The Climate Change Crisis

Edited by Justin Healey

ISSUES IN SOCIETY
The Climate Change Crisis

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The Climate Change Crisis is Volume 375 in the ‘Issues in Society’ series of educational resource books. The aim of this series is to offer current, diverse information about important issues in our world, from an Australian perspective.

KEY ISSUES IN THIS TOPIC
Climate change is perhaps the defining issue of our time, yet its extent and impacts are called into doubt as we struggle to understand and accept climate science and agree on how to reduce emissions in order to deal with this looming global environmental crisis.

The causes, consequences and costs of responding to climate change are subject to heated political debate in Australia and worldwide, in spite of a growing number of expert reports warning against the irreversible and catastrophic effects of dangerous climate change.

This book presents the latest findings and projections, and examines what Australia and the rest of the world is doing to mitigate and adapt to the climate crisis. How much of global warming and extreme weather is human-induced? As we continue to weigh up the costs of action in relation to the risks, is it time to ask: are we leaving it too late to effectively tackle climate change?

SOURCES OF INFORMATION
Titles in the ‘Issues in Society’ series are individual resource books which provide an overview on a specific subject comprised of facts and opinions.

The information in this resource book is not from any single author, publication or organisation. The unique value of the ‘Issues in Society’ series lies in its diversity of content and perspectives.

The content comes from a wide variety of sources and includes:

- Newspaper reports and opinion pieces
- Website fact sheets
- Magazine and journal articles
- Statistics and surveys
- Government reports
- Literature from special interest groups

CRITICAL EVALUATION
As the information reproduced in this book is from a number of different sources, readers should always be aware of the origin of the text and whether or not the source is likely to be expressing a particular bias or agenda.

It is hoped that, as you read about the many aspects of the issues explored in this book, you will critically evaluate the information presented. In some cases, it is important that you decide whether you are being presented with facts or opinions. Does the writer give a biased or an unbiased report? If an opinion is being expressed, do you agree with the writer?

EXPLORING ISSUES
The ‘Exploring issues’ section at the back of this book features a range of ready-to-use worksheets relating to the articles and issues raised in this book. The activities and exercises in these worksheets are suitable for use by students at middle secondary school level and beyond.

FURTHER RESEARCH
This title offers a useful starting point for those who need convenient access to information about the issues involved. However, it is only a starting point. The ‘Web links’ section at the back of this book contains a list of useful websites which you can access for more reading on the topic.
Questions and answers: climate change

CSIRO addresses some of the common questions raised about the changing climate and the science involved in studying it

WHAT IS CLIMATE CHANGE? (NATURAL AND HUMAN-INDUCED)

Weather, climate and climate change

Weather and climate refer to different aspects of meteorology. Weather is the brief, rapidly changing condition of the atmosphere at a particular place and time, usually changing from hour-to-hour and town-to-town, influenced by the movement of air masses.

Climate, on the other hand, is more stable, describing the average weather over at least 30 years.

For example, winter is colder than summer, and Melbourne is colder than Darwin. Just as a cricketer’s batting average is rarely hit during a particular match, the (average) climate conditions do not always exist in a particular year.

Climate variability and climate change are different facets of climate.

Climate variability refers to the year-to-year variations around the average conditions, meaning that consecutive summers will not all be the same, with some cooler and some warmer than the long-term average.

Climate change refers to any long-term trends or shifts in climate over many decades, around which climate variability is evident year to year.

Hence, a single warmer or cooler decade on its own is not sufficient evidence to assert climate change is or isn’t occurring, but statistically significant changes in average conditions over many decades do provide evidence of a changing climate.

Australians have learned to live with climate variability such as droughts and flooding rains, or hot and cold years, but our coping capacity is limited.

We are vulnerable to extreme events, as shown by the economic, social and environmental costs of recent fires, floods, heatwaves, droughts and cyclones.

Human-induced climate change, represents a raft of new challenges for this generation and those to come, through increases in extreme weather events and other changes, such as sea-level rise and ocean acidification.

Climate change will be superimposed on natural climate variability, leading to a change in the frequency, intensity and duration of extreme events.

Climate risk profiles will be altered and adaptation will be necessary to manage these new risks. Adaptation includes new management practices, engineering solutions, improved technologies and behavioural change.

HOW HAS CLIMATE CHANGED IN THE PAST?

There is a great deal of evidence that the Earth’s climate has warmed over the past century. Both natural and human influences have affected climate over this time, but it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

The evidence that climate has changed over the past century includes temperature observations over land and sea, as well as measurements of rainfall, sea levels, and ocean acidity and salinity. Over time, these measurements give us a picture of how climate has changed, both in Australia and globally.

The heat content of the world’s oceans has increased during recent decades and accounts for more than 90 per cent of the total heat accumulated by the land, air and ocean since the 1970s.

On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by between 0.09°C and 0.13°C per decade over the period 1971-2010.

In Australia, surface temperatures on the land have been recorded at many sites since the mid to late 19th century.

By 1910, Australia had a reliable network of thermometers and the data they produced have been extensively analysed by the Bureau of Meteorology and scientists at CSIRO, Australian universities and international research institutions.

This reveals that since 1910, Australia’s annual-average daily maximum temperatures have increased by 0.75°C and the overnight minima by more than 1.1°C.

Since the 1950s, each decade has been warmer than the one before. We’ve also experienced an increase in record hot days and a decrease in record cold days across the country.

Some years have been relatively cool due to effects such as La Niña, but overall the trend is clear and distinct: Australia has become warmer.
There has been a general trend towards increased spring and summer monsoonal rainfall across Australia’s north during recent decades, and decreased late autumn and winter rainfall across southern Australia. Sea-surface temperatures around Australia have increased faster than the global average.

**WHY DO SEA LEVELS CHANGE?**

Sea levels can change for a variety of reasons over a range of different time scales. At the daily timescale, sea levels might change as a result of tides, wave activity or storm surges, as well as events such as earthquakes and tsunamis.

There are some changes that occur as a result of seasonal changes, such as warming in summer and cooling in winter in both hemispheres, and some are annual changes associated with natural climate variability, such as El Niño and La Niña events.

Of greatest interest to researchers studying climate change are the sea-level changes occurring over multiple decades.

Average global sea levels have been rising consistently since 1880 (the earliest available robust estimates) largely in response to increasing concentrations of greenhouse gases in the atmosphere and the consequent changes in the global climate.

There are two main processes behind long-term sea-level rises, which are a direct result of a warming climate.

Firstly, as the ocean has warmed the total volume of the ocean has increased through thermal expansion of water.

Secondly, water has been added to the oceans as a result of melting glaciers and ice sheets.

Sea levels began to rise in the 19th century and the rate of sea-level rise since the mid-19th century has been larger than the average rate during the previous two millennia.

Global-average sea levels are currently (between 1993 and 2010) rising at around 3.2 mm per year, faster than during the 20th century as a whole.

Rates of sea-level rise are not uniform around the globe and vary from year to year.

Since 1993, the rates of sea-level rise to the north and northwest of Australia have been 7 to 11 mm per year, two to three times the global average, and rates of sea-level rise on the central east and southern coasts of the continent are mostly similar to the global average.

These variations are at least in part a result of natural variability of the climate system.

**HOW ELSE ARE THE OCEANS CHANGING?**

**Ocean heat**

One of the best indicators of changes in the climate system is the amount of heat stored in the oceans.

The heat content of the world’s oceans has increased during recent decades and accounts for more than 90 per cent of the total heat accumulated by the land, air and ocean since the 1970s.

This warming increases the volume of ocean waters and is a major contribution to sea-level rise. Ocean warming is continuing, especially in the top several hundred metres of the ocean.

Sea surface temperatures in the Australian region were very warm during 2010 and 2011, with temperatures in 2010 being the warmest on record. Sea surface temperatures averaged over the decades since 1900 have increased for every decade.

Sea surface temperature datasets are separate to land temperature datasets, but both land and ocean surface temperatures have shown very similar warming trends over the last century, confirming that temperatures are rising.

**Ocean acidification**

As well as storing heat, the world’s oceans absorb a vast amount of carbon dioxide (CO₂). The ocean currently absorbs about a quarter of the CO₂ emitted into the atmosphere each year.

As atmospheric CO₂ concentration increases, the amount of CO₂ absorbed and stored in the ocean also increases.

Ocean acidification is a direct result of CO₂ absorption. The CO₂ taken up by the ocean reacts in the seawater to increase the oceans acidity levels, measured in terms of pH.

Since the beginning of the industrial era, the absorption of the increasing amounts of atmospheric CO₂ has decreased ocean surface water pH by 0.1, or a 26 per cent increase in the hydrogen ion concentration, and changes are expected to decrease pH by a further 0.06-0.32 by 2100, depending on the level of CO₂ emissions in future.

Ocean acidification has been shown in laboratory and field studies to reduce the growth of carbonate shells and skeletal material of many key organisms, including reef-building corals.

Other effects include causing a change in the development of early life stages of some species, although the response to ocean acidification varies considerably between species.

As these organisms span the entire marine food chain, ocean acidification could have far reaching implications for the health and productivity of the world’s oceans.

**HOW IS THE COMPOSITION OF THE ATMOSPHERE CHANGING?**

Greenhouse gases in the atmosphere insulate our planet’s surface against the chill of space, something known as the greenhouse effect.

The main greenhouse gases influenced directly and emitted by human activities are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and synthetic gases such as chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs).

Water vapour and ozone are also significant greenhouse gases, whose concentrations in the atmosphere are controlled mainly by the Earth’s temperature and the emission of ozone producing chemicals, such as reactive...
hydrocarbons, and ozone destroying chemicals like CFCs.

Global CO₂, CH₄, and N₂O concentrations have risen rapidly during the past two centuries, which has enhanced the greenhouse effect and contributed to global warming. The amount of these long-lived greenhouse gases in the atmosphere reached a new high in 2013.

The concentration of CO₂ in the atmosphere in 2011 was 391 parts per million (ppm) – much higher than the natural range of 170 to 300 ppm during the past 800,000 years.

The relative contributions to the enhanced greenhouse effect from pre-industrial times to 2013, due to the long-lived greenhouse gases, are: CO₂ (64 per cent), CH₄ (18 per cent), synthetics (12 per cent) and N₂O (6 per cent).

Global CO₂ emissions are mostly from fossil fuels (more than 85 per cent), land use change, mainly associated with tropical deforestation (less than 10 per cent), and cement production and other industrial processes (about 4 per cent).

Energy generation continues to climb and is dominated by fossil fuels – suggesting emissions will grow for some time yet.

**HOW IS CLIMATE LIKELY TO CHANGE IN THE FUTURE?**

With greenhouse gas emissions continuing to increase, we expect the warming trend of the past century to accelerate throughout this century. We also expect changes to rainfall patterns and to the frequency of extreme weather events like cyclones and droughts.

The Earth’s future climate will depend on whether the world manages to slow or even reduce greenhouse gas emissions. Since greenhouse gases have a long lifetime in the atmosphere, any change in emissions will have a delayed effect on atmospheric concentrations, so these concentrations are expected to increase, leading to further warming and climate change for many decades.

Different emissions scenarios have been developed, based on different assumptions about future demographic change, economic development and technological advances. The concentrations paths are similar up to about 2030, and then diverge markedly.

Average temperatures across Australia are projected to rise by 0.4 to 1.8°C by 2030, compared with the climate of 1990. By 2070, warming is projected to be 1.0 to 2.5°C for a low emissions scenario, and 2.2 to 5.0°C for a high emissions scenario.

Australians will experience this warming through an increase in the number of hot days and warm nights and a decrease in cool days and cold nights.

Climate models show that there may be less rainfall in southern areas of Australia during winter and in southern and eastern areas during spring. Wet years are likely to become less frequent and dry years and droughts more frequent.

Climate models suggest that rainfall near the equator will increase globally, but it’s not clear how rainfall may change in northern Australia.

Australia will also experience climate-related changes to extreme weather events. In most areas of the country, intense rainfall events will become more extreme.

Fire-weather risk is also likely to increase and fire seasons will be longer. And although it is likely that there will be fewer tropical cyclones in the Australian region, the proportion of intense cyclones may increase.

**WHAT IS EXTREME WEATHER AND HOW IS IT CHANGING?**

A changing climate leads to changes in the frequency, intensity, spatial extent, and duration of extreme weather and climate events. These include extreme temperatures, heatwaves, drought, flooding, bushfires, tropical cyclones, and storm surges.

The natural climate variability that underlies all extreme weather events is now influenced and altered by the effect of human-induced warming of the climate system.

Future climate change impacts will be experienced mostly through extreme events rather than gradual changes in mean temperature or rainfall.

Heatwaves, floods, fires and southern Australian droughts are expected to become more intense and more frequent. Frosts, snow and cyclones are expected to occur less often.

Extreme events and natural disasters place a huge burden on individuals, communities, industry and the government and have an enormous impact on Australia’s economy, social fabric and environment.

Better preparing for extreme events through planning, management, engineering and awareness has proved to be effective in reducing their cost.

Over recent decades, we have developed approaches to better prepare for and manage the impacts of extreme
events: e.g. new cyclone building codes, improved warning systems, greater coordination between emergency management responses, and improved pest and disease surveillance.

However, in the last four years more than 550 people lost their lives in natural disasters and the costs of repairing public and private infrastructure, insurance claims and lost productivity has run to tens of billions of dollars.

Sudden and unexpected disease or pest outbreaks can also heavily impact human health, the economy and the environment: agriculture, tourism and water supplies all depend on the integrity of our biosecurity systems.

**HOW DOES CSIRO STUDY AND PREDICT THESE FUTURE CHANGES?**

CSIRO climate researchers use climate simulations to project future climate decades in advance. These models are based on the laws of physics and are run on supercomputers.

They use mathematical representations to simulate the complex interactions of the Earth’s climate system, including atmospheric, oceanic, hydrological and terrestrial processes and atmospheric chemistry.

The models are validated by simulating climate in previous decades and then comparing the results of the model with recorded measurements of temperature, rainfall and other climatic variables.

There are over 40 climate models around the world. Some simulate the past climate better than others, especially at the sub-continental scale, so it is important to derive regional projections from models that perform well.

One such model is ACCESS, the Australian Community Climate and Earth System Simulator. ACCESS produces the Bureau of Meteorology’s Australian weather forecasts, which you see on the evening news.

This is one of the models that CSIRO researchers are using to project climate in the coming century, building on more than 20 years of research into developing climate projections for Australia.

**WHAT ARE THE IMPACTS OF CLIMATE CHANGE**

Australia is expected to experience an increase in extremely high temperatures, extreme fire weather, extreme rainfall events, tropical cyclone intensity, extreme sea levels, and droughts in southern areas.

A decrease in the frequency of extremely cold temperatures is expected, along with fewer tropical cyclones.

These changes will pose significant challenges for disaster risk management, water and food security, ecosystems, forestry, buildings, transport, energy, health and tourism.

For example, many animal and plant species may decline or become extinct, water resources are expected to decline in southern Australia, agricultural zones are likely to shift, coastal erosion and inundation is expected to occur more often, energy demand is likely to increase, snow cover will decline and heat-related deaths may rise.

**HOW IS SCIENTIFIC RESEARCH INFORMING OUR RESPONSES TO CLIMATE CHANGE?**

Climate mitigation refers to the reduction of greenhouse gases to limit the amount of climate change that may occur. Climate adaptation equips society to cope with the changes that are already happening or that are unavoidable in the future.

Adaptation and mitigation are closely linked: the less we mitigate, the more we will be forced to adapt to inevitable changes in the climate, and the bigger the adaptations will have to be.

Conversely, success in mitigation through early and deep cuts to greenhouse gas emissions will necessitate fewer, less extreme adaptations in the long term.

**Climate mitigation**

Research and development is vital for the continuous creation, improvement and adoption of new technologies to help mitigate climate change.

For example, research into renewable energy is an essential part of Australia’s energy mix and will play an increasingly important role as we move to reduce greenhouse gas emissions and secure future energy supply.

Wind, solar and geothermal energy provide sustainable options to deliver our energy and transport needs.

Scientific research can also:

- Improve the reliability, efficiency and affordability of renewable energy technologies enabling them to become a major energy source in Australia
- Improve building design and energy efficiency to reduce our energy consumption and carbon dioxide emissions from commercial buildings and homes
- Develop alternative routes to fuel production and transportation power that could lead the way to a sustainable future for road, rail, air and water transport
- Develop new technologies to improve efficiency in the resources sector and maximise the benefits of Australia’s abundant coal, uranium, gas and oil resources.

**Climate adaptation**

Some climate change and consequent impacts are unavoidable due to the greenhouse gases that are already in the atmosphere and as future emissions increase. To limit the social, economic, and environmental impacts of these changes, we need to adapt.

Scientific research can lead to the development of solutions to help us adapt to climate challenges.

Three areas are critical to successful adaptation to climate change – decision making and how to go about it, the development of specific solutions (technical and other) to climate challenges, and the analysis of barriers to the adoption of systems and technologies that will help us adapt.

Australia is leading the way in the coordinated approach to these areas of adaptation research.
**IS THE SCIENCE SETTLED?**

A distinction needs to be made between science that is robust and science that is relatively uncertain. All conclusions should be based on peer-reviewed literature, and, where possible, levels of confidence should be provided.

In climate change science, the robust findings include:

- Clear evidence for global warming and sea level rise over the past century
- Changes observed in many physical and biological systems are consistent with warming
- Due to the uptake of anthropogenic CO2 since 1750, ocean acidity has increased
- Most of the global average warming over the past 50 years is very likely due to anthropogenic greenhouse gas increases
- Global greenhouse gas emissions will continue to grow over the next few decades, leading to further climate change
- Due to the time scales associated with climate processes and feedbacks, anthropogenic warming and sea level rise would continue for centuries even if greenhouse gas emissions were to be reduced sufficiently for atmospheric concentrations to stabilise
- Increased frequencies and intensities of some extreme weather events are very likely
- Systems and sectors at greatest risk are ecosystems, low-lying coasts, water resources in some regions, tropical agriculture, and health in areas with low adaptive capacity
- The regions at greatest risk are the Arctic, Africa, small islands and Asian and African mega-deltas. Within other regions (even regions with high incomes) some people, areas and activities can be particularly at risk
- Some adaptation is underway, but more extensive adaptation is required to reduce vulnerability to climate change
- Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed

**GREENHOUSE EFFECT**

**GREENHOUSE EFFECT**

The greenhouse effect is a natural process that warms the Earth’s surface. When the Sun’s energy reaches the Earth’s atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth’s temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist.

**ENHANCED GREENHOUSE EFFECT**

The problem we now face is that human activities – particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing – are increasing the concentrations of greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.
and human systems to adapt
• Many impacts can be reduced, delayed or avoided by mitigation (net emission reductions). Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower greenhouse gas stabilisation levels.

