
3. What mechanisms exist that could be used to shape Commonwealth resilience and risk reduction funding? (Line of Enquiry 6).

The synthesis and analysis were derived from the final list of priority papers, totalling 38 academic articles.

Grey literature review

The initial scan of grey literature identified 100 documents that were mapped against the eight lines of enquiry. The grey literature review was also guided by the two primary exploratory guiding themes identified above. The documents were prioritised into three categories:

1. Documents that discussed both leading practice/principles and administration of funding,
2. Documents that discussed leading practice/principles only,
3. Documents that discussed administration of funding only.

Based on this exercise, the report developed its synthesis and analysis from the prioritised documents, totalling 26 pieces of grey literature.

Comparative case study

The international comparative case study focused on four countries of interest – the United States of America, Canada, New Zealand and Japan. A grey literature review was conducted on each country with four themes acting as the parameters for the search:

- Structure of the disaster management arrangements of the country.
- Principles of disaster management for the country.
- How funding is administered.
- Lessons to be learnt from the country and its approach to disaster management.

With these themes, a preliminary grey literature review was conducted to find between 10 – 20 documents or articles per country for further review and analysis. The research and insights workstream team reviewed each relevant country and provided a summarised report of findings, which has formed the basis of this synthesis.

Following this, a scan of recent academic literature on each of the four countries of interest was conducted, identifying 20 academic articles. A rapid review of the literature was then conducted to validate findings from the comparative case study analysis.

Comparative analysis of the current state and leading practice

Using the reviews, engagement and research from tranches 1 and 2, a comparative analysis of the current state of disaster funding against leading practice in Australia and internationally was undertaken. This analysis investigated four topics:

1. Disaster planning.
2. Advancing financial investment in disaster resilience and risk reduction.
3. Public-private partnerships (PPPs).
4. Outcomes-based decision making.

These four topics were chosen through the inductive thematic coding of the data from the Literature Review. Where required, additional academic literature was reviewed and analysed to facilitate a comparison between leading practice and the current Australian context.

2. Findings

The literature review highlighted various themes across the academic, grey literature and international comparative studies. These are summarised below and were analysed and synthesised into overall themes.

Systematic academic literature review key findings

Key themes emerging from the systematic academic literature review:

- Funding prioritisation that is cost-effective and institutionally simple, with key investments in mitigation to avoid compounding impacts and risks of natural disasters, is a key underpinning of a best practice disaster management system.
- Effective pre-disaster planning allows for efficient and coordinated funding and disaster management.
- Whilst it is accepted that mitigation investment is cost-effective, there are significant barriers; including a lack of political capital achieved through such measures and political pressures to achieve visible and tangible forms of disaster management. These impact the implementation of mitigation initiatives and need to be addressed to ensure an efficient funding system.
- Consistency, collaboration across government and sectors and multi-sectoral initiatives are key to an effective disaster management system.
- There is a need for a risk-based approach to disaster planning, with a view to long term implementation and outcome-based decision making.

Grey literature key findings

Key themes emerging from the grey literature review themes:

- The varied nature of both overt and inferred disaster funding principles, relevant to the disaster continuum across Australian and in international grey literature. Australia's federated system of government adds to this challenge, meaning that there are no consistent, structured guiding principles for Australia's disaster management system.
- Resilience is a key focus of the grey literature, in many areas including public and private sector investment, and resilience initiatives.
- There is a need for consistent and timely data and information to inform disaster management decisions.
- There is a need for national consistency in disaster information, governance and administration to ensure a consistent approach is applied to funding decisions and support by the Commonwealth.
- There is a need for clearer and more transparent monitoring and evaluation across funding arrangements and decisions to ensure consistency and equity.

Comparative case study key findings

Key themes emerging from the comparative case study analysis:

- Resilience and risk reduction is a key focus in disaster management and forms both an overt and inferred guiding principle for disaster management decisions for the United States of America, Canada, and Japan.
- The recognition of First Nations people and communities and the invaluable knowledge and information they have on land use management, and that their knowledge should be embedded in disaster management systems.
- Education and pre-disaster planning and preparedness is a cornerstone to an effective disaster management system that can cope with and respond to natural disasters more effectively.
- Reliance on other sectors and methods, such as public-private sector partnerships, as a mechanism for alternative financial assistance can provide relief for the Commonwealth’s spend.

Thematic analysis of literature summary

A synthesis of the outcomes from each review (systematic academic, grey literature and comparative case study) resulted in the following holistic list of themes:

- The need for national consistency and clarity in roles and responsibilities, across the disaster continuum.
- Strategic planning and risk-based approaches to disaster management.
- Multi-sectoral collaboration: ‘top down’ and ‘bottom up’ as an example of good practice in disaster management.
- The key role of First Nations people and communities in disaster management.

These themes are a distilled example of what is reflected across the academic, grey literature and international comparative case studies, and provide contextual information for Australia across the disaster management space. When understood and synthesised as themes across the three reviews, they offer a holistic view of topics of focus across these literature spaces. These synthesised themes provide a foundation for the Commonwealth to examine and draw from when considering gaps or opportunities for change within the Commonwealth disaster funding system, as well as providing key ideas and practices that can be further explored.

Comparative analysis of the current state and leading practice findings

Topic	Leading practice	Australia's current state
Disaster planning	• Accurate data and information to support disaster planning. • A systematic and operationalised methodology for assessing vulnerability and risks from disasters. • Collaboratively derived and strategically aligned disaster planning arrangements and artefacts.	• Uncoordinated data and information. • Recent shift in climate change policy posture demonstrates a move towards risk-based approaches. • Established frameworks in place to guide planning for disaster response but not across the continuum.
Advancing financial investment in disaster resilience and risk reduction	• Develop an evidence base for disaster resilience and risk reduction through accurate and reliable data and effective appraisal tools for analysing the benefits of investment. • Create an enabling environment for investment by aligning policy settings, institutional arrangements and coordinating across sectors / levels of government. International Examples: • Canada's focus on mitigation. • New Zealand's national insurance arrangement. • FEMA's National Mitigation Framework and Investment Strategy.	• Underutilisation of data and lacking standard tools to analyse the benefits of investment. • Emerging emphasis on resilience and risk reduction, as demonstrated by the policy direction of frameworks (e.g., Second National Action Plan). • Recent financial investment through the Disaster Ready Fund (DRF) and Disaster Risk Reduction Package (DRRP). • Recent initiatives related to emergency preparedness and resilient critical infrastructure (e.g., Mobile Network Hardening Program).

Topic	Leading practice	Australia's current state
Public-private partnerships (PPPs)	• The literature provides extensive description of the various sector-specific opportunities for the private sector to partner with government across the literature. However, the underlying factors which enable these effective partnerships are not well documented. • The indicators and processes for measuring the effectiveness of PPPs are not clearly defined or well-articulated within the literature.	• The private sector has increasingly played a role in disaster management. • Australia is comparatively less mature than other jurisdictions in terms of developing formalised initiatives and partnerships with the private sector. • Australia lacks a holistic view of PPPs in disaster management. • There is no consistent basis, or established practice to measure the value of private sector contributions, relative to government funding.
Outcomes-based decision making	• Clearly defined and consolidated outcomes. • A regular working mechanism for evaluating the performance of the given program or policy in meeting the defined outcomes. • A systematic process for incorporating outcomes-evaluation findings into decision-making processes.	• Numerous initiatives describe outcomes (e.g., 2NAP), however these efforts are uncoordinated with little alignment. • Inconsistent monitoring and evaluation, lacking an overarching framework. • Inconsistent and ad hoc sharing of learnings when evaluations are conducted. Information is siloed and not centralised.

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Appendix F: Financial and financial and economic modelling and analysis workstream: methodology, findings, sources and references

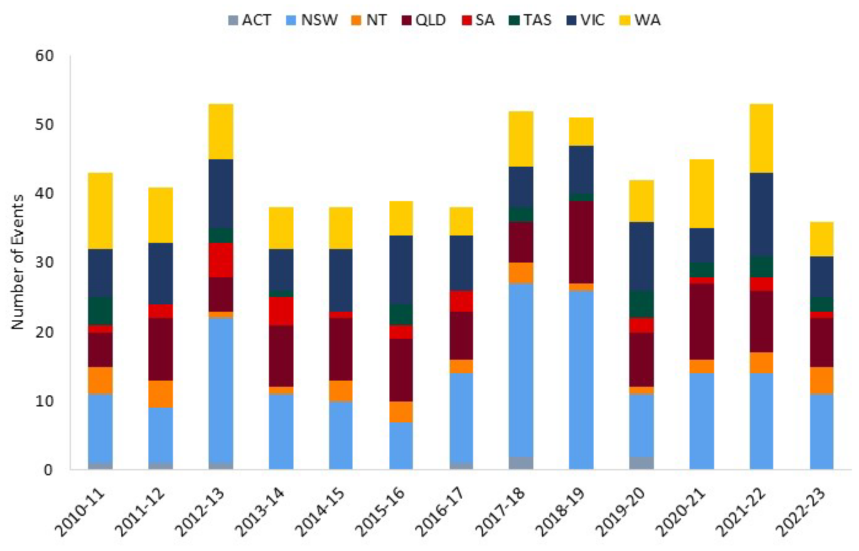
This appendix provides an overview of the historical financial analysis and the financial and economic modelling and analysis including the methodology, findings, sources and references associated with the workstream.

1. Historical financial analysis

1.1 An overview of declared natural disaster events

Between 2010-11 and 2022-23, Australia experienced on average 44 declared natural disaster events a year (refer to *Figure 9*). The largest number of declared disaster events have been experienced by New South Wales, Queensland and Victoria. It is noted that the data relating to the number of declared disaster events does not provide an indication of the size or severity of those events. For example, despite the impact of the 2019-20 bushfire season in New South Wales, the data only captures two declared bushfire events compared to 17 in 2018-19.

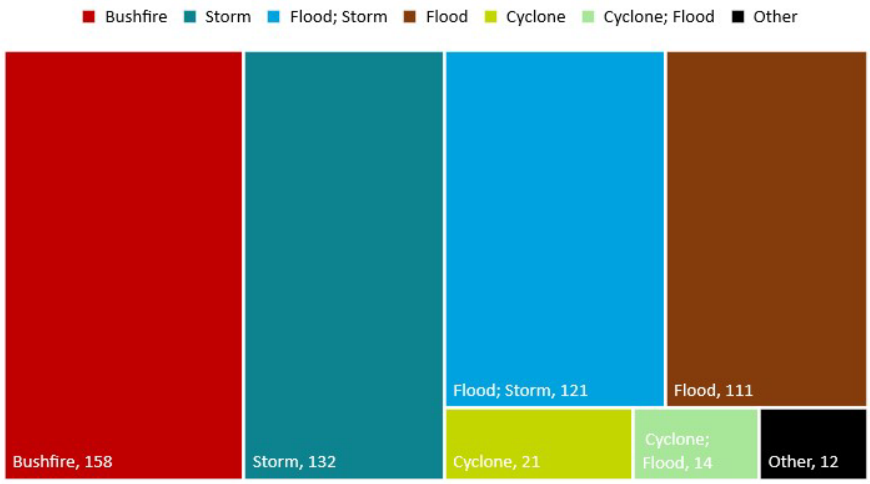
Figure 9 Number of declared natural disaster events | 2010-11 to 2022-23



Source: NEMA 2023a.

The type of declared natural disaster events varies. Bushfire, storm, flood and cyclone are the most common events (refer to *Figure 10*).

Figure 10. Number of declared natural disaster events by type | 2010-11 to 2022-23

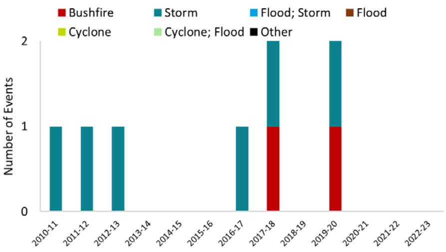


Source: NEMA 2023a.Notes: (1) Other includes declared 'Cyclone; Flood; Storm', 'Cyclone; Storm', 'Bushfire; Storm', and 'Earthquake' events. (2) Storm includes declared Hailstorm events.

Figures 11 to *Figure 18* examines the number and type of declared natural disaster events by jurisdiction. The analysis shows that between 2010-11 and 2022-23:

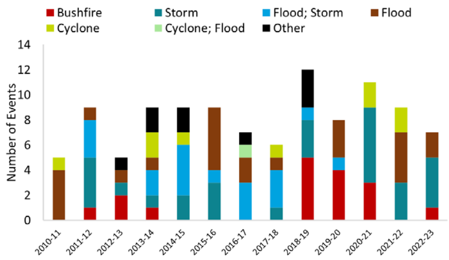
- New South Wales has experienced the highest number of declared natural disaster events, experiencing on average 14 events per year. 50 percent of these events have been bushfires,
- Queensland and Victoria both experienced, on average, eight declared natural disaster events a year, these have been a mix of event types,
- Western Australia has experienced an average of seven declared natural disaster events per year,
- The Northern Territory, South Australia and Tasmania have all experienced an average of two declared natural disaster events a year,
- The Australian Capital Territory has experienced the lowest number of declared natural disaster events, experiencing a total of eight declared events over the period,
- Bushfires and storms have been experienced across all states and territories,
- Cyclones have been experienced by the Northern Territory, Queensland and Western Australia, and
- The Australian Capital Territory, Tasmania and South Australia were the only jurisdictions to have years without any declared natural disasters.

Figure 11 Number of declared disaster events in Australian Capital Territory | 2010-11 to 2022-23



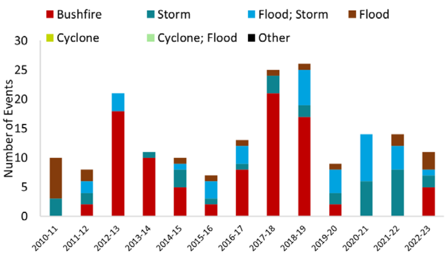
Source: NEMA 2023a.

Figure 14 Number of declared disaster events in Queensland | 2010-11 to 2022-23



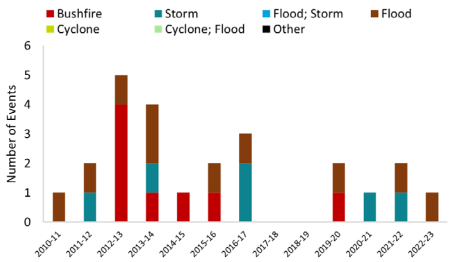
Source: NEMA 2023a.

Figure 12 Number of declared disaster events in New South Wales | 2010-11 to 2022-23



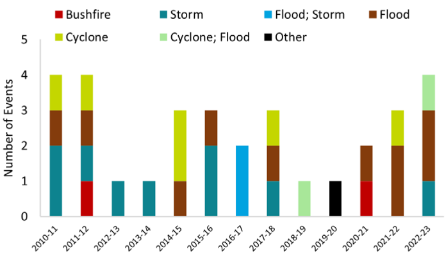
Source: NEMA 2023a.

Figure 15 Number of declared disaster events in South Australia | 2010-11 to 2022-23



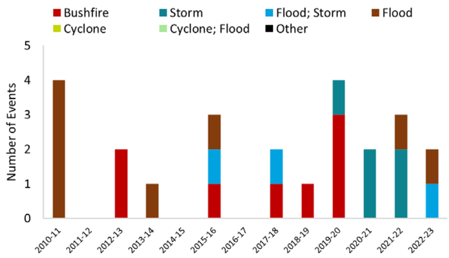
Source: NEMA 2023a.

Figure 13 Number of declared disaster events in Northern Territory | 2010-11 to 2022-23



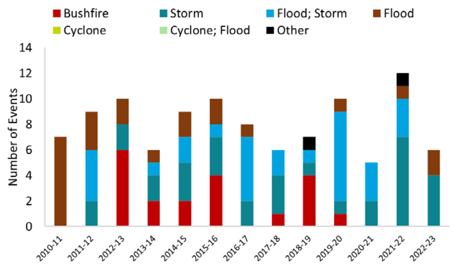
Source: NEMA 2023a.

Figure 16 Number of declared disaster events in Tasmania | 2010-11 to 2022-23



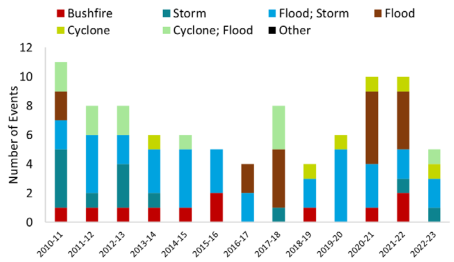
Source: NEMA 2023a.

Figure 17 Number of declared disaster events in Victoria | 2010-11 to 2022-23



Source: NEMA 2023a.

Figure 18 Number of declared disaster events in Western Australia | 2010-11 to 2022-23



Source: NEMA 2023a.

1.2 Total Commonwealth disaster funding

The following data sets were provided by NEMA and were used to inform the Commonwealth administered disaster funding expenditure:

- National Emergency Management Agency, Disaster Resilience Funding Data, 2023.
- National Emergency Management Agency, DRFA Data, 2023.

As part of the Review, the NEMA Review Taskforce coordinated the collection of Commonwealth disaster funding support provided since 2018-19, known as the NEMA Disaster Resilience Funding Dataset (Funding Dataset). The collation and update of the Funding Dataset is a manual process, completed in consultation with relevant Commonwealth Departments and Agencies. While the Funding Dataset includes a mix of administered and departmental expenditure, the scope of the Review is limited to considering Commonwealth administered funding in relation to rapid onset natural disasters. The exercise undertaken by the NEMA Review Taskforce represents one of the most significant attempts by the Commonwealth to holistically understand the historic and committed spend across all areas of Commonwealth disaster funding.

The collection of a complete and accurate picture of Commonwealth disaster funding has been challenging for several reasons, mostly related to how data is understood, captured and stored. To provide as much insight into disaster funding as possible, NEMA collected a range of information including the responsible department or agency, the nature of the activity and the intended beneficiaries. This data has not been populated consistently, limiting the ability to accurately attribute the data and draw insights. Since it was first collected, NEMA has undertaken further data validation, however concerns continue to be raised about the completeness and accuracy of what has been captured.

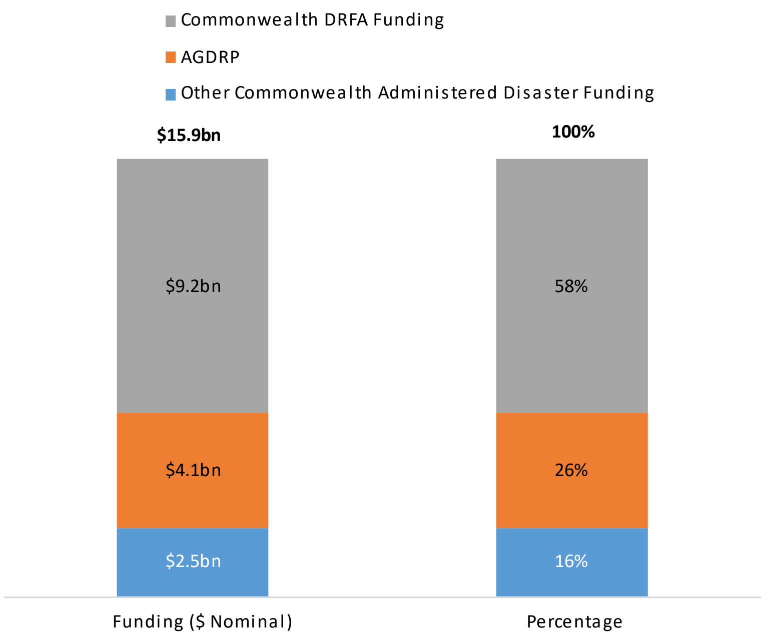
Through the Funding Dataset validation process, NEMA has applied number-based categories to understand the purpose of the allocated disaster funding. These categories inform much of the funding analysis and are:

- *Category 1:* Primary purpose is to address part of the disaster continuum – a standalone program, not an extension or pivot of a pre-existing program,
- *Category 2a:* Initial intent is not in response to disaster event but has since been extended or pivoted towards part of the disaster continuum (with funding amount to disasters quantifiable),
- *Category 2b:* As above, however the funding amount to disasters is not quantifiable,
- *Category 3:* Primary purpose to achieve policy objectives not directly related to disasters but provides an assumed general benefit to disaster resilience,
- *Category 4:* Activities unrelated to disasters, with outcomes that are more diffuse in relation to how they impact natural disasters or focus on non-Australian settings.

For the purposes of the financial analysis presented, the analysis is based on Category 1 and 2a, quantifiable funding that has been used to address part of the disaster continuum.

Analysis undertaken by Deloitte found that between 2018-19 and 2022-23, Commonwealth administered disaster funding was $15.9 billion (refer to *Figure 19*). Commonwealth funding associated with the Disaster Recovery Funding Arrangements (DRFA) represents the largest administered funding program, accounting for 58 percent of the total Commonwealth administered spend on natural disasters. In addition to expenditure associate with the DRFA, over this period the Commonwealth has directed a further $6.7 billion of administered funding towards natural disasters. It should be noted that in addition to the administered expenditure, departmental expenditure has also been directed towards responding to the disaster continuum. While consultation has indicated this is likely to be significant, it has not been quantified or considered as part of this Independent Review.

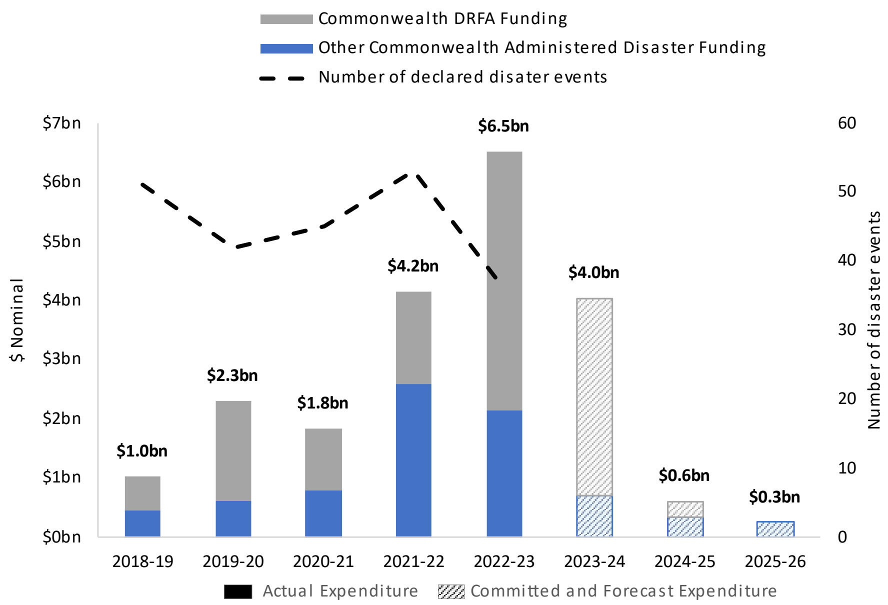
Figure 19 Summary of total Commonwealth disaster funding | 2018-19 to 2022-23



Source: NEMA 2023b and NEMA 2023c. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

Commonwealth disaster funding, including both the DRFA and other administered Commonwealth funding, has increased over the past five years. As shown in *Figure 20*, the Commonwealth provided over $6.5 billion of disaster funding in 2022-23, reflecting the significant disaster events that occurred in Queensland and New South Wales during this period. When considering the forward estimates period, which include both committed and forecast expenditure provided by NEMA, it is important to note that these amounts do not take into consideration disasters that may occur. Hence the Commonwealth funding beyond 2022-23 is likely to increase in direct response to the occurrence of natural disaster events.

Figure 20 Annual total Commonwealth disaster funding | 2018-19 to 2025-26

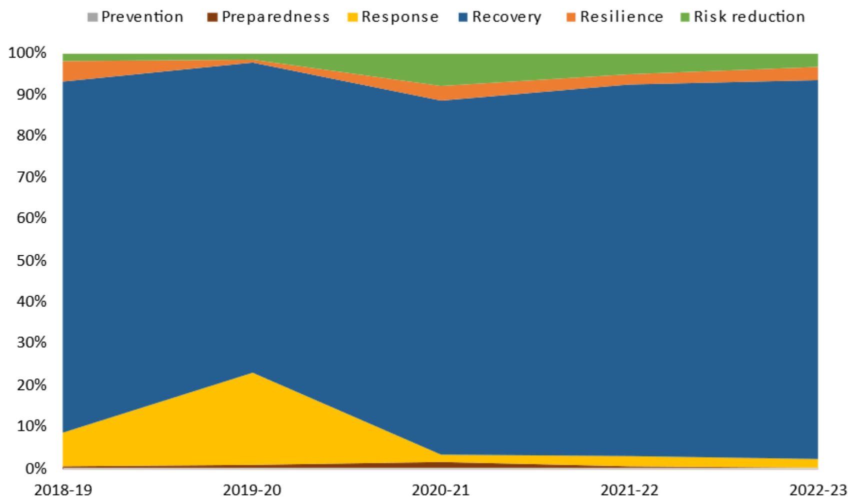


Source: NEMA 2023a, NEMA 2023b and NEMA 2023c. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

1.3 Funding across the disaster continuum

Analysis of the Commonwealth administered funding across the disaster continuum, indicates that the current landscape of Commonwealth disaster funding is largely reactive. *Figure 21* shows that the majority of Commonwealth disaster funding is directed towards response and recovery. In addition, there is no Commonwealth disaster funding directed to prevention.

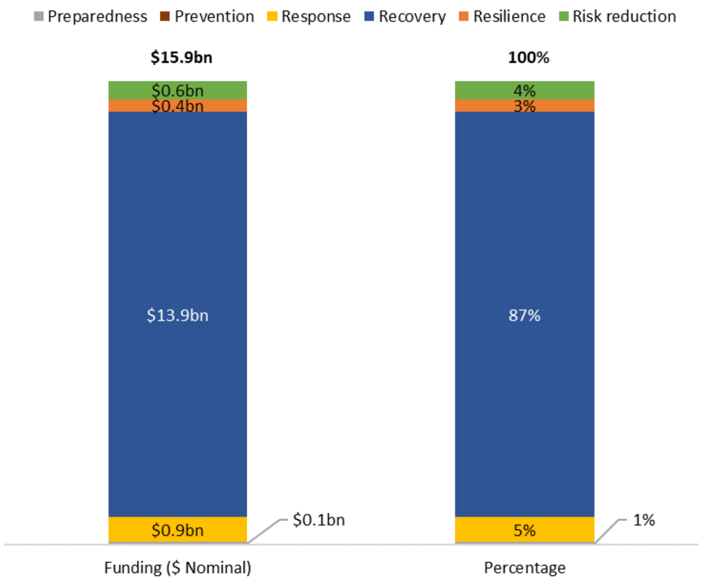
Figure 21 Proportion of total Commonwealth funding across the disaster continuum | 2018-19 to 2022-23



Source: NEMA 2023b, NEMA 2023c and Deloitte 2024. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

Deloitte analysis of the data provided by the NEMA Review Taskforce found that recovery spending (87 percent) dominates the disaster continuum spending between 2018-19 and 2022-23. After recovery spending, other aspects of the disaster continuum receive comparatively little funding, albeit there has been a small increase in funding directed towards resilience and risk reduction. *Figure 22* presents the total Commonwealth funding across the disaster continuum over these years, while *Table 8* identifies the corresponding top three funding programs for each component of the disaster continuum.

Figure 22 Total Commonwealth funding across the disaster continuum | 2018-19 to 2022-23



Source: NEMA 2023b, NEMA 2023c and Deloitte 2024. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

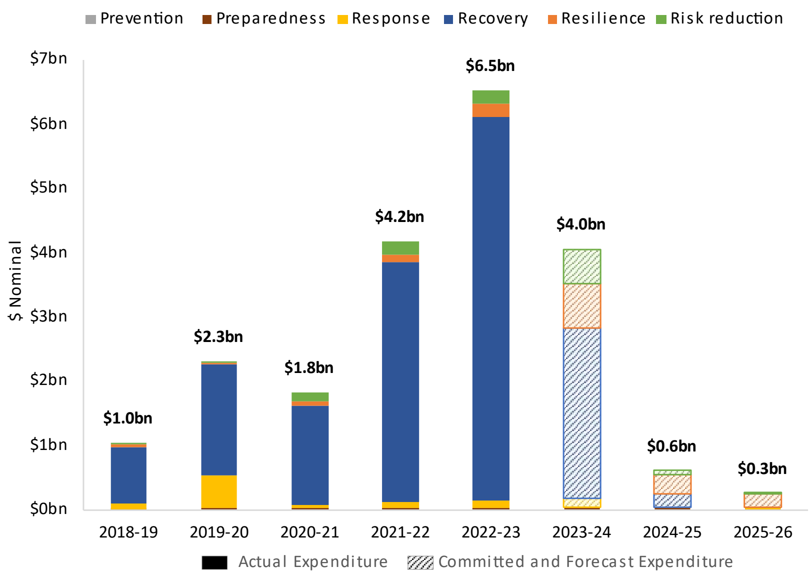
Table 8 Top Commonwealth non DRFA funding programs across the disaster continuum

Disaster Continuum	Program Name	Funding Amount (2018-19 to 2025-26)
Prevention	-	-
Preparedness	Budget 2020-21 – Bushfire Response Package – Royal Commission into Bushfires	$30.0m
	Australian Fire Danger Rating System	$26.7m
	Mobile Network Hardening Program (Rounds 2 and 3)	$24.0m
Response	National Aerial Firefighting Program	$189.9m
	National Messaging System	$113.5m
	NBRF – Additional Emergency Relief and Financial Counselling	$50.0m
Recovery	Australian Government Disaster Recovery Payment	$4,142.3m
	NBRF – Black Summer Bushfire Recovery (BSBR) Grants	$388.4m
	Disaster Recovery Allowance	$259.3m
Resilience	Disaster Ready Fund (DRF)	$600.0m
	Telecommunications Resilience Disaster Innovation Program	$50.0m
	Natural Hazards and Disaster Resilience Research Centre Ad Hoc Grant Program	$42.3m
Risk Reduction	Preparing Australian Communities – Local (PAP Local)	$149.9m
	Disaster Risk Reduction Package (DRRP) – National Partnership Agreement on Disaster Risk Reduction	$103.4m
	Christmas Island Storm Water, Landslide and Rockfall Works	$67.0m

Source: NEMA 2023b.

The allocation of funding across the disaster continuum over time is shown below in *Figure 23*. While the portion of spend on recovery decreases over the forward estimates, this reduction is a reflection of the fact that recovery spend is in direct response to natural disasters.

Figure 23 Total annual Commonwealth disaster funding across the disaster continuum | 2018-19 to 2025-26



Source: NEMA 2023b, NEMA 2023c and Deloitte 2024. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

1.4 Funding by domain

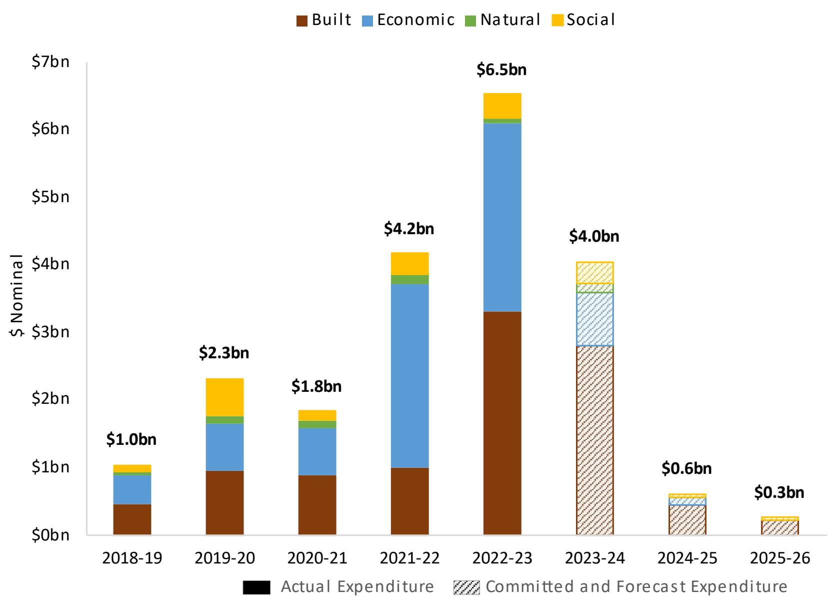
Natural disaster funding is commonly considered over four domains: built, economic, natural and social (see *Table 9*). The analysis in *Figure 24* indicates that, based on the primary purpose, the total Commonwealth disaster funding is largely directed towards economic and built infrastructure and that there is a pressing need to acknowledge the social cost of disasters.

Table 9 Definition of natural disaster value domains

Domain	Definition
Built	Physical and social infrastructure assets such as transport, energy and telecommunications, water utilities, housing, cultural and commercial precincts and other assets.
Economic	Public sector, private sector and individual economic activities; workforce participation; credit, debt, and finance; and small, medium, national and multinational business.
Natural	Natural assets such as wetlands, rivers, land, forests, oceans, other complex natural ecosystems, agriculture and water sources.
Social	Socioeconomic and demographic trends, social networks and relationships, cultural practices, technology, innovation, wellbeing, essential services such as health, education and lifestyles.

Source: NEMA 2023b.

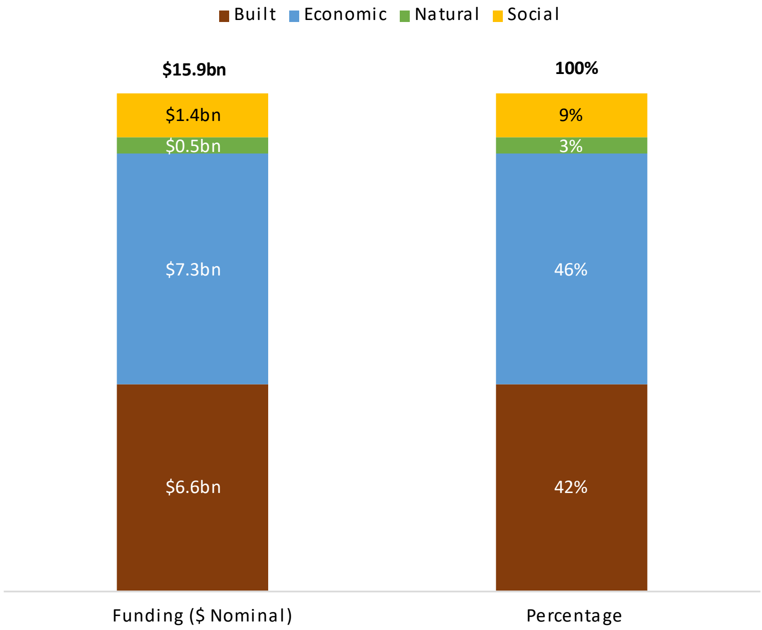
Figure 24 Total annual Commonwealth disaster funding by domain | 2018-19 to 2025-26



Source: NEMA 2023b, NEMA 2023c and Deloitte 2024. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

Based on the primary domain, nearly 90 percent of Commonwealth disaster funding is allocated to the economic and built domains (refer to *Figure 25*). *Table 10* identifies the top funding programs across the domains providing an indication of the key drivers of these results.

Figure 25 Total Commonwealth disaster funding by domain | 2018-19 to 2022-23



Source: NEMA 2023b, NEMA 2023c and Deloitte 2024. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs), and DRFA Funding. (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified. (3) DRFA funding is based on the time of expenditure.

