Australian National University

Professor Mark Howden
Director
ANU Institute for Climate, Energy & Disaster Solutions
+61 2 6125 7266
mark.howden@anu.edu.au

5 April 2023

The Hon Ed Husic MP
Minister for Industry and Science
House of Representatives
Parliament House
PO Box 6022
Canberra ACT 2600

Re: Submission for 'Developing Australia's Science and Research Priorities and National Science Statement – a National Conversation Starter'

Dear The Hon Ed Husic,

Please find enclosed a submission by the ANU Institute for Climate, Energy and Disaster Solutions (ICEDS) on developing Australia's science and research priorities.

ICEDS connects industry, governments and broad communities with climate, energy & disaster-risk research from the Australian National University. Our goal is to advance innovative solutions to address climate change, energy system transitions and disasters. We facilitate integrated approaches to research, teaching and policy engagement across disciplines.

The following Institute members have contributed to this submission (in alphabetical order): Dr Anna Sanders, Dr Bob Webb, Caitlyn Baljak, Carla Alzamora, Dharani Sabba, Ewelina Przybyszewski, Professor Frank Jotzo, Dr Jason Alexandra, Dr Lorrae Van Kerkhoff, Professor Mark Howden, Professor Roslyn Prinsley, Dr Steven Crimp.

We will be happy to elaborate on the points made in the submission. Our wider network of ANU researchers are well-positioned to provide further insights. We offer our coordination of further consultation with experts who are currently involved in the spectrum of research priorities identified in this submission.

Sincerely,

Prof Mark Howden
Director,
ANU Institute for Climate, Energy & Disaster Solutions

Australian National University

Submission on Australia's science and research priorities

April 2023

ANU Institute for Climate, Energy and Disaster Solutions with the ANU Institute for Water Futures

Lead author

Dr Jason Alexandra

Contributors:

Dr Anna Sanders, Hon Prof Bob Webb, Caitlyn Baljak, Carla Alzamora, Dharani Sabba, Ewelina Przybyszewski, Prof Frank Jotzo, Georgina Robinson, Prof Lorrae Van Kerkhoff, Prof Ken Baldwin, Prof Mark Howden, Prof Roslyn Prinsley, Dr Steven Crimp, Prof Steven Dovers, Prof John Handmer.

Executive summary

The ANU Institute for Climate, Energy & Disaster Solutions (ICEDS), with the support of the ANU Institute for Water Futures (IWF) welcomes the opportunity to provide this submission on Australia's Science and Research Priorities. The submission reflects the expertise and research capabilities available across the Australian National University (ANU) for addressing Australia's greatest challenges related to climate, energy, water and disasters, and strengthening Australia's regional partnerships across the Asia-Pacific. ICEDS is focused on mobilising science and building research capacity on the following national challenges:

1. **Climate change mitigation**: emissions reduction to limit warming to 1.5 degrees Celsius;
2. **Energy transitions**: accelerating just and effective energy transitions;
3. **Greenhouse gas removal**: including landscape carbon sequestration;
4. **Climate change adaptation**: including sustainable development;
5. **Disaster solutions**: especially climate related disasters, linking to adaptation actions;
6. **Water futures** and adaptation: crosscutting health, food security, disaster solutions;
7. **Place-based solutions:** relevant for land use changes, and for an urban context.

These challenges need integrated approaches to research, policy and governance. Interdisciplinary and innovative scientific research, both natural and social, is critical to addressing them.

Structure of Submission

This submission is structured in response to the main consultation questions, described in the conversation starter document.

In **Part 1**, we provide an overview of ICEDS, then outline national challenges relevant to climate mitigation and adaptation, including energy transitions, greenhouse gas removal, disaster solutions, water futures, and urban systems sustainability. For each of these themes we briefly outline:

- The nature of the challenges, and how science can address them;
- Opportunities to be seized;
- Research strengths Australia should maintain or build;
- Key recommendations that reflect on the capability and capacity needed to address these challenges and opportunities through research priorities and how to best progress work on them.

In **Part 2**, we argue there are significant opportunities to enhance Australia's research capabilities and capacities. We discuss how revitalising and refocusing Australian scientific and research capabilities are critical to addressing national, regional, and global challenges. We suggest opportunities to enhance these capabilities and increase capacity, including through investment in novel and integrated approaches. We emphasise the need to reform and reorganise the policy and institutional settings that determine, not only what research priorities are funded, but also identify opportunities for collaborative partnerships intended to ensure findings are applied.

Integrative and multi-disciplinary institutes, like ICEDS and IWF, are critically important in harnessing research capacities and in focusing collaborative research on the nation's significant challenges. However, we identify the need for targeted government support for more strategic approaches. To this end, we recommend establishing new national research funding agencies, whose role(s) would be as strategic investors and facilitators across the spectrum of climate, water, energy, and disaster related challenges. These agencies should prioritise long-term relationships and partnerships that build capabilities in diverse locations including regional and remote areas.

In **Part 3**, we comment on the proposed principles designed to guide discussion on the priorities and the statement. We suggest strengthening several principles and adding to them to better emphasise the necessary strategic national investment, policy and institutional reform, and international cooperation that will be needed to support Australia's research directions.

Recommendations

Recommendation 1: Strategic directions

To ensure Australia has the capabilities needed for adaptation to climate change impacts and rapid de-carbonisation of the economy, and to meet the challenges and opportunities involved in climate change mitigation and emissions reductions we recommend that the Australian Commonwealth Government:

- Increase funding and national coordination of climate change R&D;
- Establish a new, well-resourced, national climate R&D agency to strategically fund R&D on climate responses (climate adaptation and emission reduction), and mobilise community and industry responses;
- Provide targeted, flexible and long-term research for rapid decarbonisation;
- Establish new Commonwealth-funded PhD scholarships and Postdoctoral Fellowships targeting different disciplines and regions focused on the integration of climate adaptation and mitigation;
- Develop long-term strategic partnerships between Commonwealth agencies responsible for climate change response, science and industry policy and research agencies like ANU.

