Final report

Independent Review of the Australian Climate Service

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Dear Ministers

Final Report – Independent Review of the Australian Climate Service

In late 2023, you commissioned the Independent Review of the Australian Climate Service.

I am pleased to present the Final Report of that Review.

It includes 11 recommendations, designed to guide processes and structures to meet Australia's climate information needs as a matter of priority and thereby speed up climate change adaptation across all sectors of the society and the economy.

The Review acknowledges the extensive help it received from many Australian and international individuals and organisations, not least the Australian Climate Service and its partners, the Bureau of Meteorology, the Australian Bureau of Statistics, CSIRO and Geoscience Australia, as well as the National Emergency Management Agency.

We would also like to thank the Department of Climate Change, Energy, the Environment and Water which provided excellent secretariat support under the capable leadership of Ms Lena Saboisky. Specifically, we acknowledge the contribution of Sophie Shilling, Rowena York, Callum Murison, Aidan Menzies and Vijaya Tangirala.

Yours sincerely

Mary O'Kane
Chair
30 April 2024

Foreword

Australia's climate is changing. We are experiencing more climate extremes – heavier and more intense rainfall, extreme heat events, longer fire seasons and rising sea levels. Natural hazards resulting from severe weather are expected to become more frequent, complex and unpredictable.

Disasters arising from climate extremes are increasing the burden on Australia's natural systems, communities and the economy. The cost of disasters to the Australian economy was $38 billion per year in 2021, and this cost is estimated to reach at least $73 billion per year by 2060.[1]

Hazards and disasters are only part of the story. Australian citizens, businesses and governments are making many important climate-related decisions that will greatly influence our future standard of living and our capacity to adapt efficiently. As the changing climate presents further challenges, they will need to make many more. It is critical that these decisions are well-informed to ensure the best outcomes for the lowest cost over the long term.

The Australian Climate Service (ACS) was established in 2021 to better connect and leverage Australia's data, information and capabilities that facilitate climate and disaster risk management. In 2023 the Independent Review of the Australian Climate Service (the Review) was established to review the performance of the ACS, and to assess Australia's future climate information needs and the suitability of the ACS to deliver on them.

The Review has identified structural issues and information and capability gaps that the government must attend to in order to meet the climate information needs of Australia. Climate information is a global need and the Review has considered lessons from the growing international experience with the provision and use of climate information services.

The recommendations in this report outline why and how Australia should reform its approach to climate information services from the current science and data-led (supply) focus to a user-focussed, service-oriented (demand) model.

[1] Deloitte Access Economics, 2021, Special report: Update to the economic costs of natural disasters in Australia. Available at: https://www.deloitte.com/au/en/services/economics/perspectives/building-australias-natural-disaster-resilience.html.

Executive summary

The strong message from this Review is that there is an urgent and rapidly growing demand for trustworthy, accessible and authoritative climate information. This demand comes from all levels of government, businesses in most sectors of the economy, communities and households. Government policy and regulation (such as climate-related risk disclosure obligations), commercial pressures and community expectations will accelerate this demand. Given the scale and scope of decisions informed by climate information, the economic costs of failing to meet this demand in an efficient and orderly way could be significant.

The ACS was a policy experiment responding to a genuine public need and much can be learned from its operation since 2021.It is now evident that the ACS had little chance of success, with conflicting priorities and a governance model that diligent ACS staff have not been able to make work. The ACS in its current form cannot meet the national needs for climate services and a different delivery model is required.

Although aspects of the ACS operations are starting to work more effectively, the performance of the ACS was limited in the first two years by its competing short- and longer-term responsibilities, its governance and resourcing model, and the challenges presented by the scale and number of natural disasters during this time. The ACS has had responsibility for both climate information for short-term emergency management and longer-term climate information services. Emergency management priorities have taken precedence over longer-term climate information needs, resulting in a gap in accessible information to inform Australia's broader adaptation requirements. Emergency management needs should be serviced separately from climate adaptation needs to enable a climate service focus on Australia's longer-term needs. The National Emergency Management Agency (NEMA) is best placed to take on the responsibility for operational support services for emergency management, and this function should be transferred to NEMA.

The existing ACS partnership model does not incentivise partners to prioritise the mission of the ACS and does not empower ACS management to prevail over partner interests to deliver for a wide client base. The partners supply data and information that they consider necessary through partner-led governance committees. This hinders impartial and user-focussed decision-making, and has led to a research-driven focus on building the partners' data and science capability rather than working to adapt existing information to the needs of diverse users. Additionally, the co-ordination costs of the partnership model are high, resulting in challenges for the ACS to mobilise new projects quickly and get agreement for priorities across all partners. This undermines both the ability of the ACS to deliver projects efficiently and its capacity to commit to customers with confidence.

Australia needs a climate service that is user-oriented and accountable for its outputs. It should have authority to control its own resources and their deployment. Its authority to deliver should be commensurate with its significant responsibilities while still enabling it to capitalise on the value of its partners and collaborators. To enable these outcomes, the current formal partnership should be dissolved and replaced with arrangements that better align capacity, responsibilities, authority and accountability and which enable the sourcing of information from the wider array of partners necessary to provide users with the best available information. A user-oriented approach to climate services, with enhanced Commonwealth leadership and co-ordination to support all Australians' understanding and use of high-quality climate information, will assist the systemic shift needed for Australia to adapt to climate change.

A new entity should be established, called the National Climate Service (NCS), which should build capability over several years using a phased approach. The NCS needs to begin by meeting the urgent needs of priority sectors that have the largest influence on mitigating climate change impacts or which will be most impacted by climate change, and scale quickly to service broader needs.

Initially, the NCS should be located within the Department of Climate Change, Energy, the Environment and Water (DCCEEW). The Review recommends DCCEEW investigate synergies from co-locating the NCS with Environment Information Australia (EIA). EIA's data analytics and geospatial capabilities, its data co-ordination functions and its ambition to uplift and publicise Australian environmental data align with the Review's proposed priorities for the NCS. Climate change is a vital factor in environmental change so the two bodies would have interdependencies regardless of the outcomes of this Review.

The NCS should be the first port-of-call for climate information for all Australians. As such, it will require an identity and public profile that attracts users and gives them confidence in its products and services. The leadership of the NCS will need authority to develop this public identity to ensure it is visible, responsive and accountable.

To deliver benefits for users and rapidly disseminate actionable climate information, it is essential that the NCS deliver an accessible central information portal (i.e. a 'one stop shop') of quality-assured climate information, supported by a service centre that delivers knowledge brokering, tailored information and targeted outreach to priority users of climate products and services. This climate information portal needs to be an authoritative source of best practice guidance, tools, data, and information that helps individuals and organisations navigate the complex climate information environment. It should provide users with a single-entry point and a uniform interface to a wide range of climate data, products and services hosted by multiple providers, with a common framework for communicating uncertainty and quality.

Knowledge brokering will support the centralised information portal and accelerate the uptake of climate services by facilitating the exchange of information, expertise and resources between climate specialists and climate information users. Climate information is complex and decision-makers often require assistance to identify the types of information they require, derive insights from it and answer their complex climate-related questions.

A quality assurance function should oversee the provision of both the climate information portal and knowledge brokering, as well as extending to the provision of climate services beyond the federal government. This should include the establishment of climate information and data standards, service standards, and an accreditation process to provide assurance of the quality of climate services from all providers in Australia.

To support these three functions, Australia's climate information ecosystem requires leadership and co-ordination. This would enable the efficient allocation of resources, prevent duplication, and ensure the co-ordination of data interoperability, platforms and services in a manner useful to all Australians. A range of high-quality research and data is available, including from states and territories, but it is not coordinated or easily accessible, and its value is not being maximised. The federal government has a role in creating frameworks to harmonise this data and present a national view.

The value proposition for a climate service is to minimise the significant costs of adapting to our changing climate by ensuring decision-making on climate risk is informed by accessible and reliable climate information and decision-making tools. Climate adaptation will be expensive, but poorly informed and inefficient adaptation will be far more so.

This report draws on ACS experiences, international developments, and contributions from many Australian organisations and individuals in its recommendations for potential approaches to meeting Australia's future climate information needs and a new delivery model.

List of recommendations

1. That the Australian Government make the following changes to the provision of climate and hazard information to the National Emergency Management Agency.
    1.1. Transfer responsibility for operational support services for emergency management (as set out in the *Australian Climate Service Operational Support Services – Service Level Agreement 2023-24*) from the Australian Climate Service to the National Emergency Management Agency, to reinforce the real time connection of information and decision-making on emergency responses.
    1.2. Allow the National Emergency Management Agency to make judgements about how to best meet its needs, including by managing its own tasking, data and analysis, with the ability to draw on external sources.
    1.3. Require the National Emergency Management Agency make its data and products open-source and accessible to government and the public wherever possible.
2. That the Australian Government reaffirm the importance of accessible and useable climate related information to inform effective and efficient adaptation to climate change challenges.
    2.1. Establish the National Climate Service, which will be available to serve all Australian governments (Commonwealth, state, territory, local) and, over time, provide information to all Australians. The National Climate Service should absorb the remaining Australian Climate Service functions (which are not transferred to the National Emergency Management Agency), and should be able to broaden its services to new users with agreement from the responsible Minister.
    2.2. Ensure the National Climate Service has adequate budget allocation to reasonably meet escalating needs for a national climate service capability.
3. That the Australian Government establish the National Climate Service within the Department of Climate Change, Energy, the Environment and Water, and consider opportunities for resource and systems sharing, potentially integrating its back office data and computational systems with Environment Information Australia.
4. That the Australian Government set clear expectations for the National Climate Service.
    4.1. Provide a Statement of Expectations to the National Climate Service to meet the national requirement for trusted and accessible climate information, products and services and for effective national co-ordination of Australia's climate services.
    4.2. Place the National Climate Service under a leader with the authority to ensure the service is customer-focused, connected effectively to core user groups, and well managed with appropriate budget, resources and priorities.
    4.3. Establish a multidisciplinary Advisory Committee with an independent Chair to inform priorities and support the focus on user needs (including representatives from Commonwealth, state and local governments, First Nations Australians, the private sector, climate science, public health and the community sector).
5. That the National Climate Service be service-oriented, helping all Australians access authoritative information with a commitment to transparency and open-source information provision. It should:
    5.1. Conduct a gap analysis of Australia's climate data and information needs and user literacy and refresh this regularly.

5.2. Establish a portal for climate information, products and services sourced from across a range of quality assured providers that:

5.2.1. gradually builds over time a library of open-source climate information products and services

5.2.2. provides publicly available, up-to-date climate information for Australia (including states and territory regions and coastal zones, Australia's oceanic Exclusive Economic Zone and external territories)

5.2.3. presents information in easy-to-understand ways with a variety of formats for download and visualisation

5.2.4. includes external, reputable information from up-to-date sources domestically and around the world, including from other national and transnational climate services.

5.3. Establish and grow a knowledge brokering service that assists users to find the data, information and advice needed to resolve their climate questions and understand the uncertainty inherent in climate models.

5.4. Promote climate literacy through public information to empower users to understand and apply climate information for their own adaptation needs.

5.5. Improve access and usability of climate information by making Commonwealth-funded products free and open-source by default.

5.6. Incorporate culturally appropriate climate information services in response to the National Climate Risk Assessment of First Nations climate risks and when developing the National Adaptation Plan.

6. That the Australian Government position the National Climate Service to have sufficient public profile and trust to attract users and providers, and to enable it to deliver its services effectively to all Australians.

6.1. Establish the National Climate Service within the Department of Climate Change, Energy, the Environment and Water with arrangements that encourage the development of a separate and strong public profile.

6.2. Deliver National Climate Risk Assessments through the National Climate Service on a regular program, aligned to the Intergenerational Report.

6.3. Require the National Climate Service to develop and publish a climate services roadmap, describing how to build to a national capability with explicit and ambitious time frames.

6.4. Publish all National Climate Service strategic documents by default to provide transparency on the National Climate Service's program and timelines for implementation.

7. That the Australian Government through the National Climate Service coordinate and encourage the participation of all relevant stakeholders in the national climate information ecosystem.

7.1. Review and update the *COAG Roles and Responsibilities for Climate Adaptation in Australia*.

7.2. Develop an intergovernmental agreement on climate data and information.

7.3. Formalise the National Partnership for Climate Projections as a sub-committee to the Adaptation Working Group and support it through the National Climate Service with appropriate resources to drive the broader co-ordinated work program and achieve national participation.

7.4. Leverage the expert knowledge, capabilities and climate data, information and services of public and private entities.

7.4.1. Signal to partners and suppliers that the National Climate Service is open to collaborating and data sharing.

7.4.2. Establish a biannual National Climate Service forum, to bring together key climate service stakeholders from across public, private and community sectors to advance the climate services industry and its understanding of user needs.

7.4.3. Support the National First Peoples Platform on Climate Change, funded under the NESP Climate Systems Hub.

8. That the National Climate Service establish a data governance framework to enable consistent, high-quality climate-related data, information and services for Australia.

   8.1. Establish best practice for climate service providers in Australia, either via a climate service provider accreditation scheme or climate service standards.

   8.2. Promote data standards to integrate and connect data from different fields, aligned with international best practice.

   8.3. Develop robust quality assurance processes for data, tools, information and services provided by the National Climate Service and made available on the climate information portal.

9. That the Australian Government ensures the National Climate Service has the data and computational infrastructure it needs to succeed.

   9.1. Develop a long-term national strategy and funding approach for computational infrastructure and data storage for climate data and modelling.

   9.2. Review roles and responsibilities for climate, hazard, exposure, vulnerability and impact data across the Commonwealth.

   9.3. Establish an appropriate data solution (e.g. a data platform) to publish climate and hazard data; enable federated data curation including for domain data; support access for a broad range of data providers and public; create data insights and publish information as needed.

   9.4. Require all publicly funded climate models to be published on the National Computing Infrastructure with minimal restrictions, to encourage wide reuse and scientific scrutiny.

   9.5. Require, and fund as necessary, the responsible agencies to uplift natural hazard data inputs to a level required by the National Climate Service and the National Emergency Management Agency, with co-ordination of data for emergency management (e.g. hazard extent mapping, forecasting and tracking of historical events) to be managed by National Emergency Management Agency and hazard projections to be co-ordinated by the National Climate Service.

10. That the Australian Government establish an effective monitoring, evaluation, reporting and improvement (MERI) framework for the National Climate Service.

    10.1. Regularly monitor against the new Statement of Expectations (refer Recommendation 4.1 and KPIs in Box 7) to ensure the National Climate Service is meeting expectations.

    10.2. Task the Climate Change Authority with a regular review of the National Climate Service against the KPIs.

        10.2.1. The first review should consider whether National Climate Service should be an independent statutory authority.

10.2.2. Establish a mechanism within the National Climate Service to track user experience and satisfaction which gathers user needs and preferences, to guide the development of future products and services.

11. That the Australian Government build a national climate service capability using a phased approach that allows the National Climate Service to deliver as much information as possible, as quickly as possible, and to prioritise needs while scaling over time to deliver a more sophisticated service that can meet the rapidly increasing national requirements for climate information. In the Foundational phase:

    11.1. concentrate on servicing Commonwealth and then state and territory agencies while a strategy to expand to broader services for the public is developed

    11.2. review ACS initiatives and work program and decide which should be continued to support the planned National Climate Service's scope and objectives. Start a phased wind back (over 4 years) of the funding commitments to ACS partners.

    11.3. prepare a workforce plan and resulting recruitment and training to build strong capabilities in climate services, knowledge brokering, communication and user engagement.

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1 Introduction

This is the final report of the Independent Review of the Australian Climate Service (the Review). It includes the Review's findings and recommendations.

The Review Panel was appointed by the Australian Government through the Minister for Climate Change and Energy, the Hon Chris Bowen MP, and the Assistant Minister for Climate Change and Energy, Senator the Hon Jenny McAllister, to consider Australia's climate and disaster information needs, and how the Commonwealth should be positioned in future to support these, including:

- reviewing the performance of the Australian Climate Service (ACS) since its establishment, its governance arrangements, resourcing and capabilities
- assessing Australia's future climate information needs and the suitability of the ACS to deliver on them.

The Panel comprised Professor Mary O'Kane (Chair), Mr Daryl Quinlivan and Dr Russell Reichelt. The Terms of Reference are at Appendix B.

The findings and recommendations have been informed by consultation and information gathered from a diverse range of stakeholders and sources, including 100 meetings with 57 different stakeholder groups (Appendix C) and 32 written submissions following the release of the Review's Discussion Paper.[2] This includes input from the ACS, its partners and customers, Commonwealth agencies, state and territory governments, the emergency management sector, universities and research institutions, peak industry bodies, science professionals, and international climate services.

The Review also presented early findings to the Energy and Climate Change Ministers Council (ECMC), which brings together Ministers with portfolio responsibility for climate change and energy from the Commonwealth, each state and territory and New Zealand. The presentation outlined the broad need for good quality climate information, knowledge brokering and national co-ordination. Members expressed strong support for having a national climate service and welcomed the opportunity to participate and gain access to services.

The findings of past and current inquiries about emergency management and disaster risk reduction have also been considered. This includes the Royal Commission into National Natural Disaster Arrangements, the Independent Review of National Natural Disaster Governance Arrangements (Glasser Review), the Independent Review of Commonwealth Disaster Funding (Colvin Review) and the 2023 ACS Gateway Review undertaken by the Department of Finance. Consultations with the reviewers and their teams revealed a strong consistency with our findings and recommendations.

This report includes contextual information relevant to the Terms of Reference, including definitions and examples of climate information, climate adaptation, and climate services within Australia and in other countries. It also gives a brief insight into Australia's climate information needs through the characteristics of potential users of climate information services.

[2] DCCEEW, 2023, ACS Independent Review public consultation process. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process.

2 Context

To address future climate and natural hazard risks effectively, Australia needs comprehensive disaster and climate information capabilities so that the scope and scale of climate change risks and their potential impacts across the country can be understood. Australia is large and geographically unique with a variety of climatic zones and diverse socioeconomic contexts. We need a strong sovereign capability to understand the climate impacts we are likely to experience in our own country.

Both disaster information and climate information rely on the same foundational source data. This includes weather observations, satellite imagery, projections of future climate and historical records, overlaid with multidisciplinary data that describe the different trends, attributes and risks that may be affected by climate change or disaster events exacerbated by climate change.

2.1 Climate information

Climate information includes both short-term information (to improve understanding of disaster events that have been exacerbated by climate change, such as the 2019–20 bushfires) and longer-term information (for example, heat increase over time causing health and critical infrastructure issues).

Climate information, for the purpose of climate services, is not simply climate data or climate projections. Whilst climate projections can indicate what the climate will *be*, climate information seeks to indicate what a changing climate and related severe weather events will *do* – in other words, the impacts that climate change will have. Climate information is the combination of climate data and data from other disciplines relevant to risk impacts (e.g. population, geography, health and land use), from which climate impacts on these domains can be understood. The Hazard, Exposure, Vulnerability and Impact (HEVI) chain is used by the ACS to identify impacts (Box 1; Figure 1).

Box 1: Examples of the Hazard, Exposure, Vulnerability and Impact chain in climate services

Example 1: Rain in southern Western Australia and South Australia caused a flooding **hazard** in November 2022, which **exposed** infrastructure in parts of inland New South Wales to inundation. Key highways were **vulnerable** to the flooding and were closed, which prevented delivery of essential foods, **impacting** people living in eight local government areas.[3]

Example 2: As cyclone weather patterns in Australia move south, the threat of tropical cyclones poses a **hazard** to a greater area of Australia. These cyclones will **expose** infrastructure in areas of the Pilbara to more extreme winds. The National Construction Code has been updated with new climate risk zones; however, older buildings will be more **vulnerable** to damage. Industries are also at risk, with damage to the accommodation for essential workers likely to **impact** the mining sector, resulting in economic losses.[4]

[3] ACS, 2022, 14:00 18NOV22 ACS Impact Brief, supplied.

[4] WA Department of Energy, Mines, Industry Regulation and Safety, 2022, NCC 2022 State variation for wind Region D. Available at: https://www.commerce.wa.gov.au/announcements/ncc-2022-state-variation-wind-region-d.

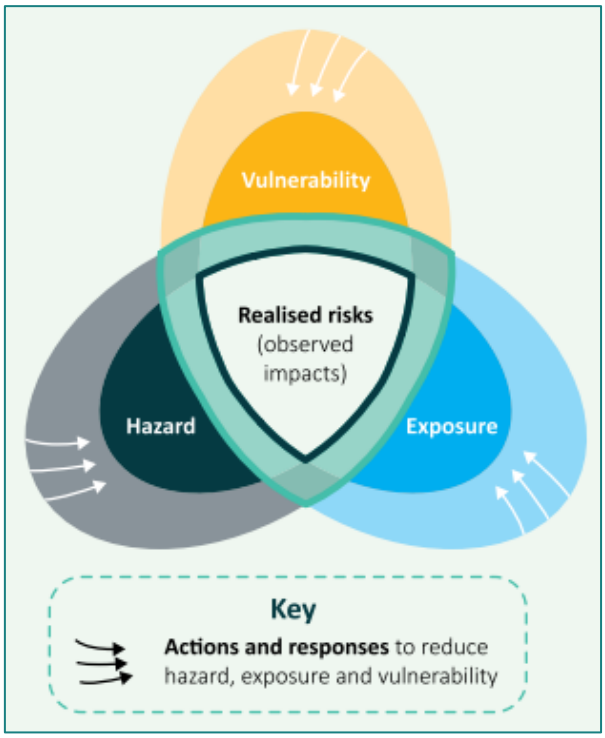

Figure 1: Understanding climate risk, from the NCRA First Pass Assessment, DCCEEW.

2.1.1 Climate projections

Australia's most recent national climate projections, released in 2015, were co-produced by CSIRO and the Bureau of Meteorology (the Bureau). They are available on the Climate Change in Australia website.

There are three significant projects producing the next generation of climate projections in Australia using models from the Coupled Model Intercomparison Project phase 6 (CMIP6) — the ACS, the NSW and Australian Regional Climate Modelling Project (NARCliM2.0) and the Queensland Future Science Program (Long Paddock). Detailed downscaled (regional) climate models are valuable for making climate projections relevant to local decision-makers' needs but are computationally intensive to produce.

The Commonwealth government has made investments in climate modelling including via CSIRO, the Bureau, the National Partnership for Climate Projections (NPCP), the National Environmental Science Program (NESP), and the Australian Research Centres of Excellence for Climate Extremes and Weather of the 21st Century.

The various governments operate independently but have formed a voluntary partnership to provide some co-ordination, the NPCP.

Box 2: The National Partnership for Climate Projections (NPCP)

The NPCP is a voluntary collaboration of federal, state and territory governments, universities and research institutions. The Partnership brings together relevant players across all jurisdictions to increase collaboration. The Climate Projections Roadmap for Australia – led by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) with contributions from across the Partnership – has provided a national approach to deliver the CMIP6 projections. Forward planning for the next generation of projections – Coupled Model Intercomparison Project phase 7 (CMIP7) is underway.