Table 10 Top three Commonwealth non DRFA funding programs by domain

Domain	Program Name	Funding Amount (2018-19 to 2025-26)
Built	Disaster Ready Fund (DRF)	$600.0m
	Christmas Island Storm Water, Landslide and Rockfall Works	$67.0m
	ERF – National Flood Mitigation Infrastructure 2020-21 (NFMIP 1)	$50.0m
Economic	Australian Government Disaster Recovery Payment	$4,142.3m
	Disaster Recovery Allowance	$259.3m
	2019 Monsoon Trough – Replanting and On-Farm Infrastructure Grants (RRIG)	$240.0m
Natural	Bushfire Recovery for Wildlife and Habitat	$203.1m
	National Aerial Firefighting Program	$189.9m
	NBRF – Additional Firefighting Aircraft	$20.0m
Social	National Messaging System	$113.5m
	NBRF – Supporting the mental health of Australians affected by bushfire	$53.4m
	NBRF – Additional emergency relief and financial counselling	$50.0m

Source: NEMA 2023b. Note: (1) Excludes programs that were classified as targeting 'All Domains'.

1.5 DRFA Expenditure

The DRFA is a joint cost sharing arrangement to alleviate the financial burden on the states and territories for responding to natural disasters. The DRFA provides support following an eligible disaster in circumstances where a coordinated multi-agency response is required, and the state or territory expenditure exceeds the small disaster criterion of $240,000. While the small disaster criterion does not take into consideration the financial capacity of the state or territory, this is considered in the context of the first and second thresholds for reimbursement which are based on a percent of the state or territories total general government sector revenue and grants. The thresholds are used to calculate the portion of eligible expenditure funded by the Commonwealth, which varies across the different categories. The rate of Commonwealth assistance for Category A and Category B measures, is defined as 50 percent of a state's/territory's expenditure between their first and second threshold, plus up to 75 percent of state/territory expenditure above the state's/territory's second threshold (Threshold 2). If state/territory expenditure does not exceed the state's/territory's first threshold (Threshold 1) then the Commonwealth will provide 50 percent reimbursement for Category A measures, with no assistance activated for Category B measures (Department of Home Affairs, 2018).

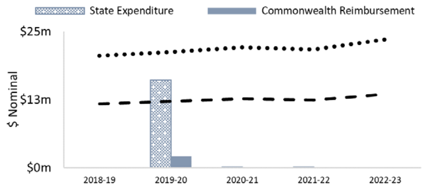
The amount of Commonwealth assistance for state/territory expenditure on Category C measures is calculated at the rate of 50 percent. However, under Category D the Commonwealth has the flexibility to agree to an alternate cost sharing ratio, including fully funding the extraordinary assistance measures. Between the introduction of the DRFA in 2018 and financial year 2022-23, the Commonwealth has funded on average 58 percent of eligible DRFA expenditure.

To claim reimbursement from the Commonwealth under the DRFA, an audit report must be submitted within nine months from the conclusion of the financial year that costs were incurred, after which the Commonwealth has three months to complete its assurance activities. This results in a delay between the commencement of expenditure and confirmation of reimbursement. *Figure 26* to *Figure 33* presents the DRFA expenditure by jurisdiction, including the relevant thresholds and associated Commonwealth reimbursement. The analysis shows that between 2018-19 and 2022-23:

- Queensland was the only jurisdiction to exceed Threshold 2 in all five periods,
- New South Wales exceeded Threshold 2 in four periods, both Tasmania and Western Australia exceeded Threshold 2 in three periods and South Australia exceeded Threshold 2 in two periods,
- The Northern Territory and Victoria only exceeded Threshold 2 in one period,
- The Australian Capital Territory exceeded Threshold 1 in one period and did not exceed Threshold 2 over the five-year period of analysis,
- Eligible DRFA expenditure has increased over time in New South Wales, Queensland, South Australia, Victoria and Western Australia,
- Tasmania's eligible DRFA expenditure has decreased each year with the exception of an increase in 2022-23, and
- The Australian Capital Territory and Northern Territory have experienced one and two periods respectively of DRFA eligible expenditure above $10 million.

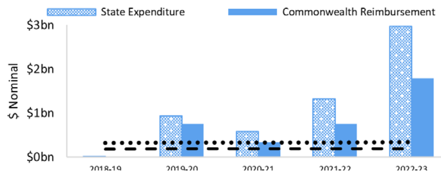
For the results presented, it is important to note that the Commonwealth reimbursement includes 100 percent Commonwealth funded measures. As a result, there are years where the Commonwealth reimbursement is higher than the state or territory's DRFA expenditure. Claims for reimbursement can be submitted by the states and territories up to 24 months after the end of the financial year in which the disaster event occurred. In addition, Category A measures may be reimbursed by the Commonwealth up to 50 per cent even if Threshold 1 is not exceeded.

Figure 26 DRFA expenditure in Australian Capital Territory | 2018-19 to 2022-23



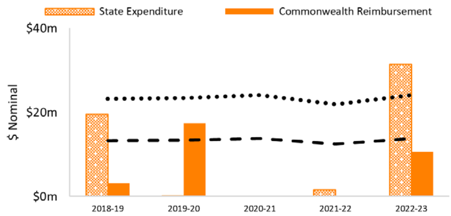
Source: NEMA 2023c.

Figure 27 DRFA expenditure in New South Wales | 2018-19 to 2022-23



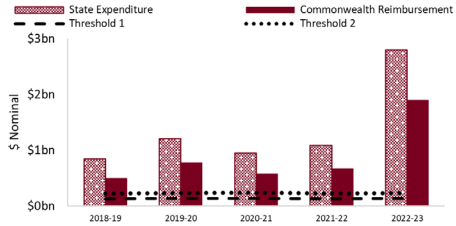
Source: NEMA 2023c.

Figure 28 DRFA expenditure in Northern Territory | 2018-19 to 2022-23



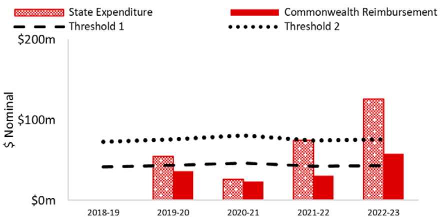
Source: NEMA 2023c

Figure 29 DRFA expenditure in Queensland | 2018-19 to 2022-23



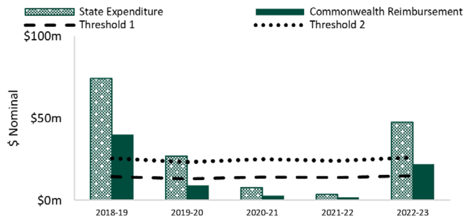
Source: NEMA 2023

Figure 30 DRFA expenditure in South Australia | 2018-19 to 2022-23



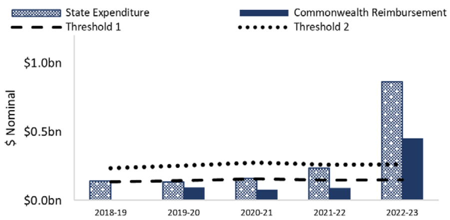
Source: NEMA 2023c.

Figure 31 DRFA expenditure in Tasmania | 2018-19 to 2022-23



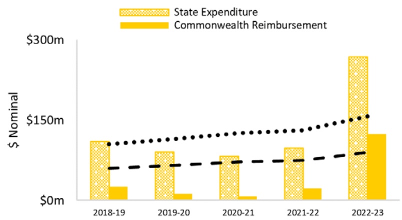
Source: NEMA 2023c.

Figure 32 DRFA expenditure in Victoria | 2018-19 to 2022-23



Source: NEMA 2023c.

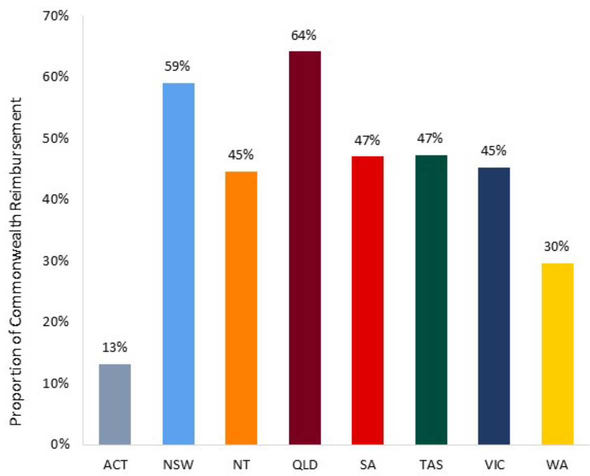
Figure 33 DRFA expenditure in Western Australia | 2018-19 to 2022-23



Source: NEMA 2023c.

From a state and territory perspective, the Commonwealth has funded more than 50 percent of the eligible DRFA expenditure for New South Wales and Queensland, having funded 59 and 64 percent respectively. In comparison, the Australian Capital Territory and Western Australia have received the lowest level of reimbursement, 13 and 30 percent respectively. The reimbursement across the states and territories is summarised in *Figure 34* and *Figure 35* below.

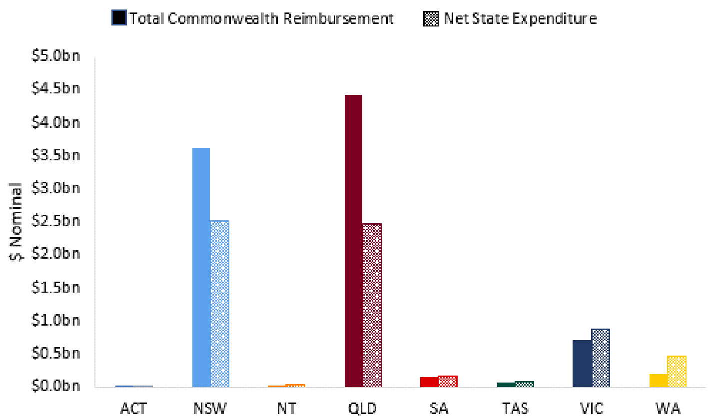
Figure 34 Commonwealth share of DRFA expenditure by jurisdiction | 2018-19 – 2022-23



Source: NEMA 2023c. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 100 per cent Commonwealth funded measures.

Figure 35 Total DRFA expenditure by jurisdiction | 2018-19 – 2022-23

Source: NEMA 2023c. Notes: (1) DRFA funding is based on the time of expenditure. (2) Total Commonwealth Reimbursement includes 100 per cent Commonwealth Funded Measures. (3) Net state expenditure is calculated as the amount of the state's/territory's eligible DRFA expenditure less the Commonwealth's reimbursement (excluding any Commonwealth 100 percent funded measures).



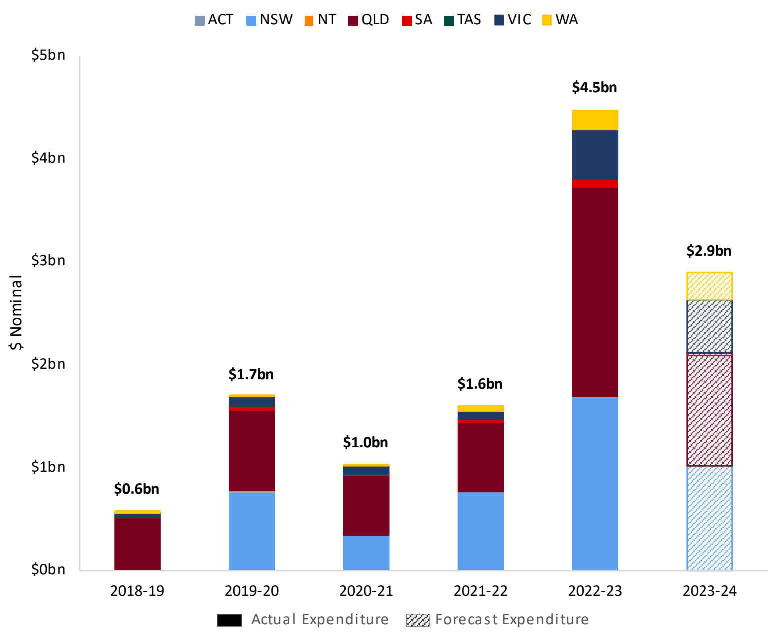
From a national perspective, between 2018-2019 and 2022-23, 58 percent of total expenditure under the DRFA has been funded by the Commonwealth (refer to *Figure 36*). It is important to note that these results are based on actual DRFA expenditure and not the announced value of the various programs.

Figure 36 Total DRFA expenditure | 2018-19 – 2022-23

Source: NEMA 2023c. Notes: (1) DRFA funding is based on the time of expenditure. (2) Commonwealth Reimbursement includes 100 per cent Commonwealth Funded Measures.

The annual Commonwealth DRFA reimbursement by jurisdiction is summarised in *Figure 37* below.

Figure 37 Annual Commonwealth DRFA reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Commonwealth Reimbursement includes 100 per cent Commonwealth Funded Measures.

Table 11 and *Table 12* present the net state DRFA expenditure and Commonwealth DRFA expenditure respectively across the analysis period on a per capita basis. Consistent with the above analysis, Queensland and New South Wales received the highest level of funding on a per capita basis. From a per capita perspective, Western Australia and Northern Territory have a higher average net state DRFA expenditure than Victoria. Between 2018-19 and 2023-24 the Australian Capital Territory received, on average, the lowest Commonwealth DRFA reimbursement on a per capita basis.

Table 11 Net state DRFA expenditure per capita by jurisdiction | 2018-29 to 2023-24

Jurisdiction	Average Net State DRFA Expenditure per Capita	Minimum Net State DRFA Expenditure per Capita	Maximum Net State DRFA Expenditure per Capita
ACT	$5.31	$0.00	$31.73
NSW	$73.14	$0.26	$143.17
NT	$37.46	$0.00	$82.47
QLD	$104.59	$67.24	$165.54
SA	$18.38	$0.00	$37.68
TAS	$27.76	$3.31	$62.55
VIC	$33.11	$11.49	$68.32
WA	$43.81	$26.88	$97.67

Source: NEMA 2023c, ABS 2023e and ABS 2023f. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) 2022-23 population data is from the March quarter. Includes 2023-24 population projection.

Table 12 Commonwealth DRFA reimbursement per capita by jurisdiction | 2018-29 to 2023-24

Jurisdiction	Average Commonwealth DRFA reimbursement per Capita	Minimum Commonwealth DRFA reimbursement per Capita	Maximum Commonwealth DRFA reimbursement per Capita
ACT	$0.81	$0.00	$4.66
NSW	$96.71	$0.26	$216.34
NT	$22.65	$0.00	$70.58
QLD	$175.05	$97.84	$351.69
SA	$16.61	$0.00	$31.50
TAS	$24.49	$3.32	$73.18
VIC	$30.72	$0.69	$76.85
WA	$35.68	$2.90	$145.25

Source: NEMA 2023c, ABS 2023e and ABS 2023f. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) 2022-23 population data is from the March quarter. Includes 2023-24 population projection. (4) Commonwealth Reimbursement includes 100 per cent Commonwealth Funded Measures.

Commonwealth DRFA reimbursement has been allocated across the disaster continuum based on the primary purpose of the expenditure.

The accurate classification of Commonwealth funding provided under the DRFA is complex, due to the approach to reimbursement applied in the DRFA. Specifically, the reimbursement rates are dependent on the total state or territory expenditure for the relevant financial year. Accordingly, it was necessary to make assumptions to determine the Commonwealth reimbursement by category. The Commonwealth reimbursement by DRFA category was estimated based on the proportion of Category A-D DRFA expenditure against total DRFA expenditure.

The portion of reimbursement for Category A-D was allocated across the disaster continuum using the methodology summarised in *Table 13* below.

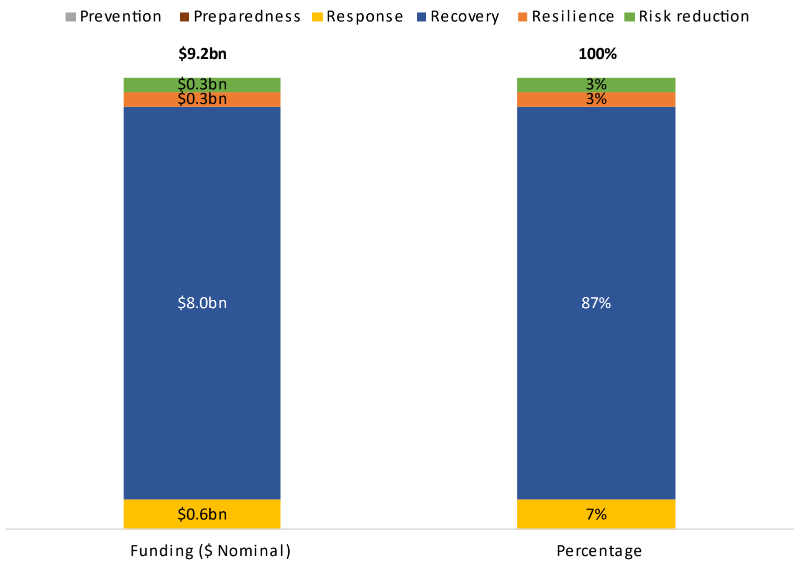
Table 13 Approach for allocating the DRFA across the disaster continuum.

DRFA Category	Methodology
Category A	Calculated proportion of counter disaster operations for the benefit of an affected individual against total Category A expenditure. This proportion was then applied to the estimated Category A Commonwealth reimbursement to determine the amount allocated to response activities. The remainder was assumed to be allocated to recovery activities.
Category B	Calculated proportion of counter disaster operations for the protection of the general public against total Category B expenditure. This proportion was then applied to the estimated Category B Commonwealth reimbursement to determine the amount allocated to response activities. The remainder was assumed to be allocated to recovery activities.
Category C Category D	Each activity was individually assigned to the disaster continuum leveraging previous analysis on the DRFA undertaken on behalf of NEMA.

Source: Deloitte, 2024.

It should be noted that no Commonwealth DRFA reimbursement was allocated to prevention or preparedness activities. As a significant component of total Commonwealth disaster funding, the allocation of the DRFA reimbursement across the disaster continuum is a key driver of the findings relating to Commonwealth disaster funding. *Figure 38* provides a summary of DRFA expenditure across the disaster continuum.

Figure 38 Commonwealth DRFA reimbursement across the disaster continuum | 2018-19 to 2022-23

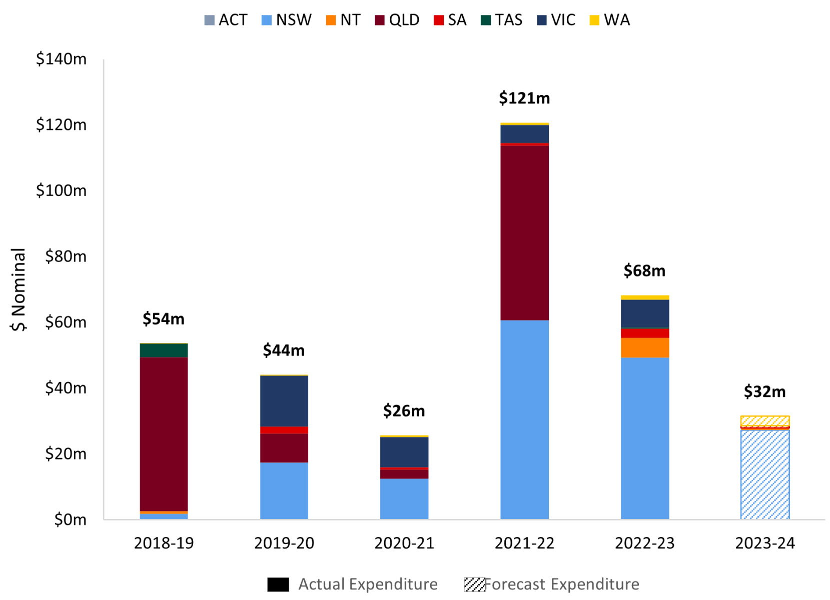


Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Commonwealth Reimbursement includes 100 per cent Commonwealth Funded Measures.

1.5.1 *Category A DRFA Expenditure*

Category A measures are specifically to provide assistance to individuals to alleviate personal hardship or distress, as a direct result of a disaster. These measures are provided by the states and territories without requiring prior approval from the Commonwealth. On average, between 2018-19 and 2023-24, the Commonwealth reimbursement for Category A measures is $57.3 million per annum. *Figure 39* presents the estimated Commonwealth Category A reimbursement across jurisdictions.

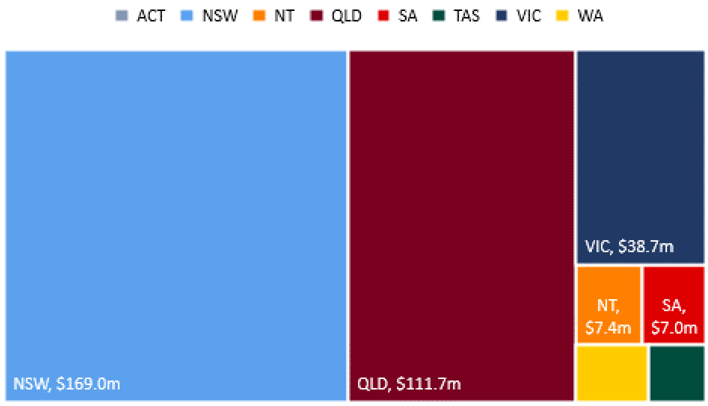
Figure 39 Estimated annual Category A DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure.

Between 2018-19 and 2023-24, New South Wales received the largest Commonwealth reimbursement for Category A measures, with the majority of the DRFA funding received in recent years. Across the analysis period, Queensland was the second largest recipient of Category A Commonwealth reimbursement followed by Victoria. The estimated Category A DRFA Commonwealth reimbursement by jurisdiction is summarised in *Figure 40*.

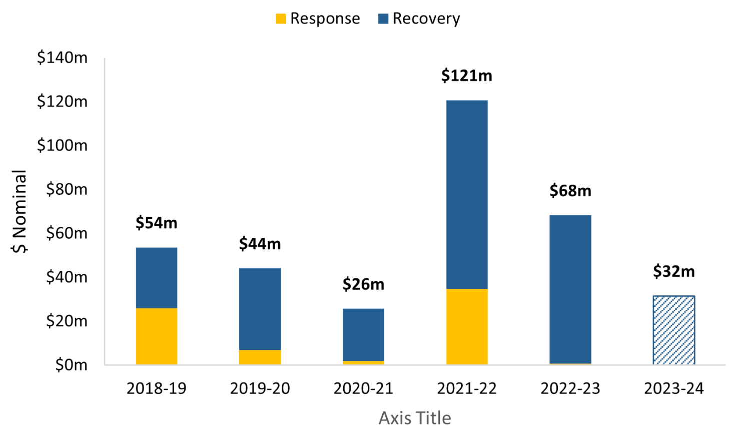
Figure 40 Total estimated Category A DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) ACT is not visible as the total estimated Category A Commonwealth reimbursement between 2018-19 and 2023-24 totalled $0.03m.

Consistent with the methodology described in *Table 13*, estimating the Commonwealth Category A reimbursement across the disaster continuum indicates that Category A expenditure on response (counter-disaster operations) is lower in comparison to Category A expenditure on recovery (refer to *Figure 41*).

Figure 41 Estimated Category A DRFA Commonwealth reimbursement across the disaster continuum | 2018-19 to 2023-24



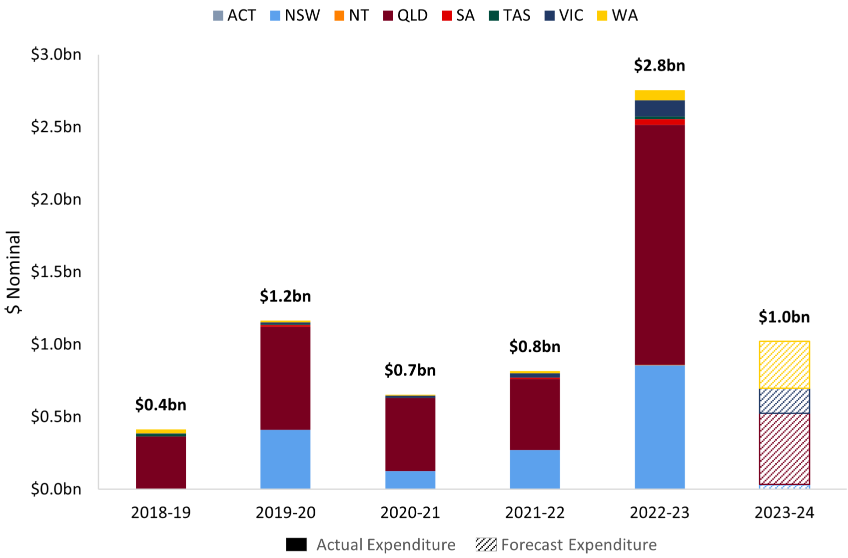
Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure.

1.5.2 *Category B DRFA Expenditure*

Under the DRFA the Commonwealth provides financial assistance directly to the states and territories to assist them with costs associated with certain disaster relief and recovery assistance measures. Category B assistance is provided to the state, territory and/or local governments for the restoration of essential public assets and certain counter-disaster operations for the protection of the general public. Whilst the majority of these measures can be claimed 24 months from the end of the financial year in which the natural disaster event occurred, essential public asset reconstruction works must be claimed in a period of 12 months and emergency works have up to three months to be claimed by the states and territories.

In contrast to Category A, between 2018-19 and 2023-24 the Commonwealth reimbursement for Category B measures is, on average, over $1.1 billion per annum (refer to *Figure 42*).

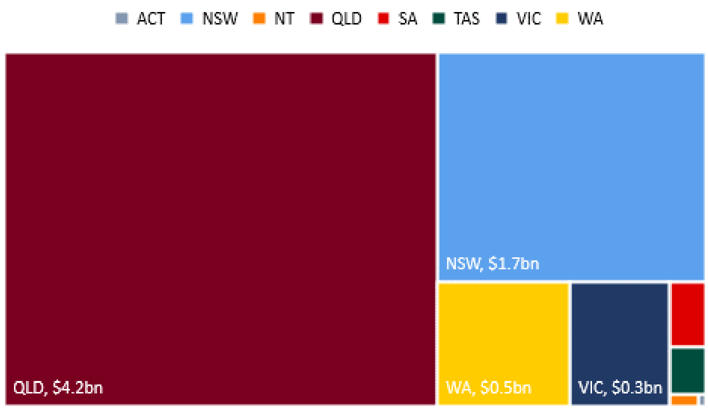
Figure 42 Estimated annual Category B DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure.

Queensland received the largest Commonwealth reimbursement for Category B measures between 2018-19 and 2023-24, at 2.5 times higher than that of the second largest recipient of Category B funding, New South Wales. Each of the remaining jurisdictions did not receive more than $0.5 billion in total across the analysis period. These results could suggest that the maturity of jurisdictions plays a role in the amount of Commonwealth funding received. States and territories which experience rapid onset natural disasters more frequently are better equipped to submit claims for emergency and reconstruction works within the timeframe. The estimated Category B DRFA Commonwealth reimbursement by jurisdiction is summarised in *Figure 43*.

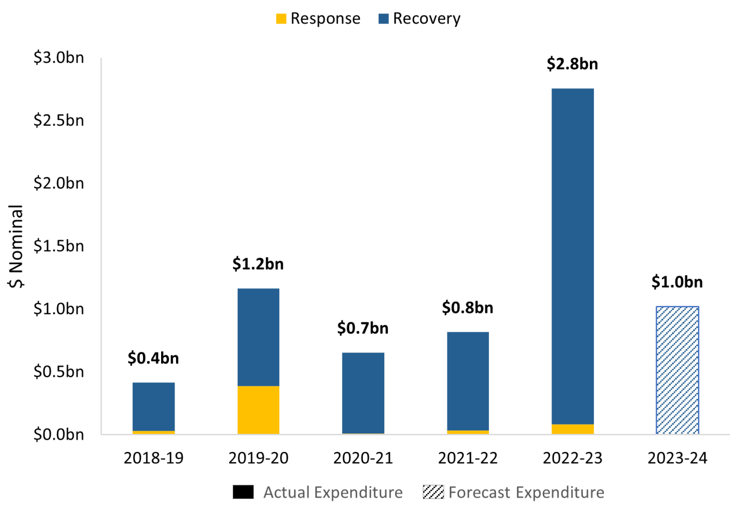
Figure 43 Total estimated Category B DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure.

Applying the methodology described in *Table 13*, the estimated Commonwealth Category B reimbursement is largely allocated to recovery measures, with response funding under Category B (counter disaster operations) only noticeably occurring in 2019-20 and 2022-23 (refer to *Figure 44*).

Figure 44 Estimated Category B DRFA Commonwealth reimbursement across the disaster continuum | 2018-19 to 2023-24



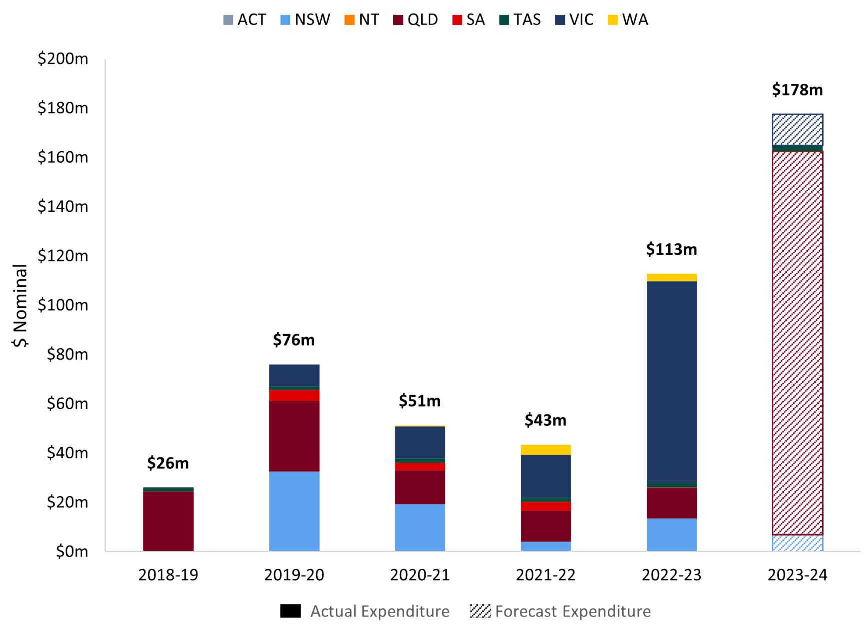
Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure.

1.5.3 Category C DRFA Expenditure

Category C measures are intended for severe impact events with a focus on community recovery packages. This includes clean-up and recovery grants to small business, non-profit organisations and primary producers. Similar to Category B measures, states and territories have 24 months from the end of the financial year in which the natural disaster event occurred to submit a claim. However, the cost sharing ratio between the Commonwealth and the states and territories for each Category C measure is equal (i.e., 50:50). Between 2018-19 and 2023-24, the average Commonwealth reimbursement for Category C measures was $81.2 million per annum.

Figure 45 displays a consistent increase in the estimated Commonwealth reimbursement paid to Victoria across recent periods, while the value of the reimbursement paid to Queensland has remained largely consistent, albeit there is significant forecast reimbursement in 2023-24. This increase is driven by the *'Community and Recreational Asset Recovery and Resilience Program'* which was established in response to the February 2022 South East Queensland Rainfall and Flooding event.

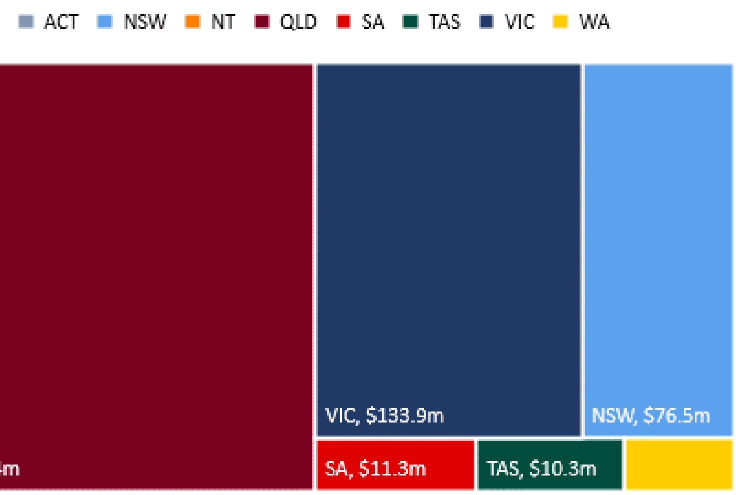
Figure 45 Estimated annual Category C DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures.

Considering the actual expenditure between 2018-19 and 2022-23, Victoria was the largest recipient of estimated Category C Commonwealth reimbursement. However, incorporating the current forecast data for 2023-24 provided by NEMA, alters the results – with Queensland becoming the largest recipient at 1.8 times Victoria. Excluding New South Wales, the remaining jurisdictions received less than ten per cent of Victoria's estimated Category C Commonwealth reimbursement. In particular, the Australian Capital Territory and Northern Territory have had no Category C activations between 2018-19 and 2023-24. The estimated Category C DRFA Commonwealth reimbursement by jurisdiction is summarised in *Figure 46*.

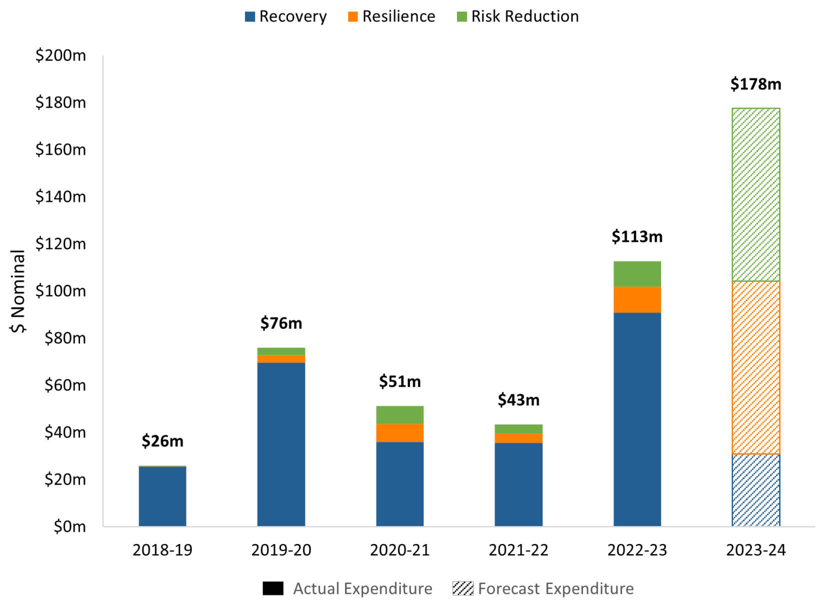
Figure 46 Total estimated Category C DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures. (4) ACT and NT are not visible as the total estimated Category C Commonwealth reimbursement between 2018-19 and 2023-24 totalled $0.

Analysing the estimated Category C Commonwealth reimbursement across the disaster continuum using the methodology described in *Table 13*, indicates that expenditure has largely focused on recovery measures, with a consistent small proportion focused on resilience and risk reduction activities. However, this proportion is forecast to increase in 2023-24 from a total dollar value perspective, driven by the increase in Queensland's estimated Category C reimbursement (refer to *Figure 47*). It is important to note that this forecast expenditure does not consider future disasters and therefore does not consider additional recovery measures, which may influence the overall Commonwealth expenditure in 2023-24.

