Australian Government
Department of Home Affairs

National Disaster Risk Information Services Capability

Pilot project outcomes report

September 2020

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Executive summary

About this project

What

The National Disaster Risk Information Services Capability (NDRISC) pilot project used narrative scenarios to frame climate and disaster risk discussions for freight supply chains, and then modelled climate and disaster risks for specific case studies.

The pilot confirmed the need for a national capability to provide decision makers across the entire economy with the information and advice they need about climate and disaster risk. The pilot indicated that the national capability should comprise an information platform embedded within a service centre that brings people together to understand climate and disaster risk and inform decision on risk reduction options and approaches.

This report provides the publicly releasable outcomes of the NDRISC pilot project. These outcomes support the proposition of a federated, national-scale climate and disaster risk information capability (the national capability).

Why

Improving our understanding of hazard, exposure and vulnerability and enabling collaboration between government, research and industry sectors are key to reducing systemic climate and disaster risk. Fragmented, patchy, inaccessible and, in some cases, missing data and information hampers climate and disaster risk reduction efforts. The scale, complexity and uncertainty of the climate and disaster risk challenge, and the need for collaboration across sectors, disciplines and professions, requires national coordination. A national capability that unites information, analytics, risk assessment processes and networks of collaborating scientists, technical specialists, decision makers in government and industry and citizens, is critical to understand and collectively manage risks from a variable and changing climate.

This need has been recognised in the Australian Government's National Disaster Risk Reduction Framework, by industry (Australian Business Roundtable), the Government's National Climate Science Advisory Committee, and is reflected in evidence provided to the Royal Commission into National Natural Disaster Arrangements (Royal Commission).

What we found

The pilot project demonstrated the benefits and challenges of modelling climate and disaster risk using case studies linked to a current strategic policy initiative, the Freight and Supply Chain Strategy This report provides practical recommendations for the development of a national capability based on insights and lessons learned from the pilot.

Vision for a national capability

A national capability would provide access to reliable, authoritative, governed and trusted information, modelling capability, processes and tools, together with networks of collaborating scientists, technical specialists and decision makers, to develop a shared understanding of the problem and co-development of climate and disaster risk reduction activities. The national capability could be delivered via an information platform, together with a network of experts, providing guidance and expertise to share knowledge and develop decision support.

The pilot project

Climate change is driving an increase in extreme weather, which in turn is leading to increased frequency, intensity and duration of natural hazards. Land use planning and development activities increase exposure to hazard and, combined with the vulnerability caused by the nature of our interconnected systems, contributes to increasing disaster risk across Australia.

Many approaches to reducing disaster risk, such as design specifications for infrastructure and critical assets, are currently based on an understanding of historical climate information, which may present an inaccurate picture of future natural hazards and risk. Similarly, investment decisions are being made with limited knowledge of climate risk information and in the absence of appropriate guidance or the authoritative means to test risk assumptions.

From February to December 2019, a pilot project was undertaken to demonstrate the benefits of establishing a national climate and disaster risk information capability for Australia (referred to as NDRISC within this report). This was done using several case studies linked to a current strategic policy initiative, the Freight and Supply Chain Strategy[1]. Specific objectives of the pilot project were to:

- understand and specify the requirements for a national capability;
- explore and propose a way forward to overcome barriers that inhibit effective access to and use of climate and disaster risk information, including potential pathways to develop a national capability; and
- present options for consideration by government.

The pilot project comprised two main activities:

- exploring the use of high-level narrative scenarios to stimulate thinking and frame discussion around climate and disaster risk for freight supply chains; and
- modelling climate and disaster risks for selected case studies based on the insights from the narrative exploration process.

Pilot project outcomes

The case studies demonstrated the value of applying current information and risk modelling capability to support climate and disaster risk assessments and identified issues with the use of scenarios and modelling. Although representing a narrow slice of the total climate and disaster risk reduction decision-making context, the case studies have highlighted a set of considerations that would need to be addressed by a scaled-up, cross-sectoral national capability.

Key recommendations and observations from the pilot (explored in detail in Section 3 and presented in Appendix 1) indicate:

- the need to address complexity, uncertainty and systemic risk (recommendation 1);
- the design and development of the national capability as a socio-technical system rather than an information technology platform (recommendations 2–6);
- prioritisation, coordination and leadership of national information products and standards development and the provision of an assurance function for data information and services (recommendations 7–10);
- specific national scale data and information needs and requirements including:
    - hazard information (recommendation 11);
    - scenarios (recommendation 12);
    - exposure information (recommendations 13 and 14);
    - vulnerability information (recommendations 15 and 16);
    - risk assessment processes and information (recommendations 17-20); and
    - disaster consequence information to guide and monitor disaster risk reduction efforts.

[1] Department of Infrastructure, Transport Cities and Regional Development, 2019, *National Freight and Supply Chain Strategy*, https://www.freightaustralia.gov.au/sites/default/files/documents/national-freight-and-supply-chain-strategy.pdf

The case for a national capability

The need for a national capability, called for by the Australian Business Roundtable for Disaster Resilience and Sustainable Communities[2] and defined through consultation around the development of an initial NDRISC design plan,[3] has been validated through this pilot project.

The Royal Commission's Interim Observations[4] broadly discuss topics relevant to the findings of the pilot project, in particular, the importance of nationally consistent data and information, to deliver efficiencies, improve understanding, and facilitate decision-making (observations 46, 49, 60-63).

The Government's National Climate Science Advisory Committee in its 2019 report *Climate Science for Australia's Future* states 'decision makers need climate risk information tailored to their organisations and sectors. A comprehensive climate services capability would enable customers in industry, government and the community to better manage their risks from a variable and changing climate.[5] Climate risk is a growing consideration for business investment and finance with the G20 Task Force on Climate-related Financial Disclosures developing voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to investors, lenders, insurers, and other stakeholders.[6] The Australian Prudential Regulatory Authority, the Australian Securities and Investments Commission and the Reserve Bank of Australia, are all demonstrating that they are taking the issue of climate and disaster risk and disclosure seriously and expect businesses to do so as well.

The national capability represents a foundational element for evidence-based systemic climate and disaster risk reduction and decision-making. It is also central in realising a sustained policy posture to build climate and disaster risk reduction considerations into decisions and actions taken by the Commonwealth.

The National Disaster Risk Reduction Framework (the Framework)[7] guides national action to address existing disaster risks and minimise new risks, setting the five-year foundation from 2019–2023 to address systemic disaster risk in all sectors against four priorities. Priority one of the Framework recognises that improved understanding of our vulnerability is essential to reducing disaster risks. Additionally, improved understanding is foundational for a broader integrated approach to disaster risk reduction and action on other priorities of the Framework. While islands of excellence exist throughout the public, private and academic sectors, information produced and used in these islands is generally disconnected and can be difficult to access.

The scope and scale of the challenge requires national coordination, and guidance to ensure all relevant decision makers have the information, tools and support needed, as recognised in the Framework.

The concept of a national capability also aligns with international best practice. Recognising the complex and cross-cutting nature of disaster risk reduction, national platforms are recognised by the United Nations Office for Disaster Risk Reduction as playing a key role to 'provide and mobilise

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[2] Deloitte Access Economics, 2016, *Building an open platform for natural disaster resilience decisions*. Australian Business Roundtable for Disaster Resilience & Safer Communities. Available at: http://australianbusinessroundtable.com.au/assets/Building%20an%20Open%20Platform%20for%20Natural%20Disaster%20Resilience%20Decisions%20CLEAN.pdf

[3] National Resilience Taskforce - National Disaster Risk Information Services Capability - Design Plan (was Blueprint)
September 2018.

[4] The Interim Observations of the Royal Commission into National Natural Disaster Arrangements https://naturaldisaster.royalcommission.gov.au/system/files/2020-08/Interim%20Observations%20-31%20August%202020_0.pdf

[5] Climate Science for Australia's Future - A report by the National Climate Science Advisory Committee https://publications.industry.gov.au/publications/climate-change/climate-change/publications/climate-science-australia-future.html

[6] Task Force on Climate-related Financial Disclosures – High-level Overview
https://www.fsb-tcfd.org/wp-content/uploads/2020/03/TCFD_Booklet_FNL_Digital_March-2020.pdf

[7] Department of Home Affairs, 2019, *National Disaster Risk Reduction Framework*,
https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf

knowledge, skills and resources required for mainstreaming disaster risk reduction into development policies, planning and programs.'[8]

Finally, in recognising the importance of building a national capability to enable decision makers access to the information needed to reduce climate and disaster risks, the former Council for Australian Governments asked on 13 March 2020 that the Australian Data and Digital Council, in consultation with the Ministerial Council for Police and Emergency Management, improve national natural hazard data and intelligence to enable the development of new information products such as a national fire map. A national capability directly aligns with this shared intent and objective.

Vision for a national capability

A national capability would provide access to reliable, authoritative, trusted, analysis-ready information products, modelling capability, processes and tools. It would be delivered via an information platform together with a network of experts providing guidance, expertise, and knowledge translation and brokerage. This national capability would provide climate and disaster risk understanding, assessment and action across all sectors. The national capability is envisioned as a service centre, providing an intelligence and decision support capability that comprises:

- an integrated information environment composed of an information platform, information products, intelligence analysis and decision support tools; supported by networks of 'information communities' across the public and private sector and academia enabling information production, interpretation and use;
- a service delivery function including an advice network, innovation hub, co-design of tailored products and services, and regular industry and cross-sector outreach and education; and
- a governance and authorising environment to provide oversight and assurance for the information and services offered, creating a trusted source of information, and tools and advice for users.

Experience with the NDRISC pilot project strongly suggests these elements should be reflected in the design of a national capability and in the broader strategic, reform and policy functions that it would support.

[8] UNISDR, 2007. *Guidelines: National Platforms for Disaster Risk Reduction*. United Nations International Strategy for Disaster Reduction. 2007. Geneva https://www.preventionweb.net/files/1680_GuidelinesNationalPlatformsforDRR.pdf

1. Introduction

1.1. Overview

Climate change is driving an increase in extreme weather, which in turn is leading to increased natural hazards and disaster risk in Australia. Many approaches to improving resilience and reducing disaster risk, such as design specifications for infrastructure and critical assets, are currently based on an understanding of historical climate data and local hazards, which may provide an inaccurate picture of future natural hazards. Similarly, investment decisions are often made with limited climate and disaster risk information and in the absence of appropriate guidance or the authoritative means to test assumptions around risk.

From February to December 2019, a pilot project was undertaken to explore the feasibility and benefits of a National Disaster Risk Information Services Capability (NDRISC) for Australia to inform future options for development of a national capability. NDRISC is a proposed national capability that would ensure decision makers have access to the best information and guidance needed to make risk-informed decisions to improve Australia's future resilience.

This report summarises the pilot project, details the lessons learned and provides recommendations that could assist in progressing a national capability.