2.1.2 Domain data

Climate information aims to identify climate impacts on the social, economic, built and natural domains. This requires access to non-climate datasets including non-climate projections. For example, the social domain requires data on the location of current and likely future populations and their social and economic characteristics, cultural backgrounds, health and disabilities in addition to climate information by location. Integrating datasets relevant to other domains enables more detailed insights into how Australia will be affected by the changing climate and informs relevant decisions.

2.2 Climate services

Climate services is an emerging field and 'there is no single and unambiguous, formal definition of climate services in the literature; mostly because the development, delivery and application of climate services is highly context specific'.[5] Climate services are generally understood to mean the generation and provision of climate information to decision-makers in various forms, such as websites, visualisation tools, charts, descriptive storylines, and in some cases access to relatively unprocessed, but quality assured data.

Climate services are often classified using a supply chain comprising upstream, midstream and downstream information and services (Figure 2). The share of non-climate information (e.g. socio-economic, built, natural, etc) increases when moving to 'midstream' and on to 'downstream' climate services.

- Upstream: collecting raw data, assuring its quality, and processing it into meaningful information.
- Midstream: interpreting processed data into public good climate information products, including tools, models, information platforms, tailored datasets, and visualisations.
- Downstream: tailoring and curating information on specific risks and impacts to the needs and language of specific users.

The products or services most useful to different types of users will come from different stages of the supply chain. For example, some entities (e.g. research organisations) only want to receive upstream datasets, which they will ingest and use in their own platforms. However, many decision makers will derive greater value when the information is tailored to their requirements (i.e. downstream).

Upstream services in Australia are generally provided by a small number of federal agencies and departments. For example, the Bureau and CSIRO carry out the majority of earth systems observation and climate modelling, whilst midstream and downstream services are delivered by a broad range of actors integrating multidisciplinary data across various sectors and jurisdictions. The need for national coordination increases with the greater diversity of actors and information sources further along the supply chain.

[5] NESP ESCC Hub, 2021, Informing strategic development of a national climate services capability for Australia. Available at: https://nespclimate.com.au/towards-a-national-climate-services-capability/.

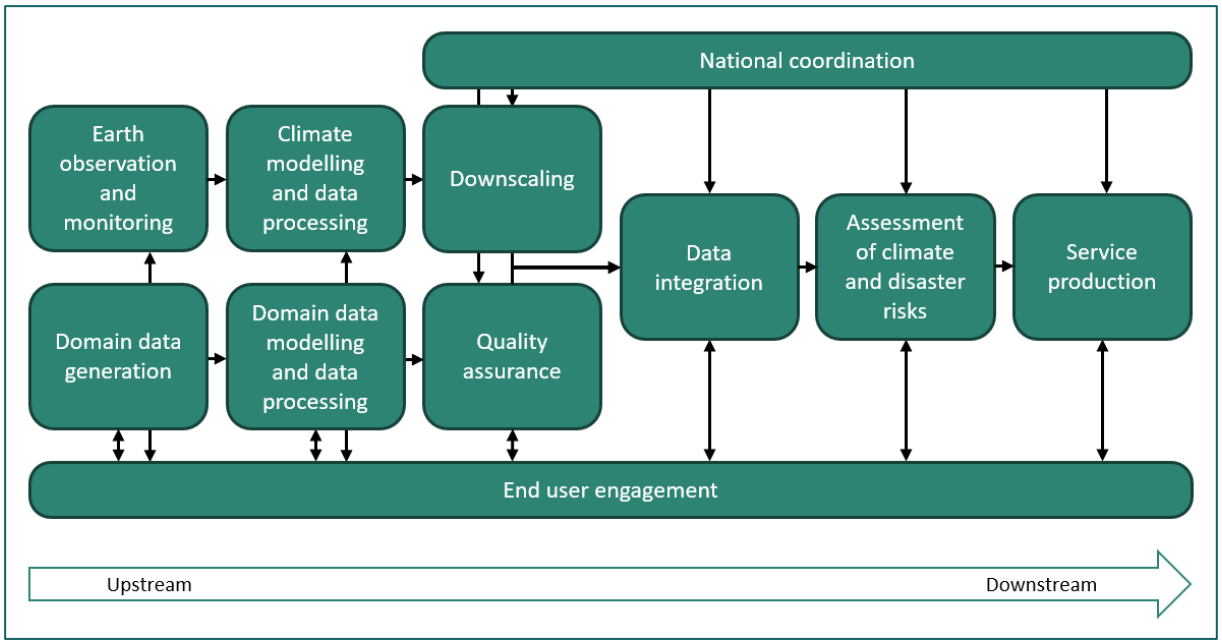

Figure 2: The climate services supply chain.

2.3 Climate adaptation

Climate adaptation refers to the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.[6] Climate data, information, products and services play a pivotal role in climate adaptation by providing information and tools that enable informed adaptation strategies and decisions to avoid, mitigate or benefit from the effects of climate change.

2.4 Organisations involved in climate services

2.4.1 The Australian Climate Service

Establishment

On 13 November 2020, the then Prime Minister announced that a new climate and resilience services function would be established by 1 July 2021 in response to the *Royal Commission into National Natural Disaster Arrangements* ('the Royal Commission', Appendix E).[7] At the time of the Royal Commission, the mood in Australia regarding natural disasters and climate change had reached a crisis point, with 'images of the unprecedented Black Summer bushfires seared into the psyche of all Australians'.[8] The heightened public interest in disaster response and climate action was reflected in the formation of the ACS.

Although the Royal Commission served as the catalyst for creating the ACS, multiple related initiatives had been underway before 2020 to enhance climate projections and develop a national view of climate and natural hazard risks. The National Disaster Risk Information Capability (NDRISC)

[6] IPCC, 2022: Annex II: Glossary, *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC*. Available at: https://www.ipcc.ch/report/ar6/wg2/.

[7] Royal Commission, 2020, Report, National Natural Disaster Arrangements. Available at: https://www.royalcommission.gov.au/natural-disasters/report.

[8] G. Mullins, 2020, In 50 Years of firefighting I had never seen fires like I did last summer. Australia must take climate change seriously, The Guardian. Available at: https://www.theguardian.com/commentisfree/2020/oct/31/in-50-years-of-firefighting-i-had-never-seen-fires-like-i-did-last-summer-australia-must-take-climate-change-seriously.

included these aspects and was ultimately used as the basis for the Royal Commission's recommendation to establish a national climate and disaster information service.[9] The NDRISC pilot had envisaged a broad user base, with the expectation that a national capability would bring together and share knowledge across providers, governments, industries, sectors and communities.[10]

Following the Royal Commission, significant structural and governance changes occurred across the Commonwealth's climate and disaster functions. The ACS and the National Recovery and Resilience Agency (NRRA) were established, and the roles, functions and capabilities of the Emergency Management Agency (EMA) were enhanced. The government's response to the Royal Commission stated that the soon-to-be-formed ACS would 'connect and leverage the Commonwealth's data information and capabilities to manage climate and disaster risk, including those of the Bureau, CSIRO, Geoscience Australia and the Australian Bureau of Statistics'.[11] These four agencies and the then Department of Agriculture, Water and the Environment worked together to deliver a series of priority work projects.

Organisational structure

The ACS formally commenced operations on 1 July 2021. The government noted that the soon-to-be-formed ACS would 'connect and leverage the Commonwealth's data information and capabilities to manage climate and disaster risk, including those of the Bureau, CSIRO, Geoscience Australia and the Australian Bureau of Statistics'.[12] It was set up as a Type F agency (non-statutory function with separate branding), operating within the Bureau as the accountable authority. It has a central co-ordination function but sources its data and products from a virtual partnership across the agencies mentioned in the government response to the Royal Commission, drawing on their capabilities as follows:

- The **Bureau** provides weather and climate knowledge and advice. Meteorologists, climatologists and hydrologists provide real time knowledge and advice during severe weather events.
- **CSIRO** provides its science with a focus on climate observations and modelling, resilience, adaptation, and transformation science and practice.
- The **Australian Bureau of Statistics** (ABS) provides social and economic information, enabling an improved picture of the vulnerability of geographical locations to help prevent or prepare for natural hazards.
- **Geoscience Australia** advises on integrated earth sciences, and provides national natural hazard and exposure information, and national geospatial and location services.

The virtual model was chosen by the then government to capitalise on the strengths of the key partner agencies. Expertise was to remain with home agencies and be drawn on by the ACS to address priority problems and respond to information needs. It was thought that by building on partners' existing data, analytics and expertise, guided by overarching governance, the ACS would avoid duplication and inefficiencies.

As a virtual partnership, funding, personnel and responsibilities are distributed amongst the four partners via operational agreements, driven and managed by a set of committees (the Customer Committee, Operational Steering Group, and Program Control Group). The Bureau is allocated

[9] Royal Commission, 2020, Report, National Natural Disaster Arrangements.

[10] NEMA, 2020, National Disaster Risk Information Services Capability pilot project outcomes report. Available at: https://nema.gov.au/about-us/policies/information-and-resources.

[11] Prime Minister & Cabinet, 2020, A National Approach to National Disasters, Government response to the Royal Commission. Available at: https://www.pmc.gov.au/resources/national-approach-national-disasters.

resources in its role as the accountable authority, which are then distributed based on the resourcing and operational needs for each project. Each partner is responsible for delivery of its respective components of the project as allocated through an operating agreement.

Staffing is split between staff in the ACS 'Office' and those in the partner agencies, who remain employed by their home agency. Partners often collaborate across several projects at a time. Throughout this process, the partner agencies must balance the work contracted through the operating agreements with their agencies' own priorities and pressures.

All of the ACS staffing authority (ASL - approved average staffing level) is allocated to the ACS via the Bureau, and the ACS then allocates ASL to each partner via an operational agreement. The Bureau, as the accountable authority, provides corporate services on a cost recovery basis to the ACS Office and reports on ACS operations in its annual report. For financial year 2023–24, the ACS is funded for 84.2 ASL and 98.5 contractors across all partners and the ACS Office, and receives corporate services at a cost of $1.8 million.

Governance

Originally, the ACS was to be overseen by a Ministerial Committee comprising the Minister for Environment and the Minister for Emergency Management. That Ministerial Committee never met.

Following the 2022 election, the relevant ministers met on several occasions but not as a formal Ministerial Committee. Decisions were made collaboratively between the two ministers and formal briefs were agreed by both ministers as required.

Following Budget 2023–24, the ACS Ministerial Committee was disbanded, and Assistant Minister McAllister was appointed the lead ACS Minister. The Assistant Minister consults with the Ministers for Climate Change and Energy, Emergency Management, and the Environment on significant matters.

DCCEEW provides policy support and direction for the ACS. It does this by supporting the responsible Minister for the ACS, providing strategic policy advice to the ACS and supporting its governance. DCCEEW is responsible for delivering an evaluation and annual summary (performance report) to the lead ACS Minister. Initially, information on performance was provided through ad hoc written and verbal briefings to the Assistant Minister, rather than via a performance report. The formal evaluations and annual summaries did not progress in part due to demands on the ACS and the National Emergency Management Agency (NEMA) during extreme events, and the Gateway Review processes.

Following the 2023 Statement of Expectations, the ACS established new reporting procedures requiring a biannual report to the Minster responsible for the ACS. The ACS provided its first biannual report to Assistant Minister McAllister in March 2024.

ACS operations are steered by the following bodies:

- The Program Control Group, a monthly senior governance committee that provides operational oversight of the ACS in line with its strategic direction. The meetings are chaired by the ACS Senior Responsible Officer (CEO, the Bureau) and members are heads of the other delivery partner agencies (CSIRO, ABS and Geoscience Australia) and Deputy Secretary (DCCEEW).
- The Operational Steering Group which coordinates capabilities and services and oversees implementation. The members are senior officers from each partner agency. The Chair is the ACS Group Executive. This group meets monthly.
- The Customer Committee which provides advice to the Minister on strategic priorities for the ACS, identifies customer priority services and approves ACS annual work programs. Members

are the ACS Senior Responsible Officer (CEO, the Bureau), Coordinator General (NEMA) and Deputy Secretary (DCCEEW). Heads of the other delivery partner agencies (CSIRO, ABS and Geoscience Australia) are amongst the observers. It meets quarterly, or as required.

In practice, most of the responsibilities for management of the ACS sit with the Program Control Group. It is the decision-making body within the ACS with oversight of program risks, and has control of cost, schedule, scope and benefits realisation.

The Customer Committee commenced in June 2021 and initially had a decision-making role over the ACS work plan. However, this arrangement was seen by the ACS and DCCEEW as giving the customers disproportionate control and blocked progress of the ACS work program. Following the Gateway Review in 2021, the customers agreed to hand responsibility for work planning and budget allocation to the ACS Senior Responsible Officer. No Customer Committee meetings were held in 2022; however, meetings recommenced following Budget 2023–24.

The government updated the Terms of Reference for the Customer Committee when it issued the Statement of Expectations for the ACS, following the Budget in July 2023.[13]

Scope

Original scope of the ACS

In its establishment phase, the focus of the ACS was on supporting the natural hazard preparedness functions in the NRRA and the response functions in EMA during a period of frequent and significant natural disasters including the 2021 eastern Australia flooding events.[14]

The then government allocated $210 million over four years from 2021–22, with $37.3 million in ongoing funding beyond 2025–26. This funding was for the delivery of projects and capabilities to:

- understand built, social, economic and natural assets
- assess disaster and climate risks – now and in the future
- analyse impacts and risk reduction actions
- integrate and harmonise data
- deliver tailored products and services for Commonwealth emergency management and resilience agencies
- support operations and governance of the service.

Redefined 2023–24 scope

In Budget 2023–24, the government re-focused the ACS to support both short-term and longer-term responses. The reforms included:

- DCCEEW becoming a customer of the ACS to deliver the evidence base for the National Climate Risk Assessment
- positioning ACS to support both medium- and long-term climate and natural hazard analysis and information availability to the government and all sectors, in addition to its operational support for NEMA in response to natural disasters
- positioning the ACS to make data available for reuse within and outside the Commonwealth.

[13] Australian Government, 2023, Statement of Expectations. Available at: https://www.acs.gov.au/documents/f9ea7fcb6ad64eff968adcf3265b0399.

[14] Prime Minister & Cabinet, 2020, A National Approach to National Disasters, Government response to the Royal Commission.

This shift in strategic direction for the partnership was formalised through the Statement of Expectations.[15] It highlighted that the government expected the ACS to support both short-term and longer-term climate related responses by continuing to support NEMA and maturing its services over time. It flagged that this Review would identify the appropriate level of support to NEMA, whilst maintaining current levels for the 2023–24 higher risk weather season.

2.4.2 States and territories

State and territory governments are responsible for most critical climate adaptation functions including the bulk of planning powers and processes (along with local government), land and water management, health and infrastructure planning and provision. Ideally, in considering climate change, state and territory governments must understand and account for future risks related to climate (for example, ensuring that infrastructure intended to exist for 50 years will withstand the climate described in 50-year projections).

Some climate information and tools developed by state and territory governments are directed at local governments to assist their risk assessment and planning, and others are created for their population more broadly. The scope, methodology and format varies across jurisdictions and these are not necessarily comparable.

State and territory governments are key partners in the NPCP but there are no formal co-operation agreements in operation at present. They make significant and welcome contributions and in some cases their work supports efforts outside of their jurisdictional boundaries (e.g. through NARCliM2.0 New South Wales supports South Australia and Western Australia in developing downscaled climate models).

2.4.3 Local government

Local governments are grappling with how to manage the impact of climate change and extreme events for local communities, which is where most immediate impacts are experienced. Local government capability varies but is generally under significant pressure and most councils have a limited budget for climate adaptation.

COAG (Council of Australian Governments) Roles and Responsibilities for Climate Change Adaptation,[16] for local governments, include:

- Administer relevant state and territory and/or Commonwealth legislation to promote adaptation as required including the application of relevant codes, such as the Building Code of Australia
- Manage risks and impacts to public assets owned and managed by local governments
- Manage risks and impacts to local government service delivery
- Collaborate across councils and with state and territory governments to manage risks of regional climate change impacts
- Ensure policies and regulations under their jurisdiction, including local planning and development regulations, incorporate climate change considerations and are consistent with state and Commonwealth government adaptation approaches

[15] Australian Government, 2023, Statement of Expectations.

[16] DCCEEW, 2012, COAG Roles and Responsibilities for Climate Change Adaptation in Australia. Available at: https://www.dcceew.gov.au/climate-change/strategies.

- Facilitate building resilience and adaptive capacity in the local community, including through providing information about relevant climate change risks
- Work in partnership with the community, locally based and relevant NGOs, business and other key stakeholders to manage the risks and impacts associated with climate change
- Contribute appropriate resources to prepare, prevent, respond and recover from detrimental climatic impacts.

Small and medium-sized businesses look to local government for help in their adaptation planning. Whilst many councils are not able to provide this kind of support, there are some cases where this is working:

- The Victorian Greenhouse Alliances – a local government partnership delivering coordinated mitigation and adaption programs. Their programs include capacity building and a framework and tools to assist local government to measure responses to climate change. [17]
- How Well Are We Adapting – another Victorian partnership between Victorian local government areas to seek consistency in climate monitoring, evaluation and reporting. It includes a checklist for councils to assess their adaptive capacity. [18]

2.4.4 Private sector

The private sector has a range of experts and consultants who provide climate and natural hazard services for investment, systems and infrastructure planning and insurance, and community readiness. They include climate risk assessments and disclosures, adaptation planning, climate modelling, scenario analysis, cost benefit analysis, decision-support tools, and development of standards and guidelines.[19]

These firms are offering services to a wide range of users, for example:

- the Australian financial sector – relies on private advisors to support its climate risk disclosures, risk pricing and investment decision-making
- agriculture producers and advisers and other heavy water users such as miners and energy generators – use climate risk assessments as essential elements of their decision-making processes
- government entities – use climate adaptation plans and risk assessments
- insurers and underwriters – use hazard risk profile for assets and products to determine the availability of insurance cover and pricing.

Consultations have indicated that there are some limitations in the private climate services market:

- Public products for existing and future users to draw on are limited, with models, data and advice drawn from a variety of sources with varying degrees of transparency. This means that it can be difficult to assess the quality and applicability of models and information to a given scenario, and in some extreme cases, assess conflicting advice.
- There is currently no certification of the data that practitioners use, or of the practitioners themselves. While some are undoubtedly very professional, many users are not confident

[17] Victorian Greenhouse Alliances, 2024, About us. Available at: https://www.victoriangreenhousealliances.org/.

[18] How Well Are We Adapting, About this tool, 2024. Available at: https://adapt.waga.com.au/.

[19] Keele, S., 2017, Outsourcing adaptation: examining the role and influence of consultants in governing climate change adaptation. Available at: https://minerva-access.unimelb.edu.au/items/9fe189c8-5358-5c22-a07b-088579fb2663.

about their capacity to be informed consumers of these services and there is no 'official' or regulatory guidance to assist them.

- Soon, both the private and public sectors will be obliged to disclose climate-related risks. Large organisations will be able to procure the services of private consultants; however, small businesses and organisations lack the resources to do so.

Private consultants have an important role as a connection between climate science, businesses and government.[20] They should not be seen as competitors with a national climate service, but an essential part of the climate services supply chain.

2.4.5 Climate services in other countries and regions

International models have provided the Panel with useful examples of what success could look like for a future national climate service. Climate services vary based on the existing climate information contexts, capabilities and infrastructure in which they have been established.

Defining national climate services

Interpretation of the role of climate services varies across countries, and even varies across organisations within a country.[21,22] Climate service organisations are often established by bringing together existing climate information organisations in a region, or climate service functions are added to an existing organisation with similar capabilities, rather than building a new climate information network from the ground up. Even locally agreed definitions can play a role in shaping the establishment of a climate service.

How a country defines climate services – and the framework it follows when building one – shapes its outputs, their priorities, and their allocation of resources towards achieving outcomes (Appendix G).

The Review observed that, internationally, two broad frameworks of climate service organisations are common: (1) climate services vertically integrated within meteorological agencies, and (2) climate services with a fundamental user-orientation and comprehensive knowledge brokering function.

Climate services vertically integrated within meteorological agencies

These entities offer 'vertically integrated' climate data and information, with responsibilities along the full climate information supply chain. This includes responsibilities for both weather and climate services extending from generating raw data, to interpretating data into generic public good resources, through to tailored products and tools. Examples include the UK Meteorological Office and the United States' National Oceanic and Atmospheric Administration.

These entities are well-established and authoritative with advanced science and research programs. They lead national co-ordination of climate modelling and research, have diverse and established national and international partnerships, and host vast, open-source datasets with tailored information available for most sectors. They leverage their large size, existing infrastructure and significant data resources to meet a range of needs for different stakeholders across meteorological, disaster response and climate service portfolios.

Two key issues with this model in the Australian context are in the extension of weather services to climate services, which requires data from a much broader variety of domains than weather

[20] Keele, S., 2017, Outsourcing adaptation: examining the role and influence of consultants in governing climate change adaptation.

[21] Bessembinder et al., 2019, Need for a common typology of climate services. Available at: https://www.sciencedirect.com/science/article/pii/S2405880719300767.

[22] US Government, 2023, National Science and Technology Council, A Federal Framework and Action Plan for Climate Services. Available at: https://www.whitehouse.gov/ostp/news-updates/2023/03/22/nstc-a-federal-framework-and-action-plan-for-climate-services/.

alone; and the need to distinguish between research, operational product development, and service delivery. The current state of the ACS, as part of the Bureau, creates confusion, as observed by the research sector:

> *Without such clarity, internal processes are difficult to define. Furthermore, external partners and clients will find it difficult to connect at the right level. For example, stakeholders in search of services will frequently contact scientists for their inquiries instead of the service layer. The absence of an operational layer leads to confusion concerning whose job it is to provide versus develop services and external research partners do not know who to approach for potential collaboration.*[23]

Climate services with a fundamental user-orientation and comprehensive knowledge brokering function

These entities are focused on co-delivering midstream and downstream climate information and services. Examples include the Canadian Centre for Climate Services (CCCS), Copernicus Climate Change Service (C3S) and California's Integrated Climate Adaptation and Resiliency Program (ICARP). The United States is also currently developing a national climate services system aligned with this framework, to address perceived shortcomings in its existing integrated arrangements.[24]

These entities connect users to a diverse range of national, regional and local climate information sources through web platforms, data libraries and directories. They commission work to meet user needs via partner networks, leveraging the capabilities, resources, data and existing infrastructure of their partners and host agencies to deliver significant climate services and tools. A range of knowledge brokering services are available to support users to find and use climate information, including in-person expert assistance, virtual support using artificial intelligence, online resources and community-driven guidance and forums.