Recommendation 2: Energy transitions

To ensure Australia has the capabilities needed to address the challenges and opportunities arising from energy transitions, we recommend that Australia:

- Increase R&D on electricity generation, transmission, storage, and other infrastructure to underpin new investment;
- Understand the potential for hydrogen production and road mapping the trajectory to net zero;
- Understand options for innovative and cost-effective financing that can address credit constraints and provide returns on Government investment in new industries;
- Adopt robust research plans (such as the Australian Energy Transition Research Plan) to inform and guide Australia's Energy Transition to ensure that it is efficient, economic and effective;
- Collaborate with current and potential trading partners through technology partnerships and green economy trade agreements and to overcome coordination problems that constrain the growth of cross-border green supply chains.

Recommendation 3: Carbon sequestration and greenhouse gas removal

To ensure Australia has the capabilities needed to address carbon sequestration and greenhouse gas removal challenges and opportunities, we recommend that Australia:

- Identify and quantify landscape carbon sequestration methods that generate multiple benefits;
- Maintain independent research that can support the integrity of Australian Carbon Credit Units;
- Leverage domestic innovation systems to support interdisciplinary collaboration on developing novel carbon dioxide removal and use methods and technology;
- Support greenhouse gas removal research to develop a science-based target for national greenhouse gas removal and use;

- Support research on rapid decarbonisation and effective sequestration methods and techniques.

Recommendation 4: Climate adaptation

To ensure Australia has the capabilities needed to address climate adaptation challenges and opportunities we recommend that Australia:

- Establish a new, well-resourced, national climate response R&D agency to strategically fund climate adaptation R&D that assists in mobilising community and industry planning and responses;
- Formalise regional, community and industry engagement approaches catalysing planning that includes adaptation pathways principles (including disaster preparedness);
- Support the work of cross-disciplinary national research institutes like the ANU Institute for Climate, Energy and Disaster Solutions, and the Institute for Water Futures, to work with regional universities to undertake regionally-relevant adaptation research;
- Establish new Commonwealth funded PhD scholarships and Postdoctoral Fellowships targeting different disciplines, sectors and regions focused on climate adaptation (integrated with climate mitigation and disaster responses).

Recommendation 5: Disaster solutions

To ensure Australia has the necessary capabilities to address disaster solutions challenges and opportunities we recommend that the Commonwealth Government:

- Develop transformational solutions to ameliorate natural hazards, and prevent and mitigate disasters, through building significant national transdisciplinary research "missions".
- Understand the root causes of vulnerability to disasters, including those arising from inequity – and propose solutions.
- Harness new and emerging R&D to make warning systems more effective and robust in a complex environment in terms of governance, communication and funding.
- Coordinate research on mainstreaming disaster preparedness across policy sectors (land-use planning, development approval, transport, infrastructure, housing, food and agriculture, public health, and communications) and the community-at-large to ensure disaster risk reduction is not the sole responsibility of the emergency response sector.

Recommendation 6: Water futures

To ensure Australia has the necessary capabilities to address complex water futures we recommend that the Commonwealth Government:

- Enable transdisciplinary, engaged, problem-focused approaches to complex water-related challenges;
- Acknowledge and support the public-good values of water as well as efforts to enhance private sector water efficiency;
- Specifically encourage long-term perspectives in research relating to critical national resources such as water, in the context of climate change, transformation in agricultural industries, cultural values and consumer demands.

Recommendation 7: Urban systems sustainability

To ensure Australia has the necessary capabilities to address urban sustainability we recommend that the Commonwealth Government:

- Enable transdisciplinary, engaged, problem-focused approaches to complex urban-related challenges;
- Acknowledge and support the public-good values of urban systems research;
- Accelerate the transition to more sustainable, climate-friendly urban systems.

Recommendation 8: International cooperation

ICEDS recommends that international consideration and cooperation are central to Australia's national research priorities, particularly as relevant to the challenges faced by our region in transformational approaches in response to climate change and its impacts.

Recommendation 9: Institutional arrangements and organisational models

To ensure national capacity for working on national priorities, ICEDS recommends that serious consideration be given to establishing policy settings and institutional arrangements that ensure that Australia has the highest levels of scientific integrity and independence. This includes developing robust institutional arrangements and organisational models that ensure 'arm's length' funding decisions that explicitly minimise direct and indirect interference by Ministers and policy agencies.

Recommendation 10: Statutory independence

To ensure Australia has the strategic and coordinated investment needed to deliver on its national R&D priorities, consideration needs to be given to establishing a statutory authority, chartered with a clear legislated purpose of accelerating climate response and sustainability transformations. The new authority will be funded to mobilise multiple policy and research agencies and engage communities and industries in the wider climate, energy and sustainability challenges.

Recommendation 11: Adaptive, engaged, transdisciplinary modes of research

Australia's major national challenges require more adaptive models of governance. These need to be supported by equally adaptive, engaged and transdisciplinary modes of research. This challenge requires 1) traditional departments for disciplinary research; 2) institutes for inter- and transdisciplinary engaged, problem-focused research, and 3) accelerators for driving social and industrial change. This three-dimensional approach recognises that adaptive approaches to governance and science call for reforms to the way science is understood and how it engages with society, not simply the changing of research priorities.

Recommendation 12: Additional principles

ICEDS recommends that consideration be given to two additional principles to inform development of the national research priorities:

- **Recognising our unique responsibilities for our cultural and natural heritage** that arise from sixty million years of separate evolution and from being home to the oldest continuing culture.
- **Contributing to our global society** by recognising our place in the southern hemisphere, and our commitments to contributing to cooperative, international research efforts that support the meeting of international targets.

