

A primary goal of the National Urban Policy is to advance the sustainability of Australia's natural and built environment, including through better resource and risk management. In working towards this goal there are four interrelated objectives:

- Protect and sustain our natural and built environments
- Reduce greenhouse gas emissions and improve air quality
- Manage our resources sustainably
- Increase resilience to climate change, emergency events and natural hazards.

In this chapter we look less at the resources we consume in our cities than at the positive role our urban systems can play in protecting and contributing to natural systems and at how our natural environment impacts on and integrates into the urban fabric. The chapter discusses the potential to ameliorate the urban heat island effect, urban waterway management issues, the state of key natural resources and how cities are challenged by ongoing climate changes and bushfire risk. The chapter showcases several examples of cities' efforts to adapt to increasing temperatures and reduce greenhouse gas emissions.

There is evidence of increasing average temperatures and decreasing rainfall in most of Australian cities. They are vulnerable to heatwaves, bushfires, storms, floods and sea level rise, all of which are predicted to become more prevalent in coming decades. In addition, city growth puts pressure on ecosystems and resources. These issues are starting to be managed in an integrated natural and urban systems management framework, particularly regarding water sensitive research and development, and urban heat island and green infrastructure management. The management of sea level rise impacts on our coastal major cities at state/territory and local government levels is progressing to varying extents. Positive steps are being taken by state governments following the release of recommended actions by the 2009 Victorian Bushfires Royal Commission and there is now a nationally agreed policy framework to address bushfire arson in Australia. Various cities are exploring avenues of climate change mitigation and more efficient use of energy by investing in renewable energy projects.

Summary indicators

Dimension	Indicators
Temperature/rainfall	City annual average daily temperature 1952–2011 City annual average rainfall 1952–2011 Australian temperature anomaly 1910–2010 and 11-year moving average
Coastal vulnerability	Observed sea level rise 1993–2011 Threatened species
City edge vulnerability	Percentage of buildings close to bushland Incidence of arson-related vegetation fires 2002–08 Urban surface water quality Food security Threatened species Water-sensitive cities management
Climate change mitigation	Number of Green Star buildings Low carbon precinct-based distributed energy generation projects
Climate change adaptation	State and local government adaptation strategies and plans Precinct-based distributed energy generation projects Green infrastructure management
Energy	Electricity consumption 1974–75 to 2009–10 Gas consumption
Biodiversity conservation	Threatened, endangered and vulnerable species in the metropolitan region
Agricultural production	Metropolitan region's contribution to state agricultural production

Key findings

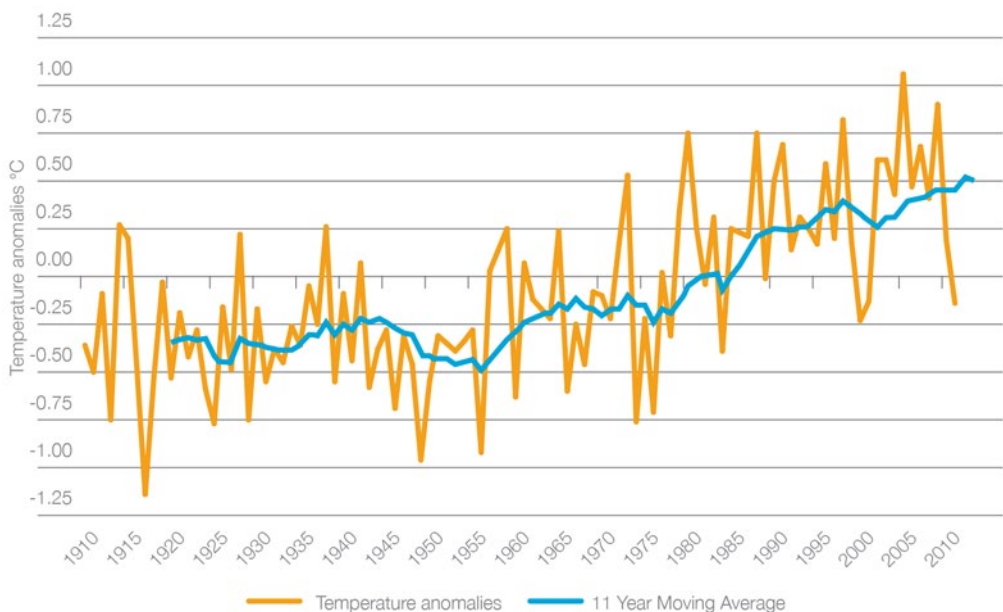
- Australia's major cities since 1952 have experienced increases in average maximum temperatures of up to 2°C.
- Most Australian cities, except for those located in the far north, have experienced declines in annual rainfall over the last 60 years.
- The management of sea level rise impacts in our coastal major cities at state/territory and local government levels is progressing to varying extents.
- Increasing prevalence and severity of natural perils have natural regional differences, giving rise to varying costs and losses – for example, Sydney has a historically very high prevalence of hailstorm damage.
- The number of very high and extreme fire weather days is estimated to increase by between 15 and 60 per cent by 2020 and double to quadruple by 2050.
- It is reported that 65 per cent of Australian superannuation investment fund managers have not recognised the impacts climate change will have on investment portfolios. Similarly 83 per cent of superfunds replied in a key survey, 'no' to the question 'do you believe that systemic risks like climate change are currently being priced into asset valuations properly?'.

- It is estimated that about 490,000 or six per cent of addresses in capital cities are within 100 metres of substantial bushland. Over 750,000 are within 200 metres, posing substantial risks of property loss from bushfire.
- The fresh food production on the fringes of our cities plays a key role in providing staple perishable vegetables. These areas are under threat from the outward expansion and economic pressures of our cities.
- Our cities continue to place high biodiversity pressures on urban waterways and estuarine environments, many of which contain sites of international heritage significance.
- Proper management of natural systems and 'green infrastructure' can make major contributions to the sustainability and liveability of our cities.
- Total open space in and around our cities can amount to 60 per cent of the urban area.
- Local, state and territory governments are moving to better manage natural and urban systems and are addressing challenges such as urban heat islands, cleaning waterways and more sustainable buildings.

Temperature and rainfall changes

The Bureau of Meteorology's *State of the Climate 2012* repeats the finding of the previous *State of the Climate* report in 2010 that Australia's climate is highly variable, with evidence growing that land and ocean temperatures are increasing and rainfall distribution patterns are changing. The report concludes that the long-term warming trend for Australia and the globe has not changed, despite 2010 and 2011 being Australia's coolest years since 2001: the world's 13 warmest years on record have all occurred in the past 15 years (Bureau of Meteorology 2012).

Figure 4-1 Changes in average temperature for Australia for each year and the 11-year moving average



Note: Anomalies are the departure from the 1961–90 average climatological period.

Source: CSIRO 2012

As represented in Figure 4-3, in general terms, Australia's major cities since 1960 have experienced increases in average daily temperatures of between 0.4 and 0.8°C (Bureau of Meteorology 2012). Changes in average temperature for Australia for each year and decade are shown in Figure 4-1, demonstrating a clear nation-wide increase in average temperatures, particularly since the 1980s. There has been an increase in record hot days and a decrease in record cold days, the former associated with some serious heatwave and bushfire events, as reported in *State of Australian Cities 2011*. Climate change is also associated with more extreme events. For example, in 2011 Perth experienced a total of 50 days over 35°C, being the peak of a three-year spike of hot weather, and since 2009 the number of days over 35°C eclipsed the previous total of 35 days in 2004 (Figure 4-2). However, until 2009 the number of days above 35°C in Perth since 1982 stayed roughly within the same bounds of between about 20 and 30 days per year over a four year cycle.

Figure 4-2 Number of days in Perth over 35°C 1982–2012



Source: Data from Bureau of Meteorology

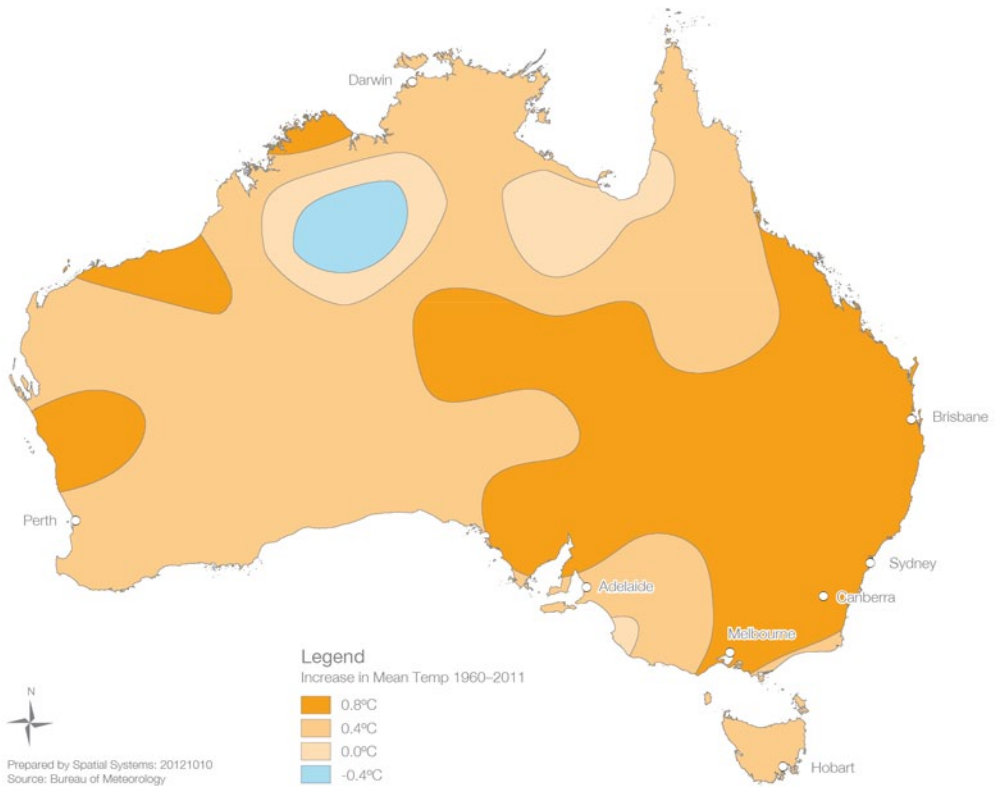
It is not only increasing extreme heat events that are associated with climate change in Australia; there is also a possible link with heavy rainfall events. The Climate Commission notes that the record high sea surface temperatures around northern Australia in spring and early summer 2010 and 2011 were likely to have contributed to the heavy rainfall over much of Australia in the past two years (Climate Commission 2012). Further research is still being conducted in this area, including the role that increased evaporation from higher sea surface temperatures played in the intensity of the flooding that occurred in Brisbane in 2009–11.

As reported in *State of Australian Cities 2011*, a future with more frequent and intense rainfall events would have major impacts on Australia's cities (particularly in northern Australia), including for transport systems and essential services. In addition to an increased prevalence of floods in coastal plain river cities such as Brisbane, intense rain and hail storms can cause flash floods and wind-related physical damage over very short periods of time. The flash floods that hit Toowoomba in January 2011 and Sydney in March 2012 caused road closures and traffic chaos. In Sydney public transport was affected during these episodes. There were

delays on seven of 16 rail lines, ferries were cancelled and bus routes were affected by road closures. Power was lost to about 2,000 homes and businesses in Sydney and damage is estimated to have been in excess of \$500 million (Climate Commission 2012).

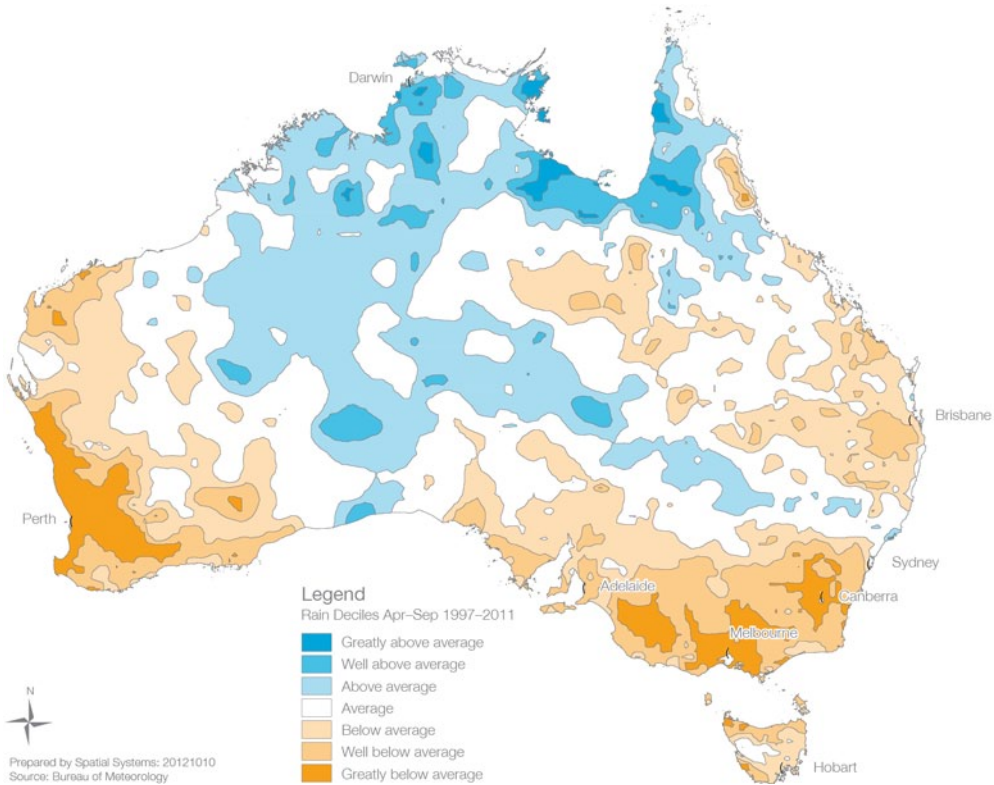
Figure 4-3 and Figure 4-4 illustrate the broad changes in temperature and rainfall across Australia. Figure 4-3 reflects the increasing temperature anomalies shown in Figure 4-1 as well as those for each city below. Interestingly, parts of the Kimberley show a cooling trend. Figure 4-4 also shows rainfall averages over the previous 15 years compared with the average since 1900. Parts of the north of the continent are receiving above average rainfall, whereas much of the south and east of Australia have recorded below average rainfall – for several major cities, the lowest on record.

Figure 4-3 Change in average daily mean temperature from 1960 to 2011



Source: CSIRO 2012 using Bureau of Meteorology data

Figure 4-4 April to September rainfall deciles from 1997 to 2011



Note: Decile rainfall maps show where rainfall is above average, average or below average for the most recent 15-year period in comparison with the entire rainfall record from 1900. Areas of highest and lowest rainfall on record are also shown.

Source: CSIRO 2012 using Bureau of Meteorology data

Temperature and rainfall trends in Australia's major cities 1952–2011

Long-term trends in the Bureau of Meteorology's weather observations for Australia's major cities over the past 60 years clearly show increases in average temperatures for most cities and decreases in average rainfall over all non-tropical cities. Small increases in long-term averages mean that there can be significant changes to normal climate variability at a local level from year to year. This section summarises long-term overall trends in temperature and rainfall, which is not to imply that future climate change will necessarily be a gradual trend along the same lines. Uncertainties inherent in climate change mean that within an overall smooth long-term trend, sudden changes can occur in steps as 'tipping points' are reached. This has implications for decision makers helping communities adapt to climate change. The discussion in this section is based on the graphs on the following pages, in which minimum temperatures are represented by darker lines and maximum temperatures are shown by lighter lines.

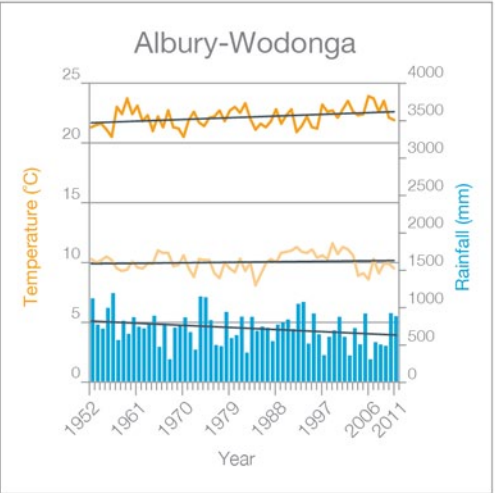
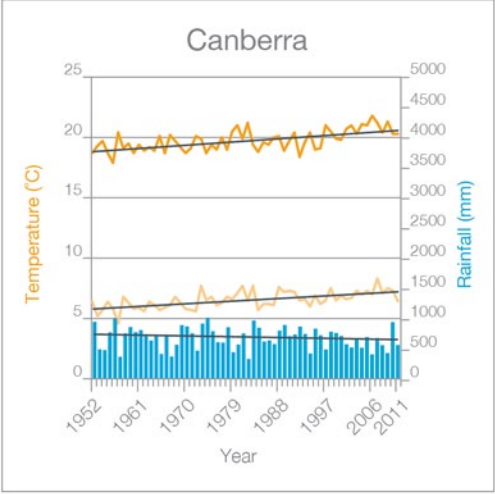
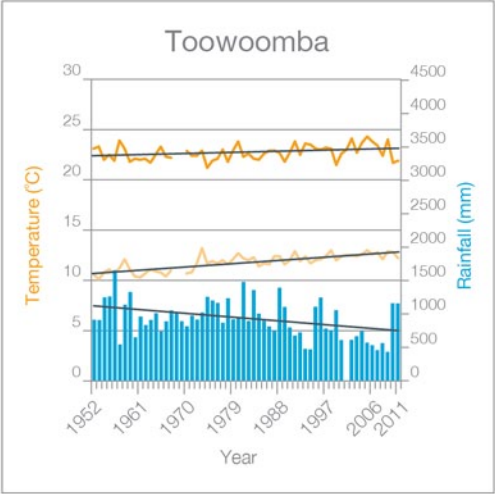
Increasing temperature, decreasing rain

In general, inland major cities (including Toowoomba, Canberra and Albury-Wodonga) are recording larger increases in average temperature and decreases in rainfall than major cities in coastal zones. Toowoomba shows the highest rate of rainfall decrease of all major cities, dropping from an annual average of 1,113 mm in 1952 to 744 mm in 2011, a 33 per cent drop. Five other major cities experienced average rainfall reductions of 20 per cent or more in the past 60 years: Perth, Melbourne, Hobart, Geelong and Albury-Wodonga.

Toowoomba, Melbourne and Canberra had the highest rates of increase in annual average minimum temperatures, rising by between 1.4 and 2.1 degrees from 1952 to 2011. In Geelong, Canberra and Perth, average maximum temperatures have increased the most, by 2.0°C, 1.7°C and 1.7°C respectively.

Increasing rain

Only two cities are showing a trend towards higher average rainfall, with Darwin's rate of increase relatively steep compared to that of Cairns. Darwin's average annual rainfall in 1952 was 1,582 mm, whereas in 2011 it had risen to 1,941 mm, an increase of 359 mm or 23 per cent. On the other hand, there has been little change to three cities over the past 60 years. Sunshine Coast's average maximum temperature has changed by less than 0.1°C and similarly, its average minimum has increased by only 0.4°C. Its average rainfall has declined by approximately 7 per cent. Townsville has experienced the lowest rate of decrease in rainfall, from an annual average of 1,142 mm to 1,111 mm. Townsville's average maximum and minimum temperatures have increased by about 1°C each. Cairns has experienced a trend increase in average temperatures of less than 1°C and an increase in average rainfall of 115 mm or 6 per cent. Liverpool in Sydney's west also has experienced a small decrease in average rainfall (60 mm) while temperature has increased approximately 1°C since 1963 (Bureau of Meteorology). Like Liverpool, Sydney City's annual average minimum and maximum temperatures have increased by about 1°C. However, Sydney's Observatory Hill has recorded a drop in rainfall of 149 mm, or two and a half times that of Liverpool over the same time.

