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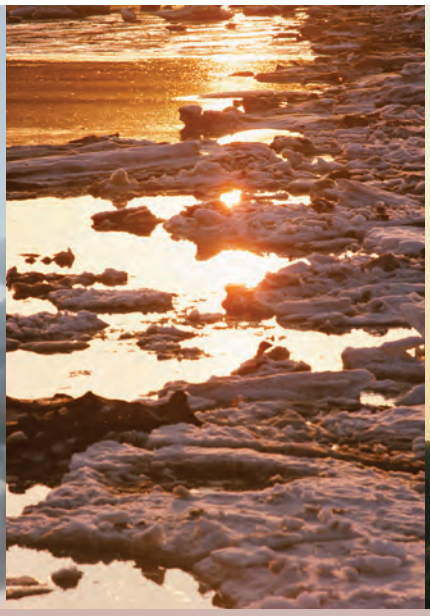
Australia's Environment Issues and Trends 2010



Special issue: Climate Change

Australia's Environment: Issues and Trends 2010

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Preface

Australia's Environment: Issues and Trends 2010 is the 5th edition in a series that presents a broad selection of environmental statistics and information on topical environmental issues. By drawing on a wide range of ABS statistics and statistics from other official sources, *Australia's Environment: Issues and Trends* describes major aspects of Australia's environment and how these are changing over time. It is designed to assist and encourage informed decision-making, and to meet the information needs of a general readership.

The material presented in *Australia's Environment: Issues and Trends* is organised into two main parts. The first part explores an issue of major environmental concern, and the issue chosen for the 2010 edition is climate change. The second part covers major trends of relevance to the environment, included under five broad headings: population and urban, human activities, atmosphere, water and landscape.

The opportunity has been taken to use the most recently available data to update analysis of topics examined in previous editions. The publication does not aim to present data on all environmental issues and other topics may be covered in future editions.

The production of this publication would not have been possible without the contributions of numerous organisations and individuals. The ABS is grateful for this help.

The ABS welcomes readers' suggestions on how the publication could be improved. To comment or to ask for more information, please contact the Director of the Centre of Environment and Energy Statistics.

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There is a wealth of statistical information on the ABS website <http://www.abs.gov.au>.

ABS publications and services

ABS publications are available on the ABS website <http://www.abs.gov.au>.

In many cases, the ABS can also provide information which is available on request or which is historical or compiled from a variety of sources. Information of this kind may be obtained through the Information Consultancy Service. Charges are generally made for such information. The ABS also issues a daily release advice on the website which details products to be released in the week ahead.

Abbreviations

The following abbreviations have been used in this publication.

Australia, states and territories of Australia

Aust.	Australia
NSW	New South Wales
Vic.	Victoria
Qld	Queensland
SA	South Australia
WA	Western Australia
Tas.	Tasmania
NT	Northern Territory
ACT	Australian Capital Territory

Other abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
CFCs	chlorofluorocarbons
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Department of the Environment, Water, Heritage and the Arts
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GDP	gross domestic product
GVIAP	gross value of irrigated agricultural production
HFCE	household final consumption expenditure
HFCs	hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IUCN	World Conservation Union (International Union for the Conservation of Nature)
LNG	liquefied natural gas
NEPM	National Environment Protection Measure
PFCs	perfluorocarbons
OECD	Organisation for Economic Co-operation and Development
NWC	National Water Commission
PM	particulate matter
PPP	Purchasing Power Parity
SLA	Statistical Local Area
UNFCCC	United Nations Framework Convention on Climate Change

Conversions

One billion = 1,000 million
One gigalitre (GL) = 1,000 megalitres (ML)
One megalitre (ML) = 1,000 kilolitres (kL)
One kilolitre (kL) = 1,000 litres (L)
One megatonne (Mt) = 1,000,000 tonnes (t)
One tonne (t) = 1,000 kilograms (kg)
One petajoule (PJ) = 1,000,000 gigajoules (GJ)
One gigajoule (GJ) = 1,000,000 kilojoules (kJ)

Symbols and usages

The following symbols and usages mean:

CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
°C	degrees Celsius
$	dollars
$m	million dollars
g	grams
GJ	gigajoules (of energy)
GL	gigalitres
ha	hectares
kL	kilolitres
km	kilometres
km^2	square kilometres
ML	megalitres
Mt	megatonnes
MW	megawatts
µg	micrograms
$\mu g/m^3$	micrograms per cubic metre
µm	micrometres (micron)
N_2O	nitrous oxide
n.a.	not available
n.p.	not published
no.	number
PJ	petajoules (of energy)
ppm	parts per million
SO_2	sulphur dioxide
SF_6	sulphur hexafluoride
%	per cent
'000	thousand
'000 ha	thousand hectares
–	nil or rounded to zero

Where figures have been rounded, discrepancies may occur between the sums of the component items and totals.