Some of the key uncertainties include:
• Observed climate data coverage remains limited in some regions
• Analysing and monitoring changes in extreme events is more difficult than for climatic averages because longer data sets with finer spatial and temporal resolutions are required
• Effects of climate changes on human and some natural systems are difficult to detect due to adaptation and non-climatic influences
• Difficulties remain in reliably attributing observed temperature changes to natural or human causes at smaller than continental scales
• Models differ in their estimates of the strength of different feedbacks in the climate system, particularly cloud feedbacks, oceanic heat uptake and carbon cycle feedbacks
• Confidence in projections is higher for some variables (e.g. temperature) than for others (e.g. precipitation), and it is higher for larger spatial scales and longer averaging periods
• Direct and indirect aerosol impacts on the magnitude of the temperature response, on clouds and on precipitation remain uncertain
• Future changes in the Greenland and Antarctic ice sheet mass are a major source of uncertainty that could increase sea level rise projections
• Impact assessment is hampered by uncertainties surrounding regional projections of climate change, particularly precipitation
• Understanding of low-probability/high-impact events and the cumulative impacts of sequences of smaller events is generally limited
• Barriers, limits and costs of adaptation are not fully understood
• Estimates of mitigation costs and potentials depend on uncertain assumptions about future socio-economic growth, technological change and consumption patterns.

Hence, the science isn’t settled but there are enough robust findings to provide a basis for action through mitigation of greenhouse gases as well as adaptation to reduce our vulnerability to climate change impacts.

WHERE CAN I FIND OUT MORE INFORMATION ABOUT CLIMATE CHANGE?

There is a lot of information on climate change science available in the media and on the web, but how can you ensure what you are reading is independent and not influenced by personal, social or political agendas?

The peer-review process provides a mechanism to quality control scientific discourse and therefore peer-reviewed papers provide a reliable and quality-assured source of information on climate change science.

Science relies on the continued questioning and challenging of ideas. When a new hypothesis or finding is published in a scientific journal, other scientists will take it seriously because it has been through the peer-review process.

Once an article is published in a peer-reviewed journal, its ideas can be challenged or supported by other scientists with peer-reviewed articles of their own.

For scientific journals, the process starts with the submission of a manuscript. The editorial staff refer the manuscript to at least two impartial reviewers who are qualified to judge the competence, significance and originality of the research.

The reviewers’ comments are passed to the authors of the manuscript with a covering note from the editor, indicating whether changes need to be made before the manuscript is acceptable for publication.

The final decision about whether the manuscript should be published lies with the editor.

Major reports are normally peer-reviewed. For example, the Intergovernmental Panel on Climate Change (IPCC) assesses the peer-reviewed literature on climate change every five to six years.

The reports are subject to an intense peer-review process involving hundreds of scientific experts and government reviewers. This unprecedented level of peer and government review makes this compendium of climate change science one of the most scrutinised documents in the history of science.

Drawing from peer-reviewed information, CSIRO and the Bureau of Meteorology release a regular a snapshot of the state of the climate; a summary of the latest climate science, adaptation and mitigation peer-reviewed research is available in CSIRO’s free climate book; and CSIRO’s website has a large amount of general information about climate change.

You may also like to look at a number of other non-CSIRO sites, including:
• Australian Bureau of Meteorology, www.bom.gov.au
• Skeptical Science, www.skepticalscience.com
• Real Climate, www.realclimate.org
• UK Met office, www.metoffice.gov.uk


INDICATORS OF CLIMATE CHANGE

There are multiple lines of evidence that show the climate system is changing, reveals the Department of the Environment in this fact sheet.

**AIR TEMPERATURES**

Air temperatures have increased globally, by around 0.85 degrees Celsius since 1880, with most of the warming occurring since the 1970s. All three major global surface temperature records show that the Earth's atmosphere has warmed since 1880:

- Hadley Centre of the UK Met Office, www.cru.uea.ac.uk/cru/data/temperature/

In Australia, annual average daily mean temperatures have increased by 0.9 degrees Celsius since 1910, and each decade has been warmer than the previous decade since the 1950s. Australia has observed a decrease in cold days, and an increase in warm days with more than double the number of record hot days observed since 1960. I

**OCEANS AND SEA LEVELS**

One of the best indicators of climate change is the amount of heat stored in the world's oceans. The heat content has increased during recent decades and accounts for more than 90 per cent of the total heat accumulated by the land, air and ocean since the 1970s.

Australia has observed a decrease in cold days, and an increase in warm days with more than double the number of record hot days observed since 1960.

Ocean warming is continuing, especially in the top several hundred metres of the ocean. Sea surface temperatures in the Australian region have increased every decade since 1900. I

Global sea levels have risen at an average rate of 1.8 millimetres per year over 1961 to 2003. This rate has risen to around 3.2 millimetres per year from 1993 to 2012. Rates of sea level rise are not uniform around the globe and vary from year to year. Since 1993, the rates of sea level rise to Australia's north and northwest have been 7 to 11 millimetres per year, with rates of sea level rise on the central east and southern coasts between 2 to 5 millimetres per year. III

Current scientific understanding indicates that natural climate variability (on decadal timescales) is the driver of this temporary higher rate of regional rate.

Ocean currents are also changing, particularly in the Southern Ocean. Scientists have found a large reduction in the coldest deep ocean water, called Antarctic Bottom Water, over the past few decades. IV In addition, studies have shown that Antarctic Bottom Water has been warming and freshening over recent decades. V The world's deep ocean currents play a critical role in transporting heat and carbon around the planet, thus regulating the climate.

**MULTIPLE LINES OF EVIDENCE THAT SHOW THE CLIMATE SYSTEM IS CHANGING**

- Glaciers and ice sheets
- Arctic sea ice
- Ocean heat content
- Sea surface temperatures
- Sea levels
- Ocean acidification
- Intensity and frequency of extreme weather events (e.g. fires, floods)
- Air temperatures
- Changing rainfall pattern
- Number of hot days per year
- Number of cold days per year

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EXTREME WEATHER EVENTS

Extreme weather events include heatwaves, bushfires, tropical cyclones, cold snaps, extreme rainfall and droughts.

There is increasing evidence that the frequency and intensity of many extreme weather events are changing. Extreme hot days in Australia are getting hotter, with the rate of very hot (greater than 40°C) daytime temperatures increasing since the 1990s. In addition weather associated with high fire danger has shown a rapid increase in the late 1990s to early 2000s at many locations in southeastern Australia.

Individual extreme events occur as a result of a number of contributing climatic factors. While it is difficult to isolate the role of climate change in any given event, there are some studies that provide evidence for a link between climate change and specific extreme events.

Research through the South Eastern Australian Climate Initiative (SEACI) provides evidence that the Millennium Drought (1997-2009) was the worst drought of the instrumental record (since 1865). SEACI research established that the observed increase in the intensity of the sub-tropical ridge was associated with global warming, and therefore the decline in rainfall across southeastern Australia during the Millennium Drought was at least partly attributable to climate change.

Early January 2013 saw unprecedented temperatures across Australia with a record breaking seven days where the national average maximum daily temperature exceeded 39 degrees Celsius. On 7 January 2013 a record daily maximum temperature across Australia was reached. The heatwave contributed to extreme bushfire conditions with extensive bushfires across New South Wales, Victoria and Tasmania. Research shows that human influences likely played a role in the extreme heat experienced during the 2012/13 Australian summer.

RAINFALL PATTERNS

Rainfall patterns are changing around the world. Research shows the global water cycle is intensifying with a warming climate, which means wet areas are likely to get wetter and dry regions are likely to be drier in response to climate change.

Footnotes:

i. CSIRO and BoM, State of the Climate 2012.
ii. CSIRO and BoM, State of the Climate 2012.
iii. CMAR sea level rise website, www.cmar.csiro.au/sealevel
vi. CSIRO and BoM, State of the Climate 2012.
viii. BoM, Special Statement 43.
ix. CSIRO and BoM, State of the Climate 2012.

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The Climate Change Crisis

STATE OF THE CLIMATE 2014: a clear picture of Australia’s climate

A definitive report on observed changes in long term trends in Australia’s climate has been released by the CSIRO and Bureau of Meteorology

Bureau Chief Executive Dr Rob Vertessy said temperatures across Australia were, on average, almost 1°C warmer than they were a century ago, with most of the warming having occurred since 1950.

“Temperatures across Australia were, on average, almost 1°C warmer than they were a century ago, with most of the warming having occurred since 1950.”

Dr Rob Vertessy, Bureau of Meteorology Chief Executive

“Australia’s mean temperature has warmed by 0.9°C since 1910,” Dr Vertessy said.

“Seven of the ten warmest years on record in Australia have occurred since 1998. When we compare the past 15 years to the period 1951 to 1980, we find that the frequency of very warm months has increased five-fold and the frequency of very cool months has decreased by around a third.

“The duration, frequency and intensity of heatwaves have increased across large parts of Australia since 1950.

“Extreme fire weather risk has increased, and the fire season has lengthened across large parts of Australia since the 1970s.

“We have also seen a general trend of declining autumn and winter rainfall, particularly in southwestern and southeastern Australia, while heavy rainfall events are projected to increase. Australian average annual rainfall has increased slightly, largely due to increases in spring and summer rainfall, most markedly in southwestern Australia.”

CSIRO Chief Executive Dr Megan Clark said Australia has warmed in every state and territory and in every season.

“Australia has one of the most variable climates in the world. Against this backdrop, across the decades, we’re continuing to see increasing temperatures, warmer oceans, changes to when and where rain falls and higher sea levels,” Dr Clark said.

“The sea-surface temperatures have warmed by 0.9°C since 1900 and greenhouse gas concentrations continue to rise.”

CSIRO and the Bureau of Meteorology play a key role in monitoring, measuring and reporting on weather and climate, contributing to improved understanding of our changing global climate system. State of the Climate 2014 is the third report in a series and follows earlier reports in 2010 and 2012.

For further information and to download the full report:

- CSIRO, State of the Climate – 2014

STATE OF THE CLIMATE: FAST FACTS

Temperature
- Australia’s mean surface air temperature has warmed by 0.9°C since 1910.
- Seven of the ten warmest years on record have occurred since 1998.
- Over the past 15 years, the frequency of very warm months has increased five-fold and the frequency of very cool months has declined by around a third, compared to 1951-1980.
- Sea-surface temperatures in the Australian region have warmed by 0.9°C since 1900.

Rainfall
- Rainfall averaged across Australia has slightly increased since 1900, with a large increase in northwest Australia since 1970.
- A declining trend in winter rainfall persists in southwest Australia.
- Autumn and early winter rainfall has mostly been below average in the southeast since 1990.
Heatwaves and fire weather
- The duration, frequency and intensity of heatwaves have increased across large parts of Australia since 1950.
- There has been an increase in extreme fire weather, and a longer fire season, across large parts of Australia since the 1970s.

Global atmosphere and cryosphere
- A wide range of observations show that the global climate system continues to warm.
- It is extremely likely that the dominant cause of recent warming is human-induced greenhouse gas emissions and not natural climate variability.
- Ice-mass loss from the Antarctic and Greenland ice sheets has accelerated over the past two decades.
- Arctic summer minimum sea-ice extent has declined by between 9.4 and 13.6 per cent per decade since 1979, a rate that is likely unprecedented in at least the past 1,450 years.
- Antarctic sea-ice extent has slightly increased by between 1.2 per cent and 1.8 per cent per decade since 1979.

Oceans
- The Earth is gaining heat, most of which is going into the oceans.
- Global mean sea level increased throughout the 20th century and in 2012 was 225 mm higher than in 1880.
- Rates of sea-level rise vary around the Australian region, with higher sea-level rise observed in the north and rates similar to the global average observed in the south and east.
- Ocean acidity levels have increased since the 1800s due to increased CO2 absorption from the atmosphere.

Greenhouse gases
- Atmospheric greenhouse gas concentrations continue to increase due to emissions from human activities, with global mean CO2 levels reaching 395 ppm in 2013.
- Global CO2 emissions from the use of fossil fuel increased in 2013 by 2.1 per cent compared to 3.1 per cent per year since 2000.
- The increase in atmospheric CO2 concentrations from 2011 to 2013 is the largest two-year increase ever observed.

Future climate scenarios for Australia
- Australian temperatures are projected to continue to increase, with more hot days and fewer cool days.
- A further increase in the number of extreme fire-weather days is expected in southern and eastern Australia, with a longer fire season in these regions.
- Average rainfall in southern Australia is projected to decrease, with a likely increase in drought frequency and severity.
- The frequency and intensity of extreme daily rainfall is projected to increase.
- Tropical cyclones are projected to decrease in number but increase in intensity.
- Projected sea-level rise will increase the frequency of extreme sea-level events.

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AUSTRALIA HAS WARMED BY 0.9C SINCE 1910, WITH MORE IN STORE

Australia is almost a degree warmer, on average, than it was a century ago, according to the State of the Climate 2014 report compiled by the CSIRO and Bureau of Meteorology. Michael Hopkin reports

Australia has warmed by 0.9C since 1910 – roughly in line with global rates of atmospheric warming – and is set to continue warming at a rate that depends on how fast greenhouse emissions can be reduced. The finding reiterates the previous State of the Climate report, released in 2012.

According to the 2014 report:

- Seven of Australia’s 10 warmest years have happened since 1998
- Over the past 15 years, very warm months have occurred at five times the long-term average, while very cool months have declined by a third
- By 2070, temperatures will be anywhere between 1C and 5C warmer than the 1980-1999 average, depending on future emissions cuts
- Winter rainfall has declined by 17% since 1970 in Australia’s southwest, and by 15% since the mid-1990s in the southeast;
- Tropical cyclones are forecast to decrease in frequency but increase in severity
- Sea-level rises will increase the frequency of extreme sea-level events.

More heatwaves

Bureau of Meteorology assistant director Peter May said the report shows that Australia is “loading the dice” for more future heatwaves.

“The warming both in Australia and globally is certain, and is human-induced. The impacts of that are making themselves felt through an increased frequency of heatwaves, and fewer periods of extreme cold temperatures,” he said.

“We are locked into a certain degree of future changes even if we stopped carbon emissions tomorrow.”

He said it was beyond the report’s scope to advocate for political action, or to advise on whether the government’s commitment to cut emissions by 5% by 2020 goes far enough.

“(The report is) really about providing information for policymakers – it’s neither the Bureau nor CSIRO’s role to dictate what those responses should be. We’re providing the scientific advice on the way things are,” May said.

Sarah Perkins, a climate research fellow at the University of New South Wales, said: “No matter how you slice and dice it, the evidence is clear that human-induced climate change is continuing to increase the risk of extreme weather and temperatures.”

“This is coming from Australia’s national research institutions. We’re all saying it, because the science is clear and the evidence is there for us all to see,” she said.

Heatwaves are a pressing issue for Australia, both because of their direct link to warming temperatures, and because of their rapid impacts on health, Perkins said.

“When you have a heatwave it kills people and damages infrastructure within a matter of days – when you have a drought the crops die slowly, the economic impacts are much slower. Impacts via short, intense extreme temperatures are generally more measurable.”

“Even if we did completely switch to green technology tomorrow, the next 50 years we would see this projected change. However in the next 100 years we could start to see a reduction in extreme events and changes to rainfall because we’ve started to make those changes.”

“More and more reports are coming out globally. Despite the polar vortex bringing some very cold conditions to parts of America, they were not on the same scale as the record-breaking hot temperatures that are consistently occurring across the globe. No state in America had its coldest winter on record, and many other parts of the Northern Hemisphere had very mild winters, including Alaska.”

Consistent findings

Roger Jones, a professorial research fellow at Victoria University, said the findings were consistent with a recent report from the Climate Council that dangerous fire weather is already on the rise.

“Fire weather is currently around the worst case predicted for 2030-2050,” he said.

The picture in terms of rainfall is less clear-cut. Australia had very wet years in 2010 and 2011, and overall rainfall has increased. But many heavily populated areas are enduring declining rainfall, Jones said.

“If you do a spatial average over Australia you find, as the report says, that rainfall has increased slightly. But if you do a population-weighted average it has decreased. The increase in rainfall in northern Australia coincides with warming in the region,” he said.

Sophie Lewis, a postdoctoral research fellow at the University of Melbourne, said the report reflects an increase in scientific knowledge since the 2012 report.

“We now have studies for extreme events in Australia that provide scientifically robust attribution that can be used to understand observed events. We knew that by increasing average temperatures we would see an increase in the frequency and severity of extremes, but we hadn’t analysed specific events. That’s why we’re seeing these official reports issue quite definitive statements about the causes of extremes,” she said.

Michael Hopkin is Section Editor, Energy and Environment at The Conversation.

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Issues in Society | Volume 375

The Climate Change Crisis
Heatwaves are one of the most important climate-related risks for Australians. Sometimes called the 'silent killers', they cause the greatest number of deaths of any natural disaster type in Australia, and have significant impacts on infrastructure, agriculture and biodiversity. As the climate continues to warm, heatwaves are becoming hotter, longer and more frequent.

The extreme heat in Melbourne that frazzled the Australian Open tennis tournament and the record-breaking heat in large areas of Queensland this summer remind us of the risks that heatwaves pose. Hot on the heels of the 'angry summer' of 2012/2013, this summer's heat is part of a longer-term trend towards hotter weather.

HEATWAVES ON THE RISE

The Climate Council’s latest report – Heatwaves: Hotter, Longer, More Often, which we co-authored – delivers four key findings.

First, climate change is already increasing the likelihood and severity of heatwaves across Australia. Second, heatwaves have widespread impacts including increased deaths, reduced workplace productivity, damage to infrastructure such as transport and electricity systems, mortality of heat-sensitive plants and animals, and stress on agricultural systems. Third, record hot days and heatwaves are expected to increase further in the future. And finally, limiting future increase in heatwave activity requires urgent and deep cuts to greenhouse-gas emissions.

Since 1950, the annual number of record hot days across Australia has more than doubled, and both maximum and minimum temperatures have increased by around 0.9°C. Over the past decade, the frequency of record hot days has been more than three times the frequency of record cold days. The hottest area-averaged national maximum temperature ever recorded was 40.3°C on 7 January 2013, and extreme temperature records were broken in every state and territory throughout the course of the 2012/2013 summer.

Almost all of Australia has experienced a lengthening of the heatwave season, with the first heatwave event occurring much earlier than it did 60 years ago. The intensity of heatwaves, as measured by the temperature of the hottest day (the peak of the heatwave), is also increasing.

This summer, Australians again endured record-breaking, extreme heatwaves and hot weather. On 3 January, Queensland experienced its hottest area-averaged day on record and for the week ending 4 January, average maximum temperatures were a staggering 8°C or more above normal in the southern inland part of the state.

Record high maximum temperatures occurred over 8.8% of Australia during the first four days of January, including 17% of New...
South Wales, 17% of the Northern Territory, 16% of Queensland and 8% of South Australia. On 2 February, Adelaide reached a new February record of 44.7°C, some 15°C above average.

THE GLOBAL PICTURE
Heatwaves are also on the increase worldwide, with severe heatwaves affecting many countries and regions in the last 10-15 years. One of the most severe was the European heatwave of July and August 2003, with France and Switzerland particularly affected. This heatwave was followed in 2010 by an even more intense and widespread heatwave, which scorched large swathes of Eastern Europe, including western Russia, Belarus, Estonia, Latvia, and Lithuania.

Long-term temperature reconstructions show that these were the hottest summers that Europe has experienced for at least 500 years. North America has also experienced several recent heatwaves, with a major heatwave affecting the state of Texas in July 2011 and a heatwave covering a greater area of the country in 2012.

DIVERSE IMPACTS
The impacts of heatwaves are surprisingly large and diverse. The Bureau of Meteorology has dubbed heatwaves “the most under-rated weather hazard in Australia”. While heatwaves do not result in obvious violent effects on the landscape, unlike many other weather-related disasters such as high-intensity storms and bushfires, their impacts on health, the workplace, infrastructure, agriculture, and the environment are serious, costly and long-lasting.