1.2. Background

In 2017, the Australian Government directed that work be undertaken in collaboration with the states and territories to develop a five-year national mitigation framework, including the creation of a national disaster risk information platform. As part of this approach, in April 2018, the Department of Home Affairs (Home Affairs) established the National Resilience Taskforce (the Taskforce).

The Taskforce delivered a range of policy and guidance materials, notably:

- the National Disaster Risk Reduction Framework[9] (the Framework), released in April 2019 and endorsed by the Council of Australian Governments on 13 March 2020;
- a report on Australia's vulnerability to disasters – *Profiling Australia's Vulnerability*;[10]
- guidance for strategic decisions on climate and disaster risks;[11] and
- initial scoping of a national climate and disaster risk information and services capability (subsequently referred to as NDRISC), which commenced a pilot project linked to the National Freight and Supply Chain Strategy.

The Framework guides national action to address existing disaster risks and minimise new risks, setting the five-year foundation from 2019–23 to address systemic disaster risk in all sectors. A national capability is foundational to a broader, integrated approach to disaster risk reduction. Data and information underpin achievement of the implementation of the Framework, and specifically a national capability would support decision makers across public and private sectors, against the four priorities of the Framework:

- to *understand disaster risk*, whereby consistent and agreed information on hazard, exposure, vulnerability and risk is accessible and fit-for-purpose;

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[9] Department of Home Affairs, 2019, *National Disaster Risk Reduction Framework*, https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf
[10] Department of Home Affairs, 2018, *Profiling Australia's Vulnerability: The interconnected causes and cascading effects of systemic disaster risk*, https://www.aidr.org.au/media/6682/national-resilience-taskforce-profiling-australias-vulnerability.pdf
[11] https://knowledge.aidr.org.au/resources/strategic-disaster-risk-assessment-guidance/.

- to make *accountable decisions*, whereby risks and vulnerabilities are assessed, understood and addressed in all types of decision making;
- to make *investment* that is targeted to reduce risks and vulnerabilities, and to minimise the creation of new risks; and
- by providing *governance, ownership and responsibility*, whereby partnerships and independent and ongoing accountability for disaster risk assessment and reduction is provided across all sectors.

2. Pilot project

2.1. Overview

From February to December 2019, a pilot project was undertaken to demonstrate the benefits of establishing a national climate and disaster risk information capability for Australia.

This was done using several case studies linked to a current strategic policy initiative, the Freight and Supply Chain Strategy. Specific objectives of the pilot project were to:

- understand and specify the requirements for a national capability;
- explore and propose a way forward to overcome barriers for effective access to and use of climate and disaster risk information, including potential pathways to develop a national capability;
- present well-informed, prioritised options for consideration by Government.

The pilot comprised two main activities:

- exploring the use of high-level narrative scenarios to stimulate thinking and frame discussion around climate and disaster risk for freight supply chains; and
- modelling climate and disaster risk for selected case studies based on the insights from the narrative exploration process.

The case studies selected were:

- case study 1 – Flooding of the Bruce Highway south of Townsville (led by Geoscience Australia);
- case study 2 – Multi-hazard freight impacts surrounding the Victoria-Tasmania transport and freight network (through the Bushfire and Natural Hazards Cooperative Research Centre by the University of Adelaide); and
- case study 3 – Coastal inundation and subsidence in the Port of Adelaide (led by the University of Adelaide).

Further information exploring the use of narrative scenarios and modelling the case studies is at Appendix 2.

2.2. Lessons learned from the pilot project

Project participants identified several key areas where additional work would be required to assist the freight supply chain community and policy makers to factor climate and disaster risk into decision-making. The themes for these key areas (summarised in this section) included:

- the need for improved understanding of the freight and supply chain system across spatial and temporal scales;
- the limits of information to describe and model a complex system;
- the nature of values and attitudes of stakeholders in decision-making; and
- the complexity of decision-making in multi-stakeholder and cross-scale risk management and investment.

More holistic understanding of the freight supply chain system is required, particularly for gaps in understanding and data related to exposure and vulnerability of freight supply chains. This includes information about operating capacity under stress, design tolerances of the physical infrastructure, impacts of shocks on supply and demand for goods and services, interdependencies with other critical infrastructure such as communications, ability to model and understand the system and its components from multiple spatial and temporal scales, and magnitude and location of costs on the impact of natural hazards on services as well as the physical infrastructure.

Risk management decisions and investments interventions are challenging in their nature. Risk management decisions and investments are beyond the scope of any one actor, department of government, or industry to manage in isolation. Thus, a collective, collaborative and a whole-of-system (national) perspective is required. These decisions and interventions require co-creation of agreed views on current and future risk through dialogue around narrative scenarios and information products.

Tailored, co-created narrative scenarios are required. Recognising the limitations in our ability to model complex systems, narrative scenarios of the future provide an invaluable tool for engagement and discussions around an uncertain future. However, their use is challenging, requiring significant engagement of the imagination and the ability to work across multiple dimensions and scales concurrently. Scenarios need to be co-developed with users and tailored for specific usage contexts. They must not only embed future climate but also potential future configurations of society, environment and the economy to enable an exploration of exposure and vulnerability.

Values, attitudes and practices of key stakeholders across government, industry and society shape perceptions of the future, and climate and disaster risk reduction activities. Improved understanding of, and an ability to shape (where necessary), stakeholders' attitudes and practices is needed, particularly for disruption and adoption of new technology, the ability to develop a shared vision of the future to guide change, cultural perspective on risk, social processes (such as social licence) in decision making, and understanding of societal values and how these values change during a shock such as a disaster event.

Handling spatial and temporal scale of climate and disaster risk requires a range of products from national overviews to detailed place-based information products that are integrated to enable assessment of system exposure, vulnerability and risk. A critical need for support in addressing specific questions about placement of infrastructure assets; and a need to work at different temporal scales and extents to understand disaster risk (short term) and climate risk (longer term), the relationship between them, and decisions about appropriate interventions.

Co-design with end users is a fundamental requirement for effective development and application of risk tools and intelligence. While a general understanding of the decision context and business need (i.e. identifying climate risk to the freight supply chain) was co-developed by participants in the early stages of the pilot project, this understanding did not mature sufficiently to crystallise how the risk modelling and observations derived through the case studies would be applied by the user.

Continued deep engagement and dialogue between data and modelling capability providers and end users is critical throughout the entire life cycle of a risk assessment, to enable iterative model improvement, effective application, rapid learning, and continual capability enhancement. This should form a critical element of any monitoring and evaluation framework for disaster risk reduction activities.

3. Implications for a national capability

The pilot project has demonstrated the value of applying scenarios and data and modelling to a specific decision context, despite resource constraints and limited times. It has also identified a range of issues that would need to be addressed by a national capability that meets the needs of users across multiple sectors.

The national capability would provide a platform to support a wide range of users to collaboratively understand, assess and address climate and disaster risk. Improved decisions rest on an ability to co-design, develop and use knowledge about systemic climate and disaster risks in a variety of forms. These include narratives and scenarios that can account for the complexity and the emerging and changing nature of risks, together with data, information and analytical models, required to assess risk, and guide and monitor mitigation efforts.

3.1. Complexity and systemic risk

Several global trends are changing the nature of natural hazards and risk and the requirements and potential for knowledge and information systems to help address them. The growing footprint and resource demands of over 7 billion people worldwide in a climate increasingly characterised by more frequent and extreme natural hazards is challenging the stability of the social, economic and natural systems on which we depend.

Climate change affects the timing, scale, intensity and location of weather-related natural hazards. Response to changing climate, such as transition to a low carbon economy, is also likely to cause structural change in society and the economy. The effects of rapidly changing natural hazards are already visible and are having a significant effect on our collective wellbeing.

Disasters cost the Australian economy around $18 billion a year, with this figure projected to rise to $39 billion by 2050 without including the consequences of climate change.[12] Rising disaster costs are putting current insurance regimes under significant pressure as evidenced by increasing insurance premiums, concerns about insurance affordability[13] and insurance industry calls for government action around climate change mitigation and adaptation to address these pressures.[14]

Unprecedented heatwaves, cyclones, floods, storms, bushfires and drought are no longer rare events but are instead becoming the new normal. A growing population and changing lifestyles and livelihoods, associated with changing economic and technological systems, also influence people’s exposure to hazards (as people become increasingly dependent on highly interconnected critical services) and the ways in which they are vulnerable to them. More complex, interconnected supply chains and production systems, increase and change exposure and vulnerabilities to a wider range of hazards. These changes to the behaviours of hazards, combined with the growing exposures of highly interconnected systems, increase the likelihood of compounding and cascading disasters. While outside of the scope of this report, but a useful example nonetheless, had the COVID-19 pandemic arrived during the bushfire crisis, it would have created numerous conflicting demands on support systems and resource prioritisation.

Systems complexity and change – the increasing interdependency and connectivity across economic, societal and environmental systems creates complex and changing threats. We have a

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[12] Deloitte Access Economics (2017) Building Resilience in our States and Territories, page 120, http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf .
[13] Australian Competition and Consumer Commission Northern Australia Insurance Inquiry 2019 https://www.accc.gov.au/focus-areas/inquiries-ongoing/northern-australia-insurance-inquiryAust
[14] Insurance Council of Australia press release Statement on climate change, insurance affordability and accessibility Oct 2019 - https://www.insurancecouncil.com.au/assets/media_release/2019/231019%20Statement%20on%20climate%20change,%20insurance%20affordability%20and%20accessibility.pdf

limited ability to understand and model specific aspects of these systems as modelling activities occur in a disjointed manner focusing on specific dimensions, geographies, and spatial and temporal scales. Using modelled climate projections to model future hazards and intersecting this with information about the potential future state of complex social and economic systems has compounding assumptions, and increasing levels of uncertainty.

The prevailing ways data, information, methods and tools used in organisational risk assessment are unable to cope with this complexity. They tend to focus largely on the 'tame risks' – those that are understandable, quantifiable and manageable within the mandate or remit of each organisation, sector or jurisdiction. Existing risk governance arrangements and the remits of most organisations and government departments, which tend to have siloed mandates defined by their specific sector, portfolio or jurisdiction, also limit our ability to engage with and address complex and systemic risks.

Complex systems approaches recognise limitations in the ability to model and predict systems behaviour. They use an adaptive learning approach based on an 'observe-orient-decide-act' loop, with the 'observe' and 'orient' phases using a range of historic data, modelled projections and forecasts together with scenarios and other forms of knowledge to explore and understand systems. However, adaptive learning requires a broader and deeper approach to knowledge production in order to identify, explore and address new potential threats in addition to modelling known threats.

Sustained collaboration and experimentation across scales and sectors, supported by monitoring, evaluation and learning mechanisms, is required to co-develop and apply novel approaches to risk assessment and risk mitigation. This requires collaboration across actors to enable more effective knowledge co-production and sharing at every stage of the process. Narratives and scenarios – forms of models – are powerful tools that support this process.