Introduction

Aims

Many current approaches used when discussing issues on the environment divide environment into component areas of concern, e.g. biodiversity, land, water and air. While this approach is intuitive and useful, and largely mirrors the way in which environmental welfare is publicly administered, its success is partly dependent on the extent to which information can be re-integrated to provide a cohesive picture of Australia's environment and environmental trends. Certainly, when policy makers, environmental practitioners or researchers seek information, their focus is on complex environmental issues which often cut across such areas. For example, to usefully inform on an issue such as salinity, a researcher would need to bring together data relating to soils, agricultural activities, water, biodiversity, and vegetation; and data on drinking and irrigation water may also be relevant. Thus, *Australia's Environment: Issues and Trends* aims to bring together data from a wide range of statistical collections, and to present these data from an issue and trends driven perspective. More specifically, *Australia's Environment: Issues and Trends* aims to:

- Inform decision-making, research and discussion on environmental conditions in Australia, environmental issues of current and ongoing concern, environmental pressures of interest, and changes in these over time – by drawing together up-to-date environmental data and analysis from both ABS and other official sources, and incorporating readily understood commentary about the statistics.

- Support the monitoring and review of progress towards environmental goals, changes in environmental conditions, and levels of environmental pressures and responses by presenting a range of issues and trends on a regular basis.

Approach

Australia's Environment: Issues and Trends 2010 comprises two main parts: a feature article (the issue), and trends. The feature article explores an issue of environmental concern. The issue chosen for this year is climate change. The feature article aims to provide relevant statistical facts surrounding the issue, together with context and explanation through highlighting relevant environmental developments. It is the intention that the topic of the feature article will change with every edition, with some topics refreshed as new data become available. Thus, each edition will remain responsive to contemporary concerns and a more comprehensive picture of Australian environmental conditions will accumulate across editions.

The second part, the trends section, is broken into five discrete areas that encapsulate major environmental indicators of interest to Australians. These are: Population and urban, Human activities, Atmosphere, Water and Landscape. The main data sources used in the trends sections are included at the bottom of the tables and graphs or referenced at the bottom of each page.

A key aspect of the publication is its readability. Information is deliberately presented in non-technical language that can be readily understood by the general reader. Statistics are organised to illustrate specific issues and to highlight the meaning behind the data, and the main patterns and exceptions.

Environmental trends and progress

Australia's Environment: Issues and Trends complements the ABS publication *Measures of Australia's Progress (*MAP, cat. no. 1383.0.55.001). MAP presents a suite of indicators for reporting on economic, social and environmental progress and considers the interrelationships between these aspects of life. MAP 2009 used six headline indicators to discuss progress in the health of the environment: biodiversity, land, inland waters, air quality, atmosphere and oceans and estuaries. In addition, MAP presents a number of supplementary and other indicators.

It should be noted that there is no definitive set of indicators that encapsulate progress in the environmental domain. Any suite cannot fully reveal the total picture of Australia's environment. *Australia's Environment: Issues and Trends* extends both the breadth and depth of the environmental investigation presented in MAP.

Looking at indicators is useful for the following:

- evaluating conditions and trends
- comparing places and situations
- offering early alert information
- anticipating future conditions and trends
- evaluating conditions in relation to certain policy goals.

The indicators included in *Australia's Environment: Issues and Trends 2010* have been chosen to strike a balance between considerations of approachability, technical precision and the availability and quality of data. The indicators used in this publication have been selected on the basis that, as far as possible, they should be:

- relevant
- supported by timely data of good quality
- available preferably as a time series to see if changes are significant over time
- summary in nature
- preferably capable of disaggregation by, say, geography or population group
- intelligible and easily interpreted by the general reader.

Data gaps and data inconsistency present problems in many areas of environmental analysis. For example, water quality is measured in many states and territories, but not on a comparable basis.

Feature Article

Issue: Climate change

Climate change is a global problem with global consequences. Warmer-than-average temperatures are being recorded across the world. Glaciers and polar ice caps are melting and sea levels are rising. Mounting evidence indicates that these changes are not the result of the natural variability of climate.

The International Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Program (UNEP), released its fourth assessment report in 2007. It declared that 'warming of the climate system is unequivocal' and it is 'very likely' that greenhouse gas emissions from human activity have caused most of the observed global temperature increase since the mid-1900s.[1]

In Australia and internationally, there has been an increasing focus on the issue of climate change and the demand for credible statistics and information has grown accordingly.

This feature article begins with a brief discussion of the science of climate change, followed by a statistical examination of Australia's contribution to global greenhouse gas emissions, and opportunities for reducing emissions in Australia. The last section presents statistics related to the impacts climate change is projected to have on Australia's society, economy and environment and some broad adaptation measures being undertaken.

- **What is climate change?** While climate changes can occur naturally, there is now general agreement that global warming over the last 50 years is very likely the result of human activities, specifically the emission of greenhouse gases into the atmosphere. Increased levels of greenhouse gases in the atmosphere trap heat and increase the earth's temperature. Since 1950, Australia's average annual temperature has increased by 0.9°C. If global emissions remain high, by 2070 the average annual temperature is projected to increase by a further 2.2 to 5.0°C.[2]

- **Australia's greenhouse gas emissions:** Australia has about 0.3% of the world's population, but contributes about 1.5% of total greenhouse gas emissions.[3] This puts Australians among the highest per capita emitters. In 2007, Australia's net greenhouse gas emissions across all sectors totalled 597.2 million tonnes of carbon dioxide equivalent (Mt CO_2-e) under the accounting provisions of the Kyoto Protocol.[4]

- **Reducing our greenhouse gas emissions:** Reducing greenhouse gas emissions is necessary to mitigate human-induced climate change. There are many opportunities for households and businesses in Australia to reduce emissions, including large-scale use of renewable energy sources, improving energy efficiency and greater use of public transport. Atmospheric levels of greenhouse gases can also be potentially reduced by activities which increase the amount of carbon stored in our soils and forests. Putting a price on carbon emissions would change the relative prices of different forms of energy and accelerate the move to a low carbon economy.