Invitation for further consultation

Given the significance of the process of resetting Australia's Research and Science Priorities, we offer our coordination of further consultation with experts across ANU who are currently involved in the spectrum of research priorities identified in this submission.

The ANU Institute for Climate, Energy & Disaster Solutions

The Australian National University (ANU) has responsibilities to form strong relationships with parliamentary representatives and government agencies and to ensure ready access to the breadth and depth of the expertise needed by them. ANU formed the Institute for Climate, Energy and Disaster Solutions (ICEDS) in 2021 to catalyse long-term, regionally-appropriate and integrated solutions to some of the major challenges facing Australia and the world – namely climate change mitigation and adaptation, greenhouse gas removal (sequestration), effective and equitable energy transitions, maintenance of agriculture and food security and reducing the likelihood and impacts of disasters.

ICEDS connects industry, governments, and diverse communities with climate, energy and disaster-risk research. Our goal is to advance innovative solutions to address climate change, energy system transitions, and disaster prevention and preparedness. Through our extensive network of over 570 expert members at ANU, we facilitate integrated approaches to research, teaching and policy engagement. The Institute provides a useful model for driving integrated and multi-disciplinary approaches to working on major national challenges.

This submission calls attention to transdisciplinary approaches that could revitalise Australia's Science and Research Priorities and National Science Statement. On behalf of our expert member network, we offer ANU support and engagement for an extended conversation to further explore the vision for research priorities that will help Australia meet its major challenges.

Part 1: National R&D priorities

This section outlines major national priorities based on ICEDS work in catalysing research on climate science and adaptation, energy transition, and disaster risk and resilience, underpinned by the ongoing need for emission-reduction and greenhouse gas removal. The themes outlined in this section are intended to promote further discussion and deliberation on Australia's Research and Science Priorities.

Strategic direction

Some opportunities and existing Australia strengths are relevant across all suggested research themes, for they focus on the necessary exploration of intersections across priority areas. In fact, the recommendations presented throughout this submission interplay with one another and will require a full embrace of systems and transformational thinking.

To shift Australia's strategic direction, the opportunities we should seize include:

1. Improved national coordination of climate mitigation and adaptation research and development.
2. Developing and extending partnerships with other countries in the Asia-Pacific.
3. International collaborations with Australian universities with strategic and bilateral funding over extended timeframes. ANU has strong partnerships with government, industry leaders, and academics from universities across the Asia-Pacific. These partnerships could be further developed through funding opportunities by the Australian government. This includes funding existing projects to discover new findings with changing geo-political priorities in the region as well as extending funding opportunities to new partnerships.
4. Integrating adaptation, mitigation and disaster preparedness (including greenhouse gas removal) responses in ways which maximise positive outcomes for communities, the built environment, landscape and ecosystems (e.g., savanna burning programs which enhance biodiversity conservation, cultural connections and landscape health;

community based agricultural productivity programs that address improved livelihoods, ecosystem function, and gender and social inequalities) whilst identifying systemic issues and adaptation barriers.
5. Promoting and enabling innovation and learning through targeted funding and learning partnerships.

Australia's current strengths include:
1. Having universities working in diverse locations with research capabilities that engage with local industries, communities and governments.
2. Academic freedom of expression.
3. Industry and community linkages, via programs like the ARC linkage grants and the CRC program.
4. Flexibility in establishing national R&D programs.

Recommendation 1: Strategic directions

To ensure Australia has the capabilities needed for adaptation to climate change impacts and rapid de-carbonisation of the economy, and to meet the challenges and opportunities involved in climate change mitigation and emissions reductions we recommend that the Australian Commonwealth Government:

- Increase funding and national coordination of climate change R&D;
- Establish a new, well-resourced, national climate R&D agency to strategically fund R&D on climate responses (climate adaptation and emission reduction) and mobilise community and industry responses;
- Provide targeted, flexible and long-term research for rapid decarbonisation;
- Establish new Commonwealth-funded PhD scholarships and Postdoctoral Fellowships targeting different disciplines and regions focused on the integration of climate adaptation and mitigation;
- Develop long-term strategic partnerships between Commonwealth agencies responsible for climate change response, science and industry policy and research agencies like ANU.

Climate Change Mitigation

The problems of climate change and challenges of climate mitigation are defined by scientific evidence. Effective policy and industry responses will depend on continuing research. For Australia, one of the greatest challenges that science can help to address are the need for rapid and **urgent decarbonisation of the economy** including for high emitting sectors such as construction, energy, transport and agriculture.

The main opportunities are in combining technological, policy and social innovations for emission-reduction that can support economy-wide transitions.

Energy Transitions

Australia has great potential to decarbonise its energy systems with access to low-cost renewable energy resources and shared interests to help neighbouring countries in the Asia-Pacific to build technological innovations and strengthen economic and strategic relationships. There are gaps in knowledge about innovation in infrastructure and energy transition policies, and their implications for socio-economic benefits.

The opportunities we should seize include:
1. Drawing on extensive Australian expertise (at universities, research agencies, etc.) to provide scientific advice to different levels and parts of government on topics related to energy transition in Australia and the Asia-Pacific.
2. Transformation of industries and urban systems to maintain or improve quality of life while mitigating climate change.

3. Mobilisation of industries and communities to identify, trial, and implement solutions.
4. Increasing skilled employment and educational pathways for future industries.
5. Trialling and expanding application of low-emissions technologies enabling energy transitions.