Recommendation 1 – The national capability should lead the development and application of methodologies and processes for climate and disaster risk assessment that address complexity, uncertainty and systemic risk. This would entail convening and developing partnerships across communities; utilising existing risk assessment processes; developing and applying novel assessment methodologies through a portfolio of strategic projects; monitoring, evaluating, and capturing and sharing learning from these activities to enable replication and scaling up.

3.2. Users and usage context

3.2.1. Information communities: providers and users

Existing systems of information and knowledge production and use, including within government portfolios or industry sectors, tend be siloed. This is despite the focus of cross-agency committees to share information between agencies. These highly dynamic systems, which can be characterised as 'information communities,' comprise organisational actors, relationships, processes and systems for the production and use of certain information for specific purposes.

Each information community is made up of a variety of producers and users of information. This information is generated through a range of mechanisms from dedicated strategic research programs to transactional business and administrative data systems operated by government, the research sector and industry organisations. Interactions and exchange of information between actors are supported by data platforms enabling aggregation and analysis. There has been significant investment in these data infrastructures such as the National Computational Infrastructure Strategy through Department of Education, Skills and Employment, the National Environmental Science Program through the Department of Agriculture, Water and the Environment, and the Data Integration Partnership for Australia through the Department of the Prime Minster and Cabinet. Interactions and activities within these systems are shaped by a range of institutions, polices, standards, funding, reviews and inquiries, and decision-making bodies, such as steering committees.

To address the complexity of climate and disaster risk, there is a central requirement to better collaborate, connect, and exchange knowledge across currently disparate groups and information communities. Of particular importance in this context is the co-production of knowledge between the scientific, technical, and subject matter experts and end users to develop a shared understanding of the problem and potential solutions, and the development of partnerships between public and private sector actors. Both are fundamental for developing collective approaches around mutually beneficial agendas.

This continually changing installed base of objectives, drivers, and information production and use needs to be understood and leveraged in order to effectively connect, align and harmonise currently independent activities. Steering this extended network of providers and users is a critical role for a national capability.

Recommendation 2 – The national capability should be developed as a socio-technical system, comprising the collaborating providers and users, enabled by governance arrangements and supported by a technical platform to support production, storage and use of data, information and knowledge. From a technical perspective, it would need to assist in connecting independent information systems and data supply chains that produce, exchange, and analyse data and information. From a social perspective, through its governance (i.e. leadership authorising environment and decision-making mechanisms), it should seek to activate, align, catalyse and coordinate action across providers and user communities.

This may be achieved by connecting into pre-existing governance mechanisms that steer relevant activity in the broader ecosystem and which cannot be directly tasked by a national capability. These mechanisms include decision-making bodies, such as standards development organisations, and professional peak bodies.

3.2.2. Tailoring information to decision contexts

The pilot project focused on a specific decision context and, as will be the case for any other usage contexts, it required a combination of climate and natural hazard information at appropriate scales, together with tailored information related to the functioning of the sectors, activities, systems and infrastructure for which climate and disaster risk is being assessed.

While each decision context may need similar forms of knowledge (e.g. narratives, scenarios, data), tailoring of information and tools to the decisions is likely to be required. The need to tailor for any given decision context will be determined by a number of variables including the nature of the decisions being made, the time horizon, the complexity and state of knowledge about the system under consideration and the stakeholders involved. A national capability would need to service the significant variability in the acknowledgment, awareness, understanding and capacity to address climate and disaster risk within and between the decision contexts and information communities. Knowledge brokerage and translation will also be required to assist users to access, use and interpret information.

Specific recommendations for the national capacity in relation to production and provision of specific types of information and knowledge are provided in section 3.3.

Recommendation 3 – Identify priority information communities and address their data information and knowledge needs, while providing a knowledge, translation and brokering function and user capacity building. The national capability should provide a means for bridging and knowledge exchange between information communities including: provider and user communities; government, industry and research communities; and sectoral communities.

3.2.3. Bridging climate and disaster risk information communities

The Framework articulates a whole-of-government, industry and society approach to disaster risk reduction. Therefore, there is a need for the national capability to assist in bridging disaster management oriented information communities and those attempting to address longer term climate risk.

Recognising this need, the European Union is investing in collaborative initiatives to bridge disaster risk reduction and climate adaptation communities. These include the development of platforms for sharing knowledge and enhancing collaboration between the climate change adaptation and disaster risk reduction research, policy and practice communities;[15] innovation programs to support development of methods and tools for climate adaptation and disaster resilience;[16] and collaborations to develop coherent national and European approaches on disaster risk reduction, climate change adaptation and resilience strengthening.[17]

In Australia, the need for enhanced collaboration between the climate and disaster risk information communities has also been recognised in the recent report *Climate Science for Australia's Future*.[18]

Recommendation 4 – Establish technical and institutional connectivity to more effectively bridge and coordinate action between climate and disaster risk information communities.

3.3. Knowledge forms: narratives, scenarios, frameworks

There are a variety of forms of knowledge such as narratives, scenarios, frameworks and analytical models, information and data (shown in Figure 11). These are used for a range of purposes such as orientating, organising, structuring and analysing, that are critical to developing a shared understanding and determined collective action to solve problems. These knowledge resources are interconnected as narratives shape scenario development and analysis, which shape frameworks for structuring activity, which in turn guide data collection, development of analytical models and tools and the production of information. Information and data also support the development and use of these other forms of knowledge.

However, real-world complexities mean the connection between these activities is rarely linear. In practice, data and information of many types are used across these processes. Shared narratives may develop based on video footage, while scenarios may draw upon lived experience, expert judgement and geospatial data from Geographic Information Systems.

Function	Knowledge form	
Organising	Narratives	Data & information
Orientating	Scenarios	
Structuring	Frameworks	
Analysing	Analytic models	

Figure 1 – Functions and forms of knowledge for disaster risk reduction

Indigenous knowledge systems are used by Indigenous people to understand, interpret and manage their biophysical environment, which represent a different worldview to that of Western scientific knowledge systems. They embody deep knowledge of natural systems and land management practices

[15]Placard interchange https://www.placard-network.eu/
[16] BRIdges the GAp for Innovations in Disaster resilience (BRIGAID) http://brigaid.eu/
[17] Enhancing Synergies for disaster Prevention in the European Union (ESPREssO) http://www.espressoproject.eu/
[18] 'Climate Science for Australia's Future', NCSAC, July 2019, https://www.industry.gov.au/data-and-publications/climate-science-for-australias-future

that can be used for disaster risk reduction. For example, Australian Indigenous[19] people have used fire (and cultural burning practices) to manage land for millennia. A key challenge for a national capability is to improve the connections between these activities, recognising they happen at different scales and timeframes.

3.3.1. Narratives and scenarios

Narratives are stories we develop to explain the world around us. Narratives assist in developing a shared understanding of key issues, values and strategies for coordinated responses. Place-based narratives of change are used to address the mismatch between the typically science-based and technical framings of climatic risk and the local place-based understandings of climate extremes and responses of people living in these places.[20]

These narratives need to be co-developed with communities, so their individual value judgements can be reflected and be incorporated as knowledge products along with climate science-based information to gain a broader and inclusive understanding of climate risk and efforts to mitigate it. Narratives therefore play a key role in learning and adaptation. They motivate more structured enquiry, such as scenario analysis and modelling, and can draw on many forms of knowledge.

Scenarios provide a plausible representation of a future state developed to assist users to explore implications for any given decision context, including climate or disaster risk. To be plausible, scenarios are typically based on available evidence and assumptions about trajectories of change. Future climate scenarios based on climate projections are typically used to present a range of potential future states of the climate based on different modelling assumptions. Climate scenarios have been developed at global, regional, national and state level.

When attempting to assess climate and disaster risk, users experience several challenges. Firstly, in determining the appropriate scenarios to use. Secondly, reconciling potentially different answers given by different scenario products. Finally, and perhaps most importantly, attempting to imagine a future state to explore the intersection of future climate and hazard with a future state of society, environment and the economy. This challenge requires scenarios to be co-created, enabling stakeholders to explore an uncertain future encompassing climate, hazard, exposure and vulnerability.

Under climate change, scenario exercises play a vital role in developing a shared understanding of potential futures, identifying and prioritising emerging issues, and developing robust responses. They have the capacity to combine a range of formal models with expert and local knowledge. Scenarios and related techniques such as visualisation, simulation and gaming provide platforms for analysis and learning about complex risks.

Recommendation 5 – Support ongoing efforts to develop and use consistent climate projections, together with tailored scenarios on hazard, exposure and vulnerability that are being undertaken within the climate science, risk and adaptation communities in Australia. In particular, it should support the development of a suite of national and downscaled regional climate projections and tailored, localised scenarios of hazard, exposure and vulnerability developed for place-based risk assessment.

3.3.2. Frameworks

Frameworks are used to describe the structure of underlying systems. They are constructs that express a shared understanding of how things work, enabling a definition of roles and guiding coherent action. In knowledge systems, frameworks shape the production and use of data, models and information.

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[19] In this report, the terms Aboriginal and Indigenous refer to Aboriginal and Torres Strait Islander and First Nation peoples of Australia and where we talk of “communities” it includes Aboriginal and Torres Strait Islander communities

[20] Krauß, W., & Bremer, S. (2020). The role of place-based narratives of change in climate risk governance. Climate Risk Management, 28, 100221. doi:https://doi.org/10.1016/j.crm.2020.100221

As noted in the Commonwealth Scientific and Industry Research Organisation *Climate and Disaster: Technical Reports*,[21] there has been a recent proliferation of frameworks and related analytic models and tools to assess climate and disaster risk. To some extent, these diverse frameworks have developed organically within jurisdictions and sectors, to inform independent disaster risk reduction and climate adaptation responses. This diversity is a healthy reflection of the extent of activity and the wide variety of potential modelling approaches available.

However, this proliferation often reflects a failure to learn from previous experience, with fragmented and uncoordinated development of climate adaptation tools and methods, and insufficient critical mass and continuity of resourcing. Efforts to coordinate and harmonise frameworks and modelling activities can play a vital role in fostering shared understanding, increasing user adoption.

Recommendation 6 – Through the national capability's governance arrangements and collaborative networks, support improved harmonisation and integration of existing frameworks for climate and disaster risk reduction.

3.4. Analytical models and tools

Modelling is a fundamental element of the information production process for disaster risk reduction, focusing on predicting short and long-term natural hazards and the climate and disaster risk. An analytical model is a set of mathematical equations that describe the behaviour or relationship of elements of the system being modelled. This type of model is well suited to dealing with linear systems. Models take data and information and process it into new information products.

There is strong demand for climate and disaster risk analytical models and tools from across government and the private sector due to a recognition that climate and disasters are a strategic risk to their ongoing viability (e.g. the insurance sector) or are due to regulator influence (e.g. Australian Prudential Regulation Authority) or credit ratings agencies.

The increase in system complexity and our limited ability to adequately model and predict behaviour, together with a shift from a stable to a changing climate, limit the value of current approaches. However, innovations in data collection and processing capabilities, emerging modelling techniques and advances in information technology is broadening where, why and how models may be used.