- **Impacts and adaptation:** Australia's climate is already changing and in coming decades the Australian community will probably need to take steps to adapt to the impacts of climate change that cannot be avoided by mitigation. Some of the areas considered most vulnerable to the impacts of climate change include water, agriculture, biodiversity, coastal settlements and human health. In some cases, households and businesses are already taking voluntary action to adapt to a changing climate. Some areas are vulnerable precisely because their capacity to adapt is limited.

Climate change in Australia

What is climate change?

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as *"a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer"*. [5] Climate change is also often referred to as global warming.

Globally, there is evidence of climate change, including increases in air and ocean temperatures, widespread melting of snow and ice and rising sea levels.[6]

The Greenhouse Effect

The earth's atmosphere is like a blanket that keeps the planet warm. Incoming energy from the sun penetrates the atmosphere to warm the earth. The earth then radiates heat back toward space. Some of the outgoing heat is absorbed by greenhouse gases in the atmosphere and re-emitted back to earth, keeping the planet at a level warm enough to support life. This is called the *greenhouse effect*.

An enhanced greenhouse effect can cause climate change as increased levels of greenhouse gases (mostly carbon dioxide) in the atmosphere lead to more heat being trapped, so the earth's temperature increases. While natural phenomena have caused the climate to change in the past, there is now a general consensus that human activities are largely responsible for today's very high levels of greenhouse gas emissions and associated climate change.

Important terms

Adaptation – adjustments in natural or human systems in response to actual or anticipated climate changes or their effects.

Carbon sink – a natural or human activity or mechanism that removes carbon dioxide from the atmosphere, such as the absorption of carbon dioxide by growing trees.

Climate in a narrow sense is usually defined as the 'average weather' a region experiences, usually calculated over a 30-year period. It usually encompasses surface variables such as temperature, precipitation and wind. While weather can vary dramatically from one day to the next, climate cannot.

Extreme weather event – meteorological conditions which are rare for a particular place and/or time, such as an intense storm or heat wave. An **extreme climate event** is an unusual average over time of a number of weather events, for example heavy rainfall over a season.

Greenhouse gases – both natural and anthropogenic gases in the atmosphere that absorb and emit infrared or heat radiation, causing the greenhouse effect. The main greenhouse gases are water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Mitigation – refers to response strategies that aim to limit human-induced climate change by reducing greenhouse gas emissions or removing greenhouse gases from the atmosphere through sequestration.

Sequestration refers to the uptake and storage of carbon. For example, trees and plants absorb carbon dioxide, release the oxygen and store the carbon in above-ground organic matter or in the soil. In the context of response strategies, sequestration usually refers to the process of increasing the storage of carbon (for example via reforestation), increasing the carbon content of the soil, or removal of carbon dioxide from flue gases for storage below ground or in the deep ocean.

Weather is the state of the atmosphere at a given time and place. It refers to the temperature, air pressure, humidity, wind, cloudiness and precipitation of a region over a short period of time (e.g. daily maximum temperature).

Note: Many of these definitions are in a climate change context and may not apply in other fields.

Source: Australian Greenhouse Office, 2003, *Climate Change: An Australian Guide to the Science and Potential Impacts.*

Australia's changing climate

"Global warming is real, humans are very likely to be causing it, and …it is very likely that there will be changes in the global climate system in the centuries to come larger than those seen in the recent past"

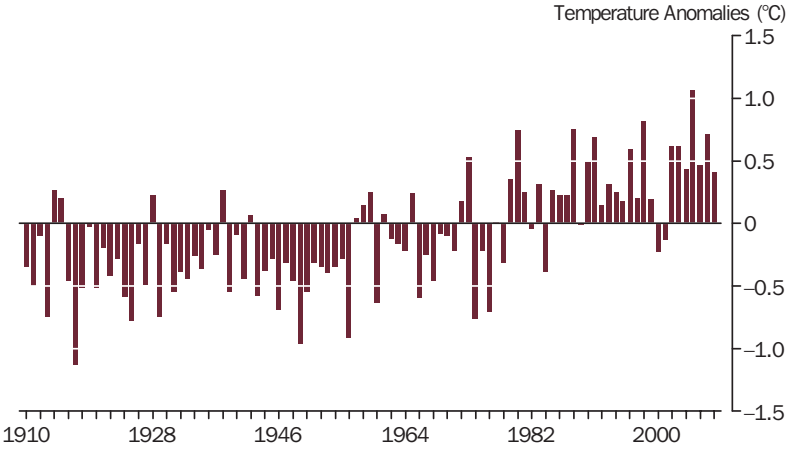
CSIRO and Bureau of Meteorology, 2007.[7]

Australia's climate is changing. Since 1950, Australia's average annual temperature has increased by 0.9°C. Scientists conclude that most of this change is likely due to human emissions of greenhouse gases. Declines in snow cover, increases in warm days and decreases in cold days are also likely to be attributable to human activity.[8]

Rainfall is also changing but the causes of these changes can be difficult to determine. Studies have estimated that 50% of the decrease in rainfall in south-western WA over the last 30 years has been due to human-induced climate change.[9] Recent CSIRO climate modelling indicates effects on Australia's climate due to aerosol pollution[a] from the northern hemisphere. These include increased rainfall in north-western Australia, and increased air pressure over southern Australia, leading to less rainfall there.[10]

[a] Fine particles suspended in the atmosphere. Main sources include: industry, vegetation burning, volcanoes and dust storms.