Strengths that Australia should maintain, or build are:

1. As the world's largest exporter of coal, liquefied natural gas, iron ore, and alumina, Australia, plays a leading role in meeting regional energy and resource needs. However, these exports generate sizeable consequential emissions at the point of use or processing, accounting for about 8.6% of the total greenhouse gas emissions of the Asia-Pacific. A combination of geopolitical shifts and decarbonisation policies is placing traditional Asian fossil fuel export markets in question. To continue Australia's position as a leading exporter of energy resources, Australia should utilise its vast renewable energy resources to export low-emission commodities like green iron, green steel, green aluminium, etc.
2. ANU Zero Carbon Energy for the Asia-Pacific Initiative (ZCEAP) demonstrates that transdisciplinary research is effective in providing evidence-based advice on energy transition. Increased government support will enable Australian universities to further pursue such initiatives.
3. Australia has policies in place for energy transition, however, to accommodate the changing geo-political priorities, the Australian Government should underpin this policy intervention with research.
4. Building community, civil society, and industry partnerships to rapidly transition our industries and energy systems is essential, including through mobilising the dispersed expertise in university and agencies across the continent,

Recommendation 2: Energy transition

To ensure Australia has the capabilities needed to address the challenges and opportunities arising from energy transitions, we recommend that the Australian Government support and increase R&D on:

- Electricity generation, transmission, storage, and other infrastructure to underpin new investment.
- Understanding the potential for hydrogen production and road mapping the trajectory to net zero.
- Understanding options for innovative and cost-effective financing that can address credit constraints and provide returns on Government investment in new industries.
- Research to inform and guide Australia's Energy Transition to ensure that it is efficient, economic and effective.
- Collaborating with current and potential trading partners through technology partnerships and green economy trade agreements and to overcome coordination problems that constrain the growth of cross-border green supply chains.

Carbon sequestration and greenhouse gas removal

Australia cannot achieve alignment with the Paris Agreement goals without greenhouse gas removal. This is an important contribution to climate action. Although Australia has a net zero target, it does not have a specific policy on greenhouse gas removal, nor an innovation and research hub for effective greenhouse gas removal methods and technologies. Although Australia is a global front-runner in terms of landscape management to achieve greenhouse gas removal, through mechanisms such as the Emissions Reduction Fund (ERF), Australia lacks research investment into landscape, biological, chemical and geological greenhouse gas removal technologies. Further, following the Independent Review into Australian Carbon Credit Units, there is a growing desire to ensure that greenhouse gas removal projects deliver non-climate benefits such as supporting First Nations traditional knowledge and ecosystem health. Innovation policy has a key role to play to ensure that landscape carbon methods deliver multiple benefits, and that emerging chemical and geological greenhouse gas removal methods are effectively scaled and cost-effective.

The greatest challenges that science could help to address include:

1. The integration of a specific, measurable, achievable, and relevant national greenhouse gas removal target into Australia's net zero target.
2. Developing cost-effective and scalable options for greenhouse gas removal and use.
3. Defining ways that Australia can achieve multiple societal benefits (social, environmental, economic, and cultural) through landscape carbon sequestration.
4. Ensuring that greenhouse gas removal activities are aligned with local and national natural resource management plans.
5. Improving the quality and transparency of verification of greenhouse gas removal projects to ensure public confidence in methods and techniques.

The opportunities we should seize include:

1. Integrating greenhouse gas removal responses to maximise positive outcomes for communities, landscape and ecosystems.
2. Testing emerging greenhouse gas removal methods and technologies.
3. Supporting the growing demand for high-integrity greenhouse gas removal with evidence-based measurement, monitoring, reporting and verification.
4. Innovative industries that contribute to national, regional, and global solutions, such as decarbonising fundamental industrial processes, like steel or cement manufacture or developing new industries around carbon capture and use (not carbon capture and storage).
5. Developing and adopting new standards, like industry and building technologies that mitigate climate change.

Strengths that Australia should maintain, or build are:

1. Leveraging Australia's large land area, extensive coastline, mineral abundance, renewable energy and geological storage potential to develop innovative biological, ecological, chemical and geological greenhouse gas removal and use technologies.
2. Building international collaborations on greenhouse gas removal R&D.
3. Research-industry partnerships in agriculture, renewable energy, and critical minerals.

Recommendation 3: Carbon sequestration and greenhouse gas removal

To ensure Australia has the capabilities needed to address these challenges and opportunities, we recommend that Australia:

- Identify and quantify landscape carbon sequestration methods that generate co-benefits;
- Maintain independent research that can support the integrity of ACCUs;
- Leverage Australia's innovation systems to support interdisciplinary collaboration on developing novel carbon dioxide removal and use methods and technology;
- Support greenhouse gas removal research to develop a science-based target for national greenhouse gas removal and use;

- Support research on rapid decarbonisation and effective sequestration methods and techniques.

Climate Change Adaptation

Despite progress, Australia suffers from a climate adaptation deficit and there are pressing needs for more research to support adaptation policy and planning at the local, state, national and international scales. The greatest challenges that science can help to address are:

1. Research support for more proactive and effective adaptation across a broad range of industry sectors, regions and communities.
2. Development of integrated climate risk assessment, adaptation response and decision models suited to Australia's diverse sectors and regions that identify integrated adaptation responses, including ensuring water and food security, reducing disaster risks, ensuring mitigation options are adapted to future climate changes and preparing for more extreme climatic conditions.
3. Developing robust and scalable engagement approaches that facilitate better understanding of adaptation options suited to diverse sectors and systems (including urban systems and the built environment), climatic zones and bioregions.
4. Developing integrated socio-ecological models of ecosystem management suited to the changes driven by climate change, including minimising the impacts of climate change on vulnerable ecosystems, e.g., coral reefs, wetlands, tropical savannas, different forest types, river systems.
5. Working with industries and communities, including First Nations Peoples to integrate diverse knowledge and build learning partnerships to mobilise action on adaptation.
6. Working with partners to identify systemic issues and ensure socially responsible and just adaptation responses.