Figure 47 Estimated Category C DRFA Commonwealth reimbursement across the disaster continuum | 2018-19 to 2023-24



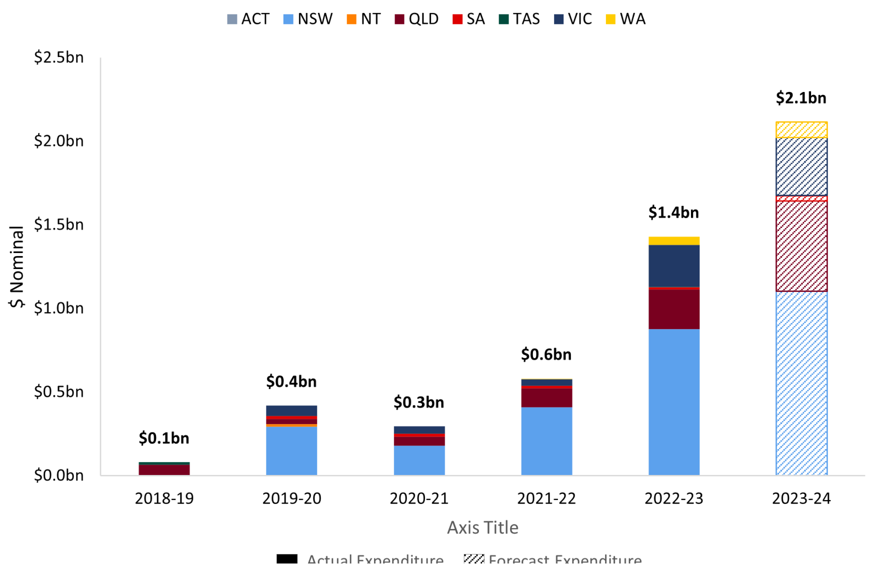
Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures.

1.5.4 Category D DRFA Expenditure

The purpose of Category D funding measures is to provide assistance to alleviate distress or damage in circumstances that are considered exceptional, subject to approval by the Prime Minister. States and territories have 24 months from the end of the financial year in which the relevant disaster event occurred to incur state/territory expenditure for Category D measures which have been requested by the state/territory and agreed to by the Commonwealth. As such, Category D assistance is generally considered once the impact of the disaster has been assessed and specific recovery gaps identified. The Commonwealth reimbursement for Category D measures between 2018-19 and 2023-24 is, on average, $819.4 million per annum.

The analysis shows that Category D funding measures have been increasing over the period of analysis, this is expected to continue into the forward estimates. The expenditure presented in *Figure 48* may be influenced by the recommendation of the Royal Commission into National Natural Disaster Arrangements. In October 2020 the Royal Commission recommended Australian, state and territory governments should broaden Category D of the DRFA to encompass funding for recovery measures that are focused on resilience, including in circumstances that are not 'exceptional'.

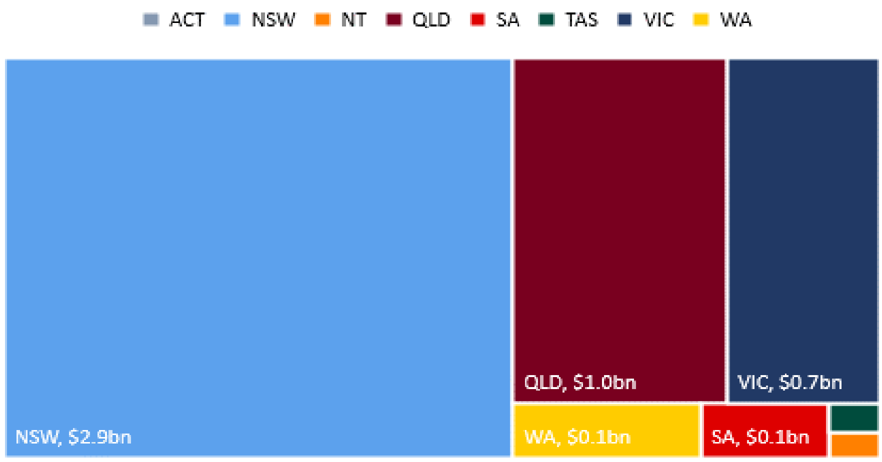
Figure 48 Estimated annual Category D DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures.

While actual expenditure is increasing in the majority of jurisdictions receiving Commonwealth reimbursement for Category D measures between 2018-19 and 2023-24, New South Wales was the largest recipient at 2.9 times Queensland. Consistent with expenditure across other DRFA categories, the jurisdictions with the highest reimbursement are New South Wales, Queensland, Victoria and Western Australia. Which is reflective of the frequency of natural disasters experienced in these jurisdictions compared to the rest of the country. The estimated Category D DRFA Commonwealth reimbursement by jurisdiction is summarised in *Figure 49*.

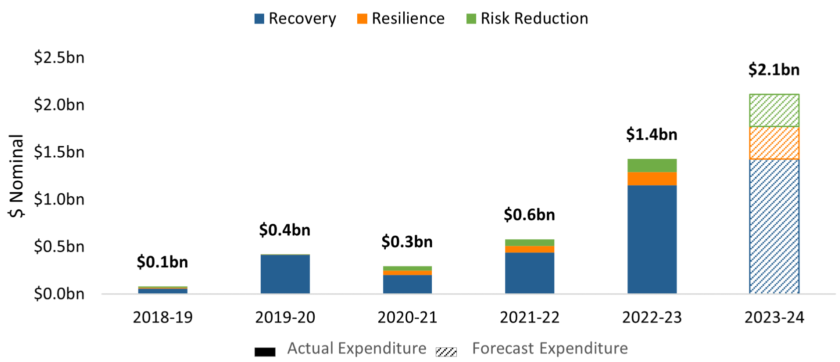
Figure 49 Total estimated Category D DRFA Commonwealth reimbursement by jurisdiction | 2018-19 to 2023-24



Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures. (4) ACT is not visible as the total estimated Category D Commonwealth reimbursement between 2018-19 and 2023-24 totalled $89k.

Estimating the Commonwealth Category D reimbursement across the disaster continuum consistent with the methodology described in *Table 13,* shows that in recent years there has been an increase in Commonwealth reimbursement directed towards resilience and risk reduction (see *Figure 50*). This is expected to increase in 2023-24 based on the current data provided by NEMA.

Figure 50 Estimated Category D DRFA Commonwealth reimbursement across the disaster continuum | 2018-19 to 2023-24

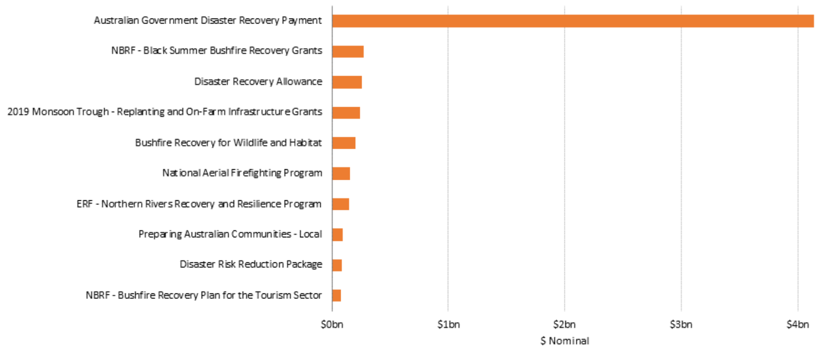


Source: NEMA 2023c and Deloitte 2024. Notes: (1) DRFA funding is based on the time of expenditure. (2) Includes 2023-24 forecast expenditure. (3) Includes 100 per cent Commonwealth funded measures.

1.6 Non DRFA expenditure

Non DRFA Commonwealth administered expenditure on disaster funding accounted for 42 percent of the total Commonwealth funding between 2018-19 and 2022-23. The biggest contributor to this spend is the Australian Government Disaster Recovery Payments (AGDRP) which equate to over $4 billion dollars in funding across the five years. It should be noted that while *Figure 51* below captures expenditure between 2018-19 and 2022-23, between 2023-24 and 2025-26 there is $600 million in committed expenditure for the Disaster Ready Fund.

Figure 51 Top ten non DRFA disaster funding related programs by value | 2018-19 to 2022-23



Source: NEMA 2023b. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs). (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified.

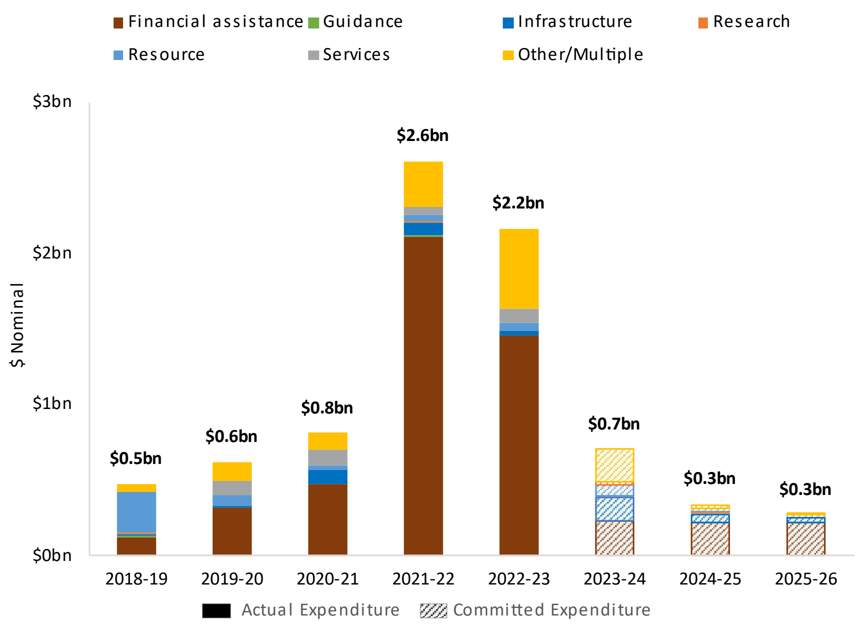
1.6.1 Funding by Activity Type

The Commonwealth administered non DRFA funding relating to disasters can be described based on the type of activity it supports, namely:

- Financial assistance, including payments, vouchers, concession loans, insurance offsets,
- Guidance such as a framework, guidelines, strategies, royal commissions, legislation,
- Infrastructure,
- Research,
- Resource such as personnel, equipment, and materials,
- Services such as counselling, business support, legal assistance, insurance advice, interpreting support, and training, and
- Other endeavours such as locally led projects, and programs which support multiple activities.

Figure 52 shows annual Commonwealth non DRFA funding by activity type.

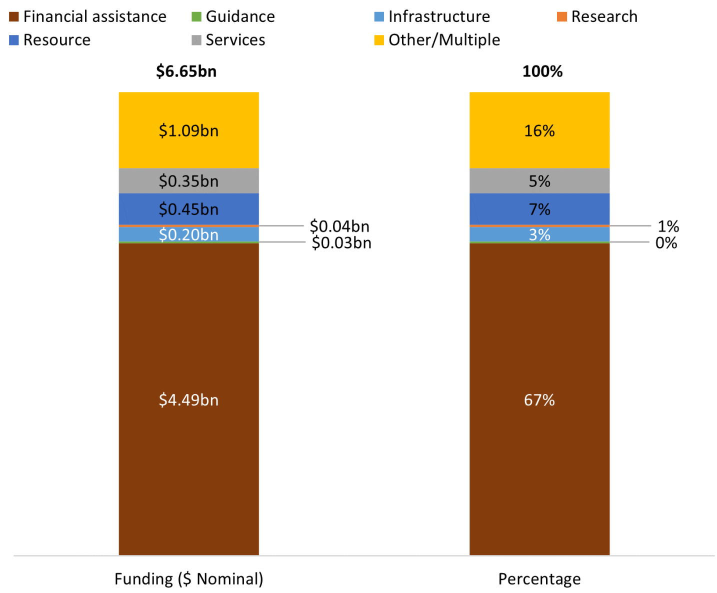
Figure 52 Annual Commonwealth non DRFA disaster funding by activity type | 2018-19 to 2025-26



Source: NEMA 2023b. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs). (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified.

Between 2018-19 and 2022-23, financial assistance represents 67 percent of Commonwealth non DRFA expenditure on natural disasters (refer to *Figure 53*). Other activities make up 16 percent of this expenditure, examples of the different activity types are included in *Table 14*.

Figure 53 Total Commonwealth non DRFA disaster funding by activity type | 2018-19 to 2022-23



Source: NEMA 2023b. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs). (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified.

Table 14 Top three Commonwealth non DRFA funding program by activity type

Activity Type	Program Name	Funding Amount (2018-19 to 2025-26)
Financial assistance	Australian Government Disaster Recovery Payment	$4,142.3m
	Disaster Ready Fund (DRF)	$600.0m
	Disaster Recovery Allowance	$259.3m

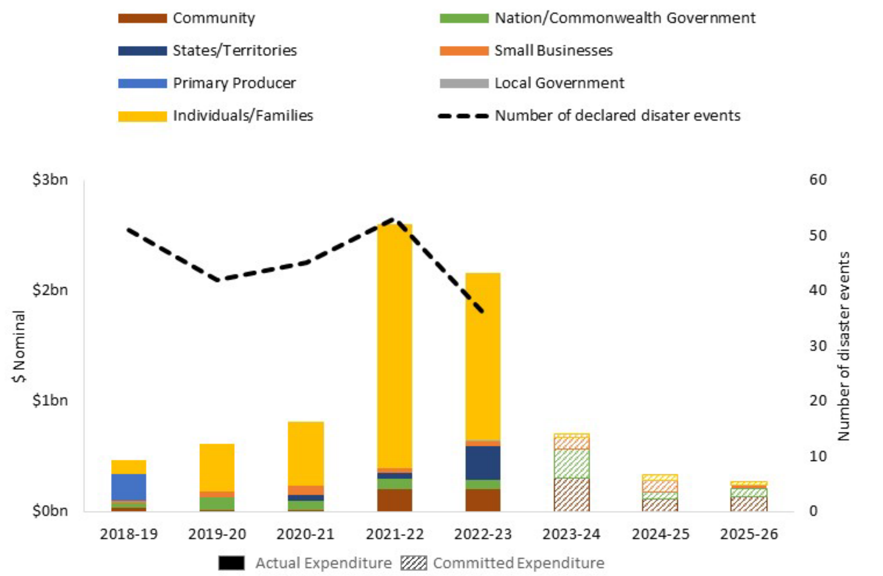
Activity Type	Program Name	Funding Amount (2018-19 to 2025-26)
Guidance	Australian Fire Danger Rating System	$26.7m
	National Capability Package – National Recovery Training Program	$0.6m
	Update of the climate change chapter of the Australian Rainfall and Runoff Guidelines	$0.5m
Infrastructure	National Messaging System	$113.5m
	Christmas Island Storm Water, Landslide and Rockfall Works	$67.0m
	ERF – National Flood Mitigation Infrastructure 2020-21 (NFMIP 1)	$50.0m
Research	Natural Hazards and Disaster Resilience Research Centre Ad-hoc Grant Program	$42.3m
	Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC)	$18.8m
	Cocos (Keeling) Islands Coastal Vulnerability Study and Coastal Hazard Risk Management Adaption Plan	$0.9m
Resource	2019 Monsoon Trough – Replanting and On-Farm Infrastructure Grants (RRIG)	$240.0m
	National Aerial Firefighting Program	$189.9m
	North Queensland Strata Title Resilience Pilot Program (NQSTRPP)	$40.0m
Services	NBRF – Bushfire Recovery Plan for the Tourism Sector	$76.0m
	NBRF – Supporting the Mental Health of Australian's affected by Bushfire	$53.4m
	Regional and Small Business Support Program Pilot	$27.8m
Other	NBRF – Black Summer Bushfire Recovery (BSBR) Grants	$388.4m
	Preparing Australian Communities – Local (PAP Local)	$149.9m
	Budget 2020-21 – Bushfire Response Package – Royal Commission into Bushfires	$30.0m

Source: NEMA 2023b. Note: (1) Excludes programs that were classified as targeting 'Multiple' activity types.

1.6.2 Funding by Primary Beneficiary

Commonwealth, non-DRFA funding largely targets financial assistance for individuals and families. From 2020-21 there has been an increase in activities benefiting states, territories and communities. Since 2018-19, there has also been a notable decrease in funding targeting primary producers (refer to *Figure 54*).

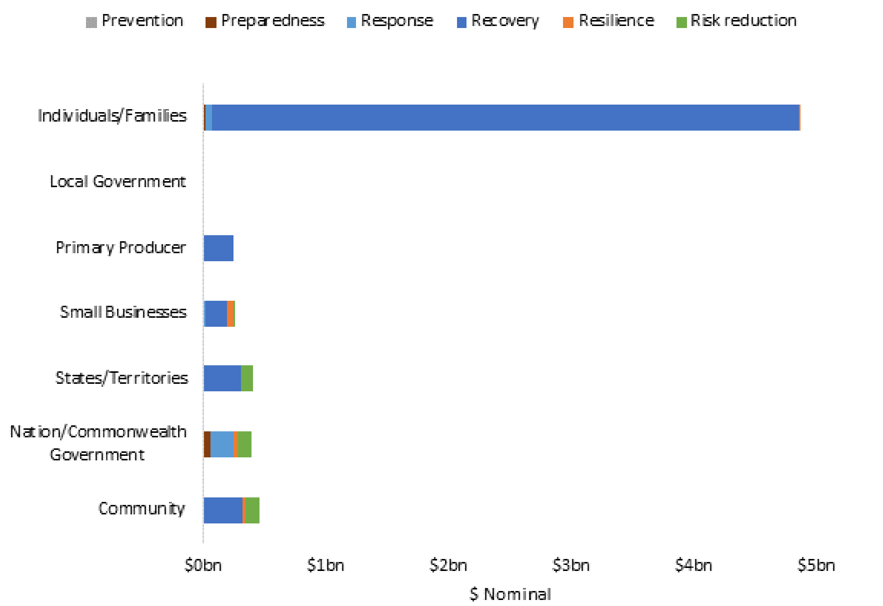
Figure 54 Annual Commonwealth non DRFA disaster funding by primary beneficiary | 2018-19 to 2025-26



Source: NEMA 2023b. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs). (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified.

Analysis of the Commonwealth non-DRFA funding across the disaster continuum finds that recovery activities consistently account for a significant proportion of funding provided across the different beneficiaries, with the exception of the Nation/Commonwealth Government (refer to *Figure 55*). Resilience activities are targeted towards industry, with small businesses as the primary beneficiaries. Communities are also one of the main recipients of Commonwealth non-DRFA funding, which has a risk reduction intent.

Figure 55 Total Commonwealth non DRFA disaster funding by primary beneficiary across the disaster continuum | 2018-19 to 2022-23



Source: NEMA 2023b. Notes: (1) Chart presents Other Administered Funding (Category 1 and Category 2a Disaster Resilience Funding Programs). (2) Category 1 refers to Commonwealth spend where the primary purpose of the activity is to address disaster resilience, while Category 2a spending is associated with an activity that was not initially established in response to a specific natural disaster risk, however, has since been extended towards disaster resilience and the funding amount attributable to disasters can be quantified.

2. Financial and economic modelling

The following sections summarise the financial and economic modelling undertaken as part of the review, including:

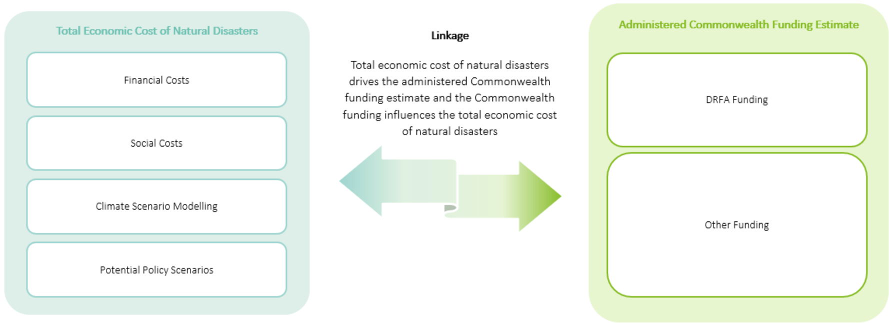
- The financial and economic modelling methodology,
- The climate modelling methodology used to inform the financial and economic modelling,
- The modelling limitations and assumptions,
- The financial and economic modelling findings, and
- A summary of data sources and references used.

2.1 Methodology

2.1.1. Financial and economic modelling methodology

This section outlines the methodology used to forecast the total economic cost of natural disasters and the associated Commonwealth administered funding estimate, which has been used to inform the Review. *Figure 56* demonstrates the linkage between the two components and outlines the underlying cost drivers and funding pathways.

Figure 56. Financial and economic analysis approach



Source: Deloitte 2024.

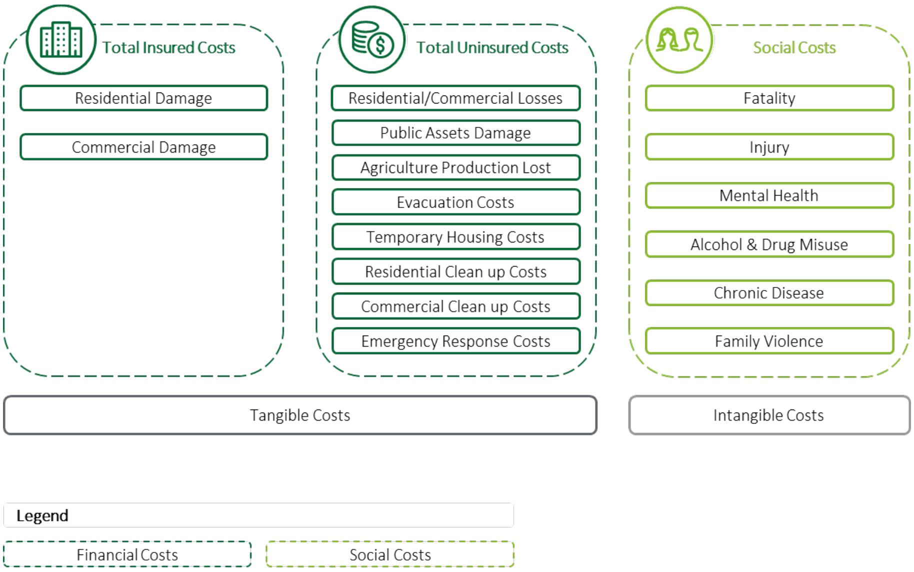
Total economic cost estimate

The total economic cost estimate captures both the financial and social costs associated with natural disasters. Financial costs, such as the direct damage to residential and commercial buildings are only a portion of the total economic cost, which includes broader social impacts relating to death, injury, health and wellbeing. The modelling approach draws on fundamental research conducted by the Bureau of Transport Economics (BTE) (now the Bureau of Infrastructure, Transport and Regional Economics (BITRE)) and Deloitte Access Economics:

- BTE's report (Bureau of Transport Economics 2001) developed a framework for estimating the economic cost of natural disasters, which identified costs that should be included in the analysis and suggested approaches for estimation.
- Deloitte Access Economics' report (Deloitte Access Economics 2016), commissioned by the Australian Business Roundtable, estimated the economic cost of the social impact of natural disasters. This report revised the BTE framework to develop a bottom-up approach for estimating the economic cost of disasters in Australia, using available data relating to disaster impacts.

The financial and economic modelling methodology applies the framework developed and refined through the above-mentioned reports, to enable the estimation of the total economic costs, including financial losses (insured and uninsured) and the broader social impacts associated with natural disasters. These cost components are identified in *Figure 57*.

Figure 57. Components of the total economic cost of natural disasters



Source: Deloitte 2024.

Financial cost estimate

Insured Cost Estimate

Insurance Council of Australia (ICA) data is used to predict the insured costs for 2023-24, with the following steps taken:

- Filtered the historical normalised losses ('normalised losses are estimates of the cost if historic events were to impact current societal and demographic conditions. Loss normalisation is a necessary step before attempting to draw conclusions about trends in the costs of natural disasters and/or climate change attribution' (McAneney et al. 2019)) to exclude events where the event was associated with a zero-loss value,
- Separated the normalised losses into extreme and non-extreme, to account for the infrequent but severe nature of the extreme natural disaster events. Disaster types considered include flood, bushfire, storm, tropical cyclone, hailstorm, earthquake and 'other'. This step was not applicable to modelling tropical cyclone and earthquake upon examination of the distribution of the data and performing statistical tests.
- Modelled the frequency and severity by disaster type at a national level due to insufficient data at a state and territory level,

- Performed statistical tests and produced visual plots to examine the goodness-of-fit of the selected distributions, including Pearson's chi-squared test, Kolmogorov-Smirnov test, Cramér-von Mises test, Anderson-Darling test and Quantile-Quantile plots,
- Ran 10,000 simulations using the fitted distributions to simulate occurrences and loss value in a given year,
- Calculated range estimates which comprise the average, P95 and P99 losses from the simulated results, and
- Applied two years of inflation to arrive at 2023-24 figures as the normalised loss value in the ICA dataset is real as at 2021-22.

The estimated costs for each jurisdiction by disaster type were calculated by applying the probability adjusted state/territory to national ratios for the average, P95 and P99 normalised loss values. This assumes the underlying statistical distributions of insured losses at the state/territory level align with the insured losses at the national level.

The 2023-24 insured cost estimates were indexed to 2049-50 for each state, considering household projections and real housing value growth to account for increases in population, number of dwellings, changes in building materials and average size of dwellings. It was assumed that the real housing value growth at a state and territory level will revert to national growth after five years.

Limitations and assumptions of the insured costs estimation are further discussed in *Appendix F, Section 2.1.3.*

Tangible Uninsured Cost Estimate

To derive the total tangible uninsured cost estimate, the ratios of insured costs to each tangible cost category were applied to the state and territory insured cost estimates. Recognising the fact that different types of natural disasters have different cost profiles, the ratios have been determined based on reference events. The reference events are summarised in *Table 15* below. The ratio of insured costs to tangible cost categories for the 'other' disaster type, is calculated as the average of flood, bushfire, storm, tropical cyclone, hailstorm and earthquake.

Table 15. Financial and economic modelling reference events

Natural Disaster Type	Reference Event
Flood	The Southeast Queensland Floods (Queensland, 2010–11)
Bushfire	The Black Saturday Bushfires (Victoria, 2009)
Storm	The 'Pasha Baulker Storm', and East Coast Low Event (New South Wales, 2007)
Tropical Cyclone	Cyclone Yasi (Queensland, 2011)
Hailstorm	Canberra Hailstorms (Australian Capital Territory, 2020)
Earthquake	Newcastle CBD Earthquake (New South Wales, 1990)

Source: Deloitte 2024.

The source data used to estimate the tangible costs share for different disaster types can be found in *Appendix F, Section 3*.

Social Cost Estimate

To estimate the social costs, the reference events provided the incident rates to undertake a detailed bottom-up approach to quantify the broader social impact of each disaster type. Different natural disaster types have different social impact profiles, for example, storms and tropical cyclones tend to have significantly fewer fatalities than bushfires. Based on the literature it has been possible to estimate the social impacts associated with fatality, physical injury and disability, mental health, alcohol and drug misuse, family violence and chronic disease.

While insured and uninsured costs tend to be one-off costs, social impacts can persist over a person's lifetime and may be multiple or compounding (i.e., not necessarily linear). Evidence also suggests that "there is generally a spike in social impacts immediately after a disaster, but most people recover to an extent over the medium- to long-term. However, a small proportion of people never recover and continue to experience trauma. Hence, the analysis assumes that a small proportion have lifelong impacts" (Deloitte Access Economics 2016). The bottom-up methodology for estimating the social impacts of the reference events included:

- Defining the catchment population; the number of people directly affected by the disasters through injury, damage to their property or loss of belongings,
- Estimating the incidence of outcomes driven by natural disasters, to apply a rate informed by researched case studies to the catchment population,

- Undertaking a literature review to identify the associated unit cost of each of the social impacts quantified. Each unit cost is indexed to 2023-24 dollars and multiplied by the incidence of social impacts, and
- Calculating the Net Present Value (NPV) of each social cost based on a seven percent real discount rate (Department of the Prime Minister and Cabinet – The Office of Impact Analysis 2023) as at 2023-24.

It is important to note that the social costs associated with the reference events include only those costs for which there was sufficient data and as such, these costs represent are a subset of total social impacts.

Climate Scenarios Overlay

To understand the impact of climate change on the estimated total economic cost of natural disasters, climate scenarios were applied to the 2049-50 insured cost estimate. The uninsured and social costs were then recalculated to estimate the 2049-50 total economic cost adjusted for the predicted impact of climate change. Climate scenario outputs were produced for two plausible and distinct climate futures (further detail in section 1.2), which consider the historical likelihood, future likelihood and change in intensity of climate hazard for each state and territory. Four climate hazards were modelled:

- Extreme Rainfall (Flood),
- Bushfire,
- Storm Surge (a 1-in-100-year event), and
- Tropical Cyclone.

Where possible the median, P95 and P99 change in likelihood and intensity were applied to the insured cost estimates for each natural disaster type. Within the financial and economic modelling, the 2049-50 total economic cost of floods and bushfires were estimated including the impact of climate change. For tropical cyclones, the impact of climate change could only be forecast under a high emission scenario at the median and P95 estimates. Due to data availability, the impact of climate change could not be considered in the analysis for storm, hailstorm, or 'other' disaster events. It should be noted that storms are not modelled separately to storm surges in the insured cost estimate, accordingly the climate scenarios for storm surge have not been applied in this step.

Table 16. Climate scenarios applied for economic cost modelling by disaster type.

Natural Disaster Type	Moderate Emission Scenario		High Emission Scenario	
	P95 Estimate	**P99 Estimate**	**P95 Estimate**	**P99 Estimate**
Flood	Yes	Yes	Yes	Yes
Bushfire	Yes	Yes	Yes	Yes
Storm Surge	No	No	No	No
Tropical Cyclone	No	No	Yes	No
Hailstorm	No	No	No	No
Earthquake	N/A	N/A	N/A	N/A
'Other'	No	No	No	No

Source: Deloitte 2024.

Note that the historic value presented in the climate scenarios data is the mean value for the period between 1986 and 2005 (except for tropical cyclones which covers 1980 and 2022), which acts as a constraint when applying the change in likelihood and intensity to obtain the 2049-50 insured cost estimates. This implies that the likelihood and intensity of climate hazards has not changed significantly between 2005 and 2024. This assumption is considered reasonable as there is not sufficient evidence to suggest that the insured losses have increased substantially due to climate change (John M. et al. 2019).

Detailed information on the climate modelling can be found in Section 2.1.2.

Total Commonwealth Administered Funding Estimate

The total Commonwealth administered funding estimate provides an indication of the possible Commonwealth funding requirement based on the forecast total economic cost of natural disasters in any given year. The Commonwealth administered funding estimate captures both funding associated with the Disaster Recovery Funding Arrangements (DRFA) and non-DRFA funding.

Estimating DRFA Expenditure

The single greatest spend on disaster support by the Commonwealth is through the DRFA as part of a cost sharing arrangement with the states and territories. The amount that the Commonwealth will reimburse the states and territories varies based on the measures they activate and the funding thresholds that have been met. This approach is summarised below:

- It is assumed that the 'Public Assets Damage' in the uninsured cost category of the 2049-50 total economic cost estimate, approximates the total state and territory Category B DRFA expenditure,

- The state and territory estimate of Category B expenditure is grossed up to the total state and territory DRFA expenditure by jurisdiction, based on the historical proportion of DRFA expenditure across the categories (i.e., Category A, B, C and D) between 2018-19 and 2022-23,
- Consistent with the DRFA, the Commonwealth reimbursement in 2049-50 is calculated as 50 percent of expenditure between a state's or territory's first and second threshold, plus up to 75 percent of expenditure above the second threshold for each jurisdiction, and
- As the analysis has been completed in 2023-24 real terms, it has been assumed that the Threshold 1 and Threshold 2 for each state and territory is consistent with the 2022-23 thresholds provided by NEMA.

Estimating Other Commonwealth Administered Funding

To estimate the Commonwealth funding associated with administered funding programs other than DRFA, the historical relationship between; other administered funding programs, insured costs as a result of disaster events and total Commonwealth DRFA expenditure was analysed. A ratio of annual average insured costs and annual average Commonwealth DRFA expenditure to annual average other Commonwealth administered disaster funding was developed based on data between 2018-19 and 2022-23. This ratio is applied to the 2049-50 forecast of combined insured costs and Commonwealth DRFA expenditure, to estimate the 2049-50 Commonwealth administered funding on other programs.

2.1.2. Climate modelling, informing financial and economic modelling

To align with the other data inputs into the financial and economic modelling, regional-level estimates for each Australian state and territory are calculated for four physical hazards:

- *Flood:* Extreme rainfall frequency and intensity as a proxy for changes in flood risk,
- *Bushfire:* Frequency of days per year with very high fire weather conditions are conducive to fires,
- *Storm surge:* Annual exceedance probability for the current 1-in-100-year extreme sea level event, and
- *Tropical Cyclone:* Category 4/5 tropical cyclone frequency and intensity.

To accommodate differences in how future climate may evolve arising from different trajectories across multiple socioeconomic factors, two plausible and distinct climate scenarios are used. These scenarios follow the Representative Concentration Pathways (RCPs) that underpin the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, published in 2013 and include:

- *RCP8.5:* High emissions scenario involving limited climate action and global warming over 4°C by 2100,

- *RCP4.5*: Moderate emissions scenario associated with current global targets and pledges with global warming of 2°C to 3°C by 2100.

Climate model overview

Both global and regional climate models are four-dimensional (latitude, longitude, time and height) representations of the climate system globally at every point in time for the past, present and future. The climate scenarios data from global climate models is generally updated every 5 to 7 years, with regional climate model estimates updated in between. Therefore, estimates can vary between generations of climate projections and the types of climate models used.

Each global climate model and the underlying physics is different. There is a range in magnitude (and sign/direction) in how the climate evolves at each simulated point on Earth in each model – this leads to a spread in climate model projections and model 'uncertainty'. A multi-model estimate can be used to capture the overarching trends and has been shown to outperform individual models across multiple metrics.

Improving resolution via statistical and/or dynamical downscaling

Downscaling methods intend to increase the granularity and add value to coarser global climate model projections, to support climate change information needs at regional to local scales (Giorgi et al. 2009). There are two main methods for downscaling: statistical and dynamical. Both of these methods have been applied for the development of the climate datasets described in this report.

The following summarises approaches to climate model downscaling:

- Dynamical downscaling involves the use of a regional climate model, at fine scale resolutions, which is underpinned by the same physics as a global climate model but with differences in how these models are configured and run. As implied by the name, regional climate models only simulate the climate for a regional domain (e.g., Australia) and rarely globally, therefore, information is required at the boundaries of the domain to define the large-scale characteristics of the climate system (e.g., wind, temperature, pressure, humidity). The datasets used to define these boundary conditions can include gridded observational datasets to understand current and recent past climate and global climate model projections, to understand future potential changes in climate at a finer scale resolution. Dynamical downscaling with regional climate models are particularly advantageous in modelling weather and climate over highly variable terrain, including coastlines and mountainous regions and a growing requirement for vulnerability impact assessments (Giorgi 2019).
- Statistical downscaling is a methodological process applied to coarse resolution, global climate model data, to transform it to a higher resolution that resolves the

finer spatial scale detail across a region. The method uses observed relationships between different local climate conditions and large-scale climate, to build a statistical model to process the global climate model data. These data have also been bias corrected using a quantile mapping approach to remove systematic biases in the global climate model outputs (Werner and Cannon 2016). Statistical downscaling does not necessarily provide more credible climate projections as the process will inherit the biases of the global climate models that are used. However, downscaling increases the resolution to the spatial scales needed for impact assessment by increasing the level of spatial detail. Statistical downscaling is faster to produce high resolution datasets than dynamical downscaling but has limitations in how well climate extremes are characterised.

Climate Data Sources and Attributes

The physical climate hazards assessed, available climate scenarios, horizons including data sources and granularity are detailed in the table below. The climate hazards selected are based on best publicly available and commercially usable data from credible sources, in order to provide the most robust projections of physical climate risk at the state level. Further information on the data assumptions, statistical methods and likelihood calculations are provided later.

Table 17. Characteristics of the climate datasets used in this project.

