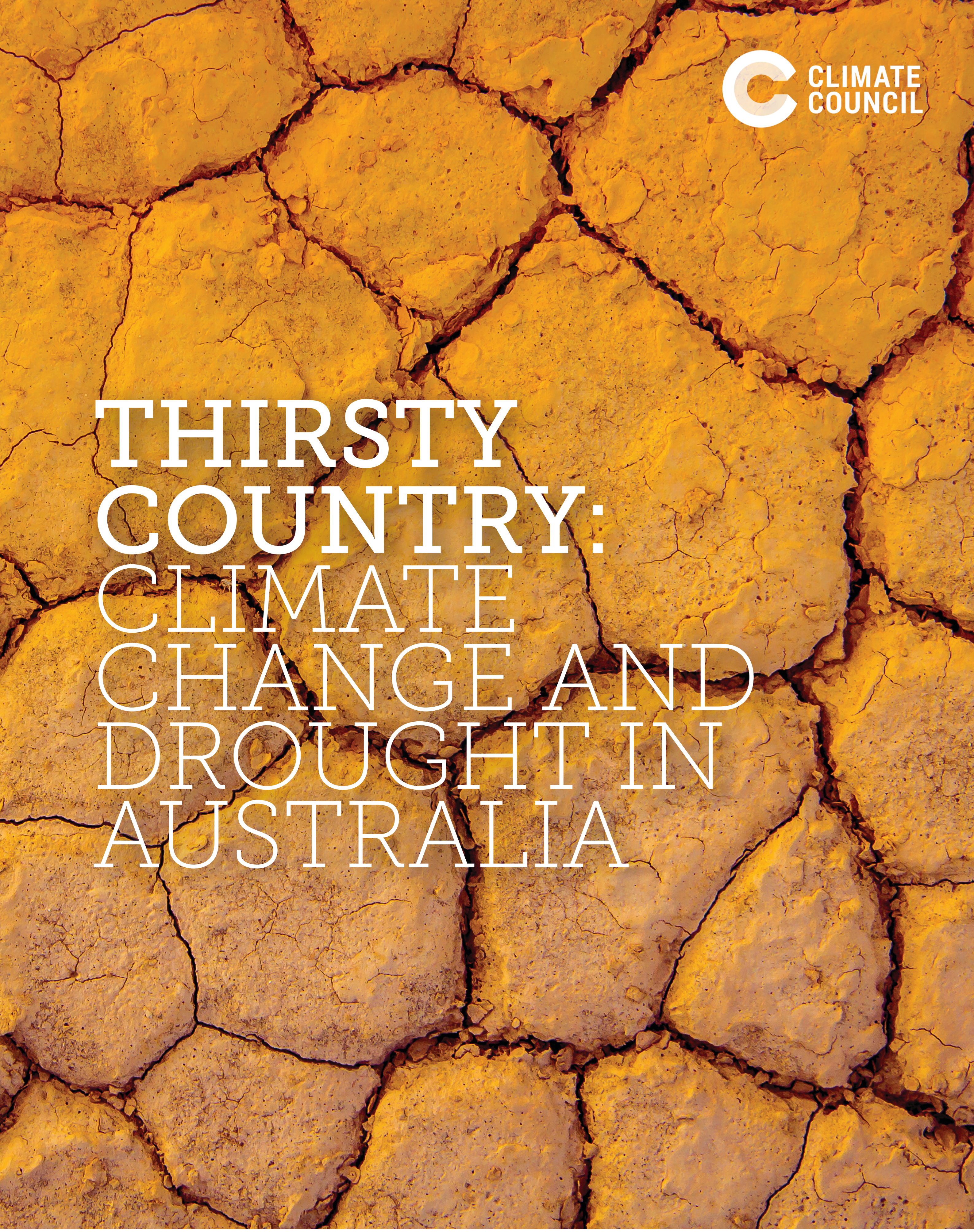

CLIMATE COUNCIL

THIRSTY COUNTRY: CLIMATE CHANGE AND DROUGHT IN AUSTRALIA

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

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Key Findings:

1. Climate change is likely making drought conditions in southwest and southeast Australia worse.

› Fronts from the Southern Ocean, which typically bring rain across southern Australia during winter and spring, have shifted southwards with a warming climate, leading to declines in rainfall in southwest and southeast Australia and increasing the risk of drought conditions in these regions.

› Since the mid-1990s, southeast Australia has experienced a 15 percent decline in the late autumn and early winter rainfall and a 25 percent decline in average rainfall in April and May.

› Average annual stream flow into Perth's dams has already decreased by nearly 80 percent since the mid-1970s.

› Climate change is driving an increase in the intensity and frequency of hot days and heatwaves in Australia, in turn increasing the severity of droughts.

2. Droughts have far-reaching impacts on health, agriculture and native species in Australia.

› The relative risk of suicide can increase by up to 15 percent for rural males aged 30-49 as the severity of drought increases.

› Between 2002 and 2003 decreases in agricultural production due to drought resulted in a 1 percent fall in the Gross Domestic Product (GDP), which is equivalent to half of Australia's decline in annual GDP following the global financial crisis in 2009.