The opportunities we should seize include:

1. Working cooperatively with neighbouring countries in the Asia-Pacific on adaptation.
2. Mobilising and enabling industries and local communities in different regional and urban settings to assess and implement local solutions to economic, livelihoods, health, and other intersectional challenges.
3. Increased global attention and investment in adaptation and sustainable development.

Strengths that Australia should maintain, or build are:

1. Working in areas where Australia has regional, sectoral and competitive advantages due to our variable climate, like flexible and adaptive water resources management.
2. Using the expertise developed across Australia's diverse climates and bioregions – from sub-Antarctic to the tropics.
3. Capacity for quality applied science in urban, rural, terrestrial, freshwater and marine environments.

Recommendation 4: Climate adaptation

To ensure Australia has the capabilities needed to address the climate adaptation challenges and opportunities we recommend that the Commonwealth Government:

- Establish a new, well-resourced, national climate response R&D agency to strategically fund climate adaptation R&D that assists in mobilising community and industry planning and responses.
- Formalise regional, community and industry engagement approaches catalysing planning that includes adaptation pathways principles
- Support the work of cross-disciplinary research institutes like ICEDS alongside of options to support regional universities and institutes to develop place-based and regionally specific adaptation research
- Establish new Commonwealth funded PhD scholarships and Postdoctoral Fellowships targeting different disciplines, sectors and regions focused on climate adaptation (integrated with climate mitigation and disaster responses)

Disaster Solutions

Climate change is increasing both the frequency and intensity of natural hazards such as bushfires and floods. In Australia in 2019-2020, current technologies and approaches were not sufficient to extinguish catastrophic bushfires, and nor were they successful in mitigating severe flooding in 2022. On average, natural disasters cost the Australian economy $38 billion per year. This represents approximately 2% of Australia's Gross Domestic Product (GDP) in 2020. It is estimated that climate change-fuelled natural disasters will cost Australia $73 billion per annum by 2060, under a low emissions scenario; and $94 billion/annum, under a high emissions scenario (Deloitte 2021). This may be a severe underestimate given the urban areas, infrastructure and industries that could be impacted. APRA warns Australia must spend at least $3.5bn/year to limit damage from climate-related natural hazards. Responding to bushfires, storms and cyclones after the fact is likely to cost 11 times more (APRA October 2020).

In Australia, disaster R&D is driven by the emergency response sector (see Natural Hazards Research Australia (NHRA) research priorities). This can lead to incremental solutions and can leave little room for transformational approaches – necessary to successfully mitigate against disasters. Looking outside the emergency response sector is essential to mainstream disaster risk management into all sectors of the economy e.g. land-use planning, development approval, environmental management, transport, infrastructure, housing, public health, communications (Dovers et al., 2022).

Science has a significant role in identifying and developing transformational approaches to disaster mitigation. Unique and transformational solutions should aim to prevent disasters where it is possible and minimise their impacts where it is not. For example, ANU has the ambitious goal to research the combination of multiple novel technologies and approaches to detect a bushfire within one minute of ignition and extinguish it within five minutes. We are also researching how to stop cyclones. We do not have any competitive government funding for either of these projects. Yet, if we do not find a way to stop bushfires developing in remote bushland from spreading uncontrollably as they did in 2019-20; or a way to intervene in ever intensifying cyclones, then we know that our governments will be up for ever increasing costs.

For Australia to be better prepared, the main research challenges are:

1. Cultural and end-user reliance on incremental solutions e.g. better fire trucks and more resilient buildings.
2. Build an awareness and capacity to support national level research to build transformational solutions.
3. Funding for novel interdisciplinary research. Research in a single discipline is unlikely to achieve the required breakthroughs necessary to prevent disasters.
4. Development of a broader approach, which builds on siloed disaster research and extends it into other sectors.
5. Understand how effectively disaster risk reduction is considered in decision-making across different policy sectors, and thus whether the goal of 'mainstreaming' disaster risk reduction is being achieved

The opportunities we should seize include:

1. Technologies and approaches developed in other sectors (e.g. defence, astronomy, space science, computer science, atmospheric and ocean physics and modelling). For example, ANU has the ambitious goal to research multiple novel technologies and approaches that can detect a bushfire within one minute of ignition and extinguish it within five minutes.
2. Integrate climate adaptation research with disaster prevention and preparedness, including at scales relevant to local management agencies.
3. Build significant national transdisciplinary research "missions" to develop transformational solutions to disasters.

Strengths that Australia should maintain, or build are:

1. Drawing on and integrating “unrelated” disciplines to research new ways to mitigate against disasters.
2. Working cooperatively with neighbouring countries to Australia's immediate north, given that almost half the world's natural disasters occur within the Asia Pacific region.
3. Incorporating community knowledge and establish and strengthen community intelligence networks for disaster prevention and preparedness.

Recommendation 5: Disaster solutions

To ensure Australia has the necessary capabilities to address disaster solutions challenges and opportunities we recommend that the Commonwealth Government:

- Develop transformational solutions to ameliorate natural hazards, and prevent and mitigate disasters, through building significant national transdisciplinary research “missions”.
- Understand the root causes of vulnerability to disasters, including those arising from inequity – and propose solutions.
- Harness new and emerging R&D to make warning systems more effective and robust in a complex environment in terms of governance, communication and funding.
- Coordinate research on mainstreaming disaster preparedness across policy sectors (land-use planning, development approval, transport, infrastructure, housing, food and agriculture, public health, and communications) and the community-at-large to ensure disaster risk reduction is not the sole responsibility of the emergency response sector.