Physical Hazard	Climate Metric	Metric Description	Unit	Data Granularity	Emission Scenarios	Data Source
Flood	Extreme rain intensity	The maximum amount of rainfall in mm in a single day for a year	mm/day	250km	Moderate (RCP4.5) High (RCP8.5)	IPCC AR5 via the KNMI Climate Explorer[1]
	Extreme rain frequency	Annual count of days where the rainfall in a day is greater than 20mm	mm/day	250km	Moderate (RCP4.5) High (RCP8.5)	IPCC AR5 via the KNMI Climate Explorer

Physical Hazard	Climate Metric	Metric Description	Unit	Data Granularity	Emission Scenarios	Data Source
Bushfire	Very High Fire Days	Number of days annually where the Forest Fire Danger Index exceeds 25 (very high rating)	days	5 km	Moderate (RCP4.5) High (RCP8.5)	ESCI
Storm Surge	1-in-100-year storm surge event	Return period of a 1-in-100-year extreme sea level event that includes storm surge	years	100 km	Moderate (RCP4.5) High (RCP8.5)	Vousdoukas et al. (2018)[2]
Tropical Cyclones	Tropical cyclones	Future change in CAT4/5 cyclone frequency, intensity and landfall rain rate	%	100km	High (RCP8.5)	BoM. (2022)[3] Knutson et al. (2020)

Due to year-to-year climate variability and to assess the step change in climate between today and 2050, assessing the physical hazards requires using data across multiple decades. Here, to align with leading scientific practice, 20-year periods are used for each climate scenario, metric and time horizon. For the financial and economic analysis and modelling, one future time horizon will be considered: '2050' represents the 2040 to 2059 period. A historical period is also used to inform the current baseline these are 1986-2005 (bushfires and flood), 1980-2014 (storm surge) and 1980-2022 (tropical cyclones).

Data Processing Analysis Approach

Data processing methods have been required to reduce the dimensionality of the climate data. This has been necessary to ensure that all data inputs for the financial and economic modelling are consistent with the state-level estimates. The sequence of steps to calculate state-level estimates for each metric[4], climate scenario and time horizon include:

- Calculate the multi-year average for each model individually.
- Extract the data that falls within each state or territory boundary.
- Calculate the future change as:

$$future\ change = future\ value - historical\ value$$

- Calculate the future percent change as:

$$percent\ change = 100 \times \frac{future\ value\ - historical\ value}{historical\ value}$$

- Combine data for all models to calculate the 5th, 25th, 50th, 75th and 95th percentile estimates.
- Convert the estimates into a measure of the historical and future likelihood (%), between 0 and 100. This varies between the different metrics and are described in *Table 18*.

Table 18. Calculation of likelihood estimates per hazard.

Physical Hazards	Climate Metric	Description of calculation
Flood	Extreme Rain Intensity	Proportion of the maximum extreme rain intensity for Australia Likelihood = State Historic Value / Australia Max Value
	Extreme Rain Frequency	Proportion of days per year Likelihood = value / 365
Bushfire	Very High Fire Days	Proportion of days per year Likelihood = value / 365

Physical Hazards	Climate Metric	Description of calculation
Storm Surge	1-in-100-year Storm Surge Event	**Historical** Proportion of the maximum 1-in-100-year event height in metres for Australia Likelihood = State Historic Value / Australia Max Value
		Future Convert the future return period (years) into Annual Exceedance Probability (AEP) Likelihood = 100 / Future Value
Tropical Cyclone[5]	Future change in CAT4/5 cyclone frequency, intensity, and landfall rain rate	**Future** Future change in CAT4/5 cyclone frequency, intensity, and landfall rain rate

Quality control and review

The calculations described above underwent quality control and review checks throughout the analysis to provide confidence in the methods applied to calculate the hazard estimates in a scientific and robust manner. This included:

- Reviewing and approving the scope with NEMA,
- Active engagement and review by Deloitte climate scientists, as well as frequent alignment and discussions with the broader Deloitte financial and economic analysis and modelling team,
- Defining a consistent methodology for all data gathering, processing and calculations,
- Data processing and calculations performed by climate scientists with experience in climate science modeling and climate data analysis,

[5] Australian states are impacted by tropical cyclones (TC) that form within two different ocean basins: South Indian (SI) and the South-West Pacific (SWP). Future TC projections are provided on a basin-wide scale only. To obtain estimates of future exposure specific to each state, historical TC observations were used to obtain a count for each state of the category 4/5 event that originated from each basin. Based on this count, the future changes to TC exposure for each state was weighted as follows:

$$Weighted\ exposure = \frac{SWP_{historical\ count}}{SWP_{historical\ count} + SI_{historical\ count}} \Delta SWP_i + \frac{SI_{historical\ count}}{SWP_{historical\ count} + SI_{historical\ count}} \Delta SI_i$$

Where i is either the TC frequency, intensity or landfall rain rate

- Python code for data download, processing and calculations developed and reviewed and approved by internal peers who are climate scientists,
- Data download, processing and calculations performed by climate scientists, with segregation of preparation and review activities,

- Review of all data download and processing undertaken to confirm consistency with the established and approved methodology, and
- Comparison of the multi-model model findings with literature and other data sources.

Caveats

This analysis is intended to give insight into the historic and potential future projections of trends and exposures across different Australian states and territories, leveraging global and regional climate model datasets as referenced in this document. Additional analysis of localised data and geographic conditions may need to be considered at finer scales to understand and monitor specific risks related to assets, infrastructure and operations and inform disaster response, resilience and adaptation planning decisions.

Weather and climate are not the same thing, where weather refers to short-term atmospheric conditions associated with an event (e.g., storm), climate refers to the long-term characteristics in a region that considers conditions over multiple decades. Therefore, the climate hazard estimates represent the statistical characteristics of different types of physical climate hazards and not individual weather events.

Climate projections are based on assumptions about future greenhouse gas emissions associated with human activity and other policy choices. Climate projections are NOT predictions and they do not attempt to predict the timing of meteorological events such as storms, droughts, or floods. Projections vary from model to model: the best projection dataset for one location and purpose may not be the best for other situations. Considering a range of projections from multiple climate models supports a more complete picture of potential future risks. Thus, multiple climate models and datasets are used in this report. Many climate metrics, particularly acute metrics associated with extreme weather events, are not outputted directly from climate models and are estimated post-modelling by specialised climate scientists. As such, not all scenarios are available for all metrics (e.g., tropical cyclones).

It is important to note that the climate system does not change linearly and that the frequency and intensity of various weather systems does not always increase under future climate scenarios. A key example is rainfall – the hydrological cycle is amplified under future climates in various ways and so there are many instances where the trends are larger under a future where the globe aligns with the Paris Agreement, compared to one with no climate action. Due to the non-linear changes occurring within the climate system associated with climate change, a linear extrapolation between the climate estimates for today and 2050 is not recommended.

Climate models do not simulate the Earth's system at a site scale, but rather across a region. The model granularity means that models are a summary of the climate within each grid box/region and can average out large variations (e.g., a mountain region with high rain adjacent to a coastal region with no rain). Due to the distribution of the Australian population concentration in urban areas, the assessment of projected changes for each of the climate hazards can vary in contrast to rural areas with the potential to lead to differences in the estimation of disaster-related costs. Therefore, future assessment would benefit from utilising smaller statistical regions than the state-level estimates that were prepared for this project. Statistical estimates for each state include measures of the average condition and the spread, to enable sensitivity testing of any subsequent modelling that uses this climate data.

2.1.3. Modelling limitations and assumptions

Total average economic costs represent the expected value of future costs, rather than a forecast of actual (realised) costs in any given year. This means that, in some years, the total economic costs of natural disasters will likely be much higher (or much lower) than the cost predictions from the modelling. Providing the cost predictions in ranges captures the high uncertainty associated with climate risk modelling and long-term projections. The P95, P99 estimates assist to understand the upper tail risk of costs resulting from natural disasters.

Financial cost estimate

<u>*Insured Cost Estimate*</u>

An important assumption underpinning the risk modelling used to predict the 2023-24 insured losses, is the independence of occurrences of natural disasters and associated insured losses of a single event, such that:

- Occurrences of natural disaster events are independent year to year,
- Losses from a single event are not correlated with other events, and
- Extreme and non-extreme events are independent.

Further, it is assumed that when predicting the insured losses for jurisdictions, the observed ratios of sample estimates (for each jurisdiction) to simulated estimates (at a national level) hold constant for the average, P95 and P99 estimates in 2049-50.

The following limitations are noted for the approach to index 2023-24 insured costs estimate to 2049-50:

- The calculation of Compound Annual Growth Rates (CAGR) based on projected households in 2041 and households in 2016 relies on the assumption that the growth rates observed between these years will persist over the entire projection period. This assumption may not fully capture potential changes in demographic trends or economic conditions.

- The reliance on historical data, specifically the historical CAGR derived using the Total Value of Dwellings dataset and Producer Price Index (PPI), assumes that past trends will continue to be indicative of future developments. Changes in economic structures or policy frameworks may not be fully captured in this historical data.
- The transition from state and territory-specific real housing value growth CAGR to the national average after the initial five years simplifies the adjustment process. This assumes a sudden and uniform shift in growth dynamics, potentially overlooking nuanced variations that may persist over time.
- PPI CAGR is subtracted from the housing value growth CAGR to obtain the real CAGR for housing value across states and territories. This assumes a uniform relationship between building materials cost inflation and the total housing value. This may oversimplify the complex factors influencing construction costs.
- The changing insurance landscape has not been considered. State and territory stakeholders are hearing of increased insurance premiums particularly for rural councils to the point that it is becoming cost prohibiting, or insurance companies are not offering coverage for natural disaster events. This could result in overestimation of insured costs.

Uninsured Cost Estimate

The selection of reference events may generalise the social impacts for each disaster type. Nuances in the magnitude and social outcomes across jurisdictions are not fully accounted for, potentially leading to underestimation or overestimation of costs in specific regions. It is noted that the reference events occur between 1990 and 2020. These reference events have been selected due to the availability of information relating to the financial costs and the social impacts. While the cost structures of the different event types have been tested where data is available, it is noted that the lack of more recent event data may result in the analysis failing to capture some structural changes impacting on the total economic cost of different types of natural disasters.

The 'other' disaster type primarily consists of tornadoes and no dedicated research has been conducted to identify a reference event for this category. Instead, an average across the remaining disaster types has been applied to calculate the categorical share of uninsured losses and the social costs. The total economic cost for the ‘other’ disaster type could be better approximated if a tornado reference event was utilised.

A key limitation of using the reference events is under-representation of agriculture production loss. Using case studies shared by the SA Government and the ICA dataset, analysis has found that the underestimation could be as much as $0.8 per $1 of insured cost for flood events, $0.31 per $1 of insured cost for bushfire events and $0.06 per $1 of insured cost for hailstorm events.

Social Cost Estimate

Recognising the non-linear nature of social impacts, the analysis assumes a spike in impacts immediately after a disaster, with most people recovering over the medium- to long-term. The complexity of long-term recovery and the potential for compounding impacts introduce uncertainty in the accuracy of this assumption.

The social costs presented in the analysis include only those with sufficient data. As such, they represent a subset of total social impacts, potentially leading to an underestimation of the overall impact of natural disasters.

The use of reference events facilitates a bottom-up costing of the financial and social impacts directly attributable to the natural disaster event. Hence the catchment population only includes those impacted through injury or property damage. The analysis does not quantify secondary effects, due to limited data availability on these impacts and as such, does not apply the entire impacted population within the analysis.

Environmental impacts have not been explicitly costed in the modelling. While it is partially captured in other costs (such as clean-up costs), the flow-on intangible impacts (such as asset damage on water quality, habitat and biodiversity) cannot be reliably estimated due to the availability of data.

Environmental damage caused by natural disasters is also highly location specific (e.g., compare the damage of a tropical cyclone impacting the Great Barrier Reef with the impact on remote bushland) which is difficult to consider in the modelling at a state and territory level.

If incorporating environmental impacts, it would also be important to consider the benefits to ecosystems associated with natural disasters. For example, the benefits that flooding brings to flood plains and their ecosystems. However, these benefits lack the availability of data to reliably quantify.

Climate Scenarios Overlay

The change in likelihood and intensity of climate hazards were directly applied to the 2049-50 indexed insured costs, based on the assumptions that one percent change in likelihood of climate hazard translates into one percent change in likelihood of a natural disaster event occurring; and one percent change in intensity of climate hazard is equivalent to one percent change in the financial consequences of a natural disaster event. Further analysis could be undertaken to better account for the relationships between changes in likelihood and intensity of climate hazards and the resulting changes in occurrences and consequences of the corresponding natural disaster event.

In addition, the P95 and P99 results of the climate scenarios have been applied to the P95 and P99 insured loss estimates, assuming that the underlying statistical distributions of insured losses align with the distributions of likelihood and intensity for the modelled climate hazards. Further analysis could be undertaken to better understand the relationship between the distributions of climate hazards and insured losses (both occurrences and consequences).

Further limitations are recognised in relation to the availability of climate data:

- The data for tropical cyclone events is only available for the high emission scenario at the P50 and P95 estimates,
- Climate scenarios are not applied to the storm category as the underlying climate modelling provides estimates for the 1-in-100-year storm surge event. The ICA natural disaster data however, groups storms, storm surges and east coast lows. It would be inappropriate to apply the storm surge climate scenarios to the estimated likelihood and intensity of all storm types, and
- No climate scenario overlay is applied to hailstorm, earthquake or 'other' disaster type events due to no appropriate datasets available to assess them.

Total Commonwealth administered funding estimate

For the purposes of this analysis, the NEMA Disaster Resilience Funding data is assumed to be comprehensive, accurate and complete. Minimal data cleansing/processing has been performed by Deloitte and the assumption is made that the pre-populated data and subsequent consultation, ensures data integrity.

The classification of funding programs into NEMA categories (e.g., Category 1, Category 2a) is assumed to be consistent across Australian Government agencies. This assumption is essential for quantification and categorisation of disaster funding.

The following limitations should be noted for the Commonwealth administered funding estimate methodology:

- Due to the variability in measures activated and funding thresholds within DRFA, it is not possible to precisely estimate the expenditure the Commonwealth will reimburse per DRFA category. The use of proportional splits is a simplifying assumption.
- Assuming the calculated ratios for DRFA categories (Category A, B, C and D) and their respective activities remain constant in 2049-50 and assumes the current approach is maintained and does not fully account for potential shifts in policy, disaster management, or funding priorities.
- The reliance on historical relationships and ratios for forecasting introduces a limitation, as it assumes that past trends are indicative of future expenditure patterns. Changes in disaster management strategies or policy will impact the reasonableness of these assumptions.

2.2. Findings

2.2.1 Climate modelling informing financial and economic modelling

Below is a summary of the projected changes to the climate hazards for each state and territory in Australia that were used in the financial and economic modelling. Tables 34 to 48 present medians (50th percentile) and ranges (5th and 95th percentile estimates) for each climate hazard over each Australia state and territory, using the data processing techniques described earlier. Future values are presented as the multi-year average over 2040 to 2059, centred on 2050 for two future scenarios (a moderate emission scenario RCP4.5 and a high emission scenario RCP8.5).

Flood: Extreme Rain Intensity

Table 19. Median and 5th to 95th percentile range of the projected value in extreme rain intensity for two future scenarios by 2050 for each state and territory in Australia, with the historical average estimate over 1986 to 2005 provided for context. All values have units of mm per day.

State / Territory	Historical	2050	
		Moderate Emission Scenario	High Emission Scenario
New South Wales	42.1 (35.1 to 60.1)	45.8 (37.4 to 62.3)	45.1 (36.2 to 61.4)
Victoria	34.4 (29.9 to 40.1)	36.5 (32.9 to 43.9)	35.9 (30.8 to 42.9)
Queensland	59.9 (41.1 to 73.7)	65.1 (43.7 to 81.5)	66.1 (42.7 to 87.7)
South Australia	34.0 (28.7 to 41.3)	35.6 (29.9 to 42.2)	35.7 (30.0 to 44.5)
Western Australia	40.5 (29.0 to 88.0)	42.5 (29.5 to 89.1)	43.0 (30.0 to 95.5)
Tasmania	31.0 (28.5 to 34.5)	34.0 (30.7 to 36.7)	31.7 (30.2 to 36.3)
Northern Territory	59.6 (39.9 to 84.5)	64.9 (40.8 to 90.2)	64.7 (42.8 to 96.9)
Australian Capital Territory	41.4 (30.6 to 51.9)	45.8 (29.9 to 60.2)	44.3 (31.9 to 59.1)

Flood: Extreme Rain Frequency

Table 20. Median and 5th to 95th percentile range of the projected value in extreme rain frequency for two future scenarios by 2050 for each state and territory in Australia, with the historical average estimate over 1986 to 2005 provided for context. All values have units of days.

State / Territory	Historical	2050	
		Moderate Emission Scenario	High Emission Scenario
New South Wales	5.4 (2.8 to 12.0)	5.4 (3.0 to 11.7)	5.2 (3.0 to 11.0)
Victoria	3.2 (2.2 to 5.3)	3.6 (2.5 to 5.7)	3.3 (2.4 to 5.7)
Queensland	8.1 (4.1 to 23.3)	8.1 (4.1 to 23.4)	7.5 (4.0 to 23.9)
South Australia	2.5 (1.7 to 4.2)	2.7 (1.8 to 4.0)	2.7 (1.8 to 4.2)
Western Australia	4.0 (1.8 to 16.2)	3.7 (1.7 to 16.0)	3.6 (1.6 to 15.9)
Tasmania	3.0 (2.2 to 3.5)	3.5 (2.8 to 4.0)	3.2 (2.6 to 4.0)
Northern Territory	9.7 (3.8 to 25.9)	10.1 (3.8 to 25.1)	9.7 (3.8 to 25.3)
Australian Capital Territory	5.6 (2.2 to 10.4)	6.1 (2.0 to 11.4)	6.0 (2.4 to 11.4)

Bushfire: Very High Fire Days

Table 21. Median and 5th to 95th percentile range of the projected value in Very High Fire Danger Days for two future scenarios by 2050 for each state and territory in Australia, with the historical average estimate over 1986 to 2005 provided for context. All values have units of days.

State / Territory	Historical	2050	
		Moderate Emission Scenario	High Emission Scenario
New South Wales	57.3 (3.5 to 137.6)	72.7 (6.1 to 155.6)	77.1 (6.6 to 159.6)
Victoria	22.2 (2.3 to 77.1)	28.8 (4.1 to 88.0)	30.0 (4.6 to 90.5)
Queensland	80.9 (4.1 to 197.6)	106.7 (7.2 to 227.6)	112.3 (8.3 to 229.8)
South Australia	145.3 (32.7 to 190.5)	165.7 (42.6 to 211.5)	166.8 (43.9 to 214.7)
Western Australia	157.5 (32.7 to 233.0)	186.1 (47.0 to 267.9)	184.6 (47.5 to 261.8)
Tasmania	0.5 (0.0 to 2.1)	0.6 (0.0 to 2.9)	0.9 (0.0 to 3.6)
Northern Territory	170.5 (20.7 to 206.3)	207.4 (41.3 to 244.2)	203.5 (38.4 to 240.4)
Australian Capital Territory	9.6 (3.2 to 16.3)	13.8 (5.2 to 21.9)	15.2 (5.6 to 23.5)

Storm Surge: 1-in-100-year Storm Surge Event

Table 22. Median and 5th to 95th percentile range of the projected return period of the current 1-in-100-year Storm Surge Event for two future scenarios by 2050 for each state and territory in Australia, with the historical average estimate over 1980 to 2014 provided for context.

State / Territory [a]	Historical [b] *(wave height in metres)*	2050 [c] *(return period in years)*	
		Moderate Emission Scenario	High Emission Scenario
New South Wales	2.12 (2.07 to 2.25)	26.6 (12.0 to 42.8)	10.2 (7.3 to 22.4)
Victoria	2.36 (2.20 to 2.72)	15.6 (12.0 to 41.8)	9.2 (7.5 to 26.0)
Queensland	2.57 (1.65 to 3.38)	33.6 (0.8 to 79.2)	19.6 (0.1 to 50.2)
South Australia	2.72 (1.96 to 3.03)	15.7 (8.3 to 23.4)	10.2 (5.8 to 18.8)
Western Australia	2.47 (1.77 to 5.31)	24.5 (8.7 to 93.8)	15.5 (5.8 to 90.7)
Tasmania	2.56 (2.08 to 2.68)	9.2 (8.1 to 14.7)	6.0 (5.0 to 8.5)
Northern Territory	2.85 (2.15 to 4.23)	93.8 (49.6 to 164.9)	71.2 (16.4 to 85.8)

[a] Note: values are not available for the Australian Capital Territory due to large distance from the coast and therefore no exposure to storm surges.

[b] Historical values correspond to the sea level height in metres for the current 1-in-100-year storm surge event.

[c] Future values are the new return period (in years) of the (1980-2014) 1-in-100-year storm surge event.

Tropical Cyclones: Frequency, Intensity and Landfall Rain Rate

Table 23. Median and 5th to 95th percentile range of the projected change in the frequency, intensity and landfall rain rate of category 4-5 tropical cyclones for one future scenario by 2050 for each state and territory in Australia. The historical count of the weighted exposure to South-Indian (SI) and South-West Pacific (SWP) category 4-5 tropical cyclones over the period 1980 to 2022 is provided for context. All values have units of percent (%).

State / Territory [d]	Historical *(count)*	2050 [e] (% change)		
		Frequency	Intensity	Landfall rain Rate
Queensland	8	-12.1 (-40.1 to 24.6)	1.5 (-5.3 to 12.0)	8.9 (-0.9 to 16.8)
Western Australia	31	0.9 (-27.0 to 54.9)	4.5 (0.1 to 11.1)	17.3 (1.5 to 24.1)
Northern Territory	5	-14.5 (-42.5 to 19.1)	0.9 (-6.3 to 12.2)	7.3 (-1.3 to 15.4)

[d] Category 4-5 tropical cyclones have only been observed to historically impact Queensland, Western Australia and the Northern Territory and therefore estimates are only available for these regions.

[e] Weighted estimates from the South Indian and South-West Pacific Basin are presented.

2.2.2 Estimated cost of natural disasters and associated Commonwealth funding

Based on the approach outlined in the financial and economic modelling and analysis methodology section, the total economic cost of natural disasters and the associated Commonwealth administered funding has been estimated. *Table 24* presents the estimated average total economic cost of natural disasters in 2023-24, 2049-50 and the associated 2049-50 Commonwealth funding by jurisdiction in real 2023-24 dollars. The 2049-50 results estimate the anticipated underlying growth in the impact of natural disasters due to increased population, number and average size of dwellings at risk and changes in building materials. Consistent with the historical analysis, Queensland, New South Wales and Victoria are predicted to experience the highest economic cost of natural disaster events in 2049-50.

Table 24 Total economic cost and Commonwealth funding by jurisdiction | Average estimate Excl. climate overlay

Jurisdiction	Unit	2023-24 Total Economic Cost Average Estimate	2049-50 Total Economic Cost Average Estimate	2049-50 Commonwealth Funding Average Estimate
ACT	$ M | Real 2023-24	106	385	48
NSW	$ M | Real 2023-24	3,181	11,246	2,668
NT	$ M | Real 2023-24	1,098	2,943	764
QLD	$ M | Real 2023-24	5,075	17,747	2,694
SA	$ M | Real 2023-24	217	607	146
TAS	$ M | Real 2023-24	342	996	246
VIC	$ M | Real 2023-24	1,195	4,495	1,989
WA	$ M | Real 2023-24	624	1,855	269
National	**$ M | Real 2023-24**	**11,837**	**40,275**	**8,823**

Source: Deloitte 2024. Note numbers may not add due to rounding.

To accommodate differences in how future climate may evolve arising from different trajectories across multiple socio-economic factors, two distinct climate scenarios are used (a moderate emission scenario and a high emission scenario) and are compared to the analysis excluding the climate overlay. *Table 25* to *Table 32* provides a summary of the predicted total economic cost by natural disaster type for each jurisdiction in 2049-50 in real 2023-24 dollar terms.

Table 25 2049-50 total economic cost of natural disasters by disaster type | ACT

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	-	-	-	-	-	-
Bushfire	$ M | Real 2023-24	-	-	-	9,854	15,924	18,239
Storm	$ M | Real 2023-24	-	-	-	-	-	-
Cyclone	$ M | Real 2023-24	-	-	-	-	-	-
Hailstorm	$ M | Real 2023-24	-	-	-	3,333	3,333	3,333
Earthquake	$ M | Real 2023-24	-	-	-	-	-	-
Other	$ M | Real 2023-24	-	-	-	-	-	-

Source: Deloitte 2024.

Table 26 2049-50 total economic cost of natural disasters by disaster type | NSW

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	18,482	18,640	17,350	52,340	52,015	49,785
Bushfire	$ M | Real 2023-24	3,981	5,093	5,356	8,659	10,941	11,368
Storm	$ M | Real 2023-24	12,152	12,152	12,152	30,275	30,275	30,275
Cyclone	$ M | Real 2023-24	5,658	5,658	5,658	40,652	40,652	40,652
Hailstorm	$ M | Real 2023-24	9,353	9,353	9,353	79,779	79,779	79,779
Earthquake	$ M | Real 2023-24	405	405	405	11,935	11,935	11,935
Other	$ M | Real 2023-24	427	427	427	3,445	3,445	3,445

Source: Deloitte 2024.

Table 27 2049-50 total economic cost of natural disasters by disaster type | NT

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	-	-	-	3,802	3,756	4,089
Bushfire	$ M | Real 2023-24	-	-	-	-	-	-
Storm	$ M | Real 2023-24	-	-	-	271	271	271
Cyclone	$ M | Real 2023-24	2,072	2,072	2,768	79,495	79,495	79,495
Hailstorm	$ M | Real 2023-24	-	-	-	-	-	-
Earthquake	$ M | Real 2023-24	-	-	-	-	-	-
Other	$ M | Real 2023-24	-	-	-	5	5	5

Source: Deloitte 2024.

Table 28 2049-50 total economic cost of natural disasters by disaster type | QLD

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	39,535	43,786	48,224	104,870	122,524	131,290
Bushfire	$ M | Real 2023-24	-	-	-	4,521	6,207	6,198
Storm	$ M | Real 2023-24	7,500	7,500	7,500	9,259	9,259	9,259
Cyclone	$ M | Real 2023-24	36,464	36,464	50,915	142,275	142,275	142,275
Hailstorm	$ M | Real 2023-24	8,731	8,731	8,731	33,321	33,321	33,321
Earthquake	$ M | Real 2023-24	-	-	-	5	5	5
Other	$ M | Real 2023-24	-	-	-	-	-	-

Source: Deloitte 2024.

Table 29 2049-50 total economic cost of natural disasters by disaster type | SA

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	-	-	-	915	911	962
Bushfire	$ M | Real 2023-24	2,664	3,282	3,382	10,427	12,779	13,179
Storm	$ M | Real 2023-24	623	623	623	2,502	2,502	2,502
Cyclone	$ M | Real 2023-24	-	-	-	-	-	-
Hailstorm	$ M | Real 2023-24	169	169	169	2,777	2,777	2,777
Earthquake	$ M | Real 2023-24	-	-	-	-	-	-
Other	$ M | Real 2023-24	-	-	-	6	6	6

Source: Deloitte 2024.

Table 30 2049-50 total economic cost of natural disasters by disaster type | TAS

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	-	-	-	4,168	5,039	4,983
Bushfire	$ M | Real 2023-24	8	16	24	26,807	51,140	75,530
Storm	$ M | Real 2023-24	324	324	324	1,926	1,926	1,926
Cyclone	$ M | Real 2023-24	-	-	-	-	-	-
Hailstorm	$ M | Real 2023-24	-	-	-	-	-	-
Earthquake	$ M | Real 2023-24	-	-	-	-	-	-
Other	$ M | Real 2023-24	-	-	-	-	-	-

Source: Deloitte 2024.

Table 31 2049-50 total economic cost of natural disasters by disaster type | VIC

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	5,820	6,899	6,651	12,671	15,237	14,579
Bushfire	$ M | Real 2023-24	12,553	18,710	19,812	47,697	70,218	72,327
Storm	$ M | Real 2023-24	5,646	5,646	5,646	22,303	22,303	22,303
Cyclone	$ M | Real 2023-24	-	-	-	-	-	-
Hailstorm	$ M | Real 2023-24	1,581	1,581	1,581	14,961	14,961	14,961
Earthquake	$ M | Real 2023-24	24	24	24	262	262	262
Other	$ M | Real 2023-24	46	46	46	171	171	171

Source: Deloitte 2024.

Table 32 2049-50 total economic cost of natural disasters by disaster type | WA

Natural Disaster Type	Unit	2049-50 P95 Estimate Excluding Climate Scenario	2049-50 P95 Estimate Moderate Emission Scenario	2049-50 P95 Estimate High Emission Scenario	2049-50 P99 Estimate Excluding Climate Scenario	2049-50 P99 Estimate Moderate Emission Scenario	2049-50 P99 Estimate High Emission Scenario
Flood	$ M | Real 2023-24	-	-	-	990	959	1,028
Bushfire	$ M | Real 2023-24	1,075	1,421	1,357	1,713	2,255	2,171
Storm	$ M | Real 2023-24	882	882	882	8,837	8,837	8,837
Cyclone	$ M | Real 2023-24	11,475	11,475	19,756	16,251	16,251	16,251
Hailstorm	$ M | Real 2023-24	-	-	-	113	113	113
Earthquake	$ M | Real 2023-24	156	156	156	210	210	210
Other	$ M | Real 2023-24	5	5	5	267	267	267

Source: Deloitte 2024.

2.2.3 Quantitative policy analysis

To support the development of the policy recommendations, where relevant, quantitative analysis has been undertaken to further inform decision making. Quantitative analysis has been undertaken in relation to three policy options:

- Embedding betterment within the DRFA,
- Increasing funding on resilience and risk reduction, and
- Increasing support to mental health programs.

This analysis builds on the estimate of total economic cost. It should be noted that this analysis:

- Considers the impact over the period to 2049-50,
- Uses the average estimate (as opposed to the P95 or P99 estimate) of the forecast total economic cost, and
- Does not take into consideration the impact of climate change.

A key assumption in the quantitative policy analysis is the Benefit Cost Ratio (BCR) of betterment investment to the associated benefits. A number of different sources and cases studies (summarised in *Table 33*) were considered.

Table 33. Summary of literature review into benefit cost analysis of resilience measures

Article Name	Benefit Cost Ratio	Timeframe	Metrics/Methodology
The Economics of Early Response and Resilience[1]	2.3:1 – 13.2:1	20 years	Commercial destocking, early provision of aid.
International Cooperation in Disaster Risk Reduction[2]	Up to 15:1	9 years	Summary report ranging across a number of metrics, including property damage, business interruption, loss of life and injuries, public health and well-being and environmental impacts.
National Hazard Mitigation Saves - 2019 Report[3]	4:1 – 11:1	23 years	Casualties and PTSD, property, additional living expenses and direct business interruption, insurance, indirect business interruption and loss of service.

Article Name	Benefit Cost Ratio	Timeframe	Metrics/Methodology
Flood and Coastal Risk Management in England: Long-Term Investment Scenarios (LTIS) 2019[4]	9:1	50 years	Direct costs: construction, maintenance and operation of Flood and Coastal Erosion Risk Management (FCERM) measures. Indirect costs: loss of land use, disruption to businesses and psychological impacts of flooding. Benefits: Reduced flood damage to property and infrastructure, improved business continuity and saved lives.
Global Assessment Report on Disaster Risk Reduction[5]	Up to 8:1	-	Summary report ranging across a number of metrics including property damage, business interruption, loss of life and injuries, public health and well-being, environmental impacts
Building our nation's resilience to natural disasters[6]	1.3:1 – 8.5:1	-	Reduced direct property damage e.g., buildings and contents.

Sources: (1) United Kingdom Government 2022 (2) United Nations Office for Disaster Risk Reduction 2021 (3) National Institute of Building Sciences (USA) 2019 (4) The Environment Agency (UK) 2019 (5) United Nations International Strategy for Disaster Reduction, 2015 (6) Deloitte Access Economic 2013.

The Federal mitigation grants case study from the *National Hazard Mitigation Saves - 2019 Report* was cited to determine the mid case for the BCR. This study is an assessment of the economic impact of mitigation measures, commissioned by the National Institute of Building Sciences (USA) focusing on the BCR as a key metric. The metric makeup includes casualties and post-traumatic stress disorder (PTSD), property damage, additional living expenses, direct business interruption, insurance costs, indirect business interruption and loss of service, emphasizing a comprehensive assessment. The study employs a benefit-cost analysis framework involving the identification and quantification of mitigation costs, estimation of potential benefits and the calculation of the BCR by discounting future costs and benefits to present value over a 23-year timeframe. The study may not reflect the full range of benefits that would accrue over a longer period.

While the case studies presented in this report focus on the United States, the lessons learned and methodologies employed, can be applied to a variety of hazard contexts and regions globally. The transferability of the benefit-cost ratios presented in this report are dependent on differences in hazard profiles, building codes and economic factors. However, given the similarities between the United States and Australia socially and economically, and the similar BCRs when compared with Australian case studies, it was considered reasonable to consider the studies' findings to inform policy decisions related to disaster risk reduction and mitigation in Australia.

Embedding betterment within the DRFA

The purpose of this analysis is to quantify the costs and benefits to the Commonwealth if betterment was embedded within recovery measures in the DRFA. This considers the potential additional funding required from the Commonwealth to cover the increased Restoration of Essential Public Assets (REPA) cost, with the intention of reducing the impact of natural disasters in the future as a result of more resilient infrastructure.

Assumptions

The assumptions summarised in *Table 34* were applied in the quantitative analysis to understand the potential benefit of embedding betterment within the DRFA.

Table 34. Key assumptions | Embedding betterment within the DRFA

Assumption	Unit	Low Case	Mid Case	High Case
Betterment cost as a portion of REPA cost[1]	%	65%	60%	55%
Portion of economic benefits resulting in avoided damages[2]	%	20%	20%	20%
Benefit Cost Ratio[3]	x	3:1	6:1	8:1
Number of periods for benefits realisation[3]	#	23	23	23
Real discount rate[4]	% p.a.	7%	7%	7%
2023-24 National REPA cost [5]	$ M | Real 2023-24	4,314	4,314	4,314
2023-24 National total economic cost [5]	$ M | Real 2023-24	11,837	11,837	11,837
2049-50 National total economic cost [5]	$ M | Real 2023-24	40,275	40,275	40,275

Sources (1) Based on analysis of Queensland Reconstruction Authority case studies (Queensland Reconstruction Authority 2023) (2) Based on analysis of Summary of Recovery of Assistance Table (SORAT) data (NEMA 2023a) (3) Based on analysis of National Institute of Building Sciences 2019 (4)

Department of the Prime Minister and Cabinet – The Office of Impact Analysis 2023 (5) Outputs from Deloitte forecast modelling. Numbers represent the average estimate excluding the impact of climate change.

Approach

The quantitative policy analysis leverages the forecast modelling, which estimates the total economic cost of natural disasters from 2023-24 to 2049-50. As part of the total economic cost modelling, the annual REPA cost due to natural disaster events is estimated.

The additional cost associated with betterment activities is estimated based on an assumed portion of the REPA cost. This assumption is informed by Queensland Reconstruction Authority's published cost-benefit analyses for various historical betterment projects completed (Queensland Reconstruction Authority 2023). These case studies identify the total restoration cost and total additional cost for betterment of each project. Based on the publicly available case studies, the weighted average of the betterment cost as a portion of the total restoration cost is calculated to be 60 percent.