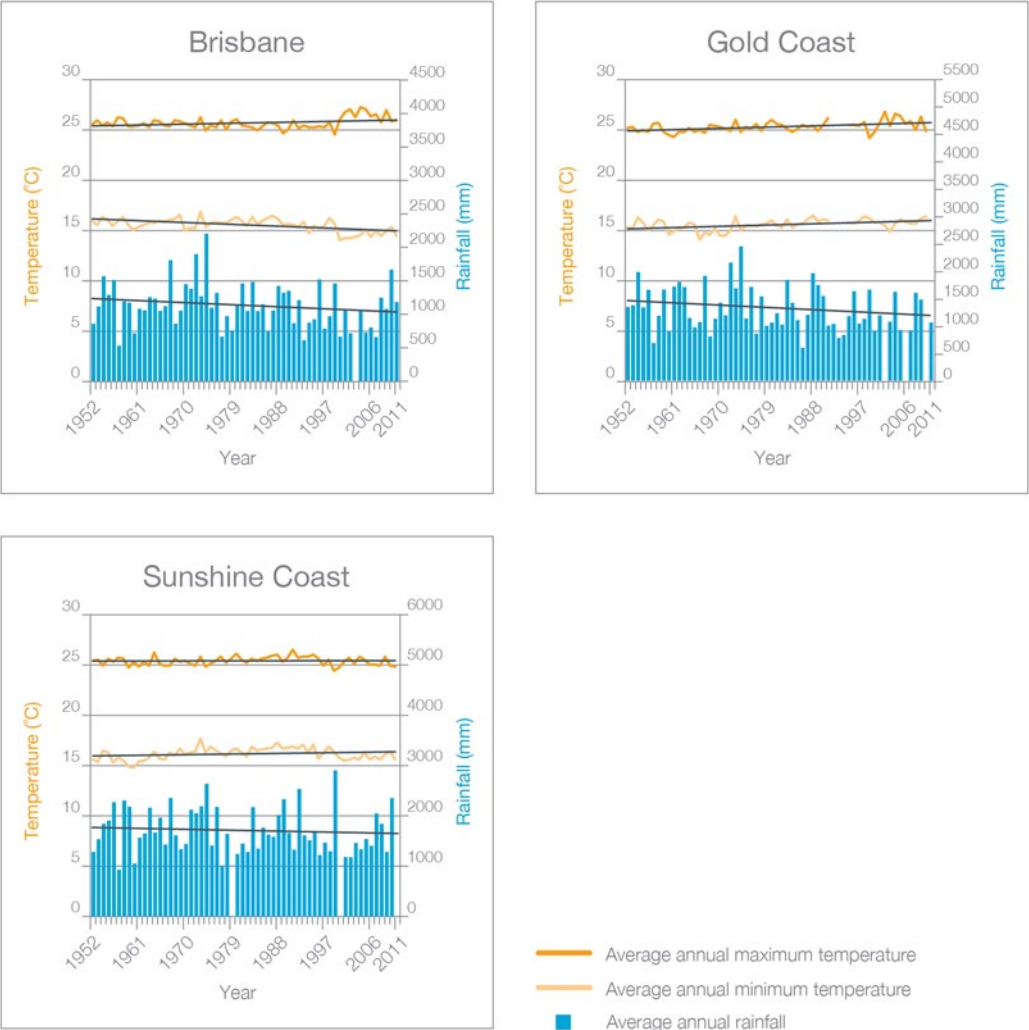


— Average annual maximum temperature
— Average annual minimum temperature
■ Average annual rainfall

Note: Variation in Albury-Wodonga's minimum temperatures could be influenced by different stations being used over the time period.

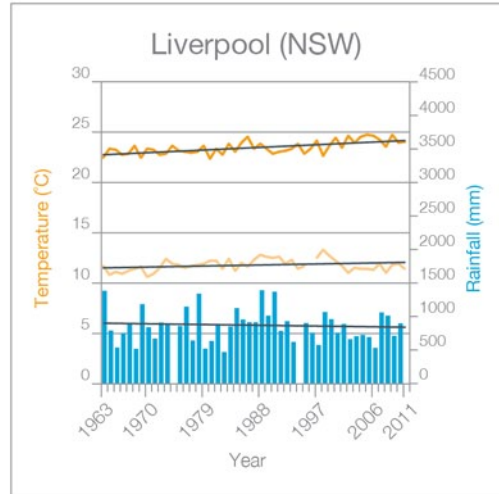
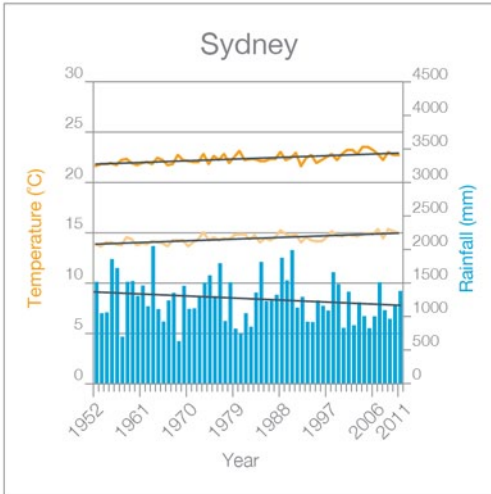
Source: Data from Bureau of Meteorology

Since 1952, trends in average temperatures for Queensland's southern coastal cities have shown less change than other major cities apart from those in the tropics. Brisbane's apparent trend of decreasing minimal temperatures is possibly in part due to another weather station being used from 2000.

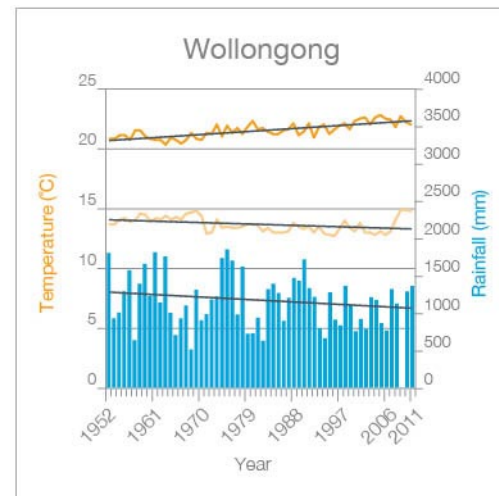
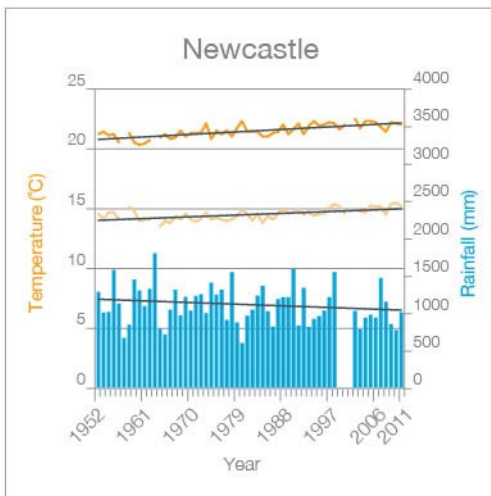


Source: Data from Bureau of Meteorology

With the exception of Wollongong's minimum temperature, which shows a decrease, Sydney, Newcastle, Wollongong and Liverpool all have similar patterns of long-term average temperature increases and rainfall decreases.



Note: Liverpool is included as an inland comparison with Sydney City (data available from 1963).



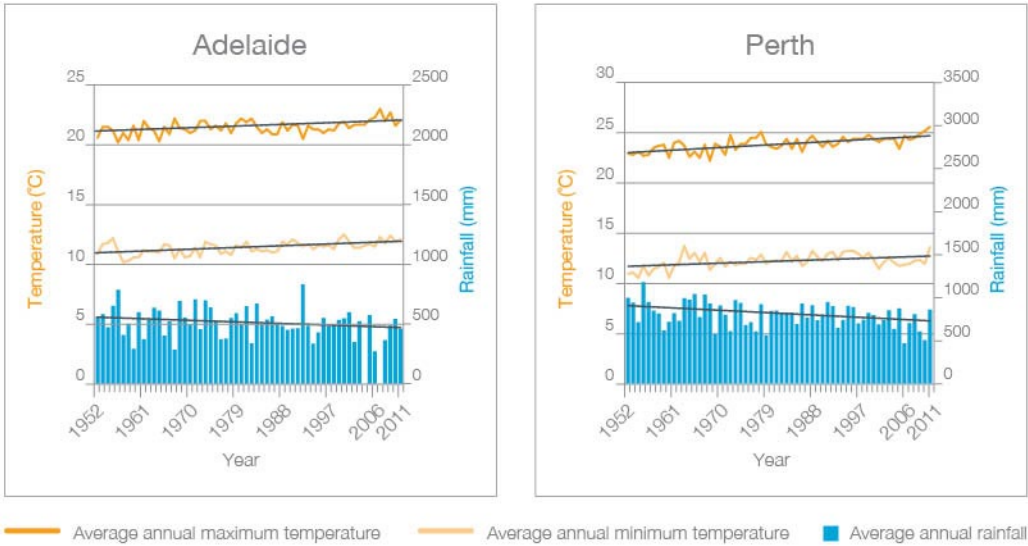
— Average annual maximum temperature — Average annual minimum temperature ■ Average annual rainfall

Note: Variation in Wollongong's minimum temperatures could be influenced by observations of minimum temperature being obtained from different weather stations over the time period.

Source: Data from Bureau of Meteorology

Drying cities

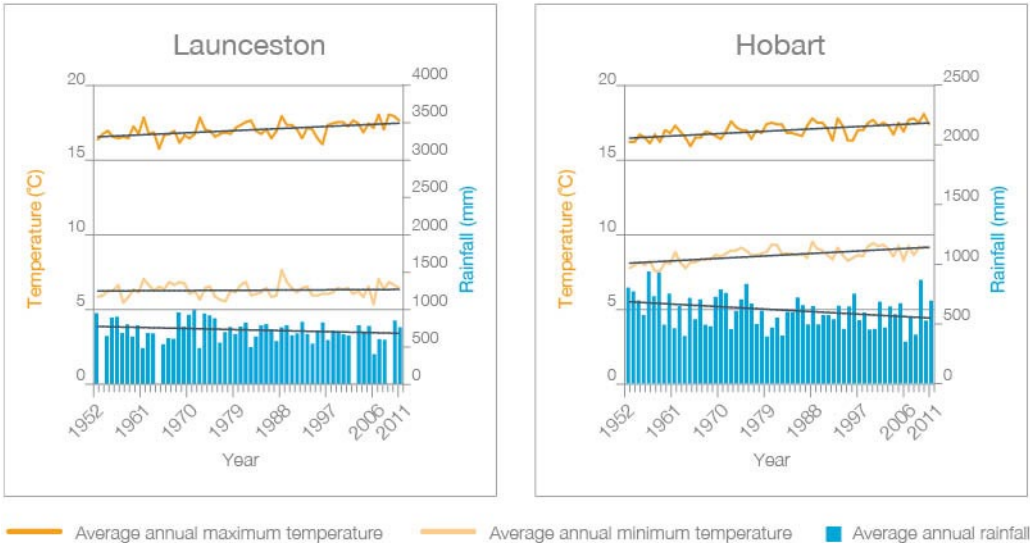
Australia’s two driest capital cities, Adelaide and Perth, display similar overall rates of increase in temperature and rainfall decline, although Perth has experienced a greater drop in average rainfall. South-west Western Australia has seen a significant reduction in rainfall and a rise in average temperatures since the mid-1970s. The reasons for this change in Perth’s climate are complex. One study concludes the likely cause to be a large-scale reorganisation of atmospheric circulation which sees a reduction in the intensity of low pressure cells’ development and some storms being deflected southwards (Frederiksen et al. 2007). Another hypothesis is that it is due to large-scale land clearing (Pitman et al. 2004). This may have implications for urban greenfield development in Perth and other major cities as they expand.



Source: Data from Bureau of Meteorology

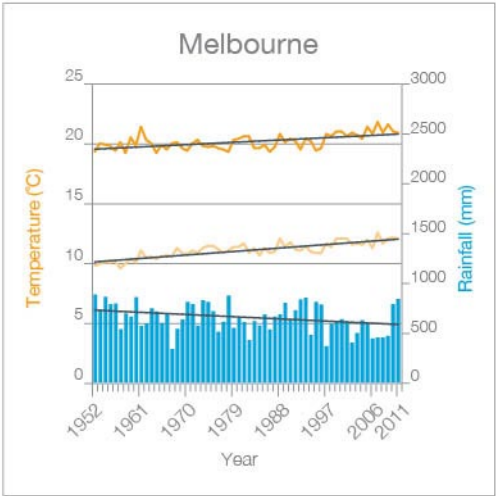
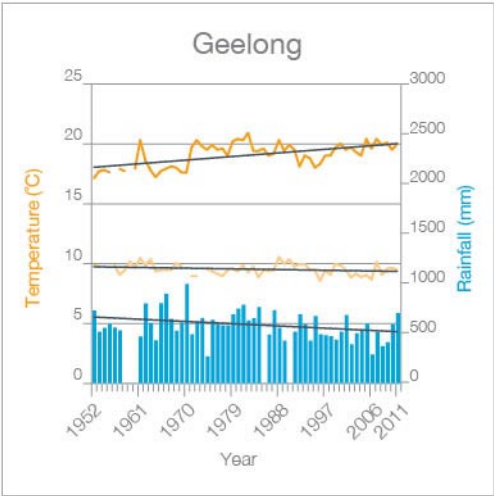
Southern cities

The two most southern major cities of Launceston and Hobart clearly show changes in average temperature and rainfall. Hobart shows a steeper decline in average rainfall from 676 mm to 538 mm and also a greater increase in minimum temperature compared to Launceston, which has experienced virtually no rise in average annual minimum temperatures since 1952.

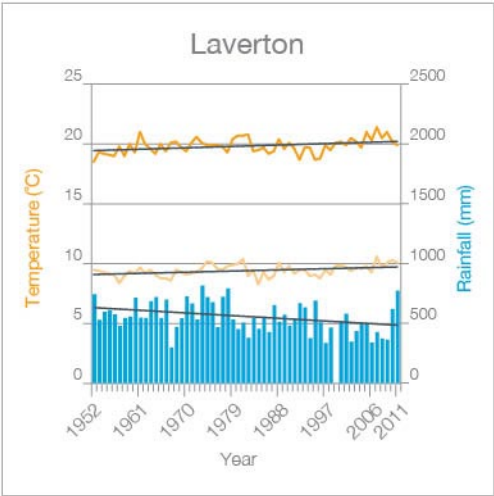


Source: Data from Bureau of Meteorology

Melbourne has experienced a consistent long-term rise in minimum temperatures since 1952, from an annual average of 10°C to 12°C. Records for Laverton RAAF Base to Melbourne's west show a very slight increase in average maximum and minimum temperatures. Geelong has had a similar rate of increase in maximum temperatures to Melbourne. However, its average minimum temperature shows a declining trend, perhaps reflecting different weather stations used over the sample time period. All three centres have experienced approximately the same rate of decline in average rainfall over the last 60 years.



Note: Variation in Geelong's minimum temperatures could be influenced by observations being taken from different stations being used over the time period.



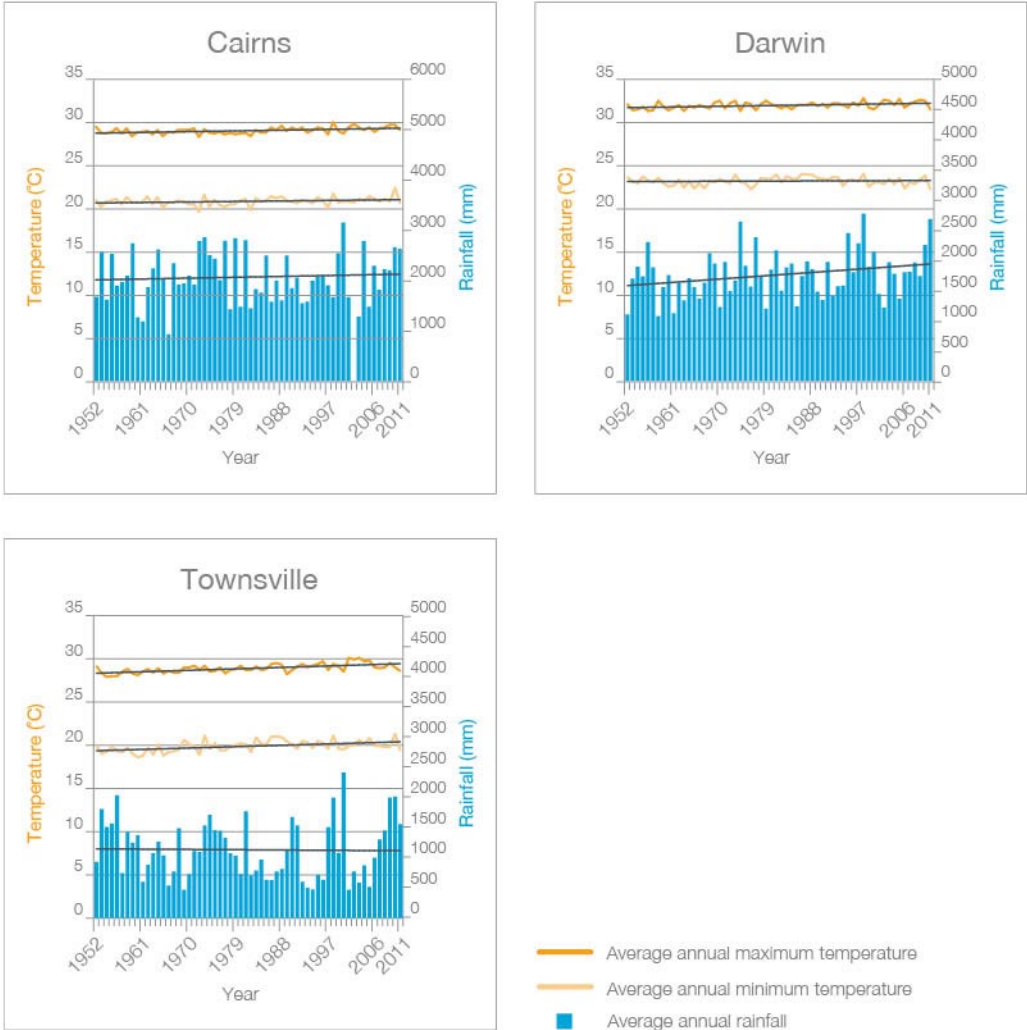
- Average annual maximum temperature
- Average annual minimum temperature
- Average annual rainfall

Note: Laverton included as an inland comparison with Melbourne.

Source: Data from Bureau of Meteorology

Northern cities

For the three tropical cities of Cairns, Darwin and Townsville, only Townsville has experienced any noticeable increase in temperatures of approximately 1°C and Darwin has had the only significant increase in average rainfall trend.



Source: Data from Bureau of Meteorology

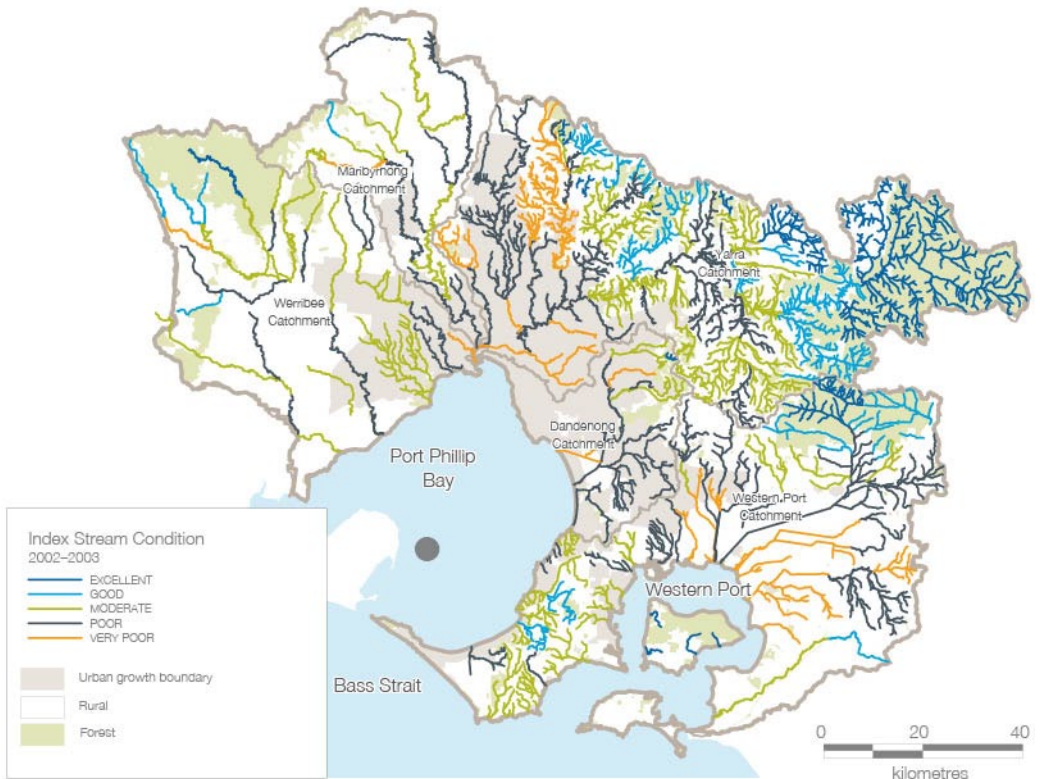
Urban surface water quality

While Australia's coasts and surrounding oceans are in relatively good condition, inshore waters vary considerably, particularly in areas near human settlement. The ecosystems in coastal estuaries, bays and freshwater systems face direct pressure from urban runoff as well as significant long-term disturbance from sea level rise. Nutrient build-up is one of the most threatening elements in these coastal systems. The health of our urban waterways is a significant indicator of the sustainability in the design and management of our urban green infrastructure (Natural Resource Management Ministerial Council 2006). In the context of this report 'green infrastructure' refers to the network of natural and man made landscape assets that include waterway, parklands and reserves.