Their leadership and co-ordination function can be broad or more tightly scoped. For example, ICARP has a distinct leadership and co-ordination function that enables it to direct state-wide climate research and policy priorities delivered by other agencies, whereas the CCCS maintains a focus on knowledge brokering, developing tailored products and services and leadership of a national network of regional climate service providers, leaving science and policy leadership to its host agency.

Box 3: Canadian Centre for Climate Services

The CCCS was established in 2018 to provide Canadians with access to reliable climate information, tools and expertise to support decision-making in various sectors through an online climate information portal and knowledge brokering. It coordinates and collaborates with a partnership network of regional climate services covering all Canadian provinces to jointly deliver climate services that respond to local needs.

What it does

- **Delivers climate services driven by user needs** by conducting outreach and engagement to assess which data, information and tools Canadians need to incorporate climate risks into their decisions. Services are regularly updated to reflect evolving needs.

[23] Pitman, A. & Jakob, C., 2023, Submission to the Independent Review of the ACS.

[24] Ibid.

- **Provides access to climate data, tools and information** from across the country through the climate information portal. The portal consists of:
    - climate information basics to help Canadians better understand climate change
    - a climate data portal (climatedata.ca), which provides an interactive environment that allows users to explore, visualise and download high-resolution climate data and information tailored to their specific needs
    - a library of climate resources which provides access to external information for decision-making (e.g. climate datasets and resources consolidated across federal, provincial, and territorial governments, national professional organisations, climate consortia and established international organisations).
- **Builds local capacity by coordinating and collaborating** through its network of regional climate services. Regional climate services also provide direct feedback to inform service and research priorities at a federal level.
- **Offers training and support** to help Canadians make sense of climate information through a Support Desk. This includes help finding and interpreting climate data, information or tools, and applying it to their decisions.

Capabilities

The CCCS has a multi-disciplinary team with expertise across a broad range of climate-related disciplines, including in-house technical analysis capability and knowledge brokering. The CCCS has approximately 45 staff across three main areas:

- Data product development – bespoke data analysis
- Support desk – knowledge brokering, training and climate literacy
- Outreach and engagement – user research and marketing of services.

Governance

The CCCS is hosted by Environment and Climate Change Canada, the federal department responsible for coordinating environmental policies and programs. It has multiple layers of governance overseen by an expert advisory panel and a regional co-ordination committee:

- **Expert advisory panel:** comprised of multidisciplinary experts to provide advice on how the CCCS can shape and evolve its services to help Canadians plan for climate change.
- **Regional coordinating committee for climate services:** comprised of representatives of regional climate services to advance national co-ordination of climate services and align work planning across organisations. It is informed by a community of practice and provides strategic advice to other committees.

2.5 Users of climate information

An increasing number of decision-makers throughout the economy and the community are considering climate risks across long time horizons, to inform their decisions under uncertain future conditions. This need is urgent and increasing, having been largely unmet by the information currently accessible in Australia.

There are two categories of climate-related risks that need to be considered by Australian organisations – physical and transition risks. The Review has only considered the issue of data and information services to support decisions relating to physical risk.

- **Physical risks** are driven by extreme weather resulting from climatic events as well as long-term shifts in climate patterns, such as changing rainfall patterns and increased heatwaves.
    - Acute physical risks are those that are event driven. For example, increased severity of extreme events, such as floods.
    - Chronic physical risks arise due to long term changes to climate, for example, high temperatures, changed rainfall patterns, sea level rise, ocean acidification and their cumulative impacts generally and on the performance of our land use sectors and natural ecosystems.
- **Transition risks** result from the policy changes to shift to a low emissions economy and society. They can include technological changes, policy shifts, changes in consumer preferences and prices. These are generally seen as risks but for some firms they will provide commercial opportunities.

Decision-makers can also identify **opportunities** when understanding their climate risks. For example, these could be activities that improve resilience against hotter conditions.

Decision-makers are trying to account for these climate-related risks in their decision-making processes and will require access to appropriate data, information and advice for efficient adaptation and responses to events. Table 1 indicates the large number and variety of users, the pervasive influence of these considerations throughout our society and economy, and the very large aggregate impact of our adaptation to climate risk.

Systems	Types of decisions/uses
Infrastructure and the built environment	Planning infrastructure investment Assessing the vulnerability of their assets and networks Embedding resilience into land use planning and development decisions Construction design, practices and technology Understanding flow on effects to all systems e.g. risks to essential supply chains, health and services, and energy production due to infrastructure risks and/or impacts
Economy, trade and financial system	Understanding climate risks (market, reputational, assets, supply chains, including that of regional partners) Preparing a climate risk disclosure statement to meet the Taskforce for Climate-related Financial Disclosures (TCFD) requirements and other regulatory requirements Identifying climate opportunities
Natural environment	Understanding climate risks to environmental assets (including water) and natural resource management activities and industries Understanding climate risks to cultural practices as a result of ecosystem disruption Understanding changes to ecological threats due to changing climate (e.g. pests, weeds and diseases) Understanding opportunities to incorporate traditional knowledges and cultural practices into land management

Systems	Types of decisions/uses
Primary industries and food systems	Understanding climate risks and opportunities to agricultural and fisheries assets Understanding short-term and seasonal impacts, and risks to agricultural outcomes Understanding long-term climate and weather trends, and their impact on the productivity and viability of different commodities/agricultural products Understanding climate related biosecurity risks
Health and social support	Understanding climate risks to health systems including (heat, disease, food safety and air quality) Understanding risks of community displacement due to disasters or increasingly inhospitable climates Understanding cultural impacts and incorporating First Nations knowledge Understanding climate related biosecurity risks
Defence and national security	Understanding international security risks and impacts of climate change Understanding international trade risks and opportunities and impacts of climate change Understanding climate related biohazard risks Assessing risks of climate change to critical infrastructure Anticipating human migration in response to climate change Developing early warning systems for environmental threats to national security
Regional and remote communities	Understanding climate risks to communities that are supported by the natural environment, especially those with a strong mining, agribusiness, and/or tourism industry Understanding risks to water supply availability Understanding risks to governance, community cohesion, physical and mental health as a result of direct weather impacts and displacement Understanding risks to supply chain infrastructure for a multitude of businesses, in addition to essential services and goods
First Nations values and knowledge systems	Recognising the value of First Nations leadership and knowledge to inform mitigation of climate risks Inclusion of First Nations perspectives in decision-making and co-design of climate change adaptation actions (e.g. cultural burning and control of pests influenced by climate change) Understanding climate risks to culturally important species, habitats, and cultural sites Understanding risks to cultural safety of First Nations peoples Understanding risks to wellbeing, equity and justice Understanding climate-related risks to cultural economies

Table 1: Types of users and the decisions they make across different systems

2.5.1 Characteristics of climate services users

User needs for climate information and services are varied and complex; some require access to raw data, some find that broad information resources are sufficient, and others require more tailored information.

Climate information is complex and is changing as climate science evolves. Users need to be informed by contemporary data and information acquired from known credible sources using clear assumptions and methodologies. That information must be presented in a format that is understandable to the user, and with enough detail that they feel confident in taking action towards climate risk mitigation.

Levels of climate literacy vary across users of climate information but, generally, Australia's climate literacy levels are low. Even with adequate availability of climate information, climate literacy is often a barrier to users being able to apply it to their decision-making.[25]

General literacy issues can also contribute to the accessibility of climate information and advice. For example:

- Some migrants and First Nations communities face a language barrier when accessing climate information, as English is not their first language.
- Low digital literacy is a barrier to using online climate information for 9.4% of Australians who are considered highly digitally excluded, due to issues around digital access, affordability and technological ability.[26]
- Terms such as 'adaptation', 'vulnerability' and 'resilience' used often by policymakers can evoke different meanings to users, for example for First Nations Peoples.[27]

The level of information required by climate decision-makers depends on two factors: their existing knowledge (climate literacy), and their assessment of what they think they need to know.[28] Box 4 describes this variation in terms of the complexity of questions and desired answers.

Box 4: Illustration of user needs

Users require support to request, interpret and apply climate information depending on their level of climate literacy and their varied needs. Examples of the range of questions and types of data and information that users may require include:

I don't know what I want.
e.g. I'm completing my company's climate-related financial disclosures for the first time, so I don't know how to describe what I need from a climate service.

I have simple questions and I'd like simple answers.
e.g. I'm purchasing a house and would like to know the likelihood of weather-related natural disasters at this location and possible future insurance costs.

I have complicated questions, but I'd like simple answers.
e.g. I'm completing a risk assessment for my small business and need to know the primary and secondary impacts of the changing climate on my business.

I have complicated questions and I'd like in-depth answers.
e.g. I need to ensure that my clients' investments are unlikely to be impacted by climate change or understand the risks if they are.

I have complicated questions that I could answer myself if I had the data.
e.g. I'm a researcher looking into the impacts of climate change on a local species.

The NESP Climate Systems Hub has identified that the greatest demand for accessible and usable information is with their Novice and Intermediate personas (see Box 5).[29]

[25] NESP Climate Systems Hub, 2023, An analysis of user needs for climate information and data, existing portals, user personas, and recommendations for meeting priority gaps. Available at: https://nesp2climate.com.au/resource/delivering-quality-climate-information-and-data/.

[26] Australian Digital Inclusion Index, 2024. Available at: https://www.digitalinclusionindex.org.au/key-findings-and-next-steps/.

[27] Nursey-Bray, Melissa, 2019, Old ways for new days: Australian Indigenous peoples and climate change, Local Environment, Vol. 24, no. 5. Available at: https://www.tandfonline.com/doi/epdf/10.1080/13549839.2019.1590325?needAccess=true.

[28] Choo, C. W., 2023, Climate change information seeking. Available at: https://asistdl.onlinelibrary.wiley.com/doi/10.1002/asi.24805.

[29] NESP Climate Systems Hub, 2023, Understanding Our Audience. Available at: https://nesp2climate.com.au/resource/understanding-our-audience/.

Box 5: NESP Climate Systems Hub Personas

The following personas were developed by the NESP Climate Systems Hub.

Alf

Experience: Novice

Could be: Government policy officer, land manager, general public

Needs:

- simple, non-technical, easy to understand information on climate change for my region
- information on the impacts of climate change
- likely future climate scenarios.

Bob

Experience: Intermediate

Could be: Risk manager, strategic policy maker, planning officer

Needs:

- to know how to find the most appropriate data and the best ways to apply it
- explainers of ranges and uncertainty
- translation of projections to impacts
- hazards and their likelihood of impacting my area
- clear narratives around scenarios and model selection
- curated regional future climate projections.

Carol

Experience: Advanced

Could be: Climate professional, researcher, modeller, consultant

Needs:

- datasets from a range of models
- understanding methodologies, research gaps and limitations
- detailed information on modelling methods, assumptions made and assessment of results.

Box 5: NESP Climate Systems Hub personas

2.5.2 Case studies

The following case studies demonstrate the range of users from different sectors with varying information needs to help them, and Australia, manage climate risk.

Case study: climate-related risk disclosure obligations

The Australian Government is developing climate-related disclosure reform that will require public and private entities which meet statutory reporting thresholds to report on climate-related risks and opportunities. Australian entities are increasingly making decisions based on climate knowledge and risk perceptions due to increasing exposure to a range of climate related risks, including physical and transition risks, as well as liability risks (potential litigation if entities fail to adequately identify, report on and address climate risks).

Climate-related disclosure reforms aim to support informed decisions that reduce the overall cost and consequences of climate change by increasing transparency, accountability and credibility in how risks are managed, and helping prepare entities for future climatic conditions. The introduction of

any mandatory climate change-related reporting regime remains subject to the passage of legislation through Parliament, but will become a market requirement in some form in any case.

Across public and private entities, it is estimated that at least 6,000 Australian entities[30] will be affected by the government's mandatory climate risk disclosure obligations in the next four years. These entities will need access to good quality climate risk data and information along with appropriate guidance, tools and resources to interpret and apply it to ensure the integrity of climate-related disclosures. This information is not publicly available at present and most entities will need to procure services from private consultants and assurance organisations.

Case study: Heat management and health protection

As Australia's climate continues to warm, heatwaves are expected to become more frequent, more intense and longer lasting. The First Pass National Climate Risk Assessment identifies risks to health and wellbeing from slow onset and extreme climate impacts, including increasing temperatures and heat extremes, as a nationally significant climate risk.[31]

Government, industries and community service organisations need climate information integrated with public health strategies, urban planning and other social, economic, built environment and natural domain data to understand how heat risk varies between populations and locations. This enables them to create effective policy, planning and interventions to minimise that risk. For example:

- tree canopy maps to develop greening projects that reduce heat exposure
- heat hotspot maps to inform decisions on the placement of cooling centres (i.e. public locations, such as libraries, with reliable air conditioning) and other heat-resilient infrastructure
- climate projections integrated with health impact assessments to guide heat action plans and resource allocation for healthcare services during heatwaves
- real time heat warnings for employers to identify if, where and when workloads should be reduced during heatwaves.

In April 2024, the ACS released a pilot Heat-Health Index[32] to support decision-makers from a range of industries to improve health outcomes for Australians vulnerable to heat events. The pilot will help to identify other information needed to improve approaches that mitigate the adverse health impacts of heatwaves.

Case study: Dwellings and home insurance

The Climate Council found that one in 25 Australian homes will be uninsurable by 2030.[33] Already, the insurance sector is reporting that an increasing number of buildings can either no longer be insured or attract premiums that make insurance cover unrealistic for many people.[34]

Australians need accessible and clear information that is tailored to their circumstances to understand the climate risks they and their communities face, and protect their safety and financial

[30] Treasury, 2023, Policy Impact Analysis, Climate-related financial disclosures. Available at: https://treasury.gov.au/consultation/c2024-466491.

[31] DCCEEW, 2024, National Climate Risk Assessment First Pass Assessment Report. Available at: https://www.dcceew.gov.au/climate-change/publications/ncra-first-pass-risk-assessment.

[32] ACS, 2024, Understanding risk with the Heat-Health Index. Available at: https://www.acs.gov.au/pages/heat-health-insights.

[33] Climate Council, 2024, One in 25 Australian homes uninsurable by 2030: Climate Council launches cutting edge digital climate-risk map. Available at: https://www.climatecouncil.org.au/resources/australian-homes-uninsurable-2030-climate-risk-map/.

[34] Insurance Council of Australia, 2023, Building Australia's Resilience: Policy Recommendations for federal and state governments. Available at: https://insurancecouncil.com.au/issues-in-focus/building-resilience/.

wellbeing. This includes local-scale climate risk assessment tools to assess and appropriately respond to the risk of bushfire, flood, cyclone, sea level rise and other climate-driven events in their location. This information could inform decisions on home purchasing, building design, renovations, energy efficiency, insurance coverage and other risk mitigation efforts that build community resilience to climate change.

The Climate Council developed an interactive Climate Risk Map,[35] based on climate risk analysis undertaken by a private climate service, to help Australians to better understand their local risk of natural hazard events, based on low, medium and high emissions scenarios and across decades (by 2030, 2050 and 2100).

The insurance industry, though it has been a leader in gathering climate information, also needs support. It reports that more consistent and accessible climate projections and datasets that define risk levels for natural hazards at longer timescales would build resilience and support more accurate insurance decisions at a property level.[36]

[35] Climate Council, 2022, Climate Risk Map of Australia. Available at: https://www.climatecouncil.org.au/resources/climate-risk-map/.

[36] Insurance Council of Australia, 2023, Building Australia's Resilience: Policy Recommendations for federal and state governments.

3 The Review's findings and recommendations

The findings of this Review are grouped broadly into seven themes. Key findings for each theme are covered in a short summary of the evidence base, drawn from research and stakeholder consultations. The seven themes are:

- The need for structural changes to the ACS
- The critical need for a comprehensive national climate service
- The broad requirements and capabilities of climate service users in Australia
- The national co-ordination and leadership gap that needs to be filled
- Measures needed to increase the quality of climate and domain data
- Evaluation measures needed to ensure user needs are being met
- Expectations for the transition from the current governance structure.

3.1 Performance of the Australian Climate Service

Key findings

Because of the way it was established, ACS had to prioritise short-term emergency management needs at the expense of long-term climate information services. Consequently, the ACS has been unable to meet Australia's wider climate information requirements.

And, in the emergency management domain, the ACS was also unable to cope with the variety of requests resulting from the scale and number of natural disasters since it commenced operations. It could not respond adequately to the high volume of urgent requirements from its primary client, NEMA and its predecessors. Also, it appears that the emergency agencies were not sure what they could expect of the ACS, and their needs shifted significantly, particularly as their organisational structures and senior leadership changed.

At times, NEMA's needs could arguably have been better met by alternative suppliers, but it did not have the flexibility to choose its preferred provider. NEMA responded by increasing its in-house capabilities to address its needs.

Although aspects of the ACS's operations are now working more effectively, it is clear that the ACS structure is not fit-for-purpose for the type of service the Review repeatedly heard is needed, and the model as originally established is unlikely ever to be effective in delivering a comprehensive national climate service. The ACS governance structure does not align capacity, responsibilities authority and accountability appropriately.

The co-ordination arrangements of the ACS partnership model are complex, resulting in challenges for the ACS to mobilise new projects quickly, adjust resources to changing needs, and get agreement for priorities from all partners. The need to make decisions with agreement of all four partners is at odds with the need for efficient delivery and the capacity to commit to customers with confidence.

The ACS has worked hard under difficult circumstances. It has established its operations during machinery of government changes and several years of frequent natural disasters. It is evident that the staff across the ACS partnership are dedicated and have demonstrated outstanding resilience.

The ACS has delivered products for emergency management, hazard preparedness, insurance and climate projections, including:

- Higher-risk weather season scenarios
- Satellite derived insights of national floods (ICEYE)
- Supply chain impact data and reports
- National Climate Risk Assessment methodology and first pass report
- Basic training and resources on hazards
- Data sharing approaches to develop insurance coverage and affordability data asset for the Hazard Insurance Partnership
- Climate projections information for the Australian Government.

Consultations have identified that two major structural issues with the ACS have prevented strong performance. These are: (1) servicing both short- and long-term information needs creates conflicting demands on resources; and (2) the governance structure does not align capacity, responsibilities, authority and accountability. These challenges have prevented the ACS from being a national climate service.

3.1.1 Emergency management needs were prioritised over climate information needs

When it was established, there was a widely held expectation (especially across federal government departments) that the ACS would quickly scale to a national capability with a broad user base. This was articulated in the Royal Commission and the *National Climate Resilience and Adaptation Strategy 2021–2025.*[37] However, the then government set up ACS primarily to provide climate information in the context of short-term disaster services. The ACS was not given the policy authority, funding or governance to meet the broader long-term expectations.

Even with this more limited brief, the ACS was unable to cope with the variety of requests that resulted from the scale and number of natural disasters occurring at that time. The ACS did not have the time and capacity to develop workable arrangements with its partner agencies, which were providing the primary advice.

This led to short-term, operational disaster needs taking precedence and has affected the ACS's ability to scale up to provide longer-term climate information capabilities. Although there is common data needs for both functions, the ACS has indicated that separate, dedicated resources are required for short- and long-term capabilities.

> *…the approach should consider how the resource 'pie' can be expanded to meet both [short-term emergency management and long-term climate adaptation] needs, and not at the expense of short-term outcomes.*[38]

[37] DCCEEW, 2021, National Climate Resilience and Adaptation Strategy 2021 to 2025. Available at: https://www.dcceew.gov.au/climate-change/policy/adaptation/strategy.

[38] NEMA, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

3.1.2 The National Emergency Management Agency's operational information needs

The ACS has made some significant contributions to NEMA to support operational emergency management. Many of these functions have been provided directly by ACS partner agencies but were arranged and funded through the ACS. Examples include satellite derived insights of national floods from Geoscience Australia, and the meteorology experts providing decision support into the National Situation Room, sourced via the Bureau. NEMA has stated that the 'ability to consult directly with specialists on forecast, modelling and impact information is of incredibly high value'.[39]

Initially, however, there were challenges in meeting NEMA's needs, due to two major issues. Firstly, NEMA's expectations exceeded the ACS's initial capabilities, which led to reputational concerns. The ACS did not have the time and capacity to develop workable arrangements with its partner agencies, which were providing the services. The ACS was therefore unable to cope with the variety of requests resulting from the number of natural disasters, despite being established with a central aim of assisting with emergency management and response. This lack of foundational capabilities led to poor delivery at times and a breakdown in trust with NEMA, which has not been restored.

Secondly, the dynamic nature of operational services for emergency management and the increasing frequency of disasters are at odds with the ACS's current structure and capabilities. The ACS has said it 'is likely to be best utilised in an operational context if the scope of information and intelligence it delivers is well-defined and pre-agreed, with respect to customer expectations, partner expectations, and ACS priorities'.[40] This certainly is not achievable in the short term.

> *NEMA [formerly EMA and NRRA] urgently needed data and information from across the whole climate service supply chain… and assumed that the ACS would have this readily available. The emerging maturity of the ACS and lack of mutual understanding meant that needs were not met in a timely manner, and trust was broken.*[41]

The current model, whereby funding is allocated to the ACS and then NEMA accesses ACS services as a customer, does not allow NEMA to choose the information sources it considers would best meet its needs. Another provider may be better placed to deliver at the required speed and with the specific information NEMA requires. As a consequence, NEMA has matured its own capabilities and become more sophisticated about meeting its operational requirements and rapidly evolving data needs to support decision-making. It has built an in-house data analytics capability, drawing on information from the ACS and external providers.

The Review is of the view that NEMA is best placed to take on the responsibility for operational support services for emergency management, and that this function should be transferred to NEMA.

3.1.3 The virtual partnership

Following the announcement to establish the ACS, competing priorities, incentives and interests came into play. The proposed structure and functions of the ACS were highly contested across key agencies. Multiple proposals from different entities were drawn on to form the ACS. An ineffective governance model and funding structure was implemented, which significantly impaired the ACS's

[39] NEMA, 2023, Submission to the Independent Review of the ACS.

[40] ACS, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[41] Ibid.

capacity to deliver on its original charter from the outset, and prevented the development of clearly defined functions and priorities and a publicly recognised identity.

The co-ordination costs of the virtual partnership model are high, affecting the ability to mobilise new projects quickly and respond to user needs. This is due to the model of procurement and operating agreements, whereby ACS partners bid for projects. Partners take on projects via operating agreements, which take reasonable time to develop, particularly where there are intellectual property negotiations. This mode of engagement is not ideal:

- it does not allow competitive procurement and therefore may not provide value for money
- it limits the type of data and services the ACS can use
- it increases the ACS's time to delivery.

Whilst there are no restrictions preventing the ACS from accessing external capabilities, a decision has been made to implement the partnership model in a way that makes it challenging to engage external sources. If a partner can deliver a project, there is no scope to conduct a value for money assessment with external entities. Only if all partners decline a project does an external procurement go ahead.