Water Futures

Australia is already experiencing the water resource challenges emerging as a result of climate change, including more severe droughts and extreme flooding. The impacts of more variable rainfall together with an overall drying trend for much of Australia is largely unknown. It is a matter of national urgency to better identify and address these impacts.

The opportunities we should seize include:

1. Building strong linkages and partnerships with water management agencies at all levels to collaboratively develop shared understandings of the future of water in Australia.
2. Enabling researchers to work in problem-focused, transdisciplinary ways that advance our understanding of likely and plausible water scenarios at relevant spatial scales.
3. Capitalising on emerging technologies in Earth Observation and data generated from upcoming satellite missions to enhance our abilities to monitor and forecast water availability.

Strengths that Australia should maintain, or build are:

1. Australia already has strengths in adaptive water governance and in integrated modelling and innovative approaches to building more robust and accurate analysis and forecasting tools. Further work to build our capacities to connect that capability with decision-making and planning will grow the practical application of these approaches.
2. ANU has made independent strategic investments in transdisciplinary, engaged research for water management through the Institute for Water Futures. The IWF brings together researchers from earth sciences, mathematics, economics, social sciences and engineering to work with public and private water managers to better address long-term water challenges. Further support for these problem-focused, engaged modes of research will bring more evidence into policy- and decision-making towards better preparedness and more sustainable water management outcomes.

Recommendation 6: Water futures

To ensure Australia has the necessary capabilities to address complex water futures we recommend that the Commonwealth Government adopt national research priorities that:

- Enable transdisciplinary, engaged, problem-focused approaches to complex water-related challenges.
- Acknowledge and support the public-good values of water as well as efforts to enhance private sector water efficiency.
- Specifically encourage long-term perspectives in research relating to critical national resources such as water, in the context of climate change, transformation in agricultural industries, cultural values and consumer demands.

Urban science and place-based solutions

There are clear links between the challenges and opportunities discussed already. While some are specific to mitigation, adaptation or disaster management, it is striking how they are heavily interconnected across issues, opportunities, sectors and communities. As noted, this was one of the driving forces behind the formation of ICEDS at the ANU.

A key national challenge is how to extend solutions from coherent national and cross-sector policies right through to integrated and just local solutions, across the diversity of Australian cities, communities and ecosystems; and from these national capabilities to international collaborations and impacts.

Alignment and interconnections are needed between national/sub-national policies and local place-based solutions that also integrate successfully with local communities and businesses. Australia is one of the most urbanised countries in the world (90%). This means climate change and related solutions need to be integrated with other desired urban outcomes. Future Earth Australia (hosted by Australian Academy of Science) developed a decadal strategy for enhanced 'urban science' (FEA 2019). This was followed by a coastal/oceans strategy (FEA 2021) and a just adaptation strategy (FEA 2022), which both intersect with the urban strategy. These strategies make clear that nationally connected but locally distributed research capabilities are needed. A networked model can ensure local suitability of solutions while providing an enhanced ability to share useful practices nationally and internationally.

Australia focusing on urban systems science is also supported by:

- The fact that urban issues like local governance, land-use planning, energy, transport, housing, jobs, water, food, public health, natural environment, social infrastructure, are profoundly relevant to climate mitigation and adaptation.
- The need to address the current fragmentation of urban research, notwithstanding the high international reputation of individual research centres and bodies.
- Sustainable urban development is critical to Australia moving to a more desirable future.
- Urban science is an integral part of future sustainable development.

Recommendation 7: Urban systems sustainability

To ensure Australia has the necessary capabilities to address urban sustainability we recommend that the Commonwealth Government adopt national research priorities that

- Enable transdisciplinary, engaged, problem-focused approaches to complex urban-related challenges.
- Acknowledge and support the public-good values of urban systems research.
- Accelerate the transition to more sustainable, climate-friendly urban systems.

Part 2: Revitalising Australian science and research

This section discusses three key approaches that we believe are central to revitalising and refocusing Australian scientific and research capabilities, needed to address our national challenges.

International cooperation

The need to establish clear priorities and to maintain and increase international cooperation on research and development is clear for several reasons:

1. Australia is a small contributor to the global research effort but makes significant contributions in areas that are nationally relevant, and in which we have expertise and capabilities, such as climate and Antarctic science, water and land management, and biodiversity conservation.
2. Australia plays a major role in research relevant to the many smaller states in the Pacific.
3. Australia has a huge area of ocean and needs to advance its understanding of these systems.
4. Australia can learn from advances in knowledge generated overseas.
5. There is much to be gained for our education and research systems and in terms of diplomacy and bilateral and multilateral cooperation by engaging cooperatively in international research endeavours.

Recommendation 8: International cooperation

ICEDS recommends that international considerations and cooperation are central to Australia's national research priorities.

Strategic reforms for strategic investments in research

This section briefly outlines why Australia needs strategic reforms to ensure strategic investments in research that address national research priorities. This section draws on the experience of Australia having statutory authorities to independently fund R&D and why this model should be considered as an option in delivering any policy reforms.

Institutional arrangements that enable and protect scientific independence are central to resolving environmental problems in advanced liberal democracies. In Australia, independent and impartial scientific research is needed for contemporary policy debates, on drought policy, climate adaptation, rivers, and bushfires.

Controversies highlighting the need for reforms to ensure scientific independence include Australia's climate policy debates, the South Australian Royal Commission into the Murray-Darling Basin, the groundwater plan for the Adani Carmichael mine, ongoing debates about the health of the Great Barrier Reef and the massive fish kills in the Darling River.

These controversies highlight the need for institutional processes of ensuring scientific independence that can address issues of national relevance while being insulated from political interference. However, achieving this ideal can be particularly challenging because most of the Australian science is publicly funded, and funding decisions made by governments affect projects, programs and future of entire agencies. Therefore, institutional arrangements and organisational models that have 'arm's length' funding decision processes and that minimise direct and indirect interference by Ministers and bureaucrats deserve serious attention.