Annual mean temperature anomalies 1910 to 2008



Note: Anomalies are based on 1961 to 1990 average of 21.8ºC.
Source: Bureau of Meteorology, 2009, *Australian Climate Change and Variability, <http://reg.bom.gov.au/silo/products/cli_chg>, last viewed October 2009*.

Predicting future climate change

Climate models are used by scientists to simulate the climate system and predict how greenhouse gas emissions are likely to change the climate in the future.[11]

Building on global scientific knowledge, CSIRO and the Australian Bureau of Meteorology have used climate models to project future climate change in Australia. Their 2007 report presents climate change projections to 2070 for a range of emissions scenarios:[12]

- assuming a low emissions scenario, by 2050 annual warming is projected to increase by 0.8 to 1.8°C and by 2070 to 1.0 to 2.5°C;
- assuming a high emissions scenario, annual warming is projected to increase by 1.5 to 2.8°C by 2050 and by 2.2 to 5.0°C by 2070.

Australia is a vast continent and the projected changes to climate vary considerably from region to region and from season to season. For example, over the next few decades warming is expected to be greater in inland areas than in coastal areas and rainfall is projected to change little in the far north but decrease elsewhere. [13]

Other projected changes – the magnitude of which depends on the emissions scenario – include:

- increases in the frequency of hot days and warm nights;
- changing rainfall, (e.g. by 2070, under the high emissions scenario, rainfall in southern areas is projected to change by between -30% and +5%);
- decreases in snow cover, average snow season lengths and peak snow depths;
- increases in annual potential evapotranspiration (the transport of water into the atmosphere from the earth's surfaces and vegetation);
- increases in the occurrence of drought, particularly in south-western Australia;
- increased fire weather risk in some areas; and
- global seal level rise of 18 to 59 cm, with an additional contribution of up to 17 cm from ice sheet dynamics.[14] However, larger values cannot be excluded,[15] and recent research indicates that a sea level rise of one metre or more by 2100 is possible.[16]

Australia's greenhouse gas emissions

Greenhouse gases are produced by human activities such as burning of fossil fuels (e.g. coal, oil and gas), agriculture and land clearing. The concentration of greenhouse gases in the atmosphere varies naturally over time, but since around 1750, human activities associated with industrialisation have dramatically increased these concentrations. For example, concentrations of carbon dioxide now far exceed the natural range over the last 650,000 years.[17]

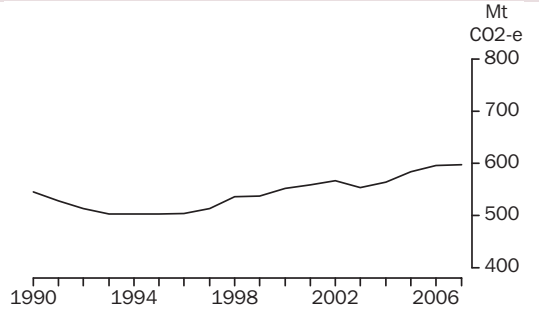
While Australia only accounts for around 1.5% of global greenhouse gas emissions, its per capita (per person) CO_2 emissions are nearly twice the OECD average and more than four times the world average.[18]

Australia's relatively high per capita emissions can be attributed to factors such as the high usage of coal in electricity generation and agricultural emissions from large numbers of sheep and cattle.[19]

Australia's Department of Climate Change provides annual estimates of Australia's greenhouse gas emissions, under the accounting rules that apply for the Kyoto Protocol.[20]

Australia's net greenhouse gas emissions in 2007 totalled 597.2 Mt (million tonnes) of CO_2-e (carbon dioxide equivalent). This represented a 9% increase from the 1990 level of 547.7 Mt CO_2-e.[21]

Australia's net greenhouse gas emissions 1990 to 2007



Note: Kyoto-based estimates of Australia's net greenhouse gas emissions.
Source: Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009.*

Global warming potential of major greenhouse gases

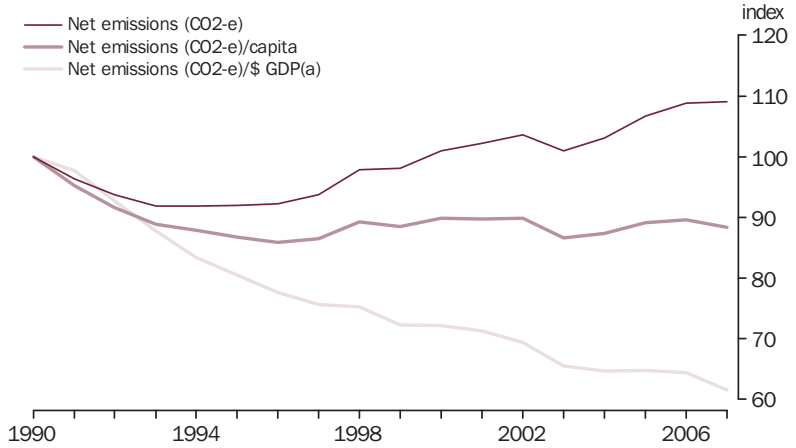
Carbon dioxide (CO_2) is the most commonly emitted and probably the best-known greenhouse gas, but there are many others, such as water vapour, methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (CF_4 and C_2F_6), and hydrofluorocarbons (HFCs).