The virtual partnership has also resulted in a lack of clarity between the ACS Office and the staff working on ACS projects in each partner agency. The Group Executive of the ACS has limited visibility and therefore little control over delivery of the initiatives for which it is responsible. This model does not give the ACS the capacity to resolve conflicting priorities and interests in accordance with its own charter and requirements.

There have been some improvements following the provision of the Statement of Expectations and there is considerable commitment among the partners to the ACS's success. However, the governance, operating model and incentive structure will prevent the ACS from realising its potential regardless of this goodwill and commitment. The Review finds that the provision of Australia's current and future climate information needs is at odds with the current ACS operating model, including the partnership arrangements.

3.1.4 Capability beyond the current partnership

The ACS implemented its partnership model in a way that builds internal capability of the four ACS partners. This model has made it challenging to draw in other external sources and is not a viable long-term approach, which requires access to a wide range of high-quality climate information.

While there are no formal restrictions preventing the ACS from accessing other capabilities, it is not using the expertise of several high-quality institutions across governments, or the research sector both domestically and internationally. As a result, the significant resources being invested in data, capabilities and products outside of the four partners are not being leveraged to best meet user needs. There is a risk that the ACS is not able to ensure best value for money.

The benefits of a broader multidisciplinary approach are clear, for example, in the product My Climate View. My Climate View is an Australian tool that was developed by a multidisciplinary team from CSIRO, which allows farmers and advisors to anticipate crop suitability under a variety of future climate conditions. The team producing it included diverse skills such as climate, agriculture and social sciences, as well as human-centred product development and modern software engineering practices. Tailored information tools for a range of purposes, users and sectors will be increasingly necessary to support climate-related decision-making.

The removal of capability silos … has allowed domain experts to come together with user engagement specialists to ensure the right questions are asked and the right combinations of ears are present to hear the responses. The outcomes from this deep collaboration have been incorporated into the product so that farmers and farm advisors are able to understand and reliably use future climate information in their decision-making processes.[42]

Although stakeholders in consultations have consistently stated they are willing to collaborate with the ACS, the Review has found additional incentives may be required. These are described in section 3.4.5 *Build mechanisms to integrate information from other providers*.

The research sector (notably ACS partner organisations and the universities) could be used to drive research into particular aspects of climate change that are required by users, or service provision, such as motivating factors for climate adaptation. Strategic partnerships with the research sector would connect the science to services in a more meaningful way.[43]

3.1.5 A climate services roadmap

In several consultations the Review heard that it is not clear what the ACS is doing, who its principal clients are, or what its vision is. Until recently, the ACS has had one primary customer, and the need for broad visibility of its work program has not been a priority. Its original public-facing mandate (to "support communities and business to better anticipate, manage and adapt to the risks that a changing climate will bring'')[44] is not aligned with what it was actually required to do initially – have a singular focus on NEMA's (and its predecessors') needs.

At present, the external view is that the ACS claim to do everything, when in fact its capability and remit are both quite focused and limited. This has led to major problems with expectation management and significant disquiet outside the ACS concerning failure to deliver products that they are not actually expected to produce.[45]

Australia needs to publicly articulate its approach to building a national climate information capability, to manage expectations around scope and availability. The European Union developed *A European research and innovation roadmap for climate services* which was successful in building a shared framework for phasing services over the long-term.[46]

An Australian climate services roadmap should include the establishment and gradual expansion of a national co-ordination role. This role will increase over time from monitoring climate services activities, through to making recommendations on the full climate services supply chain, from

[42] CSIRO, 2023, CSIRO Collaboration Award Nomination Form, Climate Services for Agriculture, supplied.

[43] Pitman, A. & Jakob, C., 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[44] Bureau of Meteorology, 2021, Media release: Australia's top science and statistical agencies welcome world-leading climate service. Available at: https://media.bom.gov.au/releases/833/australias-top-science-and-statistical-agencies-welcome-world-leading-climate-service.

[45] Pitman, A. & Jakob, C., 2023, Submission to the Independent Review of the ACS.

[46] European Commission, Directorate-General for Research and Innovation, 2015, R. Street, M. Parry, J. Scott, et al., *A European research and innovation roadmap for climate services*. Available at: https://op.europa.eu/en/publication-detail/-/publication/73d73b26-4a3c-4c55-bd50-54fd22752a39.

science to end users. Further detail on this gradual expansion is provided in section 3.7 *Transition planning*.

3.1.6 The need for change

There is a conflict between ACS's responsibility for climate information for short-term emergency management and its responsibility for longer-term climate information services. As discussed above, emergency management priorities have taken precedence over longer-term climate information needs, resulting in a gap in accessible information to inform Australia's broader adaptation requirements.

The Review considers that an effective climate service focus on the longer-term needs can only be delivered by servicing emergency management needs separately from climate adaptation needs.

Given that the emergency management services provided to date have not been meeting the needs of its primary client, NEMA, which has consequently been independently developing its own capability in this area, the Review considers that NEMA is best placed to undertake this role, as specified in Recommendation 1.

Even with this change, the current ACS operating model, including the partnership arrangements, is not well suited to the provision of current and future climate information needs in the long term. A new entity is needed. This is discussed further in section 3.2 *Increasing Australia's capacity to respond to climate change*.

Recommendation

1. That the Australian Government make the following changes to the provision of climate and hazard information to the National Emergency Management Agency.
    1.1. Transfer responsibility for operational support services for emergency management (as set out in the *Australian Climate Service Operational Support Services – Service Level Agreement 2023-24*) from the Australian Climate Service to the National Emergency Management Agency, to reinforce the real time connection of information and decision-making on emergency responses.
    1.2. Allow the National Emergency Management Agency to make judgements about how to best meet its needs, including by managing its own tasking, data and analysis, with the ability to draw on external sources.
    1.3. Require the National Emergency Management Agency make its data and products open-source and accessible to government and the public wherever possible.

Outcomes by 2030

- NEMA has flexibility to generate information internally or procure from sources of its choosing.
- Dedicated, distinct resources are applied to emergency management and climate information needs, with coordinated sharing of data and system investment plans.

3.2 Increasing Australia's capacity to respond to climate change

Key findings

Australia is highly exposed to climate change risks and the impacts will increase over the coming decades. Climate adaptation decisions will be needed across all areas of society to reduce its impact.

Climate adaptation will be expensive, but the costs of poorly informed and ineffective adaptation will be far greater. Climate risk decisions will significantly influence our future standard of living and our capacity to manage the social and economic impacts of a changing climate.

Across both the public and private sectors of the economy, there is an urgent, growing demand for authoritative climate risk information. Government policy and co-ordination and community expectations will accelerate this growth.

Climate services are a necessary investment to meet this demand, and at this stage must be led by government.

Establishing the ACS was a start in the process of creating a national climate service, but its structure and organisational capacity are inadequate to deliver the type of climate service Australia needs, nor are they sufficient to respond to government's ambition, as outlined in the Australian Government's Statement of Expectations for the ACS (July 2023).

3.2.1 Urgent demand for authoritative climate risk information for all Australians

Throughout consultation for this Review there was unanimous support for a national climate service to increase our capacity to adapt to climate risks. A wide range of decision-makers have cited the need for accessible, up to date, nationally coordinated and reliable climate information, presented in various timescales, for different purposes and locations. Many users will require assistance to interpret this information.

To meet this need, Australia urgently needs an adaptive and flexible national climate service with sufficient capacity to meet the scale of this increasing challenge and nurture a broader system for informing climate related decisions.

3.2.2 The economic case for investment in a national climate service

The financial impacts of climate change are already being felt throughout Australia as the cost of natural disasters is increasing.[47] This is projected to increase over time, with the cost of Australian disasters expected to rise to $73 billion per year by 2060 under a low emissions scenario, and $94 billion per year under a high emissions scenario.[48]

[47] The McKell Institute, 2022, The Cost of Extreme Weather. Available at: https://insurancecouncil.com.au/resource/new-research-shows-every-australian-pays-for-extreme-weather/.

[48] Deloitte Access Economics, 2021, Special report: Update to the economic costs of natural disasters in Australia.

The impacts of extreme events and disasters will increase the cost of living for all Australians through higher product prices, insurance premiums or taxes. [49]

However, the larger impacts of climate change will be experienced in almost every aspect of our economy due to the interdependencies between the economy and the trade and finance systems, insurance, primary and food industries, health and social support, regional and remote communities, infrastructure and built environment systems.[50]

For a modest investment overall, a national climate service can support planning and adaptation of climate risks that will have economy-wide benefits. As stated in the 2023 Intergenerational Report, 'Australia's future social, economic and fiscal impacts of natural disasters will depend in large part on the extent of proactive and well-targeted investment in resilience'.[51] Governments can anticipate adaptation investments now, or incur larger costs arising from future extreme events and the cumulative costs of long-term and ongoing adaptation.

The synergies between climate adaptation, cost efficiency and emissions reduction should also be considered. For instance, designing and investing in built and natural infrastructure that accommodates the changing climate and likelihood of extreme events offers both emissions reductions and cost savings compared to a repetitive cycle of emissions-intensive and costly construction, demolition and rebuilding.[52]

Commonwealth investment in a national climate service will also act as a cost-sharing mechanism. Communities, sectors, businesses and individuals will have information to act on self-funded climate adaptation and mitigation investments. Additionally, it will also provide greater support to states and local governments which can in turn provide more detailed advice to their most vulnerable communities.

There is the potential for large economic gains from investment to improve Australia's resilience to natural disasters.[53]

Recommendation

2. That the Australian Government reaffirm the importance of accessible and useable climate related information to inform effective and efficient adaptation to climate change challenges.
    2.1. Establish the National Climate Service, which will be available to serve all Australian governments (Commonwealth, state, territory, local) and, over time, provide information to all Australians. The National Climate Service should absorb the remaining Australian Climate Service functions (which are not transferred to the National Emergency Management Agency), and should be able to broaden its services to new users with agreement from the responsible Minister.
    2.2. Ensure the National Climate Service has adequate budget allocation to reasonably meet escalating needs for a national climate service capability.

[49] The McKell Institute, 2022, The Cost of Extreme Weather.

[50] DCCEEW, 2024, National Climate Risk Assessment First Pass Assessment Report.

[51] Treasury, 2023, Intergenerational Report. Available at: https://treasury.gov.au/publication/2023-intergenerational-report.

[52] OEDC, 2018. Climate-resilient infrastructure. Available at: https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf

[53] Deloitte Access Economics, 2021, Special report: Update to the economic costs of natural disasters in Australia.

3.2.3 Administrative location of the National Climate Service

The Review has identified three options for the initial structure of the National Climate Service (NCS).

Option 1: Establish the NCS as a stand-alone statutory agency

This model would provide the NCS with a level of independence and high visibility. However, the Review does not consider that it would be wise to establish a statutory agency at this time when the climate information services market is at an embryonic stage.

Option 2: Host the NCS in the Bureau of Meteorology

The Bureau is currently the ACS accountable authority. There is some precedence internationally for climate services vertically integrated within meteorological services (refer section 2.4.5 *Climate services in other countries and regions*). This would provide the Bureau with responsibility for all phases of the climate services supply chain, with corresponding efficiencies from co-locating functions with the Bureau's existing Climate and Research Programs.

However, the Review considers that climate services diverge from the Bureau's core business of providing upstream, observational meteorological and climate data. Climate services require a multidisciplinary collaboration. Meteorological and climate data are only one input to a climate service, which will need to integrate data from many domains (e.g. socioeconomic, cultural and environmental) across a range of sectors. The capability also needs to be centred around sustained user engagement, business analytics, communication and relationship building. Therefore, the expertise and organisational structure to deliver this integrating capability for Australia is better located outside of a meteorological agency at this early stage.

Option 3: Incubate the NCS in DCCEEW

Establish the NCS initially within DCCEEW and transition to a standalone statutory agency over time. This would enable the new service to leverage DCCEEW's national role across Commonwealth agencies and state governments, and regularly report to the Energy and Climate Change Ministerial Council (ECMC). It should improve the service's alignment with climate adaptation policy, and leverage the communication and policy expertise across DCCEEW's broad portfolio remit. Assisted by an expert advisory committee, it should facilitate the development of a national information service independent of the partner agencies' priorities. Given this national climate service will have natural synergies with Environment Information Australia (EIA), the NCS and EIA could integrate or at least align systems and professional capabilities within DCCEEW where this promises efficiencies (Box 6). Moving the function to DCCEEW will enable provision of a climate service with a fundamental user-orientation remit.

Recommendation

3. That the Australian Government establish the National Climate Service within the Department of Climate Change, Energy, the Environment and Water, and consider opportunities for resource and systems sharing, potentially integrating its back office data and computational systems with Environment Information Australia.

Box 6: Synergies between the NCS and EIA

EIA is being established to provide an authoritative source of high-quality environmental information for Australia. Once legislated, EIA will:

- have a statutory role to improve availability and access to quality, authoritative environment data
- provide data to the national Environment Protection Australia consistent with the National Environmental Standard for Data and Information
- deliver State of the Environment reporting, including trend analysis and progress toward environmental goals
- deliver Environmental Economic Accounts in partnership with key agencies
- develop a Monitoring Evaluation and Reporting Framework to track progress towards Nature Positive.

EIA's existing data analytics and geospatial capabilities, data co-ordination functions and ambition to uplift and publicise Australian environmental data align with proposed priorities for the NCS. Given the synergies, integrating the NCS with EIA could be considered, with options ranging from sharing core functions through to fully integrating both entities within EIA.

Option 1

Soft integration would primarily focus on creating combined ICT infrastructure and geospatial expertise, collaborating on data collection and integration where appropriate. This option would ensure that both entities retain a strong focus on their individual missions, while drawing co-benefits through shared services.

Option 2

Both NCS and EIA remain separate, but they are brought together in a new group within DCCEEW with responsibility for delivering both their objectives. Shared core functions could also form part of this model.

Option 3

Full integration would house the NCS entirely within the EIA. This option would provide benefits from aligning climate and environment data and would draw on EIA's data and geospatial capability. Careful management would be needed to ensure that both functions can be uplifted in parallel without impacting the NCS's establishment and early delivery phase. The NCS would need to develop a strong public identity and profile which may be difficult within the EIA.

Recommendation

4. That the Australian Government set clear expectations for the National Climate Service.
    4.1. Provide a Statement of Expectations to the National Climate Service to meet the national requirement for trusted and accessible climate information, products and services and for effective national co-ordination of Australia's climate services.
    4.2. Place the National Climate Service under a leader with the authority to ensure the service is customer-focused, connected effectively to core user groups, and well managed with appropriate budget, resources and priorities.
    4.3. Establish a multidisciplinary Advisory Committee with an independent Chair to inform priorities and support the focus on user needs (including representatives from Commonwealth, state and local governments, First Nations Australians, the private sector, climate science, public health and the community sector).

Outcomes by 2030

- Climate adaptation information needs are resourced appropriately.
- The NCS is run with the main aims of being customer-focused and responsive.
- The NCS is successful in providing all Australians with the basic climate information they need to inform adaptation decisions.
- The NCS is sufficiently resourced to scale up over time as demand for climate-related services increase.

Box 7: Future vision for Australia's National Climate Service

Purpose

To provide a single authoritative source of trusted data and advice on climate risks for all Australians, which is freely accessible by all types of users.

It would do this by making climate data and information products (including tailored datasets, decision-support tools, case studies and visualisations) available via a climate information portal, to satisfy the need for a 'one stop shop' for Australian climate data and information products. This self-service portal will be designed to meet most basic user queries.

Users will have access to climate information assistance through a service centre which provides guidance and expertise via the knowledge brokering function. This service will provide advice and available data to answer complex climate information questions.

Other parties (e.g. state and local governments, researchers and the private sector) will be asked to collaborate on new data products and tools to meet the needs of users with more specific needs. This broadens the reach of useful and actionable (user-specific) climate information.

To coordinate Australia's climate science and information capability by driving a step change in the provision of integrated data and knowledge services and Commonwealth capabilities, and improve returns from climate service investment, and thereby foster resilience, adaptation and effective decision-making in the face of climate change.

As a relatively small body, partnerships with data provider organisations (including the original ACS partners) are needed to deliver effective climate services. Other Commonwealth agencies and departments, state and territory and local governments, research institutes (e.g. universities and ARC Centres of Excellence), other Commonwealth entities (e.g. Natural Hazards Research

Australia), and the private sector (e.g. insurance companies) are eager to collaborate incentivised by the benefits flowing from national co-ordination, standards, resources, and new insights.

Australia's National Climate Service will coordinate the strategic direction of Australia's climate information capability by identifying gaps and duplication to improve climate services return on investment. This includes maintaining an awareness of and informing strategic decisions by actors including:

- other Commonwealth entities
- state and territory governments
- universities and the research sector
- private sector.

Open-source data will be mandated to ensure equitable exchange and use of data. The national capability will lead engagement on data standards, interoperability of data, state and territory contributions to the national climate projections and climate information holdings.

The National Climate Service will champion innovation, efficiency and continuous improvement in data, information and services (e.g. through artificial intelligence, next-generation climate models, First Nations perspectives, etc).

Collaboration will be enhanced by convening, coordinating and supporting partnerships and forums across silos (sector, jurisdiction) and among diverse stakeholder groups to ensure user needs are well understood and material gaps are identified.

The future of Australia's scientific and technical skills will be fostered through engagement across Australia's research and development sector.

Goals

Profile: be a trusted and authoritative source of climate and related data and information, tailored to the needs of different sectors.

National co-ordination: foster collaboration and coordinate resources to meet Australia's climate information needs efficiently, minimise duplication risks and inform knowledge and capability investments.

Accessibility: expand access to and awareness of climate information for all Australians, through open and user-friendly climate data, information, services and tools (including visualisation tools).

User-focus and capacity building: engage and co-design services with stakeholders, to tailor information, build climate literacy and ensure that information meets the needs of various users.

Science and data innovation: foster innovation in climate science, data and communication.

Impact: measure the real-world impact of services and information, driving continuous improvement, and ensuring that climate-related decisions are based on the best available information to facilitate orderly, efficient and cost-effective climate adaptation processes.

International view: be rated as one of the best national climate services globally and be seen as a good partner by other national climate services.

3.3 A service for all Australians

Key findings

There is widespread uncertainty amongst decision-makers about where to find the right climate data and information to meet their needs, especially as climate change information is being updated as the rapidly evolving field of climate science refines climate models.

There is significant demand for a publicly available and accessible central website/portal (i.e. a 'one stop shop') of climate information. This 'one stop shop' needs to be an authoritative source of best practice guidance, tools, data and information that helps individuals and organisations navigate the complex climate information environment.

Australia's climate literacy levels are low. Many people and organisations do not know how to interpret and apply climate information to understand the impacts of climate change on their circumstances and on decisions they are considering or need to make.

Some users need a knowledge brokering service to connect them to appropriate expertise and information sources and to facilitate the effective communication and translation of complex climate information into actionable insights and decisions.

Information producers need a knowledge brokering service to help them understand the needs of users in order to better direct research priorities and to produce better climate service products.

Customers of the ACS have been more satisfied with climate information, data and products that are informed by and co-designed with users compared to ones initiated by ACS itself.

Open-source climate information will accelerate user access to services and speed up adaptation actions by enabling the climate service market to meet broad user need for tailored products.

A range of domestic and international sources indicates that effective climate services have several key attributes[54,55,56,57] and that the Australian climate services ecosystem has specific requirements that should be filled by a national capability.[58,59,60,61,62] The Review considers that the following attributes are central to the function of an effective climate service in the Australian context:

- a strong service ethos with broad skills in user engagement, service design, communication, policy and digital transformation including visualisation
- a demand driven approach focusing on co-design and understanding user needs

[54] Boon, E. et. al, 2024, Defining successful climate services for adaptation with experts. Available at: https://www.sciencedirect.com/science/article/pii/S1462901123002903.

[55] Jacobs, K. L. & R. B. Street, 2020, The next generation of climate services. Available at: https://www.sciencedirect.com/science/article/pii/S2405880720300510.

[56] World Meteorological Organization, 2018, Step-by-step Guidelines for Establishing a National Framework for Climate Services. Available at: https://library.wmo.int/records/item/55867-step-by-step-guidelines-for-establishing-a-national-framework-for-climate-services.

[57] US Government, 2023, National Science and Technology Council, A Federal Framework and Action Plan for Climate Services.

[58] NESP Earth Systems and Climate Change Hub, 2021, Informing strategic development of a national climate services capability for Australia.

[59] NEMA, 2020, National Disaster Risk Information Services Capability pilot project outcomes report.

[60] NESP Climate Systems Hub, 2023, Synthesis, communication, and data: Tailored information for stakeholders. Available at: https://nesp2climate.com.au/resource/delivering-quality-climate-information-and-data/.

[61] UTS Institute for Sustainable Futures, 2020, Mapping Climate Services Capabilities in Australia. Available at: https://nespclimate.com.au/mapping-users-and-providers-within-australias-climate-services-capability/.

[62] Department of the Environment and Energy (now DCCEEW), 2019, Climate Science for Australia's Future. Available at: https://www.dcceew.gov.au/climate-change/publications/climate-science-for-australias-future.

- information, services and products that service the needs of a broad range of users including Commonwealth, states and territories, local government, the private sector and community groups
- the capacity to coordinate a national climate services program with states and territories and other participants, minimise duplication, discourage investment in low return projects and identify material gaps and potential solutions
- the ability to commission its own work to meet gaps and public needs
- infrastructure, programs and partnerships to make up-to-date climate data publicly available
- a focus on knowledge brokering, including working with clients to find high-quality, timely solutions to their climate problems, linking clients to relevant organisations and enabling rapid delivery by leveraging knowledge available domestically and globally
- mechanisms to improve climate information literacy and improve the capacity of users
- the ability to use diverse information sources from a range of high-quality providers (including across governments, universities, research centres and international sources)
- the ability to keep its products up to date and its clients informed of changes as climate science matures and consequentially climate models change.

3.3.1 User needs

Climate information needs across Australia are diverse and complex. The specific needs across Australia are not well understood and could not be comprehensively determined in the timeframe of this Review. Many potential climate information users have difficulty articulating their needs, due to:

- low climate literacy
- lack of awareness of the products or services that could be useful
- the fact that climate risk management and climate adaptation are still emerging fields.[63]

An early and ongoing task of a National Climate Service (NCS) must be to build a comprehensive understanding of user needs. This will require a cross-sectoral assessment that aims to identify priority sectors and their climate information needs along with an assessment of the capability of the Australian climate information ecosystem to meet those needs. This will support the development and prioritisation of climate services.

Australia's low climate literacy has affected users' ability to source and apply the available data to understand the likely impact of climate change. Improving the climate knowledge of Australians will increase our collective capacity to use climate information and respond to climate change. We need more educated users at the household, school, firm, industry, local, regional and national levels. Climate literacy needs will be different for each individual and organisation but will range from general knowledge through to significant technical expertise.