Figure 4-5 shows the river health condition of the urban and greater metropolitan catchment for Melbourne. Melbourne has some environmentally sensitive estuarine areas such as Western Port, which contains sites of international significance.

While urban areas are less than 20 per cent of the Port Phillip catchment by area, they contribute over 50 per cent of diffuse nitrogen loads and 60 per cent of diffuse phosphorus loads, which are precursors for blue-green algal blooms. Urban areas make up around two per cent of the Western Port catchment and yet contribute 14 per cent of diffuse nitrogen loads and 15 per cent of diffuse phosphorus loads (Melbourne Water 2012).

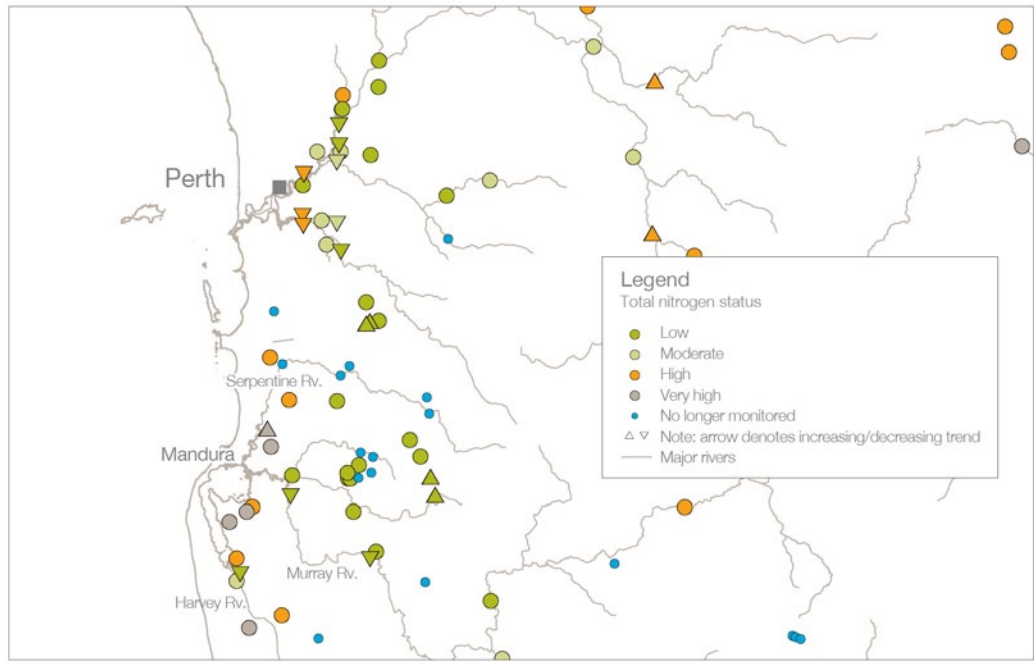
Figure 4-5 Greater Melbourne waterway condition 2002–03



Source: Melbourne Water 2012

In Perth a similar situation prevails in the Peel-Harvey Estuary near Mandurah. This area was well known for almost annual blue-green algal blooms from 1978 to 1994. Construction of the Dawesville Channel in 1994 increased ocean flushing and there have been no more blue-green algal blooms in the estuary. Unfortunately, blooms still frequently occur in the Serpentine and Harvey rivers near Mandurah's urban areas. Catchment modelling indicates that agricultural activities contribute most nutrients to the rivers and estuary (about 70 per cent). Developed urban areas represent six per cent of catchment area but contribute about 30 per cent of nutrient input (Environmental Protection Authority 2007, p.111).

Figure 4-6 Total nitrogen status at water quality monitoring sites – South-west WA

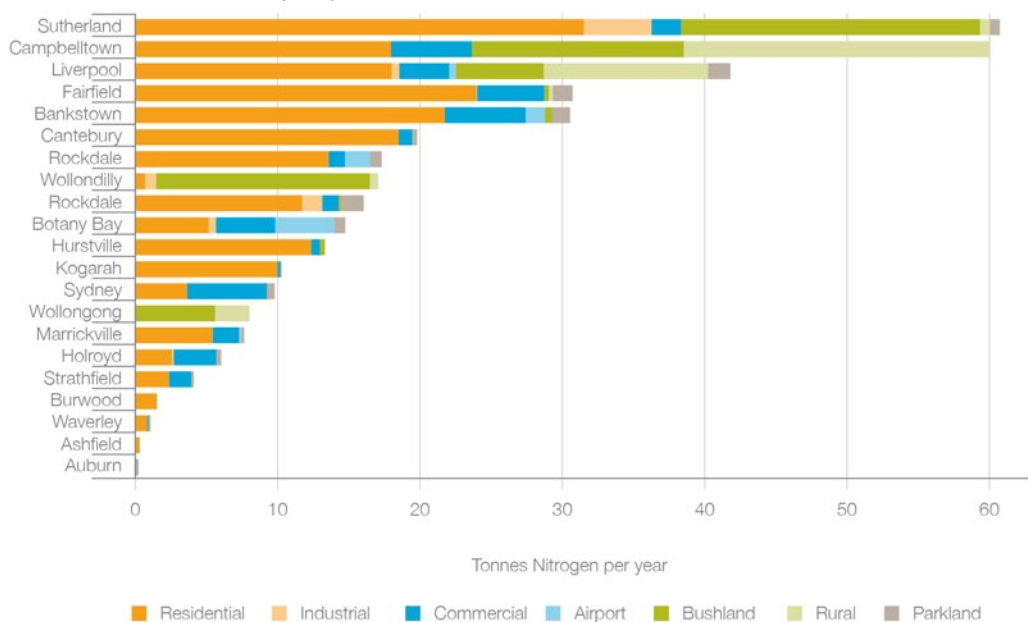


Source: Environmental Protection Authority 2007

The contribution of urban sourced pollutants to waterways can be further illustrated in Sydney's Botany Bay catchment. The Bay is also a national priority hotspot for water quality improvement and contains up to 36 threatened species, several of which are considered rare and endangered.

Figure 4-7 shows the levels of key pollutants by land source within the Botany Bay catchment. Modelling of future development impacts shows that if best practice water-sensitive design and waterway management systems are employed, a further 25,000 people could be accommodated in the catchment area and still see a reduction in the pollutant levels evident today (Sydney Metropolitan Catchment Management Authority 2008).

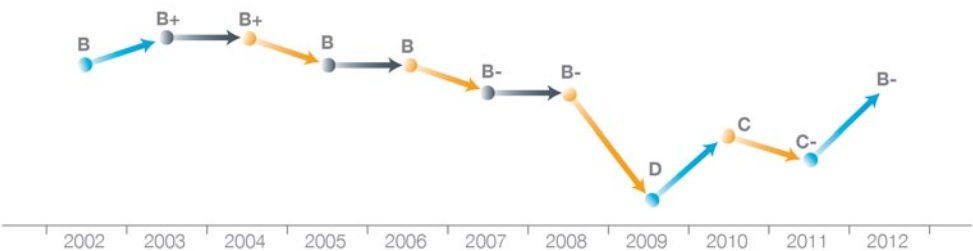
Figure 4-7 Mean annual pollutant loads per council area (total nitrogen tonnes/year)



Source: Sydney Metropolitan Catchment Management Authority 2008

Brisbane’s Moreton Bay has faced a decline in water quality standards since 2004, demonstrating the need to better manage their urban drainage and surface waters in an integrated and sensitive manner (Healthy Waterways 2011). The bay’s pollution levels are monitored against an integrated catchment management rating scale where A, B, C, D, and F respectively represent excellent, good, fair, poor and failed achievement of marine conditions.

Figure 4-8 Moreton Bay health index report



Source: Queensland Government Healthy Waterways 2011

The development of integrated management and design systems for our cities is now the subject of an Australian Government funded Cooperative Research Centre (CRC) for Water Sensitive Cities

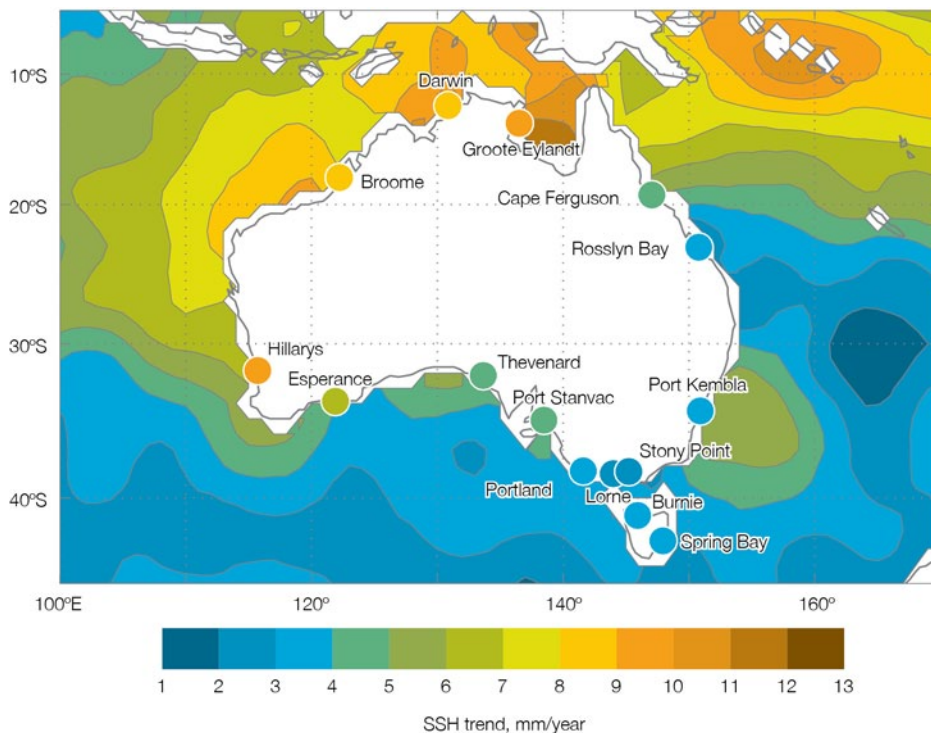
Cooperative Research Centre for Water Sensitive Cities

Established on 1 July 2012 as a 'public good', the Cooperative Research Centre for Water Sensitive Cities has funding for nine years until 30 June 2021. The Centre brings together the inter-disciplinary research expertise and thought-leadership to undertake research that will revolutionise water management in Australia and overseas. In collaboration with over 70 research, industry and government partners, it is set to deliver the socio-technical urban water management solutions, education and training programs, and industry engagement required to make towns and cities water sensitive. With a research budget in excess of \$100 million, the work of the CRC will help guide capital investments of more than \$100 billion by the Australian water sector and more than \$550 billion of private sector investment in urban development over the next 15 years. The goal is for Australian cities to become more liveable, resilient, sustainable and productive. The research teams will be located in Brisbane, Melbourne, Perth and Singapore.

Sea level rise

A key issue for Australia with our predominance of coastal cities is sea level rise and associated coastal hazards including coastal erosion and estuarine flooding. Sea level rise around Australia since 1993 has been greater than or equal to the global average (Bureau of Meteorology 2012).

Figure 4-9 Rates of sea level rise around Australia from January 1993 to September 2011



Note: As measured by coastal tide gauges (circles) and satellite observations (contours).

Source: CSIRO 2012

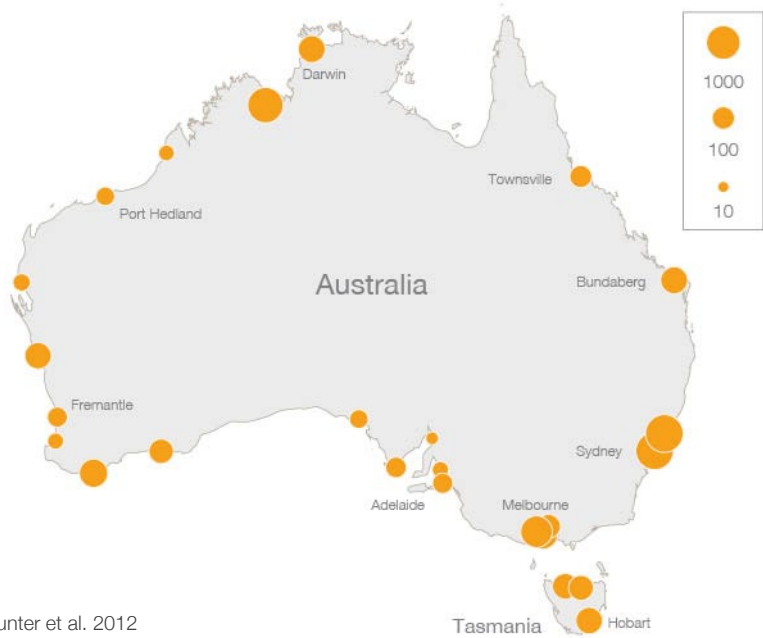
Sea level rise is not uniform around Australia and the variations will have added consequences for increased coastal erosion and storm surges for any given state or territory. Figure 4-9 and Table 4-1 show tidal gauge data for coastal sites and satellite data derived contours for open-sea observed changes around Australia from 1993 to 2011. According to the tidal gauge indications shown, Perth (Hillarys) and Darwin are the cities experiencing the highest rates of sea level rise, between eight and 10 millimetre per year. Townsville (Cape Ferguson) and Adelaide (Port Stanvac) have experienced sea level rises in the order of four to five millimetre per year whereas Melbourne (Stony Point), Hobart (Spring Bay – 70 kilometres north of Hobart) and Wollongong (Port Kembla) have recorded lower annual rises. Tools such as the Oz Coasts website show examples of the projected sea-level rise on maps of some of our major cities. This helps decision makers understand not only the current rate of sea level rise, but also the projected geographic changes that may result from it.

Table 4-1 Tidal gauge measures of annual sea level rise 1993–2011 for selected coastal major cities

City	Sea level rise (mm)	Total average change (mm)
Perth	9–10	162–180
Darwin	8–9	144–162
Adelaide, Townsville	4–5	72–90
Hobart, Wollongong	3–4	54–72
Melbourne	1–2	18–36

Source: CSIRO 2012

Figure 4-10 Sea level rise multiplying effects



Source: Hunter et al. 2012

State of Australian Cities 2011 discussed the multiplying effect of sea level rise on events such as storm surges, both in their intensity and the frequency. Figure 4-10 shows an estimate of increased prevalence of flooding events of a given height that might be expected to occur from a sea-level rise of 0.5 metres. For example, the middle-sized circles show that one in 100 year events will happen 100 times more frequently, and could be expected to happen on average once each year. This assumes that a place gets the same number of storm surges, but that they will each be slightly higher – and this ‘slightly higher’ causes a large increase in flooding events for a given height. In other words, if the sea comes over a sea wall once a year at present, it can be expected to break over it every day after the 0.5 metres of sea level rise is reached.

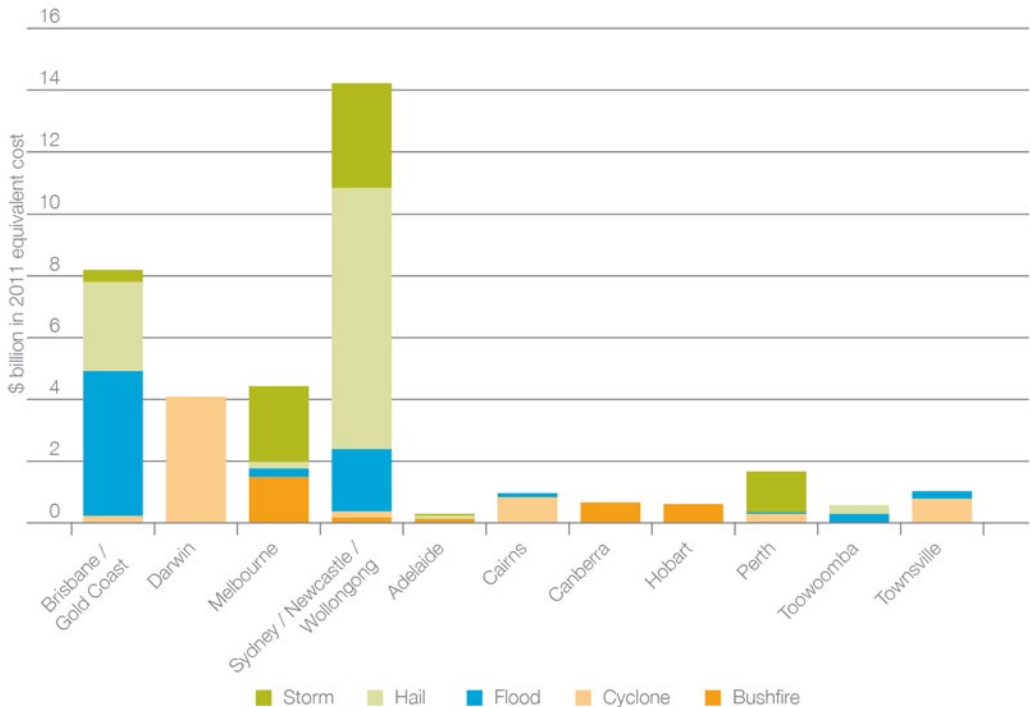
State of Australian Cities 2011 illustrated a range of globally averaged projected sea level rises of between approximately 0.2 metres and 0.8 metres by 2100, based on the 2007 International Panel on Climate Change’s (IPCC) 4AR report on high and low ranges. Authoritative studies published since 2007 reveal the likelihood of much wider ranges of possible sea level rise by 2100: three studies estimate maximum sea level rise of more than 1.5 metres above present levels (Department of Sustainability and Environment, Victorian Government 2012).

The National Sea Change Taskforce has commissioned further work on the preparedness of coastal Australia for climate change adaptation (Gurran et al. 2011) to follow-up on the findings of its 2008 study. The report found different levels of adaptation awareness and planning among the private and public sectors across Australia. While most local government climate adaptation action is in early stages, many coastal councils have developed formal climate adaptation initiatives, ranging from studies of vulnerability to amending local Planning regulations, with some developing community engagement mechanisms. Cities with local climate change adaptation initiatives include Cairns, Geelong, Newcastle and the Sunshine Coast (Gurran et al. 2011). Several coastal major city councils were funded under the Australian Government’s Local Adaptation Pathways Program (2008–10) including Wollongong, Cairns, the Gold Coast, the Sunshine Coast, Perth and Launceston.

Climate-related urban perils

Climate change will lead to more frequent severe weather events including severe fire danger days, floods and storms, as noted in *State of Australian Cities 2011*. Severe weather events affecting Australia's cities cost our communities dearly, as shown by Figure 4-11. Some cities are dominated by one particular climate-related peril – for example, Darwin, Cairns and Townsville by cyclones, Perth by storms and Sydney by hailstorms. Despite its overall mild climate, Sydney has historically incurred costs from most types of damaging weather events, with hailstorms being predominant. This may reflect not just Sydney's geographical position in relation to climate patterns but also its physical extent; its sheer spread means it is more exposed. Australia comprises about two per cent of the global insurance market, yet in the last half decade it has incurred six per cent of losses (Climate Institute 2012 p. 9).

Figure 4-11 Insured costs (payments) of severe weather events in selected major cities 1967–2011



Note 1: This figure is an indication only of the relativities of different weather disasters in cities from data based on insurance payments for residential and commercial properties. It does not represent the actual total cost of each event.

Note 2: Some flood events are the result of cyclones – for example, Cyclone Wanda-related flooding of Brisbane in 1974.