How much a given mass of a particular greenhouse gas contributes to global warming varies with the type of gas, and so the Global Warming Potential (GWP) index has been developed to place all gases on a common measurement footing. Calculating this index for different gases allows the relative contributions of all greenhouse gases to be expressed in terms of their CO_2 equivalence. For example, methane has 21 times the global warming potential (GWP) of CO_2. Some substances, such as sulphur hexafluoride, have GWPs thousands of times that of CO_2 and are of concern even though they are emitted in small quantities.

Gas	100-year global warming potential (GWP)
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Sulphur hexafluoride (SF_6)	23,900
CF_4	6,500
C_2F_6	9.200
Hydrofluorocarbon (HFC)-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800

Note: These are the greenhouse gases regulated under the Kyoto Protocol. Solvent and other product use can also cause emissions of NMVOCs (non-methane volatile organic compounds).
Source: Department of Climate Change, 2009, *National Inventory Report 2007 Volume 1.*

Carbon dioxide equivalent (CO_2-e) emissions, net, per capita and per $ GDP



Note: Graph refers to Kyoto Protocol-based estimates of net greenhouse gas emissions. Index displays emissions as a percentage of emissions in 1990.
(a) GDP used is a chain volume measure; reference year 2007–08.
Source: Australian Bureau of Statistics (ABS), 2008, *Australian Historical Population Statistics (cat. no. 3105.0.65.001);* ABS, 2009, *Australian National Accounts: National Income, Expenditure and Product September 2009 (cat. no. 5206.0);* Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009.*

Changes in emissions

Although Australia's annual greenhouse gas emissions increased slightly between 1990 and 2007, the country's per capita emissions rate decreased by 12%. Despite this reduction, Australia continues to emit a large volume of greenhouse gases per capita, in comparison to other OECD countries.[22]

The greenhouse gas emissions intensity of the Australian economy, expressed as emissions per dollar of GDP (chain volume measure), declined by 38% over the period 1990 to 2007, from 830 g of carbon dioxide equivalent emissions (CO_2-e) per dollar GDP in 1990 to 510 g per dollar GDP in 2007.[23] The falling trend in emissions per unit of GDP reflects:[24]

- specific emissions management activities across sectors;
- a decline in net land use, land use change and forestry (LULUCF) emissions over the period; and
- stronger growth in the services sector of the Australian economy, relative to the more energy-intensive manufacturing sector.

By ratifying the Kyoto Protocol in 2007, Australia agreed to stabilise its emissions (for the five-year commitment period of 2008 to 2012) at no more than 108% of its 1990 (base year) emissions level.[25]

The October 2008 estimate of Australia's 1990 net emissions was used to calculate Australia's target emissions under the Kyoto Protocol. The 1990 emissions were estimated at 547.7 Mt CO_2-e, so the target emissions under the Protocol were set at 591.5 Mt CO_2-e per year (over the period 2008 to 2012).[26]

Australia's net greenhouse gas emissions between 1990 and 2007 increased by 9%. Therefore, in order to meet its Kyoto target for the 2008 to 2012 period, Australia will need to lower its emissions slightly from the 2007 level.

Net greenhouse gas emissions by sector

	Emissions Mt CO_2-e		Percent of total emissions	Percent change in emissions
	1990	2007	2007	1990 to 2007
Energy	286.4	408.2	68.4	42.5
Stationary energy	195.1	291.7	48.8	49.5
Transport	62.1	78.8	13.2	26.9
Fugitive emissions	29.2	37.7	6.3	29.1
Agriculture	86.8	88.1	14.8	1.5
Land use, land use change and forestry (a)	131.5	56.0	9.4	-57.4
Industrial processes (b)	24.1	30.3	5.1	25.7
Waste	18.8	14.6	2.4	-22.3
Australia's net emissions (c)	**547.7**	**597.2**	**100.0**	**9.0**

(a) Kyoto Protocol-based figures
(b) Includes confidential N_2O emissions from industrial processes and solvent and other product use reported as CO_2-e.
(c) Strictly speaking the net credits from land use change and forestry should only enter the account during the first commitment period (2008 to 2012). Their inclusion in this table helps our understanding of Australia's emissions in relation to the Kyoto emissions target which is 591.5 Mt CO_2-e each year over the first commitment period.
Source: Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009*.