These countervailing trends represent a need and potential for innovation in disaster risk reduction modelling, in the purpose of models, and the ways in which they are created and used.

Model uses - At the science-policy interface, information products such as simulations, graphs and maps that visualise the outputs of analytic models, provide a way to compare worldviews, develop shared understanding, define objectives and identify issues and implications of options. Modelling not only connects research and policy, but it also serves as a means of communication and alignment across policy domains, and across information communities.

Analytical models take different forms such as conceptual, process or data driven, or coupled or integrated. They reflect different framings, are based on different modelling paradigms and use different types and sources of data. The primary function of models is similarly diverse. They may be used to describe, understand, explore, forecast, project, simulate or evaluate. Their purpose may extend beyond simply informing decisions to justifying (for compliance or accountability), evaluating (to frame issues) or defining, sharing and legitimising options and expectations. Models can therefore become an integral part of organisational and knowledge systems. For example, credit rating systems and infrastructure cost–benefit analysis methods become required steps in large-scale investments. In these roles, models play important functions in the interactions across hierarchies and organisations.

Innovation in risk models - There is significant collaboration around development of analytical models in some domains (such as global modelling efforts in climate sciences and health), however much of the activity around development of analytical models is uncoordinated, with models being developed within individual organisations, designed for specific usage contexts. This variety may create issues of incompatibility between assessments that use different approaches. This would require harmonisation and standardisation. In the European Union, for example, harmonisation of risk modelling is being addressed through an innovative public-private partnership and investment in developing a shared open risk-modelling platform (OASIS).[22]

As models are typically developed for specific purposes, understanding which models to use in any given context requires expert judgement. A key challenge for model users is trying to determine which of the variety of scenarios, frameworks, analytical models, methods and tools to use in any given situation. As end users often interact with analytical models through digital tools, they need to be confident they are using the most appropriate tool and analytical model, before investing in learning to use it, and embedding it in their business or operational practices.

There are increasing calls for trusted, authoritative, credible, repeatable and comparable information, tools and methods for the assessment of climate and disaster risks. In the climate adaptation context, the proliferation of tools, lack of clarity around the 'best' tool to use, and uncertainty about ongoing resourcing and support for these tools has led to confusion, lack of confidence and, ultimately, lack of tool adoption among end users.[23]

Recommendation 7 – Support and coordinate the development and assurance of appropriate, relevant, recommended frameworks, models, tools and approaches for climate and disaster risk assessment and disclosure. An authorising environment that gives certainty to users on recommended frameworks, methods and tools is of critical importance.

3.5. Data availability and access

Discovery, access, and preparation of data and information for risk assessment is a time-consuming process. Scientific data on climate, natural hazard and the underlying hydrological, environmental and weather systems is complex, with typically large volumes of data being difficult for all but the most sophisticated of users to access, interpret and use. Critical data required to understand risk – covering hazard, exposure and vulnerability – is held within numerous different systems and has varying access arrangements across public, private and research sectors. This data relates to building footprints, infrastructure location, land valuation, supply chains and economic activity and also covers localised flood and bushfire hazard footprints.

In its report *Building an open platform for natural disaster resilience decisions*,[24] the Australian Business Roundtable highlights that 'crucial natural disaster information is difficult and costly to access, often incomplete or out of date and frequently duplicated across sources. It is often single purpose and the needs of multiple stakeholders have not been considered.' This was also discussed in the Royal Commission into National Natural Disaster Arrangements' (Royal Commission) Interim Observations[25] and the Commonwealth Scientific and Industrial Research Organisation report to the Prime Minister on climate and disaster resilience,[26] which highlights the role of data as a key enabler and the 'compelling

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[22] OASIS Loss Modelling Framework https://oasislmf.org/

[23] Webb, R & Beh, J 2013, *Leading adaptation practices and support strategies for Australia: An international and Australian review of products and tools*, National Climate Change Adaptation Research Facility, Gold Coast, page 105

[24] Deloitte Access Economics (2016) Building an open platform for natural disaster resilience decisions. Australian Business Roundtable for Disaster Resilience & Safer Communities. http://australianbusinessroundtable.com.au/assets/Building%20an%20Open%20Platform%20for%20Natural%20Disaster%20Resilience%20Decisions%20CLEAN.pdf

[25] The Interim Observations of the Royal Commission into National Natural Disaster Arrangements (Observations 46, 49, 60-63) https://naturaldisaster.royalcommission.gov.au/system/files/2020-08/Interim%20Observations%20-31%20August%202020_0.pdf

[26] CSIRO (2020) Climate and Disaster Resilience https://www.csiro.au/en/Research/Environment/Extreme-Events/Bushfire/frontline-support/report-climate-disaste-resilience

case' for common approaches and platforms for resilience planning and operational disaster management.

Efforts in the research sector to make data more Findable Accessible Interoperable and Reusable[27] have helped to address these challenges. However, even if data is openly available, the size of the data may make it difficult to use. Transaction costs may also be involved in preparing the data for analysis. Data that is not openly available may be time consuming to process or prohibitively expensive to negotiate access and secure licences for use.

Recommendation 8 – Identify priority national disaster information needs and coordinate efforts to improve availability of, access to, and use of this data and information and, where necessary, address gaps. The initial focus should be on improved access and use of existing information, scaling up existing processes and providing guidance and education in how to most effectively apply it to users' business needs. This includes arrangements for accessing and holding sensitive data and information held by insurance and infrastructure managers. This also includes supporting Indigenous community led efforts to manage and use Indigenous knowledge (in particular, cultural burning practices) for disaster risk reduction, and ensuring CARE Principles guide its governance (Collective Benefit, Authority to Control, Responsibility, Ethics).[28] Specific recommendations related to generating critical disaster risk information are provided in sections 3.5.2 to 3.5.7.

Addressing these challenges requires a socio-technical approach based on the establishment of improved data storage, access and analytic infrastructure, together with development of appropriate institutional arrangements such as data governance, data licensing and data supply chain optimisation that addresses the privacy, commercial interest and openness concerns that currently hamper data exchange and use.

3.5.1. Heterogeneity and standardisation of data

Inconsistencies in data standards and the challenges in management of and access to data were key findings of the stakeholder engagement undertaken as part of the NDRISC design plan development. These issues also surfaced through the pilot project, which constrained modelling efforts.

A national approach is required to catalyse standardisation of natural hazard data. Hazard data is generated at a variety of different scales with different extents ranging from low-resolution national-scale products often produced through satellite imagery and modelling, to state and local-scale data generated using field-based techniques, remote sensing and modelling.

This results in a spatial patchwork of inconsistent data of variable quality, at different scales, related to different periods of time. Specific sectors and jurisdictions are addressing aspects of these challenges resulting in consistent information products. For example, state bushfire risk maps or the industry-led Climate Measurement Standards Initiative.[29]

Exposure and vulnerability data, which includes data on the built and natural environment, the economy and society, are the responsibility of other departments and levels of government. The governance mechanism for a national capability should adequately interface with, link to, leverage, connect and empower these efforts so that the required data is available to support understanding, assessment and mitigation of disaster risk.

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[27] https://www.go-fair.org/fair-principles/
[28] CARE Principles for Indigenous data governance - https://www.gida-global.org/care
[29] https://climate-kic.org.au/our-projects/cmsi/#:~:text=The%20Climate%20Measurement%20Standards%20Initiative,oversee%20financial%20and%20community%20stability.

Recommendation 9 – Support and promote the development and adoption of standards for disaster risk data information and processes. These efforts should focus as a priority on standardisation of hazard data.

In addition, through its governance and collaboration networks, the national capability should interface with and provide disaster risk oriented requirements (including standardisation needs) to information communities that are generating, and the governance bodies (such as the Australian Data and Digital Council) that are enabling, the production of exposure and vulnerability information.

Recommendation 10 – As a key element of its governance, the national capability should provide continual and, where appropriate, independent evaluation to assess and ensure the integrity, traceability and reliability of information models, methods and approaches used for decision making, ensuring their alignment with current science and research.

3.5.2. National natural hazard information products

There is a need to improve the collation and integration of near real-time disaster event data and information to enable national response. Collection of historic event data is also required to inform risk reduction activities.

Some historic hazard extent data exists at a national scale. This data was collected through satellite imagery, such as for bushfires and floods, and at state and local levels through a combination of satellite imagery and localised data capture. This information is useful for response and recovery and the data resources are useful to inform modelling about future events. However, these events are non-linear, with changes in intensity, duration and frequency, extent and location becoming increasingly difficult to predict. There is therefore a need to improve prediction of future events through modelling techniques.

Harmonising and integrating historic hazard data from states is expensive and time consuming, demonstrated through the process of creating national bushfire information products such as the operational boundaries map for the 2019–20 fire season and national burn extent dataset for National Bushfire Recovery Agency.

Opportunities exist to optimise these data supply chains and improve the exchange and integration of state-level data to produce national products. Opportunities also exist to develop and run modelling processes to cost-effectively generate national-scale prediction products based on agreed, consistent standards and approaches.

These could be used to supplement jurisdictional products where they exist, and fill gaps and meet unmet needs in jurisdictions that lack this data.

National product generation could involve harmonisation of existing jurisdictional activities through the development of agreed standards and/or government co-investing in new approaches. For example, predicting future hazards such as the potential worst-case fire intensity expected over the next fire season. Increasingly sophisticated modelling techniques are available, based on models of climate, terrain, hydrology and vegetation growth. There are significant opportunities to better coordinate the development of these fundamental datasets that can be used to improve predictions from a variety of different kinds of models.

Recommendation 11 – Coordinate, catalyse action and, where appropriate, take on development of national natural hazard information products. Immediate priorities include bushfire, severe wind and flood hazard information products. In this context, it is critically important to develop partnerships with the private sector to enable exchange of public and private data.

3.5.3. Climate projection information and scenarios

The changing climate is increasing the duration, frequency and intensity of some natural hazards. Climate change is increasingly becoming a driver of change to society and the environment more broadly, affecting the exposure and vulnerability to natural hazards. However, the most significant uncertainties associated with climate and disaster risk reduction relate to a limited ability to predict the magnitude of changes. Uncertainty particularly relates to complex adaptive systems such as climate, socioeconomic development, ecosystem functioning and societal vulnerability.

Anticipatory decisions involving highly uncertain situations could lead to substantial over or under-investment in disaster risk reduction. Under-investments may lead to additional costs being incurred through large residual climate change impacts or through the failure to seize new opportunities. Over-investment runs the risk of leading to waste of these investments if changes are not as severe as projected.

Making decisions in the face of uncertainty means that the need to include scenario planning for climate risk is becoming mandatory. Additional drivers include legal opinion that Australian company directors who fail to consider climate change risks now could be found liable for breaching their duty of care and diligence under the *Corporations Act* in the future[30], and the increasing number of companies disclosing risk in line with the G20 Financial Stability Board's Task Force for Climate-related Financial Disclosure. As an example of the equity involved, the Investor Group on Climate Change alone represents $2 trillion[31] worth of total funds under management.