While the 2009 Black Saturday bushfires killed more than 170 people, the preceding heatwave killed double this figure. The economic burden of heatwaves is significant, through the demand placed on emergency services, infrastructure stress and breakdown, and agricultural losses. For example, as temperatures soared during the 2009 heatwave, the Basslink electricity cable between Tasmania and Victoria reached maximum operating temperature, causing the system to shut down and resulting in widespread blackouts in Melbourne.

Plants and animals are also susceptible to extreme heat events, with flying foxes, birds and rainforest marsupials being particularly vulnerable. Marine heatwaves can trigger coral bleaching events, affecting large areas of reefs. Bleaching events on the Great Barrier Reef have occurred repeatedly since the late 1970s, with none reported before then. These bleaching events have contributed to the observed 50% loss of coral cover in the Great Barrier Reef over the past 30 years.

THE CASE FOR DECARBONISATION
As greenhouse gases continue to rise in the atmosphere, heatwaves will continue to worsen.

According to the Intergovernmental Panel on Climate Change’s 2012 Special Report on Extremes and last year’s release of the first part of the IPCC Fifth Assessment Report, it is virtually certain that hot extremes will increase and cold extremes will decrease through the century compared to the current climate. It is also very likely that the length, frequency and/or intensity of heatwaves will increase over most land areas around the globe.

This is the critical decade for action. Global emissions are still rising and Australian emissions are yet to make a decisive turn downwards. Despite the promising developments in low-carbon technologies and energy-efficiency measures, there is not yet widespread acceptance in Australia of the urgent need to decarbonise our economy and implement policies to facilitate a decarbonised future. This challenge must be met if we are to minimise the risk of worsening heatwaves and other extreme events for ourselves, our children and grandchildren. It’s time to get on with the job.

Will Steffen is Adjunct Professor, Fenner School of Environment and Society at the Australian National University. Lesley Hughes is Professor, Department of Biological Sciences at Macquarie University. Sarah Perkins is Research Fellow at the University of New South Wales.

The Climate Council is a crowdfunded body that advises the Australian public on climate change.

THE CONVERSATION

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The nation’s top climate scientists and science bodies have for the first time endorsed a major report that says Australia’s climate has shifted permanently in some cases. Here are the key facts from the report by the Climate Commission:

1. **Climate change is already increasing the intensity and frequency of many extreme weather events, adversely affecting Australians.** Extreme events occur naturally and weather records are broken from time to time. However, climate change is influencing these events and record-breaking weather is becoming more common around the world.

Some Australian examples include:

- **Heat:** Extreme heat is increasing across Australia. There will still be record cold events, but hot records are now happening three times more often than cold records.

- **Bushfire weather:** Extreme fire weather has increased in many parts of Australia, including southern NSW, Victoria, Tasmania and parts of South Australia, over the last 30 years.

- **Rainfall:** Heavy rainfall has increased globally. Over the last three years Australia’s east coast has experienced several very heavy rainfall events, fuelled by record-high surface water temperatures in the adjacent seas.

- **Drought:** A long-term drying trend is affecting the southwest corner of Western Australia, which has experienced a 15% drop in rainfall since the mid-1970s.

Extreme weather has always occurred. But due to additional greenhouse gases in the atmosphere, the climate system now contains significantly more heat compared to 50 years ago.

This means that all extreme weather events are influenced by climate change.

The severity and frequency of many extreme weather events are increasing due to climate change.

How quickly and deeply we reduce greenhouse gas emissions will greatly influence the severity of extreme events our children and grandchildren experience.
1. **Sea-level rise**: Sea level has already risen 20 cm. This means that storm surges ride on sea levels that are higher than they were a century ago, increasing the risk of flooding along Australia’s socially, economically and environmentally important coastlines.

2. **Climate change is making many extreme events worse in terms of their impacts on people, property, communities and the environment. This highlights the need to take rapid, effective action on climate change.**

   - It is crucial that communities, emergency services, health and medical services and other authorities prepare for the increases that are already occurring in the severity and frequency of many types of extreme weather.
   - The southeast of Australia, including many of our largest population centres, stands out as being at increased risk from many extreme weather events – heatwaves, bushfires, heavy rainfall and sea-level rise.
   - Key food-growing regions across the southeast and the southwest are likely to experience more drought in the future.
   - Some of Australia’s iconic ecosystems are threatened by climate change. Over the past three decades the Great Barrier Reef has suffered repeated bleaching events from underwater heatwaves. The freshwater wetlands of Kakadu National Park are at risk from saltwater intrusion due to rising sea level.

3. **The climate system has shifted, and is continuing to shift, changing the conditions for all weather, including extreme weather events.**

   - Levels of greenhouse gases from the combustion of fossil fuels have increased by around 40% since the beginning of the Industrial Revolution, causing the Earth’s surface to warm significantly.
   - All weather events are now occurring in a global climate system that is warmer and moister than it was 50 years ago. This has loaded the dice towards more frequent and more severe extreme weather events.

4. **There is a high risk that extreme weather events like heatwaves, heavy rainfall, bushfires and cyclones will become even more intense in Australia over the coming decades.**

   - There is little doubt that over the next few decades changes in these extreme events will increase the risks of adverse consequences to human health, agriculture, infrastructure and the environment.
   - Stabilising the climate is like turning around a battleship – it cannot be done immediately given its momentum. When danger is ahead you must start turning the wheel now. Any delay means that it is more and more difficult to avert the future danger.
   - The climate system has strong momentum for further warming over the next few decades because of the greenhouse gases that have already been emitted, and those that will be emitted in future. This means that it is highly likely that extreme weather events will become even more severe in Australia over that period.

5. **Only strong preventive action now and in the coming years can stabilise the climate and halt the trend of increasing extreme weather for our children and grandchildren.**

   - Averting danger requires strong preventative action. How quickly and deeply we reduce greenhouse gas emissions will greatly influence the severity of extreme events in the future.
   - The world is already moving to tackle climate change. Ninety countries, representing 90% of global emissions, are committed to reducing their emissions and have programs in place to achieve this. As the 15th largest emitter in the world, Australia has an important role to play.
   - Much more substantial action will be required if we are to stabilise the climate by the second half of the century. Globally emissions must be cut rapidly and deeply to nearly zero by 2050, with Australia playing its part.
   - The decisions we make this decade will largely determine the severity of climate change and its influence on extreme events that our grandchildren will experience. This is the critical decade to get on with the job.

Australia’s hottest year was no freak event: humans caused it

The Bureau of Meteorology has confirmed that 2013 was the hottest year in Australia since records began in 1910. Sophie Lewis and David Karoly explain

Unusual heat was a persistent feature throughout the year. For the continent as a whole, we experienced our hottest day on record on January 7. Then January was the hottest month on record, and the 2012-13 summer was the hottest recorded for the nation.

The nationwide temperature record set for the month of September exceeded the previous record by more than a degree. This was the largest temperature anomaly for any month yet recorded.

Averaged across all of Australia, the temperature for 2013 was 1.2°C above the 1961-1990 average, and well above the previous record hot year of 2005 of 1.03°C above average.

What caused these extreme temperatures? Climate scientists have a problem: because climate deals with averages and trends, we can’t attribute specific records to a particular cause.

But our research has made significant headway in identifying the causes of climate events, by calculating how much various factors increase the risk of extreme climate events occurring. And we have found sobering results.

We previously analysed the role human-caused climate change played in recent extremes across Australia.

For various record-breaking 2013 Australian temperatures, we investigated the contributing factors to temperature extremes using a suite of state-of-the-art global climate models. The models simulated well the natural variability of Australian temperatures.

Using this approach, we calculated the probability of hot Australian temperatures in model experiments. These incorporated human (changes in greenhouse gases, aerosols and ozone) and natural (solar radiation changes and volcanic) factors. We compared these probabilities to those calculated for a parallel set of experiments that include only natural factors. In this way, natural and human climate influences can be separated.

In the model experiments, it is impossible to reach such a temperature record due to natural climate variations alone.

In our previous studies, we then applied an approach (known as Fraction of Attributable Risk) widely used in health and population studies to quantify the contribution of a risk factor to the occurrence of a disease. Health studies, for example, can quantify how much smoking increases the risk of lung cancer.

Using the climate models, the Fraction of Attributable Risk (FAR) shows how much the risk of extreme temperatures increases thanks to human influences.

In our earlier study of our record hot Australian summer of 2012-13, we found that it was very likely (with 90% confidence) that human influences increased the odds of extreme summers such as 2012-13 by at least five times.

In August 2013, Australia broke the record for the hottest 12-month period. The odds of this occurring increased again from the hottest summer. We found that human influence increased the odds of setting this new record by at least 100 times.

Recent extreme temperatures are exceeding previous records by increasingly large margins. The chance of reaching these extreme temperatures from natural climate variations alone is becoming
increasingly unlikely. When we considered the 12-month record at the end of August, it was nearly impossible for this temperature extreme to occur from natural climate variations alone in these model experiments.

We have just completed a preliminary investigation of contributing factors for the record Australian temperature in the 2013 calendar year. In the model experiments, it is impossible to reach such a temperature record due to natural climate variations alone. In climate model simulations with only natural factors, none of the nearly 13,000 model years analysed exceed the previous hottest year recorded back in 2005.

In contrast, in model simulations including both natural and human factors, such as increasing greenhouse gases, record temperatures occur approximately once in every ten years during the period 2006 to 2020. (On a mathematical note, as there is no instance in which the record hot yearly temperature occurred without human contributions, the FAR value is one.)

Clearly both natural climate variability and global warming from humans contribute to recent temperature records. Natural variability always plays a major role in the occurrence of weather and climate extremes. But in the case of our recent hottest year on record, human-caused global warming made a crucial contribution to our extreme temperatures.

Our extensive catalogue of 2013 record-breaking events in Australia occurred in a global context of increasing temperatures that must be considered. Globally, 2013 will likely rank as the 6th hottest year recorded.

So to return to our question, what caused the 2013 record hot year across Australia? Simply put, our climate has changed due to human activities. Recent extremes, such as this hot year, are occurring well outside the bounds of natural climate variations alone.

Sophie Lewis is Postdoctoral Research Fellow at the University of Melbourne.
David Karoly is Professor of Atmospheric Science at the University of Melbourne.

THE CONVERSATION

Global warming is ‘unequivocal’, according to the fifth IPCC report which, after six years in preparation, delivers a detailed picture of the science behind climate change. Michael Parker reports

In the strongest language yet deployed in the fight against increasing temperatures, the report concluded that the 30 years until 2012 were probably the warmest in 1,400 years, driven by ‘unprecedented’ levels of greenhouse gases – these are now at levels not seen for 80,000 years.

The conclusion of hundreds of authors is that it is ‘extremely likely’ that human activity has been the ‘dominant cause’ of the warming witnessed during the 20th century.

The report is from the IPCC Working Group I, which examines the physical basis of climate change. Introducing the report’s Summary for Policymakers, which will be read by governments and form the basis of policy worldwide, co-chair Dr Thomas Stocker said “the human influence on the climate system is clear”.

The conclusion of hundreds of authors is that it is ‘extremely likely’ that human activity has been the ‘dominant cause’ of the rising temperatures witnessed during the 20th century.

“This is an assessment of a string of assessments, and we have confirmed again that warming in the climate system is unequivocal, a conclusion re-confirmed since the last report with the help of new evidence from the atmosphere, oceans, ice and land,” he said.

Michel Jarraud, Secretary-General of the World Meteorological Organization, one of the founding organisations of the IPCC, said the report will be essential for forming the basis of the international UN climate agreement in 2015. “This should come as yet another wake up call that our activities have an impact on the world,” he said.

Temperatures between 2001-2010 were the highest on record, a decade that saw more records than ever broken. “It would have been even higher were it not for the role of the deep oceans in absorbing heat,” he added. “But this does not mean that the oceans will save us from global warming.”

One of the questions raised since the previous report in 2007 was the so-called ‘hiatus’ in global warming.

Observed change in average surface temperature 1901-2012
warming that was not predicted by models. Having led the delegation of scientists and government representatives that thrashed out the final wording, Dr Stocker explained it was an emerging scientific question that had been looked at very carefully. He said that while too few measurements were available in the deep ocean, a large amount of the recent ‘pause’ in global warming was due to natural variability, including: a series of recent volcanic eruptions, natural Pacific cooling cycle, and absorption of heat in the deep oceans.

Temperatures between 2001-2010 were the highest on record, a decade that saw more records than ever broken.

He added: “At current levels we are facing rates of warming higher than those assessed in the report’s lowest emissions scenarios. But this is dependent on our carbon emissions each year, so humankind has a choice on which emissions path they will follow.”

Other findings highlighted in the report are that global sea level rise will very likely exceed that recorded between 1971-2010, fuelled by the loss of glaciers and Arctic sea ice. Oceans will continue to absorb CO2 which will increase acidification. Perhaps most worrying is that most aspects of climate change – fuelled by already committed historical, present, and future emissions – will persist for centuries, even if CO2 emissions are stopped.

Ban Ki-moon, UN Secretary General, speaking from Geneva, said: “The world’s eyes are on Stockholm today, you have used the best science to fight the world’s biggest problem.”

“The heat is on; now we must act.”

Michael Parker is Environment and Energy Editor at The Conversation.

CLIMATE RISKS AROUND AUSTRALIA

This brief from The Climate Institute explains what the latest report of the Intergovernmental Panel on Climate Change means for Australians.

On 31 March, the Intergovernmental Panel on Climate Change (IPCC) releases the Fifth Assessment Report of Working Group II. The report assesses the impacts of climate change and looks at where adaptive strategies are needed around the world to minimise the costs to society. This brief outlines some of the likely consequences projected for Australia from unchecked climate change and highlights how, in contrast to governments elsewhere and some Australian municipalities, state and federal governments often seem in retreat from good risk management. Despite the overwhelming case for adaptation, many in government, as well as business, are walking backwards into the 21st century, presuming the future climate will be like the past or that adapting to a world warmed by 2°C, 3°C, and 4°C will be straightforward and simple.

What is the IPCC Working Group II report about?
This upcoming report by Working Group II is on Impacts, Adaptation, and Vulnerability. In other words, it looks at the consequences of the physical impacts of climate change for society, the economy, and nature. The report will include sections on each global region, including Australia.

Working Group II is made up of experts on society, economics, risk management, security, health and disease, food and agriculture, water and other natural resources, and ecosystems and wildlife.

The new report builds on IPCC work released in September 2013, which provided an update on the latest around the science on how the climate has changed, what is driving this change and what influence human activities will have on the climate system in the future.

What is Working Group II likely to say?
The table at the end of this brief gives examples of observed and predicted impacts and risks associated with climate change across Australia.

Key messages on global risks and impacts will likely include:

- **Climate change threatens agriculture globally.** The impact of climate change on global agriculture has been and will continue to be overwhelmingly negative. Despite a few benefits, scientists are confident that the risks are much greater than the opportunities, especially if warming continues unabated. More and more intense extreme events leads to greater uncertainty and insecurity for farmers, disruptions to the food supply, and sustained higher and more volatile food prices for consumers.
- **Coastal systems and low-lying areas are under threat.** Sea level rise and coastal flooding will impact hundreds of millions of people globally. Regions particularly vulnerable include Australia’s neighbours in the Pacific, South-East Asia, East Asia and South Asia.
- **Human health is being put at risk.** Climate change will lead to illness and death from extreme climate events like more intense and frequent heatwaves and fires. It will also increase the risks of food and water-borne diseases and impacts on agriculture will exacerbate malnutrition, particularly in children. Drought and changes in rainfall are expected to significantly reduce water security in many, particularly sub-tropical, regions.
- **Climate change multiplies security risks.** Defence experts – including senior military officers in the United States, the United Kingdom, and NATO – are increasingly worried about how climate change and multiply the threats to security and stability. Rising temperatures, sea-level rise, changes in rainfall, food insecurity, the spread of infectious diseases, and population displacement can mix with ethnic, economic, and political tensions to catalyse conflict.
- **Climate change will exceed the ability of many natural environments to adapt:** Coral reef and alpine ecosystems are particularly vulnerable to climate change, but many others will be degraded too. Many impacts will be irreversible with local and global species extinctions likely.

Are governments failing to adapt to climate change, putting Australians at risk?
Climate change is and will continue to increase the frequency and severity of many kinds of extreme weather, including heavy downpours and flooding, heatwaves, fire weather and droughts, and intense storm surges.

We are already committed to some warming, so
adaptation is essential, but urgent action is needed to avoid dangerous warming of 2°C or more – beyond which adaptation become increasingly more costly and in many cases impossible. Even with the unprecedented level of action that is occurring to limit pollution and drive renewable energy investments the world is currently on track to 4°C warming or more. This is the potential world we must be prepared for.

In Australia, investment in adaptation is uneven, at best. Current efforts are weak, poorly co-ordinated, and piecemeal, where they exist at all.

Positively, the Commonwealth Department of the Environment is preparing a new national adaptation assessment framework against which to measure Australia’s progress in adapting to climate change and the country’s resilience to its impacts. However, the previous 2007 Framework, agreed to by the Council of Australian Governments, was poorly followed through. The Climate Institute’s Coming Ready or Not report examined the exposure of our infrastructure to climate risks. It found that only the water sector was relatively well advanced in adjusting to projected climate change impacts. However, even this is being overwhelmed by poor government policies and a lack of business preparedness, raising climate risks to communities and infrastructure.

For example, the IPCC predicts a sea-level rise of up to 1.1 metres by 2100 – a projection widely regarded as conservative. For Australia, this means at least 14,800 commercial and industrial buildings, and as much as 35,000 km of road and rail are at risk of inundation and storm damage. Transport and building assets, today worth $226 billion, are exposed to consequences of this sea-level rise. However, policy to manage this risk to coastal assets is inconsistent and inadequate.

New South Wales and Queensland have withdrawn planning policy tools to help local councils manage these risks to coastal development. To illustrate, New South Wales has removed projected climate-risk warnings from mandatory disclosures when buying a property. This increases the exposure of communities to storm surges and sea-level rise.

Also, Infrastructure Australia (IA) is legally required to report to the Federal Government on how climate change would affect infrastructure policy. IA was set up to assess infrastructure investments on their productivity. The Garnaut Review conservatively estimated climate costs to Australian infrastructure alone would be worth $9 billion annually by 2020, it makes sense for our independent infrastructure advisory body think about how to minimise risks.

The Commonwealth Government is proposing to remove IA’s climate risk reporting mandate. This is despite the Infrastructure Coordinator’s warning that rising sea levels and heat stress are among the climate impacts threatening “a significant proportion of Australia’s existing infrastructure assets ... and adaptation will require changes to the scope and mix of infrastructure investment”.

Other countries provide examples of how to do it better:

- In the UK, the government has already carried out a nationwide climate risk assessment and requires organisations responsible for essential services and infrastructure to report on the current and predicted impacts of climate change, and how they propose to manage the associated risks.
- In the US, every federal agency is required, by Presidential order, to study their climate risks and vulnerabilities, and to draw up plans for managing risks – short- and long-term. Recently, President Obama requested US$1 billion for a climate resilience fund to help prepare vulnerable communities for more frequent and more intense extreme weather events. Also, the 2014 US Quadrennial Defense Review identified climate change as a clear risk to global security, with implications for how the American military operates and for its long-term strategy.