Source: Insurance Council of Australia 2012

Queensland floods 2009–12

Further to the *State of Australian Cities 2011* article on the 2010–11 Queensland floods, the Queensland Reconstruction Authority <http://www.qldreconstruction.org.au/> has since added the 2009–10 and 2012 weather disasters to its remit. Together these disasters have affected each of the six major cities in Queensland, some of them more than once. The Authority estimates that a total of \$12.2 billion worth of infrastructure repair work was needed, much of it for roads. Of this, the government-funded repair bill for the 2009–10 events is estimated to be \$3.2 billion, for 2010–11 events \$7.5 billion and for 2012 an estimated \$1.5 billion (Queensland Reconstruction Authority 2012). In addition to major infrastructure damage, the Queensland Floods Commission of Inquiry (2012) found that approximately 29,000 homes and businesses suffered some form of inundation. Over 58,000 residential and commercial insurance claims were made as a result of the 2010–11 floods. Just under half were residential claims (excluding contents). Brisbane City Council (2012) reports that the city's estimated cost of flood recovery work is now in excess of \$400 million (in addition to the value of the clean-up work done by thousands of volunteers in the immediate aftermath of the January 2011 flood), including:

- \$122 million for roads and related infrastructure
- \$41 million for disaster operations and clean-up
- \$23 million for parks
- \$19 million for the drain network
- \$12 million for creek remediation
- \$4.5 million for pools and libraries
- \$3 million for wharves, jetties and pontoons.

A state-of-the-art Damage Assessment and Reconstruction Monitoring system (DARMSys™) is now being used to monitor Queensland's rebuilding progress. Real time data is collected by assessors using a hand held monitoring device and sent via Wi-Fi to provide map-based damage data. Introduced as a pilot program in April 2011, the Queensland Reconstruction Authority is using the system to travel street-by-street and house-by-house through flood- and cyclone-affected communities to identify where the greatest needs exist. The Authority has also established interactive maps (Flood Check maps) which show 2010–11 Queensland natural disasters – flood lines and disaster imagery as well as floodplain mapping and reconstruction projects. The Australian Government has, through Geoscience Australia, launched the National Flood Risk Portal to give easy access to communities and planners to better prepare for flood disasters see <http://www.ga.gov.au/flood-study-search/> for more information.

Bushfires

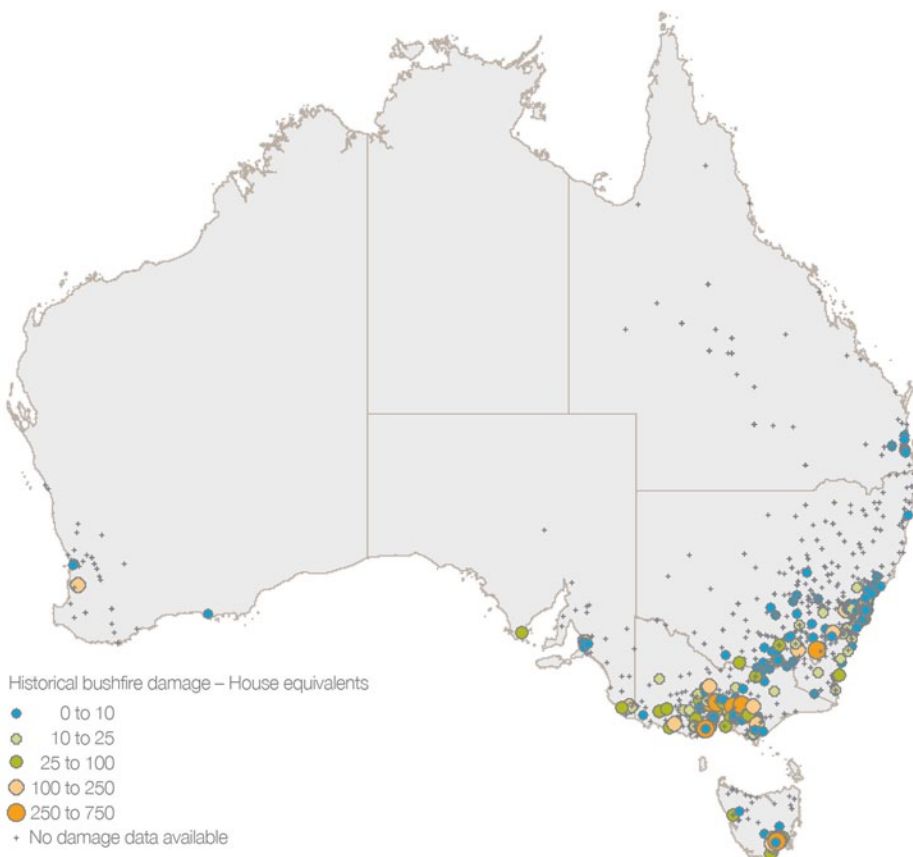
State of Australian Cities 2011 discussed heatwaves as Australia's deadliest natural disaster; however, bushfires have also resulted in significant loss of life and injury and capture more media attention. The Climate Institute estimates that the number of very high and extreme fire weather days will increase by between 15 and 60 per cent by 2020 and double to quadruple by 2050 (Climate Institute 2007). During the past 100 years, over 600 people have died and over 4,000 have been injured due to bushfires (Australian Emergency Management Institute 2012).

According to the *State of the Environment 2011* report (State of the Environment 2011), the pattern of vegetation fires across Australia consists of:

- frequent fires in the tropical savannahs
- regular fires in arid and semi-arid grasslands following years of above average rainfall
- major fires in the south-east and south-west of the continent and in Tasmania associated with major drought cycles.

While the greater land area affected by fires is in the north of Australia, the greatest loss of property and life from fire is in the south, where most people live (Figure 4-12). The report notes that severe bushfire weather conditions appear to be becoming more frequent, with an upward trend in the cumulative forest fire danger index (a measure of predicted fire severity) since the 1980s (State of the Environment 2011). The Climate Institute (2012) notes the non-linear increase in bushfire risk against temperature rise: with a 1.5°C temperature increase, bushfire risk increases by up to five per cent.

Figure 4-12 Annual number of buildings (in House Equivalents) lost in bushfires in Australia 1900–2009



Note: House Equivalents are used to normalise losses of various types of destroyed structures – residential homes, commercial buildings, churches, etc. – onto a common footing of equivalent residential houses using relative building costs and average floor areas.

Source: PerilAUS in Chen and McAneney 2010, reproduced with kind permission of the authors

The Forest Fire Danger Index (FFDI) for Victoria’s Black Saturday fires in February 2009 rose to unprecedented levels, ranging between 120 and 200 (noting that a FFDI over 50 represents extreme fire danger) (Fisher 2012). Many severe fires penetrate a long way into major population centres. On Black Saturday, one of the major fires burned to within two kilometres of the central business district of Bendigo, a city of almost 100,000 people (Fisher 2012). Bushfires around major cities not only just threaten properties and lives by fire, they can also contaminate water storage as was the case in Canberra when heavy rain following the 2003 fires washed ash and mud into dams. Serious contamination of Melbourne’s already depleted supply would have occurred in 2009 had rain followed the fires, as fire entered its water catchments on 10 February (Fisher 2012).

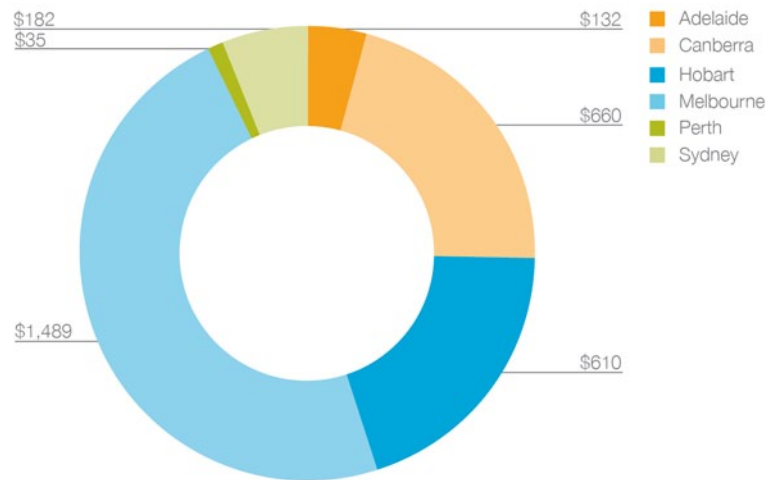
Table 4-2 summarises building loss and fatalities in four major bushfires since 1967, showing that the largest proportion of losses occurred in a limited number of extreme bushfires (Chen and McAneney 2010).

Year	Location	Houses destroyed	Lives lost
1967	Tasmania (Hobart)	1,557	62
1983	Victoria and South Australia (Melbourne, Adelaide)	2,253	75
2003	ACT (Canberra)	530	4
2009	Victoria (Melbourne)	2,029	173

Source: Chen and McAneney 2010 and Australian Emergency Management Institute 2012

Figure 4-13 shows that, between 1967 and 2011, Melbourne suffered the majority of bushfire-related costs of almost 50 per cent of the total \$3.1 billion, followed by Canberra and Hobart with about 20 per cent of total costs each.

Figure 4-13 Proportion of major bushfire-related building costs in selected major cities 1967–2011

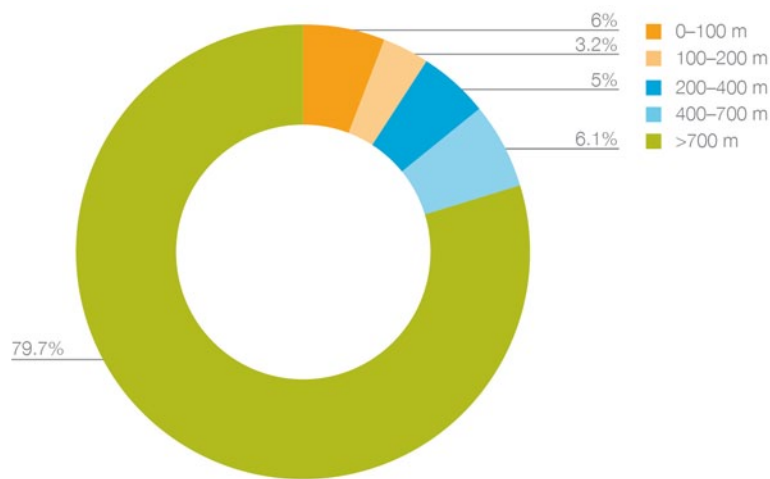


Note: Figure in 2011 cost equivalents (millions).

Source: Insurance Council of Australia 2012

The increased frequency of extreme fire danger days due to climate change and population growth are increasing the risk to lives and property from bushfires, as evidenced by recent major fires in California and Russia, as well as Victoria’s Black Saturday fires, which cost 173 lives and 2,133 houses (Gibbons 2012).

Figure 4-14 Proportion of Australian addresses by distance from large areas of bushland



Source: Chen and McAneney 2010

Distance from significant bushland

Figure 4-14 shows the percentages of Australian addresses by distance category from large areas of bushland. Chen and McAneney (2010) estimate that about 490,000, or six per cent, of addresses in capital cities are within 100 metres of substantial bushland, and over 750,000 within 200 metres. The encroachment of peri-urban greenfield development into bushland and the attractiveness of living close to Australia’s eucalypt bushland mean that increasing numbers of buildings in Australia’s cities will be exposed to risk from bushfires. In particular, communities around urban parklands are largely unaware of the bushfire risk they face, and current communication campaigns about such risks in our cities may be ineffective (Everett et al. 2012). Distance between buildings and bushland is not the only bushfire vulnerability variable, but it has been shown to be the most important.

Studying landscape management in the context of bushfires can yield some important lessons for urban decision makers. One such study analysed the effectiveness of fuel reduction in providing greater protection to fire-prone peri-urban areas. The study examined 499 houses destroyed in the 2009 Black Saturday bushfires in Victoria (Gibbons 2012) and found that six variables have the potential to reduce the chances of dwellings being destroyed by bushfire. These are, in order of importance:

- tree and shrub cover within 40 metres of houses
- the type of such cover (remnant or planted)
- upwind distance from houses to groups of woody vegetation
- upwind distance from houses to public forest
- the upwind distance to prescribed burning (within five years)
- the number of buildings/structures within 40 metres of houses.

The study concluded that clearing vegetation within 40 metres of houses was twice as effective at protecting houses than prescribed burning (over a large area as well as close to houses) (Gibbons 2012). This is not to say that prescribed burning should not be a part of land management practices in bushfire-prone peri-urban areas: Gibbons notes that ‘15 per cent fewer houses were destroyed if prescribed burning occurred at the observed minimum distance from houses (0.5km)’ (Gibbons 2012 p. 8).

Other studies have shown that roughly half of destroyed dwellings in the Como-Jannali fires (Sydney, 1994), the Otway Ranges (Victoria’s 1983 Ash Wednesday fires) and Hobart (1967) occurred at a distance less than 50 metres from bushland and (excluding the Canberra fires), 80–90 per cent of all destroyed buildings were within 100 metres of bushland (Chen and McAneney 2010).

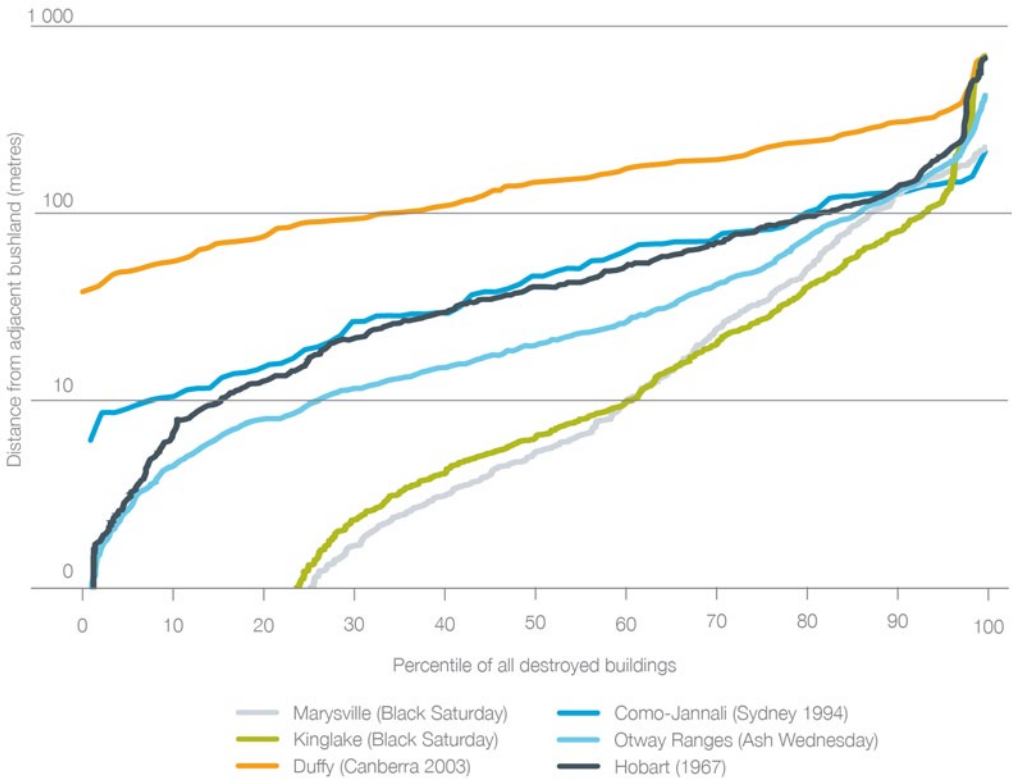
Figure 4-15 shows the cumulative distribution of buildings destroyed in selected major bushfires in relation to distance from bushland.

CSIRO Pyrotron Bushfire Research Facility, Canberra.

Image courtesy of CSIRO



Figure 4-15 Percentiles of destroyed buildings in selected major bushfires by distance from bushland



Note 1: The trend for Duffy is different owing to forced evacuations during the Canberra bushfires and thus buildings were subject to more unprotected sustained ember attack.

Note 2: Percentile is the range of a frequency distribution divided into 100 parts by percentiles: for example, 15 per cent of the data lies below the 15th percentile, 40 per cent below the 40th, etc.

Source: PerilAUS in Chen and McAneney 2010, reproduced with kind permission of the authors

Table 4-3 Distances at selected percentiles of destroyed buildings in selected major bushfires (metres)

Percentiles	50th	60th	70th	80th	85th	90th	95th
Marysville	5	10	23	48	83	126	159
Kinglake	6	10	20	40	56	79	114
Duffy	145	170	192	238	265	305	340
Como-Jannali	45	60	72	97	122	135	142
Otway Ranges	19	31	51	88	108	145	198
Hobart	39	49	66	92	104	127	191

Source: Chladil in Chen and McAneney 2010

Table 4-3 shows approximate distances in metres at various percentiles of destroyed buildings: the column labelled 50th percentile shows the distance from bushland within which 50 per cent of buildings were destroyed. In other words, buildings very close to bushland in

a bushfire are subjected to all fire perils: flames, radiant and convective heating and ember attack (Chen and McAneney 2010).

Responses to bushfires in Australia's urban contexts

In this context, the vital issue of land use planning in relation to bushfire risk in peri-urban areas needs to be considered further. Positive steps are being taken, particularly since the release of the 2009 Victorian Bushfires Royal Commission's recommendations. Victoria, NSW and South Australia are improving their mapping of bushfire-prone areas and amending their planning provisions to restrict new developments and subdivisions in those areas of highest risk, such as the Adelaide Hills. The Royal Commission's recommendations include that Victoria's Country Fire Authority amend its guidelines for assessing permit applications for dwellings, non-dwellings and subdivisions in bushfire-prone areas to:

- 'clarify that the CFA will approve new developments and subdivisions only if the recommended bushfire protection measures – including the minimum defendable space – can be created and maintained on a continuing basis
- emphasise the need for enduring permit conditions – in particular, conditions for the creation and maintenance of minimum defendable space to be maintained for the life of the development'

(2009 Victorian Bushfires Royal Commission 2010, Recommendation 40).

In response to the 2009 Victorian Bushfires Royal Commission, defendable space requirements have been developed in conjunction with the CSIRO and promulgated by the Victorian Government (Department of Planning and Community Development 2012). The new rules allow trees to be cleared within 10 metres of buildings and 40 metres from fence-lines: if applied across an urban area, this could denude a suburb's landscape of trees (Fisher 2012).

The Dandenong Ranges on Melbourne's outskirts will feature in a pilot program designed to improve bushfire preparedness among local community, government and fire agencies. The Dandenong Ranges has a complex bushfire risk due to the intersection of public and private land. The Dandenong Ranges Bushfire Landscape Plan will address existing gaps in fire management plans, while identifying short- and long-term issues and priorities to improve bushfire safety. The Plan will review a range of issues, including public and private land management, demographics and population, community planning and preparation and understanding fire behaviour (Fire Services Commissioner Victoria 2012).

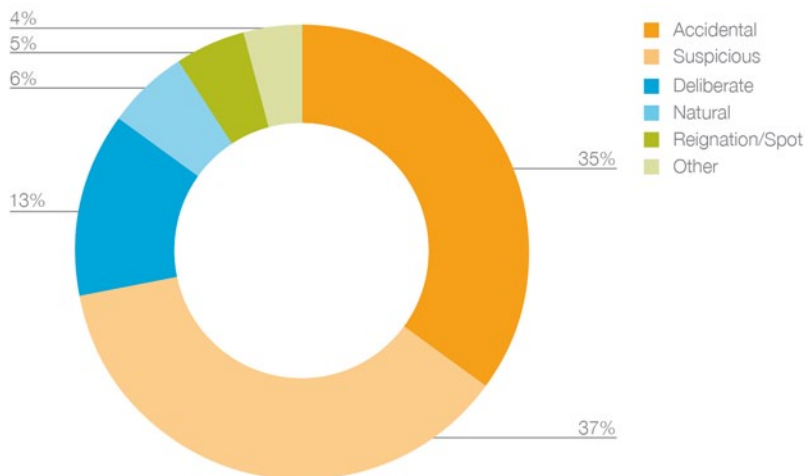
As Western Australia's leading hazard management agency, the Fire and Emergency Services Authority of Western Australia (FESA) performs a critical role coordinating emergency services for a range of natural disasters and emergency incidents threatening life and property. FESA was established to improve the co-ordination and planning of emergency services in Western Australia. FESA has adopted an 'all hazards' approach to emergency management, working in partnership with the community and other government agencies to prevent, prepare for, respond to and recover from natural disasters and emergencies. In response to inquiries into the Perth Hills fires of 2011 and 2012, Western Australia is developing an integrated bushfire risk management system for the state. Objectives include ensuring bushfire risk is identified, considered and reflected in planning processes and controls and development decisions, and to also progressively decrease the legacy bushfire risks in existing development areas.