3. Water scarcity will become an increasing challenge as the pressure on urban water supplies intensifies.

- Water inflows to key Sydney dams such as Warragamba and Shoalhaven could decrease by as much as 25 percent by 2070 if greenhouse gas emissions continue on their current trajectory.
- Annual water demand is projected to outstrip supply in Perth and surrounding regions by as much as 85 billion litres by 2030. That's enough water to fill 34,000 Olympic sized swimming pools.
- Average annual stream flows to Melbourne's four major water harvesting storages could decrease by seven percent by 2020 and by 18 percent by 2050.

4. Droughts are likely to worsen in severity and duration in southern Australia if greenhouse gas emissions are not cut deeply and rapidly.

- Average rainfall in southern Australia during the cool season is expected to decline further, and the time spent in drought conditions is projected to increase.
- In Western Australia total reductions in autumn and winter precipitation could be potentially as high as 50 percent in the next 80 years.
- To stabilise the climate, we must rapidly reduce greenhouse gas emissions, increase investment in clean energy, and most of the world's fossil fuel reserves – coal, oil and gas - must remain in the ground.

Introduction

Drought has deeply affected Australia throughout its history. The Millennium Drought from 1996-2010 serves as a recent reminder of the wide-reaching impacts that drought can have on Australia's people and environment.

Australia is the driest inhabited continent on Earth and drought is an important feature of Australia's climate. Whilst Australians have always lived with drought and its consequences, it is likely that climate change is making drought worse in the southeast and southwest, some of our most populous regions.

We begin this report by describing what a drought is, before considering its consequences for health, the economy, ecosystems and urban water supplies. We then outline the changing drought conditions and increasing drying trends in Australia and explore recent dry conditions in various parts of the country. We conclude by exploring how climate change is influencing drought conditions in the southeast and southwest of the continent as well as drying trends globally.

1. What is a drought?

Australia is the driest inhabited continent on Earth, with some of the world's most variable rainfall and stream-flow (DFAT 2014). The country has been deeply affected by drought throughout history, with significant droughts such as the Federation Drought (1895–1903), which led to the loss of millions of cattle, and the World War II drought (1939–1945), which contributed to plummeting wheat yields and disastrous bushfires (BoM 2014a; 2014b). The 'Big Dry' of 1996–2010 (also called the Millennium Drought) went down in history as one of the worst droughts on record for Australia, with devastating impacts (van Dijk et al. 2013).

Drought can be defined in a variety of different ways. In terms of its links to climate change, drought is best defined as meteorological drought, which is 'a prolonged, abnormally dry period when the amount of available water is insufficient to meet our normal use' and is generally measured by assessing rainfall deficiencies over three or more months (BoM 2014c).

In addition to meteorological drought, two other definitions of drought are used by different economic sectors or areas of research: agricultural drought, which is measured through deficits in soil moisture, and hydrological drought, which is based on anomalies in stream flow, lake and/or groundwater levels (IPCC 2012). Both of these definitions are important in terms of understanding the impacts of drought, and the consequences of climate change for these impacts.

As outlined by the Intergovernmental Panel on Climate Change (IPCC), 'climate extremes, such as drought, may be the result of an accumulation of weather or climate events that are not extreme when considered independently' (IPCC 2012, p.7). In Australia, the Bureau of Meteorology (BoM) measures drought by monitoring 'serious' or 'severe' rainfall deficiencies that have occurred for three months or more. A rainfall deficiency is considered 'serious' when rainfall is in the lowest 5-10 percent of the full range of rainfall amounts, from the very lowest to the very highest, for the period measured, and 'severe' when rainfall is in the lowest 0-5 percent of the range. Whilst BoM tracks rainfall deficiencies, it is the responsibility of the State and/or Federal Governments to officially declare a drought (BoM 2012).

2. What are the consequences of drought?

Drought has significant impacts on health, the economy, ecosystems and urban water supplies.

"The World Meteorological Organization has linked drought to 680,000 deaths globally from 1970–2012."

2.1 Health

Droughts can have wide ranging effects on health including on nutrition, infectious diseases, on forest fires causing air pollution, and mental health problems, such as post-traumatic stress and suicidal behaviour (Haines et al 2006; Climate Commission 2011). Droughts can also contribute to increases in mortality rates. The World Meteorological Organization (WMO) has linked drought to 680,000 deaths globally from 1970–2012 (WMO 2014). Declines in physical health are also particularly prevalent amongst the elderly in drought affected rural communities in Australia (Horton et al. 2010). Furthermore, drought can play a role in exacerbating mental health issues and increasing suicide rates in Australian drought-affected rural populations, especially amongst male farmers (Alston 2012). A recent study in New South Wales (NSW) found that the relative risk of suicide can increase by up to 15 percent for rural males aged 30–49 as the severity of drought increases (Hanigan et al. 2012).

"Drought can contribute to declines in human health and increases in mortality rates."

2.2 Economic

Drought affects agriculture, tourism, employment and livelihoods in Australia, with severe economic repercussions. Between 2002 and 2003 decreases in agricultural production due to drought resulted in a 1% reduction in the Gross Domestic Product (GDP) and a 28.5% fall in the gross value added for the agricultural industry compared to the preceding year (ABS 2004). This is a significant hit to the economy, considering that the global financial crisis caused a reduction of 2 percent in Australia's annual GDP from 2008 to 2009 (World Bank 2015). The predicted increase in drought frequency in the future has been estimated to cost $5.4 billion annually, reducing GDP by 1 percent per annum (Carroll et al 2007).