At a more local level, in the wake of Hurricane Sandy, the Mayor of New York City last year unveiled a US$19.5 billion climate change adaptation plan, including more than 250 initiatives to reduce the vulnerability of the city to flooding and storms. Many other cities, including London, Quito, Durban, and Rotterdam have or are developing climate change adaptation plans, while Melbourne and Geelong are internationally recognised leaders.

In stark contrast to state and federal governments, the insurance sector is beginning to price in climate risk, and skyrocketing premiums and uninsurability may well emerge as a key driver of adaptation. Already, household insurance premiums are rising and policies are changing in parts of the country exposed to extreme weather. Australia makes up less than 2 per cent of the...
global reinsurance market but over 6 per cent of losses in the five years to 2013, according to the Insurance Council of Australia.

What should governments be doing?

- Avoid unmanageable risks of climate change by working with the international community to keep global warming below 2°C above the pre-industrial average. This includes having policies that can reduce the nation’s carbon pollution by 25 per cent on 2000 levels by 2020 and around 60 per cent by 2030.
- Manage the unavoidable risks of climate change by:
  - Integrate climate change risks associated with 2- and 4-degree climate change scenarios into all appropriate national policies, standards, targets and oversight (e.g. health policy, natural disaster responses, defence).
  - Require private-sector proponents or owners of infrastructure – especially those seeking Commonwealth approval or funding – to disclose how their assets and interdependencies will manage climate risks under 2 and 4 degrees of warming.
  - Establish the Commonwealth as a leader in climate risk management, in particular by requiring all relevant federal agencies to publish reports on their climate risk readiness for 2- and 4-degree warming scenarios. The Commonwealth should also lead collaboration, across jurisdictions, to develop agreed approaches to adaptation, including standards and guidelines in planning, developments, and approvals.

What are the likely risks and impacts of climate change in Australia?

The impacts of climate change can already be seen in Australia now, and are clearer and more pronounced than when the last IPCC Assessment Report was released in 2007.

Currently, emissions have the world heading to 4°C or more above the pre-industrial temperature. Australia and the world risk missing the chance to keep warming to 1.5°C.

The following tables give examples of observed and predicted impacts and risks associated with climate change across Australia. These points are drawn from assessments and studies by CSIRO, the Climate Commission, the Bureau of Meteorology, the Garnaut Review, and previous IPCC reports on impacts.

NOTES

1. While this media brief uses the best available scientific reports, it will be reviewed and revised once the latest IPCC report is publicly available. Note that impacts and risks listed are not exhaustive and are matched indicatively with temperature rises above the preindustrial average.

<table>
<thead>
<tr>
<th>Changes to date (i.e. &lt;1°C)</th>
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<tbody>
<tr>
<td>• Rainfall has declined since 1970 in the southwest, mostly in winter, and in the southeast since 1990, mostly in autumn and early winter. The northwest of the country is becoming wetter, on average.</td>
</tr>
<tr>
<td>• Every decade since the 1970s has been warmer, on average, than the last. January 2013 was the hottest month January on record in the hottest summer on record.</td>
</tr>
<tr>
<td>• The duration and frequency of heatwaves have increased, with the hottest days becoming hotter.</td>
</tr>
<tr>
<td>• In the decade to 2011, the number of record-high temperatures exceeded record lows by as much five to one.</td>
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<tr>
<td>• The risk of extreme fire weather has risen across large parts of the country since the 1970s.</td>
</tr>
<tr>
<td>• In southeast Australia, there has been an extension of the fire season into November and March, with the majority of the most intense fire seasons have occurred from the 1990s.</td>
</tr>
<tr>
<td>• The extent and frequency of exceptionally hot years and drought is rising.</td>
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<tr>
<td>• Observed decline in snow cover.</td>
</tr>
<tr>
<td>• The Great Barrier Reef has lost half its coral cover in the last 27 years. The loss was due to storm damage (48 per cent), crown of thorns starfish (42 per cent), and high temperatures (10 per cent).</td>
</tr>
<tr>
<td>• The world’s oceans have become almost 30 per cent more acidic, on average.</td>
</tr>
<tr>
<td>• The average global sea level rose by more than 0.2 metres between 1880 and 2000 and is rising still.</td>
</tr>
<tr>
<td>• Many communities already show signs of vulnerability to extreme weather events, e.g. The 2009 Victorian heatwave and fires, widespread drought, and heavy flooding in Eastern Australia.</td>
</tr>
<tr>
<td>• Property insurance premiums rise dramatically in exposed parts of the country, with some policies making it difficult or even impossible to insure against extreme weather events.</td>
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<table>
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<tr>
<th>1-2°C</th>
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<tbody>
<tr>
<td>• By 2020, very extreme bushfire days are projected to occur twice as often in southeastern Australia, and catastrophic fires could occur twice as often.</td>
</tr>
<tr>
<td>• Rise in mental and physical health costs associated with extreme events.</td>
</tr>
<tr>
<td>• Significant loss of species, as adaptive capacity of wildlife is exceeded.</td>
</tr>
<tr>
<td>• Loss of some coastal developments because of increased erosion and storm surges where sea defences are absent.</td>
</tr>
<tr>
<td>• Wheat yields may increase but nutritional quality is likely to be compromised by elevated atmospheric CO2 levels.</td>
</tr>
<tr>
<td>• Areas with annual average snow cover of 30 days per year could decline by 14-54 per cent.</td>
</tr>
<tr>
<td>• Around 2,000 more heat-related deaths a year, on average.</td>
</tr>
<tr>
<td>• The sea level around Kakadu National Park likely to rise by 8-30 cm by 2030, with severe impacts on the wetland ecosystem, together with its tourism and cultural values.</td>
</tr>
<tr>
<td>• Increased demand for aid and disaster response. Rising sea levels displace citizens of low-lying small Pacific Island states.</td>
</tr>
<tr>
<td>• Changes to many ecological communities around Australia.</td>
</tr>
<tr>
<td>• Tropical cyclones are expected to increase in intensity with continued warming but remain the same or decrease in numbers making landfall.</td>
</tr>
</tbody>
</table>
By 2050, very extreme bushfire days are projected to occur four to five times as often in southeastern Australia.

Without adaptive measures, Australia is projected to become a net importer of wheat by 2050. The gradual decline and constant disruptions to primary production in Australia has grave consequences for regional and global food security.

By 2050, a 44 per cent reduction in suitable area for wine grape production expected.

Average runoff in southeastern Australia could decline by as much as 40 per cent.

Irrigated agriculture in the Murray-Darling Basin expected to fall by 12-49 per cent.

As much as 60 per cent of the Great Barrier Reef experiences regular bleaching due to high temperatures.

Further decreases in average rainfall are expected over southern Australia compared with the climate of 1980 to 1999: a decrease of up to 30 per cent by 2070 for high emissions, with largest declines in winter and spring.

A sea-level rise of 0.5 metres can lead to an increase in the frequency of coastal flooding by between one in 100 and one and 1,000. A 100-fold increase means a one-in-100-year storm surge would occur, on average, once a year.

Tropical cyclones are expected to become more intense, but are unlikely to increase overall number.

Southward spread of risk from tropical insect-borne diseases, e.g. Dengue Fever.

What are today normal activities, like growing food or working outdoors, become impossible in many regions, with consequences for health and productivity. The Australian way of life, including outdoor sporting and recreational activities, become impossible.

Dangerous water shortages widespread in urban and rural areas.

Run-off in the Murray-Darling Basin is likely to decline with further warming, such that irrigated agriculture is projected to decline by 90 per cent by 2100.

Heat-related deaths are projected to rise by around 10,000 by 2100.

The 2007 IPCC report predicted a sea-level rise of up to 0.8 metres by 2100, but this is now thought to be an underestimate.

A more acidic ocean impairs reproduction and development of many marine organisms and disrupting seafood chains. Warming of the waters accelerates this process.

A sea-level rise of 1.1 metres, projected for 2100, puts at risk as many as 14,800 commercial and industrial buildings, and as much as 35,000 km of road and rail.

$226 billion in transport and building assets exposed to consequences of sea-level rise.

Areas with annual average snow cover of 30 days per year could decline by 30-100 per cent.

Massive and widespread loss of species. More than 50 per cent of habitat of Eucalypt species likely to be lost Australia-wide.

The Great Barrier Reef, no longer dominated by corals or possess the range of marine wildlife seen today, is destroyed, along with its tourism, fishing, and cultural values.

Increased expenditure on aid and welfare required as communities, at home and abroad, require more support, with some facing breakdown.

Around the world, hundreds of millions of people face displacement, putting pressure on Australia’s and regional security. Major dislocation of population from Asian megacities, with consequences for regional security and stability.
Climate change is already having a major impact on the planet, with impacts forecast to worsen significantly, according to the latest summary of peer-reviewed climate science from the Intergovernmental Panel on Climate Change (IPCC). But the risks of climate change can be alleviated with adaptation. James Whitmore and Michael Hopkin discuss.

While some sectors and regions may benefit from low levels of warming, negative impacts will outweigh positive ones, the report says. Greater impacts will be seen at higher levels of warming. But strong mitigation now could significantly reduce the risk of severe climate impacts. The report, Climate Change 2014: Impacts, Adaptation and Vulnerabilities is released today in Yokohama, Japan.

Dr Chris Field, co-chair of the report, said the amount of research on climate impacts had doubled between 2005 and 2010. The report assesses current climate impacts, future climate risks and adaptation potential across sectors including the economy, health, agriculture, and security.

KEY FINDINGS

Global income could fall by 0.2-2% in response to a global average temperature increase of 2°C, with worse losses ‘more likely than not’, according to the report, although it adds that economic forecasts are fraught with difficulties.

Climate change will exacerbate health problems up to 2050, and post-2050 is likely to increase ill-health.

While some studies predict crop production will rise, most suggest major crop production (wheat, rice, and maize) will fall with 2°C warming, with increased variability between years.

More people will be displaced by climate impacts such as rising seas, but the report says there is low confidence in estimates of how many people will be affected.

There is medium confidence that climate change has already played an indirect role in recent conflict and civil wars, and will increase national security threats in the future.

Climate change will exacerbate health problems up to 2050, and post-2050 is likely to increase ill-health. Deaths have already risen thanks to extreme heat, although there may have been some fall in deaths from extreme cold.

The tropical and subtropical regions will see more frequent drought, and globally water quality is expected to decline. Climate impacts will disproportionately affect developing nations and people in poverty, although climate change has already been felt across the globe.

The report also summarises impacts already seen, mostly in the natural world. Glaciers and permafrost are melting, and scientists have documented shifts in species’ distributions.

Many countries have already taken steps to develop adaptation plans, the report says, which could significantly reduce further climate risks.

Climate Change 2014: Impacts, Adaptation and Vulnerabilities is the second of three reports to make up the IPCC Fifth Assessment Report. The first, The Physical Science Basis, was released in September 2013. The final part, Mitigation of Climate Change, will be released in May, with the compiled report due in late 2014.

The Conversation author and climate scientist at Victoria University Roger Jones was at the report meetings in Yokohama. A coordinating author on the report, he asked fellow authors what they thought was the key message. Their responses follow on the next page.

James Whitmore and Michael Hopkin are editors at The Conversation.
Roger Jones asked fellow authors what they thought was the key message. Their responses follow below.

Roger Jones, Victoria University; coordinating author, ‘Foundations of decision-making’

The last Working Group II report talked mainly about the impacts of climate change; particularly, how risks increase at higher levels of warming. While the analysis of key risks is repeated with new data, adaptation is a big feature of this report. The capacity to adapt is looked at across regions, sectors and key risks. The limits to adaptation are assessed but poorly known. Some of these limits may be reached at 2C warming above pre-industrial levels. At 4C above these levels, and accounting for adaptation, key risks are high across the board.

The global costs of impacts are incomplete with uncertainty pointing towards higher levels can is currently quantified. The costs of adaptation are unknown, but the benefits of undertaking adaptation are recognised. Current levels of impacts and the adaptation needed to respond to these, point to the need for prompt and ongoing action on climate change if future risks are going to be adequately managed, irrespective of future levels of mitigation.

Saleemul Huq, International Institute for Environment and Development; coordinating author, ‘Adaptation needs and options’

As a Lead Author on adaptation in the third, fourth and now fifth assessment reports, I have seen the evolution of the topic’s treatment from a single chapter in the third report, to one-and-a-half chapters in the fourth, to four chapters in the fifth. This represented the demand for information from governments (who make up the IPCC and provide the outline of topics that the scientists are then asked to write about).

The Fifth Assessment was able to provide much more information on planning adaptation, but less on actual implementation of adaptation plans. This illustrates both the explosion in adaptation plans and actions around the world and also the limitations of the IPCC’s strict restrictions on relying on the peer-reviewed scientific literature and avoiding other sources of information.

This meant that a significant body of knowledge generated by practitioners doing adaptation on the ground, but who do not write peer-reviewed journal articles, were difficult to capture in the assessment due to the strict IPCC rule on what information can be cited and what cannot be cited.

Another problem with the IPCC, at least for the major assessment reports, is the long time that they take to go through the review process and finally get published. Thus they are out of date by at least a year on the day they are published.

At least when it comes to information and knowledge on adaptation, where the need for information is urgent, this long process is not really fit for purpose anymore.

The future of IPCC reports might thus lie in more, quicker, special reports rather than the huge tomes every six or so years.

Jonathan Overpeck, University of Arizona; author, ‘Terrestrial and inland water systems’

Building on the previous IPCC reports, the new IPCC assessment report makes it clear that continued climate change will indeed create an increased extinction risk for a large fraction of terrestrial and freshwater species during and beyond the 21st century, especially as climate change interacts with other pressures on species, such as habitat modification, over-exploitation, pollution and invasive species. Although it is not possible to define the exact number of species at risk, we do know that this number could be large, and that it will increase with both the magnitude and rate of climate change.

Global species extinctions, many of them caused by human activities, are already occurring at rates that approach or exceed the upper limits of observed natural rates of extinction in the fossil record. Continued climate change will accelerate this rate of global extinction, perhaps dramatically.

John Morton, University of Greenwich; coordinating author, ‘Rural areas’

There will be complex impacts on rural areas around the world, going well beyond the projected decreases in yield for the major food crops (vitaly important as those are). Rural people will also suffer impacts on the cash crops they depend on for their livelihoods, on their livestock, their water supply, their infrastructure, and their health: some, who are net buyers of food, will suffer from higher food prices.

Generalising across the rural areas of developing and developed countries is hard; the policy and demographic contexts are very different, though there are common features of remoteness, lack of access to decision-making, and knowledge gaps on rural realities. There are emerging questions on how the drive to biofuels and other forms of renewable energy, and to the mitigation of carbon emissions by reforestation, will affect rural people.

Petra Döll, Goethe University Frankfurt; author, ‘Freshwater resources’

To support decisions on climate mitigation, it is helpful to compare the impacts on freshwater systems that are projected under different amounts of future greenhouse gas emissions or global warming.

In our work for the Fifth Assessment Report, we could for the first time evaluate a large number of modelling studies that made such comparisons. These studies, with large but better quantified uncertainties, clearly demonstrate that freshwater-related risks of climate change increase significantly with global warming.

Low-emission scenarios lead, for example, to lower increases of flood occurrence as well as to lower reductions of renewable water resources, and therefore to lower costs of adaptation.

Rachel Warren, University of East Anglia; author, ‘Emergent risks and key vulnerabilities’

We have already observed impacts of climate change on agriculture. We have assessed the amount of climate change we can adapt to. There’s a lot we can’t adapt to even at 2C. At 4C the impacts are very high and we cannot adapt to them.

Reducing emissions reduces global temperature rise, and also the rate of temperature rise. This makes it easier to adapt to the remaining impacts. We’ve left it too late to reduce emissions enough to avoid all of the impacts of climate change, but we could still avoid a large proportion of them by reducing emissions soon, and fast.
THE IPCC HAS SPELLED OUT THE RISKS – NOW WHAT DO WE DO?

Despite the mounting evidence, there are still some who would deny the veracity of human-caused climate change and its potential to disrupt and harm our communities, observes Ove Hoegh-Guldberg

Most dissenters rely on non-expert sources, which tend to have low grades of analysis, review and scientific integrity. Not so with the Intergovernmental Panel on Climate Change report, the latest part of which has been released today.

Involving hundreds of the world’s most qualified experts, the report focuses on the impacts, adaptation and vulnerability of ecosystems, economics and people to climate change. There is nothing lightweight about it.

Like the Working Group I report, released in September last year, it stretches to more than 2,000 pages and has involved more than 50,000 responses to hundreds of reviewers.

And the messages from Working Group II are also pretty stark. Here are some of those messages.

“Human interference with the climate system is occurring, and climate change poses risks for human and natural systems.”

The latest report makes no bones about stating the consensus that human-driven climate change is occurring and it is important. Hundreds of changes have already been observed that are consistent with climate change, temperature rises, and associated issues such as ocean acidification.

The most important of these impacts are detailed on the map on page 24, and include threats to ecosystems and organisms, increasing coastal erosion and inundation, decreasing crop yields, and intensifying flood frequency.

The challenge of managing risks

Risk is a prominent theme in the new report. Whether it be understanding the vulnerability of people and systems to climate change, or the benefits of adaptation, the IPCC’s Working Group II is couching its consensus, analysis and language in terms of ‘risk’, more so than the concepts of ‘vulnerability’ and ‘exposure’ discussed in previous reports.

The reason for this change comes from the perception that risk is more widely understood by the general public than the previous terms.

People understand managing and avoiding risk from an early age. Whether it is the tree you climbed as a child, or your decision to reduce your risk of harm by wearing a bike helmet, risk and its management is a familiar concept.

The new report summarises the expert consensus on risk and gives new insights into how those risks might change in the face of 2°C or 4°C of global warming. Importantly, the consensus report includes an assessment of whether the resultant risks can be reduced by adaptation.

Adaptation, as you might remember, refers to our ability as people and communities to take steps to reduce the impacts of climate change. As can be seen from looking at the examples in the table below, in most cases our adaptation options for reducing risk are limited, especially if we fail to take action that might curb temperature rises.

Oceans in flux

One of the new features of the current assessment is the greater focus on the world’s oceans. In previous IPCC reports, discussion of the ocean has been split across systems and regional chapters, reducing the opportunity to look at the bigger picture of how climate change broadly affects the ocean as a whole.

In the current assessment, the ocean (which, of course, covers 71% of Earth’s surface) is considered in a single new regional chapter, allowing all aspects of this massive system to be pulled together.

One of the outcomes of this chapter is a much improved understanding of whether climate change has is affecting marine organisms and ecosystems.

This type of information and understanding has been available for terrestrial systems going back to before the previous IPCC assessment in 2007. In 2003, for instance, many terrestrial species were found to

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have moved polewards – a discovery that was later confirmed. But similar understanding was lacking for ocean species.

The new report fills in this gap, thanks largely to CSIRO’s Elvira Poloczanska and colleagues, who assessed 1,735 marine biological responses and found that 81-83% of these published studies that showed changes that were consistent with ocean warming and other climate change related changes.

I am far from being the first person to make this point – the need to act on climate change is an economic as well as environmental argument.

That is an amazing number, and it means that life in the ocean is mostly on the move in response to the changing conditions foisted on it by climate change.

With populations of economically important organisms such as fish travelling towards the polar regions at rates of up to 200 km per decade, industries such as fishing are experiencing new challenges associated with shifting resources.