There is a significant 'installed base' of climate information products, and climate risk and adaptation services. A comprehensive evaluation of the climate service capabilities across Australia at national, state and private sector levels is being undertaken as part of a study in response to the National Climate Science Advisory Committee report *Climate Science for Australia's Future*. A related study on the next generation of regional climate projections for Australia is also being prepared.

However, Australia does not yet have an authoritative agreed set of climate change scenarios for the country nor standardised guidance on how to consistently interpret and use these scenarios at more granular levels.

Stakeholder engagement through the development of the NDRISC design plan identified the need to enable, coordinate and provide access to historic records and re-analysis of weather and climate information in timescales from hours, days, weeks, months and years together with climate projections.

Climate services are being developed to support climate change adaptation and mitigation across multiple sectors and portfolios. However, incorporating climate knowledge into existing modelling and management systems is proving to be a widespread protracted problem. Improving the interface between climate information and disaster risk reduction is critical. Key aspects of this challenge include:

- enabling improved interactions and data exchange between climate modellers and hazard modellers;
- developing and using national scenarios that highlight the sensitivity of existing systems to both individual and concurrent natural hazards; and
- developing and using scenarios to explore the effectiveness of various adaptation options that influence exposure and vulnerability of these systems.

Recommendation 12 – Inform and support the development and maintenance of national scenarios for climate and disaster risk planning and provide guidance in their use, including for downscale applications and harmonising climate risk assessment and adaptation activities with disaster risk reduction activities. Integrated scenarios of climate, natural hazard, exposure, vulnerability and risk will be required. Harmonising frameworks, exchange of knowledge and guidance will improve the coherence of activity between climate adaptation and disaster risk reduction efforts.

An agreed authoritative set of scenarios and associated guidance would contribute coherence and consistency in the consideration of future potential threats and impacts in organisational, sectoral or jurisdictional assessments of risk, exposure, vulnerability and resilience. The expertise and policy guidance resident within the Commonwealth Scientific and Industrial Research Organisation, the

[30] https://cpd.org.au/2019/03/directors-duties-2019/
[31] https://igcc.org.au/

Bureau of Meteorology and the Department of Agriculture, Water and the Environment more broadly, including the Australian National Outlook, would be needed to develop these scenarios.

3.5.4. Exposure information

Exposure refers to the things (people, activities, physical environmental assets, built and natural environmental assets) that may potentially be impacted by a hazard. This refers both to the entities that are directly impacted within the hazard area, as well as those that are indirectly impacted within and beyond the hazard area. For example, through supply or value chains. Development in hazard-prone areas increases exposure and is a significant driver of risk. Risk-informed planning, investment and development is therefore a critical element of effective disaster risk reduction.

The nature of exposure information required for risk assessment is entirely dependent on decision context. For example, an agricultural risk assessment will require information on the soil condition, hydrology and the agricultural production system. However, there are critical commonly used products on exposure information that are required to support climate and disaster risk assessment across multiple decision contexts. Among the most important of these is an integrated suite of products characterising built environment. These include:

- **buildings** – location, footprint, value, construction materials, occupancy type, dependency on utility supply;
- **infrastructure** – hydrological, telecommunications, utilities and transport networks including interactions between individual assets within infrastructure types and the interdependency between infrastructure types; and
- **services supported by infrastructure** – the social and economic activity enabled through infrastructure and impacted when infrastructure assets are damaged or inoperable as a result of natural disasters.

For both the buildings and infrastructure datasets there is a need to support production of and enable access to consistent national products. This necessitates connecting data that provide a spatial footprint of buildings and infrastructure (describing where it is and how it is connected), to data that describe its characteristics such as construction material and date, condition, ownership, and operations. These data exist in numerous disparate data systems across levels of government and in industry including land registries, building code databases, local council development applications systems, insurance company policy databases and utility company facility management systems.

The Insurance Council of Australia has called for the development of a national buildings register database to underpin construction compliance regimes in the contexts of recent compliance failures and increasing climate and disaster risk.[32]

Recommendation 13 – Foster collaboration and explore opportunities for public-private partnership to develop consistent national built environment and infrastructure information products. The governance framework and business models for the national capability should provide a mechanism for exchange, integration and use of such data. It could also play a role in catalysing action and enabling integration and exchange of built environment location data and the numerous sources of other data necessary to assess risk.

Understanding the relationship between infrastructure and the services supported by it is a complex undertaking requiring significant investment to model these complex systems. However, it is a critical task as it underpins the ability to assess and address both component and system vulnerability through risk reduction measures.

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32 http://www.insurancecouncil.com.au/assets/submission/2019/2019_08_02_The%20Director%20Public%20Accountability%20Committee_Regulation%20of%20Bu....pdf

Recommendation 14 – Support and coordinate the development of models and data to improve understanding of the relationships between infrastructure and the services it supports. This would enable a more comprehensive quantitative assessment of vulnerability, risk, and potential impacts and costs of disaster on both the physical assets and the services they support.

3.5.5. Vulnerability information

Vulnerability is the propensity of exposed elements, such as human beings, their livelihoods, assets and the services they rely on, to suffer adverse effects when impacted by hazard events. Information required to characterise vulnerability is highly fragmented, and hard to access. Relevant data sources include socioeconomic statistics from the Australian Bureau of Statistics and significant volumes of data held by private sector and small-scale localised datasets produced through targeted surveys. However, much of the required understanding of vulnerability is also based on values, attitudes and perspectives of citizens, businesses and government stakeholders.

The program of work behind *Profiling Australia's Vulnerability*[33] developed and tested methods to explore and understand the complex and interconnected systems that support society and influence resilience or vulnerability. The project used a 'Deconstructing Disasters'[34] approach to understand the root causes of vulnerability and support resilience building. This approach explored how systems work in times of stability or times of disruption, and investigated why values matter when working out how to do things differently in the future. The approach assisted in reframing thinking and planning about how to move towards resilience at local, regional and national scales ideally before, but also after large 'shocks' to society, economy and the environment.[35] Moving towards resilience after a large shock adds complexity if significant effort to reimagine and socialise what a resilient community might look like had not been undertaken prior to the shock.

This engagement methodology enables an exploration of the things that people value, the tensions and trade-offs between different values that influence priorities and choices. Co-development of system models that expressed a shared understanding about how systems work is an important social process and foundational element to explore vulnerability and options to develop resilience.

Recommendation 15 – Efforts to develop an understanding of vulnerability at a range of scales, from local community to sectoral, using vulnerability profiling techniques should be endorsed, promoted and supported by the national capability.

In addition to the deeper qualitative engagement to explore vulnerability, there is a need to improve an understanding of vulnerability of physical infrastructure assets, the interdependencies between them and of the services they support through quantitative, data-driven modelling efforts. This includes such things as the development and adoption of standardised damage functions that describe the relationship between hazard type and magnitude and expected level of damage for different classes and types of infrastructure assets.

To enable standardised assessment, these methods need to be developed, tested and made more open for wider use. This would assist in addressing some of the uncertainty in typical probabilistic catastrophe modelling. Collaboration with the insurance and utility sectors will be critical to secure access to and use of infrastructure and insurance damage data to inform development of these functions.

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[33] https://knowledge.aidr.org.au/resources/profiling-australias-vulnerability/
[34] Deborah O'Connell, Russell Wise, Veronica Doerr, Nicky Grigg, Rachel Williams, Seona Meharg, Michael Dunlop, Jacqui Meyers, Jill Edwards, Monica Osuchowski, Mark Crosweller (2018). Approach, methods and results for co-producing a systems understanding of disaster. Technical Report Supporting the Development of the Australian Vulnerability Profile. CSIRO, Australia.
[35] https://ecos.csiro.au/deconstructing-disasters-taking-stock-on-where-we-are-now-and-dreaming-our-future/?utm_source=ECOS-2020-05&utm_medium=newsletter&utm_campaign=ECOS

Recommendation 16 – In collaboration with private sector, support the development and standardisation of quantitative vulnerability assessment data, models, methods and tools for infrastructure assets, including the development of standardised damage functions for hazard magnitude and infrastructure asset types.

3.5.6. Risk information

In Australia, there is a lack of accessible, authoritative information that articulates climate and disaster risk. In particular, the intersection of hazard, exposure and vulnerability is not well understood.

The British Government has developed the *National Risk Register*, which provides an assessment of the likelihood and potential impact of a range of different risks that may directly affect the United Kingdom based on natural and other hazards.[36] This has been done as part of the development of the National Security Strategy. The register also signposts advice and guidance on what members of the public can do to prepare for these events. Similar approaches have been adopted at a city scale, for example, *The London Risk Register*.[37]

There are limits to the utility of these approaches as they are often based on models that are relatively ineffective in predicting previously unobserved loss scenarios. Such 'black swan' events by definition fall outside the predictive capability of these models. Furthermore, they do not adequately address the issue of cascading, and, compounding risk,[38] nor do they engage deeply enough with an understanding of vulnerability.

Scenarios and narratives are increasingly being used to assist communities of decision makers to explore potential futures and options. For example, the freight supply chain industry scenarios used in the pilot project. However, to assist users to engage more deeply with exposure and vulnerability, much still needs to be done to better integrate climate projection scenarios with broader co-developed scenarios of economic and societal trajectories. In addition, currently there is very little in the way of accessible guidance or good practice to explore future risk in the context of uncertainty and complexity. The *Profiling Australia's Vulnerability* project[39] has demonstrated an engagement methodology that has assisted communities to explore an uncertain future, complexity, and vulnerability. This methodology enables more effective risk assessment and exploration of mitigation options.

Recommendation 17 – Explore adoption of a similar approach to the United Kingdom in identifying key hazards and assessing risk against these hazards, to support national coordination efforts. These high-level individual risks could be used as inputs to vulnerability and risk assessment at more granular levels and to address multi-hazard, compounding and systemic risk.

Numerous climate and disaster risk assessments are undertaken and these are typically not shared. As a result, there is limited learning and knowledge exchange about the processes and results of risk assessment. Furthermore, the ability to assess effectiveness of and learning from risk management and adaptation interventions is also limited, as this requires information about the risk (contained in risk assessments), together with information about management actions, and post-hazard impact assessment.

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[36] The National Risk Register for the UK - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/61934/national_risk_register.pdf
[37] https://www.london.gov.uk/sites/default/files/london_risk_register_6.0.pdf
[38] Global Assessment Report on Disaster Risk Reduction https://gar.undrr.org/sites/default/files/reports/2019-06/full_report.pdf
https://gar.undrr.org/sites/default/files/reports/2019-06/full_report.pdf section 2.1
[39] Department of Home Affairs, 2018, *Profiling Australia's Vulnerability: The interconnected causes and cascading effects of systemic disaster risk* https://www.aidr.org.au/media/6682/national-resilience-taskforce-profiling-australias-vulnerability.pdf

Recommendation 18 – Enable access to, collate and curate completed climate and disaster risk assessments, which are currently inaccessible, or scattered across the digital landscape.

