



Australia's National  
Science Agency

# Building a disaster-resilient Australia







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Australia's unique climate and geography leave it vulnerable to natural disasters.

When events such as bushfire, drought or flood strike, the human, environmental, and economic impacts are significant. Insurance losses for the 2019/20 bushfires exceeded \$2.3 billion. The social and economic costs of the 2019 North Queensland floods exceeded \$5.6 billion.

With climate change exacerbating extreme weather events in Australia, we are now experiencing more frequent and severe natural disasters.

There has been an increase in consecutive or concurrent disaster events, with some regions of the country facing drought, heatwaves, bushfire, storms and flooding in a 12-month period. For communities, this compounds the trauma and physical impacts, and for industry and government it makes recovery more challenging.

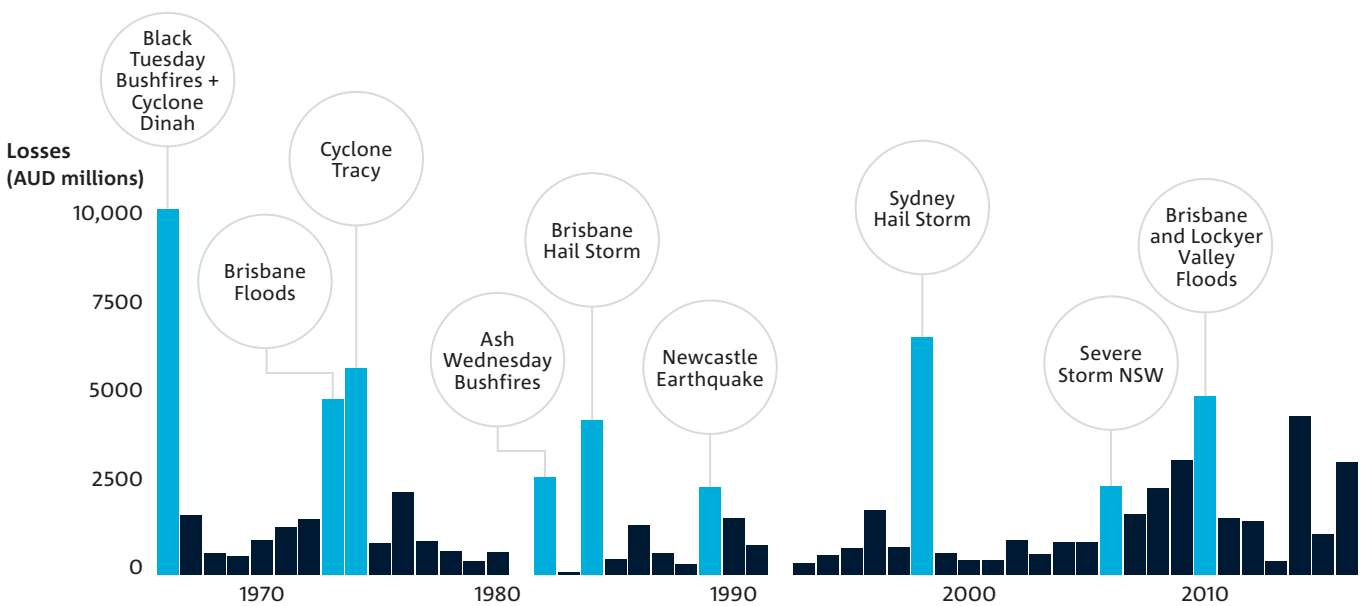
## About CSIRO

As Australia's national science agency, CSIRO is a trusted organisation, ideally positioned to support informed decision making in government and industry.

We draw on a wide range of expertise to help solve some of society's greatest challenges through innovative science and technology.

Our approach to research is a collaborative one, and we benefit from many longstanding relationships with stakeholders. These include universities and cooperative research centres (CRCs), where primary research is taking place; local, state and federal governments, who determine the policy and legislative frameworks we need to work within; and key players within business, industry, and community organisations who need to see tangible outcomes.

In the context of strengthening Australia's resilience into the future, these relationships are vitally important.