In some cases, such as high-latitude fisheries off the Scandinavian coast, fisheries are experiencing increased catch rates as ice retreats and waters warm. But these benefits are likely to be short-lived, as further warming will eventually rob these fish species of their optimum living conditions.

Our ability to adapt is limited at best

The latest IPCC report clearly shows that the consensus on changes in risk under future warming and that adaptive capacity is limited at best in terms of countering the growth of vulnerability.

When you read the 44-page Summary for Policy Makers, one thing that jumps out is the table of key risks and possible adaptation responses needed for each continent, small islands and the world’s oceans – even with only small amounts of climate change. If you are someone charged with the job of devising adaptation strategies, your eyes would no doubt be watering.

What struck me when I first looked at the aggregated risks, adaptive possibilities and resultant vulnerabilities, was how little adaptation might achieve if we head into a world that is 2C or 4C warmer. The second thought was how expensive each option is in terms of time and resources, especially given that all have to be dealt with and cannot be seen in isolation.

The cost of inaction

The third thought is one that concerns the economic argument for bringing our emissions globally to zero over the next two decades, versus trying to adapt to the changes – the subject of next month’s IPCC Working Group III report.

It argues from a powerful expert consensus among many scientists that the cost of trying to adapt to the very long list of climate change threats is likely to be excessive compared to the strategy of reducing the challenges (emissions) posed by a changing climate in the first place.

In other words – and I am far from being the first person to make this point – the need to act on climate change is an economic as well as environmental argument.

In the words of Bill Clinton: it’s the economy, stupid. Those who think adapting to climate change looks worryingly expensive would do well to start arguing in favour of spending money on reducing its effects.

Ove Hoegh-Guldberg is Director at the Global Change Institute at the University of Queensland.

THE CONVERSATION


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CHAPTER 2
Responding to climate change

IPCC: EMISSIONS CUTS ARE ABOUT ETHICS AS WELL AS ECONOMICS

For the first time the IPCC has addressed the ethical, as well as technical, issues of reducing greenhouse emissions, write report authors Frank Jotzo and David Stern.

The new report from the Intergovernmental Panel on Climate Change shows that global greenhouse gas emissions have grown faster than ever over the last decade. Taking action to achieve the world’s goal of limiting global warming to 2°C will mean making dramatic cuts in emissions. This raises not just technical and economic challenges, but also profound questions of ethics and values – such as the responsibility we bear towards future generations, and our attitude to the risk of very severe climate change damages.

The Working Group 3 report – released today as the third and final volume in the current IPCC Fifth Assessment Report – assesses the options for mitigating climate change. It draws on almost 10,000 research papers to map out our knowledge about past, present and future greenhouse emissions, and sets out the ways in which we might attempt to reduce them.

**Emissions have grown faster than ever**

The report shows that since 2000, world greenhouse gas emissions have grown much more rapidly than in previous decades. This is mainly because of rapid growth in middle-income countries like China. However, per capita emissions remain very unequal globally: people in high-income countries are responsible for nine times more greenhouse emissions, on average, than those in the poorest countries.

Therefore, under a ‘business as usual’ scenario – in which no new policies or technological breakthroughs emerge to help reduce emissions – we can expect a lot of ‘catch-up growth’ in emissions as developing economies grow. This means that we need to switch to low-carbon energy sources as soon as possible, because the majority of emissions are derived from energy use. Simply improving energy efficiency is unlikely to be enough, as the data show this tactic has historically been insufficient to offset growth in income per capita, let alone population growth.

On the other hand, the report finds that stabilising atmospheric greenhouse gas levels by significantly reducing emissions will have relatively modest financial costs. Global gross domestic product (GDP) would be 2-6% lower in 2050 than it would otherwise have been. Meanwhile, under business as usual, global income per capita is expected to double by 2050. Taking strong action on climate change would, therefore, only delay that doubling by one to three years.

**Overshoot: the negative emissions scenario**

But many of the report’s modelling scenarios that find that the cost of emissions cuts is low, do so by ‘overshooting’ the atmospheric concentration of greenhouse gases. The concentration of greenhouse gases in the atmosphere first exceeds the level that would limit the temperature to 2°C but then emissions must become negative in the second half of the century.

That means taking large amounts of carbon dioxide out of the atmosphere, perhaps by using biomass energy along with carbon capture and storage (referred to as BECCS) to replace the use of coal, oil and gas.

But there is considerable uncertainty about whether this could be made to work in practice, both technically and economically. If such options are not available, the cost of emissions reductions will be near the higher end of the 2-6% range.

And there is a big risk that future decision makers would choose the option that is cheaper in the short term but more expensive in the long run.
will not take the ambitious action that would be required when the time comes – even if today’s governments might assume they will.

**Values, ethics and risk**

For the first time, the report also explicitly looks at the ethics of climate change, and its connection to the values that we hold as individuals and societies.

In deciding whether and by how much to cut greenhouse gas emissions, today’s governments are in part shaping the wellbeing of future generations. Does the welfare of people in the future count for less, purely because they live in the future? Should it count for less because people in the future are expected to be richer than we are?

The report’s modelling shows that developing nations need to act soon and decisively, if climate change is going to be held in check. But who should pay for the costs, and how should we compare the costs and benefits of climate change action across rich and poor societies?

**Knowing the price of everything?**

Judgements about value also come into the complex debate about future economic costs and damages from climate change.

All too often, analyses focus purely on the anticipated economic damage, using lower estimates as a rationale for less action on climate change. This is a simplistic view, as it misses three crucial points.

First, as humans we care about things that are not valued in economic markets. Most Australians care far more about the Great Barrier Reef than its (nevertheless impressive) tourism revenues would suggest. Most of us also care about species going extinct, on an emotional level quite separate from the environmental and health benefits of species diversity. Ignoring these concerns means ignoring many of the values that societies hold.

Second, climate effects will vary greatly across different regions and social groups, and this is usually not reflected in simple economic cost estimates. It is often the poor who are most at risk from climate change, and will find it harder to adapt or recover. If a citizen of an Australian beach suburb loses a A$2 million house, should this be counted as 200 times worse than a Vietnamese peasant losing their A$10,000 home?

Finally, and crucially, climate change is about risks. There is a risk – perhaps small, but we do not know...
UN report calls for drastic climate change action

The third and final part of the UN’s Intergovernmental Panel on Climate Change fifth assessment focuses on the methods and costs required now to prevent runaway global warming. The IPCC advises that many pathways to substantial emissions reductions are available to avoid dangerous interference with the climate system.

The report warns that in order for the world to avoid ecological catastrophe, new technologies may be needed to remove carbon dioxide out of the atmosphere and bury it underground. Over 200 lead authors, consisting of scientists and economists from around the globe, assessed 900 mitigation scenarios for bringing carbon emissions under control.

Findings include:

- The world must give up about 5% of the projected growth in consumption by the year 2100. Current consumption growth over that time is expected to be between 300-900%.
- The current international agreements on carbon reduction are not enough to limit warming to the two degrees figure set as a goal by countries through the United Nations as the limit for avoiding dangerous climate change. Countries will meet in Paris in 2015 with the aim of negotiating a new global treaty to take effect from 2020.
- ‘Decarbonising’ electricity generation would have flow-on effects in industry, buildings and transportation.
- If significant mitigation efforts were delayed to beyond 2030, it would become much harder to keep a rise in temperature to below two degrees.
- The first mitigation steps required are to replace current coal-driven power plants with natural gas plants, as a bridging technology which would need to be phased out after 2050, when low-carbon electricity generation (from renewables, nuclear or carbon capture sources) must increase from the current 30% to more than 80% of total power generation. By 2100 there must be no use of fossil fuels at all, in order to meet the two degrees target.
- The report was critical of current ‘cap and trade’ systems for carbon emissions, noting their environmental effect has been limited by poor implementation.
- As it will take time to switch to a low-carbon economy, the report anticipates the need for BECCS technology (‘bio-energy with carbon capture and storage’) which uses trees and crops to extract carbon from the atmosphere, then burns them for fuel before capturing the emissions for burying underground for centuries.
- The report notes that nuclear energy could make an increasing contribution to low-carbon energy production, however there were a number of barriers and risks involved.
- Other positive effects on future carbon emission reductions could be brought about with more high-density urban planning, more high speed rail and support for cities designed around cycling and walking.
- There is also significant potential in switching to low-carbon fuels for motor vehicles, e.g. methane, electricity or hydrogen.

This information was compiled from the following sources:

IPCC (13 April 2014). IPCC: greenhouse gas emissions accelerate despite reduction efforts: Many pathways to substantial emissions reductions are available (Press release 2014/19/PR);

Miller, N (Berlin) and Arup, T (13 April 2014). ‘UN calls for drastic action to stop climate change’, The Sydney Morning Herald.
Swapping fossil fuels for plant material, and then burying the resulting carbon dioxide to avoid it entering the atmosphere, is the kind of tactic that could help put world greenhouse emissions into reverse, said report co-chair Ottmar Edenhofer, an economist at the Potsdam Institute of Climate Impact Research.

“If we can provide bioenergy in a carbon-neutral way, and also have the means to remove and store carbon, that would be a useful technology cluster,” Professor Edenhofer said.

However, he added that the world will need “a broad portfolio of options” if it is going to make deep enough emissions cuts to meet the internationally agreed target of limiting long-term warming to 2°C. Those options include market-based solutions such as carbon pricing, moves towards renewable energies and other alternatives such as nuclear power, and other technological fixes that have yet to be widely deployed, such as carbon capture and storage.

“We can do a lot at the national scale, at the city scale, at the regional scale, but at the end of the day what we need is global agreement.”

Edenhofer stressed that the IPCC does not make policy recommendations, but rather sets out the options so that politicians can make informed decisions.

“When we talk about technologies like nuclear power we do not assume that there is an agreement between scientists, but what we can do is we can explain that if you want to meet these targets then you have to take into account specific costs and risks,” he said.

Edenhofer said the IPCC’s calculations suggested that limiting global warming to 2°C was likely to stunt world economic growth by between 1% and 5%, relative to its current rate.

Concerted action was needed to curb the current “business as usual” trajectory, he said. “We are not running out of fossil fuels, and we cannot expect that the fossil fuel market will solve the climate problem.”

Edenhofer also stressed the importance of international co-operation: “We can do a lot at the national scale, at the city scale, at the regional scale, but at the end of the day what we need is global agreement.”
IPCC author Richard Harper, of Murdoch University, said the report shows how land-use changes can also contribute to curbing emissions.

"Basically, there are three ways the land can contribute to carbon management: by reducing emissions from existing carbon stocks (e.g. clearing forests) or agricultural activities; by increasing carbon stocks in soils or vegetation (carbon sinks); or by replacing fossil fuel emissions by burning biomass or using wood products," he said.

ETHICAL CONSIDERATIONS
For the first time, the IPCC has factored in ethical considerations, as well as economic ones, when considering emissions mitigation.

Glenn Albrecht, director of the Institute for Social Sustainability at Murdoch University, said:

“While global warming and consequent climate change are the subjects of increasing scientific investigation, our responses to such knowledge must lie within the realm of ethics. When the consensus on the accuracy of the science is near 100%, we must ask, why are we imposing such a massive risk of social, economic, industrial and agricultural disruption and failure on ourselves?”

Griffith University psychologist Joseph Reser said the issue was personal, as well as international.

“Delaying strong mitigation efforts lowers the likelihood that warming could be curtailed at 2 degrees... Delay also incurs increasingly prohibitive mitigation costs.”

“Personal engagement with the issue and ‘taking action’ in the context of one’s own lifestyle and circumstances can play crucial roles and provide multiple benefits in addition to reducing one’s carbon footprint. Being engaged and doing something helps people to come to terms with the reality and implications of climate change, and feel that they are making a difference, being informed and responsible, and part of the solution and not just the collective problem,” he said.

THE IMPACT ON AUSTRALIA
Hugh Outhred, a senior visiting fellow at the University of New South Wales, said Australia is heavily dependent on fossil fuels for both energy and export.

“Australian society has demonstrated that it has the capability to take a leading role in developing and implementing low-emission technologies and adopting low-emission lifestyles. However, that seems unlikely given the present combative and ill-informed political debate about climate change and the influence of the fossil fuel lobby,” he said.

Liz Hanna, a fellow of the National Centre for Epidemiology and Population Health at the Australian National University, described action on climate change as an “economic and moral imperative”.

“Delaying strong mitigation efforts lowers the likelihood that warming could be curtailed at 2 degrees. This wilful disregard for human safety should be recognised for what it is: short-term gain at the expense of a collective future in a world that is habitable.

“Delay also incurs increasingly prohibitive mitigation costs. Combined, these subject today’s children and young adults to a world where governments must spend more to mitigate, at a time when more extreme weather events necessitate higher costs on repairing infrastructure, and relocating vital services away from coastlines. Diminished funds will be available for health and education and nation building.”

These expert reactions were compiled with the help of the Australian Science Media Centre.

THE CONVERSATION
In 1990, the United Nations General Assembly began negotiations on international measures to deal with climate change. They led, in 1994, to the coming into force of the United Nations Framework Convention on Climate Change. The Convention sets out the long-term objective of stabilising greenhouse gas concentrations at a level that would prevent dangerous human interference with the climate. Since 1994, parties to the Convention have continued to negotiate on how the implementation of the Convention can best be advanced.

The Conference of Parties (COP) is one such forum for negotiation, meeting each year to review the implementation of the Convention. COP meetings adopt decisions and resolutions, with the aim of establishing a detailed set of practical rules for parties to follow. A key example was COP 3 in Kyoto in 1997: negotiations resulted in the Kyoto Protocol, which set binding targets to reduce emissions 5.2 per cent below 1990 levels by 2012. Australia was, however, given a very generous target. More than 100 nations have ratified the protocol, which legally entered into force in 2005. Some, but not all, developed countries have begun efforts to meet their emissions targets.

In Copenhagen in December 2009, the UNFCCC held the 15th Conference of the Parties (COP 15). An intensive series of meetings took place throughout 2009, culminating at the Copenhagen meeting. In attendance were parties to the UNFCCC, observer organisations and accredited press. The outcomes of COP 15, COP 16 (Cancun, Mexico), COP 17 (Durban, South Africa) and COP 18 (Doha, Qatar) are set out in this Fact and Issue Sheet.

**Copenhagen: uncertain success**

The Fifteenth Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 15), held in Copenhagen in December 2009, drew an unprecedented level of political attention. There were well over one hundred heads of state and government in attendance, but despite this, the summit was plagued by obstructions and divisions that sharply limited the potential for progress.

The agreement finally reached – The Copenhagen Accord – is a political accord rather than the legally binding instrument called for by the US among others. There has been uncertainty about the formal standing of the Accord within the UNFCCC negotiation processes. It was not achieved with the required level of consensus, but was instead brokered behind closed doors by President Obama and a few key developing country leaders. Because some parties opposed the Accord, the Conference of the Parties was only able to ‘take note’ of its content rather than fully accept it. The Accord upholds the scientific view that temperature rises must be contained at 2 degrees Celsius. To achieve this long-term goal, developed nations are committed to implement economy-wide emissions targets for 2020, while developing nations are committed to implementing nationally appropriate mitigation actions.

Despite its many frustrations and failures, COP 15 did achieve the difficult task of eliciting emission pledges from all the major economies, including China and other major developing countries. It is the first time in the history of UNFCCC negotiations that developed and developing nations’ emissions reductions targets have been on the table at the same time.

Agreements to the monitoring of emissions reductions and to the financing of developing countries were other achievements of the Accord. It stipulates that emissions reductions in developed nations will be measured, reported and verified (MRV’d) in accordance with stringent COP guidelines. Finance is a further strong focus of the Accord: the US came to the table committed to mobilising one hundred billion US dollars a year by 2020 to support developing nations’ mitigation efforts, an offer that was credited with bringing China back on board. As well as this long-term financial goal, developed nations committed to provide thirty billion US dollars in readily available funds until 2012 to support developing
countries’ mitigation and adaptation efforts.

In spite of these successes, the glaring failure to achieve a legally binding instrument to control emissions meant that many became disillusioned with the UNFCCC as a forum for negotiating on climate change. The need for consensus, bound into the UN process, is a double-edged sword. On the one hand it means that small countries, such as the small Pacific island nation of Tuvalu, can have a voice on a crisis that promises to submerge their very island. But on the other, powerful nations, which are the heaviest polluters, can stand in the way of tough action.

**Cancun: quiet achievements**

In December 2010, COP 16 was held in Cancun, Mexico. The Cancun conference was weighed down by much unfinished business due to Copenhagen’s failure to deliver a legally binding instrument for emissions reduction. The conference was a more subdued and less publicised summit than Copenhagen with many saying the atmosphere had greater transparency and goodwill.

The emissions reductions pledge put forward by Australia after Copenhagen was to reduce emissions by 5 to 25 per cent on 2000 levels by 2020, varying according to the level of global agreement. By the time of the Cancun summit, targets for emissions reductions had been put forward by the majority of the world’s major polluters. The task for Cancun became how to capture these pledged targets and incorporate them into a binding agreement.

In this context, the Kyoto Protocol, due to expire in 2012, was a key focus in Cancun. The Kyoto Protocol did not include and was not ratified by all nations, and consequently only covers about 30 per cent of global emissions. In Cancun, much negotiation went into addressing how to incorporate the emissions reductions targets and climate mitigation actions of nations that were not covered in the original Kyoto Protocol, particularly the US, China, India, South Africa and Brazil. This important aim was achieved in Cancun. The ‘Cancun Agreements and Decisions’ were reached, incorporating emissions limitation and reduction targets that cover 80 per cent of global emissions with 192 nations signing the agreement, including all major economies.

The UN agreements reached in Cancun addressed the measurement, reporting and verification (MRV) of mitigation actions and support for developing countries. The agreements requested more detailed reporting of both mitigation actions, and support given (on the part of developed nations) or received (on the part of developing nations).

The short- and long-term financing that was agreed upon in Copenhagen was another focus in Cancun. A significant step was taken in establishing the Green Climate Fund, which has the dedicated aim of assisting developing countries’ mitigation and adaptation efforts. The Green Climate Fund will be accountable to the Conference of Parties and governed by a 24-member board with equal representation from developed and developing nations. The World Bank will be its interim trustee. The terms of reference established in Cancun aim to enable wide stakeholder participation in the Fund, and make it subject to independent evaluation. A key demand from developing nations was that the Fund be able to access national institutions directly, rather than having to go through bodies such as the World Bank or the UN.

**Durban: a transition to action**

The Seventeenth Session of the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 17) was held from 28 November – 9 December 2011 in Durban, South Africa. After the disappointment of Copenhagen to secure a legally binding agreement for all countries in emissions reductions, Cancun reaffirmed the UNFCCC as the primary forum for managing climate risk. Building upon the trust, transparency and ambition from Cancun, the expectations of the Durban negotiations were action oriented.

With limited exposure and traction with the media compared to the Copenhagen talks, Durban was the longest UN climate conference to date. In an unprecedented move forward, four major outcomes were achieved including an agreement to establish a legally binding agreement covering all countries and all emissions by 2015; the extension of the Kyoto Protocol to 2017 and simultaneously initiating a new round of talks to produce a successor agreement commencing in 2020; and the formal implementation of the Green Climate Fund, established in Cancun, to support mitigation and adaptation in developing countries.