Many sectors will need to rapidly increase their knowledge and skills in climate adaptation. For example, when mandatory climate-related risk disclosure obligations are introduced, auditors and accountants with limited expertise in climate risk analysis will be called on to evaluate the veracity of disclosures of clients with unique contexts (i.e. sector, geographic region, supply chains, etc) and which have unique interactions with climate

[63] Department of Defence, 2024, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

risk. Several submissions to Treasury's second consultation for climate-related disclosures expressed concerns regarding the infancy of the climate-related assurance industry, when there is already a shortage of auditors.[64]

The Commonwealth has a role in supporting a strong, flexible economy, and providing a well-targeted social safety net that can assist people in vulnerable situations to adapt, as set out in the COAG roles and responsibilities for climate change adaptation.[65] The NCS will be a vital part of these activities.

To ensure that future climate services adequately account for the needs and contributions of First Nations peoples, strong engagement and co-design is needed. The *2021 First Nation Peoples Statement on Climate Change* lists recommendations to engage with First Nations people on an ongoing basis, with a view to build relationships and avoid ad hoc engagement which may contribute to community consultation fatigue.[66]

The NCS will need to consider accessibility requirements for its information. Providing climate information and advice in a variety of formats[67] ensures all Australians can understand and participate in climate adaptation.

3.3.2 A user-oriented approach to climate services is essential

Australian governments, businesses and communities in all regions of Australia are increasingly making climate-related decisions based on their unique contexts. With the variable impact of climate change across Australia, tailored climate services are essential to supporting decision-makers with useful and actionable information.

A service- and user-oriented approach is contrasted with a research-driven focus on reducing uncertainty in the climate science. While it will be necessary for the NCS to understand and communicate the uncertain and evolving nature of climate research, the primary benefit of a climate service is in the translation of climate research to practical climate information that helps users to make decisions.

Effective climate services have a strong service ethos and a firm grasp on the needs of different users. They make information accessible, coordinate across diverse partners, data sources and user groups and build the climate literacy of users to find, interpret and apply climate information in their decisions. To do this well, the NCS needs to undertake user research by working closely with future clients to understand the problems they are trying to solve and co-design effective products that consider their priorities and capabilities. Delivering services will require agility and a multidisciplinary service that can own the whole user experience.[68]

[64] Accounting professional (Confidential), 2023, Submission to Climate-related financial disclosure: Second consultation, Treasury. Available at: https://treasury.gov.au/consultation/c2023-402245.

[65] DCCEEW, 2012, COAG Roles and Responsibilities for Climate Change Adaptation in Australia. Available at: https://www.dcceew.gov.au/climate-change/strategies.

[66] NESP, 2021, 2021 First Nation Peoples Statement on Climate Change. Available at: https://nespclimate.com.au/nfpgcc/.

[67] NSW Health, 2023, Who is most at risk?. Available at: https://www.health.nsw.gov.au/environment/climate/Pages/who-is-most-at-risk.aspx.

[68] Digital Transformation Agency, 2024, Own the whole user experience. Available at: https://www.dta.gov.au/help-and-advice/digital-experience-toolkit/service-design-and-delivery-process/own-whole-user-experience.

3.3.3 A 'one stop shop' for climate information

Throughout consultation, stakeholders have consistently called for a publicly available and accessible central portal (i.e. a 'one stop shop') of climate information to help them navigate the complex climate information ecosystem. This finding correlates with the NESP research report *An analysis of user needs for climate information and data, existing portals, user personas, and recommendations for meeting priority gaps*.[69]

Many users find the amount of climate information available daunting. They will often lack the skills to judge the quality of that information, why it may differ from information available from other sources, or whether it is fit for their purpose.

Some sources of information are not available for commercial use (e.g. CSIRO's Climate Change in Australia[70]), are difficult to access (e.g. local council flood studies), are not nationally consistent, or lack transparency in their methodology and data sources.

Those consulted as part of this Review have asked for a climate information portal that is a source of good-practice information and services that enables users to easily navigate a range of quality climate information products. Stakeholders want a single-entry point and a uniform interface to a wide range of climate products and services hosted by multiple providers, with a common framework for communicating quality assurance information. Achieving this requires verification and strong links to organisations both using and creating data.

To begin with, the climate information portal should host a rapidly established directory that guides users to existing, quality assured climate data and information sources (e.g. tools such as My Climate View,[71] Heat-Health Index,[72] and Regional Explorer,[73] descriptive information such as State of the Climate,[74] and policy such as Treasury's climate-related financial disclosures[75]). The portal should be continuously expanded to include a range of core and differentiated open-source climate products, including:

- core products and services: generic products that deliver public good for a broad range of users (e.g. reports, case studies, visualisation tools), including publication of the National Climate Risk Assessment and associated datasets[76]
- explainers and programs to bolster basic climate literacy (e.g. how to choose a climate scenario)
- differentiated-need products and services published over time: tailored products and services which deliver a benefit to a specific sector, location, industry or user. They can be open-source or fee-for-service and link to non-ACS products (examples include CoastAdapt[77] or My Climate View[78]).

[69] NESP Climate Systems Hub, 2023, Synthesis, communication, and data: Tailored information for stakeholders. Available at: https://nesp2climate.com.au/resource/delivering-quality-climate-information-and-data/.

[70] CSIRO, [2020], Climate Change in Australia. Available at: https://www.climatechangeinaustralia.gov.au/en/.

[71] CSIRO, 2024, My Climate View. Available at: https://myclimateview.com.au/.

[72] ACS, 2024, Understanding risk with the Heat-Health Index.

[73] ACS, 2023, Visualising climate hazards for Australia – a prototype. Available at: https://experience.arcgis.com/experience/b68bd0bf396d44da84319873e0465c0d/page/-Regional-explorer/.

[74] Bureau of Meteorology and CSIRO, 2022, State of the Climate. Available at: http://www.bom.gov.au/state-of-the-climate/.

[75] Treasury, 2023, Climate-related financial disclosure. Available at: https://treasury.gov.au/consultation/c2022-314397.

[76] The Australian Industry Group, 2024, Response to the National Adaptation Plan issues paper. Available at: https://www.aigroup.com.au/news/submissions/2024/national-climate-adaptation-plan-issues-paper/.

[77] National Climate Change Adaptation Research Facility, 2024, CoastAdapt. Available at: https://coastadapt.com.au/.

[78] CSIRO, 2024, My Climate View. Available at: https://myclimateview.com.au/.

Information available through the climate information portal should be:

- developed collaboratively and tailored to user needs through stakeholder engagement
- credible and quality assured, with consistent and transparent assumptions and methodologies and supported by explainers on the limitations and uncertainty of climate information
- aligned with best practice data standards and using a common taxonomy for climate information
- up to date, with a clear plan for when and what will be revised.

The states and territories, and other potential providers, should be encouraged to make their data and information products available through the portal.

For example, in the Canadian model, the CCCS provides access to climate data, tools and information from a range of local and regional partners via a centralised climate information directory. The NCS could draw on the CCCS's model in developing a climate information portal for Australian climate information users.

3.3.4 Knowledge brokering

This Review has consistently heard about the need for knowledge brokers – a person or service that links clients and users to the best climate information for their needs and provides answers to difficult questions – from a wide range of stakeholders including federal, state, and local governments, the private sector, and researchers. The CCCS refers to this function as its Service Desk.

Knowledge brokering plays a crucial role in accelerating the uptake of climate services by sourcing expertise to provide answers to complex questions for clients and, more generally, facilitating the exchange of information, expertise and resources between climate specialists and climate information users. Climate information is complex and decision-makers require assistance to identify the types of information they require and derive insights from it.

Having a strong knowledge brokering function will provide ongoing benefits, including:

- a feedback loop to understand user needs and information gaps, which will lead to the creation of better climate services products
- improving users' decision-making by connecting them with information or expertise, and assisting them to interpret and apply the data, information and advice supplied to them
- developing policies and programs that incorporate knowledge on our changing climate.

It is essential that the NCS operates a service centre that delivers knowledge brokering, tailored information and targeted outreach to priority users to bridge the gap between services and users, and rapidly disseminate actionable climate information. Users need help to make decisions today while navigating highly uncertain conditions, including by:

- linking users to datasets, organisations or other sources and supporting users to navigate and apply climate information
- helping users clarify and refine their climate information questions (especially complex and tricky ones) and then put them in touch with organisations that can help solve them
- working with users to co-design their own differentiated products and services to meet their needs

- building climate literacy and developing capability of users to interpret and apply climate information (e.g. via workshops, training and guidance material)
- informing the climate research agenda by analysing and feeding back on user experience and common needs
- supporting communities with similar climate information needs.

The NCS will require many knowledge brokers to connect users to disparate information and expertise. There will be challenges to establishing this capability – stakeholders have noted that there is a shortage of these skills at present and that a broad knowledge brokering capacity will need to be built over time. Numbers might possibly taper down over time once more self-service climate services come online, and user knowledge and literacy increase.

3.3.5 Enabling growth in Australia's climate services market

The NCS will be only one player in Australia's climate services market, which includes a wide range of public and private entities across the supply chain. There is strong demand for climate services and other providers have stepped in to meet these needs. However, at present Australia's climate services market is immature and service availability is patchy at best.

> *The supply-side of the Australian market for climate services is well-established with many products and tools. However, efforts have been fragmented and poorly coordinated so there is a lack of efficiency and effectiveness... The demand-side is rapidly emerging and evolving*[79]

The Commonwealth, through the NCS, should support a broad and successful climate services market and encourage its continued growth and innovation. A strong market with many good quality providers will help to rapidly disseminate climate information and allow more users to make adaptation decisions in the near term. The Commonwealth cannot and should not do this alone but is uniquely placed to provide a co-ordination service to make the most of the always limited resources to produce these services.

The broader climate services market can be enabled by the NCS providing links to quality assured and open-source climate information that is free from intellectual property restrictions. This will allow downstream providers to draw on these inputs and create value-add and specialised services, suitable for a wider range of users and contexts.

By supporting a strong market, the NCS will be able to focus on delivering priority public good products and services that deliver widespread benefit to Australians.

> *Climate services have the potential of becoming a supportive and flourishing market, where public and private operators provide a range of services and products that can better inform decision-makers at all levels, from public administrations to business operators, when taking decisions for which the implications of a changing climate are an issue.*[80]

[79] NESP Earth Systems and Climate Change Hub, 2021, Informing strategic development of a national climate services capability for Australia.

[80] European Commission, Directorate-General for Research and Innovation, 2015, A European research and innovation roadmap for climate services.

Recommendation

5. That the National Climate Service be service-oriented, helping all Australians access authoritative information with a commitment to transparency and open-source information provision. It should:
    - 5.1. Conduct a gap analysis of Australia's climate data and information needs and user literacy and refresh this regularly.
    - 5.2. Establish a portal for climate information, products and services sourced from across a range of quality assured providers that:
        - 5.2.1. gradually builds over time a library of open-source climate information products and services
        - 5.2.2. provides publicly available, up-to-date climate information for Australia (including states and territory regions and coastal zones, Australia's oceanic Exclusive Economic Zone and external territories)
        - 5.2.3. presents information in easy-to-understand ways with a variety of formats for download and visualisation
        - 5.2.4. includes external, reputable information from up-to-date sources domestically and around the world, including from other national and transnational climate services.
    - 5.3. Establish and grow a knowledge brokering service that assists users to find the data, information and advice needed to resolve their climate questions and understand the uncertainty inherent in climate models.
    - 5.4. Promote climate literacy through public information to empower users to understand and apply climate information for their own adaptation needs.
    - 5.5. Improve access and usability of climate information by making Commonwealth-funded products free and open-source by default.
    - 5.6. Incorporate culturally appropriate climate information services in response to the National Climate Risk Assessment of First Nations climate risks and when developing the National Adaptation Plan.

Outcomes by 2030

- The NCS is a trusted and authoritative source of climate data and information with products tailored to the needs of users.
- Transparency and accountability of its operations and benefits realised for users builds public confidence in the NCS.
- All Australians have awareness of and access to climate information.
- Climate literacy at the household, school, firm, industry, local, regional and national levels has increased, and as a result decision-makers have the ability to interpret climate information.

3.4 Leadership, co-ordination and public trust

Key findings

Many climate data and service users do not know what the ACS is, what it does, or whether or how its services could be accessed to meet their climate information needs. This is due largely to a lack of public visibility of the ACS and its limited customer model.

There is a clear need for national leadership and co-ordination of climate information and services to efficiently meet growing user needs with available resources. Cooperation across all jurisdictions and sectors is required to leverage effectively the valuable information available.

The National Partnership for Climate Projections is a successful, voluntary cross-jurisdictional partnership driven largely by in-kind contributions of its partners. It would be more effective if it were given formal status and additional resourcing by contributing governments.

There are ongoing challenges to delivery of the CMIP6 regional ensemble of climate projections across NPCP partners, including accessing computing infrastructure and storage, and achieving consistent outputs and messaging.

Regular national climate risk assessments have emerged internationally as a primary means to drive strategic, coordinated climate adaptation initiatives.

Many organisations (both public and private) have expressed an interest in using ACS data to derive new insights on climate risk but have been unable to access it.

First Nations perspectives on climate change have not been incorporated meaningfully at the national level, outside of the NESP program. The current approach does not draw on First Nations' knowledge of aspects of climate change and tens of thousands of years' experience in caring for Country.

3.4.1 An awareness of the national picture

Leadership and co-ordination of climate data, information and services is required across all of Australia's climate information ecosystem. It is needed to support the efficient allocation of resources, prevent resource duplication and coordinate data interoperability, platforms and services in a manner useful to all Australians.

There has been a lack of leadership and national co-ordination. There are now significant gaps and some duplication of effort between states and the Commonwealth. National co-ordination is vital due to the vast quantities of data, information and services that are already being created and will be required in the future. Without it, users' needs will not be effectively met, and money wasted.

Maintaining a focus on the nation's climate information priorities is useful not only for the Australian Government, but also provides a guide to state and territory and local governments, the private sector and the research community where there is work to be done. Communicating gaps and opportunities will encourage new contributions.

The COAG roles and responsibilities for climate change adaptation were agreed in 2012 and have not been revised to keep up with technological advances, state government contributions and widening capability gaps and governments have not generally been effective in meeting their responsibilities in this agreement. Governments should review and refresh this description of their roles and responsibilities and provide clarity on what others can reasonably expect to receive from them. This

was strongly supported by stakeholders who at present are not clear what they can reasonably expect, nor what will be delivered in practice. [81]

A more detailed intergovernmental agreement on climate data and information could be a practical mechanism for supporting reform in the climate information system, improving coordination and leveraging the broader contributions of others to improve the national service offering.

3.4.2 International cooperation

International collaboration can also play an important role in bolstering the capability of Australian climate services by facilitating the exchange of research findings and innovations, as well as by supporting co-ordination on the development of climate information, especially where climate drivers and adaptation decisions span borders and regions.

The NCS should draw on the expertise of international climate services and research to improve Australia's offering. This Review has benefited from the expertise of international entities including the EU, USA, Canada, UK and New Zealand.

3.4.3 Coordinate state and territory contributions to climate projections

The NPCP is a voluntary collaboration of federal, state and territory governments, universities and research institutions. It is integral to Australia's climate information ecosystem. This partnership has been effective in coordinating climate modelling across jurisdictions, but its influence is limited due to lack of funding.

State governments are providing a significant contribution to Australia's regional climate modelling capability. The cost of storing and sharing high-resolution climate projections and bringing all this information into a national collection is a barrier that NPCP in its current form has not overcome.[82] States are not sufficiently incentivised to support national outcomes and a coordinated national capability for climate modelling at a regional scale does not currently exist. They operate without the co-ordination that would maximise the national returns from their limited resources. For example, there are limited incentives for states and territories to produce and publish climate projections for areas outside state boundaries due to the associated costs, even if they are marginal.

There is no clearly articulated and accessible plan or timeline for the publication and storage of Australia's regional climate projections developed by the ACS, or for the full regional climate model ensemble. These are important public resources and by coordinating with state and territory governments to develop and publish a plan, the Australian Government would address stakeholder uncertainty and build trust in Australia's climate information capabilities.

3.4.4 National climate-related risks

Natural hazards do not respect borders. Understanding our national climate risks is a necessary step in developing adaptation actions that have an impact across state and territory borders, and affect Commonwealth infrastructure investments.

[81] Boulter, S., Dalla Pozza, R., 2023, Submission to the Independent Review of the ACS.

[82] NPCP, 2023, Annual Report 2022-23. Available at: https://www.dcceew.gov.au/climate-change/policy/climate-science/climate-science/climate-change-future.

Adapting to climate change requires effectively anticipating and managing climate-related risks and impacts. Climate-related risks change over time depending on adaptation actions, emissions trajectories, local knowledges and other social and demographic factors. Our ability to understand and respond to climate change also evolves with new climate science and modelling capability.

As noted above, the ACS is developing the evidence base for DCCEEW's National Climate Risk Assessment (NCRA). The NCRA will deliver a high-level understanding of national priorities for climate adaptation action through analysis of climate hazard, exposure and vulnerability data.[83] The resulting risk assessment will inform the National Adaptation Plan to be developed by DCCEEW.

The evidence base informing the NCRA will need to be continually updated by the NCS to ensure it continues to identify and prioritise the things Australians value that are at risk from climate change. This includes regularly reviewing whether the assessment meets the needs of the Australian Government's National Climate Adaptation Plan, along with those of other government and non-government stakeholders. This aligns with the purpose of national climate risk assessments internationally, in which they are a key means to prioritise adaptation initiatives, coordinate research activities, build capacity and increase engagement.[84]

In line with the Climate Change Authority's (CCA) recommendation in its 2023 Annual Climate Change Progress Report,[85] the NCRA should be undertaken periodically to ensure it remains up to date, relevant and effective. Regular assessments should be conducted every 3 to 5 years to update and develop Australians' understanding of emerging climate risks and adaptation opportunities. The government should legislate this in the *Climate Change Act 2022* as recommended by the CCA.

3.4.5 Build mechanisms to integrate information from other providers

Although the ACS has a responsibility for integrating and harmonising data, it has focussed significant resources and effort on building data inputs (climate, natural hazards and domains) rather than integrating that data to meet the needs of users. The ACS considers that 'there is significant work required to organise, uplift and maintain the inputs essential to develop the more advanced climate and hazard risk information required to support decision-making'.[86]

The vision for the NCS requires it to prioritise collaboration and information sharing with stakeholders across Australia's climate information ecosystem. The NCS should deliver its services by working with a broad range of partners, which requires a flexible partner model that draws on the core capabilities of the current ACS partners while leveraging the expertise of other information providers.

The way expertise is sourced would depend on the type of capabilities required to meet an identified need. Partnership arrangements with a selection of core information providers may be best suited to the provision of enduring capabilities, co-investment when a new capability is being built from the ground-up, and competitive procurement for a point in time need.

[83] DCCEEW, 2023, National Climate Risk Assessment. Available at: https://www.dcceew.gov.au/climate-change/policy/adaptation/ncra.

[84] Weingartner, K., D.R. Reidmiller, and A. Dave, 2018, Looking Abroad: How Other Nations Approach a National Climate Assessment - Fourth National Climate Assessment. Available at: https://nca2018.globalchange.gov/chapter/appendix-4/.

[85] Climate Change Authority, 2023, 2023 Annual Progress Report. Available at: https://www.climatechangeauthority.gov.au/annual-progress-advice-0.

[86] ACS, 2023, Submission to the Independent Review of the ACS.

There is an ongoing role in creating, maintaining and uplifting quality inputs, for both integration and to service decision-maker needs, which ACS partners are not necessarily resourced to deliver, and the ACS funding arrangements cannot continue to service in perpetuity. If resourced, many of the inputs could be delivered by suppliers other than the ACS partners.[87]

Incentives for data sharing partnerships

Stakeholders in public consultation have consistently raised the strong desire to collaborate with a national climate service, including specific types of organisations (health, local government, state government, planning and infrastructure) which are eager to collaborate now because they need advice and assistance. These organisations need to improve the quality of their services, or to derive climate-related insights that will inform their decisions. For example, the health sector is very aware it needs to gain a better understanding of climate-related risks such as heatwaves.

However, other organisations may have reason to seek additional benefits to participate in the supply of climate services, such as:

Co-ordination

There is a wealth of climate services activity happening in Australia – what is missing is a driving force that promotes continuity and longevity, and which coordinates efforts across the climate information ecosystem. All data providers would benefit from a national climate service that provides a coordinating function, to promote collaboration and information sharing to improve efficiency and reduce duplication. The co-ordination might include:

- engaging with Australia's science communities and state and territory governments to coordinate roles and responsibility for climate information product creation
- convening, coordinating and supporting partnerships across silos (sector, jurisdiction) and among diverse stakeholder groups to build links between multidisciplinary teams and shared access to relevant datasets
- engaging across Australia's research and development sector to build the scientific and technical skills Australia needs to have best practice climate information services.

Uplifting the quality of data

All data providers would benefit from a national climate service's data quality and data assurance functions, especially by improving the consistency and interoperability of data across jurisdictions, sectors and domains. For example, such a service would:

- lead engagement on data standards, interoperability of data, state and territory contributions to the national climate projections and climate information holdings
- encourage intellectual property arrangements to be minimised and ensure equitability in the exchange and use of data
- champion innovation, efficiency and continuous improvement in Australia's climate data, information and services (e.g. through artificial intelligence, next-generation climate models, First Nations perspectives, etc).

Financial

The NCS should be resourced to engage with potential participants, providers and users in the most efficient manner. For example, co-investment when a new capability with shared benefits is

[87] ACS, 2023, Submission to the Independent Review of the ACS.

being built or competitive procurement for a point in time need. In-kind contributions can also be valuable.

Public good obligations

Many data providers will have public good obligations – the NCS would add value to their products by enabling greater integration of information across sectors, jurisdictions, domains and disciplines.

Connecting researchers to users of information

The NCS can offer a direct feedback mechanism to support useful, applied research by acting as a conduit that helps information providers understand the needs of their users.

3.4.6 The National Climate Service's partner and delivery approach

The NCS will deliver a range of functions requiring different partner and delivery approaches. Some will require delivery through in-house capability while others will require coordinating with partners across the climate information supply chain. The ACS outlined three categories of services which are likely to align with those of the NCS.[88]

- Enduring capability – activities, services and capabilities that are ongoing roles and which improve over time. For example, integration and analysis, climate science and modelling, and domain data and intelligence.
- Point in time customer need – projects with clear terms of reference and timeframes to meet specific customer needs. For example, the National Climate Risk Assessment Stage 1 Assessment.
- Piloting or uplifting capability – projects to pilot, uplift or catalyse an activity that results in in it being more effective and useful for customers and to service other needs. For example, investing in flood and bushfire mapping.

The approach to sourcing expertise would depend on the type of capabilities and resources needed and should be evaluated on a case-by-case basis.