Recommendation 9: Institutional arrangements and organisational models

To ensure national capacity for working on national priorities, ICEDS recommends that serious consideration be given to establishing policy settings and institutional arrangements that ensure that Australia has the highest levels of scientific integrity and independence. This includes developing robust institutional arrangements and organisational models that ensure 'arm's length' funding decisions that explicitly minimise direct and indirect interference by Ministers and policy agencies.

Learning from past experiences

History provides numerous examples of R&D agencies and program that Australia has established and then terminated (see Marlow, 2020). Here we concentrate on one organisational example - Land & Water Australia (LWA) a statutory authority that strategically funded R&D on environmental and natural resources management (NRM) between 1989 and 2009. Established as a statutory corporation under the Primary Industries and Energy Research and Development Act 1989 (PIERD) its legislated mandate was to organise, fund and promote R&D on the sustainable management of Australia's land, water and vegetation resources. As a research broker, it successfully initiated numerous collaborative R&D programs, facilitating purposeful co-investment with industry and governments. LWA had several discerning features that could be replicated in future arrangements if the government was willing to explore better institutional models for funding priority R&D. These include legislated arrangements for structural independence that minimised interference in research funding decisions.

Land & Water Australia (LWA) was effective and influential in promoting sustainable natural resource management due to its statutory independence. Legislation protected LWA from direct interference, enabling it to operate at arm's length from executive government. LWA contributed to changing policies and practices, and the legislation and budget support enabled LWA to coordinate, organise and fund R&D, until its abolition in 2009.

Despite significant achievements, LWA was abolished in 2009 – ostensibly as a savings measure – a decision that was widely criticised, including by political parties, the Australian Conservation Foundation (ACF) and the National Farmers' Federation (NFF).

Yet more than a decade on, Australia lacks any similar agency, despite the Productivity Commission recommending that *"if the Government is serious about having its broader research priorities appropriately addressed within the RDC arrangements, it should create and fund a new RDC — Rural Research Australia — to sponsor non-industry research directed at promoting the productive and sustainable use of resources."* In one report the Productivity Commission recommended a $50 million annual allocation to this new entity, for public-good R&D, but this has not been acted on. The government should consider establishing such an agency and giving it the mandate of funding climate mitigation, adaptation, and sequestration R&D that will enhance Australia's transition to low emission country.

LWA provides a useful precedent of a statutory authority, chartered with a clear legislated purpose with legal mechanisms for ensuring independence. LWA provided an important model of public R&D investment directed to sustainability transformations and an example of an institutional arrangement that protected scientific independence mobilised multiple policy and research agencies and engaged communities and industries. Australia should apply these lessons to how it delivers future R&D priorities.

For more information see two papers published in Proceeding of the Royal Society of Queensland: Marlow, 2020 & Alexandra, 2020. These provide examples of why scientific expertise needs to be protected from short-term political interference and why we need robust arrangements for ensuing national priorities are delivered.

Recommendation 10: Statutory independence

To ensure Australia has the strategic and coordinated investment needed to deliver on its national R&D priorities, consideration needs to be given to establishing a statutory authority,

chartered with a clear legislated purpose of accelerating climate-response and sustainability transformations. The new authority would be funded to mobilise, multiple policy and research agencies and engage communities and industries in the wider climate, energy and sustainability challenges.

The new normal, post-normal science and the science-policy interface

The rapidly changing conditions of the early 21st century mean that we must rethink our models of scientific innovation alongside the priorities themselves. The changing climate gives rise to many questions about understanding and managing natural resources and ecosystems. The new complexity of decision-making within climate change regimes necessitates institutional frameworks suited to the dynamism of a changing climate. For these we need to critically examine our assumptions about the science-policy interface – a heuristic device for interpreting the closely coupled scientific, legal and policy networks.

Instrumental models of the interface adopt narrow definitions of the roles of science in public policy - government agencies harness scientific capabilities to develop 'evidence-based' solutions to policy problems. This model of science serving the State, is known as administrative rationalism, and is the dominant research-based problem-solving model used by many government agencies.

It is important to understand why these models need to change. Administrative rationalism's structures and modes of operation evolved gradually under conditions of hydro-climatic stationarity. However, Anthropocene conditions undermine the conceptual foundations of traditional approaches to ecosystem management. Dynamic biogeochemical and ecological processes and the non-stationarity of hydro-climatic regimes are producing 'wicked' environmental problems. In these post-normal or post-natural settings, these problems are characterised by *"irreducible complexity, deep uncertainties, multiple legitimate perspectives, value dissent, high stakes, and urgency of decision-making"* with science unable to provide absolute truths and confident solutions (see Dankel et al., 2017, p.2).

Administratively rational models of the science-policy interface contrast with relational models, which interpret capacities for knowing and governing as coupled, co-evolving and co-produced. Critiques of administrative rationalism argue that hierarchical centralism and command and control approaches are unsuited to adaptively governing under Anthropocene conditions. Resilience based, adaptive governance models, are proposed for handling complex sustainability challenges because they are more responsive to ecological feedbacks and emerging scientific knowledge gained through adaptively managing complex systems. But these more adaptive models of governance need to be supported by equally adaptive, engaged, transdisciplinary modes of research. This challenge is being recognised and implemented in major initiatives around the world. For example, the Stanford Doerr School of Sustainability is structured across three pillars: Departments for disciplinary research; Institutes for Inter- and transdisciplinary engaged, problem-focused research, and Accelerators for driving social and industrial change. This three-dimensional approach recognises that adaptive approaches to governance and science call for reforms to the way science is understood and how it engages with society, not simply the changing of priorities.