**A work plan for a legally binding agreement**

A significant decision reached at Durban included the agreement to institute a new negotiating process known as the Durban Platform for Enhanced Action (ADP), to be conducted by the newly formed Ad Hoc Working Group. Their responsibility is to produce a ‘protocol, legal instrument or agreed outcome with legal force under the Convention’ by 2015 for implementation by 2020. This new agreement will be applicable to all emissions and will cover all countries, thus bringing to an end the differentiation between developed and developing countries as embedded in the Kyoto Protocol. The new working group will commence work on the agreement in 2012 for adoption at COP 21.

**Politics and the future of the Kyoto Protocol**

Durban was the last realistic opportunity to discuss the future of the Kyoto Protocol, due to expire in 2012. Leading up to COP 17, Japan, Canada and Russia stated that they would not enter a second phase of the Kyoto Protocol. The United States and Australia insisted that any agreement would have to include major developing economies such as China and India. The EU’s participation, in discussing the future of the
Kyoto Protocol, was contingent upon securing a new global regime with a comprehensive binding agreement, a position strongly supported by small island states and the majority of the least developed nations.

Agreement was reached to establish a second commitment period of the Kyoto Protocol, commencing in January 2013, extending to 2017 or 2020. Legalising the second commitment period is a decision for COP 18. Parties approved a series of decisions relating to technical issues, plus the conversion of the emissions pledges the EU and others made in the Copenhagen and Cancun Agreements into binding emission targets. By 2012, parties taking targets will be able to assess the implications of the revised rules and the realities of their targets.

Bringing the Cancun Agreements into operation

With some of the broader political commitments resolved, the parties agreed to move forward on finance, transparency and other aspects of the Cancun Agreements to assist developing nations transition to cleaner energy and lower emissions. The Green Climate Fund will provide hundreds of billions of dollars by 2020 to developing nations to implement cleaner energy projects while preparing for inevitable climate impacts. However, with this decision confirmed, there was no clear indication at Durban when developed countries will start contributing to the fund. Instead, a process for establishing a governing board, selecting a host country and an independent secretariat was determined. The aim is to bring the fund into operation within twelve months.

Progress

The Durban negotiations indicated that the global nations are beginning to comprehend the magnitude and urgency of the climate change challenge. In a critical race against time, the nations of the world will need to accelerate significant action if they are going to limit warming to a maximum of 2°C. 2012 was a year of transition on numerous political fronts. The United States, France, Germany, India, Mexico, South Korea and Russia had domestic elections, and in 2013, China’s leadership will also change. Thirty-three countries alongside Australia introduced a price on pollution, but more commitment is essential to cut global emissions. The takeaway message from Durban is that progress toward action is steady, but slow. It is critical that nations of the world shorten their timelines and be more ambitious with their targets.

Doha: a pyrrhic victory but hope remains

“Let us be under no illusion. This is a crisis. I urge all parties to work with the spirit of compromise – to take the long view and avoid getting bogged down in minuteness.”

– UN Secretary General Ban Ki-moon, opening remarks at COP 18

The world is firmly on track toward 4 degrees or more of global warming by 2100 unless ambitious commitments and rigorous decisions are made by both developed and developing nations. The Eighteenth Session of the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 18) was held between 26 November – 8 December 2012 in Doha, Qatar. This was the first time UN Climate Change negotiations were held in the Middle East. The conference drew approximately 9,000 participants with 195 nations represented.

The main deliverables considered necessary outcomes from the talks included:

• The adoption of the a ratified 2nd commitment period of the Kyoto Protocol
• Progress toward long-term climate finance
• Fully equipping the Green Climate Fund (GFC) and the Climate Technology Centre and Network (CTCN) to support developing countries adaptation and mitigation efforts
• A demonstration that negotiations for a global and legally binding instrument mechanism remains on track for signature in 2015, and
• Closing the gap between parties’ mitigation pledges and the target of preventing more than a 2°C global temperature rise.

Doha delivered just enough to keep the process moving without any significant outcomes or what some are calling ‘a pyrrhic victory’. The Doha negotiations marked 20 years since the UN Convention on Climate Change was signed in 1992 and 15 years since the Kyoto Accord (1997) was adopted before coming into action in 2005. The Kyoto Accord sanctified a stark division between developed (required to cut emissions) and developing countries (not required to cut emissions). Back then, China was a developing country. Today China is the world’s biggest GHG emitter and will soon supersede USA as the biggest economy. China wants to hold on to its developing country status making the next three years of negotiations on the treaty the most
challenging in the 20-year history of the climate change talks. We can’t have a global treaty without them. Progress emerged late in the evening of Saturday 8 December 2012, 24 hours after the conference was scheduled to close with the announcement of the ‘Doha Climate Gateway’.

Outcomes of the ‘Doha Climate Gateway’ include:
• Amending the Kyoto Protocol to establish a 2nd commitment period
• An agreed timetable to negotiate the 2015 global climate change agreement stemming from the Durban Platform in 2011 (to be signed in 2015 at a conference in Paris for effect in 2020)
• A renewed commitment to long-term climate finance, and
• An agreement to establish institutional arrangement for a ‘loss and damage mechanism’ to assist developing nations with their adaptation efforts especially those particularly vulnerable to the effects of climate change.

The second commitment period of the Kyoto Protocol
At Doha, a second commitment period of the Kyoto Protocol was adopted, extending it to 2020 to cover the period between the date where the proposed new legally binding agreement negotiated under the Durban Platform will come into force. With the protocol only covering 15% of global emissions, the new commitment period will likely have minimal impact on the growth of global emissions. Being the sole global climate agreement, its extension has more political importance than achieving significant future reductions. It means that the process has not been derailed, but also highlights potentially difficult political negotiations in the near future leading up to the signing of a new climate treaty in Paris in 2015 under work by the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP).

Finance
The second major issue at Doha was climate finance. Developing countries expected rich nations to offer a secure figure on how much they would provide between 2013-20. However, developed nations were not prepared to commit to firm funding figures beyond the USA $100 billion figure promised post-2020. In the interim, these nations will try to provide funding at the same level as previous years which equates to approximately $10 billion (USA) a year. This is partially due to tough economic times globally, but it has upset many developing nations vulnerable to the impacts of climate change. A few countries like the UK and the EU have stepped forward with more significant numbers, but the rest did not.

Loss and damage (not compensation)
Likely the most significant outcome of Doha was something called ‘loss and damage’. This refers to compensation for vulnerable nations for the loss and damage caused by climate change. There was opposition from some of the developed countries, particularly the USA, because they worried that this opened up the door for unlimited liability and compensation. An international mechanism was not set up at Doha, but next year at COP 19, the actual mechanics and content of what the international mechanism will be will be discussed.

The outcomes at Doha were modest, but at the same time were pivotal marking the point between the end of the old regime and the ambitious goals of 2015. By amending and extending the Kyoto Protocol, the process remains on course and will likely benefit the work of the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP) providing some of the architecture for that future climate treaty.

The challenge now between now and 2015 is to drive awareness, publicity and advocacy to stress to the world’s leaders that ambitious commitments must be made to reduce emissions. This now includes large developing countries like China and India. By staying the course and not getting bogged down in minutear, the long view is an ambitious emissions pathway to curb our trajectory from 4°C – where we are headed – to 2°C – where we want to go.

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Australia trounced Kyoto climate target, new report reveals

New figures reveal that Australia easily beat its first internationally-agreed climate target, raising calls for tougher targets to reduce emissions, writes Liz Minchin in this report for ‘The Conversation’

A
fter a week of mostly bad news on climate change, new figures reveal that Australia easily beat its first internationally-agreed climate target, with nearly 131 million tonnes of emissions to spare. That’s the equivalent of shutting down three-quarters of Australia’s power stations for a year.

Significantly, the better-than-expected result will make it even easier for Australia to meet emissions targets for 2020 and beyond. That’s because the 131 million tonne shortfall can be carried over and counted towards the cuts Australia has promised to make by 2020, under the Kyoto Protocol.

The Australian government’s current target is to cut emissions 5% below 2000 levels by 2020. But some experts say the new figures will add to pressure to lift the 2020 target, particularly leading up to a United Nations climate summit in New York in September and global negotiations in Paris next year.

Australia’s first Kyoto Protocol target was not to cut emissions outright by 2012, but to slow their growth, so that the total was no more than 108% of the amount of emissions produced in 1990.

However, new Australian National Greenhouse Accounts reports – published without fanfare on the Department of the Environment’s website on Tuesday – reveal that the target was beaten by more than had been predicted. The latest quarterly emissions report shows that:

Australia has met its Kyoto Protocol target of limiting emissions to 108% of 1990 levels, on average, over the Kyoto period 2008-2012. Over the five reporting years in the Kyoto period (2008 to 2012), Australia’s net emissions averaged 103% of the base year level. The estimated net surplus in 2012 was 36.9 [million tonnes of greenhouse gas emissions] and the total net surplus over the entire 5-year first commitment period was 130.8 [million tonnes].

TOUGHER TARGETS

The updated figure is 15 million tonnes more than an independent review for the Australian government estimated less than two months ago.

In February, that Climate Change Authority review estimated that Australia’s emissions from 2008-2012 had averaged 104% of 1990 levels, giving Australia 116 million tonnes of greenhouse emissions rights to carryover to its 2013-2020 Kyoto commitment. The Authority – whose members include former Reserve Bank governor Bernie Fraser, Australia’s Chief Scientist Ian Chubb, Reserve Bank board member Heather Ridout and economist Clive Hamilton – recommended:

Australia increase its minimum 2020 emissions reduction target from 5 to 15 per cent below 2000 levels. Australia has 4 per cent credit from past action to reduce emissions (‘carryover’). The Authority recommends this be used to strengthen the 2020 target to 10 per cent.
Professor Hamilton now says the Authority would have recommended an even higher target, had these updated environment department figures been available earlier this year.

“It would have led the Authority to recommend a 20% reduction by 2020, rather than a 19% reduction.”

Professor Hamilton said that beating the target so easily was “nothing to brag about”, arguing it reflected an “outrageously generous target” that Australia won at the Kyoto negotiations in 1997.

Significantly, the better-than-expected result will make it even easier for Australia to meet emissions targets for 2020 and beyond.

He also pointed to the unexpected fall in emissions from the electricity sector over recent years, “a reversal of a 100-year increasing trend that caught everyone by surprise”.

“Policy has had only a small impact, although it was starting to bite when the Abbott government was elected and began dismantling effective responses to climate change,” he said.

Melbourne University political scientist and Australian Conservation Foundation board member Peter Christoff also called for a higher climate target: “Based on these new figures, our minimum 2020 target should be lifted from 19% to at least 20%.”

Dr Christoff said other factors had inadvertently contributed to the fall in Australian emissions before 2012, including the high Australian dollar squeezing manufacturing. “What we need is good targeted policy, rather than seeing outcomes like this coming from random and uncontrolled actions.”

“It’s worth noting that the 5% reduction below what was expected between 2008 and 2012 occurred when there were no substantial policies in place to assist in emissions reductions: major initiatives like the carbon tax had not come into force. Since then, more companies have geared up to deal with climate change, and proper mitigation measures would put a higher target than we currently have for 2020 well within reach.”

**BEYOND KYOTO?**

Associate professor of law at the University of Western Australia David Hodgkinson has long been critical of the Kyoto process. He said the latest government figures highlighted what a “generous” target Australia had with its first Kyoto target.

But he remains concerned that the current United Nations process could actually get in the way of effective global action.

“A survey of climate change law and policy at the national, sub-national and city levels reveals significant – and potentially significant – bottom-up action in both developed and developing states, and outside the top-down [United Nations] framework.

“At some point ... [we may see] a shift away from a top-down, ‘Kyoto-style’ architecture for international climate action, to an approach involving smaller agreements between states and/or sectors, or to sub-national actors (including provinces, councils, cities) taking action where they can.”

Liz Minchin is Queensland Editor at *The Conversation*, and a Walkley award-winning journalist and author. She worked at *The Age* newspaper for a decade, most recently as news editor of *The Saturday Age*. She has also worked as a media trainer, and co-written a book on bigger-picture solutions to climate change, *Screw Light Bulbs*.

CCA shows 5 per cent reduction target is inadequate and economically reckless

The final report from the independent Climate Change Authority (CCA) should shatter the wilful blindness amongst political and business leaders that the current minimum 5 per cent 2020 reduction target is adequate or economically responsible, The Climate Institute says.

For too long our public debate on climate change has focused on pollution reduction goals that are inadequate and economically risky as well as internationally ignorant and unfair,” said John Connor, CEO of The Climate Institute.

“The Authority’s recommended carbon budgets and emission targets should shatter acceptance of the chronically short-sighted 5 per cent 2020 reduction target.”

“Under international agreements, the Government remains committed to bipartisan targets to cut carbon pollution by up to a quarter by 2020, and to advance a new post-2020 emission target by April next year.”

The Authority, chaired by former Reserve Bank Governor Bernie Fraser and with a Board including former industrialists and active climate scientists, released its final report today as required under the Clean Energy Act 2011. It recommended an effective 19 per cent 2020 and 40-60 per cent 2030 emission reduction targets, along with a 2050 10 billion tonne carbon pollution budget. The Act requires the Government to declare, by end of May 2014, pollution reduction caps for five years after 1 July 2015.

“Should the Government stick with the minimum 5 per cent pollution reduction target, it would be ignoring all credible independent advice that suggests this target is scientifically inadequate, economically risky and out of whack with the actions of the USA and other major emitters.”

“By recommending 2030 goals and clearly embedding our nation’s commitments in a long-term carbon budget, the CCA has clearly linked our short-term emission reductions with our longer-term interests giving business clear investment signals on the direction of policy.”

“A plan that ends in 2020 ends at the beginning. The Authority’s report and climate action elsewhere highlight that deep and significant reductions will continue to be required long after 2020.”

“Writing in The Australian today, the Business Council of Australia typified the habitual short-sightedness of some vested interests in the current climate debate.”

“The BCA and the mining industry want to end current requirements on our largest emitters to take responsibility for their pollution. They have not put forward an alternative credible policy to reduce pollution or cope with climate impacts, which our best scientists say are beyond the ability of major sectors of the economy to cope with.”

“Not ensuring that major emitters play their part in reducing national pollution levels means taxpayers must shoulder the investment in reducing emissions. Under Government proposals, this would see growing multi-billion costs to the Federal budget and growing pollution levels.”

“The Climate Institute notes that in some aspects of its report the Climate Change Authority should have been more ambitious. To achieve our national interest goal of helping avoid a 20°C increase in global temperature a more ambitious 2020 target of 25 per cent reductions and national carbon budget consistent with a high chance of avoiding dangerous climate change would further reduce the economic risks of delaying credible climate change action,” Connor said.

The Climate Change Authority has released its final report and recommendations on Reducing Australia’s Greenhouse Gas Emissions, as called for in the Clean Energy Act 2011. The Authority’s major recommendation is that Australia target a minimum reduction of 15 per cent in greenhouse gas emissions – compared with 2000 levels – by 2020. This would represent a significant tightening of Australia’s existing commitment to reduce emissions in 2020 by a minimum of 5 per cent.

Adoption of the recommended 2020 target would constitute a responsible response by Australia at this time to the challenges of climate change. These challenges will require sustained actions by Australia (and other countries) and the Authority has made a number of recommendations to help guide policymakers in the decades beyond 2020.

THE SCIENCE

As it is required to do, the Authority has consulted widely with stakeholders and carefully weighed many considerations in coming to its recommendations. Particular weight has been given to the accumulating scientific evidence that global temperatures have been trending upwards over the last 50 years and that greenhouse gas emissions from everyday activities by businesses and households are the major driver of this trend. Assessments of future social and economic consequences of ongoing global warming are necessarily more provisional than the identification and explanation of the trend itself but are nonetheless very challenging.

In broad terms, mainstream climate science suggests that many of the social, economic and environmental impacts of climate change might be manageable if, for the long term, warming could be held to 2 degrees Celsius (compared with pre-industrial levels) – certainly more manageable than they would be if temperatures were to rise by 4 or 5 degrees.

The same body of climate science also suggests there is a 2 in 3 chance – a 67 per cent probability – that the rise in global temperatures would be held to 2 degrees if total global emissions between 2000 and 2050 were to be limited to 1,700 billion tonnes of greenhouse gas emissions (in carbon dioxide equivalent tonnes). What makes climate change such a challenging task for policymakers everywhere is that roughly a third of this global emissions ‘budget’ has been used already.

There are signs that momentum in other countries to address climate change is growing. In particular, the world’s two largest emitters, China and the United States, are stepping up their efforts to reduce emissions. Australia should play its part in this global endeavour.

EMISSIONS REDUCTION TARGETS AND GUIDANCE FOR AUSTRALIA

Against this background the Authority believes adoption of its recommendation for a minimum 2020 emissions reduction target 15 per cent below 2000 levels would be a credible response by Australia to the task of containing the rise in global temperatures. It would require concerted action over the years to 2020, the more so given that emissions in 2012 were about 2½ per cent above 2000 levels.

Australia has some emission credits which have accrued under the Kyoto Protocol as a result of its emissions in recent years being less than its Kyoto target. These credits can be carried forward to the 2013-2020 period and are equivalent to an extra 4 percentage points on Australia’s 2020 target. The Authority has recommended that these credits be applied to extend the minimum 15 per cent target for 2020 to an effective target of 19 per cent (rather than be offset against the recommended minimum of 15 per cent or, for that matter, against the current commitment to a minimum 5 per cent reduction).

Even with the large reductions in emissions envisaged in the Authority’s recommendations for 2020, sustained actions would continue to be required in subsequent decades.

The Authority calculates Australia’s fair share (about 1 per cent) of the global emissions ‘budget’, estimated to give a 67 per cent probability of holding warming to under 2 degrees, as a national emissions budget of 10.1 billion tonnes of greenhouse gas emissions for 2013-2050. The Authority recommends emissions reductions of between 40 and 60 per cent below 2000 levels by 2030 – the centre of this range is consistent with this...
national emissions budget.

This recommended ‘trajectory range’ is intended as guidance for longer-term policy and investment decision making in the climate change area. It also highlights the important trade-offs involved: a smaller reduction in emissions in the period to 2020 would push more of the burden of adjustment into later periods and onto future generations.

In its deliberations the Authority has had access to various modelling activities, including work published by the Intergovernmental Panel on Climate Change (IPCC) and work commissioned from the Treasury; these are detailed in the report. The assumptions fed into these models and the outcomes produced will, inevitably, change over the years, and possibly in substantial respects. There is no reason to believe, however, that the net effect of such changes will be favourable in terms of the emission reductions tasks facing Australia and other countries.

To help manage the risks inherent in all modelling exercises the Authority has recommended that the trajectory range and national emissions budget be reviewed at least every 5 years, having regard to developments in climate science, international actions, and other relevant factors.

**COSTS OF EMISSIONS REDUCTION GOALS**

As required by its legislation, the Authority’s primary focus in this Review has been on Australia’s goals for reducing emissions (and progress towards them), rather than possible measures (and their costs) for pursuing these goals; these latter considerations, however, have necessarily entered into its deliberations.

The costs of delivering any emissions reduction target depends on the particular suite of measures implemented for the task. This is very uncertain territory at present: the carbon pricing mechanism is slated for abandonment but the details of the Government’s alternative Direct Action Plan are still being developed. The Government has also announced it will review the current Renewable Energy Target arrangements over the months ahead. These matters will need to be clarified before meaningful estimates of the costs of achieving domestic emissions reductions can be made.