Box 8: Illustrating the NCS's partner and delivery approach

Case study: Service Desk enquiries leading to a climate risk product

Scenario: The NCS Service Desk receives numerous requests for tailored climate data from similar user groups.

Approach

1. *Leverage existing resources*
   - Where possible, the NCS directs requests to existing data (for example, through state governments) via the Knowledge Brokers and its climate information portal.
2. *Conduct analysis and engage with users and suppliers*
   - The NCS works with states and territories and local governments to determine if there is a common need for information and conducts targeted user engagement.
   - If there is no suitable data to meet these needs, the NCS continues engagement to determine if relevant work is already underway (e.g. governments, research and academia and climate information providers).

[88] ACS, 2023, Submission to the Independent Review of the ACS.

3. *Collaborate and partner as necessary*
    - If work is underway, the NCS may partner with the supplier to support or expand this (e.g. via procurements, co-investment, in-kind contribution or other arrangements).
    - If no work is underway, the NCS might test if a commercial product is available for purchase, commission the work through pre-accredited suppliers, or deliver the product itself via its in-house capability (co-designed with users).

Case study: National Climate Risk Assessment

Scenario: The NCRA co-ordination function currently in the ACS Head Office moves to the NCS.

Approach

1. *Project management and planning*
    - DCCEEW leads on the policy co-ordination, and the NCS leads on the technical inputs to the NCRA (currently ACS Head Office)
2. *Leverage existing resources*
    - The NCS conducts an analysis of data it already holds or has access to via its data platform and identifies gaps.
3. *Collaborate and partner as necessary*
    - The NCS draws on data and information from external suppliers (e.g. current ACS partners, state governments), procuring this data, or paying for its uplift, if necessary.
    - The NCS makes outputs publicly available and shares NCRA data through the NCS platform.

3.4.7 Potential for new insights

Several Commonwealth departments and agencies have expressed a strong interest in partnering with a national climate service to gain a greater understanding of the climate impacts to their sector, including Treasury, Finance, Environment, Health, Infrastructure and Defence. It will be important that the NCS draws on this capacity to improve its understanding and future service offering.

Combining First Nations science with other climate science can build a comprehensive picture of Australia's changing climate and improve efforts to plan for and adapt to climate risks. First Nations biocultural knowledges (also referred to as Indigenous Ecological Knowledges or Indigenous Science) are informed by tens of thousands of years of active land management, observation and stewardship of Country and is passed down through the generations. Historically, the holistic First Nations approach has not often been translated into land management practices.[89] Given 44% of Australia's land mass is subject to varying forms of First Nations land tenure rights,[90] it is critical First Nations peoples are effectively engaged through the improvement of climate information systems.

[89] DCCEEW, 2021, State of the Environment 2021, Indigenous governance, rights and access. Available at: https://soe.dcceew.gov.au/overview/pressures/indigenous-governance-rights-and-access.

[90] Department of Agriculture, Fisheries and Forestry, 2020, Australia's Indigenous land and forest estate. Available at: https://www.agriculture.gov.au/abares/forestsaustralia/forest-data-maps-and-tools/spatial-data/indigenous-land-and-forest#australias-indigenous-forest-estate-2018.

3.4.8 Foster the development of climate services in Australia

The NCS should foster the development of climate services in Australia and the broader climate information ecosystem by establishing a bi-annual forum to serve as a platform for knowledge sharing between experts, policy makers, and the public and to promote collaboration across disciplines. The forum should be separated into a government specific forum and an open forum for all stakeholders in the climate information ecosystem.

The government-specific forum should prioritise co-ordination between Commonwealth, state and territory and local governments who deliver a significant portion of climate information, products and services, in order to support the development of mutually beneficial policies and initiatives across Australia.

The open-access forum should be targeted at building the profile of the NCS and better linking its capabilities across providers in the climate information ecosystem by engaging with broader partners.

Recommendations

6. That the Australian Government position the National Climate Service to have sufficient public profile and trust to attract users and providers, and to enable it to deliver its services effectively to all Australians.
    - 6.1. Establish the National Climate Service within the Department of Climate Change, Energy, the Environment and Water with arrangements that encourage the development of a separate and strong public profile.
    - 6.2. Deliver National Climate Risk Assessments through the National Climate Service on a regular program, aligned to the Intergenerational Report.
    - 6.3. Require the National Climate Service to develop and publish a climate services roadmap, describing how to build to a national capability with explicit and ambitious time frames.
    - 6.4. Publish all National Climate Service strategic documents by default to provide transparency on the National Climate Service's program and timelines for implementation.
7. That the Australian Government through the National Climate Service coordinate and encourage the participation of all relevant stakeholders in the national climate information ecosystem.
    - 7.1. Review and update the *COAG Roles and Responsibilities for Climate Adaptation in Australia*.
    - 7.2. Develop an intergovernmental agreement on climate data and information.
    - 7.3. Formalise the National Partnership for Climate Projections as a sub-committee to the Adaptation Working Group and support it through the National Climate Service with appropriate resources to drive the broader co-ordinated work program and achieve national participation.
    - 7.4. Leverage the expert knowledge, capabilities and climate data, information and services of public and private entities.
        - 7.4.1. Signal to partners and suppliers that the National Climate Service is open to collaborating and data sharing.
        - 7.4.2. Establish a biannual National Climate Service forum, to bring together key climate service stakeholders from across public, private and community sectors to advance the climate services industry and its understanding of user needs.
        - 7.4.3. Support the National First Peoples Platform on Climate Change, funded under the NESP Climate Systems Hub.

Outcomes by 2030

- The public has visibility of the NCS capability, including when benefits for them will be realised.
- Understanding of national climate-related risks keeps pace with the changing climate and developments in climate adaptation.
- National and regional climate projections are accessible, in one location.
- Climate services in Australia as a whole have matured.

- The Australian Government has a role across every aspect of the climate information supply chain (upstream, midstream and downstream services – see Figure 2).
- Combining First Nations knowledge and other climate science has produced new insights.
- The states and territories resource participate in the development of national climate projections.

	Upstream	Midstream	Downstream
National Climate Service	**Limited role** Support via science and research co-ordination, and prioritisation of efforts. Facilitate data governance framework, including data standards and quality assurance.	**Primary role** User engagement and interpreting processed data into useful climate information products. Assessing climate change hazards, risks and impacts on particular locations, sectors and groups, integrating climate data with other domain data and presenting climate information in easy-to-use formats (e.g. tools, models, information platforms, tailored datasets and visualisations).	**Secondary role** Data integration and insights, presentation of climate information, products and services highly tailored to specific users.
Public and private information providers Public e.g. the Bureau, CSIRO, ABS, GA, universities, ARC Centres of Excellence, states and territories, international climate services. Private e.g. firms, companies and consultants that provide private modelling or climate information products.	**Primary role** Collecting raw data, assuring its quality and processing it into meaningful information Using climate models to generate projections, forecasts, scenarios and other climate data.	**Primary role** Interpreting processed data into useful climate information products, especially via modelling and data processing.	**Discretionary** On a case-by-case basis, depending on the information providers' priorities.
Private climate services E.g. firms, companies and consultants that provide private climate information services.	**Discretionary** On a case-by-case basis, depending on the climate services' priorities.	**Discretionary** On a case-by-case basis, depending on the climate services' priorities.	**Primary role** Data integration and insights, presentation of climate information, products and services highly tailored to specific users.

Table 2: Roles in the Australian climate services supply chain

3.5 Increase the quality of Australia's climate information

Key findings

There are data governance and storage challenges which, if left unaddressed by government, will impact the NCS's success and Australia's ability to understand the future impacts of climate change.

Much of the hazard, exposure and vulnerability data and information needed for climate services is available, but not centralised, in a usable format or freely available. The fragmentation of data and capabilities is affecting the government's abilities to capitalise on the Commonwealth's previous investments, and those made by state governments and research organisations.

There is a lack of confidence in the quality of climate services from some private providers, and there is no public visibility of their methods and analysis.

Data standards enable consistency across a diverse range of data sources and improve public confidence and understanding of the available resources to inform effective decision-making.

Quality-assured processes build trust and enable informed decision-making by providing clear guidance on the suitability, quality and reliability of climate information, services and products.

Australia lacks co-ordinated access to sufficient super-computer infrastructure and data storage to ensure suppliers delivering high-performance projections modelling can share outputs and data.

An enabling environment that addresses Australia's fragmented climate information ecosystem and implements appropriate data governance mechanisms complemented by shared computational infrastructure is necessary for the NCS to deliver on the co-ordination and leadership mandate outlined in this Review (Recommendation 7).

The Review notes that a large amount of data is available across a range of organisations, but it is often not centralised or in a usable format. A significant challenge for the service provider is often just in finding relevant data, gaining access and collating the datasets together. This is then exacerbated by the range of discordant or duplicative data and lack of transparency on how the data has been produced. It is evident that significant data holdings are not yet being brought into the national picture, including from state and local governments, universities and research organisations.

The federal government has a role in creating frameworks to uplift and harmonise this data to present a national view and make it accessible. This requires a commitment to enhancing foundational data inputs and computing infrastructure while also making a coordinated effort to improve data governance by implementing broad measures that ensure consistency, interoperability, credibility and accountability in the development of climate information, products and services.

3.5.1 Improving foundational data capability

Improving foundational data will enhance the accuracy and reliability of climate information and enable informed decisions that respond to the evolving nature of climate change and climate

science. The Review has heard from a broad array of stakeholders about the need for improved data and information inputs to inform climate risk analysis and emergency management decisions[91,92,93,94]

At the Commonwealth level, several organisations have responsibility for climate-related data collections. For climate and natural hazards, these include the Bureau, CSIRO and Geoscience Australia. A broader set of Commonwealth organisations is accountable for vulnerability and exposure data necessary for understanding climate risk including, for example, the ABS and the Australian Institute of Health and Welfare.

The ACS undertook a stocktake analysis of Commonwealth capabilities (across the four ACS partners) for forecasting current risk and concluded that:

- impact information (exposure, vulnerability and consequence) is not linked to hazard prediction across many priority hazards
- further uplift is needed on intelligence for flood, bushfire and coastal inundation hazards in particular
- hazard footprints (where did the hazard occur) requires uplift for floods, fire, wind damage and hail
- digital elevation models are needed for further improvements in flood, bushfire, coastal inundation, tsunami and storm surge modelling
- there is a low level of maturity for data and information on exposure, vulnerability, impact and consequence, which is needed for current natural hazard impact assessment and for an assessment of long-term climate risk.
- Further hazard projections will also be needed for an assessment of long-term climate risk.[95]

The government will need to consider the foundational data capability it needs, what capacity, robustness and redundancy it wants the capability to have, and who will be responsible for maintaining this capability. This is particularly the case for the hazard, exposure and vulnerability data needed to understand Australia's 10 priority climate-related hazards as identified through the NCRA.

This effort will require national co-ordination across the NCS and NEMA. Co-ordination of emergency management data (e.g. hazard extent mapping and tracking of historical events) should be managed by NEMA—as recommended in this Review (Recommendation 1)—given its responsibilities for coordinating Commonwealth support for national disasters, close engagement with state and territory emergency management agencies and visibility of co-ordination extreme events across jurisdictions. The NCS should oversee the national co-ordination of hazard projections data to inform its understanding of the future risk of extreme events.

3.5.2 Data governance to facilitate an enabling environment

A system of data governance via a combination of mutually supportive data standards and quality assurance processes would establish a trusted framework for consistent, traceable and verifiable climate information and services. This would enable researchers, decision-makers, private climate

[91] ACS, 2023, Submission to the Independent Review of the ACS.

[92] Investor Group on Climate Change, 2023, Submission to the Independent Review of the ACS.

[93] Emergency Leaders for Climate Action, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[94] Australasian Fire and Emergency Service Authorities Council, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[95] ACS, 2022, Hazard Stocktake Initial Findings, Phase 1. Supplied.

services and other data users to understand and collaborate more effectively and facilitate access to and dissemination of climate information. It would introduce efficiencies by bolstering innovation through better collaboration, and reducing duplication and costs associated with data integration and management.

The NCS, in its role as the national coordinator of climate information, should work with providers and users of climate data to develop data standards and quality assurance processes that enable nationally consistent and high-quality climate data, increase interoperability with other relevant domain data and align data with recognised best practice standards internationally. Implementing data governance arrangements aligns strongly with EIA's mission (Box 6) and its capability could be leveraged to deliver these outcomes.

Data standards

Australia has good work underway on climate information data standards, notably through its participation in international climate initiatives and through global research partnerships. However, a diverse range of data producers in Australia use a variety of methods, assumptions and data sources to produce climate, natural hazard and domain data. This lack of cohesion creates inconsistencies, inaccuracy, bias and reliability issues.

A system of climate data standards and best practice guidance for data collection, verification, formatting and reporting is required. This will build trust, coordinate climate research and ensure climate data meets user needs. Building a nationally consistent picture of climate risk bears dual data challenges of combining different state-based climate change models, and also combining climate data with datasets from broader sources (e.g. natural hazard, exposure, vulnerability and consequence). Data standards will enable consistency across a diverse range of sources which in turn supports interoperability of data across producers of climate data as well as other domain data (e.g. social, economic, cultural) needed to inform climate-related decisions.

While there is a great deal of innovation and a lot of valuable data and information held within the private sector and academia, there are at times commercial considerations that can limit the transparency of the methods, data and these influence the confidence users may have in these services. Limitations from different providers often stem from:

- *potential biases or perceived biases in data collection methods*
- *variable quality of inputs such as limited access to historical data and other technical information*
- *lack of transparency and auditability of data inputs and methods*
- *varying standards and methodologies which make it difficult to bring together or harmonise with other information*
- *quality assurance processes for inputs and outputs may be unknown*
- *access to data and information is generally only possible with a fee and at times not publicly available.*[96]

Quality assurance processes

When the strengths and limitations of data and information are clearly communicated, users can make better decisions. Quality assurance processes apply data standards and other assurance checks to provide credibility and transparency on the sources, methods and assumptions inherent in the data. This supports decision-making by making actionable information widely available. It also

[96] ACS, 2023, Submission to the Independent Review of the ACS.

facilitates efficiency in the climate services market by ensuring that downstream climate services have access to credible information that can be tailored to the specific needs of their clients.

Quality assurance in the climate space also involves checking that data supplied though the service is congruent with the latest development in the fast-evolving field of climate science.

The NCS should establish robust and clearly communicated quality assurance processes for climate data, information, services and tools, including:

- basic checks of the data for completeness and consistency
- assessment of maturity of data records
- fit-for-purpose assessment for specific use cases
- assessment of strengths and limitations (including uncertainty)
- alignment with agreed climate data standards
- communication of data provenance.

The NCS could draw on international sources in developing its quality assurance framework. For example, the Evaluation and Quality Control function[97] of the Copernicus Climate Change Service (C3S) ensures that C3S services meet user requirements for high quality information, and contributes to the evolution of the service and the climate science research agenda by clearly identifying gaps in its offerings. Similarly, EIA's data capability and any efficiencies made possible by the shared data governance goals of the NCS and EIA should be leveraged.

3.5.3 Climate service standards and accreditation

Low quality climate services can lead to misguided decision-making, potentially causing harmful long-term and unnecessarily expensive outcomes, including maladaptation. It is essential that climate services offer high-quality information and services that are robust, credible, understandable, and transparent.

In Australia, climate services are being offered by a range of providers and their quality is variable. Consultation submissions outlined that clients routinely receive questionable climate services advice or are left in the dark about the methods, assumptions and other inputs into the models which climate services use to generate their advice.[98] This is due in part to the lack of quality control measures, such as established standards and guidance on best practice, as well as poor climate literacy, meaning some users are susceptible to using low quality climate services.

A climate service standard or accreditation scheme is an internationally recognised means to ensure that services are delivered to a benchmark level of quality that meets the needs of climate service users.[99] Establishing a climate service standard or accreditation scheme in Australia would build on other data governance initiatives to facilitate the growth of an effective climate services market.

…demand has not gone unrecognised outside of government. Multiple climate service providers exist – several hundred – using multiple approaches, multiple data sources and

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[97] Copernicus Climate Change Service, [2024], Quality Assurance for the Climate Data Store. Available at: https://climate.copernicus.eu/quality-assurance-climate-data-store.

[98] Keele, S., 2024, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[99] UK Climate Resilience Programme, 2020, Climate services standards and value. Available at: https://www.ukclimateresilience.org/projects/climate-services-standards-and-value/.

ranging from groups working to provide robust information to bad actors providing profoundly misleading products.[100]

There is very little trust by the community regarding quality of climate and natural hazard information services from the range of providers.[101]

3.5.4 Infrastructure and storage

Australia's 'federated' approach to infrastructure and storage has led to siloed data across Australia, and previous investments not being leveraged across Australia. A primary challenge for integration is the lack of co-ordination of super-computer infrastructure and data storage solutions to ensure public providers (Commonwealth and state government) share outputs and data from high-performance climate projections modelling.

Combining a robust data governance framework with a shared national computing infrastructure has potential to revolutionise the accessibility and utilisation of climate data. While data governance ensures credibility of data and establishes a baseline for quality, shared storage infrastructure would bring together the national network of information to enable information providers efficient access to vast amounts of climate data, enabling more accurate modelling, forecasting and decision-making.

The National Computing Infrastructure (NCI) is a critical enabler for Australia's climate information supply chain by providing supercomputing power, data storage and artificial intelligence. Through NCI, users can access and work with a range of climate datasets, and key observational and re-analysis datasets – including researchers, science agencies, government departments, industry and international researchers. This contains dependent data, including replicated data from CMIP global climate models and ERA5 climate reanalysis developed by the European Centre for Medium-Range Weather Forecasts.

However, not all of Australia's climate data is available through the NCI, or publicly through an alternate source. Although states and territories are producing high-quality climate datasets that could be used to support the delivery of national climate services, they are not being expanded nationally due to high storage costs and lack of incentives. Supporting access to shared infrastructure would leverage the existing work of the states and territories and be an efficient way to bolster foundational data capabilities and national climate science.

Also lacking is a long-term national funding strategy for computational infrastructure and data storage for climate modelling, which is critical for the development of high-quality climate projections due to the high computational power needs. Ongoing and increasing funding will be needed to run and store Australia's climate models, including nationally relevant models produced by the Commonwealth (e.g. the Bureau and CSIRO) and state and territory governments. Dependent data including CMIP and ERA5 will also need funding certainty.

Australia will need to improve its research infrastructure to support increasing technical needs for climate modelling, for example, for the development and adoption of machine learning. "Australia's scientists say the nation is at risk of being left behind when it comes to reaping the benefits of high-

[100] Pitman, A. & Jakob, C., 2023, Submission to the Independent Review of the ACS.

[101] Our Future Northern Rivers and Lismore Citizens Flood Review Group, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

performance computing without a long-term strategy and more significant strategic investment from government."[102]

Recommendations

8. That the National Climate Service establish a data governance framework to enable consistent, high-quality climate-related data, information and services for Australia.
    8.1. Establish best practice for climate service providers in Australia, either via a climate service provider accreditation scheme or climate service standards.
    8.2. Promote data standards to integrate and connect data from different fields, aligned with international best practice.
    8.3. Develop robust quality assurance processes for data, tools, information and services provided by the National Climate Service and made available on the climate information portal.
9. That the Australian Government ensures the National Climate Service has the data and computational infrastructure it needs to succeed.
    9.1. Develop a long-term national strategy and funding approach for computational infrastructure and data storage for climate data and modelling.
    9.2. Review roles and responsibilities for climate, hazard, exposure, vulnerability and impact data across the Commonwealth.
    9.3. Establish an appropriate data solution (e.g. a data platform) to publish climate and hazard data; enable federated data curation including for domain data; support access for a broad range of data providers and public; create data insights and publish information as needed.
    9.4. Require all publicly funded climate models to be published on the National Computing Infrastructure with minimal restrictions, to encourage wide reuse and scientific scrutiny.
    9.5. Require, and fund as necessary, the responsible agencies to uplift natural hazard data inputs to a level required by the National Climate Service and the National Emergency Management Agency, with co-ordination of data for emergency management (e.g. hazard extent mapping, forecasting and tracking of historical events) to be managed by National Emergency Management Agency and hazard projections to be co-ordinated by the National Climate Service.

Outcomes by 2030

- Users of private climate services are assured of the quality of the products they receive.
- Data integration has derived insights specific to different sectors and fields.
- Data required for modelling climate risks is centrally available.
- Publicly-funded climate models are freely available on the National Computing Infrastructure.
- National hazard datasets are of a suitable quality.

[102] Australian Academy of Science, 2023, Is Australia ready for our supercomputing future?. Available at: https://www.science.org.au/news-and-events/news-and-media-releases/is-australia-ready-for-our-supercomputing-future.

3.6 Continuously improve through monitoring and evaluation

Key findings

Delivering climate services is a global challenge and an emerging capability. Australia's climate service model will need to evolve and adapt to new and emerging priorities.

Continuous improvement through regular reporting against the requirements of the Statement of Expectations and independent review is essential for an effective NCS that adequately meets the increasing needs of users.

Analysing user experience and feedback informs the evolution of climate services by identifying areas for improvement, gaps in knowledge and service priorities.

The Climate Change Authority has a proven track record of delivering independent reviews on Australia's climate change capability and would be well placed to review the performance of our climate services.

3.6.1 Continuous improvement for an emerging field

As part of this Review, equivalent international organisations were interviewed. These national and transnational climate services around the world are developing simultaneously, exploring new functions and capabilities in parallel. Many are experiencing the same challenges in bringing together data from various sources and establishing the ideal roles and responsibilities of a national public climate service.

As Australia's national climate service evolves, it is reasonable to expect that it will need to adapt and pivot to ensure it continues to meet user needs. The NCS should be assessed regularly to ensure the outcomes of its work are making an impact, are aligned with international best practice, and its limited resources are being used effectively.

3.6.2 Analysing user requirements

A user experience and feedback mechanism to evaluate the NCS will ensure that data is fit-for-purpose and meeting the needs of user groups. Understanding user requirements supports improvement and expansion of useful datasets and ensures the services adapt to changing user needs. It also informs the evolution of services and the research informing services by keeping track of user requirements and gaps, and limitations and shortcomings in products and service delivered.

3.6.3 Regular, independent review

The CCA is an independent statutory body established under the *Climate Change Authority Act 2011* to provide expert advice to the Australian Government on climate change policy. The CCA has significant expertise in reviewing Australia's climate change initiatives, ensuring transparency and continuous improvement in Australia's climate change policies through independent research, analysis and public consultation.

The CCA could be tasked with undertaking a regular, review of the NCS to ensure that it continues to achieve its goals and objectives. Identifying where the NCS's processes, information and services are working well and where there is room for improvement will foster innovation in climate science,

climate services and knowledge delivery, and build trust with users. This will ensure that the NCS remains a relevant and valuable resource that enables Australians to make informed and effective decisions to adapt to the challenges of climate change.