In 2012, the Hobart City Council Strategic Risk Register identified 'Failure to appropriately adapt to and manage the impacts of climate change' as a significant risk requiring active management. Because changes in wildfire incidence and severity are likely effects of climate change, the Council is embarking on a full redevelopment of its fire management strategy. Tasmania is close to finalising a planning directive – Bushfire Prone Areas Code. Once finalised, the Code will be incorporated into all existing planning schemes, draft planning schemes and interim planning schemes. The Code is intended to ensure that bushfire issues are identified and fully considered at the planning application stage of the development process in a consistent manner across Tasmania. The Code will be applicable to all development within a defined bushfire-prone area and will require that developments be assessed by the Tasmanian Fire Service or an accredited person before they are approved.

Arson

Each year the deliberate lighting of fires causes significant damage to people, property, flora and fauna in Australia. Bushfire arson is a major threat to the Australian community, with up to 50 per cent of bushfires in Australia being deliberately lit or started in suspicious circumstances, as shown in Figure 4-16 (Bryant, 2008). The edges of our major cities are particularly vulnerable to bushfire arson by virtue of their greater population and ready access to large tracts of bushland. However, the Fire and Emergency Services Authority in Western Australia (FESA) has been able to achieve significant reductions in the number of deliberately lit fires. From July 2010 to June 2011, 196 arson related charges were laid by Western Australian Police under the *Bush Fires Act* (1954) (WA) and s44 of the Criminal Code. On 16 December 2009 the *Bush Fires Act* (1954) (WA) and the Criminal Code were amended to increase penalties and clarify the definition of property regarding charges involving arson. 'Property' now means personal or real estate property including Crown land, bushland and fauna (FESA 2012).

Figure 4-16 Proportion of vegetation fires in Australia by cause



Note: Figures are from an Australian Institute of Criminology study of 280,000 fire records between 2002 and 2008.

Source: Bryant 2008

National Work Plan to Reduce Deliberate Bushfires

The National Work Plan to *Reduce Deliberate Bushfires* is a nationally agreed policy framework to address bushfire arson in Australia. The plan was endorsed on 20 November 2009 by the Australian Government and state and territory police and emergency management ministers. It aims to reduce the incidence of bushfire arson through collaborative national approaches across all agencies and jurisdictions (Attorney-General's Department 2012).

The plan details 10 actions, which have already seen significant progress:

- Develop a national strategy to reduce bushfire arson and to provide direction to individual jurisdictions and agencies
- Use prevention and community education programs in high-risk fire and arson areas at the urban-rural interface
- Promote nationally consistent arson and bushfire offences
- Produce a best practice bushfire arson prevention handbook
- Develop programs aimed at known arsonists and recidivist arsonists
- Update nationally-accredited training programs for fire agency and police personnel, including strategies for preventing bushfire arson
- Raise community awareness of bushfire arson by incorporating arson prevention messages in existing community awareness programs
- Support a nationally consistent framework for collecting data on bushfire arson
- Research socioeconomic and demographic factors that suggest the potential for someone to commit bushfire arson
- Promote a two-way information flow on arson prevention between practitioners, researchers and policy makers.

Responses to climate change

Barriers to effective climate change adaptation

Productivity Commission Inquiry into barriers to effective climate change adaptation

In September 2011, the Assistant Treasurer commissioned the Productivity Commission to conduct an inquiry into barriers to effective climate change adaptation. The Productivity Commission released its draft report, *Barriers to Effective Climate Change Adaptation*, in April 2012. The draft report emphasised the importance of effectively managing the current climate. However, it also identified scope to build on managing the current climate in terms of adaptation to future climate trends.

The draft report included recommendations with significant implications for effective adaptation of Australia's cities. Notable city-relevant recommendations include the need for flexible land use planning and building regulation reform, new approaches to manage climate risks to existing settlements and general principles for infrastructure investment decisions.

Land use planning and building regulations

Land use planning regulation needs to be flexible to respond to climate change. In order to achieve the required flexibility land use planning systems should be revised to enable a risk management approach. In addition, state and territory governments should clarify the roles and responsibilities and legal liabilities of local governments for adaptation, particularly in the areas of land use planning and coastal management.

The National Construction Code and associated standards should be revised to take climate change impacts into account. The Australian Building Codes Board should develop a formal work program that outlines its approach to incorporating climate change in the National Construction Code.

Existing settlements

Cities need to start adapting and new approaches may be needed to manage climate change risks to existing settlements. This requires consideration of whether, how and when governments should 'protect' cities or towns, or relocate communities from high hazard risk areas. Currently, there is no well-established policy response to this issue. As a result, it may be necessary to develop national approaches to support strategic management of climate change risks for existing settlements.

Infrastructure investment decisions

There are several general principles that should be followed by government and the private sector when making adaptation decisions for infrastructure. The operator of infrastructure is likely to be best placed to consider adaptation investments. Adaptation investments should be subject to cost-benefit analysis and all investment options should be considered. The timeframes associated with adapting infrastructure should be taken into account.

Planning for risk and adaptation

Decisions about where our cities grow and source their food, energy and water will need to take account of future climate risks, including floods, fires, coastal inundation and erosion. Commercial mechanisms for risk management, such as property investment, appear to be lagging in preparedness. A report by the Australian Institute of Superannuation Trustees and the Climate Institute (2011) found that 65 per cent of funds have not recognised the impacts that climate change will have on investment portfolios, and similarly 83 per cent of superfunds replied ‘no’ to the question ‘do you believe that systemic risks like climate change are currently being priced into asset valuations properly?’. These oversights are likely to have significant implications as climate change continues to unfold.

Examples of major city climate change adaptation plans that are flexible can be seen in Perth and South-east Queensland. In Perth the Water Corporation is implementing a three-part strategy to meet the city’s changing water requirements to 2060, including reducing water consumption by 25 per cent, increasing the proportion of recycled water to 60 per cent and developing more desalination plants (Stocker et al. 2012). Southeast Queensland has developed a staged ‘bottom-up’ approach to help coastal communities become more resilient to climate change, as illustrated by the SEQ Climate Proofing Demonstration Project (Laves and Waterman 2012).

In addition, tools such as the Antarctic Climate & Ecosystems Cooperative Research Centre’s sea level calculator (“Canute”) can help decision makers with information on height adjustments for certain infrastructure (via ‘Canute’ at www.sealevelrise.info). Canute also contains a shoreline recession calculator.

The Victorian Solar Atlas maps solar energy resources across Victoria to help investors and developers make decisions about the best sites for solar projects: see <http://www.dpi.vic.gov.au/energy/sustainable-energy/solar-energy/what/victorias-solar-resource-details/solar-data/atlas>.

CSIRO Climate Adaptation Flagship research

Research in the CSIRO Climate Adaptation Flagship is aimed at helping Australia adapt effectively to climate change and variability. CSIRO scientists work in partnership with governments, industries and communities to address this urgent national challenge.

The Flagship provides urban and coastal settlements with information and knowledge to support climate-adaptive built environments. A new approach called Climate Adaptation Engineering blends traditional engineering knowledge with adaptation thinking.

The research considers safety, serviceability, durability and sustainability at the individual scale and reliability, resilience and adaptability at the broader landscape scale. It also offers decision pathways for planning, design, construction, maintenance and renewal over the lifecycle of the built environment under different climate change scenarios.

Adaptations, such as changes made to design standards and retrofitting existing homes reduce the vulnerability of new and existing infrastructure to extreme events such as cyclones and inundation. However, cost effectiveness is crucial towards the successful implementation of adaptations.

CSIRO Flagship research is looking at Queensland to assess the vulnerability of buildings to extreme wind and inundation and the cost effectiveness of the required adaptations and its effectiveness. It is also considering the benefits of timely implementation of such measures and the risks, costs and benefits of deferring such measures. As an example, increasing the design wind classifications in the *Australian Standard Wind Loads for Houses AS4055-2006* for all new housing from 2011 shows promise as a cost-effective climate adaptation strategy. However, by deferring adaptation to 2030 in Brisbane, the benefit could be halved by 2100.

In the long term, construction of new housing with higher floor heights for adaptation to coastal inundation is also sensible. The longer the adaptation policy time horizon, the larger the extent of the adaptation required to attain the optimal benefit.

Recent CSIRO Flagship research, involving the Urban Development Institute of Australia and the Property Council of Australia (Queensland), surveyed the members of the urban development sector in three Australian states about climate change and adaptation. The research found that developers are acutely aware of the potential for regulatory costs and the community expectations of the need for climate adapted urban developments.

Further CSIRO Flagship research points to land devaluation due to sea levels rising, exposing new areas of residential land to the risk of inundation and worsening the situation for those areas that already experience inundation. It concludes that the resulting devaluation of residential land is likely to match the costs of building damage due to inundation. As a result, major community-scale adaptations will return more benefit in avoided damages than they cost to build.

Urban impacts on natural resources in metropolitan fringe regions

Concern about development at the edge of Australian cities is becoming a regular fixture on the agenda of industry bodies and governments, not to mention community groups and the media (Note 1). This echoes an emerging international focus on peri-urban regions, as questions are asked about the footprint of urbanisation (Note 2). It is also the predictable consequence of steady population growth in Australia's most environmentally-favoured areas combined with an urban policy predicated on low-density development and car ownership.

Recent years have seen an emerging awareness of the significance of peri-urban regions to Australian agriculture and our food supply system. Nationally, these regions produce a disproportionately large share of total farm-gate value (Houston 2005) and are major sources of fresh produce (Donovan et al. 2011). Table 4-4 shows the amount of selected Australian cities' vegetables produced almost exclusively in their peri-urban regions.



Main South Road, cutting through McLaren Vale South, Australia
Image courtesy of Peter Houston

Table 4-4 Major city peri-urban production for typical vegetables 2007–08 as a percentage of state production (weight)

Perishable Commodities	Sydney	Melbourne	Brisbane Fringe	Brisbane and Coast	Adelaide	Perth	Hobart, South and North SDs	Australia % of total	Total Values \$m
Asian Vegetables	94%	53%	98%	50%	22%	93%	100%	72%	23.2
Asparagus	0%	93%	100%	100%	0%	0%	0%	92%	9.8
Broccoli	11%	61%	100%	70%	4%	22%	21%	50%	46.1
Capsicums	79%	12%	36%	82%	97%	31%	100%	72%	56.6
Celery	73%	100%	100%	51%	100%	74%	0%	89%	55.6
Cucumbers	63%	80%	80%	73%	91%	71%	42%	76%	15.7
French and Runner Beans	37%	1%	42%	92%	22%	51%	0%	72%	16.4
Herbs – Parsley	96%	80%	87%	61%	100%	95%	88%	83%	2.9
Herbs – Basil, Coriander, etc.	89%	48%	56%	81%	98%	88%	100%	83%	4.4
Leeks	98%	92%	100%	2%	22%	100%	8%	78%	6.3
Lettuce Head	43%	74%	100%	60%	32%	45%	100%	58%	135.4
Mushrooms	79%	84%	91%	75%	100%	0%	0%	83%	42.3
Silverbeet and Spinach	97%	55%	100%	16%	100%	93%	14%	55%	10
Spring Onions and Shallots	83%	92%	100%	99%	76%	95%	100%	94%	7.8
Zucchini and Squash	59%	4%	65%	90%	27%	14%	14%	66%	20.3
Total	67%	62%	84%	67%	59%	58%	46%	75%	453

Source: Thompson (ed.) derived from ABS agricultural commodity data 2008

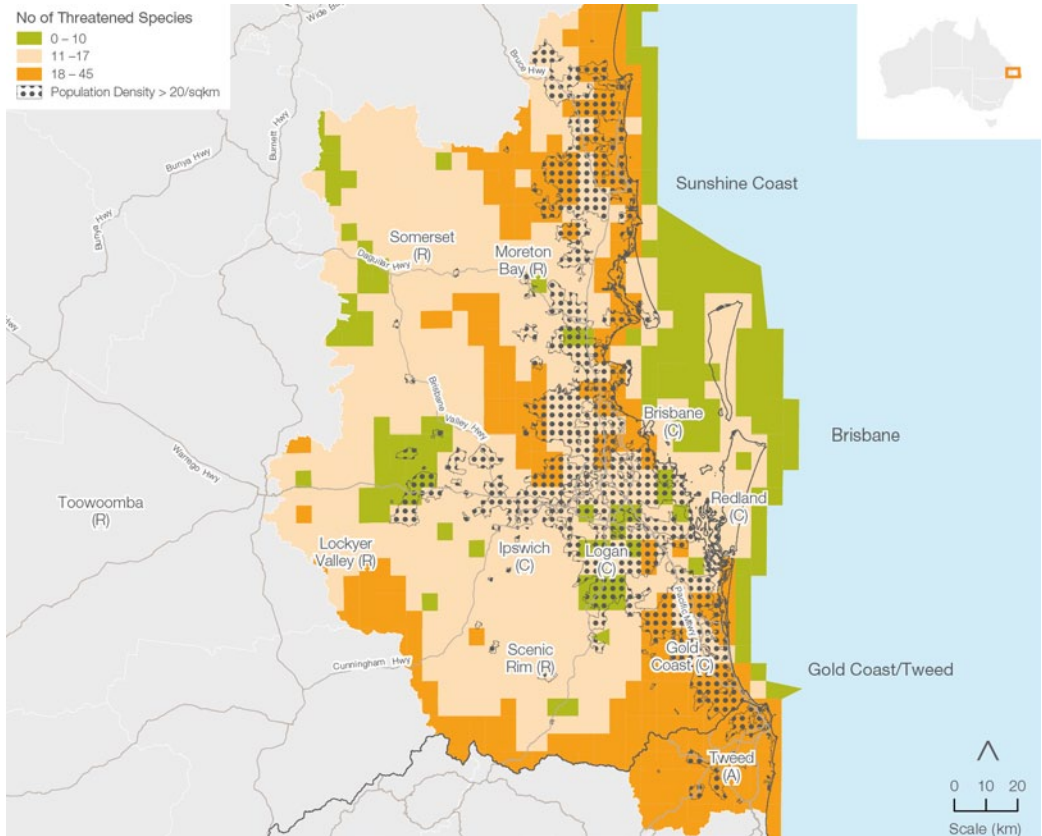
In 2010 the Australian Government's Issues Paper *A Sustainable Population Strategy for Australia* noted that:

'The amount of land which is suitable for intensive agricultural, horticultural and viticultural production in Australia is strictly limited and a substantial part of it lies on the fringe of Australia's major cities as well as around the nation's major regional centres. The rate at which this land is being alienated for urban use is high and continuation of fringe development policies threatens the nation's agricultural production' (Commonwealth of Australia).

A similar theme has begun appearing on the COAG agenda of primary industries ministers, albeit as part of a wider question about the availability of key agricultural lands in the face of changing demands on rural landscapes such as mining (DAFF pers. comm.).

Besides food and agriculture, peri-urban regions often contain areas of high ecological value. As illustrated by Figure 4-17, urbanisation places pressure on threatened species and maintenance of biodiversity (Gordon et al. 2009). Peri-urban regions also perform an important ecosystem service for cities in that they are key to their water supply catchments (Miller et al. 2009). Since 2000 this often overlooked fact has been underscored by public health water quality scares and public spending on desalination plants.

Figure 4-17 Biological assets in the Greater Brisbane metropolitan area – threatened species



Source: DSEWPAC-ERIN 2012

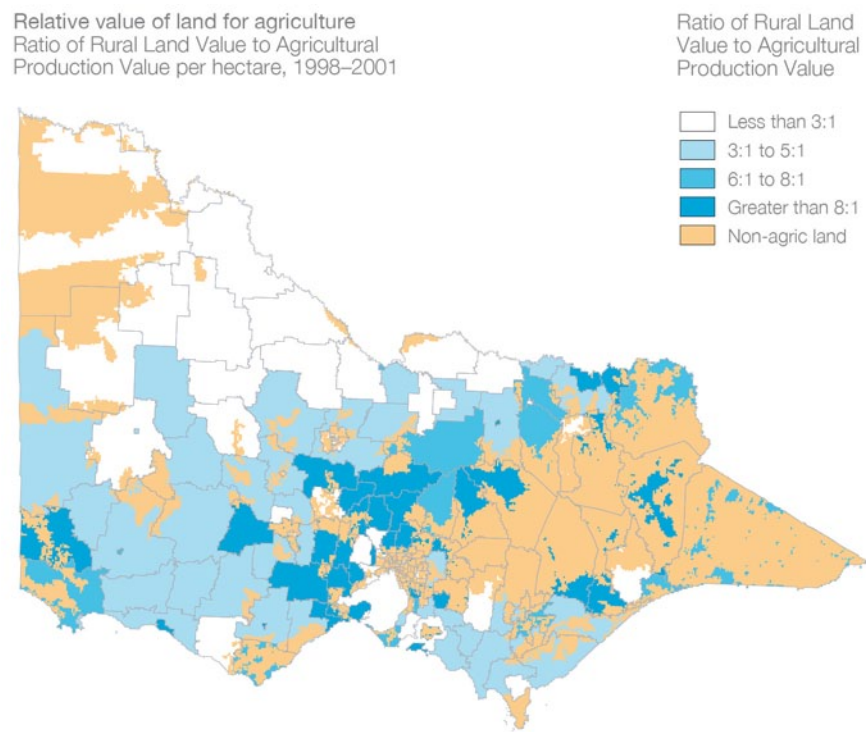
However, in Australia's major peri-urban regions, and with only a few exceptions, rural land is under constant pressure from the direct and indirect effects of urban encroachment. Despite good intentions, conventional land use policy and urban governance mechanisms appear unable to support stable peri-urban landscapes, whether for agriculture, food system resilience or natural resource management.

The most obvious examples are at the inner edge of peri-urban regions. Repeated shifting of urban growth boundaries (Millar 2011) and construction of major infrastructure projects in and through green space, rather than around it, have the effect of destabilising and fragmenting fringe landscapes and their communities (Note 3). Rather than engendering the 'certainty' that state planning systems aspire to, landholders and businesses are often left disaffected (Department of Planning and Environment 1997) and vulnerable to opportunistic development proposals.

Less obvious is the way 'consumptive' and 'speculative' values (Henderson and Rofo 2011) associated with urban property markets are spilling over into peri-urban landscapes in the form of inflated land prices. As illustrated by Victorian research shown in Figure 4-18, the land price increase effect from rural residential lifestyle demand can be seen up to 150 kilometres from the centre of the city. The implications of this phenomenon for agricultural businesses

seeking to stay ahead of the cost-price squeeze are well established in North America (Nelson 1990) and now being recognised in Australia (Barr et al. 2005).

Figure 4-18 Relative value of land for agriculture: Ratio of Rural Land Value (RLV) to Agriculture Production Value (APV) per hectare 1998–2001



Source: DSE 2005

The consequences of this phenomenon should not be underestimated. The urban price shadow surrounding Australia’s major cities arguably renders significant parts of the nation’s most environmentally favoured areas off-limits to large-scale commercial agriculture (Barr and Karunartne 2002).



Measuring Sustainability Program

The Australian Government has established the Measuring Sustainability Program recognising that sustainability requires that the wellbeing of society - the combination of community liveability, environmental sustainability and economic prosperity - is maintained or improved over time. To measure sustainability, these three dimensions will be tracked over time. Put another way, the program seeks to ensure that the resources inherited by future generations allow for the same (or greater) levels of wellbeing as enjoyed by Australians today. This means that Australia's sustainability cannot be measured by the strength of the economy, the functioning of society or the state of our environment alone, but rather by looking at these dimensions holistically.

Under this program the National Sustainability Council was established by the Australian Government in October 2012 as an independent, expert body to provide advice on sustainability issues. The council reports to the Minister for Sustainability, Environment, Water, Population and Communities. The council's key role is to deliver a public report against a set of sustainability indicators for Australia every two years.

The program will improve information about our economy, environment and society, and the linkages between them, to better inform decisions and policy making. This will also help government and industry to take a longer-term view and consider how actions and decisions today affect the opportunities available to future generations.

Open space and natural systems sustainability in cities

Our cities might look to be predominantly glass, concrete, roofs, bricks and tarmac, but as much as 60 per cent of the built-up area is composed of open space – recreation facilities, waterways, public facilities, road reserves and the like, which create an extensive public realm (McLoughlin 1991). Unlike buildings on private land such as homes and commercial buildings which tend not to change for decades, our public realm is constantly changing, conferring on our governments complex tasks of urban management and design. Importantly, active ecological systems continue to work within these spaces and are increasingly being brought back to life to enrich our urban lives. Concrete stormwater drains are being turned back into managed natural waterways, urban habitat protected, pollutant traps created, neglected weed-infested land turned into urban forests, recreational trails and parks systems expanded, and drains mined as a once-forgotten water resource. The better management of our green infrastructure is increasingly seen as at one with improved liveability of cities (Maheepala and Blackmore 2008).