The Authority has, however, drawn attention to two particular matters related to measures and costs. First, given the magnitude and complexity of the challenges posed by climate change it makes sense for policy makers to access the widest possible range of policy tools – to use market mechanisms (including prices on carbon and emission trading schemes) where these work effectively, and non-market arrangements (including regulations and standards) where they do not work well.

Several prospective opportunities for pursuing reductions in emissions are identified in the report. At this time the Authority is recommending that the Government investigate the possible early introduction of CO2 emission standards for light motor vehicles.

Secondly, to be competitive in the lower carbon global economy of the future, Australia should be developing cost effective programs now which, by reducing domestic emissions, will not only assist in the necessary structural transformation of the economy but also open up opportunities for new investments and exports.

Even in a generally receptive political environment these kinds of initiatives would have quite long lead times before any resultant reductions in emissions began to emerge. In the meanwhile, however, to bridge the gap between what domestic actions can achieve and Australia’s 2020 goals international emission reductions could be purchased. In terms of reducing global emissions and helping to limit the rise in global temperatures, such purchases would have much the same effects as reductions in domestic emissions.

A large supply of genuine emissions reductions is currently available in global markets at historically low prices. The budgetary cost of moving from the current minimum 5 per cent target to the Authority’s recommended target entirely through international purchases is estimated at between $210 and $850 million, assuming average unit prices of between $0.50 and $2 (current prices are under $1).

The Authority has recommended that the Government establish a fund to purchase international units to help meet the recommended 2020 goals.

**Background note**

The Climate Change Authority is an independent statutory body established in 2012 to provide expert and balanced advice on climate change policy issues (including Australia’s emission reductions goals). It comprises members with considerable expertise in relevant disciplines, including climate science and economic policy, and is backed by an experienced and independent secretariat. The Government has introduced a Bill to abolish the Authority; that Bill is still before the Parliament.

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Climate Change Authority (27 February 2014).
TARGETS AND PROGRESS REVIEW:
FREQUENTLY ASKED QUESTIONS

The Climate Change Authority explains its final report recommendations

What is the Authority recommending?

The Climate Change Authority is recommending a set of greenhouse gas emissions reduction goals for Australia that provide a clear course to 2020 and guidance beyond this:

- **2020**: a minimum target of 15 per cent below 2000 levels, plus 4 per cent credit from past action to reduce emissions (‘carryover’), raising the target to 19 per cent below 2000 levels
- **2030**: a trajectory range of 40-60 per cent below 2000 levels
- **2013-2050**: a long-term national emissions budget to limit Australia’s total emissions to 10.1 billion tonnes of carbon dioxide equivalent.

Why isn’t a 5 per cent target for 2020 enough?

The Authority concludes that Australia’s current minimum 5 per cent target for 2020 is inadequate:

- Australia will benefit from global action to keep warming below 2 degrees and avoid the worst impacts of climate change. Australia should be willing to play its part. A 5 per cent target for 2020 would not be a credible start by Australia towards this goal. It would leave an improbably large task for future Australians.
- An Australian 5 per cent target does not keep up with the growing momentum of global action on climate change.
- Australia can meet stronger targets while the economy and national income continue to grow.
- The Authority has also examined the government’s conditions for moving beyond 5 per cent and concludes they have been met.

What is the cost of achieving the recommended 2020 target and who will pay?

The cost of meeting the recommended targets and who pays will depend on the policies in place. Under the current legislation, if Australia pursues a 5 per cent target gross national income (GNI) per person is projected to grow by an average of 0.80 per cent annually over the period to 2020, or by 0.78 per cent with the Authority’s recommended target of 15 per cent plus 4 per cent carryover.

The Authority has recommended the government establish a fund to...
purchase international emissions reductions to bridge the gap between domestic reductions and the recommended target. The distribution of the costs of the fund through the economy would depend on how the fund is financed.

The Authority’s analysis shows Australia can achieve the recommended 2020 target while the economy and incomes continue to grow.

Have the government’s 2020 target conditions been met?

The government set out a range of conditions for increasing the 2020 target from 5 up to 25 per cent below 2000 levels.

The Authority has taken the government’s conditions into account, but it is required by law to consider a broader range of factors, including climate science, international action, equity and economic impacts in making its recommendations.

The Authority’s analysis of the government’s target conditions shows that the conditions for moving beyond 5 per cent have been met. Some of the conditions for 15 per cent have been met, others are marginal. The conditions for a 25 per cent target have not been met.

What action is the rest of the world taking on climate change?

Momentum in other countries to address climate change is growing. Ninety-nine countries covering more than 80 per cent of global emissions have made international pledges to reduce or limit their emissions.

The world’s two biggest emitters, China and the United States, are stepping up their climate action. They are investing in renewable energy technologies, introducing carbon pricing in different states and cities, and regulating pollution from cars and power plants.

The Authority’s recommended emissions reduction goals would put Australia more closely in line with the actions of other similar countries, including the United States and United Kingdom.

The recommended 2020 target would be a credible response by Australia to the latest climate science. It spreads the efforts of cutting emissions more fairly between now and future Australians, avoiding higher costs and a more disruptive transition later. It is also more in line with action being taken by countries like Australia, for example the United States and United Kingdom.

What progress has Australia made in reducing its emissions?

Australian governments have used policies to reduce emissions for more than two decades, including regulatory measures and market based schemes.

Since 1990, the size of Australia’s economy has doubled while emissions have increased by only a small amount; Australia’s emissions intensity (emissions per dollar of GDP) has halved.

Falling emissions intensity is partly due to the changing composition of the economy, away from emissions-intensive manufacturing. Policy has also played an important role, particularly in the land and electricity sectors.

What are the opportunities for future emissions reductions?

Australia has many opportunities to reduce its domestic emissions, including in:

- Electricity generation (shifting to lower emissions sources such as renewables)
- Energy efficiency in buildings and industry, as well as fuel efficiency in transport
- Installing technologies to reduce or capture gases released in mining and manufacturing
- Reduced emissions from farming and increased absorption of emissions in soils and vegetation.

Strong and well-coordinated policies are essential to realise these opportunities.

In the short term, genuine international emissions reductions are a cost-effective and environmentally sound way to bridge the gap between domestic emissions reductions and the recommended 2020 target.

Why does the Authority support the use of international emissions reductions?

Genuine international emissions reductions are a cost-effective and environmentally sound way to help Australia meet its goals.

The Authority recommends the government establish a fund to purchase high-quality international emissions reductions to bridge the gap between domestic reductions and the recommended 2020 target. International trade benefits Australia by reducing costs.
Effective action on adapting to climate change needs to be based on current and reliable information about what Australians think about climate change.

A CSIRO research project is undertaking a systematic research project to better address public perceptions and understandings of climate change.

This research complements and informs the climate and adaptation research undertaken across many science and social science disciplines within CSIRO.

Four online surveys were undertaken at approximately yearly intervals from 2010 until 2013. They all use the same method and a core component of questions to benchmark attitudes and track changes.

Some additional or alternative questions are also included every year to reflect the changing public conversation.

The first survey in 2010 was just prior to the Federal election. It shows that most Australians consider climate change is happening and the majority consider that human activities play a role.

An interesting result from this survey is the relationship between attitudes to climate change and political voting intentions.

In Australia, like many other countries, attitudes to climate change and political voting intentions are strongly linked.

The second survey in 2011 was just prior to legislation being put to parliament to introduce a price on carbon. It showed that acceptance of climate change changed little over the year.

The third survey in 2012, similar to the two previous surveys, found that most people agree that climate change is happening, but they remain divided about the role played by human activity. There was strong evidence that people overestimate the prevalence of their own views on the nature of climate change.

The fourth survey in 2013 investigated the community’s own projections of how their local climate might change in the future, and how they planned to respond. Previous experience with extreme climate and weather events was positively linked to anticipated coping. It was also revealed that most people tend to overestimate the amount of actions they’re taking to respond to climate change relative to other Australians.

In Australia, like many other countries, attitudes to climate change and political voting intentions are strongly linked.

Opinions about the causes of climate change remain relatively unchanged from 2010. However, some additional or alternative questions are also included to reflect the changing public conversation.

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Fourth annual survey of Australian attitudes to climate change

EXECUTIVE SUMMARY FROM AN INTERIM REPORT PRODUCED BY THE CSIRO

This report is the fourth in a series of publications examining Australians’ responses to climate change. The report outlines the findings from a survey of 5,219 Australians conducted in July and August of 2013. Respondents included a group of 2,202 people who had also undertaken at least one of our surveys in 2010, 2011, or 2012. We investigate five topics of climate change responses, the major findings of which are as follows.

ATTITUDES TO CLIMATE CHANGE
- A large majority of people think climate change is happening, and are slightly more likely to attribute climate change to humans than to natural fluctuations in Earth’s temperature.
  More than 80% of respondents thought climate change was happening, similar to previous surveys. On average, respondents estimated that human activity accounted for about 62% of changes to the climate.
- People are inaccurate when predicting the views of other Australians.
  When asked about the nature of climate change, fewer than 8% of respondents were of the opinion it was not happening at all, yet these respondents estimated that almost 50% of the Australian public would share their view. Further, the prevalence of the view that climate change is not happening was overestimated by people of all opinion types.
- Climate change ranks low in importance when compared to other concerns.
  Respondents ranked climate change as the 14th most important concern among 16 general concerns, and 7th out of 8 environmental concerns.
- There is little familiarity with climate change terminology.
  Roughly one in five respondents had heard of ‘climate mitigation’, while one in four had heard of ‘climate adaptation’.

CLIMATE CHANGE RELEVANT BEHAVIOUR
- People engage in climate-relevant behaviour for a variety of reasons.
  Environmental motivations figured more prominently for respondents engaging in more behaviours, while financial motivations dominated for respondents engaging in fewer behaviours.
- People tend to overestimate how much they do compared to others.
  More than 90% of respondents estimated they engaged in the same or more behaviours than other Australians. Less than 7% thought they did less than other Australians. Further, for those respondents engaging in relatively few behaviours, only 10% thought they did less than the average Australian.
- Certain attitudes toward climate change are better predictors of behaviour than opinions on what causes climate change.
  Tested together, personal relevance, feelings of moral and ethical responsibility, and experience with climate change, were the strongest predictors of pro-environmental behaviour. Levels of surety that climate change was happening and threat perception, however, made no significant additional contribution to predicting behaviour.

CLIMATE ESTIMATES AND PROJECTIONS MADE BY THE PUBLIC
- People think extreme climate and weather events will increase more in intensity than frequency in the future.
  Respondents thought heatwaves, heavy rains, and storms were most likely to increase in frequency and intensity in their region, although expected increases were low to moderate. Duststorms, cyclones, and snowstorms were expected to increase by the least amount.
There is more variability in people's perceptions of regional rainfall changes than temperature changes. The majority of respondents thought their region had become hotter since 1990, and would be hotter in 20 and 40 years' time. The majority of respondents thought their region had become wetter since 1990, but would get drier in 20 and 40 years' time. Roughly 25% to 30% of respondents thought both temperature and rainfall had remained and would remain stable in their region.

PERCEIVED VULNERABILITY, COPING APPRAISALS, AND SUPPORT FOR ADAPTATION AND MITIGATION INITIATIVES

- People's anticipated levels of coping with future extreme climate and weather events are linked to their previous experiences. Respondents anticipated they would cope moderately well (financially, mentally, and physically) with a changing climate, but lower coping was anticipated for events where respondents had little prior experience of loss, damage, or injury.

- People think key sectors in Australia are at least moderately vulnerable to climate change. Natural ecosystems and food security were rated by respondents as the most vulnerable sectors, while tourism was rated as the least vulnerable sector.

- Initiatives to adapt to and mitigate climate change are generally supported. Most hypothetical policy initiatives received, on average, at least moderate support from respondents. Most support was given to investment in renewable energy resources, while least support was given to investment in nuclear power stations. Moderate support was given for taxing industries that emit high levels of greenhouse gases.

People are slightly more positive now about the potential outcomes of responding to climate change.

CHANGES OVER TIME: 2010-2013

- Attitudes to climate change, and climate-relevant behaviours, have remained relatively stable since 2010, with a few minor exceptions. For our repeat respondents, opinions about the nature and causes of climate change were stable, except for a slight increase in the proportion of respondents who said they didn’t know. Stated levels of behavioural engagement remained static except for a small decrease in the proportion of people reducing their household water use.

- People are now slightly more trusting of a range of agencies to tell them the truth about climate change, through overall trust levels remain modest. Repeat respondents increased their ratings of trust in agencies, including environmental group scientists and government scientists, to provide truthful information about climate change. While there were no changes over time, trust in university scientists, and friends and family, remained highest throughout the time period.

- People are slightly more positive now about the potential outcomes of responding to climate change. There was a slight increase in repeat respondents endorsing the sentiments that responding to climate change would provide people with a sense of purpose, provide people with an opportunity to be part of something bigger, and foster greater community spirit. Conversely, respondents were less likely to say that responding to climate change would cost too much money and jobs, and that nothing meaningful could be done by Australia about climate change.
COMPARING THE PARTIES’ CLIMATE CHANGE AND RENEWABLES POLICIES

In this article courtesy of The Conversation, Lisa Caripis summarises the major political parties’ climate change policy platforms for the last federal election.

Serious discussion of climate change policy has been noticeably absent this election campaign – while the issue was allotted a portion of the first leaders’ debate, little time was devoted to it. Nonetheless, there are significant differences in the climate change and renewable energy policies of the ALP, Coalition and Greens. The major differences between the parties are outlined below.

REDUCING GREENHOUSE GAS EMISSIONS

There are two key questions for policymakers in this area:

- **By how much and how soon should we reduce our emissions?**
- **How should we reduce our emissions?**

**How much should we reduce emissions?**

Both the ALP and Coalition are committed to cutting emissions by at least 5% below 2000 levels by 2020, but will consider increasing that to 15% or 25% depending on the level of action around the world.

The Greens have long considered the 5% figure to be too low.

Both the ALP and the Greens supported the passage of the Clean Energy Bill that enshrines in law a commitment to cut emissions by 80% below 2000 levels by 2050. The Coalition is proposing to abolish the independent, expert Climate Change Authority, which advises the government on the targets and yearly cap under the emissions trading phase of the carbon price.

**How should we reduce emissions?**

The ALP and Greens are committed to carbon pricing to cut Australia’s emissions, while the Coalition will ‘abolish the tax’ and introduce a voluntary scheme as part of its Direct Action Plan.

**Carbon pricing:** Australia has a carbon pricing mechanism that requires the biggest producers of greenhouse gas emissions to pay for their emissions. The theory behind carbon pricing is that by making it more expensive to produce emissions, entities will have an incentive to reduce their emissions. An added incentive comes in the trading phase of the scheme when entities can sell their emissions savings (in the form of excess units).

Rather than introducing tailored regulation for different sectors, carbon pricing leaves it up to the individual polluters to work out the best way to cut their emissions.

The Greens do not support the ALP’s proposal to bring forward the emissions trading phase of the scheme by one year to July 1 2014. When Australia moves to an emissions trading scheme (ETS) it will be linked to the European Union ETS. Because the price of carbon is so low in the EU, the sooner Australia moves to an ETS, the lower our carbon price will be and the weaker the incentive emitters will have to reduce their emissions.

**Direct action:** The Coalition’s Direct Action Plan is premised on the idea that “rewarding innovation and initiative”, rather than penalising polluters is a more effective way to reduce emissions.

The plan was first articulated in 2010. The Shadow Minister for Climate Action, Greg Hunt, has provided further details in speeches.

The centrepiece of the Direct Action Plan is a voluntary, competitive scheme that offers a cash reward to entities that undertake projects to reduce their emissions. Under direct action, applicants submit project proposals to an Emissions Reduction Fund (ERF) which runs a competitive selection process. Entities are paid when their project has delivered the proposed emissions reductions.

The fund has an annual budget limit and will not favour any particular type of project. Project-specific methodologies will be developed to measure and verify emissions reductions.

**RENEWABLE ENERGY**

Australia has three main policies to support renewable energy in the short term.

**Renewable Energy Target**

The Renewable Energy Target (RET) is a legally binding target – by 2020 we have to generate 41,000 GWh of electricity from large-scale renewable energy sources such as wind and solar farms.

When the quota was legislated in 2010, it was expected that the 41,000GWh plus the electricity from federally-supported small-scale renewables would amount to 20% of all electricity consumed in 2020. But we are...
consuming less electricity than expected. This means that under the 41,000GWh target, more than 20% of the electricity consumed in Australia will be generated by renewables in 2020.

All parties support keeping the RET.

The ALP agrees with the recommendation of the expert Climate Change Authority that the next review of the RET should be in 2016. The Coalition wants it reviewed again in 2014.

Only the Greens have a policy on expanding the RET, by increasing the target to 90% by 2030.

**Clean Energy Finance Corporation**

The Clean Energy Finance Corporation (CEFC) is an independent body, established to stimulate investment in clean energy projects. A$2 billion every year for five years is guaranteed by legislation. At least half of the funding must be invested in renewable energy. Funding cannot be spent on technologies for carbon capture and storage or nuclear power.
- The ALP wants to retain the CEFC.
- The Coalition wants to scrap the CEFC.
- The Greens want to triple the CEFC’s funding and have it run for ten years.

**Australian Renewable Energy Agency**

The Australian Renewable Energy Agency (ARENA) is an independent agency that provides grants and funding for renewable energy. It has $3 billion to 2022 guaranteed by legislation to fund renewable energy projects and related research.

All parties support keeping ARENA.

**ELECTRICITY GRID REGULATION**

Only the Greens have a policy to ensure renewable energy generators have access to and can connect to the grid. Our grid was built to support centralised, coal-fired generation and often does not extend to the places where it would be best to build wind or solar farms.

Currently, planning for where to build new power lines is done on a state-by-state basis. The Greens think that the Australian Energy Market Operator (AEMO) should have a national grid planning role to ensure the grid can optimally accommodate more renewable energy.

**FOSSIL FUEL PRODUCTION**

Australia is the world’s largest exporter of coal and is a leading exporter of gas. Government policies and regulations affect the growth of the fossil fuel industry.

- **Regulating new fossil fuel developments**
  - The Coalition wants to reform national environmental protection assessment and approvals processes to reduce the complexity, cost and uncertainty for proponents of major projects, like coal mines and power stations.
  - The ALP says it will not hand over approval power to the states even though it had been considering doing so 2012.
  - The Greens want to amend our national environmental protection law, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), to ensure that federal approval processes cannot be devolved to the states. They want a moratorium on the development or expansion of coal mines and coal ports along the Great Barrier Reef.

- **Coal seam gas**
  - The Labor government expanded the EPBC Act to require that federal decision-makers consider the impact on water resources of coal seam gas and large coal project applications (also known as the ‘water trigger’).
  - The Coalition does not support the water trigger.
  - The Greens support the water trigger and want a moratorium on all new coal seam gas, shale and other unconventional gas projects.
CLIMATE DEBATE CUTS BOTH WAYS

Neither a $6 carbon price nor a direct action fund of $3.2 billion will minimise Australia’s impact on dangerous climate change, Richard Denniss writes in this opinion piece first published in the Canberra Times.

Do you think cars are better than planes? What about apples? Are apples better than sandwiches? It is hard to answer some questions because they don’t make much sense. Take our political debate about climate change, for example.