Normalised insurance losses 1966–2016 redrawn from McAneney J, Sandercock B, Crompton R, Mortlock T, Musulin R, Pielke R Jr & Gissing A (2019) Normalised insurance losses from Australian natural disasters: 1966–2017, *Environmental Hazards*, 18:5, with major disaster events superimposed.



Building resilience is the key to Australian communities resisting, absorbing and recovering from natural disasters.

Not only does natural disaster resilience planning make it faster and easier to restore essential services and infrastructure after a major event, it also has a positive impact on job security, health and wellbeing within communities, and the protection of ecosystems and cultural heritage.

With Australia's climate becoming more variable, it is critical that we effectively plan and prepare to increase our resilience. Now is the time to invest in response capacity, recovery and building back better, in order to reduce the social, environmental and economic impact of future natural disasters.

Preparing for natural disasters – and responding effectively when they occur – requires a collaborative, integrated approach. It demands a co-ordinated effort across all levels of government, communities, and the private sector. Additionally, it requires knowledge and capability from a wide range of professional and scientific disciplines.

## CSIRO's capabilities

Drawing on almost a century of expertise, CSIRO is striving to better understand, respond to, and prepare for extreme events and emergency situations.

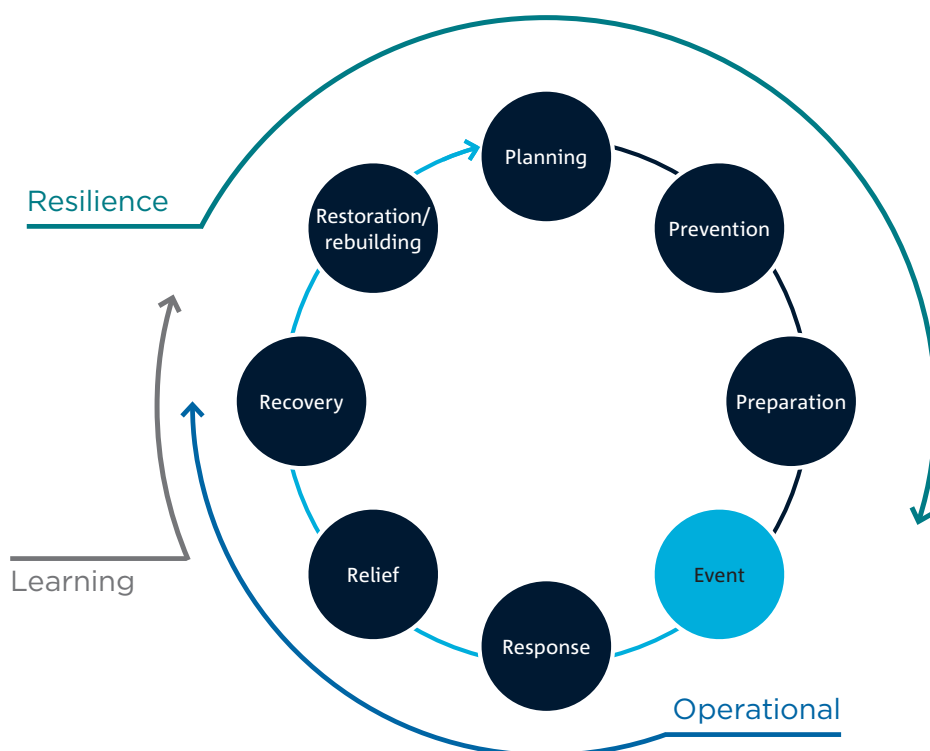
One key step in strengthening Australia's resilience – and supporting our infrastructure, communities, industries and environment - is understanding how climate change influences natural disaster events.

We have world-class facilities to enable our work in assessing and addressing climate change, and we work with industry, government and the research community to turn innovative science into real-world solutions.

We also have a long history of research on land management, building design, managing biodiversity, bushfire behaviour, and in the science and application of the concepts of resilience and adaptation.

Each of these research areas has an important role to play in building more resilient communities across Australia.

CSIRO's broad multidisciplinary capability delivers enduring national benefit providing improved scientific understanding and new technologies to all parts of building climate and disaster resilience.