Several important agricultural areas, including southwest Western Australia, parts of central Queensland and northern New South Wales, Victoria and southern South Australia, and most of Tasmania, received below-average annual rainfall for 2014 (BoM 2015a). Significantly reduced rainfall in winter and spring across eastern Australia affects the intensive cropping and livestock breeding that is commonly practiced in the region, with potentially serious economic repercussions (ABARES 2012).

Particularly noteworthy droughts in recent history include the period from 1982–1983 when Australia experienced one of the most intense droughts on record, with a total loss of $3 billion in agricultural production alone (ABARES 2012). The Wimmera Southern Mallee region of Victoria experienced an 80 percent reduction in grain production and a 40 percent reduction in livestock production (BCG 2008).

More recently the Millennium Drought in southeast Australia, which lasted from 1996 to 2010, was one of the worst on record for the region (van Dijk et al. 2013). Southeast Australia experienced its lowest 13-year rainfall record since 1865 (CSIRO 2012). The Millennium Drought had wide-ranging repercussions. For example agricultural production fell from 2.9 percent to 2.4 percent of Gross Domestic Product (GDP) between 2002 to 2009, with drought playing a significant role in these observed declines in GDP (van Dijk et al. 2013). It is estimated that between 2006 and 2009 the drought reduced national GDP by roughly 0.75 percent. Between 2007-2008 regional GDP in the southern Murray-Darling Basin fell 5.7 percent below forecast and was accompanied by the temporary loss of 6000 jobs (IPCC 2014).

Figure 1: Cows in drought stricken fields, Wagga Wagga NSW

“By mid-2010 the Australian government had paid $4.4 billion in direct drought assistance to farmers.”

Drought can also be costly due to drought relief packages provided by the federal government. By mid-2010 the Australian government had paid $4.4 billion in direct drought assistance to farmers (ABARES 2012). Drought also has economic repercussions for Australia’s tourism industry. In the Murray River region, it is estimated that the drought caused an estimated $70 million loss because of reduced visitor days in 2008 (TRA 2010). A recent report by the WMO estimated that the impacts of Australia’s 1981 drought cost US$ 15.15 billion and was Australia’s most costly weather-related event (WMO 2014).

2.3 Ecosystems

Drought has significant impacts on Australia’s natural environment. For example, aquatic ecosystems are often affected by drought, with decreased water supplies reducing the availability of suitable habitat and leading to reductions in the populations of many fish and invertebrate species and, in some cases, contributing to local extinctions (Bond et al. 2008). During the Millennium Drought, there was a marked decline in water bird, fish and aquatic plant populations in the Murray-Darling Basin (LeBlanc et al. 2012).

Figure 2: Dead trees, South Australia

Many terrestrial ecosystems are also affected by drought, with iconic species such as the river red gum dying over extensive areas in the Murray-Darling Basin (Bond et al. 2008). The factors leading to the decline and death of these trees, many of which are several hundred years old, suggest that the circumstances that led to their decline are 'beyond natural conditions' (LeBlanc et al. 2012 p.236).

Severe heatwaves and drought are also one of the biggest threats to native eucalyptus species (Butt et al. 2013). Drought also poses risks to planted forests. During the Millennium Drought, for example, 57,000 ha of planted forest in Australia were lost (van Dijk et al. 2013). This is equivalent to the area of 28,500 cricket pitches.

> "During the Millennium Drought 57,000 ha of planted forest in Australia were lost. This is equivalent to the area of 28,500 cricket pitches."

As the trend towards hotter, drier conditions continues in southern Australia (Section 3), native species will continue to face habitat degradation, population declines, and in some cases extinction (Reisinger et al. 2014). If the rate of climate change that the continent is currently experiencing continues, many thousands of terrestrial and freshwater species could be at risk, such as the green and golden bell frog, the platypus and a variety of eucalypt forests (MacNally et al. 2009; Klamt et al. 2011; IPCC 2014; Climate Council 2014a).

> "Many thousands of plants and animals could be at risk if the rate of climate change continues"

2.4 Urban water supplies

Water scarcity in major cities, particularly Melbourne, Sydney and Perth, has been exacerbated by drought and remains an ongoing challenge. As of 2013, 89 percent of Australia's population lived in urban areas (World Bank 2013), placing high demand on urban water supplies as populations continue to grow. Pressure on urban water supplies is projected to intensify as droughts increase in frequency and severity in the southwest and southeast (Collett and Henry 2011).

Drought can significantly reduce inflows into vital urban water catchments, as occurred during the Millennium Drought (Section 3), resulting in water restrictions. For example, from 2007–2010 Melbourne was placed on Stage 3 restrictions and in 2009 Melbourne's water storage levels fell to a record minimum of 25.6 percent (Melbourne Water 2013; Melbourne Water 2014).

Industries also had to adhere to water restrictions, with the agricultural sector particularly affected by water scarcity and a resulting decline in crop yields (Grant et al. 2013; Melbourne Water 2014). Similarly, during the Millennium Drought in southeast Queensland severe water restrictions were implemented that saw average water use in some areas fall to 129 litres per person per day, in comparison to a regional urban consumption of 375 litres under normal operating conditions (Queensland Water Commission 2010).