3.6.4 Key performance indicators

KPIs for the NCS will need to extend beyond delivery and capability milestones to incorporate feedback on how effective and impactful users find the service. Measuring the real-world impact of services and information will ensure that user needs continue to engage and drive the evolution of the service. Box 7 details outcome-driven goals that could help the NCS to understand whether it is successfully supporting climate adaptation decision-making across the country.

Recommendations

10. That the Australian Government establish an effective monitoring, evaluation, reporting and improvement (MERI) framework for the National Climate Service.
    - 10.1. Regularly monitor against the new Statement of Expectations (refer Recommendation 4.1 and KPIs in Box 7) to ensure the National Climate Service is meeting expectations.
    - 10.2. Task the Climate Change Authority with a regular review of the National Climate Service against the KPIs.
        - 10.2.1. The first review should consider whether National Climate Service should be an independent statutory authority.
    - 10.3. Establish a mechanism within the National Climate Service to track user experience and satisfaction which gathers user needs and preferences, to guide the development of future products and services.

Outcomes by 2030

- The NCS is meeting user needs in a timely manner.
- The NCS is responsive to changing user needs and expectations.

3.7 Transition planning

Key findings

The provision of climate and disaster information services to improve decision-making is an economic and social challenge that many countries around the world are addressing. The field of climate services is rapidly evolving, with research, information and technology providing opportunities to reduce the costs of necessary adaptation.

It is vital that the NCS commences operating as soon as possible, but it will take time and effort to improve current capabilities and scale the NCS to a fully-fledged national climate service capability. It is important that expectations of its development are realistic while it works to build capability commensurate with the scale and complexity of Australia's climate information needs.

The degree of difficulty in establishing an effective national climate service has been underestimated to date. This is evidenced by the way in which the ACS was set up, the outcomes to date and international experience.

The ACS has lacked appropriate skills and expertise related to communication and knowledge brokering climate information. The market for these skills is highly competitive.

Leveraging the existing initiatives and capabilities of the ACS, states and territories, research organisations and other actors in Australia's climate information ecosystem and learning from international best practice would facilitate a more efficient and rapid uplift in climate service capability.

3.7.1 Reasonable expectations

A new national climate service capability needs to be implemented as quickly as possible but with realistic goals and expectations set and understood by stakeholders. The NCS needs to begin by meeting the urgent needs of priority sectors that have the largest influence on mitigating climate change impacts or which will be most impacted by climate change.

Climate services is a relatively new and specialised field and Australia does not yet have the mature partnership networks, computational infrastructure and data sharing frameworks in place to integrate and synthesise multidisciplinary data to deliver a national climate service. There is also only a small knowledge brokering capability in Australia, and a very limited number of individuals with the knowledge and skills required for these roles. The continued development of communication and knowledge brokering skills alongside developing the expertise to interpret and apply climate information will be necessary to deliver effective climate services.

The Australian Government and the public will need to maintain reasonable expectations given experience to date domestically and internationally and the embryonic state of Australia's climate risk expertise. Ongoing evolution of a national climate service is to be expected.

Generating an integrated and ongoing understanding of climate and disaster risks nationally is a new function for Australia. Historically there has been limited mechanisms for integrating, coordinating and translating climate information for national use in climate adaptation and disaster risk reduction policy.[103]

[103] ACS, 2023, Submission to the Independent Review of the ACS.

3.7.2 Build on existing initiatives and achievements

It will be important to leverage and add value to successful initiatives and capabilities developed by the ACS, ACS partners, states and territories and other actors in Australia's climate information ecosystem to support the rapid innovation needed across the climate information supply chain.

Throughout the past three years, the ACS has delivered products and uplifted data inputs for natural hazards, climate and other domains. The successful initiatives and learnings from the ACS should be drawn upon when establishing the NCS. Many of the initiatives that the ACS has commenced will also take years in development before benefits are realised. Following this Review, government will need to consider which elements of the ACS should continue (Recommendation 11.2) to help guide design of future NCS services.

There are also opportunities for the NCS to fast track its work by learning from the approaches and methods of international climate services (Appendix G). For example, the establishment and operationalisation of C3S has been well documented.[104]

3.7.3 Implementation and phasing

A phased approach to building an NCS with national capability is proposed. A foundational stage that enables the transition from the current state of the ACS to establishing the NCS will see the development of the strategic partnerships, infrastructure and frameworks that will govern the operation of the NCS. Gap and opportunity analysis will guide the NCS's work program and ensure that successful components of the ACS are used as the foundation for the NCS. The foundational phase will also see NCS releasing a set of useful but relatively easy to produce products.

During this time the NCS will also establish and begin to build on a basic version of the climate information portal in order to provide users rapid access to the range of existing climate information products available across Australia.

Once the NCS is established it will take time to develop a national capability that provides climate information to all Australians. The NCS should initially concentrate on servicing Commonwealth and state and territory agencies and developing priority core products and services while it builds capability to expand services to other users (see Table 3).

[104] Buontempo, C. et. Al, 2022, The Copernicus Climate Change Service: Climate Science in Action. Available at: https://journals.ametsoc.org/view/journals/bams/103/12/BAMS-D-21-0315.1.xml.

Recommendation

11. That the Australian Government build a national climate service capability using a phased approach that allows the National Climate Service to deliver as much information as possible, as quickly as possible, and to prioritise needs while scaling over time to deliver a more sophisticated service that can meet the rapidly increasing national requirements for climate information. In the Foundational phase:
    - 11.1. concentrate on servicing Commonwealth and then state and territory agencies while a strategy to expand to broader services for the public is developed
    - 11.2. review ACS initiatives and work program and decide which should be continued to support the planned National Climate Service's scope and objectives. Start a phased wind back (over 4 years) of the funding commitments to ACS partners.
    - 11.3. prepare a workforce plan and resulting recruitment and training to build strong capabilities in climate services, knowledge brokering, communication and user engagement.

Outcomes by 2030

- Successful ACS initiatives are still delivered in the new entity, within DCCEEW.
- Australian governments have access to a climate knowledge brokering service.
- The public have access to a range of climate information products.

Phase	Foundational (Year 1)	Short term (Year 2-3)	Medium term (Year 4-6)	Long term (7+ years)
Goals	NCS establishes foundational and strategic documents, processes and infrastructure and priority core products and services for the Commonwealth and the public. Its public offering is a simple directory of climate information resources.	NCS begins to produce priority core products and services for users beyond the Commonwealth. States are contributing to the national view of climate risk.	NCS consolidates foundational structure and services, and provides core and differentiated-need products and services. Australians have a greater understanding of climate risks. Improved climate products and tools are co-designed with a variety of partners.	NCS has a mature structure and services, and continues to deliver core and differentiated-need products and services. Australians have a greater understanding of climate risks. Improved climate products and tools are co-designed with a variety of partners.

Expected outcomes	NCS is: • developing strategic documents and a governing framework to support future delivery • obtaining a thorough understanding of Australia's climate information needs • developing an understanding of its future service priorities • establishing a simple portal to meet baseline needs via a directory of existing public-good products and resources	NCS is: • centralising basic information to increase climate literacy • meeting common needs via basic public-good products • meeting priority user needs via differentiated-need products and knowledge brokering • creating public awareness of its role and services	NCS is: • providing all Australians with access to basic NCS expertise • informing better quality decisions in priority sectors and locations, including to state governments through knowledge brokering • prioritising investment and innovation in climate science research	NCS is: • an agile national climate service focused on user needs and emerging national risks • a trusted and authoritative source of open and accessible climate information products for all Australians • an effective communicator of climate and extreme event information to a wide audience • rating well in comparison with other national climate services

Table 3: Goals and expected outcomes for NCS's phased approach to a national capability

4 Appendices

4.1 Appendix A – Glossary

ABS	Australian Bureau of Statistics.
ACS	Australian Climate Service.
the Bureau	Bureau of Meteorology.
capability	The key processes necessary to maintain deliver climate service functions. These include: • people processes • data, models and analytical tools • scientific understanding and expertise • infrastructure and innovation • services and products. [105]
CCA	Climate Change Authority.
climate adaptation	The process of adjusting to actual or expected changes in climate to reduce or avoid climate impacts or exploit beneficial opportunities.[106]
climate change	Climate change refers to the changes in the earth's climate caused by global warming and is usually shorthand for 'human caused climate change' driven by the effects of rapidly rising concentration of gases that trap heat, especially carbon dioxide and methane, released through combustion of carbon based fuels buried millions of years ago. Global warming has heated both the atmosphere and the ocean, which together drive the earth's climate. Earth's climate systems are changing rapidly and are affecting the lives of most people.
climate data	Climate data and climate information refers to the weather data or climate simulation results averaged over longer time scales. For example, the climate in a geographic region can be expressed as being typically dry in winter and wet in summer. The 'climate' of a place refers to average weather between seasons, years or decades. Climate model results are computer simulations or forecasts of the changing weather conditions over time and the climate forecasts are usually expressed as trends or likelihoods. For example, 'The intensity of extreme storms is likely to increase but not the frequency of such storms'.
climate information	Information about the past, current state or future of the climate system that is relevant for mitigation, adaptation and risk management. It may be tailored or 'co-produced' for specific contents, taking into account users' needs and values.[107]
climate information ecosystem	The various government organisations, research institutions and private sector providers that contribute to a country's climate information supply chain.
climate literacy	Encompasses being aware of climate change, its anthropogenic and other causes, and implications.[108]
climate projection (or model)	A qualitative or quantitative representation of the climate system based on the physical, chemical and biological properties of its components. Climate models are applied as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal and interannual climate predictions.[109]
climate risk	Climate risk is determined by the interaction of a combination of hazard, exposure, vulnerability, and response.[110]

[105] ACS, 2023, Submission to the Independent Review of the ACS.

[106] IPCC, 2021, Climate Change 2021: The physical science basis. Available at: https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] IPCC, 2022: Annex II: Glossary, *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC.*

climate services	Climate services involve the provision of climate information in such a way as to assist decision-making. The service includes appropriate engagement from users and providers, is based on scientifically credible information and expertise, has an effective access mechanism, and responds to user needs.[111]
CMIP	Coupled Model Intercomparison Project is an international climate modelling project administered by the World Climate Research Programme. CMIP is designed to better understand past, present, and future changes in the climate. The current model in use is CMIP6 (the 6th iteration of CMIP). Members of the CMIP Core Panel are currently working on developing the design of CMIP phase 7 (CMIP7).[112]
COAG	Council of Australian Governments.
core products	Generic products and services that deliver public good to a broad range of users or user groups. They are commonly publicly funded and freely available. Examples include climate observations, model-based projections, best practice guidance, data standards, climate literacy outreach and other products and services that deliver public good to a broad range of users (such as climate services for coastal locations i.e., CoastAdapt).
CSIRO	Commonwealth Science and Industrial Research Organisation.
decision support tool	An application that integrates climate data with other domain data to enable users to evaluate the potential consequences of options for management, investment, and other decisions.
differentiated-need products	Products and services tailored for specific locations, businesses, industries, sectors, etc with limited use outside of a narrow group of users. They are often derived from data in the core products and services. They can be privately funded and used to generate a private profit. Examples include decision support tools and climate risk assessments tailored for specific businesses, industries and sectors.
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 and environmental losses and impacts.[113]
domain	A domain represents values, assets and systems that may be at risk from climate change.[114]
downscaled climate models	A method that derives local- to regional-scale information from larger-scale models or data analyses[115].
downstream climate services	Per the climate services supply chain (Figure 2). Downstream services tailor and curate information on specific risks and impacts to the needs and language of specific users.
EMA	Emergency Management Agency (now NEMA).
ensemble	A collection of comparable datasets that reflect variations within the bounds of one or more sources of uncertainty and that, when averaged, can provide a more robust estimate of behaviour.[116]
exposure	Per the HEVI chain. Exposure is the presence of things that could be adversely affected by hazards. These include people, ecosystems, services, resources, infrastructure, or economic, social or cultural assets. Examples of exposure include the geographical location of an asset with respect to its proximity to any particular hazard such as living in a flood zone.[117]
GA	Geoscience Australia.
hazard	Per the HEVI chain. Hazards are the potential occurrence of an event or trend that may cause health impacts and damage to property, infrastructure, livelihoods, services,

[111] Ibid.

[112] IPCC, 2021, Climate Change 2021: The physical science basis.

[113] United Nations Office for Disaster Risk Reduction, 2023, Sendai Framework Terminology on Disaster Risk Reduction. Available at: https://www.undrr.org/terminology.

[114] DCCEEW, 2023, National Climate Risk Assessment Methodology.

[115] IPCC, 2021, Climate Change 2021: The Physical Science Basis.

[116] IPCC, 2021, Climate Change 2021: The Physical Science Basis.

[117] DCCEEW, 2024, National Climate Risk Assessment First Pass Assessment Report.

	ecosystems, and environmental resources. Examples of hazards include bushfires and floods.[118]
HEVI chain	Hazard, exposure and vulnerability and impact chain (see climate risk). These elements can change independently of each other over time.[119]
high risk weather season	While severe weather can occur at any time of the year, October to April is the peak time for severe weather in Australia including heatwaves, bushfires, tropical cyclones, severe thunderstorms and floods.[120]
IPCC	Intergovernmental Panel on Climate Change.
midstream climate services	Per the climate services supply chain (Figure 2). Midstream services interpret processed data into public good climate information products, including tools, models, information platforms, tailored datasets and visualisations.
NARCliM2.0	NSW & Australian Regional Climate Modelling project
natural hazard	Natural hazards are predominantly associated with natural processes and phenomena. Geologic, meteorological, or biological hazard.
NCRA	National Climate Risk Assessment
NCS	National Climate Service
NEMA	National Emergency Management Agency
NPCP	National Partnership for Climate Projections
NRRA	National Recovery and Resilience Agency (now NEMA)
open-source	Open-source data refers to the information that can be freely used, modified, and shared by anyone for any purpose. It must be available under an open licence and provided in a convenient and modifiable form that is machine readable. An open licence might say that people who use the data must credit whoever is publishing it (this is called attribution). It can also say that people who mix the data with other data have to release the results as open data as well.[121]
physical risks	Physical risks are driven by extreme weather resulting from climatic events as well as long-term shifts in climate patterns, such as changing rainfall patterns and increased heatwaves.
public good products	Core products and services that are standardised, quality-assured and freely available through a centralised government-led model and which primarily deliver public good to broader users or user groups.[122]
transition risks	Transition risks result from the policy changes to shift to a low emissions economy and society. They can include technological changes, policy shifts, or changes in consumer preferences. For some firms these will provide commercial opportunities.
Type F agency	A Type F agency is a secondary Australian government body, with a non-statutory function with separate branding, as per the Australian Governments Organisation Register managed by the Department of Finance. For example, the Defence Intelligence Organisation is a Type F function within the Defence Department [123]
upstream climate services	Per the climate services supply chain (Figure 2). Upstream climate services collect raw data, assuring its quality, and process it into meaningful information.
vertical integration	The arrangement in which an organisation controls different stages along the supply chain. In the context of this report, this means the climate data supply chain.
vulnerability	Per the HEVI chain. Vulnerability is the propensity or predisposition to be adversely affected. It encompasses a variety of elements, including sensitivity to harm and capacity

[118] Ibid.

[119] Viner, D. et al., 2020, Understanding the dynamic nature of risk in climate change assessments – A new starting point for discussion. Available at: https://doi.org/10.1002/asl.958.

[120] Bureau of Meteorology, 2023, Australia's peak season for severe weather and risk of tropical cyclones. Available at: https://media.bom.gov.au/releases/1190/australias-peak-season-for-severe-weather-and-risk-of-tropical-cyclones/.

[121] European Union, 2015, Creating value through open data. Available at: https://data.europa.eu/en/publications/datastories/creating-value-through-open-data.

[122] NESP Earth Systems and Climate Change Hub, 2021, Informing strategic development of a national climate services capability for Australia.

[123] Department of Finance, 2024, Australian Government Organisations Register – Types of Bodies. Available at: https://www.finance.gov.au/government/managing-commonwealth-resources/structure-australian-government-public-sector/australian-government-organisations-register/australian-government-organisations-register-types-bodies.

	to cope and adapt. Examples of vulnerability include socio-economic status or the floor height of buildings situated in a flood zone.
weather forecasts	The results from computer models that use weather data to simulate the earth's atmosphere and predict future conditions at a place or over an area. Today's weather forecasts make useful predictions for up to about a week into the future. Weather forecasts become unreliable for any longer period because small scale air turbulence is difficult to simulate in a computer, and especially so when the atmosphere is unstable.
weather observations	Instrumental measurements made at a location, including the altitude of the measurement, air temperature and air pressure, humidity, precipitation of rain and snow, and wind speed. More detailed measurements might include concentration of gases and particles such as dust and pollen, and water level if over water in lakes, rivers, or the ocean. Weather observations can be summarised and expressed over a time period such as average rainfall.

4.2 Appendix B – Terms of Reference

Purpose

The review is to provide advice on the performance of the Australian Climate Service (ACS) to date and an assessment of the suitability of the ACS to deliver on Australia's future climate information needs.

Context

The Australian Government is committed to building national climate and disaster risk information capability that provides authoritative and trusted data, methodologies, intelligence, and analytical tools to support decision-making for governments, industry and the public.

The Commonwealth has responsibility for providing national climate science and information, and the national co-ordination of consistent and comparable climate science and services – as set out in the 2012 Council of Australian Government's principles on roles and responsibilities in adaptation policy (2012 COAG).

The National Disaster Risk Reduction Framework (NDRRF) guides national, whole-of-society efforts to proactively reduce disaster risk in order to minimise the loss and suffering caused by disasters. Priority 1 of the NDRRF is understanding disaster risk. Across all sectors, there is a demand for trusted and authoritative disaster risk information and services to inform operational and strategic decisions.

The ACS was established in 2021 in response to the Royal Commission into National Natural Disaster Arrangements to inform climate and natural hazard preparedness and adaptation action across all governments, the private sector and communities.

In its establishment phase, the focus of the ACS has been primarily to support the natural disaster preparedness, response and recovery functions now housed in the National Emergency Management Agency (NEMA). To a lesser extent, the ACS has provided program and policy data and support for natural disaster risk reduction and mitigation activities within the NEMA.

The ACS is at the centre of the government's approach to climate and natural hazard data and analysis. The ACS is a partnership made up of nation-leading science, information and expertise from the Bureau of Meteorology, Geoscience Australia, CSIRO and the Australian Bureau of Statistics. It brings the Commonwealth's extensive climate and natural hazard information into a single national view.

The government intends that over time the ACS will build and mature its capability to provide more wide-reaching national climate and natural hazard risk data and information. On 3 July 2023, Senator the Hon Jenny McAllister, Assistant Minister for Climate Change and Energy and the minister responsible for the ACS, issued a statement of expectations for the ACS, which reflects this ambition and sets out the government's revised strategic direction for the partnership. This direction includes that the ACS will develop and deliver the technical input for Australia's first National Climate Risk Assessment.

Scope of the review

The review will:

1. examine the performance of the ACS since its establishment, including:
    a. the effectiveness of ACS in delivering its strategic objectives and agreed functions, including supporting its customers' decision-making needs,
    b. the appropriateness of the ACS governance and operating model, including agreements with existing customers,

c. the adequacy of ACS resources to deliver its strategic objectives and agreed functions, and
d. the ability of ACS to access the capabilities it requires.

2. provide an assessment of Australia's future climate information needs and the suitability of the ACS to deliver on them. In addition to examining (c) and (d) from a forward-looking perspective, the review will consider:
   a. the appropriateness of the ACS governance and operating model to meet the government's statement of expectations,
   b. the ACS's role in making its products and services available and accessible to Australian governments, industry and the community,
   c. the ability of the ACS to provide a national climate risk and natural hazard capability,
   d. the ability of the ACS to support the government's climate change, environment and water decision-making needs, and
   e. the role of the ACS in enabling and supporting Australia's growing climate services sector, and practical advice on opportunities for meeting the government's future climate information needs.

The review will have regard to the statement of expectations for the ACS issued on 3 July, relevant recommendations from the Royal Commission into National Natural Disaster Arrangements, Australian Government roles and responsibilities for climate adaptation (as per the 2012 COAG principles), and other relevant reviews about or being undertaken by NEMA, ACS partners or other relevant bodies. These include the second Department of Finance Gateway Review in 2023 and any early findings from the *Independent Review into Disaster Funding* (NEMA), due for completion by April 2024.

Process

- The review will be conducted by a panel chaired by Professor Mary O'Kane, who will report to the Minister for Climate Change and Energy, the Hon Chris Bowen MP, and the Assistant Minister for Climate Change and Energy, Senator the Hon Jenny McAllister.
- The review will include targeted consultation with DCCEEW, central agencies, NEMA and the ACS (including partners). All engagement should be cognisant of the demands on NEMA and the ACS from the 2023-24 High Risk Weather Season and its lead-in.

Deliverables

- A Final Report will be delivered to government by end of April 2024.

4.3 Appendix C – List of stakeholders

Over the course of the Review, the Panel and Secretariat have conducted 100 meetings. Below is a list of consulted stakeholders.