# Climate change

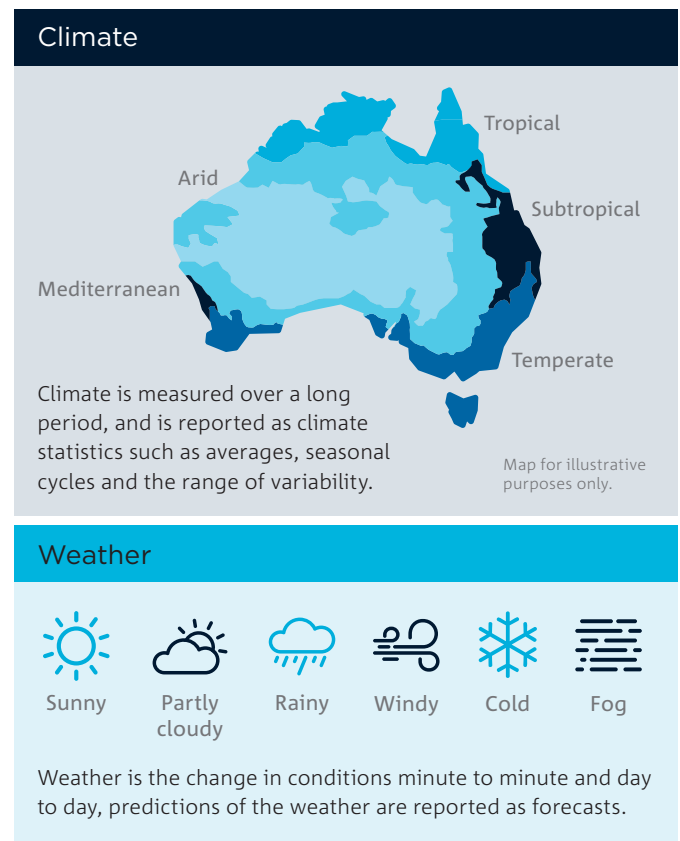
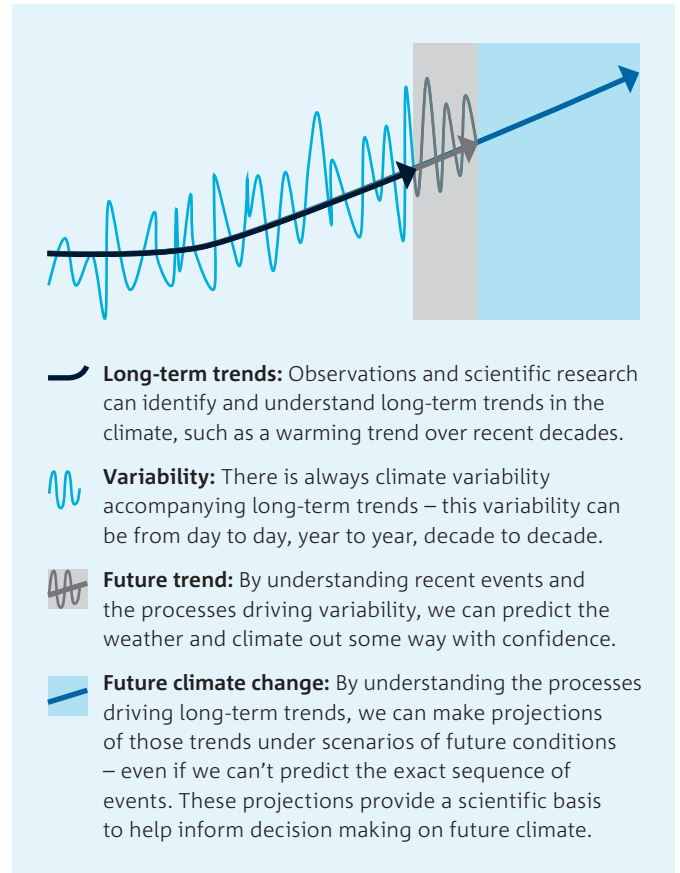
## The difference between weather, climate, and climate change

Human activity is not only increasing average global temperatures. It's also affecting rainfall, weather patterns, storms, evaporation, ocean currents, and the distribution of snow and ice. These changes are not uniform around the world.