Assessments of future impacts of drought on both water supply and urban water demand at the regional and/or catchment level suggest that water scarcity could increase across Australia. In NSW, under a high emissions scenario along with high population growth and less rapid technological change (IPCC 2000), water inflows to key Sydney dams such as Warragamba and Shoalhaven could decrease by as much as 25 percent by 2070 (NSW Office of Water 2010). These declines, coupled with a continued rise in annual demand for drinking water in the residential and commercial sectors, could increase the imposition of water restrictions in the state (NSW Office of Water 2010).

A study by Melbourne Water projects that under 'medium' climate change scenarios a potential seven percent decrease in average annual stream flows to Melbourne's four major water harvesting storages could be expected by 2020 and 18 percent by 2050 (Howe et al. 2005).

"Water scarcity could increase across Australia"

The projected increase in duration and intensity of droughts in southeast Queensland (CSIRO and BoM 2015; Section 3) is expected to increase the length of time it takes to refill key water storages in the region. An assessment of climate change impacts on water availability in Moreton catchment has found a decline in inflow into water

Figure 3: Recycling water in Melbourne

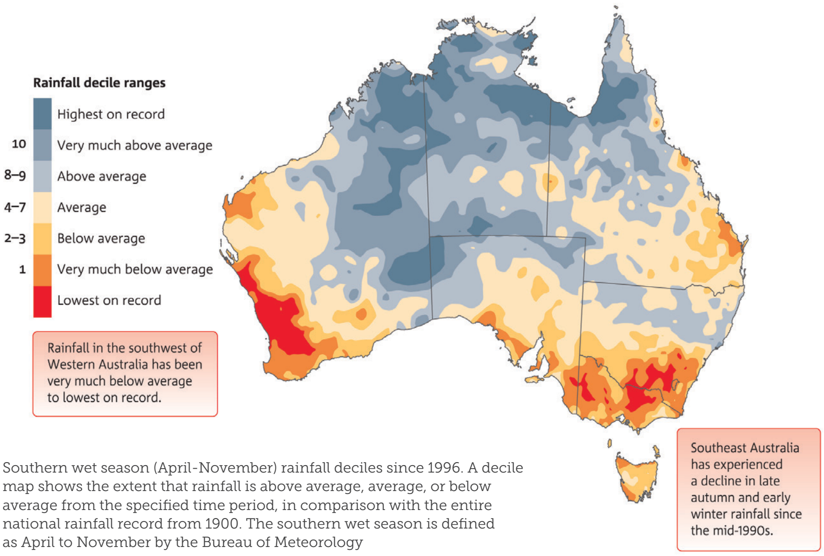
storages when it rains, and longer breaks between significant 'storage filling events' (UWSRA 2011).

Finally, the pronounced drying trend over southwest Australia, which is projected to continue throughout the 21st century (Section 3), has significant implications for urban water supplies in Perth (Collett and Henry 2011). The Western Australia Department of Water (2009) predicts a supply-demand annual deficit that is potentially as large as 85 billion litres by 2030 for the Perth, goldfields and agricultural regions and some parts of the southwest. To put this into context, Western Australia's Integrated Water Supply Scheme (IWSS) currently delivers 289 billion litres of water to over 2 million people in the region each year. A deficit of 85 billion litres is equivalent to approximately 30% of current water supply (WA Water Corporation 2014). That's enough water to fill 34,000 Olympic sized swimming pools. Desalination plants, which have been built in all mainland states in Australia, can potentially assist in easing declines in urban water supplies, although they have significantly varied water-producing capacity (Hoang et al. 2012).

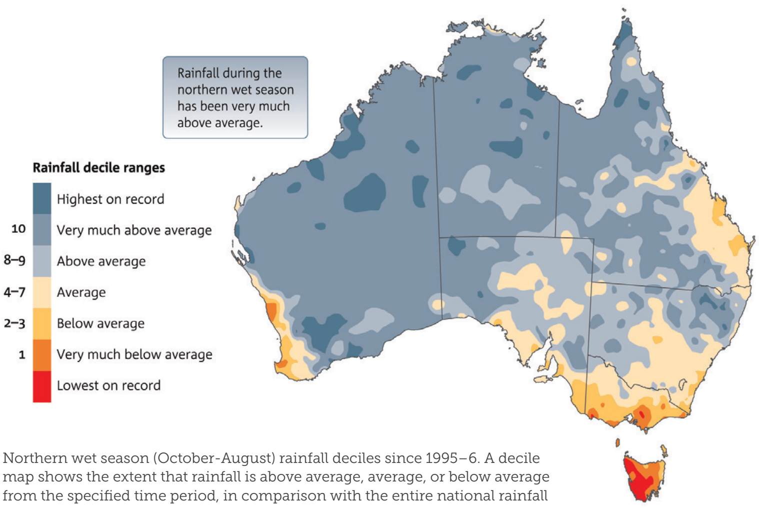
Figure 4: Lake Hume during drought in 2007, Victoria

3. What changes have been observed in drought conditions in Australia?

Whilst some parts of Australia are getting wetter, particularly the northwest of the continent, some of the most populous and agriculturally productive regions in the south are becoming drier (CSIRO and BoM 2014; Figure 5).