Emissions by sector

The Department of Climate Change classifies greenhouse gas emissions (and removals, e.g. by forests acting as carbon sinks) into six sectors. The sectors listed below represent the main human activities contributing to the release or capture of greenhouse gases into or from the atmosphere:[27]

- Energy
- Agriculture
- Land use, land use change and forestry
- Industrial processes
- Waste
- Solvent and other product use

Energy

The energy sector is responsible for the majority of Australia's greenhouse gas emissions. In 2007, the production and consumption of energy accounted for 68.4% (408.2 Mt CO_2-e) of Australia's net emissions. Of this, 370.5 Mt of emissions were from the combustion of fossil fuels (principally for electricity generation, transport and manufacturing) and 37.7 Mt were from fugitive emissions (related mainly to coal mining).[28] Between 1990 and 2007, energy emissions increased by 42.5%.

Stationary energy

Estimated emissions from stationary energy (i.e. emissions from fuel consumption for electricity generation, fuels consumed in the manufacturing, construction and commercial sectors and other sources like domestic heating) totalled 291.7 Mt CO_2-e in 2007, or 48.8% of net national emissions. Emissions from stationary energy increased by 49.5% between 1990 and 2007.

In 2007, electricity generation accounted for 199.5 Mt CO_2-e (68.4% of stationary energy emissions, and 33% of Australia's net emissions).[29] While stationary energy emissions increased by 49.5% between 1990 and 2007, electricity generation emissions increased by an even larger percentage: 54%.[30]

Fuels used in Australian electricity generation, 2006–07

Source	PJ	Share %
Thermal		
Black coal	1,379	56.4
Brown coal	671	27.4
Oil	25	1.0
Gas	284	11.6
Total thermal	2,360	96.4
Renewables		
Hydro	52	2.1
Wind (a)	23	0.9
Biomass	5	0.2
Biogas	7	0.3
Total renewables	87	3.6

Note: Figures are for energy input, not output.
(a) Includes solar photovoltaic electricity generation.
Source: Australian Bureau of Agricultural and Resource Economics, 2009, *Energy in Australia 2009*.

Transport

Transport activity is the other major source of emissions related to the combustion of fossil fuels. Transport contributed 78.8 Mt CO_2-e or 13% of Australia's net emissions in 2007. Emissions from this sector were 26.9% higher in 2007 than in 1990.

Road transport was the main source of transport emissions in 2007, accounting for 68.5 Mt CO_2-e or 11.5% of national emissions. Passenger cars were the largest transport source, contributing 41.9 Mt CO_2-e.[31]

Agriculture

The agriculture sector produces most of Australia's methane and nitrous oxide emissions. Agriculture produced an estimated 88.1 Mt CO_2-e emissions or 14.8% of net national emissions in 2007.

Agriculture sector emissions, 2007

	Emissions (Mt CO_2-e)		
	CH_4	N_2O	Total
Enteric fermentation	57.6	—	57.6
Manure management	1.9	1.6	3.5
Rice cultivation	0.2	—	0.2
Agricultural soils	—	15.0	15.0
Prescribed burning of savannas	8.1	3.5	11.6
Field burning of agricultural residues	0.2	0.1	0.3
Total agriculture sector	**68.0**	**20.2**	**88.1**

Source: Department of Climate Change, 2009, *National Inventory Report 2007 Volume 1.*

Land use, land use change and forestry

The Department of Climate Change prepares submissions of Australia's greenhouse gas emissions in two ways:

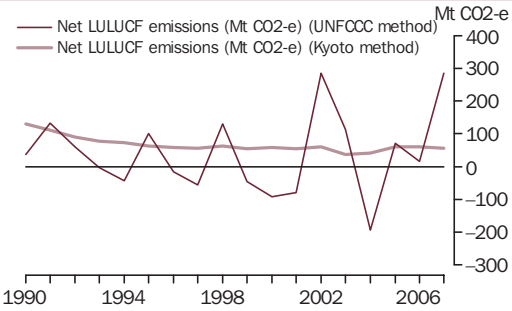
- according to the rules of the Kyoto Protocol; and
- according to the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC).

The two methods differ only in the treatment of the land use, land use change and forestry (LULUCF) sector.[32]

Under UNFCCC methodology, all emissions from the human use of land, and from natural events, are accounted for. However, under Article 3.3 of the Kyoto Protocol, emissions reported from the LULUCF sector are limited to:[33]

- afforestation and reforestation (i.e. new forest plantings, which correspond to a negative emissions value); and
- deliberate deforestation of land that was forest on the 1st of January 1990.

LULUCF emissions



Note: Estimates of Australia's net greenhouse gas emissions from the LULUCF sector, by the UNFCCC reporting method and the Kyoto Protocol method.
Source: Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009;* Department of Climate Change, 2009, *National Inventory Report 2007 Volume 2.*

Australia's net LULUCF emissions (and hence its total net greenhouse gas emissions) are much more variable from year to year under the UNFCCC reporting method than under the Kyoto accounting method. This is because Kyoto-based LULUCF emissions reporting does not include emissions from natural events, such as fire, drought and pest attack, nor does it include emissions from land under continued land use, e.g. the growth, harvesting and regrowth of forests.[34]

Therefore, Australia's net emissions in 2007 totalled 825.9 Mt CO_2-e under the UNFCCC reporting method but only 597.2 Mt CO_2-e under the Kyoto accounting method. The Kyoto-based LULUCF net emissions figure for 2007 was 56.0 Mt CO_2-e, whereas the UNFCCC-based total was 284.7 Mt CO_2-e.[35]

Industrial processes

Most greenhouse gas emissions from industrial processes are by-products of production from non-energy related sources. For example, high temperature processing of calcium carbonate to produce quicklime releases carbon dioxide emissions.