3.5.7. Impact assessments

Information about the impacts and consequences of natural hazard and disaster events is critical across all phases of the disaster management continuum (prevention, preparedness, recovery, response). This need was identified in the initial NDRISC design plan, which highlighted that some of the required data on impact and consequence would be 'sensitive' data related to critical infrastructure.

The same information is also of critical importance for broader climate and disaster risk reduction activities to:

- understand the economics of resilience – determining the (avoided) costs of impacts on infrastructure and services to inform resilient investment;
- quantify the cost and benefit of adaptation options and identification of the most robust, least regret options against a range of different scenarios; and
- monitor efforts to reduce risk and to report against the Framework and the United Nations Office for Disaster Risk Reduction's Sendai Framework for Disaster Risk Reduction (see Section 3.5.9).

A large number of assessment activities capture aspects of this information for particular geographies,[40] or for specific hazards.[41] However, these efforts are largely uncoordinated resulting in fragmented data captured in inconsistent ways, creating significant challenges for aggregation, integration and use. Furthermore, when assessing impacts and (avoided) costs of disasters it is critical to understand both the impacts on physical assets as well as the costs of disruption to social, economic and environment services and activities supported by them.

Recommendation 19 – Harmonise, aggregate and improve the coherence of natural disaster impact and consequence data to assist in guiding and monitoring national disaster risk reduction efforts and reporting against the Sendai Framework.

3.5.8. Risk reduction effectiveness

Risk assessments are undertaken to identify, quantify and guide actions to manage, mitigate and implement adaptive strategies to address climate and disaster risk. There are a wide variety of different approaches to reducing risk including infrastructure hardening, building more resilient supply chains, land use planning, fuel load management and building codes for bushfire risk reduction, resilient investment financing and risk governance mechanisms.

The national capability should play a key role in monitoring and evaluating the effectiveness of interventions to address risk. Lessons learned from interventions need to be captured, curated and rapidly shared to enable adaptation and learning across an extending network. This requires collating and curating information about risk (from risk assessments), management action, and impact and consequences on the values and assets at risk of subsequent hazard and disaster events that have occurred.

Recommendation 20 – Monitor, evaluate and exchange learnings from risk reduction activities to enable adaptive risk reduction activities at scale.

[40] See for example Queensland Reconstruction Authority's Damage Assessment and Reconstruction Monitoring System (DARMsys™) https://www.qra.qld.gov.au/key-projects/damage-assessment-and-reconstruction-monitoring-darmsystm

[41] See for example CSIRO's Rapid Impact Assessor and Bushfire House Surveyor applications https://www.csiro.au/en/Research/LWF/Areas/Landscapes/Understand-manage-bushfires/Bushfire-Assessment

4. Vision for a national capability

4.1. The need

The need for a national platform called for by the Australian Business Roundtable,[42] and defined through consultation around the development of the initial NDRISC design plan,[43] has been further validated through the pilot project. The need for a national platform has also been highlighted in the Commonwealth Scientific and Industrial Research Organisation's *Climate and Disaster Technical Reports.*[44] The Government's National Climate Science Advisory Committee report also identifies the need for a comprehensive climate services capability to provide tailored information to assist organisations and sectors in managing risks from a variable and changing climate.[45]

A national capability would enable efficient access to reliable, authoritative, trusted, analysis-ready information products and modelling capability, processes and tools, combined with guidance, expertise, knowledge translation and brokerage to enable climate and disaster risk understanding, assessment and action. As such, this capability represents a foundation for enabling the evidence-based systemic climate and disaster risk reduction envisioned through the Framework.

The development of a national capability also aligns with international best practice, which recommended the development of national platforms for disaster risk reduction characterising them as 'officially declared national coordinating multi-sectoral and interdisciplinary mechanisms for advocacy, coordination, analysis and advice on disaster risk reduction'.[46] Recognising the complex and cross-cutting nature of disaster risk reduction, national platforms are recognised as playing a key role to 'provide and mobilise knowledge, skills and resources required for mainstreaming disaster risk reduction into the development of policies, planning and programs'.[47]

The systemic nature of climate and disaster risk and the response required to address it, as framed by the Sendai Framework for Disaster Risk Reduction and echoed in the Framework, necessitates a coordinated effort across government, industry and society approach. Reframing the objectives of disaster risk reduction as systemic risk-informed approaches to sustainable development (as depicted in Figure 2) allows for more a more holistic, systemic approach than traditional hazard-oriented disaster and emergency management activities.

[42] Deloitte Access Economics (2016) Building an open platform for natural disaster resilience decisions. Australian Business Roundtable for Disaster Resilience & Safer Communities. Available at: http://australianbusinessroundtable.com.au/assets/Building%20an%20Open%20Platform%20for%20Natural%20Disaster%20Resilience%20Decisions%20CLEAN.pdf
[43] National Resilience Taskforce - National Disaster Risk Information Services Capability - Design Plan (was Blueprint)
September 2018.
[44] Climate and Disaster: Technical Reports (2020). CSIRO, Australia.
https://www.csiro.au/en/Research/Environment/Extreme-Events/Bushfire/frontline-support/report-climate-disaste-resilience
[45] Climate Science for Australia's Future - A report by the National Climate Science Advisory Committee https://publications.industry.gov.au/publications/climate-change/climate-change/publications/climate-science-australia-future.html
[46] United Nations Office for Disaster Risk reduction https://www.preventionweb.net/sendai-framework/nationalplatforms
[47] UNISDR, 2007. Guidelines: National Platforms for Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction. 2007. Geneva (page 1)
https://www.preventionweb.net/files/1680_GuidelinesNationalPlatformsforDRR.pdf

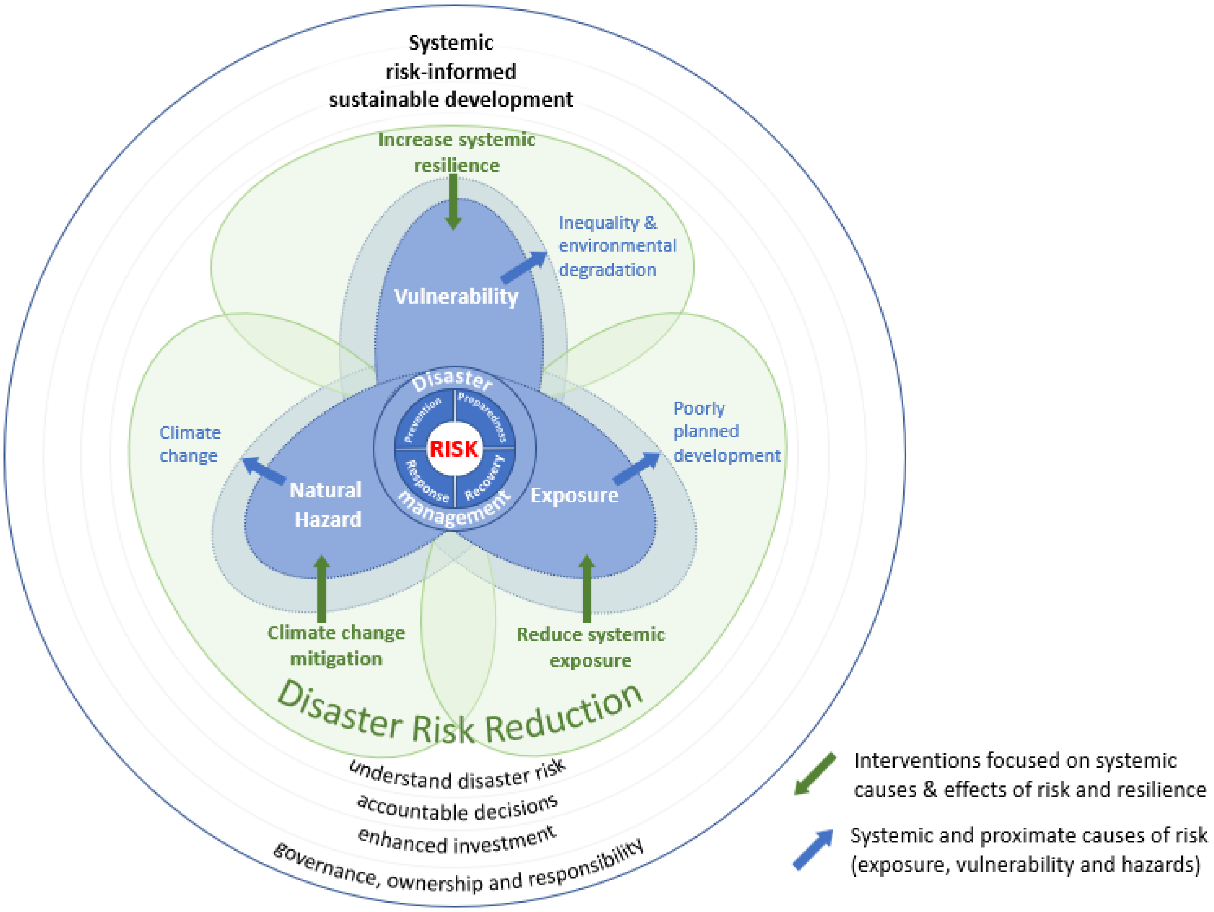

Figure 2 – Extending the scope of disaster management to disaster risk reduction[48]

4.2. Current state and design requirements

Recognising the scale and scope of the response required, a national capability would need to address a wide range of issues to meet needs of users across a large and complex set of actors, initiatives and systems. A large number of data systems, platforms, initiatives and actors across governments, research and private sectors are implicated in this realisation of a national capability. Many elements needed to support a national capability already exist or are being developed across a data ecosystem. However, a significant aspect of the role of a national capability would be to orchestrate, coordinate, connect and build on existing activities and fill gaps where needed.

Platforms of this scale, developed collaboratively and comprising multiple, discrete independent components, are developed over an extended period of time and will need to continually evolve. Given these realities, several design principles to guide the development of a national capability are recommended.

- **Federated** – a federated approach to implementation, enabling autonomous, independent organisations and initiatives to build a shared vision, align agendas and collaborate through inclusive governance mechanisms.

[48] Adapted from Climate and Disaster: Technical Reports (2020). CSIRO, Australia. (Figure 2 page 13) file:///C:/Users/box019/Downloads/CSIRO-Climate-and-Disaster-Resilience-Technical%20(2).pdf

- **Distributed –** the technical systems, human resources and other capabilities are, and would remain, distributed across organisations and sectors.
- **Networked** – as a distributed network of interacting capabilities that build on, connect and coordinate existing activities, the national capability should comprise networked governance and technical systems organised in a series of interconnected hubs.
- **Delegated** – as far as possible, responsibility for any given part of a national capability should be delegated to an existing, appropriately mandated, capable and resourced entity for implementation and operation.
- **Openness** – knowledge resources should be as open as possible ensuring that the right resources are available at the right time in the right form, to those with the right to use them to support decision-making and action.
- **Adaptive management and learning approach** – development, operation and evolution of a national capability should be guided by an adaptive management approach, based on defined theory of change, together with monitoring, evaluation and learning to guide adaptive governance and management responses.
- **Modular** – development activities to build initial elements and ensure continued evolution of the capability to incorporate new realities, technologies and needs should be implemented as discrete, modular activities within predefined but flexible programs of work. These could be implemented in an incremental manner or could be developed more expediently as part of a larger funded effort.