Southern wet season (April-November) rainfall deciles since 1996. A decile map shows the extent that rainfall is above average, average, or below average from the specified time period, in comparison with the entire national rainfall record from 1900. The southern wet season is defined as April to November by the Bureau of Meteorology



Northern wet season (October-August) rainfall deciles since 1995–6. A decile map shows the extent that rainfall is above average, average, or below average from the specified time period, in comparison with the entire national rainfall record from 1900. The northern wet season is defined as October to April by the Bureau of Meteorology

Figure 5: Long term changes in rainfall across Australia.
Source: (CSIRO and BoM 2014)

A long-term drying trend is particularly evident in the southwest and southeast of Australia, with rainfall deficiencies and declines in soil moisture indicative of dry conditions that have persisted in recent decades (CSIRO and BoM 2015). In the southwest, rainfall has declined since the mid-1970s. This drying trend has been particularly severe in the southwest corner of Western Australia, which has experienced a 15 percent drop in rainfall since the mid-1970s (WC 2012; Climate Commission 2013).

Future drying trends in Australia are projected to be most pronounced over southwest Western Australia, with total reductions in autumn and winter precipitation potentially as high as 50 percent by the late 21st century (Delworth and Zeng 2014; CSIRO and BoM 2015). This could have significant implications for the city of Perth, which has already experienced a reduction of nearly 80% in total annual inflow into its dams since the mid-1970s (Figure 6). The city may need to increase the capacity of the state's desalination plants, or find alternate sources of water in order to sustain the population of the city (The Guardian 2014).

The drying trend in the southeast of Australia is evidenced by declines in rainfall combined with increases in temperature. Since the mid-1990s, southeast Australia has experienced a 15 percent decline in late autumn and early winter rainfall and a 25 percent decline in average rainfall in April and May (CSIRO and BoM 2014). The region has also experienced significant warming during the last 50 years (Timbal et al. 2010). The warming trend was especially prominent in 2013 with two intense and prolonged heatwaves affecting the southeast in early January and March 2013 (BoM 2013).

The combination of dry and hot conditions was particularly severe in Australia during the Millennium Drought, which was concentrated in

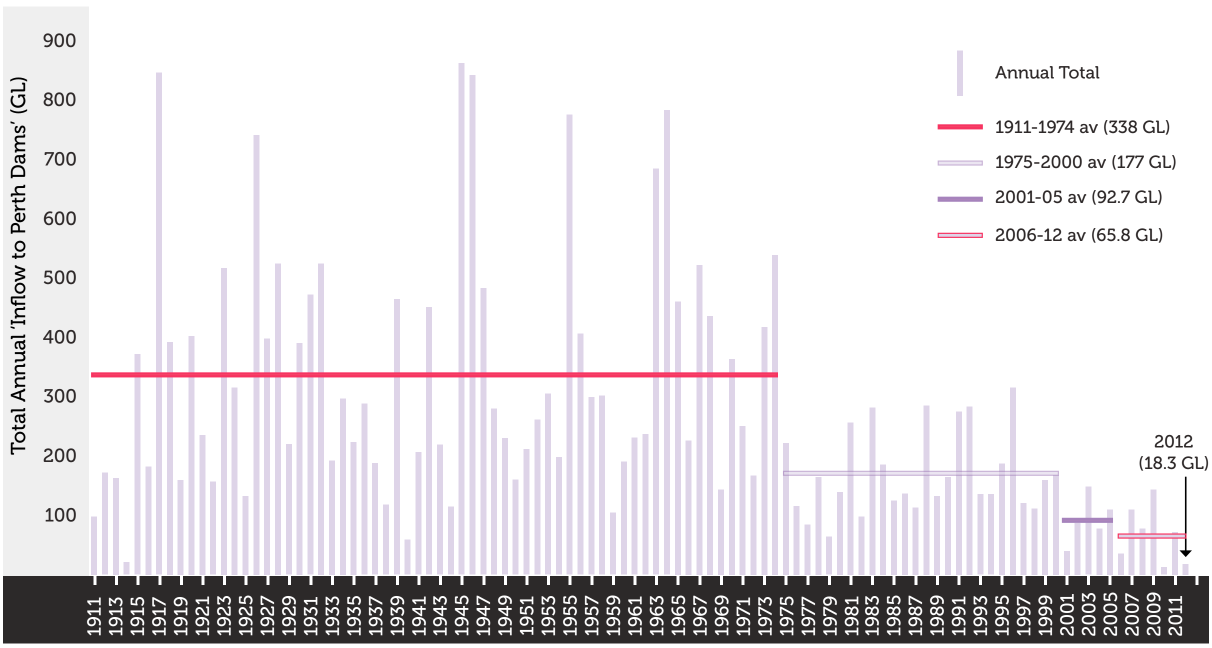


Figure 6: Trend in total annual stream flow into Perth dams 1911–2012. Source: (Climate Commission 2013)

Australia's south and was exceptional for both its length and its severity (CSIRO 2012; CSIRO and BoM 2015). During this drought, average annual rainfall was 12 percent below the long-term (1990–2010) average of 582 mm, the lowest ever 13-year rainfall period was recorded, and there was an absence of 'wet years' and 'very wet months' (CSIRO 2012). The decreases in cumulative rainfall during the Millennium Drought (Figure 7) show that it takes several years of above-average rainfall to erase the deficit created by long droughts.