Organisation/individual
Adaptation Working Group
Auditing and Assurance Standards Board
Australian Academy of Science
Australian Accounting Standards Board
Australian Banking Association
Australian Bureau of Statistics
Australian Chamber of Commerce and Industry
Australian Climate Service
Australian Institute of Health and Welfare
Australian Local Government Association
Australian Prudential Regulation Authority
Australian Strategic Policy Institute
Bureau of Meteorology
Business Council of Australia
Canadian Centre for Climate Services
Climate Change Authority
Copernicus Climate Change Service (European Union)
CSIRO
Department of Climate Change, Energy, the Environment and Water
Department of Defence
Department of Finance
Department of Health and Aged Care
Department of Prime Minister and Cabinet
Department of Treasury
Energy and Climate Change Ministerial Council
Engineers Australia
Geoscape
Geoscience Australia
Professor Mark Howden and Dr Stephen Crimp (Australian National University)
Independent Review of Commonwealth Disaster Funding (Andrew Colvin)
Independent Review of National Natural Disaster Governance Arrangements (Robert Glasser)
Insurance Council of Australia
Investor Group on Climate Change
Professor Christian Jakob (Centre of Excellence for the Weather of the 21st Century)
Professor David Karoly
Dr Svenja Keele (Monash University)

Organisation/individual
Meteorological Office (United Kingdom)
Senator the Hon Jenny McAllister, Assistant Minister for Climate Change and Energy
Ministry for the Environment (New Zealand)
National Computational Infrastructure
National Council for Fire and Emergency Services (AFAC)
National Emergency Management Agency
National Emergency Management Agency Financial Sustainability Review
National Environmental Science Program's Climate Systems Hub
National Oceanic and Atmospheric Administration (United States)
National Partnership for Climate Projections (targeted members)
Natural Hazards Research Australia
NSW Department Climate Change, Energy, the Environment, and Water
Office of National Intelligence
Professor Andy Pitman (Australian Research Council Centre of Excellence for Climate Extremes)
Planning Institute of Australia
Professor Jason Sharples (University of New South Wales)
Queensland Department of Environment and Science
Queensland Reconstruction Authority
Victorian Department of Energy, Environment and Climate Action
Professor Seth Westra (University of Adelaide)
White House Office of Science and Technology Policy (United States)

4.4 Appendix D – List of submissions to the public consultation

Organisation	Organisation Type
Prof Andy Pitman and Prof Christian Jakob	Research/university
Investor Group on Climate Change	Peak industry body
Confidential	Individual
Confidential	Private industry
Confidential	State or territory government
Confidential	Federal government
Confidential	State or territory government
ACCESS NRI	Research/university
Australasia Consulting Group (ACG) Pty Ltd	Private industry
Emergency Leaders for Climate Action	Non-government organisation
Confidential	Research/university
DCCEEW	Federal government
Australian Institute of Health and Welfare	Federal government
Climate Council	Research/university
A/Prof Boulter, Dr Ramona Dalla Pozza, UTas	Individuals
Prof David Karoly	Individual
Confidential	State or territory government
Australian Climate Service	Federal government
Confidential	State or territory government
Geoscape	Public company owned by Australian governments
Future Earth Australia and National Committee for Earth Systems Science	Non-government organisation
Australasian Fire and Emergency Service Authorities Council (AFAC)	Peak industry body
Confidential	Peak industry body
Our Future Northern Rivers and Lismore Citizens Flood Review Group	Community group
Confidential	State or territory government
Department of Defence	Federal government
Australian Securities and Investment Commission	Federal government
National Emergency Management Agency	Federal government

Organisation	Organisation Type
Confidential	Individual
Confidential	Federal government
Confidential	Federal government
Dr Svenja Keele	Research/university

4.5 Appendix E – Royal Commission into National Natural Disaster Arrangements

Supporting better decisions, recommendations 4.1 to 4.7:

Recommendation 4.1 – National disaster risk information
Australian, state and territory governments should prioritise the implementation of harmonised data governance and national data standards.
Responsibility: Australian and state and territory governments.

Recommendation 4.2 – Common information platforms and shared technologies
Australian, state and territory governments should create common information platforms and share technologies to enable collaboration in the production, analysis, access, and exchange of information, data and knowledge about climate and disaster risks.
Responsibility: Australian and state and territory governments.

Recommendation 4.3 – Implementation of the National Disaster Risk Information Services Capability
Australian, state and territory governments should support the implementation of the National Disaster Risk Information Services Capability and aligned climate adaptation initiatives.
Responsibility: Australian and state and territory governments.

Recommendation 4.4 – Features of the National Disaster Risk Information Services Capability
The National Disaster Risk Information Services Capability should include tools and systems to support operational and strategic decision-making, including integrated climate and disaster risk scenarios tailored to various needs of relevant industry sectors and end users.
Responsibility: Australian Government.

Recommendation 4.5 – National climate projections
Australian, state and territory governments should produce downscaled climate projections: 1) to inform the assessment of future natural disaster risk by relevant decision-makers, including state and territory government agencies with planning and emergency management responsibilities 2) underpinned by an agreed common core set of climate trajectories and timelines, and 3) subject to regular review.
Responsibility: Australian and state and territory governments.

Recommendation 4.6 – Consistent impact data standards
Australian, state and territory governments should work together to develop consistent data standards to measure disaster impact.
Responsibility: Australian and state and territory governments.

Recommendation 4.7 – Collection and sharing of impact data
Australian, state and territory governments should continue to develop a greater capacity to collect and share standardised and comprehensive natural disaster impact data.
Responsibility: Australian and state and territory governments.

4.6 Appendix F – Use cases for climate services

Throughout the economy and community generally, decision-makers are trying to account for climate related risks in their decision-making processes and will require access to appropriate data, information and advice for efficient adaptation and responses to events. There are key use cases with significant and unmet needs which have emerged during the stakeholder consultation process. These contribute to the strong and growing business case for the Commonwealth expanding its role in providing climate services to a wider range of customers for short and long-term needs. There are a range of climate and hazard information needs which are common across all sectors. These are outlined in this report and by other sources such as the NESP[124]. In other cases, climate data and information needs may be specific to sectors or user groups. Examples highlighted across key sectors include:

Systems	Who	Types of decisions/uses	Needs identified by stakeholders
Infrastructure and the built environment	Governments Energy market operators Operators of major infrastructure Construction businesses Asset owners Investors Asset operators Consultants First Nations peak organisations	Planning infrastructure investment Assessing the vulnerability of their assets and networks Embedding resilience into land use planning and development decisions Construction design, practices and technology Understanding flow on effects to all systems e.g. risks to essential supply chains, health and services, and energy production due to infrastructure risks and/or impacts	• National asset register of buildings containing risk and resilience characteristics (construction type, roof type, year of construction, floor height, BAL rating, renovations and retrofitting works).[125] • Nationally consistent baseline for the key extreme weather perils of flood, bushfire, cyclone and coastal erosion to inform land use planning, building codes and standards. • Impact register that includes post-event analysis and history of a hazard at a given location. • Tools for assessing vulnerability and risk for existing infrastructure. • Information on climate-resilient building materials and designs. • Standards for building and infrastructure sustainability.[126] • Site-specific analysis to inform adaptation measures.[127]
Economy, trade and financial system	Financial regulators Banks Insurers and underwriters Superannuation funds Energy market operators Private businesses Auditors and accountants Other large investors Consultants	Understanding climate risks (market, reputational, assets, supply chains, including that of regional partners) Preparing a climate risk disclosure statement to meet the Taskforce for Climate-related Financial Disclosures (TCFD) requirements and other regulatory requirements Identifying climate opportunities	• Greater access to credible, sector specific physical and transition risk data at a regional scale.[128] • Plausible worst-case scenarios and likelihoods of climate extremes, compound and extreme events for stress testing systems (low-probability, high-impact). • Market analysis based on climate impacts, including potential impacts on supply chains, the economy, and how physical and transition risks might transmit across sectors. • Guidance, tools and resources to interpret and apply climate information and disclose climate risks.[129] • Outreach and training to build climate literacy.
Natural environment	Governments, regulators and natural resource management organisations Land managers, Primary producers and agri-businesses Communities Consultants First Nations peak organisations	Understanding climate risks to environmental assets (including water) and natural resource management activities and industries Understanding climate risks to cultural practices as a result of ecosystem disruption Understanding changes to ecological threats due to changing climate (e.g. pests, weeds and diseases) Understanding opportunities to incorporate traditional knowledges and cultural practices into land management	• Mapping of climate impacts and high-concern hazards (e.g. extreme heat and ocean warming), and analysis of their direct/indirect impacts to different locations, species and habitats. • Addressing gaps in regional socio-economic impact data • Tools to assess location- and species-specific impacts and risks. • Visualisations demonstrating time series changes.
Primary industries and food systems	Governments, regulators and natural resource management organisations Primary producers and agri-businesses Wholesale and retail food businesses Consultants	Understanding climate risks and opportunities to agricultural and fisheries assets Understanding short-term and seasonal impacts, and risks to agricultural outcomes Understanding long-term climate and weather trends, and their impact on the productivity and viability of different commodities/agricultural products Understanding climate related biosecurity risks	• Seasonal datasets and medium-long term forecasting, including analysis of trends such as changing growing season, precipitation patterns, pest/disease dynamics. • Climate variability forecasts and impacts, including information on hazard events to inform investment in infrastructure, including dams, irrigation and other land settlements. • Guidance, tools, and resources to interpret and apply climate information for decision making • Case studies demonstrating successful management[130]

[124] NESP Climate Systems Hub, 2023, Synthesis, communication, and data: Tailored information for stakeholders. Available at: https://nesp2climate.com.au/resource/delivering-quality-climate-information-and-data/.

[125] Peak body (Confidential), 2024, Submission 23 to the Independent Review of the ACS.

[126] Frontier Economics, [2020], Integrating sustainability into Infrastructure Australia's Assessment Framework, supplied.

[127] Infrastructure Victoria, 2024, Weathering the Storm: Adapting Victoria's infrastructure to climate change. Available at: https://www.infrastructurevictoria.com.au/resources/weathering-the-storm.

[128] Investor Group on Climate Change, 2023, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[129] Australian Securities and Investment Commission, 2024, Submission to the Independent Review of the ACS. Available at: https://consult.dcceew.gov.au/australian-climate-service-acs-independent-review-public-consultation-process/new-survey-1363fe74/list.

[130] Department of Agriculture, Water and the Environment, Drought Resilience Self-Assessment Tool User Needs Assessment, 2021, supplied.

Systems	Who	Types of decisions/uses	Needs identified by stakeholders

Health and social support	Governments
	Medical professionals
	Organisations supporting vulnerable communities (e.g. homelessness)
	Health and wellbeing specialists
	First Nations peak organisations
	Individuals
		Understanding climate risks to health systems including (heat, disease, food safety and air quality)
		Understanding risks of community displacement due to disasters or increasingly inhospitable climates
		Understanding cultural impacts and incorporating First Nations knowledge
		Understanding climate related biosecurity risks
			• Regular collection and analysis of accurate data showing impacts of climate change on health and welfare including:
			  ○ scale (risk and costs to health, the economy, and society)[131]
			  ○ relationships and trends (e.g. population health, hospitalisations, housing and homelessness, aged care)
			  ○ indicators of vulnerability.[132]
			• Add climate datasets to the Australian National Data Integration Infrastructure.
			• Data on heat and cold days and their impact on vulnerable populations.
			• Increased modelling of climate and health conditions, e.g. higher temperatures increasing the rate of infections, food insecurity causing depleted Vitamin A levels resulting in night blindness.
			• Guidelines on calculating and considering exposure and vulnerability in combination with climate responsibilities to assess where social safety nets are needed.
			• Data, tools and expertise to support planning processes for at-risk communities.[133]

Defence and national security	Governments (including military and intelligence organisations) Businesses involving trace/ multinational companies	Understanding international security risks and impacts of climate change Understanding international trade risks and opportunities and impacts of climate change Understanding climate related biohazard risks Assessing risks of climate change to critical infrastructure Anticipating human migration in response to climate change Developing early warning systems for environmental threats to national security	• Information on climate related physical and transition risks, for medium to long-term strategic planning by all spheres of government and industry.[134] • Access to near real-time information during the preparation and response phase for extreme events or natural disasters.[135] • Climate impact information addressing interdependencies with the health and social support, economy, trade and finance and infrastructure and built environment systems.[136] • Climate attribution for extreme events.[137]

Regional and remote communities	Governments
	First Nations peak organisations
	Individuals
		Understanding climate risks to communities that are supported by the natural environment, especially those with a strong mining, agribusiness, and/or tourism industry
		Understanding risks to water supply availability
		Understanding risks to governance, community cohesion, physical and mental health as a result of direct weather impacts and displacement
		Understanding risks to supply chain infrastructure for a multitude of businesses, in addition to essential services and goods
			• Data and tools for decision-making regarding:[138]
			  ○ risks to supply chain including distribution of essentials services, goods and labour
			  ○ physical and mental health impacts resulting from climate change and extreme events
			  ○ risks to community cohesion and resilience from exacerbated outmigration, decreased liveability, and increased inequality
			  ○ risks to emergency preparedness, response and recovery that result in extended periods of isolation for regional and remote communities.

First Nations values and knowledge systems	Governments First Nations peak organisations Individuals	Recognising the value of First Nations leadership and knowledge to inform mitigation of climate risks Inclusion of First Nations perspectives in decision-making and co-design of climate change adaptation actions (e.g. cultural burning and control of pests influenced by climate change) Understanding climate risks to culturally important species, habitats, and cultural sites Understanding risks to cultural safety of First Nations peoples Understanding risks to wellbeing, equity and justice Understanding climate-related risks to cultural economies	• Increase role of First Nations perspectives to better inform adaptation efforts. • Acknowledge the value of First Nations knowledge and observations of seasonal change. • Support First Nations-led initiatives to improve cultural resilience and adaptation.[139] • Climate information tailored to First Nations territories, cultural heritage sites and other traditional land use activities.

[131] Australian Medical Association, 2023, Submission to NEMA's Alternative Commonwealth Capabilities for Crisis Response Discussion Paper. Available at: https://www.homeaffairs.gov.au/reports-and-publications/submissions-and-discussion-papers/alternative-commonwealth-capabilities-for-crisis-response-discussion-paper.

[132] Federal government (Confidential), Submission 6 to the Independent Review of the ACS, 2023.

[133] Australian Red Cross, 2024, Submission on the National Adaptation Plan Issues Paper. Available at: https://www.redcross.org.au/publications/.

[134] Department of Defence, 2024, Submission to the Independent Review of the ACS.

[135] Department of Defence, 2024, Submission to the Independent Review of the ACS.

[136] DCCEEW, 2024, National Climate Risk Assessment First Pass Assessment Report.

[137] National Council for Fire and Emergency Services (AFAC), 2024, Submission to the Independent Review of the ACS.

[138] DCCEEW, 2024, National Climate Risk Assessment First Pass Assessment Report.

[139] ACS, 2023, NCRA Rapid Literature Scan, supplied.

4.7 Appendix G – International case studies

As part of this Review, a rapid assessment of several key international climate service organisations from similar countries/governments was conducted. Information is indicative and is not an authoritative source. In developing this table, the Review has considered definitions defined in the glossary (Appendix A).

	Climate information supply chain			Governance model				Key functions			Key clients
Name	**Upstream**	**Midstream**	**Downstream**	**Data partners / providers**	**Provides disaster response information**	**Open-source data**	**Fee-for-service model**	**Leadership and/or co-ordination function**	**Knowledge brokering service**	**One stop shop**	**Key clients**
Copernicus Climate Change Service (C3S)	No (However, C3S has access to observational data of the EU Copernicus Programme).	Copernicus collates and publishes datasets that have been generated using upstream data. Examples include long-range temperature trends, wind patterns, and precipitation.	C3S provides climate data, information and tools for sector-specific impacts.	Extensive partner/provider network – C3S contracts out data services via publication of tendering opportunities.	No	The vast majority of data/information delivered by Copernicus is made available and accessible to any citizen, and any organisation around the world on a free, full, and open basis.	No	No – direct leadership and co-ordination functions held within main body of Copernicus.	Yes – offers a virtual assistant, documents centre, community forum and user support portal to assist users to find information.	Yes – links provided to Data Libraries, Climate Maps, Climate reports, and climate data case studies.	C3S provides information for EU member state governments, specific sectors/industries and for the public. C3S content is also appropriate for international audiences.
National Oceanic and Atmospheric Administration (NOAA)	Yes – NCEI is the official archive for data collected by NOAA scientists, observing systems, and research initiatives.	Yes – tools, models, visualisations, and other public good information products are available.	Yes – specified analytical tools for key sectors/regions, and curation of information.	Data collected and made available from government (state & federal), research institutions, and international organisations.	Yes – provides some emergency information, including warnings via the National Weather Service.	Yes – via the NOAA Open Data Dissemination Program.	No	Yes – NOAA has the strategic objective of coordinating scientific priorities and resources.	Yes – for example, 6 Regional Climate Service Directors (1 per region)	Yes – a range of datasets, models and climate records available via its OneStop Data Search Platform.	NOAA supports all levels of government, the private sector, and the public.
UK Meteorological Office	Yes - significant inhouse observational and research capabilities. For example, it produces and maintains a range of gridded datasets of meteorological and climatic variables.	Yes – for example, regional and global short- and long-term models, sector-based tools and guidance.	Yes – specialised tailored information is available via commercial consulting services.	Significant inhouse observational and research capability including foundational and applied science. It partners globally.	Yes – provides emergency information, including via the National Severe Weather Warning Service.	Yes – for example, observational data; climate model data;	Yes – tailored products and services are available via a commercial contract.	Yes - integrates and facilitates weather and climate modelling, research and predictions within the UK academic sector and internationally. E.g., the Joint Weather and Climate Research Programme.	Yes – not a prominent feature; however, the Met Office Customer Centre is available 24/7 to assist users to find information or products.	Yes – however, its website is extremely challenging to navigate reducing its utility as a one stop shop.	UK Met supports governments, businesses, emergency responders and the public. It's responsibility to all UK citizens is outlined in the Customer Supplier Agreement.
Integrated Climate Adaptation and Resiliency Program (ICARP)	No	No	Yes – extensive curation of public good guidance, tools and resources in partnership with other state agencies.	Data predominantly obtained via the State Clearinghouse, which has extensive sources.	No	Links provided to climate data download sites. E.g.: Data can be downloaded from Local Climate Change snapshot.	No	Yes – co-develops the California Climate Adaptation Strategy, the Vision and Principles for resilience, coordinates California's climate science assessments and other climate research, data and tools and hosts the Technical Advisory Council.	Yes – maintains a service directory and encourages information requests via email.	Yes – links to other resources via Climate Tools Library, Californian Climate Change Snapshot, Resilience planning resources.	ICARP provides links to guidance and data for use by the private sector, local/state government organisations, and the public.
Canadian Centre for Climate Services (CCCS)	No	Yes – tools, models, visualisations and other public good information products are available.	Yes – knowledge brokering and extensive tailored and curated resources are available.	Extensive partners and providers – works with all levels of government, academia and research institutions, regional climate organisations, NGOs, First Nations groups and others.	No	Yes – for example: Climate Data Portal; Climate Resources Library; Climate Data Extraction Tool;	No	No	Yes - via the Climate Service Support Desk and Climate Resources Library.	Yes – a Climate Resources Library; Climate Data Extraction Tool; Climate Service Support Desk; Climate Data Portal; Climate data viewer are all available on the CCCS website.	CCCS is a national climate service for all Canadians with information tailored across the spectrum of decision-makers.

	Core Products and Services					Differentiated Products and Services							
Name	**National Climate Maps**	**Climate risk disclosure guidance**	**Periodic climate reports**	**Historical weather data including weather forecast tools.**	**Climate literacy outreach (training, workshops, etc).**	**Hazard maps**	**Guidance on data standards and quality assurance**	**Software tools for data analysis.**	**Short term climate forecasting**	**Medium-Long term climate forecasting**	**Decision support tools**	**Area/region-specific datasets.**	**Sector-specific guidance**
Copernicus Climate Change Service (C3S)	Yes - on-demand high-resolution international climate projection tool and the Climate Atlas tool for temperature analyses.	No	Yes - monthly Climate Bulletins; the European State of the Climate Report and Climate Indicators; Annual Global Climate Highlights.	Yes - Climate pulse provides consistent data updates, offering historical data with analysis occurring up to two days behind real time.	Yes - C3S User Learning Services offers free training on the use of the Climate Data Store platform and its content.	No – however, C3S is currently inviting tenders for the provision of services aimed at facilitating the development and supply of climate hazard information.	Yes – has a comprehensive quality assurance process and requires providers to meet requirements.	Yes – various tools for the interpretation and visualisation of data are provided within the C3S data library.	Links to international maps forecasting up to 42 days hosted by the European Centre for Medium-Range Weather Forecasts website.	The Climate Atlas tool provides medium-long term climate forecasts under a variety of climate scenarios.	Yes – various key information for decision support within the climate data store. C3S also has published case studies of climate data being used for decision-making.	Yes – regional datasets provided within the C3S data library.	C3S provides climate data, information and tools for sector-specific impacts.
National Oceanic and Atmospheric Administration (NOAA)	Yes – via Climate explorer.	No	Yes – National Climate Risk Assessment, Annual Global Reports, and Monthly Climate Reports available.	Yes - U.S. Climate Atlas and Climate explorer provide historical weather data.	Yes – Climate Resilience toolkit provides resilience education. NOAA education provides training in basic climate science.	Yes – Collated data of Natural Hazards, direct link to National Risk Index.	NOAA Information Quality Guidelines ensure the quality, objectivity, utility, and integrity of the information it disseminates.	Yes – Data tools (Climate explorer) interpret NOAA Regional Climate Centres' Applied Climate Information System (ACIS) data.	Yes – National Weather Service	Yes – Climate explorer provides scenario maps out to 2100.	Yes – Examples include Climate resilience toolkit, Steps to resilience, Climate at a Glance, Climate explorer, Digital Coast.	Yes - Region-specific data provided by the Climate Resilience toolkit.	Yes – e.g., the Fisheries Resiliency Index provides a self-assessment tool for climate and storm risk
UK Meteorological Office	Yes – for example, UK Climate Projections and climate maps and data.	No	Yes – State of the UK Climate Report; monthly, seasonal and annual climate summaries.	Yes – via National Meteorological Archive	Yes – for example, the climate newsletter; climate data training courses and resources on climate basics.	Yes – via the Climate Data Portal and Climate Extremes Dashboard.	UK Met data is verified using standards developed by World Meteorological Organisation. Unclear what guidance offered to partners.	No	Yes – monthly, seasonal and decadal forecasts.	Yes – for example, long range predictions and other projections via the Climate Data Portal.	Yes – for example: visualiser (in partnership with BBC); Climate Data Portal	Yes – via the Climate Data Portal	Yes – guidance for a wide range of sectors, including governments and the private sector. For example, energy, defence forces, agriculture.
Integrated Climate Adaptation and Resiliency Program (ICARP)	No	No	No	Links to this information via CAL-ADAPT Local Climate Change snapshot	Links to technical assistance/training such as Strategic Growth Council and publishes a regular newsletter.	Links to directly to these resources via CAL-ADAPT Local Climate Change snapshot	No	Links to analysis tools via CAL-ADAPT.	No	Links directly to this information via CAL-ADAPT.	Links to a library of external tools for data visualisation planning and analysis.	Links to local and regional datasets via Local Climate Change snapshot by CAL-ADAPT	Links to sector-specific guidance.
Canadian Centre for Climate Services (CCCS)	Yes – via the Climate data viewer and; Climate Data Portal.	Links directly to guidance via the Climate Resource Library (e.g.)	No	Links directly to historical information and tools via the Climate Services Support Desk and Climate Resources Library.	Yes – via climate information basics webpage and webinars, workshops, lectures and training sessions.	Links directly to this information via the Climate Resources Library.	No	Links directly to advanced analytic tools for experts via PAVICs	Yes – via the Climate Data Portal; Climate data viewer; Climate Data Extraction Tool and links to external resources via the Climate Resources Library	Yes – via the Climate Data Portal; Climate data viewer; Climate Data Extraction Tool and links to external resources via the Climate Resources Library	Yes – via the Climate Data Portal; Climate data viewer; Climate Data Extraction Tool and links to external resources via the Climate Resources Library	Yes – via the Climate Data Portal; Climate data viewer; Climate Data Extraction Tool and links to external resources via the Climate Resources Library	Yes – for example, sector specific data for transportation, agriculture, health and building sectors is available via the Climate Data Portal.

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