Building on the original NDRISC design plan and findings from the pilot, key elements of a national capability, together with implementation modalities, are presented in the next section.

4.3. Key functional elments of a national capability

4.3.1. Governance

The governance component of a national capability comprises decision-making mechanisms including overall strategic direction setting of the capability, program governance, data governance and the governance of the capability's core components. These governance mechanisms must also connect into and network external governance mechanisms such as industry peak bodies, regulatory and standard-setting bodies and the governance mechanisms of existing platforms, initiatives and information communities.

The primary functions of the governance component are:

- **leadership** – clearly identified national leadership;
- **mandate and authority** – clearly defined mandated and authorised environment for the production and use of climate and disaster risk reduction information and services;
- **collective decision-making** – to steer the national capability and its independent but interrelated networked constituent activities;
- **policy development and promulgation** – setting priorities for, initiating, oversight, commissioning, authorising and supporting the promulgation of relevant policies, standards and other agreements;
- **focal point for climate and disaster risk reduction and adaptation activity** – within Australian government and interfaces to other policy functional areas across Commonwealth and state governments and the private sector; and
- **coordination and alignment** of activities the network of capability providers.

Governance mechanisms and an authorising environment for national products and services are critical functions. They provide users of information products and services with certainty, and assurances that the information and services they are using are recommended, reliable and trustworthy. Building trust in the quality and reliability of products and services is a key enabler to improve climate and disaster risk reduction.

Data governance will be a critical concern within a national capability. Priority focus areas would include

- establishing roles and responsibility for national information product creation and maintenance;
- determining access arrangements; and
- ensuring transparency, certainty, and equitability in the exchange and use of data while respecting privacy, addressing security requirements, and operating within the bounds of social licence.

Governance mechanisms that enable, and facilitate public-private partnerships, will be required. Ideally, private sector stakeholders, together with research sector stakeholders, should participate in governance and decision-making.

4.3.2. Information platform

The information platform component comprises the data, information and knowledge resources to support the climate and disaster risk user community, together with a technology layer that supports the production, storage, processing and analytics, access and use of resources and services.

The production of national-scale information products involves complex processing workflows using large datasets and would therefore require significant data storage, and computational resources. The environment would support the production of critical priority national natural hazard, exposure and vulnerability products, together with the risk assessment analytics into which these products are input.

A shared analytic platform enables collaboration and experimentation among user communities to innovate, develop and test data and information products, analytic methods, models and tools. A coordinated approach to data storage and processing in the cloud across a range of information communities that need to exchange data – including climate and weather, hydrology, environment for risk assessment – could be orchestrated through a national capability. This would greatly assist in reducing longer-term transaction costs to access, transform and potentially move large volumes of data between different cloud providers.

The critical functions of the information platform include:

- **data and information storage –** cloud-based mechanisms for storage and management of agreed priority hazard, exposure and vulnerability data and information products, together with input datasets used in the generation of these products;
- **information and services discovery, access and use –** a range of mechanisms to enable users to discover, access and use data, information, models, tools and other knowledge resources;
- **data, information and model production** – production of high-priority data and information products including national bushfire and flood hazard data, national built environment (buildings and infrastructure) data that provide data on location, connectivity and asset characteristics;
- **data supply chains optimisation –** a range of data supply chain issues would need to be addressed through activities undertaken as part of information platform development and operation. This would entail addressing not only the technical challenges such as data standards but also the institutional, legal and commercial constraints on optimal access and use of data;
- **supporting collaboration** – collaboration among and between technical, scientific and user communities (in industry, government and civil society) would be supported through a range of information technologies. This would include shared sandboxes and technical development environments for experimentation and learning and online ‘collabaratories’ – spaces and tools

for dialogue, collaboration and innovation to support co-production, learning and knowledge exchange; and

- **populating and curating a knowledge base –** a range of forms of knowledge would be co-created, above and beyond information products and tools.

4.3.3. Service centre

A service centre enabling deep and sustained engagement between scientists, technical specialists, policy makers and industry users is needed to support private and public sector organisations to overcome the barriers that constrain their ability to credibly assess and manage risks.

A service centre would provide a critical interface between users and the information, tools, methods and approaches offered through the national capability. Simply providing users with template information products or standardised tools and methods is not sufficient. In many cases, users would need assistance in navigating, understanding and applying the information, as well as selecting appropriate methods and tools. Furthermore, given the complexity and the nature of systemic risk, the service centre would need to provide significant assistance and support to users collaborating with them to conduct risk assessments and co-develop adaptation options and strategies.

Activities might include working with the finance sector to develop and test protocols and methods for quantifying and evaluating resilient investment options or the inclusion of Indigenous agency and cultural burning practices for bushfire prevention – addressing the cultural, social, institutional, and operational opportunities and challenges of doing this. Critical functions of a service centre include:

- **connecting and convening** – convening, coordinating and supporting partnerships across silos (sector, jurisdiction) and among diverse stakeholder groups to collaboratively generate shared understandings of root causes and effects of climate and disaster risks and innovative collective responses to mitigate these risks, drawing upon experiential, traditional and scientific knowledge types;

- **co-production, application and testing of risk assessment and adaptation tools, methods and approaches** – includes leading the development, application and testing of methodologies and processes for risk assessment and adaptation, and identifying and driving portfolios of strategically designed projects in collaboration with partners;

- **knowledge brokerage, translation and communication** – includes brokering, translating and enabling use of data information and services, bridging across communities to build consistency and commonalities, and communication to raise awareness of issues and solutions;

- **capacity building –** developing and applying capability-building materials and activities such as training and guidance notes;

- **monitoring evaluation and learning** – includes developing theories of change for priority activities to map out impact pathways; establishing monitoring, evaluation and learning frameworks, providing monitoring and evaluation services for third-party risk reduction activities; and identifying and exchanging lessons learned from across the many diverse portfolios of risk assessment and reduction projects; and

- **knowledge curation –** capturing, collating, integrating and analysing sources of data and information and knowledge to promote consistency in approaches, and develop standards, typologies and robust methodologies as the basis for informing the potential scalability of different approaches.

These functions would be performed by a mix of national capability personnel and an extended network of experts. A mix of ongoing resourcing for certain tasks, together with project-based resourcing for specific risk assessment or other activities, would be anticipated.

A wide range of multi-disciplinary scientific capabilities and competencies would need to be housed in the service centre, or readily accessible and integrated through the capability network. This would include specialists in decision sciences, data science and advanced quantitative and geostatistical analytics, fore sighting and scenario development and use, economics and institutional analysis and design, human-centred design, facilitation and mediation; and knowledge curation and science knowledge brokerage.

4.4. Implementation modalities

4.4.1. Networked hubs

Rather than a single monolithic entity, the national capability as envisaged as part of this pilot project would be formed through a network of interlinked nodes or hubs. Each hub would have a clearly defined purpose, oriented around an information community. Three type of hubs are envisioned:

- **hazard-oriented hubs** such as the proposed National Bushfire Intelligence Capability to bring together expertise and information relating to the specific hazard; ;
- **a centralised hub** to address systemic, complex, multi-hazard disaster and climate risk assessment and mitigation. This would draw on capability hubs to solve complex problems, and comprise a secure element to address the classified information and analytic requirements of agencies, such as Home Affairs, the Department of Defence, and the Department of Foreign Affairs and Trade. It would also address the sensitivities of industry partners related to the integration and use of their data and information together with information developed through NDRISC activities; and
- **sectoral or thematic hubs** such as community- or local government-oriented hub.

The national capability would be dynamic and would identify gaps in disaster risk information. The national capability would work together with other organisations with existing capacity to establish, support, institutionally host or operate aspects of new hubs, as they are needed.

External hubs, that is, hubs funded and operated independently of the national capability that provide critical capability to address aspects of climate and disaster risk, would be connected into the capability's network. Peripheral hubs would be connected through a range of mechanisms, which could include formal delegation of functions, formal alignment of agendas, co-investment, interconnection of governance mechanisms or partnership agreements. A range of technical activities would enable the exchange of information between hubs.

4.4.2. Information communities

Given the significant number of stakeholders to engage, align and coordinate through a national capability, a mechanism to partition the landscape into manageable pieces is required. The concept of information communities – a self-identified group of capability providers and resources that collaborate to meet the needs of a defined set of users – is a distributed systems design concept used to partition complex data ecosystems into discrete independent entities. Some examples of information communities are the bushfire hazard community and the climate information and services community. In the context of a national capability, relevant information communities could be interconnected through the design of technical and institutional mechanisms. Identifying and working with information communities that can deliver elements of the overall capability, significantly reduces the complexity of the system design and implementation challenge.

A national capability would interact with and wire together the governance mechanisms of each community, establishing a federation without undermining the appropriate autonomy of the individual community itself. Identified points of contact, and representation for information communities, can be identified and connected together to steer collective action. This enables autonomous and independent activity to be harnessed, aligned, coordinated and interconnected while enabling the elements to evolve.

In many cases it is likely that there will be existing identifiable information communities associated with data hubs. The bushfire hazard and climate services communities are examples of relevant climate and disaster risk information communities.

4.4.3. Development projects

Given the scale of a national capability and the continually evolving science, technology, user needs and operational context, one approach to building out a national capability is through a series of interrelated development projects. These development projects provide a means of establishing hubs and key components of the capability, such as the governance framework, that would become enduring elements of the capability. In the longer term, development projects would be run as part of an innovation program to address ongoing needs for innovation and to ensure that the capability can continue to evolve as a capability attuned and responsive to Australia's climate and disaster risk reduction needs.

Appendix 1 Summary of recommendations and key judgements

The following are recommendations for focus areas that a national capability would need to address. They are drawn from pilot project and also informed by subsequent discussions around the design of a proposed National Bushfire Intelligence Capability.

Complexity, uncertainty and systemic risk

Recommendation 1 – lead the development and application of methodologies and processes for climate and disaster risk assessment that address complexity, uncertainty and systemic risk.

Users and usage context

Recommendation 2 – the national capability should be developed as a socio-technical system, comprising the collaborating providers and users, enabled by governance arrangements and supported by a technical platform to support the production, storage and use of data, information and knowledge.

Recommendation 3 – identify priority information communities and address their data information and knowledge needs, while providing a knowledge, translation and brokering function and user capacity building

Recommendation 4 – establish technical and institutional connectivity to more effectively bridge and coordinate action between climate risk and disaster risk information communities.

Recommendation 5 – support ongoing efforts to develop and use consistent climate projections, together with tailored hazard, exposure and vulnerability scenarios, being undertaken within the climate science, risk and adaptation communities in Australia.

Recommendation 6 – through the national capability's governance arrangements and collaborative networks, support improved harmonisation and integration of existing frameworks for climate and disaster risk reduction.