It will likely be increasingly difficult to erase such rainfall deficits in future, with further declines in average rainfall projected for southern Australia in the cool season (winter and spring), mainly driven by the southward movement of winter storm systems. There are no reliable predictions yet for the direction of change in rainfall in summer and autumn (CSIRO and BoM 2015).

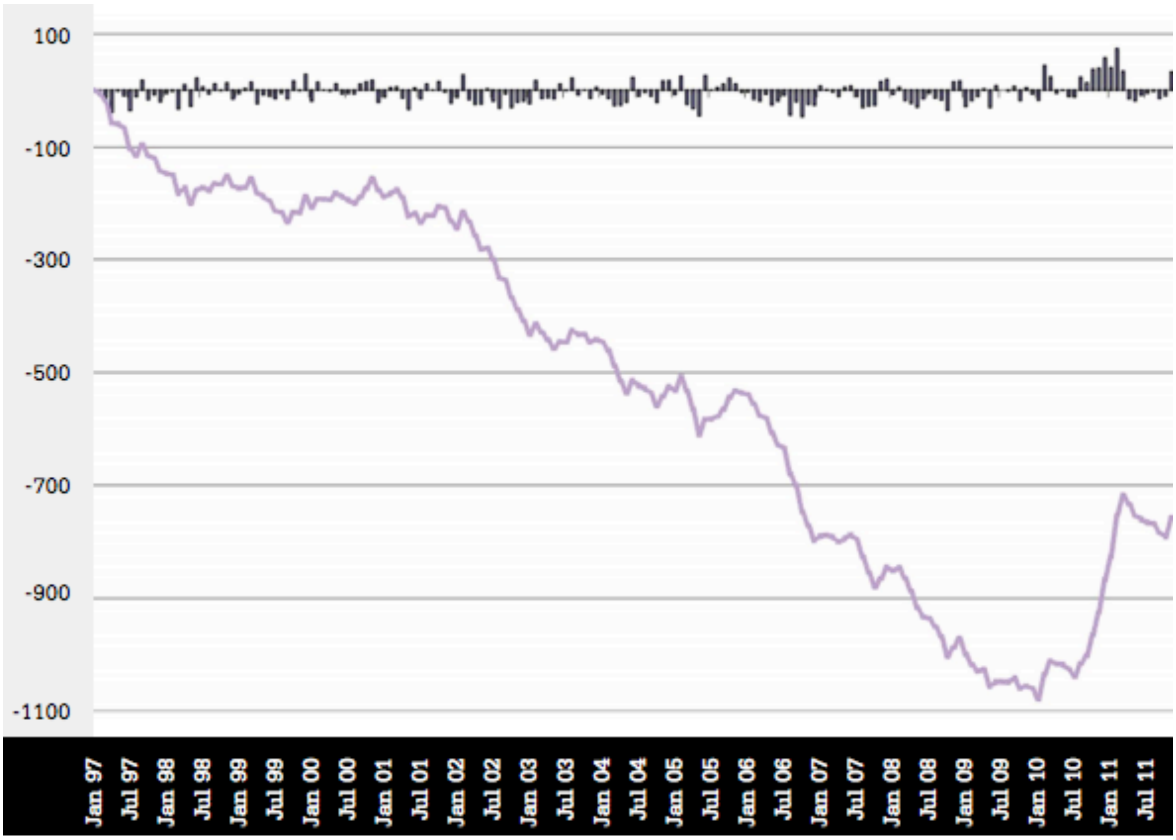


Figure 7: Cumulative rainfall variation (in mm) from the long-term average for southeast Australia for the period January 1997 to December 2011. Individual monthly variations are shown in the columns. Source: (Climate Commission 2013, adapted from BoM)

Whilst rainfall deficiencies are a key measure for meteorological drought, soil moisture is also an insightful indicator, with the physical impacts of severe droughts continuing long after the rainfall has returned because soil moisture can remain severely depleted (ABARES 2012). Some studies that use soil moisture rather than rainfall deficiency to assess dryness across Australia have also identified a potential drying pattern in some regions of the country. This is particularly evident in the more populous eastern half of the continent, although some other areas have also experienced decreases in drying, such as central Australia (IPCC 2012). Long-term trends in soil moisture down the soil profile also point to a possible drying trend in some regions (CSIRO 2014).

In Australia, between October 2012 and February 2015, rainfall deficiencies increased across central northern Queensland south of the Cape York Peninsula, extending through inland southern Queensland to northern New South Wales inland of the Great Dividing Range, and in the area covering western Victoria and adjacent southeastern South Australia.

Severe and serious deficiencies are happening in these areas and in small areas of southwestern Queensland and adjacent parts of the southeastern Northern Territory and northeastern South Australia, pockets to the east of Mildura in southern New South Wales and around the northeast of Melbourne in Victoria, and in small parts of coastal western Tasmania. Long-term rainfall deficiencies in Queensland can largely be attributed to below-average rainfall over the 2013–14 and 2012–13 'summer' wet seasons (the northern wet season spans October–April) (BoM 2015b). Drought conditions are expected to persist, particularly in Queensland and western Victoria (BoM 2015c).

"In March 2014, 75% of Queensland was declared in drought"

In March 2014, 50 local government areas in Queensland (75 percent of the state) were declared in drought, making it the largest area of Queensland to ever be declared in drought (DAFF 2014; ABC 2014a; ABC 2014b). In February 2015, the number of drought-declared local government areas decreased slightly to 44, which remains a significant portion of the state (DAFF 2015).