Green infrastructure

The public realm of Australia's cities is a network of open space reserves, rivers, drains, beaches and estuarine systems, coastal systems, parklands and shade trees in streetscapes. These natural assets also act as habitat corridors, often right into the centres of our cities. Our cities are each girt by rural landscapes that provide perishable foods and extensive parks systems while functioning as the sources of drinking water and ecological refuges. The presence of such green infrastructure enables city dwellers and visitors to enjoy the quality provision and regulation of water, air, temperature, energy and natural amenities and to gain identity from the natural settings of our major cities (Woolley 2001).

For cities, this integrated, multi-pronged approach of green infrastructure management and design (AILA 2011) can provide multiple benefits: economic (stormwater drainage); ecological (absorbing surface water run-off, trapping nutrients, filtration of pollutants and nourishing habitat); social (recreational shared path network) and cultural (enhance and protect liveability). Unlike urban planning and design processes that are more associated with new development and can be funded as a one-off process, managing our green infrastructure in the public realm requires a concerted ongoing effort through new integrated natural resource and urban management and financing systems.

The main natural resource challenges for Australia's major cities include: managing rising temperatures to mitigate the effect of Urban Heat Islands (UHI); water and air quality in the context of reduced rainfall in southern Australia and increased bushfire risk; and fostering community well-being to maintain liveability standards (State of the Environment 2011 Committee 2011). The past and present profligate use of natural resources in low-density urban form are said to provide liveability at the expense of sustainability (Newton 2012). Green infrastructure provides an active means by which we can address the imbalance of the high natural resource use through better management of our urban natural systems.

Hobart's Sullivans Cove in the foreground and Mt Wellington in the background.
Image courtesy of the Tasmanian Government

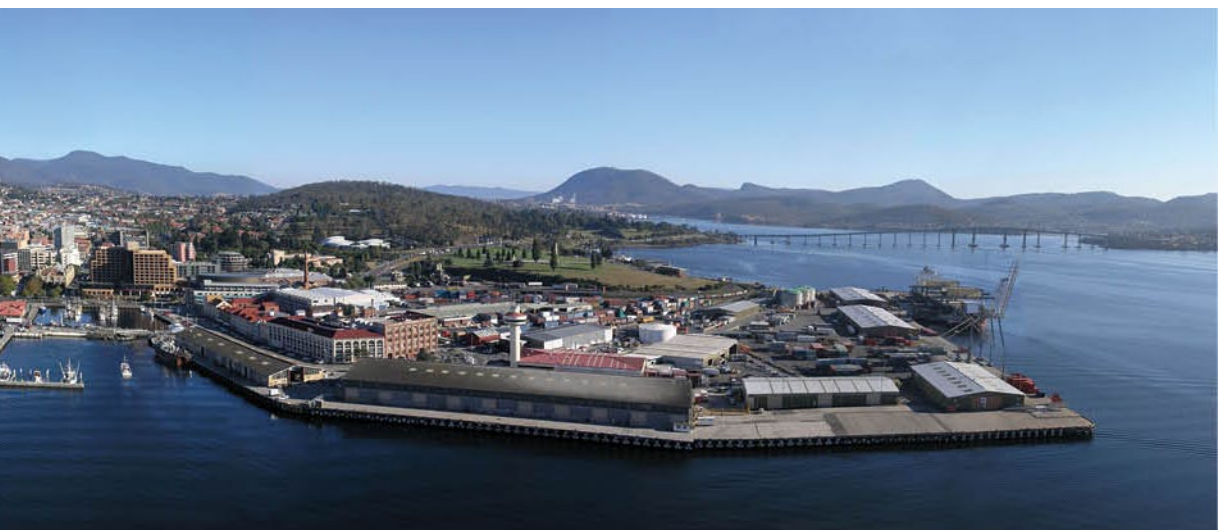


Valuing the ecological characteristics of sustainable cities

The recent inclusion of and increased valuing of ecological characteristics in the Best Cities Ranking and Report (Economist Intelligence Unit (EIU) 2012) reflect an international shift in recognising the value of green spaces when calculating levels of liveability. Its liveability index was recently adjusted to factor in previously ignored spatial characteristics of cities. Hong Kong was ranked first and Sydney fifth in the top 10 best cities in this new ranking. Hong Kong's distribution of green spaces and access to natural assets boosted its ranking. Sydney's rating was also buoyed by these qualities; however, its low-density urban spread and varying levels of accessibility to world-class cultural assets rated poorly in the overall spatial characteristics ranking. Hong Kong performed above average in seven out of the eight categories, with one of the largest amounts of green space – 105.3 square metres per person (EIU 2012). In the land use and building category, Hong Kong ranked highest of all 22 cities surveyed across Asia.

Liveability need not come at the expense of sustainability even in densely populated cities

Green infrastructure and spaces offer a tangible measure of sustainability within the mix of other land use attributes used to measure city quality. The wealth of cities strongly correlates to environmental performance, especially given that their capacity to invest in urban infrastructure and drive environmental initiatives (EIU 2011). Irrespective of population density, the challenge for growing cities to remain attractive in the global market is to maintain high liveability whilst achieving environmental sustainability. In a separate study, five Australian cities out of the eight most liveable from around the world showed that higher rates of liveability also occur with higher environmental resource consumption (Newton 2012). This is illustrated in Chapter 5, Liveability, in Figure 5-5.



Ameliorating the urban heat island effect

Figure 4-19 Thermal map of Sydney taken between 1:00am and 5:00am, 6 February 2009

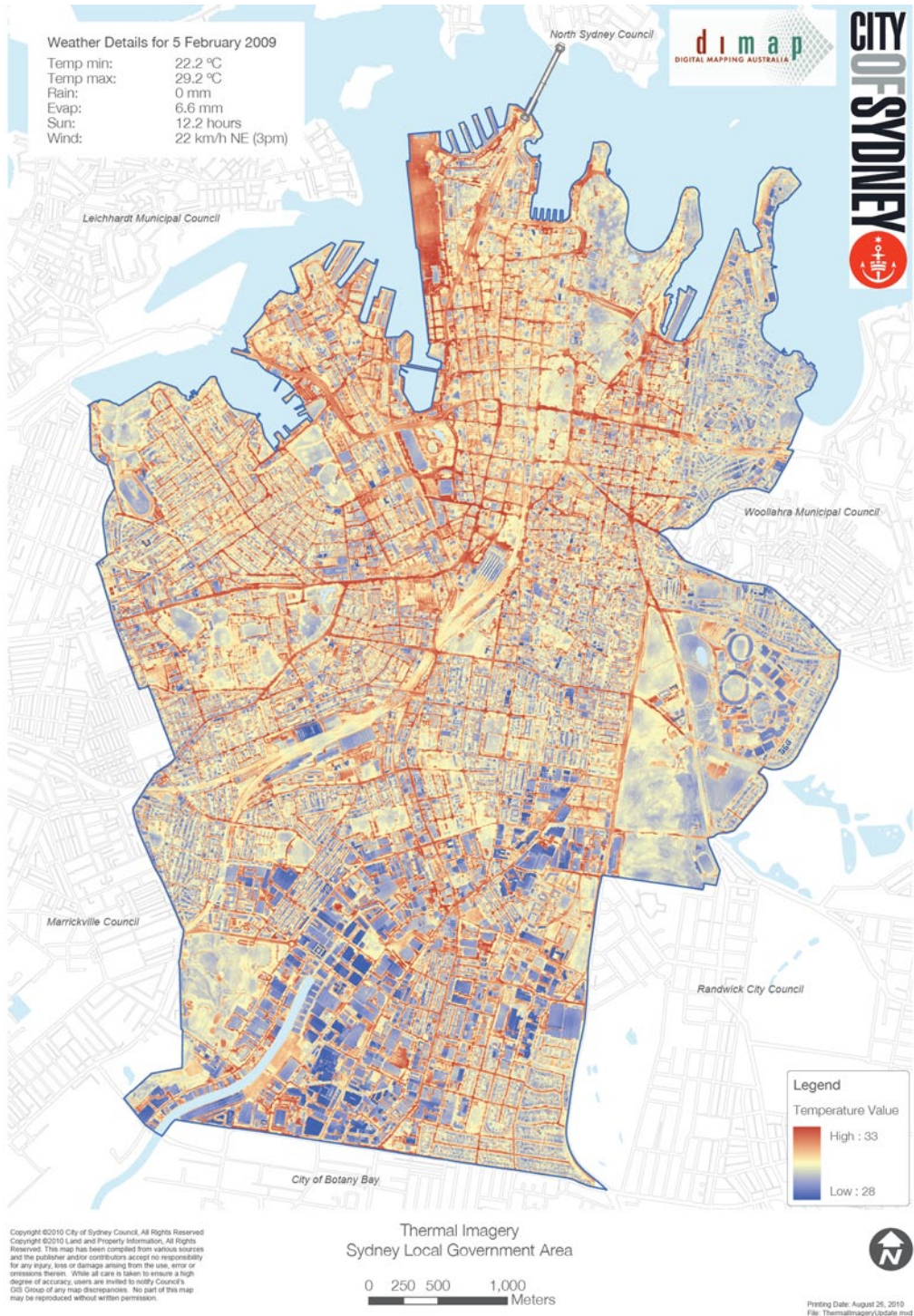


Image courtesy of City of Sydney

The City of Sydney is collecting information to see how shade trees and pavement colour affect urban temperatures. Three monitoring systems have been installed in Chippendale and Redfern. Each monitoring station contains a temperature and humidity meter, and one has a pyranometer which measures the strength of the sun. Figure 4-19 is a thermal aerial image of the City of Sydney Local Government Area taken at night. It shows the way that different road surfaces, buildings, parks and open spaces absorb heat during the day that is released overnight. It can be downloaded from the City of Sydney website

<http://www.cityofsydney.nsw.gov.au/Environment/EnergyAndEmissions>

UrbanHeatIslandEffect.asp. It is interesting to observe not only the cooler temperatures over the parks but also the significantly cooler temperatures of the buildings in the southern part of the city. These are mainly industrial buildings with lighter roof colours that reflect the sun's rays rather than converting light to heat, and thinner roofs which cool relatively rapidly.

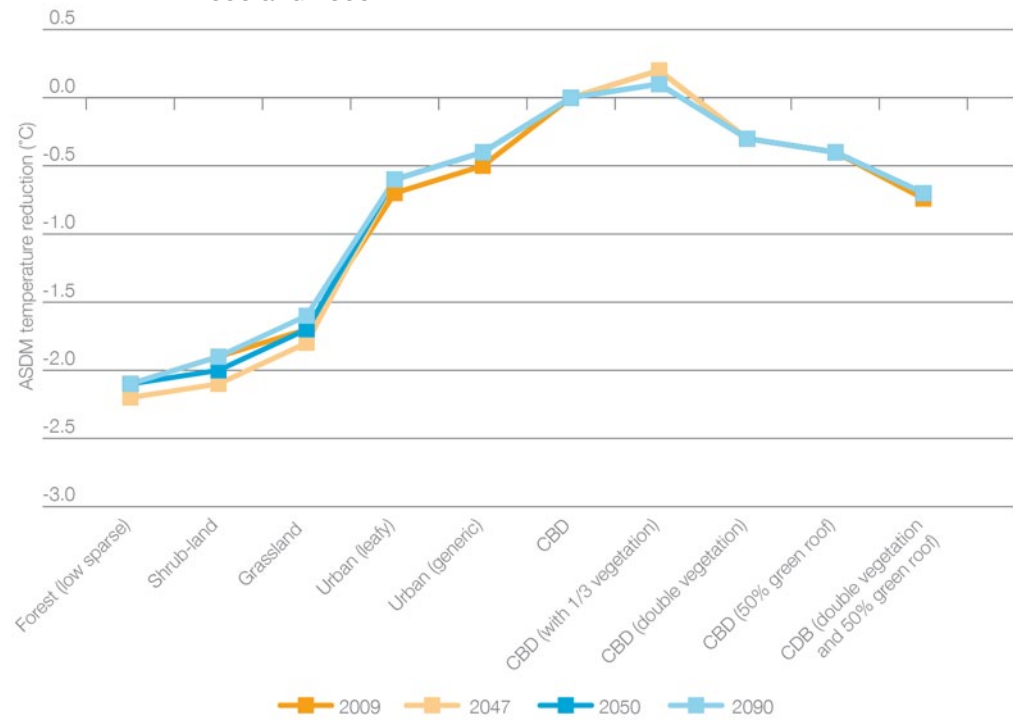
The Urban Heat Island Effect (UHI) of cities demands critical attention from a health point of view as well, because temperature increases will drive higher energy consumption through, in particular, increased air conditioning use. Carefully designed and managed green infrastructure can moderate UHI in numerous ways. For example, vegetation has been shown to reduce rising temperatures and energy costs, improve ambient microclimate conditions, air quality and urban amenity (e.g. shade/shelter) and help restore biodiversity (Livesley et al. 2010).

Urban trees in streetscapes, parks and residential gardens shade hard surfaces and return moisture to the air (Pardinas Diaz 2011). The greatest capacity to plant trees in cities is on streets where up to 60 per cent of lots have no tree at the front (Kirkpatrick et al. 2011). The City of Port Phillip, Melbourne's innermost bayside municipality, has identified up to 3069 'vacant' sites, of which 50 per cent are in front of residential lots, to implement its Urban Forestry strategy (City of Port Phillip 2010).

CSIRO research (Australian Nurseries 2012) predicting the potential benefit of vegetation in reducing extreme summer temperatures in Melbourne CBD found that the cooling may be in the range of 0.3°C to 2°C. As shown in Figure 4-20, different types of vegetation cover yielded a range of significant results for landscape schemes in Melbourne under different future climate scenarios:

- Suburban areas are predicted to be around 0.5°C cooler than the CBD
- A relatively leafy suburban area may be around 0.7°C cooler than the CBD
- A parkland (such as grassland, shrub-land and sparse forest) or rural area may be around 1.5 to 2°C cooler than the CBD
- Doubling the CBD vegetation coverage may reduce the Average Summer Day Maximum (ASDM) temperature by 0.3°C
- 50 per cent green roof coverage of the CBD area may result in 0.4°C ASDM temperature reduction. An ASDM temperature reduction of around 0.7°C may be achieved by doubling the CBD vegetation coverage and having 50 per cent green roof coverage in the CBD area.

Figure 4-20 Predicted reductions in the Average Summer Daily Maximum temperature for different urban forms and vegetation in 2009, 2047, 2050 and 2090



Source: Australian Nurseries 2012

In 2011, the South Australian Government's *Green Infrastructure Working Paper* aimed to develop a coordinated approach to managing Adelaide's rising city heat issues over the next 30 years (Oxygen 2011). The report responds to and analyses different types of growth areas, density levels, land use and built form across Greater Adelaide. It also integrates other sustainable urban initiatives such as Transit Orientated Development Corridors and small-scale urban Infill, Fringe and Townships (Oxygen 2011). The *City of Adelaide 2012–2016 Strategy Plan* has also undertaken detailed studies to address climate change exacerbated Urban Heat Islands.

Greening the West Program 2011 (City West Water, Victoria 2011)

Greening the West seeks to improve health, social outcomes and enhanced liveability for communities in Melbourne's west. It is taking a regional approach to urban greening, supporting projects and activities that deliver increased vegetation and access to quality green space.

The initiative is backed by City West Water and involves a partnership with nine local government councils, government agencies, researchers and industry and community stakeholders. Stormwater and recycled water options are being explored to support greening projects. A noteworthy attribute is the planned use of detailed satellite mapping techniques - Landsat TM (infrared) and MODIS (land surface temperature) to identify specific areas of increased temperature (built-up, impervious surfaces) and cooler zones (vegetated, permeable surfaces) (Figure 4-21(a)). The methodology overlays 'hot-spots' with Department of Health maps of vulnerable populations to prioritise vegetation planting in these areas Figure 4-21(b).

Figure 4-21 (a) Heatwave vulnerability index map for Melbourne and (b) Index of relative socioeconomic disadvantage and dwelling structure in the City of Maribyrnong and priority environmental management locations

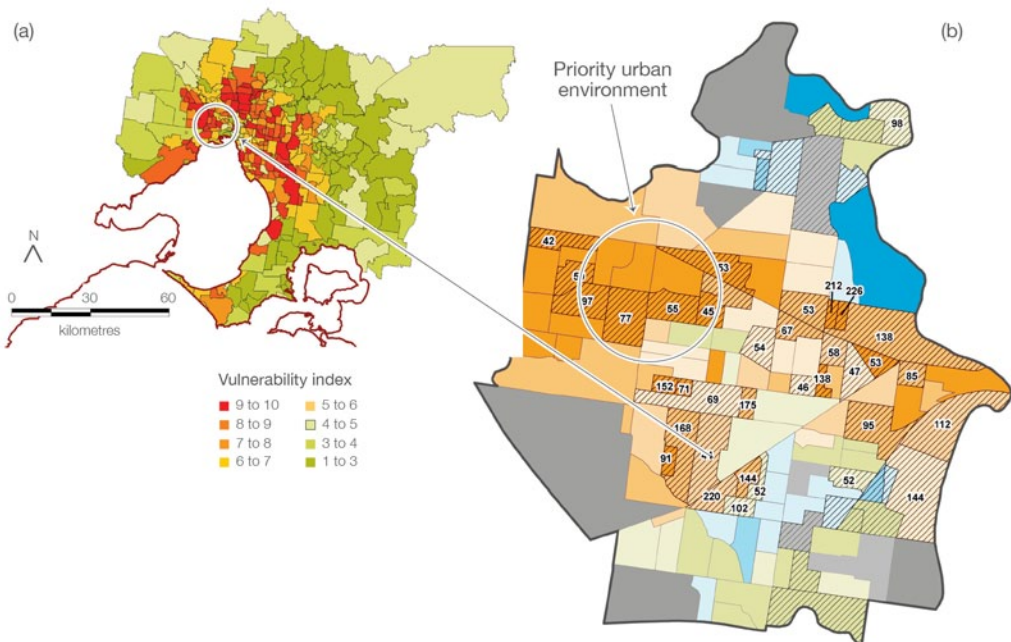


Fig 4-21(a) Source: Loughnan et al. 2012

Fig 4-21(b) Source: Dedman (Department of Health) 2011

Sustainability rating tools for the built environment

2012 has seen the further development of sustainability rating tools for the built environment. A report titled *Policy's Dramatic Impact on Green Buildings: the global hotspots*, released in June 2012, ranked Australia as one of the top three countries for sustainable building construction out of 21 countries that account for 80 per cent of the world's GDP (Lux Research 2012).

Another report, the 2012 *Global Real Estate Sustainability Benchmark* (GRESB), compared the environmental sustainability of Real Estate Investment Trusts (REITs) around the world. Almost 450 property companies and funds participated in the survey, covering 36,000 properties and representing US\$1,322 billion in assets.

Respondents from Oceania (Australia and New Zealand) represented US\$231 billion in assets or 75 per cent of the local REIT market. Our region performed more strongly than any other global region as shown in Figure 4-22. 'The Australian market is quite mature in tackling sustainability issues, which is reflected in very high scores for aspects like sustainability management, assessing sustainability risks and opportunities, and the deployment of Environmental Management Systems. A stunning 95 per cent of respondents have internal resources dedicated to sustainability' (GRESB 2012 p. 30).

Figure 4-22 GRESB Four-Quadrant Model



Source: GRESB 2012

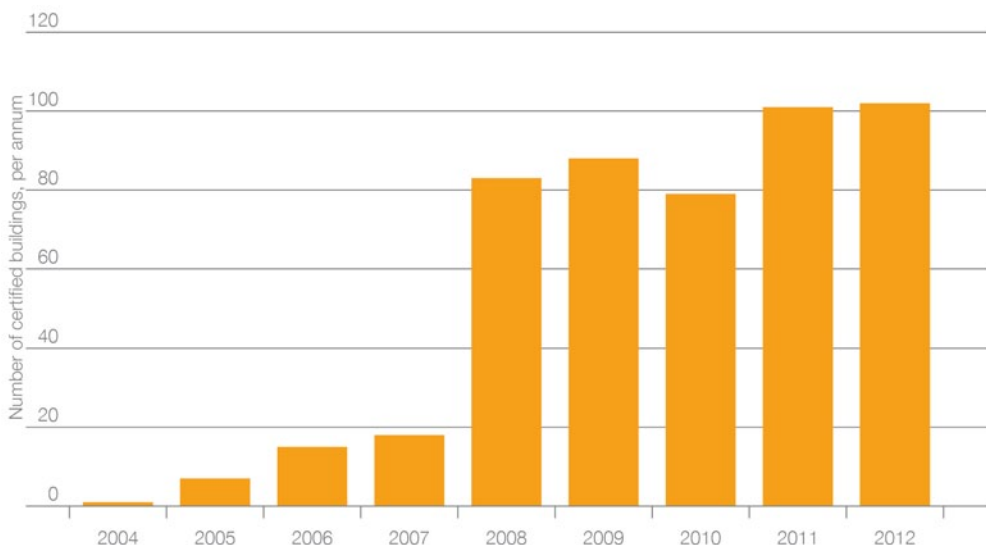
Sustainability rating tools for the built environment

Green Star building rating tools

Green Star rating tools can be used to rate the environmental sustainability for the design and construction of buildings including commercial offices and multi-unit residential, health care and education buildings. The ratings are based on energy, water, waste and other environmental parameters. A Green Star Performance rating tool is currently being developed.