Emissions from the industrial processes sector were 30.3 Mt CO_2-e in 2007, which was equivalent to 5.1% of net national emissions. This emissions level was 6.2 Mt (26%) higher than in 1990.[36] The increase can be attributed to a rise in emissions from the consumption of halocarbons and sulphur hexafluoride (SF_6), which are used particularly in refrigeration, air conditioning, foam blowing and aerosols.[37]

Waste

Waste emissions are predominantly methane and account for less than 3% of Australia's total emissions. Total waste emissions were 14.6 Mt CO_2-e in 2007. Waste emissions have decreased by 4.2 Mt CO_2-e (22.5%) since 1990.[38]

Waste emissions can be from disposal of solid waste, wastewater handling or waste incineration. Solid waste degrades very slowly and methane emissions continue long after the waste is placed in landfill. For this reason, waste emissions estimates for any year include a significant component of emissions resulting from waste disposal over the previous 50 years. Hence, any change to waste management practices are not likely to affect reported waste emission levels for a number of years.[39]

Reducing our greenhouse gas emissions

"Without effective mitigation, the mainstream science tells us that the impacts of climate change on Australia are likely to be severe"
Garnaut, 2008.[40]

It is difficult to know with certainty to what level greenhouse gas emissions should be reduced. This is partly because of the uncertainty associated with predicting future climate change and partly because views about what constitutes acceptable climate change differ depending on ethical, economic and political judgements.[41]

The Garnaut Climate Change Review was commissioned in April 2007 to examine the impacts of climate change on the Australian economy and to recommend medium to long-term policies and policy frameworks to improve the prospects of sustainable prosperity.[42] This included recommendations in relation to two global mitigation goals. One was a target for stabilisation of greenhouse gas concentrations in the atmosphere at 450 parts per million (ppm) of CO_2-e; the other a less ambitious target of 550 ppm. These targets are associated with long-term temperature increases in the order of two and three degrees Celsius, respectively.[43]

Opportunities for reducing greenhouse gas emissions

The Garnaut Review outlined various domestic policy options for reducing Australia's emissions. Market-based approaches included the introduction of an emissions trading scheme which would establish the right to emit greenhouse gases as a tradeable commodity. Examples of regulatory options included mandatory renewable energy targets and energy efficiency standards for buildings and appliances.[44]

The following section presents statistics on energy intensity of industry, carbon sequestration, passenger transport, energy sources and efficiency, and putting a price on carbon.

World's response to climate change

1988 – United Nations establishes IPCC
The World Meteorological Organisation and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC). The Panel produces periodic assessment reports on scientific information relevant to human-induced climate change.

1992 – Global targets for reducing emissions
At the United Nations Conference on Environment and Development (Earth Summit) held in Rio de Janeiro, the United Nations Framework Convention on Climate Change (UNFCCC) was signed by 154 nations (by December 2007, it had been ratified by 192 countries). It provides the overall policy framework for addressing climate change. The Convention, as originally framed, set no mandatory limits on greenhouse gas emissions for individual nations and contained no enforcement provisions; it is therefore considered legally non-binding.

1997 – Kyoto: Legally binding cuts in emissions
The Kyoto Protocol is linked to the UNFCCC. It sets legally binding commitments for the reduction of four specific greenhouse gases (carbon dioxide, methane, nitrous oxide and sulphur hexafluoride) and two groups of gases (hydrofluorocarbons and perfluorocarbons) for 37 industrialised nations and the European community, as well as general commitments for all member countries. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997, entered into force on 16 February 2005 and has been ratified by 184 Parties of the UNFCCC Convention.

2006 – The Stern report
The Stern report was published in the UK. It examined the economic impact of climate change and found that the costs of inaction far outweighed the costs of action.

2007 – Bali Roadmap
At the United Nations Climate Change Conference, held in Bali, a decision was made to step up international efforts to combat climate change and lay down measures and obligations for the world, after the first commitment period of the Kyoto Protocol expires at the end of 2012.

2008 – Australia ratifies Kyoto Protocol
Australia's ratification of the Kyoto Protocol came into effect on 11 March 2008. Under the Protocol, Australia has agreed to an annual emissions target of 108% of its 1990 emissions during the 2008 to 2012 period.

2008 – The Garnaut report
The Garnaut Climate Change Review examined the impacts of climate change on the Australian economy and the costs of adaptation and mitigation. It analysed the elements of an appropriate international policy response, and the challenges facing Australia in playing its part in that response.

2009 – Copenhagen
A series of UNFCCC meetings took place throughout 2009. These culminated in the United Nations Climate Change Conference (COP 15) in Copenhagen from 7-18 December. The Conference of the Parties (COP) is an association of all the countries which are Parties to the Convention and is the Convention's highest decision-making authority.