To estimate the potential benefit associated with the additional expenditure on betterment, the BCR informed by the literature review is applied. Under the assumption that benefits will be realised over a period of 23 years, the benefit is calculated as an annuity.

Based on the additional REPA cost associated with betterment and the potential cost reduction associated with a reduction in the ongoing Commonwealth funding requirement due to an increase in the resilience of essential public assets, the net cost reduction from embedding betterment in the DRFA funding is estimated.

Outputs

The analysis found that over the 27-year period under the mid case, the estimated betterment cost of $43.9 billion in net present value terms is projected to generate total economic benefits of $194.5 billion in net present value terms. It should be noted that these benefits may include a reduction in the total economic costs associated with future natural disasters and/or wider benefits to society through improving economic growth and wellbeing. *Table 35* provides a summary of the impact on the total forecast economic cost of natural disasters of embedding further betterment into the DRFA. The analysis indicates that betterment, coupled with risk-based analysis to identify those projects that will yield the greatest BCR has the potential to result in downward pressure on the total economic costs associated with natural disasters.

Table 35. NPV of costs and benefits of embedding betterment in the DRFA | 2023-24 to 2049-50

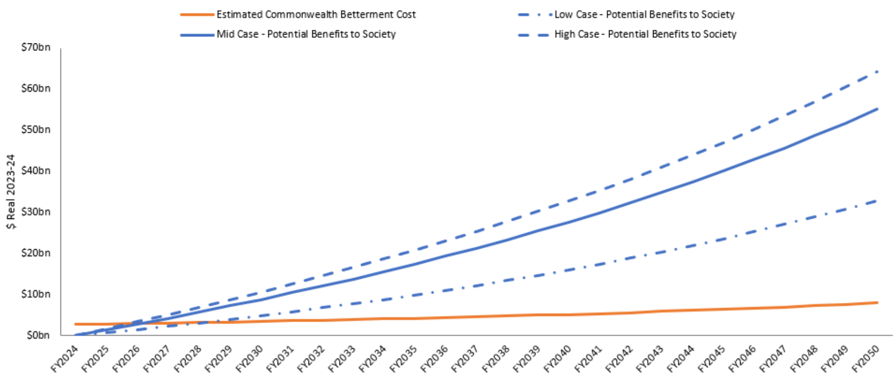
Outputs	Unit	Low Case	Mid Case	High Case
Estimated total economic cost of natural disasters excluding betterment[1]	$bn	(239.5)	(239.5)	(239.5).

Commonwealth betterment funding	$bn	(51.4)	(43.9)	(38.8)
Estimated total economic cost of natural disasters including betterment[1]	$bn	(268.5)	(244.5)	(232.1)
Net saving/(cost) from avoided damages	$bn	(29.0)	(5.0)	7.4.
Potential total economic benefits[2]	$bn	112.2	194.5	230.7.
Potential net economic benefits[3]	$bn	60.8	150.6	191.9.

Source: Deloitte, 2024. Note: (1) Analysis is based on the average estimate of the total economic cost of natural disasters excluding the impact of climate change. (2) Total economic benefits includes avoided damages when a disaster occurs and co-benefits that occur even in the absence of a disaster. (3) Numbers may not add due to rounding.

The cost of embedding betterment in the DRFA compared with the total economic benefit is presented in *Figure 58*. Consistent investment in betterment leads to accumulated economic benefits reaching $64.4 billion, $55.1 billion and $32.9 billion in 2049-50 under high, mid, and low cases respectively in real 2023-24 dollar terms.

Figure 58. Additional costs and economic benefits associated with embedding betterment in the DRFA | 2023-24 to 2049-50



Source: Deloitte 2024. Note analysis does not consider the impact of climate change.

Redirecting AGDRP Savings to Resilience and Risk Reduction Activities

Financial analysis of Commonwealth administered disaster funding shows that between 2018-19 to 2022-23, AGDRP is the largest non-DRFA Commonwealth funding program. Consultation highlighted that there may be an opportunity to tighten the scope of the AGDRP to ensure payments are targeting those with the greatest need. As part of this analysis, consideration is given to the benefit of redirecting any saving associated with the tightening the scope of AGDRP payments towards resilience and risk reduction measures.

Assumptions

The assumptions summarised in *Table 36* were applied in the quantitative analysis to understand the potential economic benefit of tightening the scope of ADGRP.

Table 36. Key assumptions | Redirecting AGDRP savings to resilience and risk reduction activities

Assumption	Unit	Low Case	Mid Case	High Case
Proportion of AGDRP redirect to resilience and risk reduction measures	%	3%	5%	7%
Implementation year of AGDRP redirect	Year	2025-26	2025-26	2025-26
Portion of economic benefits resulting in avoided damages[1]	%	20%	20%	20%
Benefit cost ratio[2]	x	3:1	6:1	8:1
Number of periods for benefits realisation[2]	#	23	23	23
Real discount rate[3]	% p.a.	7%	7%	7%
Historical average annual AGDRP funding[4]	$ M | Real 2023-24	828	828	828
2023-24 National total economic cost[5]	$ M | Real 2023-24	11,837	11,837	11,837
2049-50 National total economic cost[5]	$ M | Real 2023-24	40,275	40,275	40,275

Sources: (1) Based on analysis of SORAT data (NEMA 2023a) (2) Based on analysis of National Institute of Building Sciences 2019 (3) Department of the Prime Minister and Cabinet – The Office of Impact Analysis 2023 (4) Based on analysis of Summary of Disaster Resilience Funding Dataset (NEMA 2023b) (5) Outputs from Deloitte forecast modelling. Numbers represent the average estimate excluding the impact of climate change.

Approach

This analysis applies the BCR, informed by the literature review, to estimate the potential savings from increasing resilience and risk reduction activities. Consistent with the approach to embedding betterment in the DRFA, the total benefits are assumed to be realised over a period of 23 years, calculated as an annuity. The analysis assumes that the implementation of the policy change is not completed until 2025-26, resulting in no change to the forecast results in years prior to 2025-26.

Outputs

The potential economic benefits are estimated by considering the total economic cost before and after redirecting a portion of AGDRP funding to resilience and risk reduction activities from 2025-26. *Table 37* shows the NPV of the benefits associated with redirecting savings to resilience and risk reduction activities and considers the period between 2023-24 and 2049-50. It should be noted, that the analysis does not consider the individuals who would no longer receive the AGDRP payment, as it is considered tightening the scope of the AGDRP would not reduce payments to individuals impacted by a natural disaster within the intent of the payment.

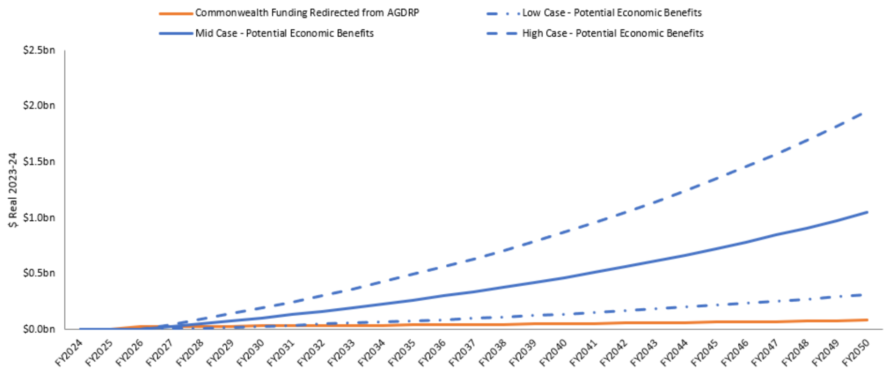
Table 37. NPV of costs and benefits of redirecting AGDRP savings to resilience and risk reduction activities | 2023-24 to 2049-50

Output	Unit	Low Case	Mid Case	High Case
Estimated total economic cost of natural disasters excluding redirected AGDRP funding[1]	$bn	(239.5)	(239.5)	(239.5)
Commonwealth funding redirected from AGDRP to resilience and risk reduction activities	$bn	(0.5)	(0.8)	(1.1)
Estimated total economic cost of natural disasters including redirected AGDRP funding[2]	$bn	(239.3)	(238.9)	(238.4)
Net saving/(cost) from avoided damages	$bn	0.2	0.6	1.1.
Potential total economic benefits[3, 4]	$bn	0.9	3.1	5.7

Source: Deloitte 2024. Note: (1) Analysis is based on the average estimate of the total economic cost of natural disasters excluding the impact of climate change. (2) Includes the cost of the redirected AGDRP funding albeit this is not an additional cost to the Commonwealth (3) Total economic benefits includes avoided damages when a disaster occurs and co-benefits that occur even in the absence of a disaster. (4) Numbers may not add due to rounding.

The analysis of the total economic benefit of redirecting any AGDRP savings, due to tightening the scope of the payment to resilience and risk reduction measures, is presented in *Figure 59*. Redirecting any savings from tightening the scope of the AGDRP towards resilience and risk reduction activities results in estimated, accumulated economic benefits reaching $2.0 billion, $1.0 billion, and $0.3 billion in 2049-50 under high, mid and low cases respectively in real 2023-24 dollar terms. It is important to note that the resilience and risk reduction funding represents the amount of funding redirected from AGDRP and does not represent additional funding on top of what the Commonwealth is forecast to spend.

Figure 59. Analysis of benefits associated with redirecting AGDRP savings to resilience and risk reduction activities | 2023-24 to 2049-50



Source: Deloitte 2024. Note analysis does not consider the impact of climate change.

Impact of the DRF

Commonwealth expenditure on resilience and risk reduction can also be considered in the form of funding under the Disaster Ready Fund (DRF). We note that Round One provided $200 million of Commonwealth investment for 187 projects in 2023-24. Modelling was undertaken to understand the potential economic benefits of this program.

Financial analysis of Commonwealth administered disaster funding showed that the DRF is the second highest Commonwealth non-DRFA funding program between 2018-19 and 2025-26. However, at the time of the analysis, expenditure associated with this program sits in the forward estimates. In total, the DRF has an announced value of $1.0 billion, with $200.0 million in grants available to fund successful projects each year between 2023-24 and 2027-28. The DRF's objectives directly align with a focus on increasing resilience and risk reduction activities, by implementing a risk-based approach to decision making the Commonwealth can direct funding towards activities with the greatest potential to reduce risks and the associated cost of natural disasters. The purpose of this analysis is to examine the potential impact of the DRF applying the current timeline of committed Commonwealth expenditure.

<u>*Assumptions*</u>

The assumptions summarised in *Table 38* were applied in the quantitative analysis to understand the potential economic benefit of the DRF.

Table 38. Key assumptions | DRF funding

Assumption	Unit	Low Case	Mid Case	High Case
Portion of economic benefits resulting in avoided damages[1]	%	20%	20%	20%
Benefit cost ratio[2]	x	3:1	6:1	8:1
Number of annuity periods[2]	#	23	23	23
Real discount rate[3]	%	7%	7%	7%
2023-24 National total economic cost[4]	$ M | Real 2023-24	11,837	11,837	11,837
2049-50 National total economic cost[4]	$ M | Real 2023-24	40,275	40,275	40,275

Sources: (1) Based on analysis of SORAT data (NEMA 2023a) (2) Based on analysis of National Institute of Building Sciences 2019 (3) Department of the Prime Minister and Cabinet – The Office of Impact Analysis 2023 (4) Outputs from Deloitte forecast modelling. Numbers represent the average estimate excluding the impact of climate change.

Approach

The analysis predicts the net cost reduction associated with DRF expenditure by estimating the change in total economic cost of natural disasters, considering the additional investment and predicted economic benefits (where benefits are assumed to be realised over a period of 23 years and calculated as an annuity) including the portion of economic benefits that can be expected to result in avoided damages when a natural disaster occurs.

Outputs

The potential impact of the DRF in NPV terms between 2023-24 and 2049-50 is presented in *Table 39*. The analysis found that over the evaluation period the Commonwealth can expect to see a net cost saving in terms of the total cost of natural disasters under the mid case and the high case. While the low case does not result in a net cost saving in the total economic cost of natural disasters, from a societal perspective the funding generates net positive benefits when the co-benefits are taken into consideration. Through the lasting effect of the DRF, the analysis estimates this program could reduce the predicted total economic cost of natural disasters by $0.2 billion and $0.5 billion in NPV terms under the mid case and the high case respectively.

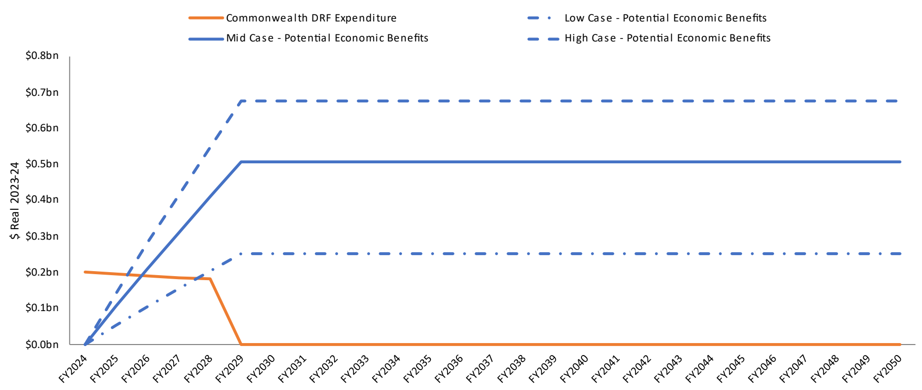
Table 39. NPV of costs and benefits of DRF funding | 2023-24 to 2049-50

Output	Unit	Low Case	Mid Case	High Case
Estimated total economic cost of natural disasters excluding DRF[1]	$bn	(239.5)	(239.5)	(239.5)
Commonwealth DRF Funding	$bn	(0.8)	(0.8)	(0.8)
Estimated total economic cost of natural disasters including DRF[1]	$bn	(239.8)	(239.3)	(239.0)
Net saving/(cost) from avoided damages	$bn	(0.3)	0.2	0.5.
Potential total economic benefits[2]	$bn	2.5	5.0	6.6.
Potential net economic benefits[3]	$bn	1.7	4.1	5.8.

Source: Deloitte, 2024. Note: (1) Analysis is based on the average estimate of the total economic cost of natural disasters excluding the impact of climate change. (2) Total economic benefits includes avoided damages when a disaster occurs and co-benefits that occur even in the absence of a disaster. (3) Numbers may not add due to rounding.

Figure 60 shows the annual cost and economic benefit of the DRF. Upon completion of the program, beyond 2027-28, the annual cost savings remain constant due to the assumption that benefits are realised as an annuity over the long-term in order to yield the implied BCR consistent with the findings of the literature review.

Figure 60. Cost benefit analysis of DRF



Source: Deloitte 2024. Note analysis does not consider the impact of climate change.

Increasing Mental Health Support Programs

Based on the total economic cost forecast of natural disasters, there are significant social impacts associated with disaster events, in which the adverse mental health effects are the primary driver. While financial costs tend to be one-off costs, social impacts can persist over a person's lifetime, and may be multiple or compounding (i.e., not necessarily linear).

To address this substantial cost component, analysis was undertaken to quantify the benefits and costs of increasing mental health support programs after the occurrence of a natural disaster event.

Assumptions

The assumptions applied in this quantitative policy analysis have been informed by the literature and are listed in *Table 40*.

Table 40. Key assumptions | Increasing mental health support programs

Assumption	Unit	Low Case	Mid Case	High Case
Mental Health Initiative – Program Cost[1]	$/person | Real 2023-24	2,092	2,092	2,092
Coverage[1]	%	39.5%	39.5%	39.5%
Effective Coverage[1]	%	20.1%	25.1%	30.1%
Real Discount Rate[2]	% p.a.	7%	7%	7%

Sources: (1) Based on analysis of Andrews et al. 2004 (2) Department of the Prime Minister and Cabinet – The Office of Impact Analysis 2023.

Approach

The forecast of the total economic cost of natural disasters, estimates the mental health impact associated with the reference events through examining the impacted population and leverages literature on the adverse impact on mental health attributable to these events. As discussed, due to the long-term nature of these social impacts, the analysis assumes these incidence rates spike in the first year after the disaster. From which the rate drops by one-third every year, to five percent of the initial impact by the fourth year onwards post disaster. *Section 1.1* of this Appendix outlines this approach.

To consider the potential impact on incidence rates from increased mental health support programs, the analysis assumes the Commonwealth funds an initiative immediately after the occurrence of a natural disaster event. The coverage assumption refers to the proportion of people affected by the natural disaster event who will access the mental health support program. Thus, by the first year after the disaster, the effective coverage proportion has decreased the population with adverse mental health impacts from the event. While the unit cost (i.e., impact) of psychological distress is unchanged by this initiative, the consistent reduction in the population suffering from post-traumatic stress disorder decreases the overall impact.

While increasing mental health support programs will reduce the adverse impacts of psychological distress, it is important to also consider the additional cost to the Commonwealth in offering these services. This increased expenditure is estimated through applying the per person program cost sourced in the literature review, against the initial population whose mental health is impacted by the disaster, taking into consideration the coverage proportion for those who would access these additional resources. As it is assumed this initiative is a one-off investment from the Commonwealth, this cost is only considered in the first period of the analysis. The effective coverage ratio is applied to the impacted population with mental health impacts assuming the programs will have immediate effectiveness, this is a limitation of the analysis as it may take more than one year for mental health treatment to become effective.

Outputs

Table 41 compares the estimated economic cost of mental health impacts from the reference events, against the cases that assume the mental health initiatives were implemented. This considers both the increased cost to the Commonwealth and the reduction in population suffering psychological distress.

Table 41. NPV of costs associated with mental health and the potential impact of support programs by reference event for period between 2023-24 and 2049-50

Event	Unit	Economic Cost of Mental Health	Economic Cost of Mental Health post Mental Health Initiative Low Case	Economic Cost of Mental Health post Mental Health Initiative Mid Case	Economic Cost of Mental Health post Mental Health Initiative High Case	Range of Net Cost Reduction post Mental Health Initiative
The South East Queensland Floods	$bn	4.5	3.6	3.4	3.2	0.9 – 1.3
The Black Saturday Bushfires	$bn	2.6	2.1	2.0	1.8	0.5 – 0.8
The 'Pasha Bulker Storm', & East Coast Low Event	$bn	0.4	0.3	0.3	0.3	0.1 – 0.1
Tropical Cyclone Yasi	$bn	3.0	2.4	2.3	2.1	0.6 – 0.9
Canberra Hailstorms	$bn	0.7	0.6	0.5	0.5	0.1 – 0.2
Newcastle CBD Earthquake	$bn	1.7	1.3	1.3	1.2	0.4 – 0.5

Source: Deloitte 2024.

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Appendix G: Climate scenario analysis and modelling workstream: methodology, findings, sources and references

This appendix provides the methodology, findings, sources and references associated with the climate scenario analysis workstream.

1. Methodology

Climate Scenarios

To examine projected changes in the primary physical hazards contributing to disasters in Australia, data from Climate Infinity was used. Climate Infinity is an interactive climate risk assessment tool developed by Deloitte's Climate and Sustainability team. The tool includes climate projections of multiple physical hazards across Australia nationally for several scenarios that span different emission scenarios and how this vary with time, from now until 2100. Different outcomes for the future arise from the underpinning assumptions about future trends across multiple socioeconomic characteristics including population growth, economic activity, urbanisation, technology change and many others that drive changes in various greenhouse gas emissions and the resulting climate changes.

There are various publicly available climate scenarios, typically developed by international research or policy groups. Such scenarios include useful information about plausible pathways for emissions, physical climate changes, environmental impacts and socioeconomic conditions. For Climate Infinity, we use the most recent suite of climate scenarios used to assess physical risks, namely the Shared Socioeconomic Pathways (SSPs) corresponding to the most recent Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC). The SSPs build upon the previous Representative Concentration Pathways (RCPs)[1] to consider both different greenhouse gas (GHG) concentrations that lead to specific global warming levels and the corresponding socioeconomic narrative required to achieve them.

Two climate scenarios were used to conduct the scenario analysis for each state and territory and intend to capture the plausible range of future changes. The specific details are as follows (*Table 42*).

Table 42: Climate Scenario narratives and nomenclature available in Climate Infinity.

Scenario	Emission Level	Indicative GWL at 2100	Narrative[2]
SSP1-2.6	Low Emission	Aligned to the Paris Agreement 1.5℃	**Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation)** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves educational and health investments, accelerates the demographic transition and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.
SSP3-7.0	High Emission	3℃ to 4℃	**Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation)** A resurgent nationalism, concerns about competitiveness and security and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

See Riahi et al. (2017) for more information on the main drivers of GHG emissions for each scenario.

Where metrics derived from the SSPs are unavailable, the most appropriate RCP scenario is used where the mapping between SSPs and RCP is noted in the table above.

Note that both the SSPs and the RCP climate scenarios represent plausible futures. They are NOT predictions and are NOT accompanied by a likelihood rating to indicate which scenario is more likely. These climate scenarios are a tool to help decision makers understand the breadth of plausible physical risks. Long term physical climate risk is dependent on transition pathways and choices such as policy, market trends, technology, legalities and decarbonisation on a global scale which is why it can be advantageous to consider the SSPs to enable an assessment of possible transition risks and opportunities. COVID-19 reduced some greenhouse gas concentrations (e.g., carbon dioxide), but no more than year-to-year variability, meaning that greenhouse gas emissions are still rising. The SSP3-7.0 high emission scenario has limited climate action and climate policy development, compared to the relatively lower emission scenarios where decarbonisation action is strong and rapid to meet the commitments made under the Paris Agreement.

Due to year-to-year climate variability and to assess the step change in climate between today and multiple future periods, assessing the physical hazards requires using data across multiple decades. Here, to align with leading scientific practice, 20-year periods are used for each climate scenario, metric and time horizon.

The time horizons available that have been used for this analysis include:

- **2030** (averaging over years 2020 to 2039) to represent near-term changes,
- **2050** (averaging over years 2040 to 2059) to represent mid-century.

Climate model overview: Both global and regional climate models are four-dimensional (latitude, longitude, time and height) representations of the climate system at every point in time and globally for the past, present and future. The climate scenarios data from global climate models is generally updated every 5 to 7 years with regional climate model estimates updated in between. Therefore, estimates can vary between generations of climate projections and the types of climate models used.

Each global climate model and the underlying physics is different. There is a range in magnitude (and sign/direction) in how the climate evolves at each simulated point on Earth in each model – this leads to a spread in climate model projections and model 'uncertainty'. A multi-model estimate can be used to capture the overarching trends and has been shown to outperform individual models across multiple metrics[7].

Improving resolution via statistical and/or dynamical downscaling: Downscaling methods intends to increase the granularity and add value to coarser global climate model projections to support climate change information needs at regional to local scales (Giorgi et al. 2009). There are two main methods for downscaling: statistical and dynamical (see Box 1 below). Both of these methods have been applied for the development of the climate datasets described in this report.

Box 1: Climate model downscaling Approaches Explained
Dynamical downscaling involves the use of a regional climate model, at fine scale resolutions, which is underpinned by the same physics as a global climate model but with differences in how these models are configured and run. As implied by the name, regional climate models only simulate the climate for a regional domain (e.g., Australia) and rarely globally and therefore, information is required at the boundaries of the domain to define the large-scale characteristics of the climate system (e.g., wind, temperature, pressure, humidity). The datasets used to define these boundary conditions can include gridded observational datasets to understand current and recent past climate and global climate model projections to understand future potential changes in climate at a finer scale resolution. Dynamical downscaling with regional climate models are particularly advantageous in modelling weather and climate over highly variable terrain, including coastlines and mountainous regions, and a growing requirement for vulnerability impact assessments (Giorgi 2019).
Statistical downscaling is a methodological process applied to coarse resolution global climate model data to transform it to a higher resolution that resolves the finer spatial scale detail across a region. The method uses observed relationships between different local climate conditions and large-scale climate to build a statistical model to process the global climate model data. These data have also been bias corrected using a quantile mapping approach to remove systematic biases in the global climate model outputs (Werner and Cannon 2016). Statistical downscaling does not necessarily provide more credible climate projections as the process will inherit the biases of the global climate models that are used. However, downscaling increases the resolution to the spatial scales needed for impact assessment by increasing the level of spatial detail. Statistical downscaling is quicker to produce high resolution datasets than dynamical downscaling but has limitations in how well climate extremes are characterised.

Data Processing Analysis Approach

Data processing methods have been required to reduce the dimensionality of the climate data that has been used so that all data inputs into a climate risk assessment are provided in a consistent manner.

Note that the climate data has been pre-processed to extract estimates for different statistical areas for Australia only. For this analysis, Local Government Areas (LGA) following the 2021 shape geographies available from the Australian Bureau of Statistics (https://maps.abs.gov.au/) have been used.

The sequence of steps to calculate LGA estimates for each metric, climate scenario and time horizon include:

- Calculate the multi-year average for each model individually.
- Extract the data that falls within each LGA boundary.
- Calculate the future change[8] as:

$$future\ change = future\ value - historical\ value$$

Calculate the future percent change as:

$$percent\ change = 100\ \times \frac{future\ value\ \ - historical\ value}{historical\ value}$$

Calculate the weighted average for each region using the grid cell areas as weights to accommodate the latitudinal distortion of areas which is particularly important for large regions.

While other statistics can be calculated (e.g., percentiles) the weighted average has been used to present a more concise synthesis of the results. It is likely that larger projected changes are possible however, due to uncertainty in the projections there is a preference towards central measures of tendency for this analysis.

Note that it is common that the presentation of metrics can vary as follows:

- Any temperature-based metrics and bushfires are generally presented using the *future change*. If using the percent change, it is common to get large values for Australia due to significant projected increases in temperature extremes,
- For rainfall-based metrics (including dry spells) and extreme wind, the future *percent change* if often used as it is common for the future change values to appear small however, they may be large changes in the context of the historical baseline. Therefore, by using the percent change, one can accommodate this nuance.

Therefore, for other future change and future percent change, positive values denote a projected increase and negative values denote a projected decrease in the physical hazard associated with a given metric.

2. Climate Data Sources and Attributes

The physical climate hazards where the aforementioned metrics were used, are described in *Table 43* below. The climate hazards are based on the best publicly available and commercially usable data from credible sources, in order to provide the most robust projections of physical climate risk at the state level. Further information on the data assumptions, statistical methods and exposure calculations are provided later.

Table 43: Climate metrics and their characteristics sourced from Climate Infinity that we were used to conduct the scenario analysis.

Type	Theme	Metric[6]	Granularity	Units	Metric Description
Acute	Extreme Wet	Extreme Rain Days	25km	days	Annual count of days where the rainfall in a day is greater than 20mm
Acute	Extreme Wet	Max Rain in a Day	25km	mm	The maximum amount of rainfall in a single day for a year
Acute	Bushfires [7]	Extreme Fire Days	25km	days	The total days per year where the Fire Weather Index exceeds the 95th percentile
Acute	Bushfires	Extreme Fire Intensity	25km	days	95th percentile of the Fire Weather Index
Chronic	Sea Level Rise	Relative Sea Level Rise	100km	n/a	n/a as there is no data
Acute	Storm Surge	1-in-100-year Extreme Sea Level	100km	m | years	Wave height and return period of the current 1-in-100-year extreme sea level event (extreme sea level = mean sea level + high tide + storm surge + waves)
Acute	Tropical Cyclones[8]	Frequency (CAT0-5)	100 km	count	Count of all category events over 1980-2022

[6] All metrics except tropical cyclones correspond to IPCC AR6. The NASA NEX-GDDP-CMIP6 dataset was retrieved from NASA CCS (https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp-cmip6), prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange and distributed by the NASA Center for Climate Simulation (NCCS). Metrics were derived by Deloitte climate scientists with the following climate models: ACCESS-CM2, ACCESS-ESM1-5, BCC-CSM2-MR, CanESM5, CMCC-ESM2, CNRM-CM6-1, CNRM-ESM2-1, EC-Earth3, FGOALS-g3, GFDL-ESM4, GISS-E2-1-G, INM-CM5-0, IPSL-CM6A-LR, KACE-1-0-G, MIROC6, MPI-ESM1-2-HR, MRI-ESM2-0, NorESM2-MM, UKESM1-0-LL. Primary Dataset Reference: Thrasher, B., Maurer, E. P., McKellar, C., & Duffy, P. B., 2012: Technical Note: Bias correcting climate model simulated daily temperature extremes with quantile mapping. Hydrology and Earth System Sciences, 16(9), 3309-3314, doi:10.5194/hess-16-3309-2012.

[7] To assess frequency and intensity of extreme bushfire weather the Copernicus Fire Weather Index (FWI) described by Abatzoglou et al. (2019) is used. FWI is derived from rainfall, temperature, relative humidity, and wind parameters and does not account for vegetation or ignition influences.

[8] The historical data is sourced from a dataset of cyclone trajectories for the period 1980 to 2022 available from the Australian Bureau of Meteorology (BoM) (2022; http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/databases/). The future data is a published dataset by Knutson et al. (2020; https://journals.ametsoc.org/bams/article/101/3/E303/345043/Tropical-Cyclones-and-Climate-Change-Assessment) and is available as summary table for each basin based off global climate data on a 100 km by 100 km spatial resolution.

Acute	Tropical Cyclones	Frequency (CAT4-5)	100 km	%	Count of all Category 4 and 5 events over 1980-2022
Acute	Tropical Cyclones	Intensity (CAT4-5)	100 km	%	N/A
Acute	Tropical Cyclones	Landfall Precipitation Rate (CAT4-5)	100 km	%	N/A

3. Findings

The results of climate scenario analysis are presented in two ways; through state-by-state assessments and in a hazard-specific overview.

New South Wales

- For NSW the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, NSW is the most exposed to projected increases in bushfire intensity under the low and high emissions scenarios by 2030 and 2050, sea level rise under multiple scenarios and time horizons.
- Compared to all other states, NSW has the smallest projected increase in extreme wet intensity under the low emissions scenario by 2030-time horizon.
- The LGAs most exposed to multiple hazards across NSW are: Port Macquarie-Hastings, Bega Valley, Bellingen, Kempsey, and Nambucca Valley.

Table 44 Climate scenario analysis results for NSW

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	2 to 16 days	-7.4% to +18.6%	-9.6% to +19.3%	-8.6% to +15.0%	-9.6% to +24.2%	Murray River, Broken Hill, Edward River, Berrigan, and Unincorporated NSW	Murray River, Berrigan, Edward River, Federation, and Murrumbidgee
Extreme Wet	Intensity *(annual maximum daily rainfall in mm)*	29 mm to 61 mm	-1.4% to +6.9%	0.7% to 10.1%	up to 9.3%	0.2% to 10.4%	Broken Hill, Unincorporated NSW, Central Darling, Albury, and Greater Hume Shire	Berrigan, Albury, Broken Hill, Unincorporated NSW, and Federation
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	11 to 21 days	2 to 6 days	3 to 8 days	2 to 5 days	5 to 11 days	Queanbeyan-Palerang Regional, Bathurst Regional, Goulburn Mulwaree, Eurobodalla, and Bega Valley	Narromine, Parkes, Bland, Bogan, and Lachlan
Bushfire	Intensity *(95th percentile of the fire weather index)*	11 to 62	1 to 2	1 to 3	1 to 2	1 to 3	Port Macquarie-Hastings, Uralla, Armidale Regional, Walcha, and Bega Valley	Brewarrina, Albury, Greater Hume Shire, Moree Plains, and Bogan
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	2.1 to 2.4 m	68 to 87 years	19 to 61 years	68 to 87 years	15 to 53 years	Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley, and Bega Valley	Port Macquarie-Hastings, Bega Valley, Bellingen, Kempsey, and Nambucca Valley
Storm surge / Sea level rise	Sea level rise *(in metres relative to the 2020 baseline)*	0.05 to 0.06 m	0.09 to 0.11 m	0.17 to 0.21 m	0.09 to 0.11 m	0.21 to 0.25 m	Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley, and Clarence Valley	Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley, and Central Coast (NSW)

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Victoria

- For VIC, the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, VIC is the most exposed to projected increases in bushfire frequency under the low emissions scenario by 2050 and bushfire intensity under the high emissions scenario by 2050.
- Compared to all other states, VIC has the smallest projected increase in extreme wet intensity under the low emissions scenario by 2050 and under the high emissions scenario by 2030 and sea level rise, across multiple scenarios and time horizons.
- The LGAs most exposed to multiple hazards across VIC are: Moyne, Corangamite, Glenelg, Warnambool and Colac Otway.

Table 45 Climate scenario analysis results for VIC

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	2 to 12	1.8% to 19.4%	-0.3% to 22.7%	-0.1% to +24.6%	-0.5% and 35.3%	Hindmarsh, Yarriambiack, West Wimmera, Horsham, and Buloke	Horsham, Hindmarsh, Yarriambiack, Buloke, and West Wimmera
Extreme Wet	Intensity *(annual maximum daily rainfall in mm)*	26 to 53	1.6% to 8.9%	5.4% to 8.7%	1.9% to 8.3%	5.0% to 10.5%	Warrnambool, Mansfield, Greater Bendigo, Mount Alexander, and Moyne	Moira, Greater Shepparton, Benalla, Wangaratta, and Indigo
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	11 to 21 days	1 to 4 days	4 to 9 days	2 to 5 days	6 to 12 days	Nillumbik, Darebin, Banyule, Wellington, and East Gippsland	Hume, Brimbank, Latrobe (Vic.), Wellington, and East Gippsland.
Bushfire	Intensity *(95th percentile of the fire weather index)*	15 to 46	Up to 1	1 to 2	Up to 1	2 to 3	Monash, Manningham, Glen Eira, Boroondara, and Bayside (Vic.).	Monash, Manningham, Glen Eira, Boroondara, and Bayside (Vic.).
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	1.9 to 2.8 m	73 to 85 years	24 to 49 years	71 to 84 years	18 to 40 years	Glenelg, Corangamite, Moyne, Warrnambool, and Colac Otway	Glenelg, Corangamite, Moyne, Warrnambool, and Wellington
Storm surge / Sea level rise	Sea level rise *(in metres relative to the 2020 baseline)*	0.04 to 0.05 m	0.08 to 0.09 m	0.16 to 0.19 m	0.08 to 0.10 m	0.18 to 0.22 m	Glenelg, Corangamite, Moyne, Warrnambool, and Colac Otway	Glenelg, Corangamite, Moyne, Warrnambool, and Colac Otway

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Queensland

- For QLD the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, QLD is the most exposed to projected increases in bushfire frequency under multiple scenarios and time horizons, bushfire intensity under both scenarios by 2030, Storm Surge under all scenarios and time horizons, and sea level rise under the low emissions scenario for both time horizons.
- Compared to all other states, QLD has the smallest projected increases in extreme wet frequency under the low emissions scenario by 2030 and in Tropical Cyclone category 0-5 in frequency under the high emissions scenario by 2050 compared to WA and NT.

- The LGAs most exposed to multiple hazards across QLD are: Torres Strait Island, Rockhampton, Livingstone, Bulloo and Burdekin.