Whilst the NSW state government no longer issues drought declarations, the NSW government's February 2015 seasonal condition report indicates that portions of the state have been impacted by severe rainfall deficiencies. For example, severe rainfall deficiencies occurred across the northwest and northern tablelands during the last 24 months and drier than normal conditions are expected to continue between February and April 2015 (DPI 2015).

The long-term drying trend in the southeast is exacerbated from time to time by the occurrence of El Niño events, a feature of natural climate variability that recurs about every three to eight years (BoM 2005). El Niño events in Australia are often associated with below average rainfall in winter and spring, particularly across eastern Australia (BoM 2010; ABARES 2012) and above average temperatures (Arblaster and Alexander 2012).

The Millennium Drought, one of the most severe droughts on record, was exacerbated by two separate El Niño events (ABARES 2012). At present, while the tropical Pacific Ocean is in neutral conditions, the likelihood of an El Niño developing in 2015 has increased. Therefore, the ENSO Tracker status has recently been raised to El Niño 'WATCH' (BoM 2015d).

Figure 8: Dry paddocks near Junee, NSW

Trends in heat also play a role in exacerbating the severity of drought. The relationship between drought and heat is often one of mutual reinforcement; the reduced soil moisture associated with drought contributes to rises in air temperature, and in turn these hotter conditions further increase loss of soil moisture (Climate Council 2014b). For example, it is likely that the impacts of Australia's Millennium Drought were exacerbated by extreme heat, with temperatures 0.3–0.6°C above the long-term average (Head et al. 2013). Australia's climate has continued to warm over the last century and 2013 was Australia's warmest year on record (BoM and CSIRO 2013). In addition, hot extremes are becoming more frequent and intense (IPCC 2014).

Figure 9: A sheep grazes in a dry paddock in Victoria, 2008

4. How is Climate Change Influencing Drought?

Climate change is exacerbating drought conditions in Australia through changes in rainfall patterns and increasing heat. In the future severe droughts are expected to happen more often.

The evidence for the influence of climate change on observed drought patterns is strongest for southwest Western Australia and the far southeast of the continent - Victoria and southern parts of South Australia (CSIRO 2012). The link is related to the southward shift of the fronts from the Southern Ocean that bring rain across southern Australia during the cool months of the year (winter and spring) (CSIRO and BoM 2015). This shift, which is consistent with the changes in patterns of atmospheric circulation expected in a warming climate system, has led to the observed declines in rainfall in the southwest and southeast of the continent and the resulting drought conditions (Timbal and Drowdowsky 2012; Climate Commission 2013).

As part of the changes in atmospheric circulation, the subtropical ridge (STR), an area of high pressure that commonly lies over the Australian continent, has intensified as global air temperatures have increased as a result of increasing greenhouse gas concentrations (Timbal and Drosdowsky 2012; CSIRO 2012). The intensification of the STR is estimated to account for roughly 80 percent of the recent rainfall decline in southeast Australia (Murphy and Timbal 2008; Climate Commission 2013).

The observed drying trends during the cooler months in the southwest and southeast of the continent, which are likely influenced by climate change already, are expected to continue. Average rainfall in southern Australia during the cool season is expected to decline further, and the time spent in drought conditions is projected to increase with a greater frequency of severe droughts in the region (CSIRO and BoM 2015).

The ongoing drying trend and projected increase in severe droughts could lead to decreases in production in Australia's most important agricultural regions, including the largest catchment and most productive agricultural area in the country, the Murray-Darling basin, and southwest wheat belt (IPCC 2014). The projected drying trend across southern Australia could also threaten urban water

"In parts of Southern Australia severe droughts are expected to continue. "

supplies, as nearly 13 million of Australia's population is concentrated in the southern cities of Perth, Adelaide, Melbourne, Canberra and Sydney (ABS 2014).

Climate change is also contributing to an increase in the intensity and frequency of hot days and heatwaves in Australia (IPCC 2013; IPCC 2014; CSIRO and BoM 2015), which in turn contributes to an increase in the severity of droughts (Climate Commission 2013). Since 2001, the number of extreme heat records in Australia has outnumbered extreme cool records by almost 3 to 1 for daytime