Changes to atmospheric circulation patterns mean that some areas are getting drier while others are getting wetter, and, in some cases, seasons are shifting or changing. Climate change is likely affecting the so-called drivers of climate variability, such as the El Niño Southern Oscillation.

Broadly speaking, climate change is increasing the frequency and severity of many natural disaster events. There is a negative feedback loop where changes in the underlying climate averages are driving an increased frequency and intensity of events which sometimes, in turn, further disrupt the climate and/or the natural recovery of an environment and the impact on our communities.

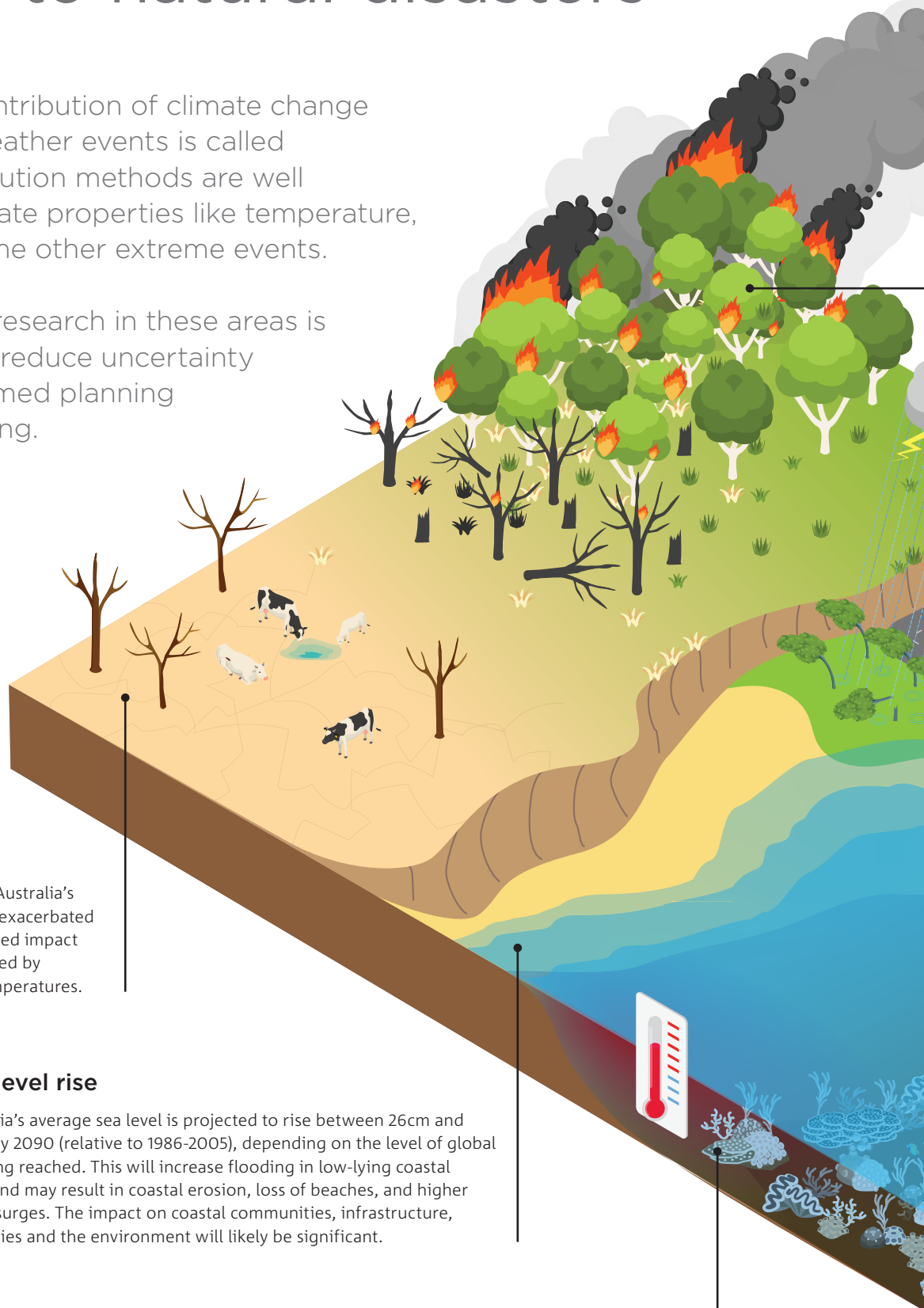
We don't know exactly what emission levels will be in the coming decades or centuries, but climate scientists can model a range of future climate scenarios based on different levels of emission reduction. This information can help us plan ahead, consider options for adaptation, and mitigate potential risks.