Recommendation 11: Adaptive, engaged, transdisciplinary modes of research

Australia's major national challenges require more adaptive models of governance. These need to be supported by equally adaptive, engaged and transdisciplinary modes of research. This challenge requires 1) traditional departments for disciplinary research; 2) institutes for inter- and transdisciplinary engaged, problem-focused research, and 3) accelerators for driving social

and industrial change. This three-dimensional approach recognises that adaptive approaches to governance and science call for reforms to the way science is understood and how it engages with society, not simply the changing of research priorities.

Part 3: Principles for setting and achieving ambitious research goals

The consultation paper proposes seven principles for shaping national science and research priorities. We have been guided by these in providing suggested priorities. In this section, we provide further perspectives on strengthening the proposed set of principles. Original principles are italicised, with reflection and amendments suggested in the text following; it is the proposed changes in intent or meaning (rather than wording) that we wish to emphasize.

- ***Be community-informed****. To build community ownership of the priorities, a public conversation about the challenges and opportunities facing Australia will inform the priority setting process. The process will recognise and support First Nations perspectives on science, technology, and innovation.*

Broad support. However, we suggest that the commitment to community and First Nation's engagement be extended beyond the priority-setting conversation, to include opportunities for collaborative implementation that recognises and values diverse ways of knowing and doing across all Australian science and research. A suggested text alternative:

> **Be community-informed**. The Australian Government is committed to engaging all communities, including First Nations peoples, in understanding and responding to the priority challenges and opportunities facing Australia. To mobilise communities' capacities for research, science, technology, and innovation the government will adopt good practice models of community engagement, participation and partnership in research and innovation, including through citizen science.

- ***Be ambitious and purpose-driven****. The priorities should be ambitious and address Australia's biggest challenges and opportunities. They should have meaningful impact and reflect Australia's competitive and comparative advantages.*

Broad support. We suggest amending to include attention to the real risks and ethical dilemmas that accompany challenges and opportunities:

> **Be ambitious and purpose-driven**. The priorities should be ambitious and address Australia's biggest challenges and opportunities, attending to the strategic risks we face. They should aim to have meaningful impact, enhancing Australia's competitive and comparative advantages.

- ***Be evidence-based****. The priority setting process will consider all national challenges and opportunities that are supported by evidence, which includes supporting and embedding First Nations knowledge and knowledge systems.*

Broad support. This principle brings together complex concepts about evidence and knowledge systems. We suggest two equally important principles:

> **Be evidence-based**. The priority setting process will consider national challenges and opportunities that are supported by rigorous and systematic assessments of the available evidence.
>
> **Respect diverse systems of knowledge**, including recognising, supporting and embedding First Nations' knowledge and knowledge systems.

- ***Be enduring and responsive.*** *The priorities should be enduring and designed to address ambitious, long-term priorities for Australia. They should provide system-level stability. The priorities should also be responsive to scientific progress and emerging issues (for example, natural, social, or economic emergencies).*

Clarity required. This principle is unclear. Providing system-level stability and responsiveness are desirable characteristics of research and governance systems, rather than of priorities themselves. A suggested text alternative:

> **Be enduring and responsive**. The priorities will set and support ambitious, long-term strategic direction for Australia. They will help provide continuity of research efforts towards identified national goals. Future revisions of the national priorities will be responsive to scientific progress, changing circumstances and emerging issues. In practice, research capabilities will be able to be directed to any urgent national needs, for example, responding to natural, social, or economic emergencies.

- ***Be relevant.*** *The priorities will be reviewed on an ongoing, regular basis to ensure they remain relevant for Australia.*

Broad support, additional context required. While the priorities should be reviewed regularly, they should also set Australia on an ambitious path that supports national and global policy leadership.

> **Be relevant.** The priorities are focused on supporting the effective, efficient and just delivery of major national policy commitments, including those articulated in international commitments, for example to biodiversity conservation and reduction in greenhouse gas emissions. The priorities will be reviewed regularly to ensure their relevance to Australian commitments and priorities.

- ***Be bounded.*** *The priorities are not intended to be exhaustive nor include all science that should be undertaken in Australia.*

Broad support. We understand that the priorities identified are intended to address national needs. They are not an exhaustive list of all the research that should be undertaken in Australia.

- ***Inform investments.*** *The priorities will be used to guide government policies and investment in science. They will also act as a signal to inform industry, international, research and community decision-making and investment*

Broad support. This principle is critically important in giving effect to the work of establishing national priorities and delivering on them.

Recommendation 12: Additional principles

ANU ICEDS recommends that consideration be given to two additional principles to inform development of the national research priorities. These are based on recognition of our unique responsibilities for our cultural and natural heritage and of our place in the southern hemisphere, representative also of our role as global citizenry.

Australia's national research priorities should also:

- **Recognise our unique responsibilities**. Australia is a country in a continent with unique responsibilities for our cultural and natural heritage. These unique responsibilities arise from sixty million years of separate evolution and from being home to the oldest continuing culture, with its sixty thousand years of knowledge, cultural evolution and expression.

- **Contribute to our global society**. Australia's priorities are shaped by our place in the southern hemisphere, our proximity to Antarctica and the Pacific, Indian and Southern Oceans and our commitments to contributing to cooperative, international research efforts. The priority setting process incorporates awareness of the world's collective challenges and targets. This context is critical identifying research priorities.

Invitation for further consultation

ANU ICEDS welcomes the opportunity to host consultation with our extensive member network to further discuss, refine and scope Australia's science and research priorities. We will be happy to elaborate on the points made in the submission.

Institute for Climate, Energy & Disaster Solutions

+61 2 6125 6611

iceds@anu.edu.au

The Australian National University

Canberra ACT 2601 Australia

www.anu.edu.au

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