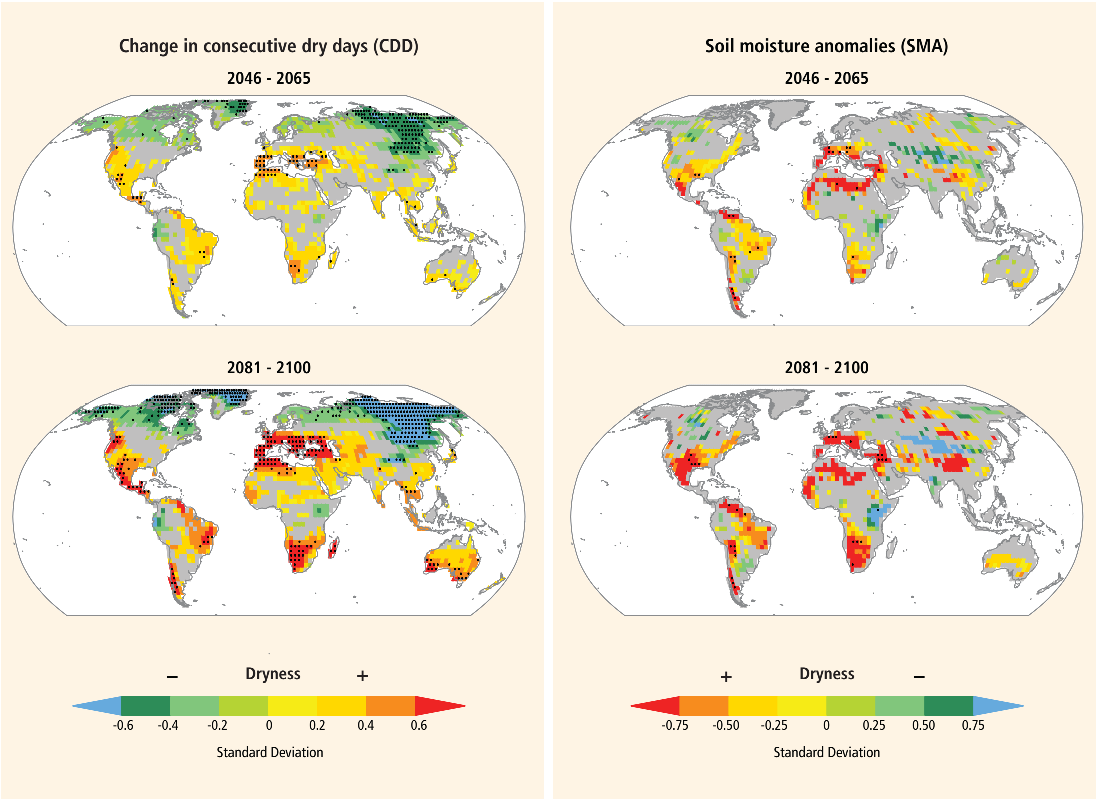


Figure 10: Projected annual changes assessed from two indices. Left column: Change in annual maximum number of consecutive dry days (CDD: days with precipitation <1 mm). Right column: Changes in soil moisture (soil moisture anomalies, SMA). Increased dryness is indicated with yellow to red colours; decreased dryness with green to blue. Projected changes are expressed in units of standard deviation of the interannual variability in the three 20-year periods 1980–1999, 2046–2065, and 2081–2100. The figures show changes for two time horizons, 2046–2065 and 2081–2100, as compared to late 20th-century values (1980–1999), based on GCM simulations under emissions scenario SRES A2 relative to corresponding sumulations for late 20th century. Results are based on 17 (CDD) and 15 (SMA) GCMs contributing to the CMIP3. Coloured shading is applied for areas where at least 66% (12 our of 17 for CDD, 10 out of 15 for SMA) of the models agree on the sign of the change; stippling is added for regions where at least 90% (16 out of 17 for CDD, 14 our of 15 for SMA) of all models agree on the sign of the change. Grey shading indicates where there is insufficient model agreement (<66%). (IPCC 2012)

maximum temperatures and almost 5 to 1 for night-time minimum temperatures (CSIRO and BoM 2015). Australia's capital cities have experienced hotter, longer or more frequent heatwaves. For example, the average intensity of heatwaves in Melbourne is now 1.5 °C hotter and they occur on average 17 days earlier than between 1950 and 1980. Whilst in Sydney, heatwaves now start 19 days earlier and the number of heatwave days has increased by 50% (Perkins and Alexander 2013). The IPCC warns that it is very likely (over 90 percent probability) that warm days will increase and cold days will decrease in Australia (IPCC 2012). In addition, it is likely that more frequent and/or longer heatwaves and warm spells will occur across the continent (IPCC 2012). These projected increases in heat will compound existing drought conditions in Australia.

Finally, on a global scale, whilst it is likely that some regions of the planet will become increasingly wetter, others are likely to experience drier conditions as measured by consecutive dry days and decreases in soil moisture (Figure 10). Consistent with the CSIRO and BoM analysis (2015), southern Australia is one of the regions that is likely to become drier through the century, with some other regions, such as the Mediterranean and southern Africa, expected to experience particularly severe drying trends (IPCC 2012).

5. This is the Critical Decade

The impacts of climate change are already being observed. Sea levels are rising, heatwaves are increasing in length and intensity, and southern Australia is experiencing a long-term drying trend.

We are now more confident than ever that the emission of greenhouse gases by human activities, mainly carbon dioxide from the combustion of fossil fuels, is the primary cause for many of the changes in climate that have been observed over the past half-century (IPCC 2013; 2014). Projections of future climate change and its impacts have convinced nations that the global average temperature, now at 0.85°C above the pre-industrial level (IPCC 2013), must not be allowed to rise above 2°C, the so-called '2°C guardrail'.

Societies will have to adapt to even more serious impacts as the temperature rises. For Australia, these impacts include increases in the severity of drought in the south, with implications for human health, agriculture, urban water supplies and the environment. Ensuring that the 2°C guardrail is not exceeded will prevent even worse impacts in the second half of the century.

The evidence is clear and compelling. To stabilise the climate, the trend of increasing global emissions must be halted within the next few years and emissions must be trending downwards by 2020. Investment in renewable, clean energy must therefore increase rapidly. And, importantly, most of the known fossil fuel reserves - coal, oil and gas - must remain in the ground.

This is the critical decade to get on with the job.

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