Table 46 Climate scenario analysis results for QLD

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	2 to 34	-13.7% to +5.1%	-14.4% to 8.3%	-11.6% to +7.0%	-11.9% to 12.5%	Bulloo, Torres Strait Island, Torres, Cherbourg, and Toowoomba	Torres Strait Island, Torres, Bulloo, Quilpie, and Boulia
	Intensity *(annual maximum daily rainfall in mm)*	30 to 79	-2.8% to +10.6%	-2.6% to +10.7%	-0.2% to +9.5%	-2.0% to +10.5%	Torres Strait Island, Torres, Hope Vale, Pormpuraaw, and Northern Peninsula Area	Mapoon, Torres Strait Island, Etheridge, Napranum, and Mount Isa
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	11 to 22 days	1 to 7 days	Up to 9 days	1 to 8 days	2 to 9 days	Townsville, Burdekin, Hinchinbrook, Whitsunday, and Tablelands.	Toowoomba, South Burnett, Isaac, Goondiwindi, and Southern Downs.
	Intensity *(95th percentile of the fire weather index)*	15 to 82	Up to 2	Up to 2	Up to 2	Up to 3	Goondiwindi, Tablelands, Bulloo, Balonne, and Paroo.	Western Downs, Paroo, Goondiwindi, Maranoa, and Balonne.
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	1.6 to 3.5 m	56 to 94 years	9 to 77 years	55 to 94 years	7 to 69 years	Lockhart River, Rockhampton, Livingstone, Torres Strait Island, and Cook	Lockhart River, Rockhampton, Livingstone, Torres Strait Island, and Cook
	Sea level rise *(in metres relative to the 2020 baseline)*	0.02 to 0.06 m	0.04 to 0.11 m	0.09 to 0.21 m	0.04 to 0.11 m	0.12 to 0.24 m	Isaac, Rockhampton, Livingstone, Burdekin, and Cairns	Isaac, Rockhampton, Livingstone, Mackay, and Burdekin
Tropical cyclone	Tropical cyclones *(count of category 0 – 5)*	84	>4°C scenario, 2050 -40% to +5% frequency				N/A	N/A
	Tropical cyclones *(count of category 4 – 5)*	8	>4°C scenario, 2050 -40% to +25% change in frequency -5% to +12% change in intensity -1% to +17% change in landfall rain rate				N/A	N/A

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

South Australia

- For SA the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, SA is the most exposed to projected increases in extreme wet frequency and intensity under all scenarios and time horizons, bushfire intensity under the high emissions scenarios in 2050, and sea level rise under multiple scenarios and time horizons.
- Compared to all other states, SA has the smallest projected increases in bushfire frequency under multiple scenarios and time horizons and bushfire intensity under both scenarios by 2030.

- The LGAs most exposed to multiple hazards across SA are: Yankalilla, Kangaroo Island, Victor Harbor, Orroroo Carrieton and Peterborough.

Table 47 Climate scenario analysis results for SA

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	1 to 3	9.4% to 35.5%	4.5% to 42.7%	14.5% to 40.1%	11.1% to 52.6%	Yorke Peninsula, Whyalla, Port Augusta, Tumby Bay, and Kangaroo Island	Yorke Peninsula, Tumby Bay, Kangaroo Island, Lower Eyre Peninsula, and Port Lincoln
Extreme Wet	Intensity *(annual maximum daily rainfall in mm)*	23 to 32	2.1% to 10.6%	2.6% to 11.8%	4.9% to 12.2%	4.3% to 14.8%	Kangaroo Island, Port Pirie, Barunga West, Port Augusta, and Flinders Ranges	Kangaroo Island, Yankalilla, Flinders Ranges, Victor Harbor, and Charles Sturt
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	11 to 22	1 to 3 days	3 to 5 days	1 to 3 days	3 to 8 days	Goyder, Northern Areas, Anangu Pitjantjatjara Yunkunytjatjara, Orroroo Carrieton, and Peterborough.	Renmark Paringa, Goyder, Orroroo Carrieton, Peterborough, and Northern Areas.
Bushfire	Intensity *(95th percentile of the fire weather index)*	15 to 82	Up to 1	1 to 2	Up to 1	1 to 3	Orroroo Carrieton, Peterborough, Anangu Pitjantjatjara Yunkunytjatjara, Unincorporated SA, and Coober Pedy.	Whyalla, Kimba, Northern Areas, Unincorporated SA, and Coober Pedy.
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	2.4 to 3.2 m	72 to 89 years	21 to 64 years	69 to 88 years	17 to 55 years	Grant, Mount Gambier, Wattle Range, Victor Harbor, and Yankalilla	Grant, Mount Gambier, Wattle Range, Victor Harbor, and Yankalilla
Storm surge / Sea level rise	Sea level rise *(in metres relative to the 2020 baseline)*	0.04 to 0.06 m	0.07 to 0.11 m	0.14 to 0.21 m	0.07 to 0.12 m	0.17 to 0.24 m	Coorong, Victor Harbor, Yankalilla, Kangaroo Island, and Kingston (SA)	Coorong, Victor Harbor, Yankalilla, Kangaroo Island, and Kingston (SA)

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Western Australia

- For WA the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, WA is the most exposed to projected increases in bushfire frequency under the high emissions scenario by 2050, bushfire intensity under multiple scenarios and time horizons, and tropical cyclone frequency and landfall rain rate under a high emissions scenario by 2050.
- Compared to all other states, WA has the smallest projected increases in extreme wet intensity under the high emissions scenario by 2030 and 2050, bushfire intensity under the high emissions scenario by 2030, storm surge under all scenarios and time horizons, and sea level rise under the high emissions scenario by 2030.

- The LGAs most exposed to multiple hazards across WA are: Menzies, Dundas, Woodanilling, Christmas Island and Kalgoorlie-Boulder.

Table 48 Climate scenario analysis results for WA

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	1 to 13	-8.7% to +22.4%	-13.7% to +29.2%	-1.1% to +8.3%	-18.5% to +31.3%	Kalgoorlie-Boulder, Dundas, Menzies, Laverton, and Quairading	Kalgoorlie-Boulder, Menzies, Exmouth, Wyndham-East Kimberley, and Dundas
Extreme Wet	Intensity *(annual maximum daily rainfall in mm)*	24 to 50	-1.3% to +8.4%	-2.2% to +9.3%	-1.1% to +8.3%	-0.9% to +9.5%	Kalgoorlie-Boulder, Menzies, Narrogin, Cuballing, and Wagin	Kalgoorlie-Boulder, Menzies, Exmouth, Wyndham-East Kimberley, and Dundas
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	4 to 21 days	Up to 5 days	2 to 8 days	1 to 6 days	1 to 14 days	Wagin, Broomehill-Tambellup, Katanning, Woodanilling, and Kojonup.	Boyup Brook, Katanning, Wagin, Woodanilling, and Kojonup.
Bushfire	Intensity *(95th percentile of the fire weather index)*	12 to 86	Up to 2	1 to 2	Up to 1	1 to 3	Kojonup, Woodanilling, Broomehill-Tambellup, Ngaanyatjarraku, and East Pilbara.	Kellerberrin, Cunderdin, Wyalkatchem, Quairading, and Tammin.
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	1.5 to 5.9 m	68 to 99 years	11 to 95 years	68 to 99 years	8 to 94 years	Christmas Island, Ravensthorpe, Plantagenet, Jerramungup, and Albany	Christmas Island, Plantagenet, Ravensthorpe, Jerramungup, and Albany
Storm surge / Sea level rise	Sea level rise *(in metres relative to the 2020 baseline)*	0.05 to 0.06 m	0.08 to 0.10 m	0.17 to 0.20 m	0.08 to 0.10 m	0.20 to 0.23 m	Dandaragan, Gingin, Carnamah, Coorow, and Christmas Island	Dandaragan, Gingin, Carnamah, Coorow and Christmas Island
Tropical cyclone	Tropical cyclones *(count of category 0 – 5)*	120	>4°C scenario by 2050 -34% to +7% frequency				N/A	N/A
Tropical cyclone	Tropical cyclones *(count of category 4 – 5)*	31	>4°C scenario, 2050 -27% to +55% change in frequency 0% to +11% change in intensity +2% to +24% change in landfall rain rate				N/A	N/A

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Tasmania

- For TAS, the largest projected increase across multiple hazards is under the high emissions scenario by 2050.
- Compared to all other states, TAS has the smallest projected increases in bushfire intensity under all scenarios and time horizons and sea level rise under multiple scenarios and time horizons.
- The LGAs most exposed to multiple hazards across TAS are: Northern Midlands, Flinders, Launceston, Break O'Day and Dorset.

Table 49 Climate scenario analysis results for TAS

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	2 to 13	6.4% to 26.4%	7.7% to 24.9%	3.9% to 21.2%	9.9% to 28.0%	Southern Midlands, Sorell, Clarence, Dorset, and Brighton	Launceston, Dorset, George Town, Northern Midlands, and Kingborough
	Intensity *(annual maximum daily rainfall in mm)*	24 to 40	3.6% to 10.2%	8.0% to 11.4%	3.8% to 9.2%	6.6% to 12.4%	Huon Valley, Kingborough, Waratah-Wynyard, Burnie, and Latrobe (Tas.)	Huon Valley, Circular Head, West Coast, Waratah-Wynyard, and King Island
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	13 to 20 days	Up to 4 days	2 to 7 days	2 to 5 days	4 to 11 days	Flinders (Tas.), George Town, Launceston, Break O'Day, and Dorset.	Launceston, Brighton, Southern Midlands, West Tamar, and Northern Midlands.
	Intensity *(95th percentile of the fire weather index)*	6 to 13	Up to 1	Up to 1	Up to 1	1 to 2	Flinders (Tas.), Break O'Day, George Town, Launceston, and Dorset.	Dorset, George Town, Northern Midlands, West Tamar, and Launceston.
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	2.1 to 3.2 m	74 to 84 (years)	31 to 47 (years)	74 to 83 (years)	19 to 37 (years)	Flinders (Tas.), Waratah-Wynyard, Glamorgan-Spring Bay, Northern Midlands, and Break O'Day	Break O'Day, Glamorgan-Spring Bay, Northern Midlands, Flinders (Tas.), and Waratah-Wynyard
	Sea level rise *(in metres relative to the 2020 baseline)*	0.04 to 0.05	0.08 to 0.10	0.16 to 0.18	0.08 to 0.10	0.19 to 0.22	Sorell, Southern Midlands, Break O'Day, Glamorgan-Spring Bay, and Northern Midlands	Sorell, Southern Midlands, Break O'Day, Glamorgan-Spring Bay, and Northern Midlands

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Northern Territory

- For NT the largest projected increase across multiple hazards is under the high emission scenario by 2050 except for extreme wet frequency by 2030.
- Compared to all other states, NT is the most exposed to projected increases in extreme wet intensity under both scenarios by 2050, bushfire intensity under the low emission scenario by 2030, and CAT4/5 tropical cyclone intensity under the high emission scenario by 2050.
- Compared to all other states, NT has the smallest projected increases in extreme wet frequency under multiple scenarios and time horizons, bushfire frequency under the high emission scenario by 2050, in bushfire intensity under the high emission scenario by 2030 and 2050, and sea level rise under the high emission scenario by 2030.
- The LGAs most exposed to multiple hazards across NT are: Alice Springs, Coomalie, Belyuen, Central Desert and Darwin.

Table 50 Climate scenario analysis results for NT

Hazard	Metric	Current[1]	Future Change				Most exposed LGAs by 2050	
			Low emission scenario		High emission scenario		Low emission scenario	High emission scenario
			2030	2050	2030	2050		
Extreme Wet	Frequency *(annual count of days at least 20mm)*	3 to 24	-6.3% to +4.2%	-5.4% to 0.7%	-3.5% to +11.4%	-3.1% to 6.8%	Alice Springs, Katherine, Victoria Daly, East Arnhem, and Roper Gulf	Katherine, Alice Springs, Victoria Daly, Roper Gulf, and Central Desert
Extreme Wet	Intensity *(annual maximum daily rainfall in mm)*	37 to 46	-2.2% to +9.4%	1.2% to 11.8%	6.0% to 10.9%	2.2% to 14.8%	Katherine, West Arnhem, Tiwi Islands, Litchfield, and Coomalie	Tiwi Islands, Litchfield, Coomalie, Palmerston, and West Daly
Bushfire	Frequency *(annual count of days where the fire weather index exceeds the 95th percentile)*	17 to 20 days	1 to 6 days	3 to 7 days	1 to 5 days	3 to 7 days	Central Desert, Barkly, Alice Springs, West Arnhem, and East Arnhem.	Barkly, West Arnhem, Alice Springs, MacDonnell, and East Arnhem.
Bushfire	Intensity *(95th percentile of the fire weather index)*	34 to 78	Up to 2	1 to 2	Up to 1	1 to 2	West Daly, MacDonnell, Central Desert, Alice Springs, and Barkly.	Victoria Daly, Barkly, Central Desert, Alice Springs, and MacDonnell.
Storm surge / Sea level rise	Storm surge *(wave height in m of the current 1-in-100yr event and future return period in years)*	2.2 to 4.4 (m)	91 to 98 (years)	67 to 94 (years)	91 to 98 (years)	60 to 92 (years)	Tiwi Islands, Belyuen, Coomalie, Darwin, and Darwin Waterfront Precinct.	Tiwi Islands, Belyuen, Coomalie, Darwin, and Darwin Waterfront Precinct.
Storm surge / Sea level rise	Sea level rise *(in metres relative to the 2020 baseline)*	0.04 to 0.05	0.09 to 0.10	0.18 to 0.20	0.09 to 0.10	0.21 to 0.23	West Daly, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct	West Daly, Belyuen, Coomalie, Darwin, and Darwin Waterfront Precinct
Tropical cyclone	Tropical cyclones *(count of category 0 – 5)*	85	>4°C scenario, 2050 -38% to +6% frequency				N/A	N/A
Tropical cyclone	Tropical cyclones *(count of category 4 – 5)*	5	>4°C scenario, 2050 -42% to +19% change in frequency -6.32% to 12.21% change in intensity -1.3% to 15.42% change in landfall rain rate				N/A	N/A

[1] For extreme wet and bushfire metrics the historical baseline corresponds to 1995 to 2014. For storm surge and sea level rise the historical baseline is 2020.

Extreme Wet

Extreme wet associated with weather systems such as storms, fronts, East Coast Lows, tropical cyclones can bring intense or prolonged rainfall events that may lead to hazards like flooding or landslides. These can lead to property damage, operational disruptions or productivity losses across different value domains. Below is a summary of some recent extreme wet events in Australia and their potential impacts on the four value domains.

Recent high impact events associated with extreme wet:

- Victorian floods, Oct 2022 - Jan 2023: damage across 64 of 79 local government areas within Victoria, waves of heavy rainfall left vast areas of eastern Australia under water as these swollen rivers flooded the landscapes from southern New South Wales, Victoria and Tasmania, costing $736 million as a result of 22,151 claims.
- Kimberly Flood, Dec 2022: Ex-Tropical Cyclone (Ellie) crossed into WA from NT. Widespread rainfall totals between 200-500mm were recorded across the Kimberley region. Major flooding occurred along the Fitzroy River to Fitzroy Crossing, reaching

record levels of 15.81m. Major roads and associated infrastructure were damaged with floodwaters leaving towns and many remote indigenous communities isolated.

- In March 2022, widespread flooding across Australia lead to considerable supply chain disruptions with the rail link between SA, NT and WA closed for 25 days.
- East coast floods, Feb – Mar 2022: rainfall records fall across south-east Queensland and north-east NSW, leading to flash and riverine flooding. More than 20 deaths, $3.35 billion of estimated insurance costs and $7.7 billion total cost of event.
- Queensland flood, Nov 2010 – Jan 2011: flooding had impacted 75 per cent of the state, 33 deaths, insurance cost of $2.38 billion, total cost of event was $5.7 billion.
- The areas at risk of flooding are influenced by topography and catchment rainfall. According to IAG, the most at-risk locations across Australia for flooding includes Brisbane and Tweed in QLD, Central Coast, Clarence Valley, Hawkesbury, Kempsey, Lismore, Shoalhaven, Tweed and Wollongong in NSW.

Potential impacts associated with extreme wet:

Built domain: • Risks to building/structures, electricity/energy infrastructure due to extreme precipitation affecting asset/structures lifetime, causing damage and increasing capital expenditure. • Risk to road or building foundations if there is considerable erosion caused by flood waters. • Damage or service disruptions due to flood waters inundating transportation routes and low-lying crossings or bridges. • Damage or service disruptions to communication network. • Healthcare, medical, and utility service disruptions from either direct flood damage or inability to access due to flooding of roads. • Risk to the food supply chain service disruption and food security (shortage, price hike, etc.).	Economic domain: • Risks to businesses and public organisations due to extreme wet weather events affecting productivity, assets, resources, site access and supply/distribution networks. • Risks to the insurability of business and public sector assets due to increased frequency and intensity of extreme wet weather events. • Major damage or disruption risks to agriculture, construction, healthcare and manufacturing industry.

Social domain:	Natural domain:
• Risks to physical, safety and wellbeing due to changes in chronic rainfall and extreme wet weather events. • Risks to social cohesion and community wellbeing due to extreme wet weather events that displace or isolate individuals, families and communities. • Risks to mental health and wellbeing. • Risks to housing and other property and shelter related crisis. • Economic damage can lead to loss of employment and financial stability in an individual or community level.	• Risks to terrestrial ecosystems and species composition/stability due to changes in chronic rainfall. This can impact in biodiversity, inland water, land and natural heritage in terms of composition/stability/quality/values. • Water contamination from enhanced floodwater runoff into waterways.

Extreme wet – NSW

The metrics used as a proxy to assess extreme rain are the annual maximum daily rainfall amount (extreme rain intensity) and the annual number of days with at least 20 mm of rain (extreme rain frequency). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- NSW has on average experienced 2 to 16 extreme rain days per year and maximum daily rainfall of 29 mm to 61 mm.
- Historically, the top LGAs with at least 15 extreme rain days per year are: Ballina, Byron, Bellingen, Nambucca and Coffs Harbour.
- Historically, the top LGAs with maximum daily rainfall of at least 58 mm are: Coffs Harbour, Ballina, Byron, Bellingen and Lismore.

Future Exposure under a low emissions Scenario:

- Extreme rain days are projected to change by -7.4% to +18.6% by 2030 and -9.6% to +19.3% by 2050. The most exposed LGAs, with an increase of at least 17% by 2050 are: Murray River, Broken Hill, Edward River, Berrigan and Unincorporated NSW.
- Maximum daily rainfall is projected to change by -1.4% to +6.9% by 2030 and 0.7% to 10.1% by 2050. The most exposed LGAs, with an increase of at least 7% by 2050, include: Broken Hill, Unincorporated NSW, Central Darling, Albury and Greater Hume Shire.

Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by -8.6% to +15.0% by 2030 and -9.6% and +24.2% by 2050. The most exposed LGAs with an increase of at least 19% by 2050 are: Murray River, Berrigan, Edward River, Federation, and Murrumbidgee.
- Maximum daily rainfall is projected to increase by up to 9.3% by 2030 and 0.2% to 10.4% by 2050. The most exposed LGAs, with an increase of at least 8% by 2050 are: Berrigan, Albury, Broken Hill, Unincorporated NSW and Federation.

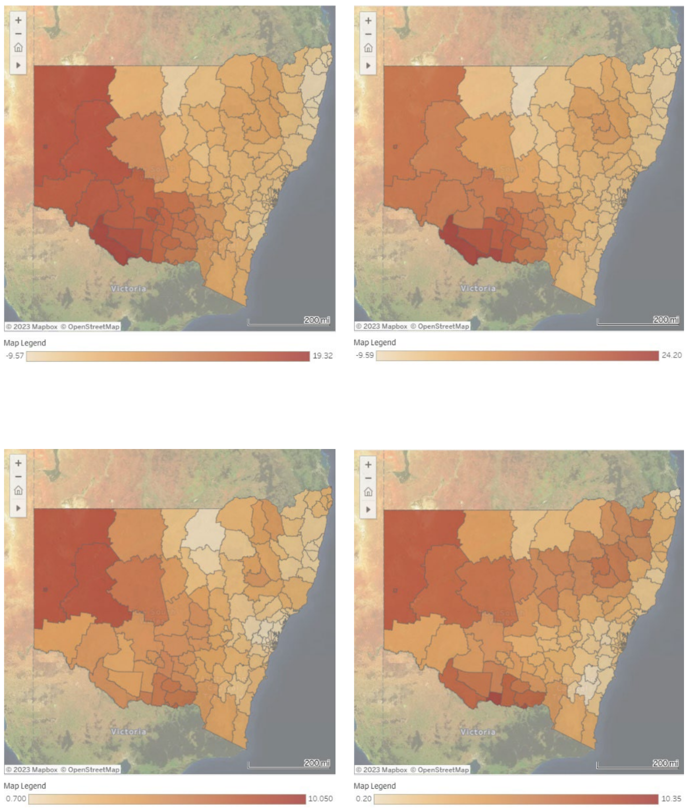


Figure 61
***Top:** Future percent change in extreme rain days by 2050 under the low (left) emission and high (right) emission scenarios compa red to the 1995-2014 historical baseline. Units are %.*

***Bottom:** Future percent change in maximum daily rainfall by 2050 under low (left) emissions and high (right) emissions scenarios compa red to the 1995-2014 historical baseline. Units are %.*

Extreme wet – VIC

Historical/Current Exposure:

- VIC has, on average, experienced 2 to 12 extreme rain days per year and maximum daily rainfall of 26 mm to 53 mm.
- Historically, the top LGAs with at least 9 extreme rain days per year are: Mansfield, Alpine, Towong, Murrindindi and Wangaratta.
- Historically, the top LGAs with maximum daily rainfall of at least 47 mm are: Alpine, Mansfield, Towong, Wangaratta and Murrindindi.

Future Exposure under a low emissions Scenario:

- Extreme rain days are projected to change by 1.8% to 19.4% by 2030 and -0.3% to +22.7% by 2050. The most exposed LGAs with an increase of at least 20% by 2050 are: Hindmarsh, Yarriambiack, West Wimmera, Horsham and Buloke.
- Maximum daily rainfall is projected to increase by 1.6% to 8.9% by 2030 and 5.4% to 8.7% by 2050. The most exposed LGAs with an increase of at least 8% by 2050 are: Warrnambool, Mansfield, Greater Bendigo, Mount Alexander and Moyne.

Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by -0.1% to +24.6% by 2030 and -0.5% and +35.3% by 2050. The most exposed LGAs, with an increase of at least 30% by 2050, are: Horsham, Hindmarsh, Yarriambiack, Buloke and West Wimmera.
- Maximum daily rainfall is projected to increase by 1.9% to 8.3% by 2030 and 5.0% to 10.5% by 2050. The most exposed LGAs with an increase of at least 10% by 2050 are: Moira, Greater Shepparton, Benalla, Wangaratta and Indigo.

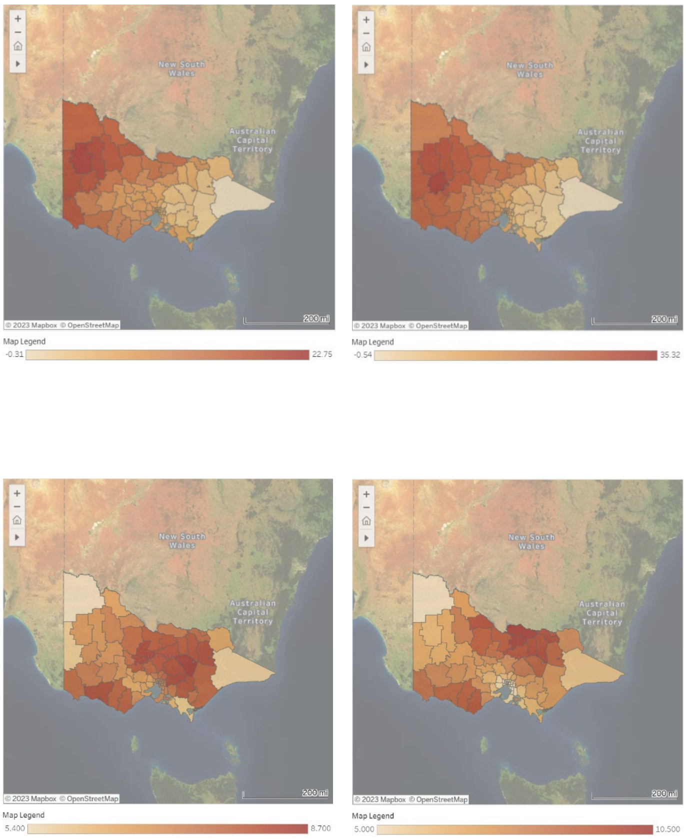


Figure 62

Top: *Future percent change in extreme rain days by 2050 under a low (left) emissions scenario and high emissions (right) scenarios compared to the 1995-2014 historical baseline. Units are %.*

Bottom: *Future percent change in maximum daily rainfall by 2050 under a low (left) emission and high (right) emission scenarios compared to the 1995-2014 historical baseline. Units are %.*

Extreme wet - QLD

Historical/Current Exposure:

- QLD has, on average, experienced 2 to 34 extreme rain days per year and maximum daily rainfall of 30 mm to 79 mm.
- Historically, the top LGAs with at least 28 extreme rain days per year are: Yarrabah, Wujal Wujal, Cassowary Coast, Hope Vale and Palm Island.
- Historically, the top LGAs with maximum daily rainfall of at least 71.5 mm are: Cairns, Cassowary Coast, Yarrabah, Palm Island and Hinchinbrook.

Future Exposure under a Low Emission Scenario:

- Extreme rain days are projected to change by -13.7% to +5.1% by 2030 and -14.4% to +8.3% by 2050. The most exposed LGAs, with an increase of at least 1% by 2050, are: Bulloo, Torres Strait Island, Torres, Cherbourg and Toowoomba.
- Maximum daily rainfall is projected to change by -2.8% to +10.6% by 2030 and -2.6% to +10.7% by 2050. The most exposed LGAs, with an increase of at least 8.8% by 2050 are: Torres Strait Island, Torres, Hope Vale, Pormpuraaw, and Northern Peninsula Area.

Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by -11.6% to +7.0% by 2030 and -11.9% to +12.5% by 2050. The most exposed LGAs with a projected increase by 2050 are: Torres Strait Island, Torres, Bulloo, Quilpie and Boulia.
- Maximum daily rainfall is projected to change by -0.2% to +9.5% by 2030 and -2.0% to +10.5% by 2050. The most exposed LGAs, with an increase of at least 9% by 2050, are: Mapoon, Torres Strait Island, Etheridge, Napranum and Mount Isa.

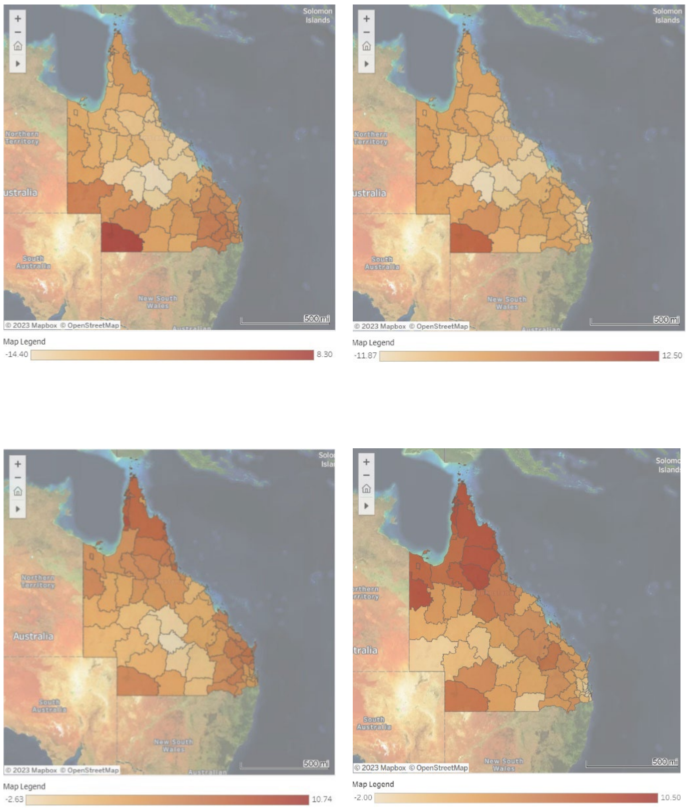


Figure 63
Top*: Future percent change in extreme rain days by 2050 under a low (left) emissions and high (high emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

Bottom: *Future percent change in maximum daily rainfall by 2050 under the low (left) emissions and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

Extreme wet – South Australia

Historical/Current Exposure:

- SA has on average experienced 1 to 3 extreme rain days per year and maximum daily rainfall of 23 mm to 32 mm.
- Historically, the top LGAs with at least 3 extreme rain days per year are: Mount Gambier, Grant, Wattle Range, Clare and Gilbert Valleys and Holdfast Bay.
- Historically, the top LGAs with maximum daily rainfall of at least 29 mm are: Anangu Pitjantjatjara Yunkunytjatjara, Clare and Gilbert Valleys, Northern Areas and Orroroo Carrieton and Peterborough.

Future Exposure under a Low Emissions Scenario:

- Extreme rain days are projected to increase by 9.4% to 35.5% by 2030 and 4.5% to 42.7% by 2050. The most exposed LGAs with an increase of at least 35% by 2050 are: Yorke Peninsula, Whyalla, Port Augusta, Tumby Bay and Kangaroo Island.
- Maximum daily rainfall is projected to increase by 2.1% to 10.6% by 2030 and 2.6% to 11.8% by 2050. The most exposed LGAs with an increase of at least 11% by 2050 are: Kangaroo Island, Port Pirie, Barunga West, Port Augusta and Flinders Ranges.

Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to increase by 14.5% to 40.1% by 2030 and 11.1% to 52.6% by 2050. The most exposed LGAs, with an increase of at least 47% by 2050, are: Yorke Peninsula, Tumby Bay, Kangaroo Island, Lower Eyre Peninsula and Port Lincoln.
- Maximum daily rainfall is projected to increase by 4.9% to 12.2% by 2030 and 4.3% to 14.8% by 2050. The most exposed LGAs, with an increase of at least 12% by 2050, are: Kangaroo Island, Yankalilla, Flinders Ranges, Victor Harbor, and Charles Sturt.

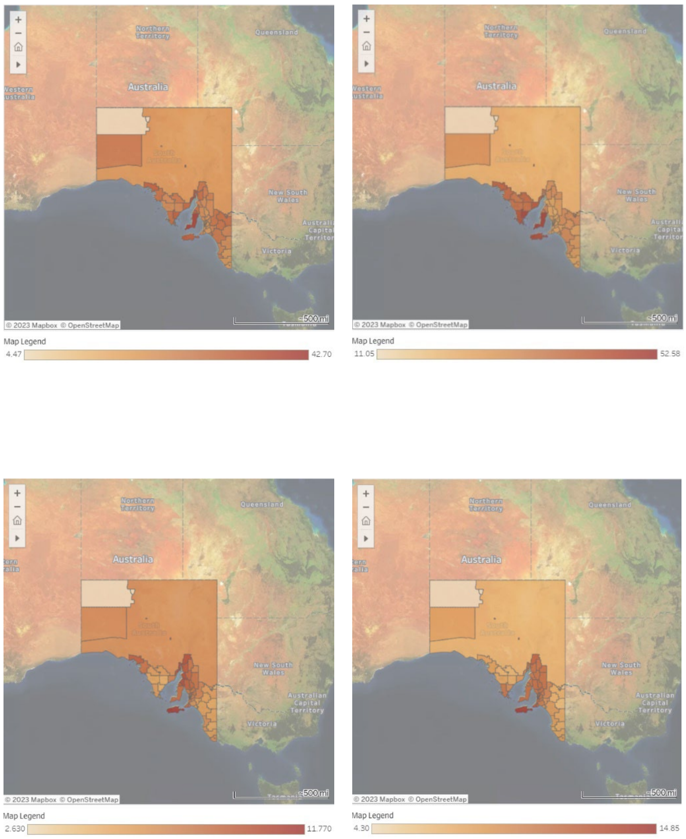


Figure 64

***Top:** Future percent change in extreme rain days by 2050 under a low (left) emissions scenario and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

***Bottom:** Future percent change in maximum daily rainfall by 2050 under a low (left) emissions and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

Extreme wet – Western Australia

Historical/Current Exposure:

- WA has on average experienced 1 to 13 extreme rain days per year and maximum daily rainfall of 24 mm to 50 mm.
- Historically, the top LGAs with at least 7 extreme rain days per year are: Wyndham-East Kimberley, Derby-West Kimberley, Christmas Island, Waroona and Broome.
- Historically, the top LGAs with maximum daily rainfall of at least 45 mm are: Wyndham-East Kimberley, Broome, Derby-West Kimberley, Port Hedland and Karratha.

Future Exposure under a Low Emissions Scenario:

- Extreme rain days are projected to change by -8.7% to +22.4% by 2030 and -13.7% to +29.2% by 2050. The most exposed LGAs with an increase of at least 13% by 2050 are: Kalgoorlie-Boulder, Dundas, Menzies, Laverton and Quairading.
- Maximum daily rainfall is projected to change by -1.3% to +8.4% by 2030 and -2.2% to +9.3% by 2050. The most exposed LGAs with an increase of at least 7% by 2050 are: Kalgoorlie-Boulder, Menzies, Narrogin, Cuballing and Wagin.

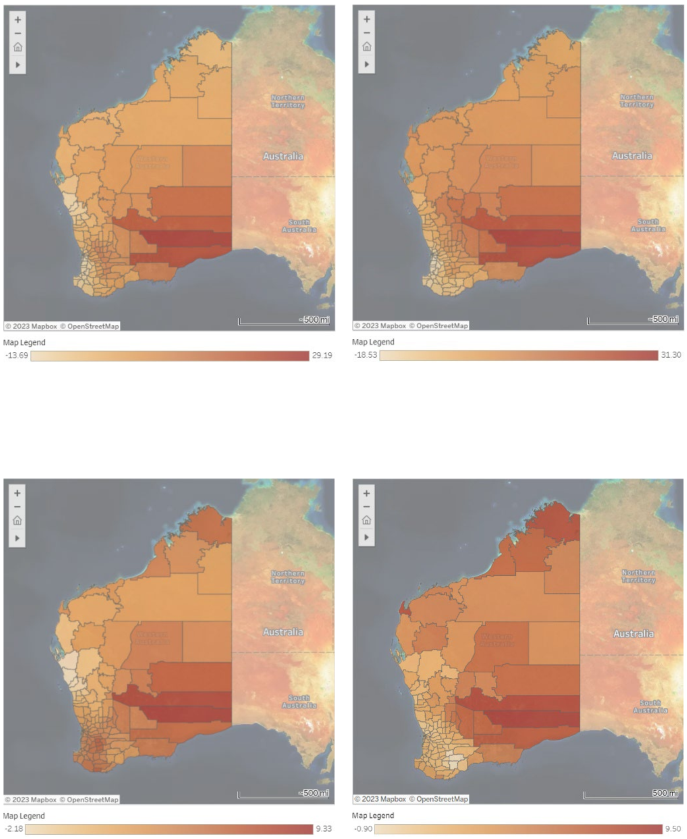
Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by -9.2% to +21.3% by 2030 and -18.5% to +31.3% by 2050. The most exposed LGAs with an increase of at least 17% by 2050 are: Kalgoorlie-Boulder, Dundas, Menzies, Coolgardie and Laverton.
- Maximum daily rainfall is projected to change by -1.1% to +8.3% by 2030 and -0.9% to +9.5% by 2050. The most exposed LGAs with an increase of at least 8% by 2050 are: Kalgoorlie-Boulder, Menzies, Exmouth, Wyndham-East Kimberley and Dundas.

Figure 65

***Top**: Future percent change in extreme rain days by 2050 under a low (left) emission scenarios and high (right) emission scenarios compared to the 1995-2014 historical baseline. Units are %.*

***Bottom:** Future percent change in maximum daily rainfall by 2050 under a low (left) emissions and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*



Extreme wet – TAS

Historical/Current Exposure:

- TAS has on average experienced 1 to 13 extreme rain days per year and maximum daily rainfall of 24 mm to 40 mm.
- Historically, the top LGAs with at least 8 extreme rain days per year are: West Coast, Waratah-Wynyard, Burnie, Derwent Valley and Kentish.
- Historically, the top LGAs with maximum daily rainfall of at least 35 mm are: West Coast, Derwent Valley, Waratah-Wynyard, Burnie and Kentish.