# Attributing the impact of climate change to natural disasters

Identifying the contribution of climate change to our extreme weather events is called 'attribution'. Attribution methods are well advanced for climate properties like temperature, but less so for some other extreme events.

CSIRO's ongoing research in these areas is important to help reduce uncertainty and support informed planning and decision making.



## Drought

Droughts are a natural part of Australia's climate but are expected to be exacerbated by climate change, with increased impact from prolonged dry spells caused by decreased rainfall and high temperatures.

## Sea level rise

Australia's average sea level is projected to rise between 26cm and 82cm by 2090 (relative to 1986-2005), depending on the level of global warming reached. This will increase flooding in low-lying coastal areas and may result in coastal erosion, loss of beaches, and higher storm surges. The impact on coastal communities, infrastructure, industries and the environment will likely be significant.

## Marine heatwaves

More frequent, extensive, intense and longer-lasting marine heatwaves are projected. This is likely to lead to more frequent and severe coral bleaching, and will have a significant impact on Australia's fisheries. The East Australia Current region is projected to continue warming faster than the global average.



## Extreme heat

Heat extremes of all kinds, including hot days, warm nights and heatwaves, are projected to increase. This has implications for human health and the operation of critical infrastructure under hot conditions.

## Bushfires

The likelihood of dangerous bushfire weather has doubled over the past decade. This trend is projected to continue in southern and eastern Australia. A warmer and drier climate increases fire risk and will likely result in changes to bushfire fuel loads, structure and type. Increasingly frequent and severe thunderstorms increase fire risk through lightning strikes igniting bushland.



## Hail and damaging storms

Climate change may increase our risk of large hail. While further research is required, our modelling indicates potential increases in severe thunderstorm events for parts of eastern Australia. Some types of damaging storms are projected to change in frequency, severity, speed and size, due to a warming climate.



## Floods

Greater, short-duration rain extremes associated with flash flooding are projected. As the climate warms, heavy rainfall is expected to become more intense.

## Tropical cyclones

Climate change may mean fewer total cyclones but an increase in more intense cyclones. It's challenging to quantify cyclone trends because Australia's tropical cyclone activity significantly varies from year-to-year, influenced by natural climate drivers such as El Niño and La Niña. Tropical cyclone impact comes from high winds, heavy rains and contribution to storm surge. During cyclones, the increased rainfall (due to warmer oceans and atmosphere) and higher storm surge (due to sea level rise) are projected to increase the overall impact.







# Resilience

## A systems approach to building resilience

The complex and fast-evolving interplay of natural events means that a national approach will be necessary to strengthen the climate and disaster resilience of Australia's communities.

This national effort to build resilience will require systems thinking: not looking at individual events in isolation, but instead taking a broader and more holistic view that incorporates foresighting, risk management, and learning and education for all stakeholders.

The availability of strong underpinning data is key, and this is one of CSIRO's key strengths. Establishing and strengthening resilience across communities, infrastructure and the natural environment will require an ongoing, up-to-date and informed understanding of hazard, vulnerability and exposure.

There needs to be a renewed focus on land-use planning and zoning to avoid unnecessary exposure to new hazards such as flooding and inundation associated with sea-level rise, or tropical cyclones tracking further south.



Building resilience in communities, infrastructure and the natural environment requires an ongoing up-to-date and informed understanding of hazard, vulnerability and exposure to drive continual improvement, and needs to be strongly linked to land use planning and zoning to avoid unnecessary exposure to new hazards e.g. flooding and inundation associated with sea-level rise or tropical cyclones tracking further south.

## Key considerations

There are four key steps to building climate and disaster resilience.