Almost 500 building projects have been Green Star certified, totalling more than 7.3 million square metres of floor space (Figure 4-23). Projects are rated 4 Star best practice, 5 Star Australian excellence or 6 Star world leadership. Recent 6 Star rated buildings include 1 Bligh Street in Sydney, 2 Victoria Avenue in Perth and The Gauge in Melbourne.

Figure 4-23 National number of Green Star certified projects, per annum



Source: Green Building Council of Australia, as at 28/8/2012

Infrastructure Sustainability rating tool

The Australian Green Infrastructure Council (www.agic.net.au) launched its Infrastructure Sustainability tool for evaluating sustainability across design, construction and operation of transport infrastructure such as roads, bridges, railways, busways, airports, ports, footpaths and cycleways. It also covers communications, electricity, water storage and supply, sewerage and drainage. Projects are rated as good, excellent or leading.

Green Star – Communities rating tool

The Green Building Council of Australia (www.gbca.org.au) launched its Green Star – Communities PILOT rating tool in June 2012, an independent, national rating tool for communities, precincts and neighbourhoods. Green Star – Communities incorporates 38 credits under categories of liveability, economic prosperity, environment, design, governance, and innovation. The Infrastructure Sustainability tool and Green Star – Communities both incorporate the Australian Urban Design Protocol (www.urbandesign.gov.au) which is discussed in Chapter 5.



Loop, Belconnen Fresh Food Markets, ACT is the first project registered for the Green Star-Communities PILOT tool.
Image courtesy of Rock Development Group

Tax concessions for sustainable commercial buildings

From 1 July 2012, managed investment trusts that hold only new, energy-efficient commercial buildings are eligible for a 10 per cent withholding tax rate. The new tax concession is available to managed investments trusts that hold office buildings with a 5-star Green Star rating or a predicted 5.5 star NABERS rating, and retail centres and non-residential accommodation that meet equivalent standards.

NABERS

The National Australian Built Environment Rating System (NABERS) measures an existing building's environmental performance during operation. It rates a building on the basis of its measured operational impacts in categories such as energy, water, waste and indoor environment. NABERS can be used to assess the sustainability of office buildings, office tenancies, hotels, shopping centres and homes.

From 1 November 2011 all commercial office space over 2,000 square metres must have energy efficiency ratings (based on NABERS) disclosed to potential buyers and tenants.

Carbon neutral commercial building at 41 Exhibition St, Melbourne

41 Exhibition Street in Melbourne is a new purpose-designed building for the Australian Institute of Architects in Victoria. It aims to be a 'carbon neutral' building, which will be measured using a detailed Total Carbon Assessment for its whole life cycle. It is also aiming for a 5 Star Green Star rating.

Construction is well underway and the project is due for completion in late 2013.

The project incorporates an efficient building envelope with high-performance glazing, energy efficient heating and cooling, rainwater harvesting, low water usage fixtures, waste management, bicycle parking and showers (in lieu of onsite car parking), and transport plans for employees and visitors to the building.

The actual carbon impact will be measured each year and savings will be achieved through reduced energy and water usage, the use of sustainable materials, the purchase of appropriate green power, and a 30-year plan to offset all the measured embodied energy in the building materials.

A Sustainability Charter within the Owners' Corporation rules will commit the owners and tenants to the goal of carbon neutrality.

41 Exhibition Street, Melbourne.

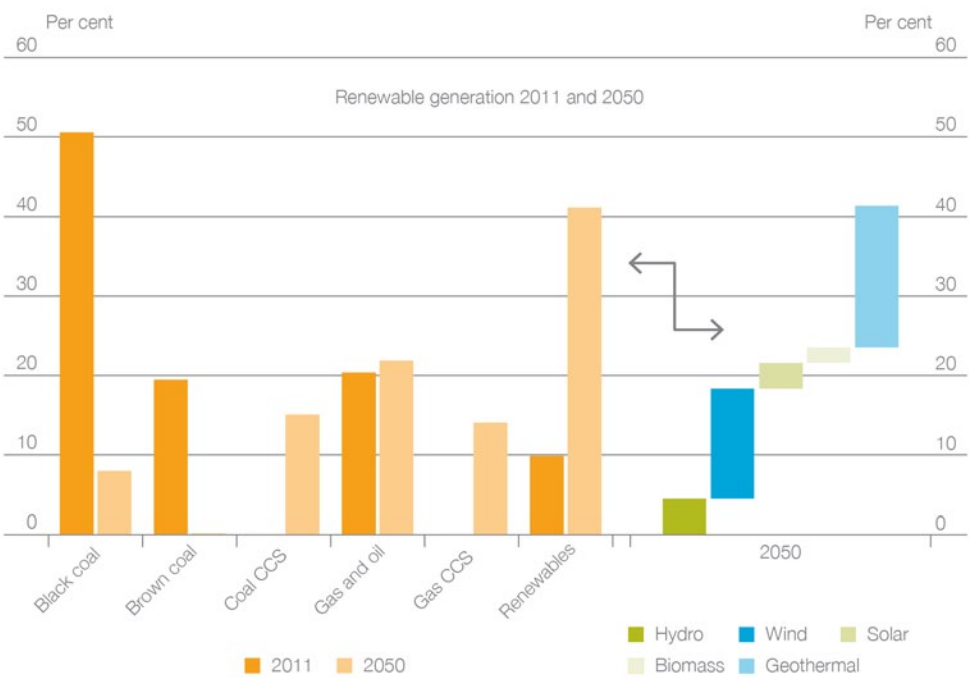
Image courtesy of the Australian Institute of Architects.



Energy

In addition to adapting to climate change and developing resilience to associated extreme weather events, Australia needs to mitigate against climate change by reducing its greenhouse gas emissions. In November 2012 the Australian Government released the Energy White Paper, *Australia's Energy Transformation*. The paper proposes four priority areas for further action to address challenges confronting Australia's energy sector. One of these is national emission reduction targets of at least five per cent below 2000 levels by 2020 and 80 per cent below 2000 levels by 2050. These were modelled by Treasury which found that 'the Government's 2050 target represents a fair contribution by Australia to the global goal of holding temperature increases to less than 2°C, and is consistent with the target adopted by countries such as the United Kingdom' (The Treasury 2011 p. 2). Treasury's modelling predicts that, with carbon pricing, renewable energy as a source of electricity generation will grow from approximately 10 per cent of total generation in 2011 to approximately 40 per cent of total generation in 2050 (or greater under a 'High price' scenario), as shown in Figure 4-24.

Figure 4-24 Renewable energy sources share of energy production forecasts 2010 and 2050



Note: Graph depicts 'Core policy' scenario.
Source: SKA and ROAM in Treasury 2011

New approaches to energy production and distribution such as Distributed Energy and Intelligent Grids are responding to the need to reduce electricity costs in cities (see box on Sydney's Green Infrastructure Plan). 'Distributed generation including co-generation and tri-generation can be a cost effective and economically efficient alternative to conventional supply arrangements, with the advantages of greater efficiency of use of the primary fuel, avoidance of transmission and distribution losses and potential reduction of the need for network augmentation. However, factors such as lack of integrated planning and design for new buildings and uncertainty among users as to legal and commercial aspects of such projects can act as barriers to the implementation of cost-effective and economically efficient distributed generation' (Australian Government 2009).

City of Sydney Green Infrastructure Plan

The City of Sydney has an ambitious Green Infrastructure Plan to reduce greenhouse gas emissions by 70 per cent, meet 100 per cent of electricity demand by local generation, and supply 30 per cent of water by local capture, by the year 2030. The city has a number of draft master plans, either on exhibition or in preparation, which form the overall Green Infrastructure Plan. A key project within these plans is the Green Square project, which covers 278 hectares and introduces Australia's first large-scale low-carbon trigeneration energy network. Trigeneneration is an energy-efficient decentralised system for generating electricity, which also simultaneously provides heating and cooling. The project has been supported under the Australian Government's Liveable Cities Program.

Decentralised energy – trigeneration and renewable energy

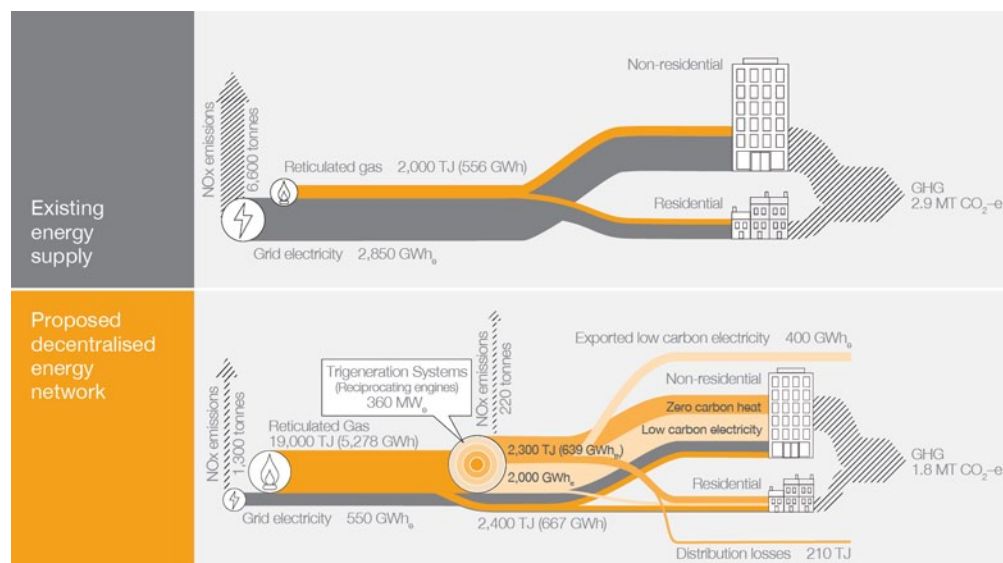
Currently, four-fifths of the City of Sydney's greenhouse gas emissions come from the production of electricity, primarily by coal-fired power stations in the Hunter Valley. Two-thirds of primary energy used by power stations is lost into the atmosphere via cooling towers as waste heat, with further losses across the grid as the electricity is transmitted.

According to the plan, by 2030, trigeneration will provide 70 per cent of the City of Sydney's Local Government Area electricity requirements and reduce overall greenhouse gas emissions by 33 per cent, electricity consumption by 30 per cent and electricity peak demand by 60 per cent.

Trigeneration is nearly three times as efficient as coal-fired power stations because it uses the waste heat from local electricity generation to both heat and cool buildings. The rest of the city's reductions in greenhouse gas emissions will come from energy efficiency, renewable energy and other carbon reducing measures such as advanced waste treatment and sustainable transport.

Renewable energy will provide 30 per cent of the city's electricity requirements and reduce overall greenhouse gas emissions by 31.5 per cent by 2030. Up to 55 per cent of this renewable electricity target can be delivered within the local government area. In addition, enough renewable gases and fuels can be sourced from renewable feedstock, primarily waste, to replace 100 per cent of the natural gas needed for trigeneration in the future.

Figure 4-25 Schematic of decentralised energy generation



Source: City of Sydney 2012, Decentralised Energy Master Plan – Trigeneration 2010–2030, (www.cityofsydney.nsw.gov.au/Council/OnExhibition/TrigenerationMasterPlan.asp)

Decentralised water

The Decentralised Water Master Plan will provide for a 30 per cent reduction in mains drinking water usage with a city-wide recycled water network; a 50 per cent reduction in sediments and suspended solids; and a 15 per cent reduction in nutrients currently discharged into waterways from stormwater run-off.

Advanced waste treatment

Using advanced gasification techniques, waste going to landfill can be reduced by up to 98 per cent. The Advanced Waste Treatment Master Plan will set out the waste treatment process and renewable gas resource from non-recyclable waste.

Automated waste collection

The Automated Waste Collection Master Plan will identify locations for automated waste collection and utilisation opportunities. Separated recycled and non-recycled waste is evacuated via underground pipes at 70 kilometres per hour to receiving stations, thereby replacing the many garbage truck movements throughout the city.

Where automated waste collection has been implemented in other world cities there has been a 90 per cent reduction in waste collection transport movements, which has improved community amenity (such as reduced noise) and reduced transport emissions.

Leading by example

The City of Sydney has already reduced greenhouse gas emissions in its own buildings by 18 per cent from 2009 to 2011 through building energy efficiency retrofits. Further work is currently underway which will reduce emissions by another 24 per cent, resulting in total emission reductions of 42 per cent by the end of 2012.

The city is also replacing its street and public domain lighting with light emitting diodes (LEDs) which will reduce emissions in its street lighting by 51 per cent. The city has accepted a tender for what will be the largest concentration of solar photovoltaics on buildings in Australia. The contract will be completed by 2014.

Further information is available at
<http://www.sydney2030.com.au/development-in-2030/city-wide-projects>.

Figure 4-26 Proposed Solar Photovoltaic Roof, Town Hall House (Sydney)



Image courtesy of City of Sydney

Smart Grids

Smart grids are electricity networks that can intelligently integrate the actions of all users connected to them in order to efficiently deliver sustainable, economic and secure electricity supplies. They have great potential to improve the efficiency of the electricity sector and transform the way Australians use energy in homes and businesses. Benefits include:

- better connection and operation of generators of all sizes and technologies
- consumers playing a part in optimising the operation of the system
- providing consumers with greater information and choice of supply
- reducing the environmental impact of the whole electricity supply system
- enhanced levels of reliability and security of supply.

Were smart grid applications to be adopted around Australia they could deliver a reduction of up to 3.5 megatonnes of carbon emissions per year (Department of Climate Change and Energy Efficiency 2010). Newcastle will be the site of Australia's first commercial-scale smart grid, in the \$100 million Smart Grid, Smart City demonstration project that commenced in mid-2010. It is expected to lead to Australia-wide advances in energy efficiency. The main demonstration site is in the city of Newcastle, with other parts of the trial to be conducted in the rural town of Scone, and in Homebush, Ku-ring-gai and the Sydney CBD.

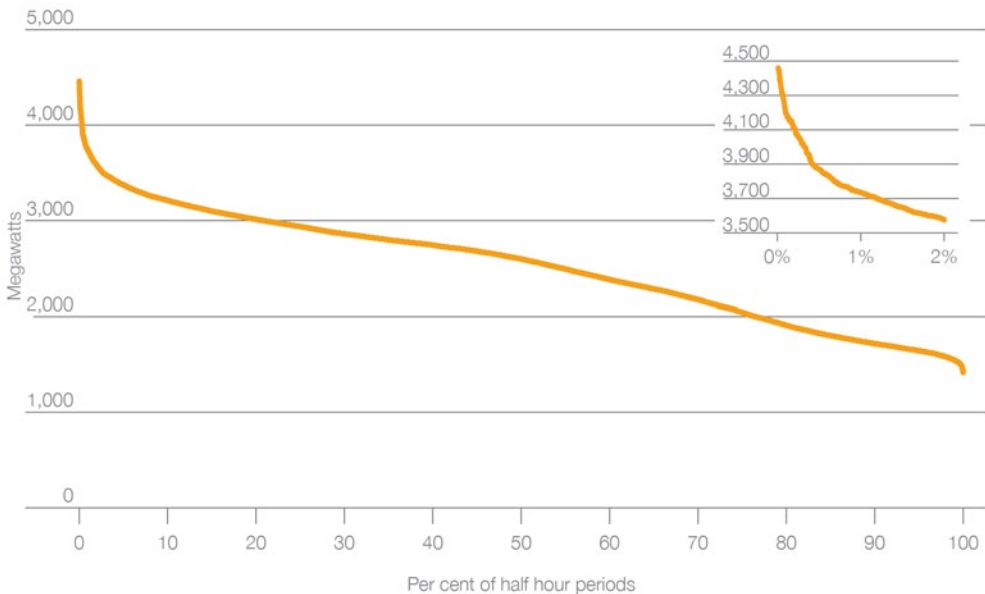
The project will include participation from the community and will demonstrate and test the integration of a range of new technologies such as smart grids, smart meters, electric vehicles and ceramic fuel cells. It will gather information about the costs and benefits of smart grids to help inform future decisions by government, electricity providers, technology suppliers and consumers across Australia.

Peak Energy Demand

One noteworthy factor in the declining productivity and rising costs of Australia's electricity system is the need to build extra capacity to meet growth in peak demand, which is growing more quickly than overall energy consumption. In Brisbane, the difference in electricity demand that can occur between hot days and cooler days, underpinned by air-conditioning usage can be as much as 65 per cent higher (Department of Resources Energy and Tourism 2011). The Queensland Government has estimated additional costs of \$3.5 million per megawatt for incremental network and generation capacity to meet peak demand growth (Department of Employment, Economic Development and Innovation 2011).

State of Australian Cities 2011 pointed to the peak electricity demand issues occurring during heatwaves or consecutive days of higher than normal temperature. Energex Limited found from analysis of its electricity network in Brisbane that the top 11 per cent of network load occurred for less than 1 per cent of the year (Figure 4-27) and that servicing this peak consumed roughly half of the capital program network investment (Energex 2012). Rising energy costs are caused by a range of factors including sharp increases in consumer use of energy-intensive appliances such as air conditioners. The number of air conditioners installed across Australia in the last five years has grown by 1.7 million or around 36 per cent (Department of Resources, Energy and Tourism 2011).

Figure 4-27 Electricity peak load duration Brisbane 12 months to 30 June 2012



Source: Energex Limited 2012

Solar air conditioning is a prospective future low emission technology for Australia. It would utilise heat from solar thermal collectors to generate cooling for buildings and would displace fossil fuel derived electricity, which would otherwise be consumed in conventional mechanical air conditioners. It would be especially useful as a 'peak shaving' technology, as it works with maximum efficiency during the hottest part of the day. Solar air conditioning has been technically proven for many years and can be constructed from readily available solar collectors and absorption chillers which use environmentally friendly refrigerants and have a low electricity demand. As yet solar air conditioning is not cost competitive.

Townsville: *Solar City*

Townsville is one of seven *Solar Cities* across Australia, part of the Australian Government's Solar Cities Program that works with all levels of government, industry and community to change the way we think about and use energy.

In 2011, Townsville won the Queensland Regional Award from the International Association for Public Participation (IAP2) Australasia, Project of the Year. These awards recognise and encourage projects at the forefront of public participation. The project is an electricity network expansion deferral initiative focused on Magnetic Island, which consists of energy behaviour change campaigns, residential trials, the installation of new and renewable technologies as well as commercial building refits in the Townsville CBD and surrounds.

The project has seen a reduction in peak electricity demand on Magnetic Island by 44 per cent during the busiest time of year. This means that \$17 million of investment in an additional underwater power transmission cable can be deferred for at least eight years. Overall energy consumption is now 12 per cent less than the peak annual usage, having returned to 2005 levels. A total of 54,000 tonnes of greenhouse gas emissions were saved by 30 June 2012.

The Townsville RSL stadium is Townsville's largest solar project, with the installation of more than 1800 solar photovoltaic panels on its roof and shade structures in the car park by Ergon Energy. The 348kW solar system will cover 90 per cent of the stadium roof space and the entire system will produce about 1400 kilowatt hours of electricity generation each day, enough to supply somewhere between two-thirds and all of the daytime use of the stadium, or between one-third and half of the daily use.



Townsville Harbour

Image courtesy of Townsville City Council

The Townsville City Council Citysolar Program aims to integrate sustainability into everyday lives.

The Program is underpinned by three principles:

1. Communicating about sustainability in ways that engage citizens and encourage them to foster sustainable change and adopt clean energy technologies
2. Involving the community in sustainability initiatives and programs
3. Building the community's capacity to undertake action towards a more sustainable future.

Under the Program, there are a range of initiatives to help residents to reduce energy use in the home. The Townsville Residential Energy Demand (TRED) project is based on research outcomes and community engagement findings and is being developed in consultation with Townsville's industry. Three behaviours were selected to become part of the project:

1. Cool roofs (painting the roofs white, or a light colour to reflect heat)
2. Shade planting (using trees and shrubs for shading the home)
3. Low-carbon hot water (switching from electric hot water systems to a less energy-consuming system).