Future Exposure under a Low Emission Scenario:

- Extreme rain days are projected to increase by 6.4% to 26.4% by 2030 and 7.7% to 24.9% by 2050. The most exposed LGAs with an increase of at least 22% by 2050 are: Southern Midlands, Sorell, Clarence, Dorset and Brighton.
- Maximum daily rainfall is projected to change by 3.6% to 10.2% by 2030 and 8.0% to 11.4% by 2050. The most exposed LGAs with an increase of at least 10% by 2050 are: Huon Valley, Kingborough, Waratah-Wynyard, Burnie and Latrobe (Tas.).

Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by 3.9% to 21.2% by 2030 and 9.9% to 28.0% by 2050. The most exposed LGAs with an increase of at least 25% by 2050 are: Launceston, Dorset, George Town, Northern Midlands and Kingborough.
- Maximum daily rainfall is projected to change by 3.8% to 9.2% by 2030 and 6.6% to 12.4% by 2050. The most exposed LGAs with an increase of at least 11% by 2050 are: Huon Valley, Circular Head, West Coast, Waratah-Wynyard and King Island.

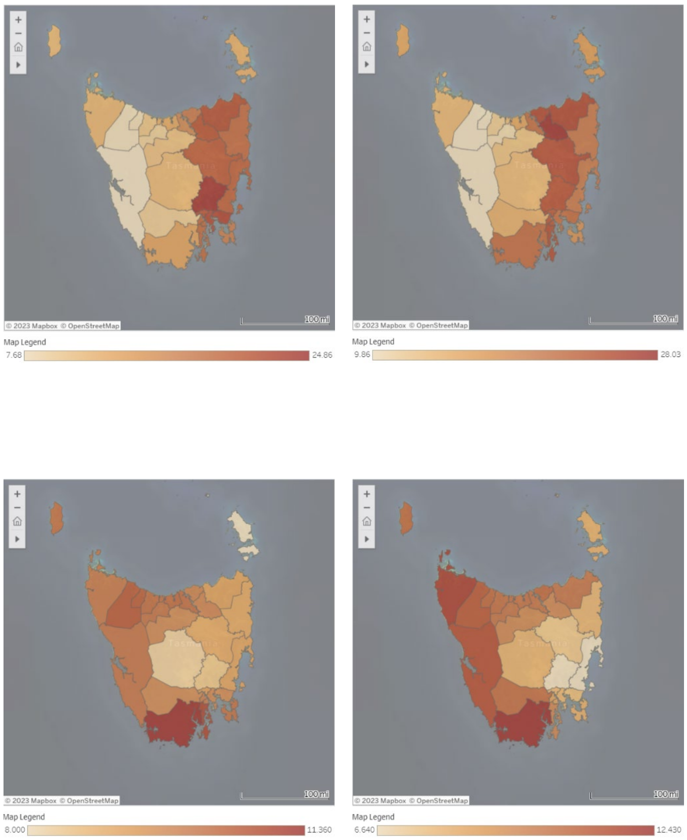


Figure 66
Top: *Future percent change in extreme rain days by 2050 under a low (left) emissions scenario and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

Bottom: *Future percent change in maximum daily rainfall by 2050 under a low (left) emission scenario and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*

Extreme wet – NT

Historical/Current Exposure:

- NT has on average experienced 3 to 23 extreme rain days per year and maximum daily rainfall of 37 mm to 46 mm.
- Historically, the top LGAs with at least 20 extreme rain days per year are: Tiwi Islands, Litchfield, Palmerston, Belyuen and Coomalie.
- Historically, the top LGAs with maximum daily rainfall of at least 45 mm are: Tiwi Islands, East Arnhem, Belyuen, Palmerston and West Daly.

Future Exposure under a Low Emissions Scenario:

- Extreme rain days are projected to change by -6.3% to +4.2% by 2030 and -5.4% to +0.7% by 2050. The most exposed LGAs with a change of at least -2% or more by 2050 are: Alice Springs, Katherine, Victoria Daly, East Arnhem and Roper Gulf.
- Maximum daily rainfall is projected to change by -2.2% to +9.4% by 2030 and 1.2% to 11.8% by 2050. The most exposed LGAs with an increase of at least 9% by 2050 are: Katherine, West Arnhem, Tiwi Islands, Litchfield and Coomalie.

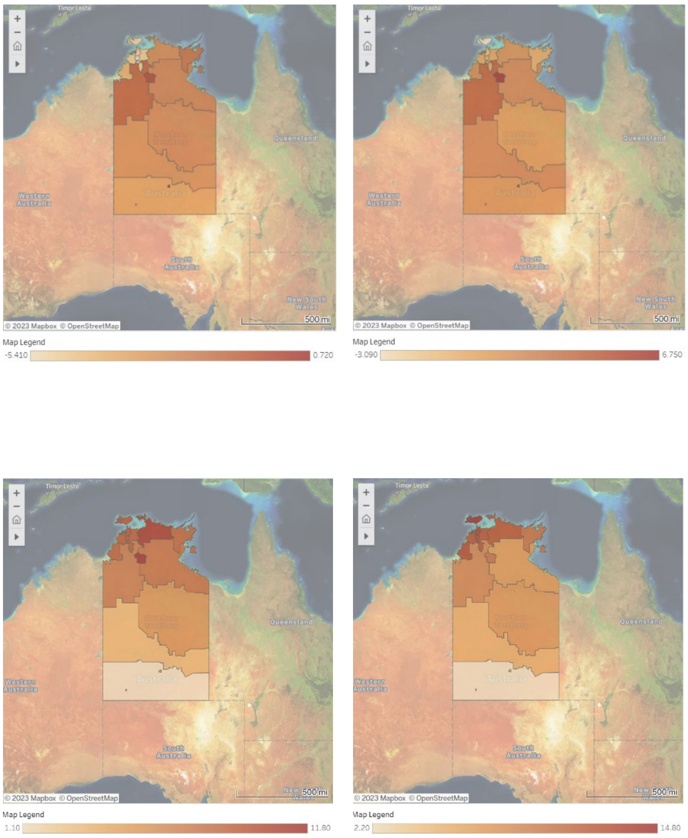
Future Exposure under a High Emissions Scenario:

- Extreme rain days are projected to change by -3.5% to +11.4% by 2030 and -3.1% to 6.8% by 2050. The most exposed LGAs with an increase of at least 2% by 2050 are: Katherine, Alice Springs, Victoria Daly, Roper Gulf and Central Desert.
- Maximum daily rainfall is projected to change by 6.0% to 10.9% by 2030 and 2.2% to 14.8% by 2050. The most exposed LGAs with an increase of at least 13% by 2050 are: Tiwi Islands, Litchfield, Coomalie, Palmerston and West Daly.

Figure 67

Top: *Future percent change in extreme rain days by 2050 under a low (left) emissions scenario and high (right) emission scenarios compared to the 1995-2014 historical baseline. Units are %.*

Bottom: *Future percent change in maximum daily rainfall by 2050 under a low (left) emissions scenario and high (right) emissions scenarios compared to the 1995-2014 historical baseline. Units are %.*



Bushfire

Multiple factors such as extreme temperatures, drought and strong winds contribute to bushfire risk. When vegetation is dry, extreme bushfires can quickly become out of control and cause massive destruction. Bushfires have been known to adversely impact public health and safety, infrastructure and to create impacts which overlap across the four domains (built, economic, social and natural). Below is a summary of some recent bushfire events in Australia and their potential impacts on the four value domains.

Recent high impact events associated with bushfire:

- Black Summer Bushfires, Jul 2019 to Mar 2020: insurance costs of $1.88 billion and 2,448 homes destroyed. Additionally, the Black Summer Bushfires caused unprecedented environmental damage with more than 24 million hectares burnt and severely degraded air quality, which had extended health implications.
- Black Saturday Bushfires, Jul 2009: insurance costs of $1.07 billion and 2,029 homes destroyed. Strong winds brought down powerlines in Kilmore East, with sparks igniting a fire, which, when combined with another fire in Murrindindi, created the Kinglake Fire Complex which swept through state forests and national parks.
- Canberra Bushfires, Jan 2003: insurance costs of $350 million and 488 homes destroyed. The Canberra Bushfires burned nearly 70% of the ACT's pastures, forests and nature parks, including the Namadgi National Park and the Tidbinbilla Nature Reserve. In addition, it destroyed 23 government and commercial buildings, including the Mount Stromlo Observatory and surrounding pine plantations.

Built domain:	Economic domain:
• Bushfires can directly damage property and critical infrastructure. Additionally, trees may fall onto power lines because of bushfires. Extreme heat from bushfires can also cause transmission lines to sag, resulting in equipment damage and power intermittency. • Bushfires can damage critical infrastructure such as cell towers, power lines, utility poles, cables and distribution cabinets	• Damage to critical infrastructure will disrupt business operations. • Risks to businesses and public organisations directly impacted by bushfires affecting productivity, access and supply/distribution networks due to impacts to the built domain. • The impacts on productivity, assets, resources, site access and supply/distribution networks will

and can lead to extended mobile and internet outages. • Electricity, mobile and internet outages can cause delays in emergency service response times and up-to-date disaster information communications.	also contribute to longer recovery times from a bushfire.
Social domain: • Bushfires create hazardous working conditions including poor air quality, which can make it hard to repair infrastructure and prolonging network outages. • Bushfires can indirectly cause risks to the physical health, safety and wellbeing of the population as smoke plumes disperse over large areas and reduce air quality. • Destructive bushfires puts Aboriginal and European cultural heritage at risk due to bushfires impacting sites of cultural significance. • Risks to mental health and wellbeing due to bushfires causing trauma and impacting identity, autonomy, wellbeing/belonging.	Natural domain: • The destructive nature of bushfires can cause severe damage to a wide range of native terrestrial ecosystems and species composition/stability. • Rain events following a bushfire can cause runoff and erosion due to the lack of ground cover and affect water quality. • Ash and timber can fall into waterways as a result of a bushfire. Rain events following a bushfire may cause contamination of fresh water sources.

Bushfire – NSW

The metrics used as a proxy to assess bushfires is based on the Fire Weather Index (FWI) that is derived from rainfall, temperature, relative humidity and wind parameters, and does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- NSW has on average experienced 11 to 21 extreme fire days per year. Historically, the most exposed LGAs, with at least 21 extreme fire days per year, are: Byron, Richmond Valley, Tweed, Tenterfield and Kyogle.
- Historically, the 95th percentile fire weather index (FWI) has been 11 to 62. The most exposed LGAs, with the 95th percentile FWI of at least 52, are: Wentworth, Bourke, Broken Hill, Central Darling and Unincorporated NSW.

Future Exposure under a Low Emissions Scenario:

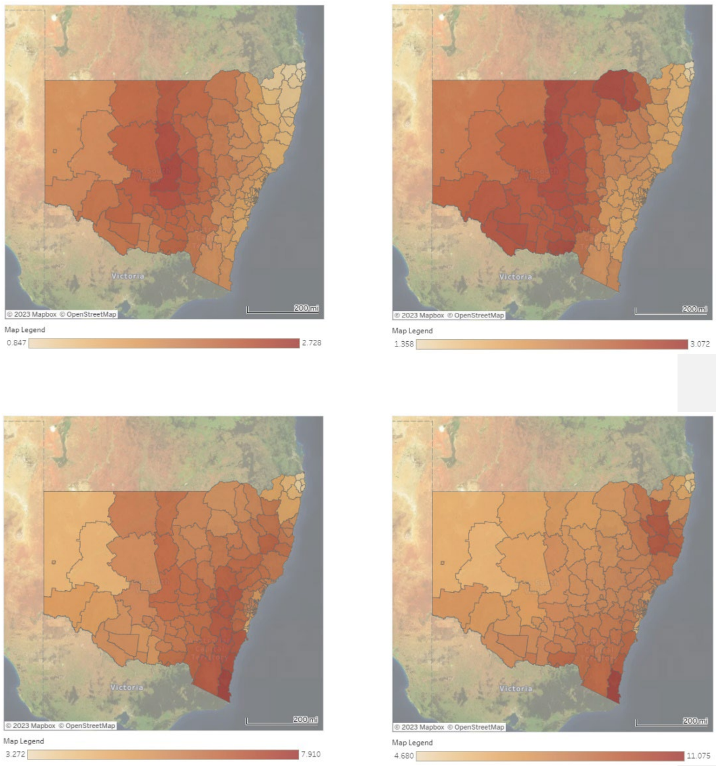
- Extreme fire days are projected to increase by 2 to 6 additional days per year by 2030, and 3 to 8 additional days per year by 2050. The most exposed LGAs, with at least 7 additional days, are: Queanbeyan-Palerang Regional, Bathurst Regional, Goulburn Mulwaree, Eurobodalla and Bega Valley.
- The 95th percentile FWI is projected to increase by 1 to 2 by 2030 and 1 to 3 by 2050. The most exposed LGAs, with FWI increasing by at least 3, are: Narromine, Parkes, Bland, Bogan, and Lachlan.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 2 to 5 additional days per year by 2030, and 5 to 11 additional days per year by 2050. The most exposed LGAs, with at least 10 additional days, are: Port Macquarie-Hastings, Uralla, Armidale Regional, Walcha and Bega Valley.
- The 95th percentile FWI is projected to increase by 1 to 2 by 2030 and 1 to 3 by 2050. The most exposed LGAs, with FWI increasing by at least 3, are: Brewarrina, Albury, Greater Hume Shire, Moree Plains, and Bogan.

Figure 68 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under a low emission scenario (left) and high emissions scenario (right) scenarios compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under a low emissions scenario (left) and high (right) emissions scenario compared to the 1995-2014 historical baseline. Units are in days.*



Bushfire - VIC

The metric used as a proxy to assess bushfires is based on the Fire Weather Index (FWI), which is derived from rainfall, temperature, relative humidity and wind parameters. It does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- VIC has on average experienced 11 to 21 extreme fire days per year. Historically, the most exposed LGAs with at least 20 extreme fire days per year, are: Corangamite, Glenelg, West Wimmera, Moyne and Southern Grampians.
- Historically, the 95th percentile fire weather index (FWI) has been 15 to 46. The most exposed LGAs, with the 95th percentile FWI of at least 38, are: Yarriambiack, Buloke, Gannawarra, Swan Hill and Mildura.

Future Exposure under a Low Emissions Scenario:

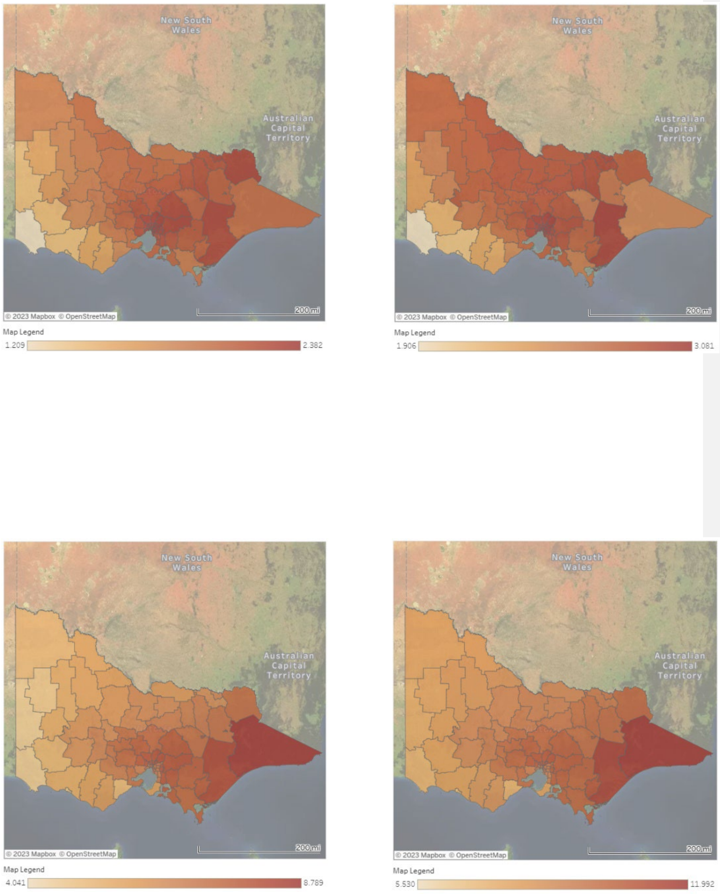
- Extreme fire days are projected to increase by 1 to 4 additional days per year by 2030 and 4 to 9 additional days per year by 2050. The most exposed LGAs, with at least 8 additional days, are: Nillumbik, Darebin, Banyule, Wellington and East Gippsland.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 2 by 2050. The most exposed LGAs, with FWI increasing by at least 2, are: Monash, Manningham, Glen Eira, Boroondara and Bayside (VIC).

Future Exposure under a High Emissions scenario Scenario:

- Extreme fire days are projected to increase by 2 to 5 additional days per year by 2030 and 6 to 12 additional days per year by 2050. The most exposed LGAs with at least 11 additional days are: Hume, Brimbank, Latrobe (VIC), Wellington and East Gippsland.
- The 95th percentile FWI is projected to increase by 1 by 2030 and 2 to 3 by 2050. The most exposed LGAs with FWI increasing by at least 3 are: Monash, Manningham, Glen Eira, Boroondara and Bayside (VIC).

Figure 69 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under low emissions scenario (left) and a high emissions scenario (right) compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 1995-2014 historical baseline. Units are in days.*



Bushfire - QLD

The metrics used as a proxy to assess bushfires is based on the Fire Weather Index (FWI) that is derived from rainfall, temperature, relative humidity and wind parameters. It does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- QLD has on average experienced 11 to 22 extreme fire days per year. Historically, the most exposed LGAs, with at least 21 extreme fire days per year, are: Southern Downs, Scenic Rim, Lockyer Valley, North Burnett and Toowoomba.
- Historically, the 95th percentile fire weather index (FWI) has been 15 to 82. The most exposed LGAs, with the 95th percentile FWI of at least 71, are: Winton, Bulloo, Barcoo, Boulia and Diamantina.

Future Exposure under a Low Emissions Scenario:

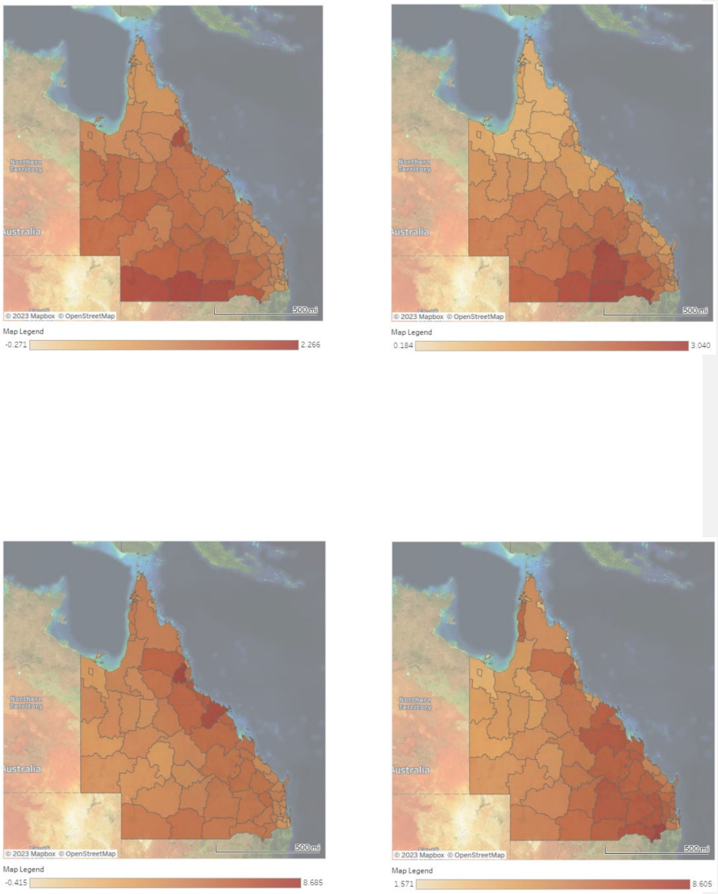
- Extreme fire days are projected to increase by 1 to 7 additional days per year by 2030 and up to 9 additional days per year by 2050. The most exposed LGAs with at least 7 additional days are: Townsville, Burdekin, Hinchinbrook, Whitsunday and Tablelands.
- The 95th percentile FWI is projected to increase by up to 2 by 2030 and 2050. The most exposed LGAs with FWI increasing by at least 2 are: Goondiwindi, Tablelands, Bulloo, Balonne and Paroo.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 1 to 8 additional days per year by 2030 and 2 to 9 additional days per year by 2050. The most exposed LGAs, with at least 8 additional days, are: Toowoomba, South Burnett, Isaac, Goondiwindi and Southern Downs.
- The 95th percentile FWI is projected to increase by up to 2 by 2030 and up to 3 by 2050. The most exposed LGAs, with FWI increasing by at least 3, are: Western Downs, Paroo, Goondiwindi, Maranoa and Balonne.

Figure 70 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under a low emissions scenario (left) and high emissions scenario (right) compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under a low emissions scenario (left) and a high emissions scenario (right) compared to the 1995-2014 historical baseline. Units are in days.*



Bushfire – SA

The metrics used as a proxy to assess bushfires are based on the Fire Weather Index (FWI), which is derived from rainfall, temperature, relative humidity, and wind parameter. It does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- SA has on average experienced 13 to 20 extreme fire days per year. Historically, the most exposed LGAs with at least 20 extreme fire days per year, are: Kingston (SA), Tatiara, Mount Gambier, Wattle Range and Naracoorte Lucindale.
- Historically, the 95th percentile fire weather index (FWI) has been 21 to 73. The most exposed LGAs with the 95th percentile FWI of at least 67 are: Roxby Downs, Maralinga Tjarutja, Unincorporated SA, Coober Pedy, and Anangu Pitjantjatjara Yunkunytjatjara.

Future Exposure under a Low Emissions Scenario:

- Extreme fire days are projected to increase by 1 to 3 additional days per year by 2030 and 3 to 5 additional days per year by 2050. The most exposed LGAs with at least 5 additional days are: Goyder, Northern Areas, Anangu Pitjantjatjara Yunkunytjatjara, Orroroo Carrieton and Peterborough.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 2 by 2050. The most exposed LGAs with FWI increasing by at least 2 are: Orroroo Carrieton, Peterborough, Anangu Pitjantjatjara Yunkunytjatjara, Unincorporated SA and Coober Pedy.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 1 to 3 additional days per year by 2030 and by 3 to 8 additional days per year by 2050. The most exposed LGAs, with at least 8 additional days, are: Renmark Paringa, Goyder, Orroroo Carrieton, Peterborough and Northern Areas.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 3 by 2050. The most exposed LGAs with FWI increasing by at least 3 are: Whyalla, Kimba, Northern Areas, Unincorporated SA and Coober Pedy.

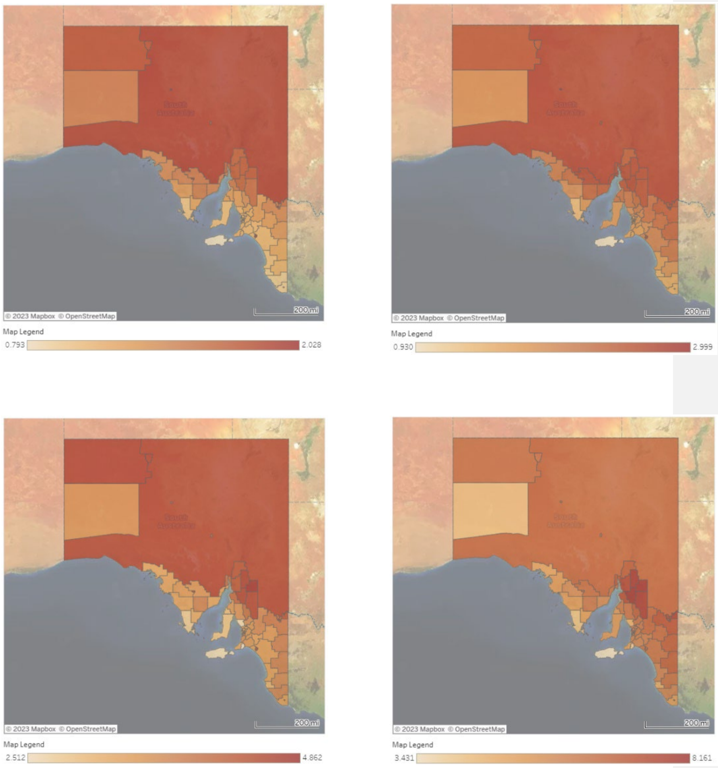


Figure 71 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under a low emissions scenario (left) and a high emissions scenario (right) scenarios, compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under a low emissions scenario (left) and a high emissions scenario (right) scenarios, compared to the 1995-2014 historical baseline. Units are in days.*

Bushfire – WA

The metrics used as a proxy to assess bushfires are based on the Fire Weather Index (FWI), which is derived from rainfall, temperature, relative humidity and wind parameters. It does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- WA has on average experienced 4 to 21 extreme fire days per year. Historically, the most exposed LGAs with at least 21 extreme fire days per year are: Swan, Mundaring, Serpentine-Jarrahdale, Kalamunda and Armadale.
- Historically, the 95th percentile fire weather index (FWI) has been 12 to 86. The most exposed LGAs with the 95th percentile FWI of at least 74 are: Laverton, Meekatharra, Wiluna, Ngaanyatjarraku and East Pilbara.

Future Exposure under a Low Emissions Scenario:

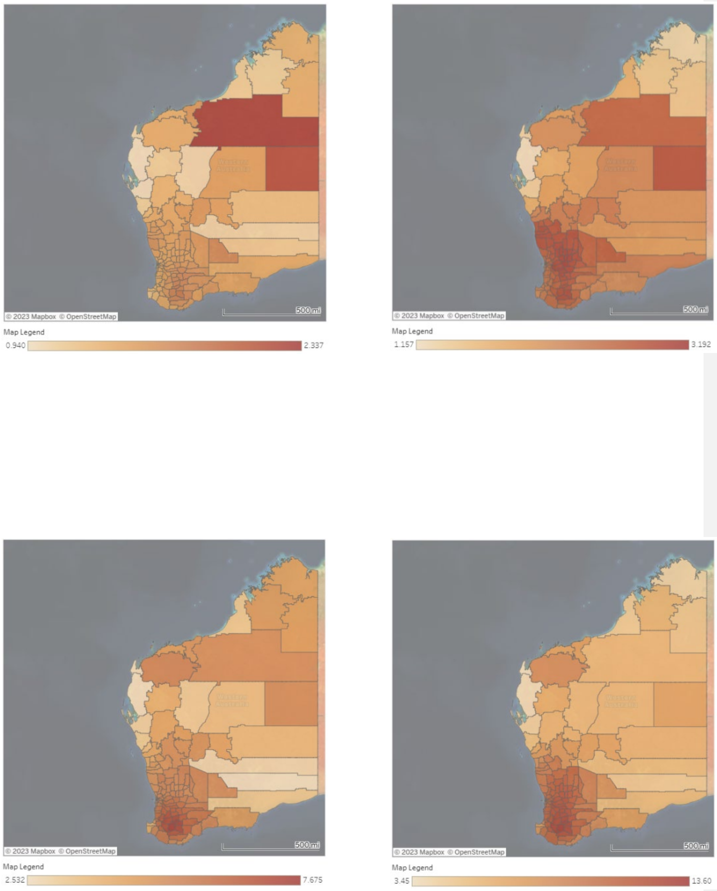
- Extreme fire days are projected to increase by up to 5 additional days per year by 2030 and 2 to 8 additional days per year by 2050. The most exposed LGAs, with at least 7 additional days, are: Wagin, Broomehill-Tambellup, Katanning, Woodanilling and Kojonup.
- The 95th percentile FWI is projected to increase by up to 2 by 2030 and 1 to 2 by 2050. The most exposed LGAs with FWI increasing by at least 2 are: Kojonup, Woodanilling, Broomehill-Tambellup, Ngaanyatjarraku and East Pilbara.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 1 to 6 additional days per year by 2030 and 1 to 14 additional days per year by 2050. The most exposed LGAs with at least 13 additional days are: Boyup Brook, Katanning, Wagin, Woodanilling and Kojonup.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 3 by 2050. The most exposed LGAs, with FWI increasing by at least 3, are: Kellerberrin, Cunderdin, Wyalkatchem, Quairading and Tammin.

Figure 72 ***Top:*** *Future change in the 95*th *percentile of the fire weather index of bushfires by 2050 under a low emissions scenario (left) and a high emissions scenario (right) compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under the low emissions scenario (left) and the high emissions scenario (right) compared to the 1995-2014 historical baseline. Units are in days.*



Bushfire – TAS

The metrics used as a proxy to assess bushfires is based on the Fire Weather Index (FWI) that is derived from rainfall, temperature, relative humidity, and wind parameters and does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- TAS has on average experienced 13 to 20 extreme fire days per year. Historically, the most exposed LGAs with at least 20 extreme fire days per year are: Brighton, Hobart, Clarence, Sorell and Glamorgan-Spring Bay.
- Historically, the 95th percentile fire weather index (FWI) has been 6 to 13. The most exposed LGAs, with the 95th percentile FWI of at least 12, are: Glamorgan-Spring Bay, Break O'Day, George Town, Launceston and Dorset.

Future Exposure under a Low Emissions Scenario:

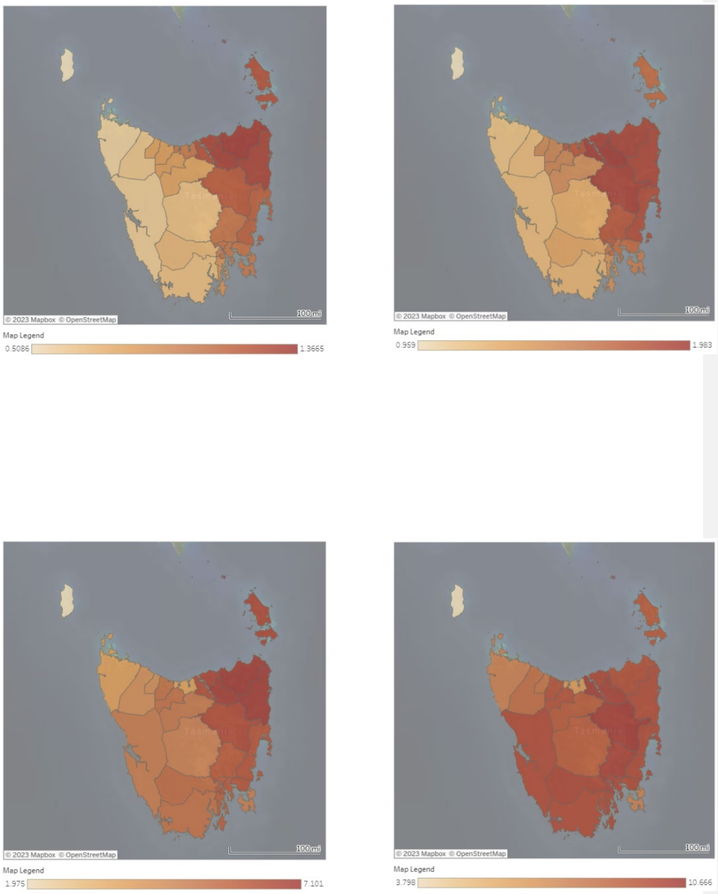
- Extreme fire days are projected to increase by up to 4 additional days per year by 2030 and 2 to 7 additional days per year 2050. The most exposed LGAs, with at least 7 additional days, are: Flinders (Tas.), George Town, Launceston, Break O'Day and Dorset.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 2050. The most exposed LGAs with FWI increasing by at least 1 are: Flinders (Tas.), Break O'Day, George Town, Launceston and Dorset.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 2 to 5 additional days per year by 2030 and 4 to 11 additional days per year by 2050. The most exposed LGAs, with at least 10 additional days, are: Launceston, Brighton, Southern Midlands, West Tamar and Northern Midlands.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 2 by 2050. The most exposed LGAs with FWI increasing by at least 2 are: Dorset, George Town, Northern Midlands, West Tamar and Launceston.

Figure 73 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under the low emissions scenario (left) and a high emissions scenario (right) compared to the 1995-2014 historical baseline. Units are in days.*



Bushfire – NT

The metrics used as a proxy to assess bushfires are based on the Fire Weather Index (FWI), which is derived from rainfall, temperature, relative humidity, and wind parameters. It does not account for vegetation or ignition sources. The metrics presented include the number of days where FWI exceeds the historical 95th percentile (extreme fire days) and changes in the future 95th percentile (extreme fire intensity). The future change is compared to the 1995-2014 historic baseline.

Current Exposure:

- NT has on average experienced 17 to 20 extreme fire days per year. Historically, the most exposed LGAs with at least 20 extreme fire days per year are: Katherine, Unincorporated NT, Roper Gulf, Barkly and West Arnhem.
- Historically, the 95th percentile fire weather index (FWI) has been 34 to 78. The most exposed LGAs, with the 95th percentile FWI of at least 53, are: Victoria Daly, Barkly, MacDonnell, Alice Springs and Central Desert.

Future Exposure under a Low Emissions Scenario:

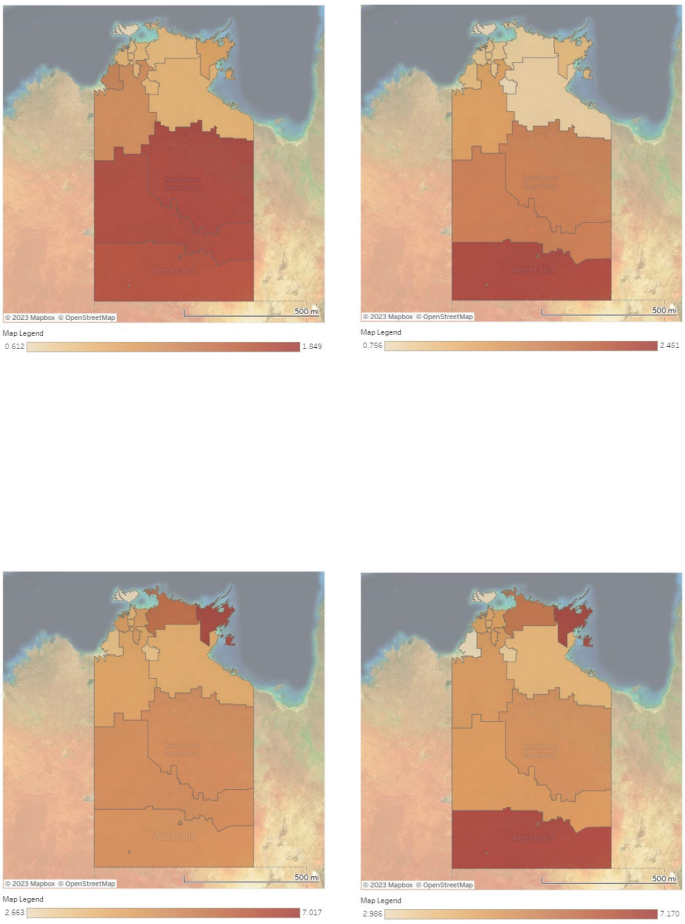
- Extreme fire days are projected to increase by 1 to 5 additional days per year by 2030 and 3 to 7 additional days per year by 2050. The most exposed LGAs, with at least 5 additional days, are: Central Desert, Barkly, Alice Springs, West Arnhem and East Arnhem.
- The 95th percentile FWI is projected to increase by up to 2 by 2030 and 2050. The most exposed LGAs, with FWI increasing by at least 1, are: West Daly, MacDonnell, Central Desert, Alice Springs and Barkly.