### 1 Planning and preparation

We need to understand the potential for future disasters to make informed decisions about how and where we live, what we value and want to protect, what a disaster-resilient Australia looks like, and how we mitigate risk.

### 2 Response

Natural disaster response is a collaborative effort that involves all levels of government, industries, and communities: it's essential that our capabilities are current, robust, fully utilised, integrated and shared.

### 3 Recovery

Australia rates highly for disaster preparedness and economic and social resilience, but an increase in major events makes recovery challenging and some regions in particular are disproportionately impacted by concurrent events.

### 4 Learning and improvement

Even as our understanding of potential threats improves, we must ensure continual improvement in resilience through review and refinement.

# Solutions for Australia

CSIRO has a significant role to play in providing reliable, actionable research and developing the best practice methods and techniques that will help Australia become a global leader in climate and disaster resilience.

Our focus is on Australia-specific solutions that take into account our unique geography, climate, cultural heritage and environment.

## Investing in infrastructure

Resilience must influence how and where we build, and must drive ongoing improvements in the standard and design of the built environment and critical infrastructure.

CSIRO is collaborating with Insurance Australia Group and National Australia Bank on the Resilience Investment Vehicle pilot project to fund built, social and natural infrastructure that will increase community resilience to natural hazards.

The project aims to direct public and private capital to finance new and/or adapt existing infrastructure that can increase resilience and reduce disaster risk as well as derive a financial return for investors.

We are sourcing data, sponsoring research to quantify benefits from resilient investment, and assessing the governance arrangements needed between the public and private sectors to promote resilience investment opportunities.



**Building resilient housing:** see page 11 for more details of the pictured One House campaign. Image: Suncorp.





The concept of ‘building back better’ is an important one, which should be incorporated into every resilience plan. It places an emphasis on using the recovery period after a disaster to increase the future resilience of the affected community.

## The role of communities

Communities play an essential role in resilience building, and it’s vital that they are provided with the appropriate support to understand and reduce risks within their influence and control.

Targeted investment in community education and engagement activities can ensure that people feel empowered to make informed decisions about their safety.

Working in partnership with Traditional Owners is another important aspect of resilience building.

In one recent project, CSIRO worked with Indigenous fire experts to design landscape burning partnerships, projects and activities across Australia. These led to cultural burning techniques being incorporated into western land management practices.

Our researchers worked with Bundjalung Traditional Owners and Park managers at Arakwal National Park in Byron Bay, New South Wales, to co-develop guidelines on effective cross-cultural conservation planning for significant and endangered species, such as the rare Byron Bay orchid and its clay health habitat.

As a result, the Bundjalung are now co-managing the national park with the New South Wales National Parks and Wildlife Service, undertaking cultural burning to look after the land and actively guiding conservation decisions.

Citizen Science can also play an important role in recovery, collecting evidence on the impacts of disasters such as large-scale fire on biodiversity.

## Building back better

Building back better requires us to consider not just where we should build, but how. Disaster-resilience needs to be explicitly embedded in planning, agricultural and urban land use, and zoning and investment decisions, to avoid unnecessary exposure to the new hazards resulting from the impact of climate change.

There has already been significant progress on increased adaptation and resilience measures for events such as tropical cyclones, but in other areas there is further work to be done.

Bushfire planning is one example where improved co-ordination could have a big impact: there is good data availability, but mapping the risk and spread of bushfires needs connected models, data sources and platforms.

CSIRO is helping to develop a national bushfire hazard planning map through the Australian Government’s National Bushfire Intelligence Capability pilot project. This project is building on existing systems, including the Australian Fire Danger Rating System (AFDRS), to improve bushfire prevention and preparation.

Another example is the Enabling Resilience Investment approach developed in partnership with Value Advisory Partners. The approach provides planning and analysis tools for creating value and mitigating systemic risk in the design and delivery of future infrastructure investments.

This work is already having an impact in two case study regions – the Bega Valley, NSW and Port Adelaide Enfield, SA – and may be used to generate outcomes from disaster recovery and resilience projects in cities, suburbs and rural and regional Australia.