Information and knowledge production and assurance

Recommendation 7 – support and coordinate the development, and assurance of appropriate, relevant, recommended frameworks, models, tools and approaches for climate and disaster risk assessment and disclosure.

Recommendation 8 – identify priority national disaster information needs, and coordinate efforts to improve availability, access to and use of this data and information, where necessary address gaps.

Recommendation 9 – support and promote the development and adoption of standards for disaster risk data information and processes. These efforts should focus as a priority on standardisation of hazard data.

Recommendation 10 – as a key element of its governance, the national capability should provide continual and, where appropriate, independent evaluation to assess and ensure the integrity, traceability and reliability of information models, methods and approaches used for decision-making, ensuring their alignment with current science and research.

Hazard information

Recommendation 11 – coordinate, catalyse action and where appropriate take on development of national natural hazard information products.

Scenarios

Recommendation 12 – inform and support the development and maintenance of national scenarios for climate and disaster risk planning and provide guidance in their use, including for downscale applications and the harmonisation of climate risk assessment and adaptation with disaster risk reduction activities.

Exposure information

Recommendation 13 – foster collaboration and explore opportunities for public-private partnership to develop consistent national built environment and infrastructure information products.

Recommendation 14 – support and coordinate the development of models and data to improve understanding of the relationships between infrastructure and the services it supports.

Vulnerability information

Recommendation 15 – efforts to develop an understanding of vulnerability at a range of scales from local community to sectoral, using vulnerability profiling techniques should be endorsed, promoted and supported by the national capability.

Recommendation 16 – in collaboration with the private sector, (insurance and utility industry stakeholders) support the development and standardisation of quantitative vulnerability assessment models, methods and tools including the development of standardised damage functions for hazard magnitude and infrastructure asset types based on the use of insurance damage data.

Risk assessment information

Recommendation 17 – explore adoption of a similar approach to the United Kingdom in identifying key hazards and assessing risk against these hazards at a high level to support national coordination efforts.

Recommendation 18 – enable access to, collate and curate completed climate and disaster risk assessments which are currently inaccessible, or scattered across the digital landscape.

Disaster consequence and risk reduction monitoring and reporting

Recommendation 19 – harmonise, aggregate and improve the coherence of natural disaster consequence and impact data to assist in guiding and monitoring national disaster risk reduction efforts and reporting against the Sendai framework.

Recommendation 20 – monitor, evaluate and exchange learning from risk reduction activities to enable adaptive risk reduction activities at scale.

Appendix 2 Narrative scenarios and modelling the case studies

Exploring the use of narrative scenarios

Scenarios encourage discussion and aid strategic planning among policy makers, and support decisions on complex issues with long-term implications. Narrative scenarios are stories about how the future might unfold at any scale – from organisational through to global. Scenarios are not predictions but are provocative and plausible stories about diverse views of the future.[49] They are a tool for engaging with uncertainty over longer timeframes, making them invaluable for thinking about and engaging with climate and disaster risk.

In the pilot project, through a series of workshops, stakeholders and experts were brought together to explore anticipated future natural hazards and factors likely to influence exposure and vulnerability to those hazards. The workshops were designed to develop and test a process that used narrative scenarios to help anticipate and prepare for possible future disaster risks and to inform and guide the risk modelling activities

Time and resources did not permit a full scenario development process for this pilot project; instead, a set of scenarios developed by the Centre for Supply Chain Logistics, as shown in Figure 1, were used to explore the future of Australia's supply chain networks. The scenarios did not focus specifically on vulnerability and disaster risk; however, they did consider many factors likely to influence these.

Through two workshops, participants from across state and federal governments, industry and academia considered:

- how disaster risks might emerge if the current freight and supply chain system was exposed and vulnerable to, the sorts of climate-related natural hazards anticipated in the next few decades; and
- how disaster risks might play out in four scenarios depicting potential future freight and supply chain systems in Australia.

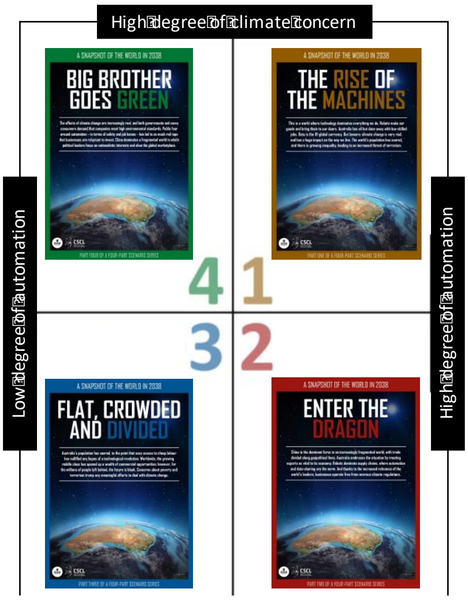

Figure 1 – The 2 x 2 critical uncertainty matrix used in the CSCL project on futures of Australia's freight and supply chains (CSCL, 2017).

Potential vulnerabilities were explored under ten categories:

- placement of communities, infrastructure and assets in exposed locations;
- insufficient standards and regulations;
- choices and trade-offs: risk transference;
- too much or too little interconnectedness;
- over-dependence on networks and supply chains;
- poor access to and supply of information, goods and services;
- ineffective cross-jurisdictional governance and organisational decision making;
- declining social cohesion and tolerance for loss;

[49] Scearce, D., Fulton, K., Global Business Network Community. (2004). *What If? The Art of Scenario Thinking for Non-Profits*. Emeryville, California, USA: Global Business Network. Retrieved from https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/report-scearce-et-al.pdf

- stretching and exhaustion of capacity; and
- inadequate capacity for long-term thinking about disaster risks.

A detailed report on the scenario exploration activity was prepared for the Department of Home Affairs.[50] The key findings are presented below.

- The use of scenarios identified many potential vulnerabilities, many of which had not been contemplated prior to engaging in scenario thinking to test assumptions and generate new ideas.
- Participants were able to explore and identify interactions among drivers of change and factors likely to influence disaster risk over coming decades.
- This is not something that can be done quickly. Compressed timelines, and reuse of scenarios developed for a different purpose (and which did not explicitly focus on climate risk and increased natural hazards) limited the utility of the scenario exercise.

A fuller implementation of this approach encompassing the co-development of scenarios, would be beneficial but would require more time to allow participants to engage in the development of scenarios, think more deeply about assumptions, understand the bases for different views and disciplinary interpretations, and systematically work through the stages of thinking through a scenario.

Modelling case studies

Informed by the narrative scenario workshops, the second activity aimed to demonstrate the use of existing data and modelling capability to explore climate and natural hazard risk issues identified by the Freight and Supply Chain Task Force, bringing together strategy developers (users) and the modelling capability providers.

Table 1 describes the criteria developed to guide selection of the case studies.

Table 1 – Criteria for selection of case studies

Criteria	Description
Utility	• Delivers insightful learnings that could inform strategy development. • Provides adequate insights and information to inform business case. • Insights could be scaled/reapplied in other contexts. • Illustrates key capabilities/needs/challenges in an accessible and understandable way.
Feasibility	• Achievable given resources and timeframes. • Sufficient data and modelling capability exists to demonstrate potential and identify gaps and limitations along the way.
Policy and political imperatives	• Salient, relevant to key policy discussions and resonates. • Linked to value drivers. • Nationally important.
Credibility	• Sufficient (but tractable) complexity is required to ensure credibility and scalability. • Based on past events (so that it is relatable). • Likelihood of re-occurrence with consideration of climate change with significant consequence.

[50] Cork, S. 2019. NDRISC Pilot Project Freight and Supply Chain Case Study Guidance Report – Narrative Scenarios.

Criteria	Description
Representativeness and realism	• Multi-hazard and explores/communicates the compounding of events. • Cross-jurisdictional and cross modes of transport. • Impacts: on government, industry and community including compounding and unexpected impacts.

Three cases studies were selected based on these criteria.

- Case study 1 – Flooding of the Bruce Highway south of Townsville (led by Geoscience Australia)
- Case study 2 – Multi-hazard freight impacts surrounding the Victoria-Tasmania transport and freight network (through the Bushfire and Natural Hazards Cooperative Research Centre by the University of Adelaide)
- Case study 3 – Coastal inundation and subsidence in the Port of Adelaide (led by the University of Adelaide).

The activity was resourced primarily through in-kind contributions[51] from organisations providing data and modelling capability (Geoscience Australia, the Commonwealth Scientific and Industrial Research Organisation, the Bureau of Meteorology, the University of Adelaide and the Bushfire and Natural Hazards Cooperative Research Centre). Execution of this activity was therefore constrained by limited timeframes as well as availability of resources in the context of numerous competing and unprecedented demands.[52] Case study reports were provided to the Department of Infrastructure, Transport, Regional Development and Communications.

A report for each case study was prepared for the Department of Infrastructure, Transport, Regional Development and Communications, presenting the results of the risk assessment together with a description of issues associated with use of existing data and modelling capability. Issues identified included: constraints on accessing available data, incapability between data sets due to lack of standards, absence of required data for modelling and in some cases insufficient understanding of and/or limited ability to model complex real world systems. The lessons learned from conducting the modelling activities and implications for the national capability presented in the next section.

[51] Noting the BNHCRC contribution was partially funded by EMA.
[52] Demands associated with the Black Summer fires and COVID-19 were significant disruptions to the completion and analysis phase of the pilot

Appendix 3 Glossary

In the context of this report, the following definitions have been used:

Natural hazard – *Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.*[53]

Disaster – *A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic or environmental losses and impacts.*[54]

Exposure – *The degree to which a system is exposed to significant climatic variations. The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.*[55]

Vulnerability – *The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, community, assets or systems to the impacts of hazards.*[56]

Disaster Risk – *The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined as a function of hazard, exposure, vulnerability and capacity*.[57]

Data is the raw facts collected for further processing and analysis. Data can be generated in a variety of ways including through direct and deliberate observation and measurement, using on-ground collection, or remote sensing and as a by-product of transactions; for example, records of emergency relief payments to citizens. It is the raw material for production of information.

Information is data that has been processed, contextualised, interpreted, categorised and prepared in other ways to communicate understanding to users of information products.

Knowledge refers to the practical or theoretic understanding of something produced through experience, learning and use of information. Knowledge can be represented and transmitted in different forms through narratives, scenarios, frameworks and information products. There are multiple systems of knowledge such as scientific and indigenous knowledge.

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[53] UNISDR Terminology 2009 - https://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf
[54] Department of Home Affairs, 2019, *National Disaster Risk Reduction Framework*, https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf
[55] Department of Home Affairs, 2019, *Climate and Disaster Risk: What they are, why they matter and how to consider them in decision making,* https://knowledge.aidr.org.au/media/7713/06-terms-and-concepts-guidance-strategic-decisions-climate-disaster-risk-2020.pdf
[56] UNDRR. 2019. Glossary: https://www.unisdr.org/we/inform/terminology
[57] Ibid