Future Exposure under a High Emissions Scenario:

- Extreme fire days are projected to increase by 1 to 6 additional days per year by 2030 and 3 to 7 additional days per year by 2050. The most exposed LGAs with at least 5 additional days are: Barkly, West Arnhem, Alice Springs, MacDonnell, and East Arnhem.
- The 95th percentile FWI is projected to increase by up to 1 by 2030 and 1 to 2 by 2050. The most exposed LGAs, with FWI increasing by at least 1, are: Victoria Daly, Barkly, Central Desert, Alice Springs and MacDonnell.

Figure 74 ***Top:*** *Future change in the 95th percentile of the fire weather index of bushfires by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 1995-2014 historical baseline.*

Bottom: *Future change in extreme fire weather days by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 1995-2014 historical baseline. Units are in days.*



Storm Surge

Storm surge and sea level rise can result in loss of life, infrastructure damage, coastal and inland inundation, dune erosion and corrosion. Storm surges are exacerbated by tropical cyclones and other midlatitude systems (e.g., East Coast Lows) which significantly intensify extreme wave heights. The higher the sea level, the more risk coastal communities face from a range of impacts, including inundation. The summary below describes recent storm surge events in Australia and their potential impacts across the four value domains.

Recent high impact events associated with storm surge:

- Tropical Cyclone Debbie, Mar 2017: crossed the QLD coast and resulted in a 2.6m storm surge at Laguna Quays. It caused damage of $700 million to public infrastructure and $450 million to agriculture sector.
- Large Swells impact Southern Australia, Aug 2011: Victoria's seaport of Portland was closed for the first time in ten years due to an 8m storm surge event. The large swells resulted in significant beach erosion along the Victorian coast causing $150 million dollars in damage.
- Tropical Cyclone Yasi, Feb 2011: crossed the QLD coastline and caused a 5m storm surge event at Cardwell. The economic impact was estimated to be $800 Mn.

East Coast Lows off the coast of NSW, Jun 2007: Thunderstorms, heavy rain and storm surges caused widespread damage to the Hunter, Central Coast and Sydney Metropolitan areas, causing an estimated damage costs of $1.5 billion. 200,000 homes lost power and thousands of homes and businesses lost telephone services.

Built domain:	Economic domain:
• Coastal erosion and metal corrosion compromising the structural integrity posing safety hazard. • Storm surge/sea level rise damaging existing coastal critical infrastructure, coastal erosion compromising major transport routes and impeded access to coastal resources. • Structural damage to properties. • Disruption to port operations impacting supply chains,	• Lower fish yields contributing to downstream impacts for supply and market prices. • Property, infrastructure and distribution networks damage, disruption in supply chain/short supply impacting business continuity and productivity particularly for downstream dependencies. • Rising insurance premiums and declining property value in high-risk coastal locations, posing

increasing product, material, repair, replacement costs and recovery delay. • Elevated water tables exerting pressure on stormwater and wastewater infrastructure and impacting drinking water supply and quality. • Containment of waste products breached leading to unintended transport of nutrients, sediments or toxic chemicals to land, waters, air that may have both environmental and population health implications.	higher risks to vulnerable households with increased incidence of under insurance.
Social domain: • Death or injury as a result of direct exposure to storm surge and coastal swell. • Increased isolation or disconnection between individuals, posing risks to mental health, wellbeing, social cohesion and community. • Land loss, land degradation and loss of cultural heritage causing distress due to inability to maintain spiritual connections to country and waters – social justice. • Population displacement and increasing homelessness, increasing demand for social housing and emergency accommodation.	Natural domain: • Reduced quality of coastal water supplies due to saltwater intrusion with consequences for species dependent on freshwater habitats. • Biodiversity losses and invasive population irruptions due to poor environmental conditions. • Abrupt and extensive mortality of key habitat forming organisms – corals, kelps, sea grasses and mangroves with implications for dependent species. • Decline in tourism due to irreversible changes in environmental conditions.

Storm surge – NSW

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Current Exposure:

- Extreme wave heights corresponding to the current 1-in-100-year event have been 2.1m to 2.4 m along the NSW coast.
- NSW has experienced relative sea level rise of 0.05m to 0.06m.
- Historically, the top LGAs with extreme wave heights of at least 2.3 m are: Tweed, Ballina, Byron, Lismore and Richmond Valley.
- Historically, the top LGAs with at least 0.06 m relative sea level rise are: Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley and Central Coast (NSW).

Future Exposure under a Low Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 68 to 87 years by 2030 and 19 to 61 years by 2050. The most exposed LGAs, with a return period more frequent than 27 years by 2050, are: Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley and Bega Valley.
- Relative sea level rise is projected to increase by 0.09m to 0.11m by 2030 and 0.17m to 0.21m by 2050. The most exposed LGAs with at least 0.20m rise by 2050, are: Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley and Clarence Valley.

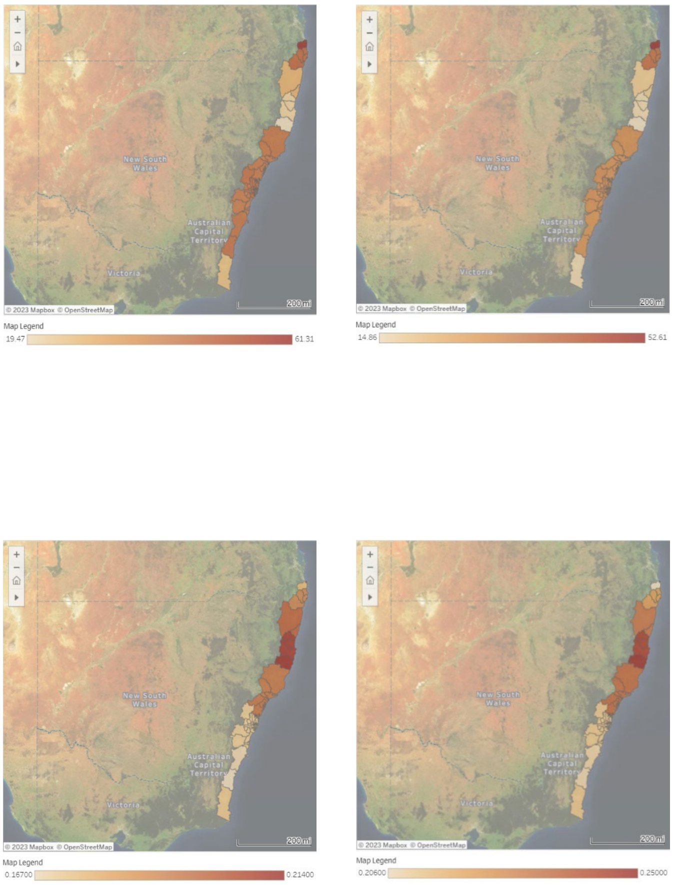
Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 68 to 87 years by 2030 and 15 to 53 years by 2050. The most exposed LGAs, with a return period more frequent than 17 years by 2050, are: Port Macquarie-Hastings, Bega Valley, Bellingen, Kempsey and Nambucca Valley.
- Relative sea level rise is projected to increase by 0.09m to 0.11m by 2030 and 0.21m to 0.25m by 2050. The most exposed LGAs with at least 0.20m rise by 2050, are: Port Macquarie-Hastings, Bellingen, Kempsey, Nambucca Valley and Central Coast (NSW).

Figure 75

Top: *Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 2020 baseline. Units are in years.*

Bottom: *Relative Sea level rise by 2050 under the low emissions scenario (left) and the high emissions scenario (right), compared to the 2020 baseline. Units are in m.*



Storm surge – VIC

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights corresponding to the current 1-in-100-year event have been 1.9m to 2.8m along the VIC coast.
- VIC has experienced relative sea level rise of 0.04m to 0.05m.
- Historically, the top LGAs with extreme wave heights of at least 2.7m are: Bass Coast, Unincorporated Vic, Mornington Peninsula, Surf Coast and Brimbank.
- Historically, the top LGAs with at least 0.05 m relative sea level rise are: Glenelg, Corangamite, Moyne, Warrnambool and Colac Otway.

Future Exposure under a Low Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 73 to 85 years by 2030 and 24 to 49 years by 2050. The most exposed LGAs, with a return period more frequent than 39 years by 2050, are: Glenelg, Corangamite, Moyne, Warrnambool and Colac Otway.
- Relative sea level rise is projected to increase by 0.08 m to 0.09 m by 2030 and 0.16 m to 0.19 m by 2050. The most exposed LGAs, with at least 0.17 m rise by 2050, are: Glenelg, Corangamite, Moyne, Warrnambool and Colac Otway.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 71 to 84 years by 2030 and 18 to 40 years by 2050. The most exposed LGAs, with a return period more frequent than 31 years by 2050, are: Glenelg, Corangamite, Moyne, Warrnambool and Wellington.
- Relative sea level rise is projected to increase by 0.08m to 0.10m by 2030 and 0.18m to 0.22m by 2050. The most exposed LGAs, with at least 0.20m rise by 2050, are: Glenelg, Corangamite, Moyne, Warrnambool and Colac Otway.

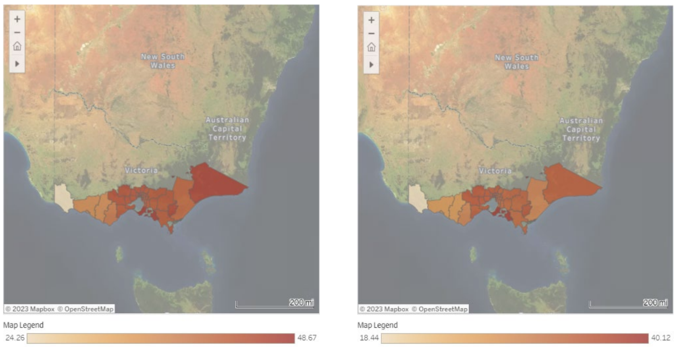
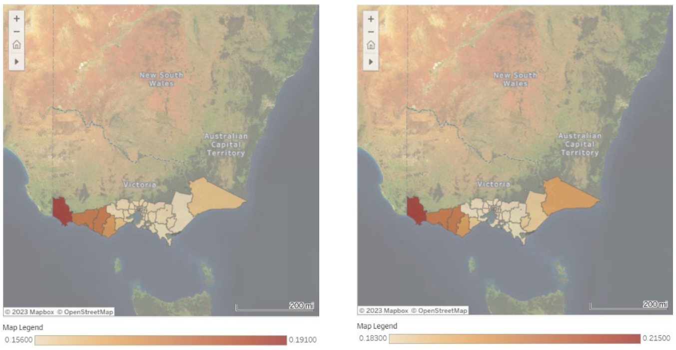


Figure 76

Top: *Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and the high emissions scenario (right) compared to the 2020 baseline. Units are in years.*



Bottom: *Relative Sea level rise by 2050 under a low emissions scenario (left) and high emissions scenario (right) compared to the 2020 baseline. Units are in m.*

Storm surge – QLD

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights, corresponding to the current 1-in-100-year event, have been 1.6m to 3.5m along the QLD coast.
- QLD has experienced relative sea level rise of 0.02m to 0.06m.
- Historically, the top LGAs with extreme wave heights of at least 3.0m are: Isaac, Mackay, Burke, Doomadgee and Gladstone.
- Historically, the top LGAs with at least 0.05m relative sea level rise are: Isaac, Rockhampton, Livingstone, Mackay and Bundaberg.

Future Exposure under a Low Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 56 to 94 years by 2030 and 9 to 77 years by 2050. The most exposed LGAs, with a return period more frequent than 40 years by 2050, are: Lockhart River, Rockhampton, Livingstone, Torres Strait Island and Cook.
- Relative sea level rise is projected to increase by 0.04m to 0.11m by 2030 and 0.09m to 0.21m by 2050. The most exposed LGAs, with at least 0.20m rise by 2050, are: Isaac, Rockhampton, Livingstone, Burdekin and Cairns.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 55 to 94 years by 2030 and 7 to 69 years by 2050. The most exposed LGAs, with a return period more frequent than 30 years by 2050, are: Lockhart River, Rockhampton, Livingstone, Torres Strait Island and Cook.
- Relative sea level rise is projected to increase by 0.04m to 0.11m by 2030 and 0.12m to 0.24m by 2050. The most exposed LGAs, with at least 0.23m rise by 2050, are: Isaac, Rockhampton, Livingstone, Mackay and Burdekin.

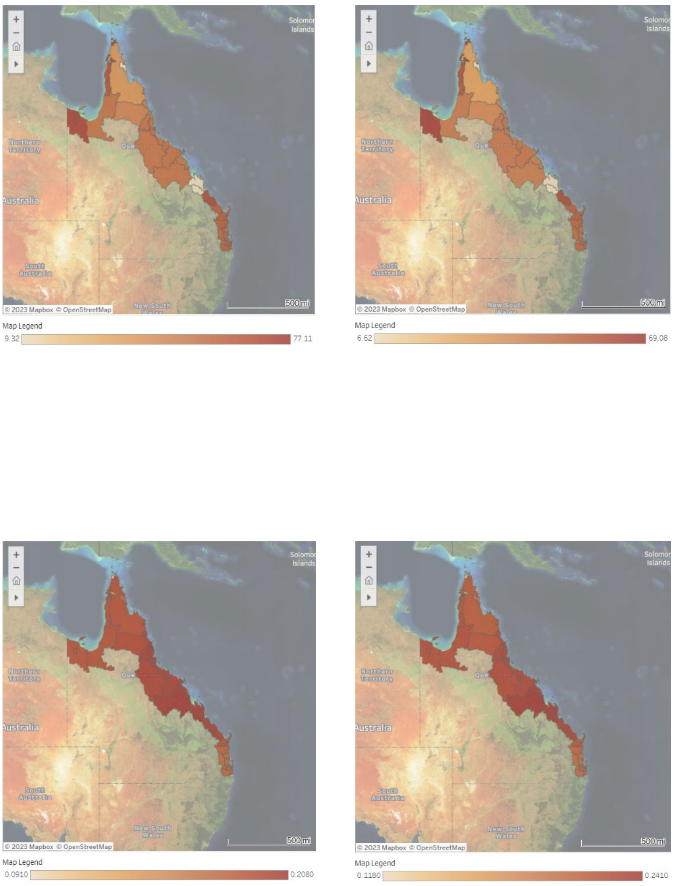


Figure 77
***Top:** Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and the high emission scenario (right) compared to the 2020 baseline. Units are in years.*

***Bottom:** Relative sea level rise by 2050 under a low emissions scenario (left) and high emissions scenario (right) compared to the 2020 baseline. Units are in m.*

Storm surge – SA

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights, corresponding to the current 1-in-100-year event, have been 2.4m to 3.2m along the SA coast.
- SA has experienced relative sea level rise of 0.04m to 0.06m.
- Historically, the top LGAs with extreme wave heights of at least 3.2m are: Adelaide, Adelaide Hills, Adelaide Plains, Burnside and Campbelltown (SA).
- Historically, the top LGAs with at least 0.06m relative sea level rise are: Coorong, Victor Harbor, Yankalilla, Kangaroo Island and Kingston (SA).

Future Exposure under a Low Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 72 to 89 years by 2030 and 21 to 64 years by 2050. The most exposed LGAs, with a return period more frequent than 26 years by 2050, are: Grant, Mount Gambier, Wattle Range, Victor Harbor and Yankalilla.
- Relative sea level rise is projected to increase by 0.07m to 0.11m by 2030 and 0.14m to 0.21m by 2050. The most exposed LGAs, with at least 0.20m rise by 2050, are: Coorong, Victor Harbor, Yankalilla, Kangaroo Island and Kingston (SA).

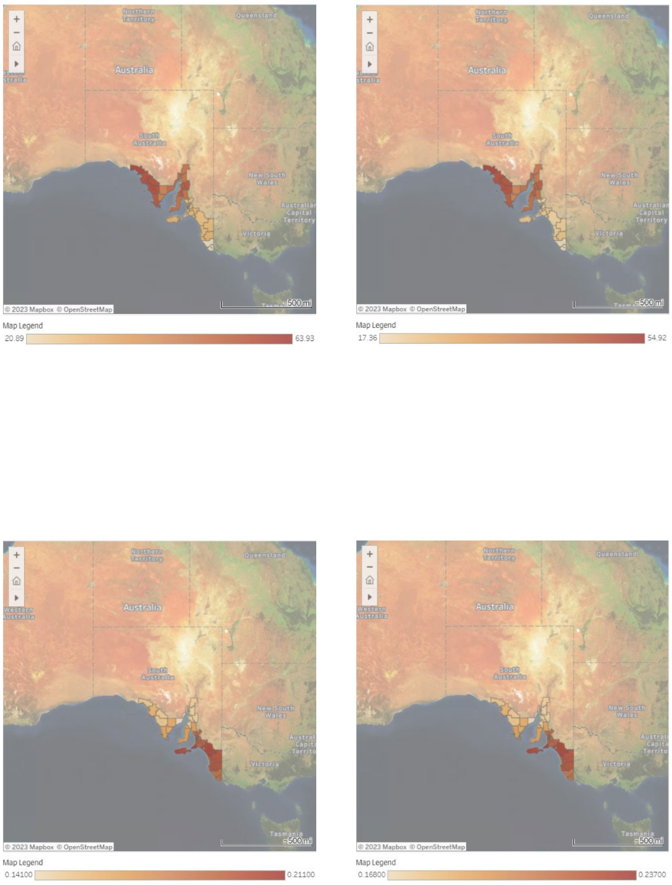
Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 69 to 88 years by 2030 and 17 to 55 years by 2050. The most exposed LGAs, with a return period more frequent than 19 years by 2050, are: Grant, Mount Gambier, Wattle Range, Victor Harbor and Yankalilla.
- Relative sea level rise is projected to increase by 0.07m to 0.11m by 2030 and 0.17m to 0.24m by 2050. The most exposed LGAs, with at least 0.23 m rise by 2050, are: Coorong, Victor Harbor, Yankalilla, Kangaroo Island and Kingston (SA).

Figure 78

***Top:** Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and high emission scenario (right) compared to the 2020 baseline. Units are in years.*

***Bottom:** Relative sea level rise by 2050 under low emissions scenario (left) and high emissions scenario (right) compared to the 2020 baseline. Units are in m.*



Storm surge – WA

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights, corresponding to the current 1-in-100-year event, have been 1.5m to 5.9m along the WA coast.
- WA has experienced relative sea level rise of 0.05m to 0.06m.
- Historically, the top LGAs with extreme wave heights of at least 4.4m are: Port Hedland, Broome, Karratha, Derby-West Kimberley and Wyndham-East Kimberley.
- Historically, the top LGAs with at least 0.05m relative sea level rise are: Carnamah, Coorow, Dandaragan, Gingin and Broome.

Future Exposure under a Low Emissions Scenario:

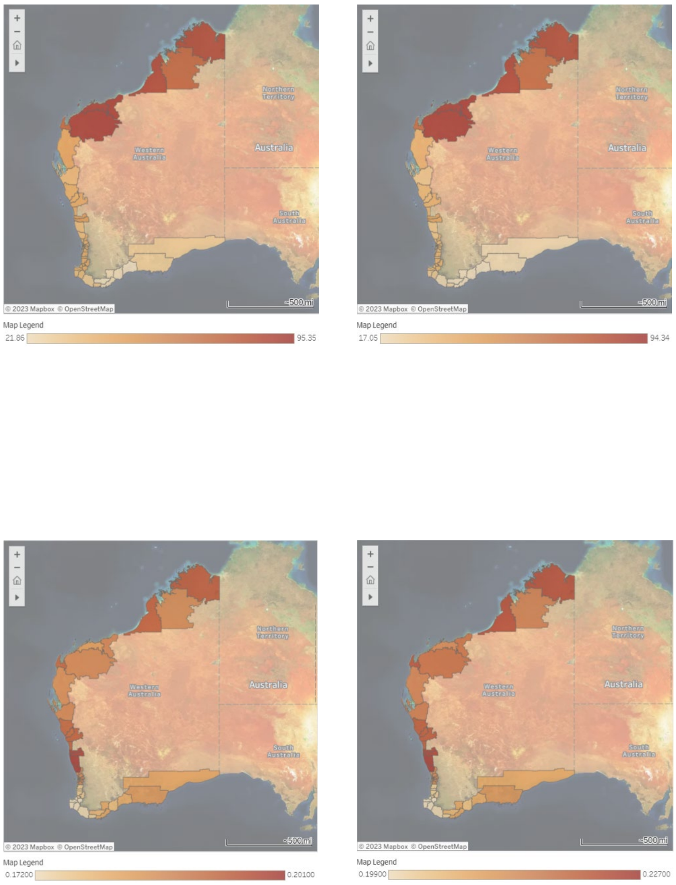
- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 69 to 99 years by 2030 and 11 to 95 years by 2050. The most exposed LGAs, with a return period more frequent than 24 years by 2050, are: Christmas Island, Ravensthorpe, Plantagenet, Jerramungup and Albany.
- Relative sea level rise is projected to increase by 0.08m to 0.10m by 2030 and 0.17m to 0.20m by 2050. The most exposed LGAs, with at least 0.20m rise by 2050, are: Dandaragan, Gingin, Carnamah, Coorow and Christmas Island.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent with a new return period of 68 to 99 years by 2030 and 8 to 94 years by 2050. The most exposed LGA with a return period more frequent than 18 years by 205 are: Christmas Island, Plantagenet, Ravensthorpe, Jerramungup and Albany.
- Relative sea level rise is projected to increase by 0.08m to 0.10m by 2030 and 0.20m to 0.23m by 2050. The most exposed LGAs, with at least 0.23 m rise by 2050, are: Dandaragan, Gingin, Carnamah, Coorow and Christmas Island.

Figure 79
Top: *Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and high emissions scenario (right) compared to the 2020 baseline. Units are in years.*

Bottom: *Relative sea level rise by 2050 under a low emissions scenario (left) and high emissions scenario (right) compared to the 2020 baseline. Units are in m.*



Storm surge – TAS

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights, corresponding to the current 1-in-100-year event, have been 2.1m to 3.2m along the WA coast.
- TAS has experienced relative sea level rise of 0.04m to 0.05m.
- Historically, the top LGAs with extreme wave heights of at least 3.2m are: Burnie, Central Coast (Tas.), Devonport, Kentis and Latrobe (Tas.).
- Historically, the top LGAs with at least 0.05m relative sea level rise are: Sorell, Southern Midlands, Break O'Day, Glamorgan-Spring Bay and Northern Midlands.

Future Exposure under a Low Emissions Scenario:

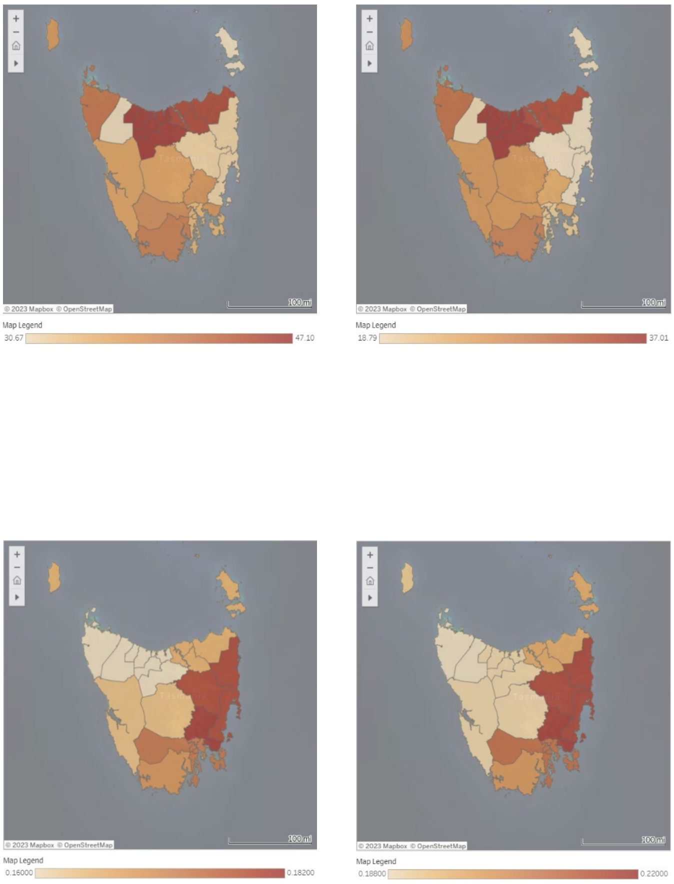
- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 74 to 84 years by 2030 and 31 to 47 years by 2050. The most exposed LGAs, with a return period more frequent than 32 years by 2050, are: Flinders (Tas.), Waratah-Wynyard, Glamorgan-Spring Bay, Northern Midlands and Break O'Day.
- Relative sea level rise is projected to increase by 0.08m to 0.10m by 2030 and 0.16m to 0.18m by 2050. The most exposed LGAs, with at least 0.18m rise by 2050, are: Sorell, Southern Midlands, Break O'Day, Glamorgan-Spring Bay and Northern Midlands.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 74 to 83 years by 2030 and 19 to 37 years by 2050. The most exposed LGAs, with a return period more frequent than 19 years by 2050, are: Break O'Day, Glamorgan-Spring Bay, Northern, Midlands, Flinders (Tas.) and Waratah-Wynyard.
- Relative sea level rise is projected to increase by 0.08m to 0.10m by 2030 and 0.19m to 0.22m by 2050. The most exposed LGAs, with at least 0.22m rise by 2050, are: Sorell, Southern Midlands, Break O'Day, Glamorgan-Spring Bay and Northern Midlands.

Figure 80
Top: *Future return period of the current 1-in-100-year storm surge event by 2050 under a low emissions scenario (left) and high emissions scenario (right) compare d to the 2020 baseline. Units are in years.*

Bottom: *Relati ve sea level rise by 2050 under low emissions scenarios (left) and high emissions scenarios (right) compare d to the 2020 baseline. Units are in m.*



Storm surge – NT

The metrics used to assess future sea level rise are relative to the 2020 baseline value. Storm surge events are assessed according to the extreme wave height corresponding to a 1-in-100-year event and the future return period corresponding to the current 1-in-100-year event.

Historical/Current Exposure:

- Extreme wave heights. corresponding to the current 1-in-100-year event, have been 2.2m to 4.4m along the NT coast.
- NT has experienced relative sea level rise of 0.05m.
- Historically, the top LGAs with extreme wave heights of at least 4.1m are: Daly, Darwin, Darwin Waterfront Precinct, Litchfield and Palmerston.
- Historically, the top LGAs with at least 0.05m relative sea level rise are: West Daly, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct.

Future Exposure under a Low Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 91 to 98 years by 2030 and 67 to 94 years by 2050. The most exposed LGAs, with a return period more frequent than 79 years by 2050, are: Tiwi Islands, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct.
- Relative sea level rise is projected to increase by 0.09m to 0.10m by 2030 and 0.18m to 0.20m by 2050. The most exposed LGAs, with at least 0.19m rise by 2050, are: West Daly, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100-year storm surge event is projected to become more frequent, with a new return period of 91 to 98 years by 2030 and 60 to 92 years by 2050. The most exposed LGAs with a return period more frequent than 75 years by 2050 are: Tiwi Islands, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct.
- Relative sea level rise is projected to increase by 0.09m to 0.10m by 2030 and 0.21m to 0.23m by 2050. The most exposed LGAs, with at least 0.22m rise by 2050, are: West Daly, Belyuen, Coomalie, Darwin and Darwin Waterfront Precinct.

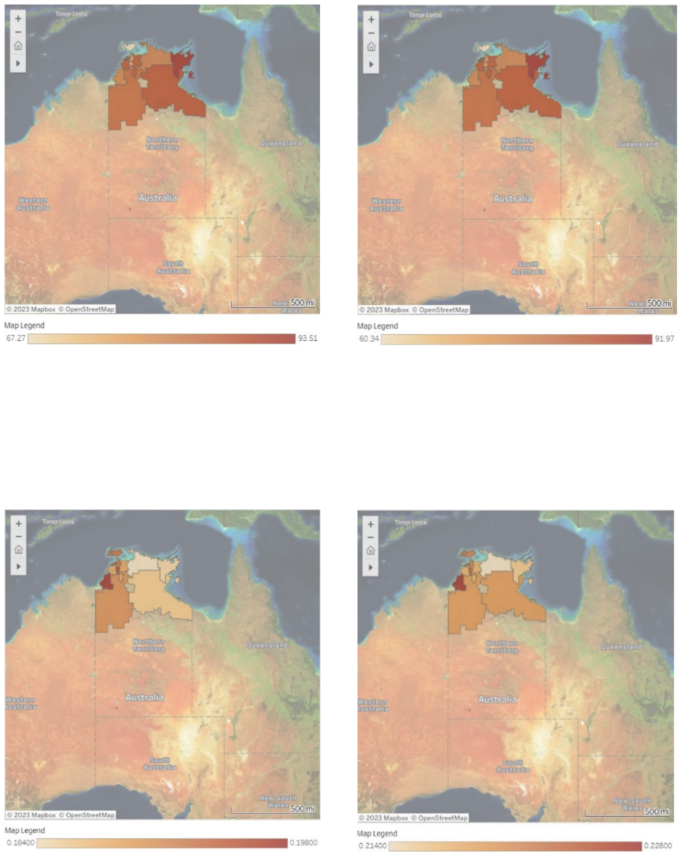


Figure 81

***Top:** Future return period of the current 1-in-100-year storm surge event by 2050 low emissions scenario (left) and the high emissions scenario (right) compared to the 2020 baseline. Units are in years.*

***Bottom:** Relative sea level rise by 2050 under the low emissions scenario (left) and the high emissions scenario (right) compared to the 2020 baseline. Units are in m.*

Tropical Cyclone

Tropical cyclone (TC) projections are a culmination of several research studies and represent the frequency, intensity and rain rate at 2℃ warming. Globally, across the main ocean basins, hurricane/cyclone/typhoon intensity and landfall rain rates, are projected to increase but with the magnitude varying per region.

Recent high impact events associated with storm surge:

- *TC Seroja, April 2021, $272 million insurance costs.* TC Seroja brought damaging wind gusts which reached 170km/hr and heavy rainfall. There was also a widespread loss of power and telecommunications due to downed powerlines from treefall and airborne debris.
- *TC Yasi, February 2011, $1.41 billion insurance costs.* It was estimated that TC Yasi caused a $300 million loss to agricultural production in Queensland, particularly in for banana and sugarcane commodities. Other impacts include residents who relocated elsewhere after the event.

Changes in cyclone tracks and timing:

- Observations and future projections of tropical cyclone tracks: Various studies have reported a poleward shift in TC intensity over recent decades, with recent studies suggesting a further poleward shift in TC tracks in the southern hemisphere under a 2oC warmer world, or in a world with double the CO2 concentrations.
- Timing and duration of tropical cyclones: Most studies focus on changes in TC intensity and frequency, with limited research on the onset of the TC season. Cattiaux et al., (2020) found that under a 2oC world, the onset of the TC season would be delayed (~1 month) in the South Indian Ocean (TCs making landfall in Western Australia or East Africa). Knutson et al., (2015) found that the duration of CAT4/5 events increases under a 2℃ scenario.
- Climate model uncertainty: Although studies generally agree on an increase in TC intensity and increased TC-related rainfall, there is less consensus on the projected changes in the frequency and TC track density. Detecting trends in historical data is limited by the quality and short duration of recent observations and paleo-proxy records, which weakens the confidence in climate models. Interannual climate variability, such as El Nino, also can have an influence on TC formation. It is not certain whether recent trends are caused by human-induced climate change or natural climate variability.

Built domain:	Economic domain:
• Direct damage to property, infrastructure and/or roads. • Containment of waste products breached, leading to unintended transport of nutrients, sediments or toxic chemicals to land, waters and air that may have both environmental and population health implications	• Rising insurance premiums and declining property value in high-risk coastal locations, posing higher risks to vulnerable households with increased incidence of under-insurance.
Social domain: • Population displacement and increasing homelessness, increasing demand for social housing and emergency accommodation. • Land loss, land degradation and loss of cultural heritage, causing distress due to an inability to maintain spiritual connections to country and waters – social justice.	Natural domain: • Reduced quality of coastal water supplies due to saltwater intrusion, with consequences for species dependent on freshwater habitats. • Biodiversity losses and expansion of invasive species due to poor environmental conditions.

Tropical cyclones – Northern Australia

Tropical cyclones (TC) of category (CAT) four or five may cause structural damage, produce dangerous airborne debris, cause power failures to coastal facilities and endanger worker health and safety due to gale force winds, lightning storms and large surf waves. CAT5 events can especially result in widespread destruction.

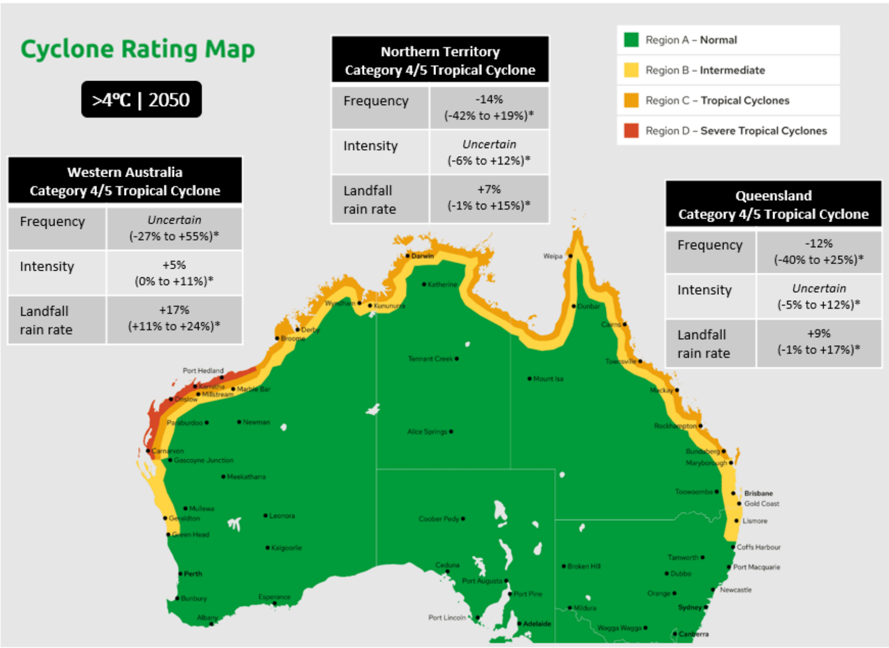
Historical/Current Exposure:

- QLD has experienced a total historic count of 84 events over 1980 to 2022, including 8 CAT4/5 events across the state.
- NT has experienced a total historic count of 85 events, including 5 CAT4/5 events across the state.
- WA has experienced a total historic count of 120 events, including 31 CAT4/5 events across the state.

Future Exposure under a High Emissions Scenario:

- In QLD, TC frequency by 2050 is projected to decrease by 18% for all event categories and by 12% for CAT4/5 events. In addition, CAT4/5 TCs' projected changes in intensity are uncertain, however the landfall rain rate is projected to increase by 9%.
- In NT, TC frequency by 2050 is projected to decrease by 18% for all event types and 14% for CAT4/5 events. In addition, CAT4/5 events intensity projections are uncertain, however the landfall rain rate is projected to increase by 7%.
- In WA, TC frequency by 2050 is projected to decrease by 17% for all event types, with projected changes in CAT4/5 frequency uncertain. In addition, CAT4/5 events are projected to become more intense by 5%, and an increase in the landfall rain rate by 17%.

Figure 82 Projected changes in CAT4 and 5 tropical cyclones across the tropical north of Australia by 2050 for a 4°C scenario (Knutson et al. (2020) and cyclone rating map).



*The median projected change value is provided, uncertain is used when the median is close to zero. Values in brackets represent the 5th to 95th percentile of the projected change.

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