With respect to cool roofs, the 'Cool Your Roof' Pilot Program was developed following extensive research conducted as part of the TRED project, which was based on world leading behaviour change methodologies.

Results of the Program found that roofs that were painted as part of the pilot have been effective in reducing house temperatures and the associated electricity use as shown in Table 4-5, in line with other national and international studies on cool roofs.

Table 4-5 **Summary of temperature reductions across participating pilot program houses**

Comparison of two similar days (average of houses)	Temperature reduction (°C)
Highest roof cavity temperature reduction during the day	4.9 – 17.5
Average daytime roof cavity temperature reduction (9am–9pm)	3.2 – 15.3
Highest internal temperature reduction during the day	0.8 – 2.5
Average daytime internal temperature reduction (9am–9pm)	0.6 – 1.5

"We had the roof painted in November when the weather was starting to warm up. We could not believe how much cooler the house was the day after it was painted. The house is normally all locked up during the day and used to be quite hot when we got home in the afternoon. After the painting the house was cool to walk into at the end of the day. We found that when home we did not put the fans on until later in the day and there was reduced use of air-conditioning ... I have certainly passed the word onto friends and know of a couple that have had their roofs painted." – (Pilot Program Participant with a single story 1980s era low-set brisbane-block house in Condon)

In 2012 Townsville was one of 24 cities world-wide to be selected for an IBM Smarter Cities Challenge. The IBM Challenge enables city communities to work together to better plan and develop a smart, sustainable and energy-efficient city through integrating technologies, data, social media/networks and behaviour change.

Other Australian *Solar Cities* include Adelaide, Blacktown (Sydney), Central Victoria (including Ballarat and Bendigo) and Perth. The Citysolar Program runs until 2013 and trials new models for sustainable electricity supply and use such as cost-reflective pricing trials and community education.

Electricity and gas consumption

The Australian Energy Regulator (2011) has estimated that network costs were the largest single contributor to residential electricity bills in 2011, due to increased investment to upgrade and replace ageing assets (Department of Resources Energy and Tourism, 2011).

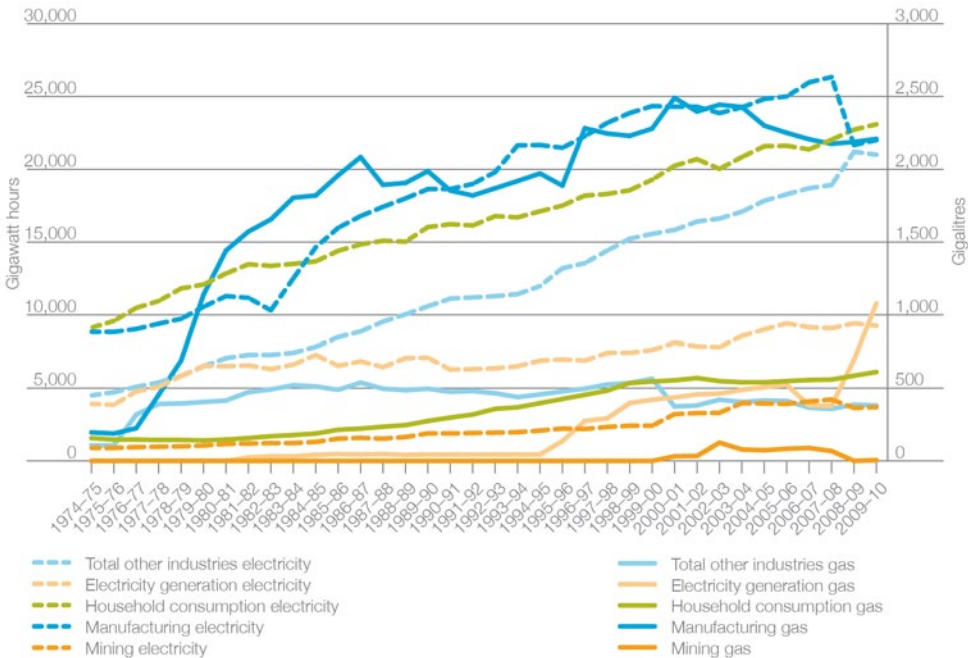
Figures 4-28 to 4-34 show the electricity and gas consumption of states and territories (as a proxy for their major cities) by broad industry sector, including households, from 1974–75 to 2009–10. The figures show that household consumption of electricity has been fairly steadily increasing (possibly in line with population growth), while household gas consumption has remained largely steady. In other sectors of the economy energy use is changing.

Electricity consumption shows a general increase overall for all states and territories and most industry sectors. In terms of electricity consumed by manufacturing industry, all states with the exception of Queensland show a noticeable drop in consumption during 2007–08, coinciding with the Global Financial Crisis. Electricity consumption by other industries apart from manufacturing has steadily increased in all states and territories with the exception of Victoria. Interestingly, all states and territories except Victoria and the Northern Territory show very similar rates of increase in electricity consumption by non-manufacturing industries and household sectors.

The industry sectors showing the biggest changes in electricity consumption across most states and territories are the mining sector and the electricity generation sector itself. For example, Queensland's electricity generation sector's peak consumption in 2003–04 was almost 12,000 gigawatt hours, and apart from one fluctuation, has been trending down since then. Western Australia shows a decline for this sector in recent years.

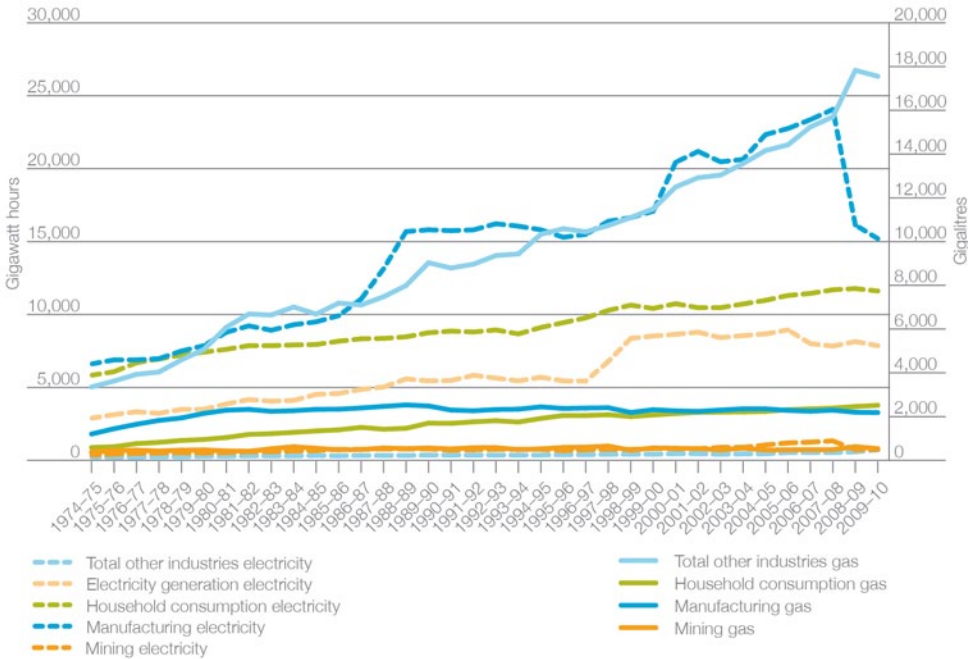
Some states and territories have seen an increase in gas consumption for some industry sectors which, if it is replacing coal, is a positive for sustainability because burning gas produces less greenhouse gases than coal-fired power stations. Western Australia and the Northern Territory, for example, show increases in gas consumption by the mining industries since 2004–05 of over 160 per cent. Gas consumed by the manufacturing industries has increased in all states for which there is data, with the exception of Victoria and South Australia, which have remained more or less steady since the 1970s. Overall, Victoria has the highest rate of gas consumption of all states and territories across all sectors except mining. Victoria's total other industries gas consumption peaked at 17,829 gigalitres in 2008–09, roughly three times the consumption of the next highest user, Western Australia's mining industries.

Figure 4-28 NSW electricity and gas consumption by industry sector



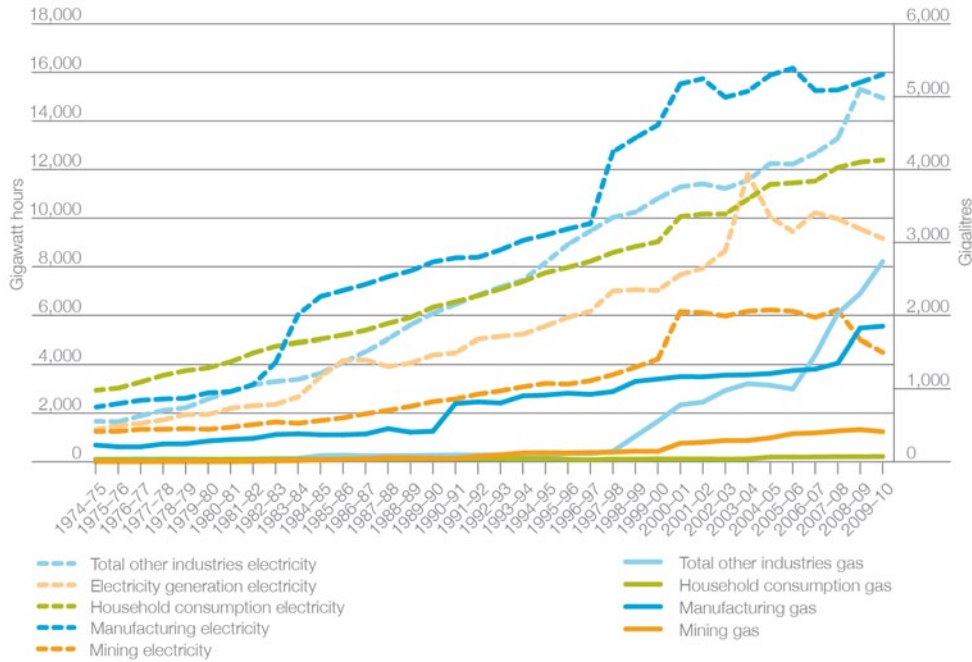
Note: Includes ACT.
Source: BITRE 2012

Figure 4-29 Victoria electricity and gas consumption by industry sector



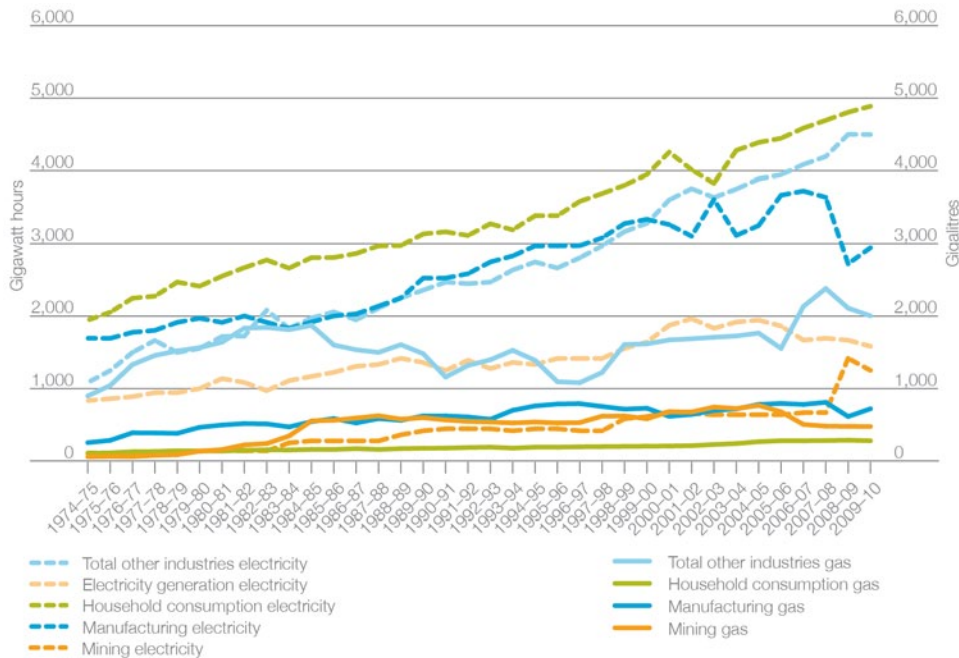
Source: BITRE 2012

Figure 4-30 Queensland electricity and gas consumption by industry sector



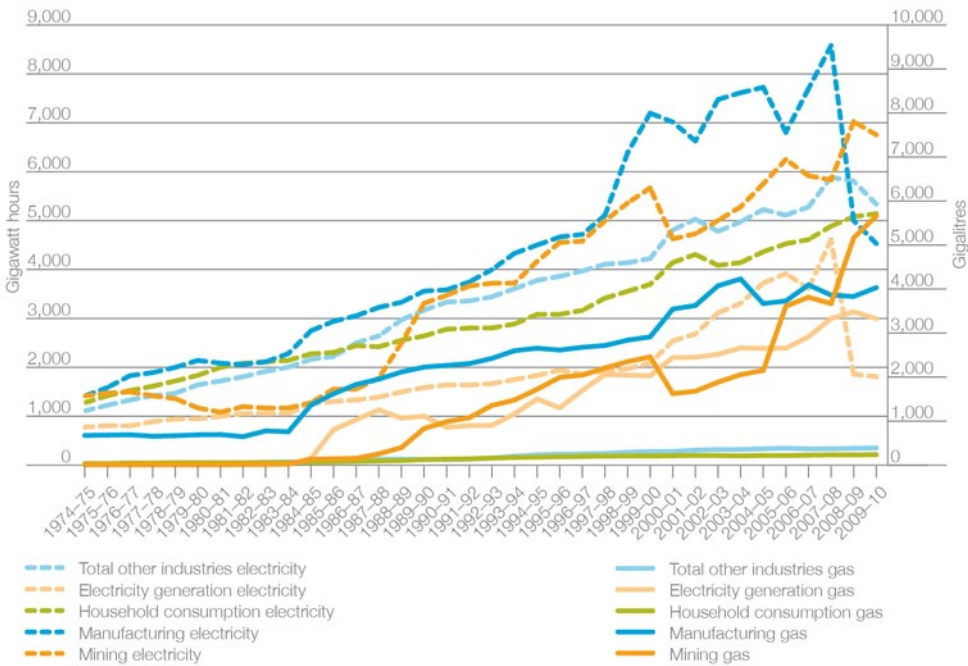
Source: BITRE 2012

Figure 4-31 South Australia electricity and gas consumption by industry sector



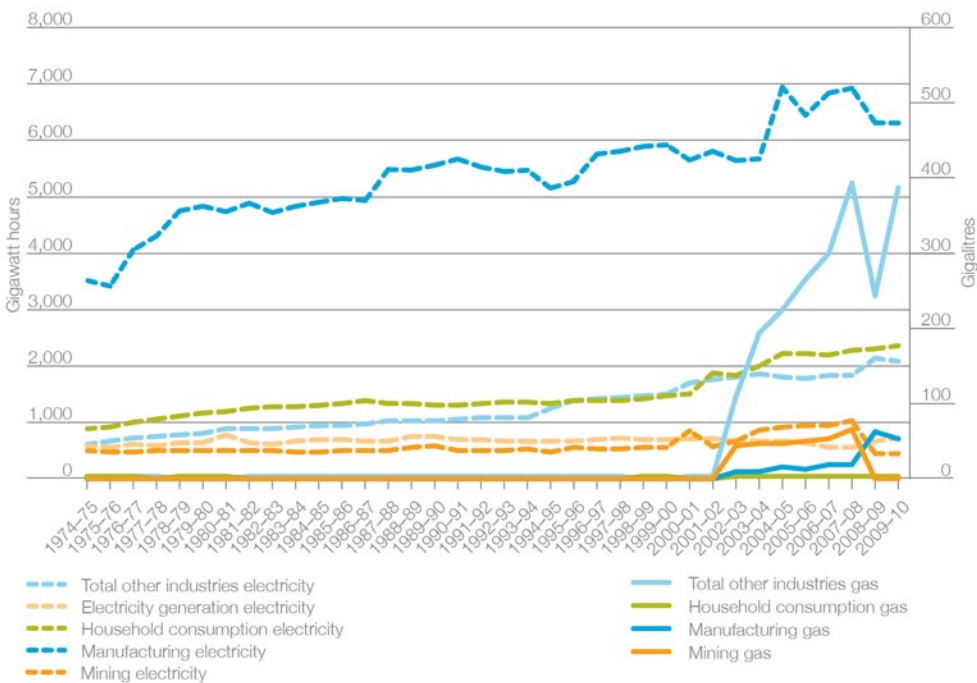
Source: BITRE 2012

Figure 4-32 Western Australia electricity and gas consumption by industry sector



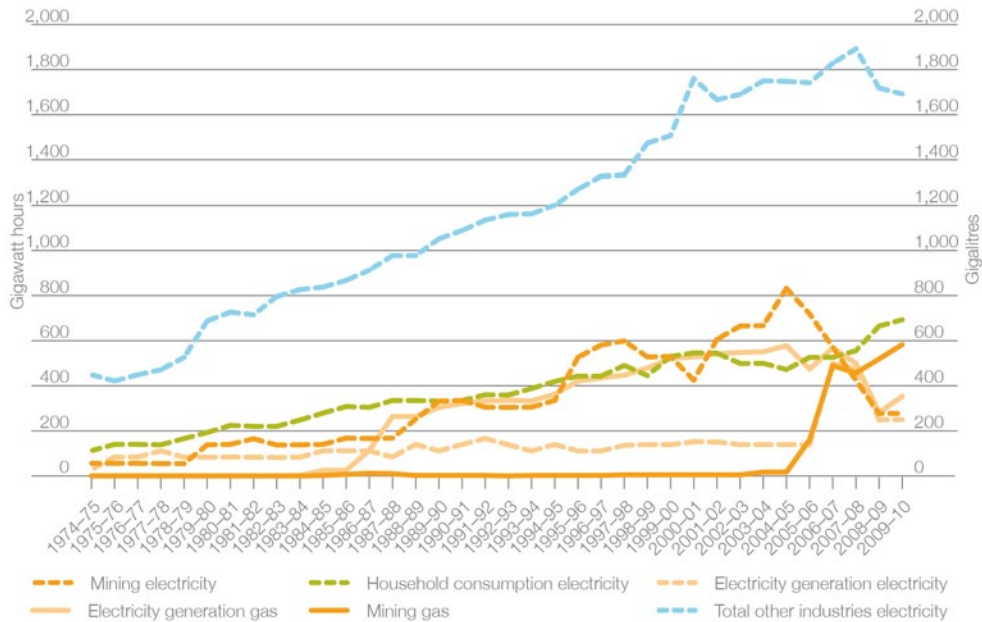
Source: BITRE 2012

Figure 4-33 Tasmania electricity and gas consumption by industry sector



Source: BITRE 2012

Figure 4-34 Northern Territory electricity and gas consumption by industry sector



Note: Manufacturing N/A for Northern Territory.

Source: BITRE 2012

Conclusion

This chapter explored the relationship between cities and the natural environment, particularly analysing the changing temperature and rainfall patterns that are linked to climate change. The Urban Heat Island effect associated with larger cities is of particular concern as city temperatures rise. Actions are currently underway through a range of initiatives to understand and counteract this phenomenon along with other urban perils such as bushfires and flooding. In this regard the role and importance of 'green Infrastructure' is increasing in prominence.

Cities' energy usage was also touched upon, with cities such as Townsville successfully piloting various ways to improve the efficiency with which they use energy and reduce the demand on non-renewable energy sources. In general, Australian cities are managing these issues with varying levels of sophistication, but it is clear that all spheres of government recognise the need to plan and manage urban systems in a manner better integrated with natural systems.

Chapter 4 References

Notes

Note 1 – See for example, a recent series in *The Age* by Royce Millar and Melissa Fyfe; Village Well's October 2011 forum 'On the Edge: A forum on food and sustainability around Australian cities'; The Australian Farm Institute's May 2012 conference 'Managing the future of Australian farm land'; Drew, C; and McEvilly, G. 2011. Issues Facing Vegetable Production in Peri-Urban Areas – Review and Scoping Study. (HAL Project no. VG10059) Report prepared for Horticulture Australia Limited by Scholefield Robinson Horticultural Services Pty Ltd. Fullarton, South Australia; the Victorian Parliament's 2010 Inquiry into Sustainable Development of Agribusiness in Outer Melbourne; and South Australia's proposed Character Preservation policies for the Barossa Valley and McLaren Vale.

Note 2 – See for example, The Peri-urban Regions Platform in Europe (PURPLE); The Toronto Global Greenbelts Declaration; Agriculture in an Urbanising Society Conference;

Note 3 – See for example, the Northern Expressway through Virginia, Adelaide.

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