**Following the 2019 north Queensland floods, sediment-laden waters of the Burdekin River flood plume flow out to the central Great Barrier Reef, about 60km offshore.**

Image: Matt Curnock, aerial footage provided by TropWATER JCU, the Marine Monitoring Program - Inshore Water Quality through the Great Barrier Reef Marine Park Authority, the Queensland Government, the Landholders Driving Change project led by NQ Dry Tropics, CSIRO and the National Environmental Science Program Tropical Water Quality Hub.



# CSIRO's program of work

## CSIRO collaborations

### Australian Climate Service

CSIRO is a key partner in the \$209 million Australian Climate Service, established by the Commonwealth Government in 2021 to support communities and business to better anticipate, manage and adapt to the risks brought by a changing climate.

Working in partnership with the Bureau of Meteorology, Geoscience Australia and the Australian Bureau of Statistics, we will support improved decision-making to help Australians prepare for natural disasters well before they occur.

The Australian Climate Service represents a significant commitment and brings together Australia's leading science and data experts to strengthen the nation in the face of natural hazards.

### Building resilience with One House

To tackle the major loss of life, property and infrastructure caused by destructive natural events, we have teamed up with Suncorp, James Cook University (JCU) and Room 11 Architects to design, build and test a prototype house resilient to multiple extreme events.

At JCU's Cyclone Testing Station and CSIRO's Bushfire Burnover Facility at Mogo, NSW, researchers tested which aspects of the house would fail or resist fire, cyclone and flood impacts. The bushfire simulator produced a 12m-wide fire front to replicate fire in a series of simulations. Up to 100 sensors were embedded in and around the house prototype to measure air and surface temperatures, radiant heat flux and track how individual elements of the house survive different fire intensities.

The results have led to a more robust and resilient house design that can help to protect against extreme weather.

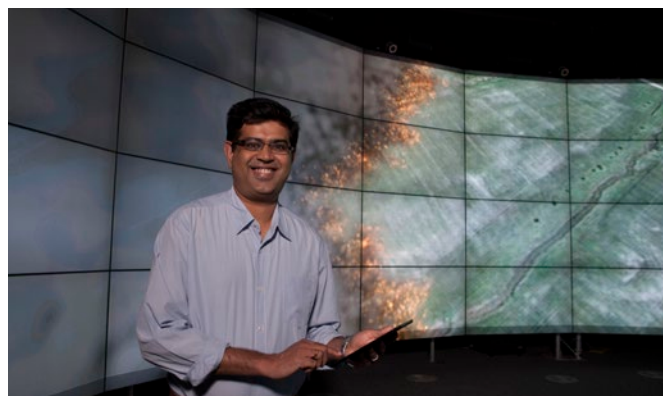


One House burnover.

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CSIRO has led bushfire research for close to 70 years, providing the best possible knowledge to firefighters on the frontline and managers planning for bushfire preparedness and resilience. Scientists have been on the ground to understand the causes and consequences of every major fire event in Australia since the Ash Wednesday fires in 1983.

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Dr Mahesh Prakash demonstrates how Spark takes current knowledge of fire behaviour and combines it with state-of-the-art simulation science to predict bushfire spread.

### Spark Operational

CSIRO is developing a cutting-edge bushfire simulation tool that will provide more accurate understanding and prediction of bushfire behaviour across borders and over different landscapes, in partnership with the National Council for Fire and Emergency Services.

Known as Spark Operational, the tool is based on our strong foundation of research, combining current fire behaviour knowledge with state-of-the-art simulation science to produce predictions, statistics and visualisations of bushfire spread within seconds.

It is being progressively developed and is expected to be used by emergency services and response teams from the 2021 fire season. With each phase of its implementation, Spark Operational will be grown and adapted into a tool that all agencies nationwide can tailor to specific landscapes and bushfire behaviour, enabling them to better predict – and thereby protect – local environments. It is on track to be fully operational by 2024.

## Enabling a business to effectively target their investment

CSIRO has been working with Optus to identify and mitigate bushfire risks to telecommunications infrastructure. This collaboration involves assessing the loss potential of all Optus sites across Australia due to bushfires and determining the best value upgrades to reduce the vulnerability of their equipment.