Do you think we need a price on carbon or do you support direct action? I struggle with that question more than most seem to. To be clear, I absolutely think that we need a price on carbon, but we could do with some direct action as well. Surely I am allowed to want both?

Until recently the ALP, the Greens and most of the big environment groups were fans of direct action. Of course it wasn’t called direct action then, it was called ‘complementary measures’ and the environment movement loved them.

But the fact that the ALP and Greens used to support direct action by another name does not mean the Abbott government’s scheme will work. It does, however, make the current debate about whether people are on the ‘side’ of carbon pricing or direct action a bit silly.

The main reason that direct action has a chance of working is that it doesn’t actually have to do much. The carbon price deal between the ALP and Greens ignored the scientific evidence in locking in a target of only a 5 per cent reduction below 2020, an unambitious and unscientific target that the Coalition shares.

Australia’s emissions had begun to fall well before the carbon price came in and before direct action was even a twinkle in Tony Abbott’s eye. In fact a significant slice of our new target comes from the ‘surplus’ we generated by exceeding our 2010 target. That is, because we did ‘too much’ emission reduction pre-2010, we don’t have to do as much in the lead-up to 2020.

And then there is the high dollar and the devastating impact of the mining boom on the competitiveness of our manufacturing industry.

To be clear, I absolutely think that we need a price on carbon, but we could do with some direct action as well. Surely I am allowed to want both?

We have already seen two aluminium smelters shut down in recent years and Ford has said it is leaving. As more smelters and car factories close, our emissions fall. When the carbon price could be blamed for such closures it was a national tragedy, but when the miners cause such job losses via the exchange rate, it seems we just call it progress.

The high dollar is also killing off the last of the export wood chip market, which has for decades been subsidised to turn old-growth trees that sequester carbon into wood chips for paper and cardboard.

The fact that we are now chopping down far fewer trees means that our emissions are far lower and, in turn, Labor’s 5 per cent target is easier to achieve.

Next is the spectacular inefficiency of our electricity market. Despite the promises that the deregulation and privatisation of our electricity industry would lead to lower prices, the retail cost of electricity has surged by more than 100 per cent since 2007. The inefficiency and profitability of the electricity market has driven far bigger increases in electricity prices than the deepest of deep greens ever hoped a carbon price would deliver. In turn, households and businesses have reined in their demand for electricity.

Finally, consider the ALP’s successful direct action policies. Schemes such as the renewable energy target and subsidies for rooftop solar panels have delivered a flood of renewable energy capacity which, contrary to popular belief, is putting downward pressure on the price of electricity. It is also
significantly reducing the amount of coal we need to run the air conditioners and clothes dryers that we tell developing countries we can’t live without.

There are, of course, some clouds on Australia’s emission reduction horizon. The massive expansion of our coal mining industry and coal seam gas industry will generate big increase in ‘fugitive emissions’. That is the methane that escapes when fossil fuels are being extracted.

Another problem for the Abbott government’s plan to achieve a 5 per cent emissions reduction without a carbon price could be the exchange rate. If the exchange rate falls and the manufacturing sector rebounds strongly, so will our emissions. A problem that no doubt some in government hope they experience.

Even if the carbon price is not repealed and we move to a floating carbon price in 2015 as planned, the carbon price would fall to about $6. And of course big polluters get 94.5 per cent of their pollution permits for free, meaning they would pay an average carbon price of 33¢ per tonne. Let’s be clear, a carbon price that low was never going to be the driving force in a ‘transition to a low-carbon future’.

While a low carbon price is better than none, the ALP’s complementary measures or the Coalition’s direct action were always going to have to do a lot of the work required to hit the 5 per cent target.

Similarly, if the Coalition botches the design of its direct action scheme then it may struggle to deliver on its promises. So what should they do?

The biggest problem with direct action as it has previously been described is that it could be an administrative nightmare. Hundreds of thousands of small and medium-sized businesses asking for grants to cut their pollution will take too long and cost too much to administer.

**The important question facing Australia’s leaders is not whether carbon pricing is good or bad. It is “how far and how fast does Australia need to cut its emissions to minimise the impact of dangerous climate change?”**

But, if the Coalition is strategic, it could buy large chunks of emission reduction at relatively low cost and, importantly, with low transaction and administration costs. The most obvious targets for such a strategic approach would be the logging and forestry sectors. Paying small amounts of money to discourage the chopping down of trees would actually be cheaper than the large amounts of subsidies we currently provide to the same industry to chop down trees.

There is big scope for cash flow-positive investments in energy efficiency in commercial buildings. The government should start with the massive stock of Commonwealth buildings and then start some conversations with the state governments. Similarly, state governments own a large stock of public housing that was ineligible for previous efficiency policies, such as the Rudd government’s insulation subsidies.

Dealing with the states allows the Commonwealth to significantly reduce its administrative costs.

Abbott and John Howard have said plenty of things that suggest they neither understand nor are concerned by, the scientific evidence about the need to massively reduce greenhouse gas emissions. The decision to scrap the carbon price suggests the Coalition cares as little about economic advice as it does about scientific advice.

But, that doesn’t mean that a $6 carbon price was going to tackle climate change. Nor does it mean the Coalition will inevitably fail to meet the ALP’s 5 per cent target.

The important question facing Australia’s leaders is not whether carbon pricing is good or bad. It is “how far and how fast does Australia need to cut its emissions to minimise the impact of dangerous climate change?”

Neither a $6 carbon price nor a direct action fund of $3.2 billion will get us within cooee of that level.

Richard Denniss is executive director of The Australia Institute.

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EXPLORING ISSUES

WORKSHEETS AND ACTIVITIES

The Exploring Issues section comprises a range of ready-to-use worksheets featuring activities which relate to facts and views raised in this book.

The exercises presented in these worksheets are suitable for use by students at middle secondary school level and beyond. Some of the activities may be explored either individually or as a group.

As the information in this book is compiled from a number of different sources, readers are prompted to consider the origin of the text and to critically evaluate the questions presented.

Is the information cited from a primary or secondary source? Are you being presented with facts or opinions?

Is there any evidence of a particular bias or agenda? What are your own views after having explored the issues?

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BRAINSTORM  52
RESEARCH ACTIVITIES  53
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MULTIPLE CHOICE  55-56
Brainstorm, individually or as a group, to find out what you know about climate change.

1. What is climate change, and what are some examples of both natural and human causes?

2. What is the greenhouse effect, and how is it relevant to changes in climate?

3. What is ocean acidification, and how does it relate to climate change?

4. What is renewal energy, and what are some examples?
Complete the following activities on a separate sheet of paper if more space is required.

1. Carry out a research project into the different ways countries are adapting to the effects of climate change. Research online to find examples of how communities around the world are altering their lifestyles in response to global warming. Do your findings differ from your expectation?

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Complete the following activity on a separate sheet of paper if more space is required.

Prepare a five-minute presentation on the current and projected future impacts of climate change. Include information on the global effects of climate change, and how climate change may affect Australia and the local area you live in. Be prepared to answer questions on your presentation from other students.
Complete the following multiple choice questionnaire by circling or matching your preferred responses. The answers are at the end of the next page.

1. Which of the following are greenhouse gases directly influenced and emitted by human activity? (select all that apply)
   a. CO2
   b. pH
   c. CH4
   d. BECC
   e. CFC
   f. HFC
   g. N2O
   h. IPCC

2. In what year was the Clean Energy Act enacted in Australia?
   a. 1880
   b. 1910
   c. 1987
   d. 1990
   e. 1998
   f. 2011
   g. 2014

3. Coral bleaching in the Great Barrier Reef is triggered by which of the following?
   a. Rising sea levels
   b. Tropical cyclones
   c. Marine heatwaves
   d. Reduced water temperatures
   e. Marine life overpopulation
   f. Tropical insect-borne diseases
   g. Extreme rainfall

4. Which of the following projected events are attributable to climate change? (select all that apply)
   a. Extreme heatwaves and hot days more often
   b. Cyclones are likely to become more intense but less frequent
   c. Droughts are likely to happen less often
   d. Sea levels will continue to rise
   e. Loss of wildlife species
   f. Daily rainfall to increase
   g. Extreme fire danger days will decrease
   h. Decline in snow cover
5. Match the following terms to their correct definitions:

1. **Climate mitigation**
   a. A market-based approach to reducing emissions by allowing entities with excess emissions units to trade with other entities.

2. **Climate variability**
   b. When carbon dioxide is released into the atmosphere.

3. **Emissions trading**
   c. Enabling society to cope with the climate changes that are already happening or that are unavoidable in the future.

4. **Climate adaptation**
   d. Reducing greenhouse gas emissions in order to compensate for greenhouse gas production somewhere else.

5. **Carbon offsets**
   e. Year to year changes around average conditions, meaning that consecutive summers will not be the same with some cooler and some warmer than the long-term average.

6. **Carbon neutral**
   f. The reduction of greenhouse gases to limit the amount of climate change.

7. **CO2 emissions**
   g. When carbon emissions are reduced to zero by reducing energy consumption, planting trees and using renewable energy sources.

**MULTIPLE CHOICE ANSWERS**

1. Climate mitigation
2. Climate variability
3. Emissions trading
4. Climate adaptation
5. Carbon offsets
6. Carbon neutral
7. CO2 emissions
The heat content of the world’s oceans has increased during recent decades and accounts for more than 90% of the total heat accumulated by the land, air and ocean since the 1970s (CSIRO, Q&A: climate change). (p. 1, 2)

On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by between 0.09°C and 0.13°C per decade over the period 1971-2010 (ibid). (p.1)

Average global sea levels have been rising consistently since 1880 largely in response to increasing concentrations of greenhouse gases in the atmosphere and the consequent changes in the global climate (ibid). (p.2)

Global-average sea levels are currently (between 1993 and 2010) rising at around 3.2 mm per year, faster than during the 20th century as a whole (ibid). (p.2)

Since the beginning of the industrial era, the absorption of increasing amounts of atmospheric CO2 has decreased ocean surface water pH by 0.1, or a 26% increase in the hydrogen ion concentration, and changes are expected to decrease pH by a further 0.06-0.32 by 2100, depending on the level of CO2 emissions in future (ibid). (p.2)

The concentration of CO2 in the atmosphere in 2011 was 391 parts per million (ppm) – much higher than the natural range of 170 to 300 ppm during the past 800,000 years (ibid). (p.3)

In the last 4 years more than 550 people lost their lives in natural disasters and the costs of repairing public and private infrastructure, insurance claims and lost productivity has run to tens of billions of dollars (ibid). (p.4)

Air temperatures have increased globally, by around 0.85°C since 1880, with most of the warming occurring since the 1970s (Department of the Environment, Indicators of climate change). (p.7)

Australia has observed a decrease in cold days, and an increase in warm days with more than double the number of record hot days observed since 1960 (ibid). (p.7)

Since 1993, the rates of sea level rise to Australia’s north and northwest have been 7 to 11 mm per year, with rates of sea level rise on the central east and southern coasts between 2 to 5 mm per year (ibid). (p.7)

Extreme hot days in Australia are getting hotter, with the rate of very hot (greater than 40°C) daytime temperatures increasing since the 1990s (ibid). (p.8)

Australia’s mean temperature has warmed by 0.9°C since 1910. (pp. 9, 11)

Over the past 15 years, the frequency of very warm months has increased five-fold and the frequency of very cool months has declined by around a third. (pp. 9, 10)

Rainfall averaged across Australia has slightly increased since 1900, with a large increase in northwest Australia since 1970. (p.9)

There has been an increase in extreme fire weather, and a longer fire season, across large parts of Australia since the 1970s. (p.10)

Arctic summer minimum sea-ice extent has declined by between 9.4 and 13.6% per decade since 1979, a rate that is likely unprecedented in at least the past 1,450 years (CSIRO, State of the Climate 2014: A clear picture of Australia’s climate). (p.10)

The increase in atmospheric CO2 concentrations from 2011 to 2013 is the largest 2-year increase ever observed (ibid). (p.10)

Tropical cyclones are projected to decrease in number but increase in intensity. (pp. 10, 11, 23)

The hottest area-averaged national maximum temperature ever recorded was 40.3°C on 7 January 2013 (Steffen, W, Hughes, L and Perkins, S, Climate Council: heatwaves are getting hotter and more frequent). (p.12)

Marine heatwaves can trigger coral bleaching events, affecting large areas of reefs. Bleaching events on the Great Barrier Reef have occurred repeatedly since the late 1970s, with none reported before then (ibid). (p.13)

The 30 years until 2012 were probably the warmest in 1,400 years, driven by ‘unprecedented’ levels of greenhouse gases – these are now at levels not seen for 80,000 years (Parker, M, Global warming ‘unequivocal’ and ‘unprecedented’ – IPCC). (p.18)

Temperatures between 2001-2010 were the highest on record, a decade that saw more records than ever broken (ibid). (p.19)

The IPCC predicts a sea-level rise of up to 1.1 m by 2100. For Australia, this means at least 14,800 commercial and industrial buildings, and as much as 35,000 km of road and rail are at risk (The Climate Institute, Climate Risks Around Australia). (pp. 21, 23)

Areas with annual average snow cover of 30 days per year could decline by 14-54% (ibid). (p.22)

Heat-related deaths are projected to rise by around 10,000 by 2100 (ibid). (p.23)

Climate change will exacerbate health problems up to 2050, and post-2050 is likely to increase ill-health. (p.24)

China is the biggest greenhouse gas emitter and will soon supersede the USA as the biggest economy (Murphy, S, and Rae, J, United Nations Climate Change Conferences: Copenhagen and Beyond). (p.35)

It is estimated that Australia’s emissions from 2008-2012 averaged 104% of 1990 levels, giving Australia 116 million tonnes of greenhouse emissions rights to carryover to its 2013-2020 Kyoto commitment (Minchin, L, Australia trounced Kyoto climate target, new report reveals). (p.37)

99 countries covering more than 80% of global emissions have made international pledges to reduce or limit their emissions (Climate Change Authority, Targets and Progress Review: Frequently asked questions). (p.43)

Since 1990, the size of Australia’s economy has doubled while emissions have increased by only a small amount; Australia’s emissions intensity (emissions per dollar of GDP) has halved (ibid). (p.43)

By 2020 we have to generate 41,000 GWh of electricity from larger-scale renewable energy sources such as wind and solar farms. (p.47)
Adaptation
In relation to climate change, adaptation aims to respond to the effects of global warming by adapting to altered environments. This includes adapting to changed food production methods, agriculture and sea levels.

Carbon cycle
The term used to describe the flow of carbon (in various forms, e.g. as carbon dioxide) through the atmosphere, ocean, terrestrial biosphere and lithosphere.

Carbon dioxide
CO2 is a naturally occurring gas; it is also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth’s temperature.

Carbon footprint
A carbon footprint is a measure of an individual’s effect on the environment, taking into account all greenhouse gases that have been emitted for heating, lighting, transport, etc. throughout that individual’s average day.

Carbon neutral
Where an individual or company’s carbon emissions are effectively reduced to zero through a combination of reducing energy consumption, using renewable energy and offsetting the remainder by (for example) planting trees to absorb carbon dioxide from the atmosphere.

Carbon offsets
Carbon offsets are a reduction in greenhouse gas emissions made in order to compensate for greenhouse gas production somewhere else. Offsets can be purchased in order to comply with caps, such as the Kyoto Protocol. For example, rich industrialised countries may purchase carbon offsets from a developing country in order to satisfy environmental legislation.

Carbon sequestration
The long-term storage of carbon dioxide in the forests, soils, oceans or underground in depleted oil and gas reservoirs, coal seams and saline aquifers. Examples include: separation and disposal of carbon dioxide from flue gases or processing fossil fuels to produce hydrogen and carbon-rich fractions; and direct removal of carbon dioxide from the atmosphere through land-use change, reforestation, ocean fertilisation and agricultural practices to enhance soil carbon.

Climate change
Climate change describes a global change in the balance of energy absorbed and emitted into the atmosphere. This imbalance can be triggered by natural or human processes. It can cause either regional or global changes in weather averages and frequency of severe climatic events.

Climate models
Scientific models designed to replicate the Earth’s climate. Scientists are able to hypothetically test the effects of global warming by simulating changes to the Earth’s atmosphere.

CO2 emissions
Carbon dioxide gas released into the atmosphere. CO2 is released when fossil fuels are burnt. An increase in CO2 emissions due to human activity is arguably the main cause of global warming.

Emissions trading
A market-based approach to reducing emissions that allows entities with excess emissions units to trade those emissions units with other entities. Trading can occur at the domestic, international and intra-company levels. International emissions trading constitutes one of the Kyoto flexibility mechanisms.

Fossil fuel
Fuel of biological origin that has become fossilised over millions of years. Largely comprised of carbon and hydrogen. Coal, natural gas and oil are all fossil fuels.

Global warming
This refers to a rise in global average temperatures, caused by higher levels of greenhouse gases entering the atmosphere which then absorb and trap radiative forces. Global warming is affecting the Earth in a number of ways, including melting polar ice caps, which in turn is leading to rising sea levels.

Greenhouse gases
A greenhouse gas is a type of gas that can absorb and emit longwave radiation within the atmosphere: e.g. carbon dioxide, methane and nitrous oxide. Human activity is increasing the level of greenhouse gases in the atmosphere, causing the warming of the Earth. This is known as the greenhouse effect.

Intergovernmental Panel on Climate Change
The IPCC is the leading scientific body which assesses and reviews global climate change. It was founded by the United Nations Environment Programme and the World Meteorological Organization and currently has 194 member countries from around the world.

Kyoto Protocol
An international treaty setting binding targets for 37 developed countries to reduce their greenhouse gas emissions by at least 5 per cent below 1990 levels for the years 2008-2012. It was made international law in 2005 and was the world’s first international agreement on tackling climate change.

Mitigation
In relation to climate change, mitigation refers to the act of reducing, or limiting, the level of greenhouse gas emissions in order to slow the rate of global warming. Emissions targets, government campaigns and the development of ‘greener’ energy sources are examples of how mitigation can be used to reduce climate change.

Renewable energy
Energy derived from the wind, sun, tides and other sources that, for all practical purposes, cannot be depleted.

GLOSSARY

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Websites with further information on the topic

Australian Climate Science Coalition  www.auscsc.org.au
Australian Conservation Foundation  www.acfonline.org.au
Bureau of Meteorology Australia – Climate change and variability  www.bom.gov.au/climate/change
Carbon Neutral  www.carbonneutral.com.au
Climate Action Network Australia  www.cana.net.au
Climate Change Authority  http://climatechangeauthority.gov.au
Climate Change in Australia  www.climatechangeinaustralia.com.au
The Climate Institute  www.climateinstitute.org.au
Climate Spectator  www.businessspectator.com.au/climate
Climate Scientists Australia  http://climatescientistsaustralia.org.au
CSIRO – Climate change and adaptation  www.csiro.au/Outcomes/Climate.aspx
Department of Agriculture – Climate change  www.daff.gov.au/climatechange
Department of the Environment – Climate change  www.climatechange.gov.au
Friends of the Earth Australia  www.foe.org.au
Greenpeace Australia Pacific  www.greenpeace.org.au
Intergovernmental Panel on Climate Change  www.ipcc.ch
Marine Climate Change  www.oceanclimatechange.org.au

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▶ The Climate Institute
▶ Climate Change Authority
▶ Intergovernmental Panel on Climate Change.

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