The research involved studying and profiling potential bushfire impacts to sites that house Optus equipment. We developed bushfire hazard maps, using information on topography, fuel load, vegetation type and local bushfire weather severity. These enabled us to identify sites most at risk, and what design changes could mitigate these risks.

The research has also supported training and site assessment tools which Optus is using to improve response preparedness and improve future design and builds.

This model is relevant and repeatable across any sector where infrastructure is at bushfire risk. Energy, emergency services and even residential housing developments stand to benefit.

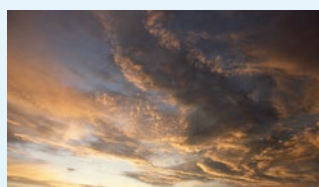


Pictured is Optus infrastructure at Dixon's Creek in Victoria. Bushfires are one of the biggest threats facing all industries that rely on critical infrastructure and telecommunications companies are seeking ways to reduce the risk of bushfire damage, improve their network resilience, and support the customers who rely on their services.

## CSIRO's facilities

CSIRO has world-class facilities to conduct its work on assessing and addressing climate change.

**CSIRO Climate Science Centre** undertakes world-leading observations and modelling of the global climate system, including Australian input to the Intergovernmental Panel on Climate Change (IPCC) assessments to understand and simulate past and future climate scenarios and the impacts of emissions.



**Cape Grim Baseline Air Pollution Station** is a globally critical research station, operated by the Bureau of Meteorology, sampling air from the Southern Hemisphere which has been unaffected by regional pollution sources. These samples are analysed at CSIRO's GASLab and enable us to track changing levels of gases that affect the global climate.



**Australia's Marine National Facility RV Investigator** conducts blue-water research into oceanographic, atmospheric, biological and geoscience research. CSIRO undertakes a wide range of observational programs from vessels, moorings and autonomous vehicles to improve our understanding of the climate system and support climate-exposed industries.







## Climate and Disaster Resilience Report

Following the 2019-20 bushfires, the Commonwealth Government tasked CSIRO to undertake a body of research on climate and disaster resilience. We drew together a multidisciplinary team of experts, including social scientists, economists, fire behaviourists, mathematicians and ecologists, who worked closely with the Australian research community, Australian Chief Scientist, national disaster recovery agencies and other local, state and federal authorities. The resulting Climate and Disaster Resilience Report provided the latest technical and scientific information and practical guidance to underpin Australia’s response to future natural disaster scenarios and how most effectively to prepare.

## CSIRO missions

In 2020, CSIRO announced a \$100 million ‘Challenges and Missions’ initiative encompassing large-scale, complex research programs directed at solving our greatest challenges. It aims to drive significant breakthroughs and outcomes for positive impacts, new jobs and economic growth.

Importantly, while missions are far-reaching and ambitious, they have time-bound goals to focus partners and inspire the nation. Missions will help:

- Mitigate the impact of disasters: drought, bushfires and floods
- Create a hydrogen industry to generate a new clean energy export industry
- Accelerate the transition to agile manufacturing for higher revenue and sovereign supply
- Farmers overcome drought, mitigate climate impacts, increase yield and profitability
- Use technology to navigate Australia’s transition to net zero emissions, without derailing our economy
- Prepare and assist Australian industry to manage impacts, risks and opportunities from a changing climate.

**Centre for Hybrid Energy Systems** has expertise and capability in integrating energy storage, renewable energy, hydrogen and fuel cell technologies, fuel processing, systems design and construction. Integration of these systems is essential to the shift to a lower emissions energy system.



**Renewable and Stored Energy Integration Facilities** can showcase and evaluate how renewable and stored energy solutions behave in a simulated grid environment, helping to ensure reliability and lower energy emissions and costs for electricity users across the country.



**Urban Living Labs** offer a new way for our researchers, industry, community and government to co-innovate, moving our cities towards a more liveable, sustainable and resilient future.



At **CSIRO’s National Bushfire Behaviour Research Laboratory** in Canberra, our 29m-long Pyrotron investigates flame propagation in bushfire fuels like grass forest litter and shrubs, while our unique 12m-tall Vertical Wind Tunnel studies the combustion and aerodynamic characteristics of burning bark and other firebrands.



As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

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