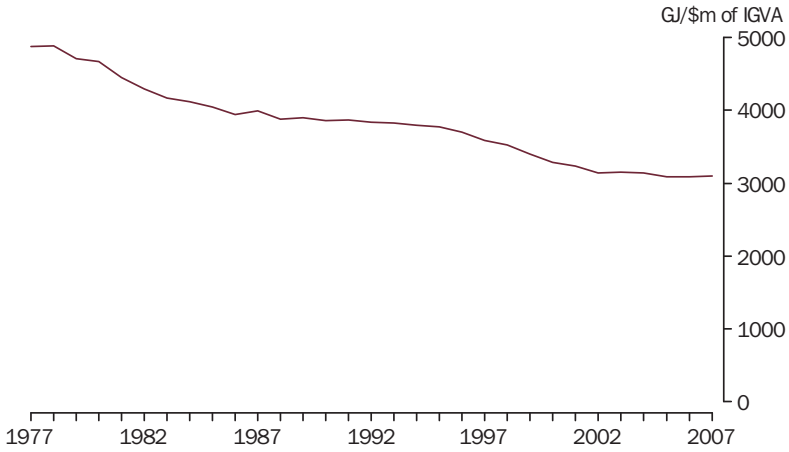
Energy intensity in Australian industry

The energy intensity of an industry is a measure of the energy consumed to produce one unit of economic output.[45] Reducing energy intensity would contribute to reducing Australia's greenhouse gas emissions.

Australia's energy intensity fell 36% over the 30 years to 2006–07, from 4,880 to 3,100 gigajoules of energy consumed per million dollars of Industry Gross Value Added.[46]

While most industries' energy intensity levels fell over the three decades to 2006–07, mining and agriculture increased. Transport and construction experienced large reductions in energy intensity (49% and 74% respectively), while other services fell only 13%. Falls in energy intensity may be attributable to factors other than more efficient use of energy. For example, within the economy it may indicate a shift from manufacturing activities to services or, within an industry such as manufacturing, a shift from heavy to light manufacturing.[47]

Energy intensity, All industries, 1976–77 to 2006–07



Note: Year refers to financial years, e.g. 1977 refers to 1976–77 financial year.
Source: ABS, 2009, *Energy Account 2006–07 (cat. no. 4604.0)*.

Carbon sequestration and offset opportunities in agriculture and forestry

Increasing the amount of carbon stored, or sequestered, in our soils can reduce the amount of greenhouse gases in the atmosphere and improve agricultural productivity.

Fifty-four per cent of Australia's land area is used for agriculture.[48] Management practices, such as increasing perennial vegetation in pastures and maintaining crop residues, can increase soil carbon in agricultural soils. However, the potential for agricultural soils to sequester carbon varies depending on climate, soil type and previous management practices.[49]

Afforestation provides another way in which carbon can be sequestered. The Australian Bureau of Agricultural and Resource Economics has estimated that between six and 28 million hectares of agricultural land (approximately 1.5% to 7% of all agricultural land) will be economically suitable for afforestation between 2007 and 2050, depending on the price of carbon. These forests (a combination of timber plantations and environmental plantings) would sequester between 296 and 885 Mt of carbon by 2050.[50]

The Indigenous community in western Arnhem Land has already taken advantage of opportunities to reduce emissions. The West Arnhem Land Fire Abatement Project undertakes strategic fire management to reduce wildfires over an area of 28,000 square kilometres. These activities reduce greenhouse gas emissions by 100,000 tonnes of CO_2-e each year, offsetting some of the emissions from the liquefied natural gas (LNG) plant in Darwin. In return, Darwin LNG is paying the Indigenous fire

managers around $1 million a year and bringing new jobs and educational opportunities to the region.[51]

Emissions and rural land use

Opportunities for reducing emissions	
Land clearing	Reduce or cease land clearing.
Enteric emissions from livestock	Reduce emissions from ruminant livestock by either use of anti-methanogen technology or shift some meat production from sheep and cattle to kangaroos.
Savanna burning	Change management to reduce emissions from savanna burning.
Biofuels	Replace fossil fuels with biodiesel made from algae or other plants.
Opportunities for carbon sequestration	
Soil sequestration	Change management practices on cropped and grazed land to sequester carbon in soils.
Restoration of mulga country	Restore degraded, low value grazing country in arid Australia.
Plantations	Establish plantations for timber production and specifically to sequester carbon.
Pre-1990 eucalypt forests	Timber harvesting and other human disturbances are reduced to allow forests to sequester the maximum amount of carbon.

Source: Garnaut, 2008, *The Garnaut Climate Change Review*.

Passenger transport

Fuel use in road transport is a significant source of greenhouse gas emissions and passenger cars make up a large component of this. In terms of kilometres travelled for every unit of energy used, buses are the most energy efficient mode of passenger transport, followed by heavy rail and motor cycles. Passenger cars and inland ferries are the least efficient.[52]

Carbon dioxide emissions in new motor vehicles are falling. According to the National Transport Commission, in 2008, the national average carbon emissions from new passenger and light commercial vehicles was 222 g/km, a 12% reduction from 2002.[53]

In Australia in 2009, the most common factor considered when buying a motor vehicle was the purchase price (53%). While fuel economy/running costs was the second most common factor (41%), environmental impact/exhaust emissions were considered by only 4%.[54] This is reflected in the fact that in 2008 only 1% of car sales in Australia were "green" cars[b], compared to 11% in the UK.[55]

[b] Emissions not exceeding 120 g/km of CO_2.

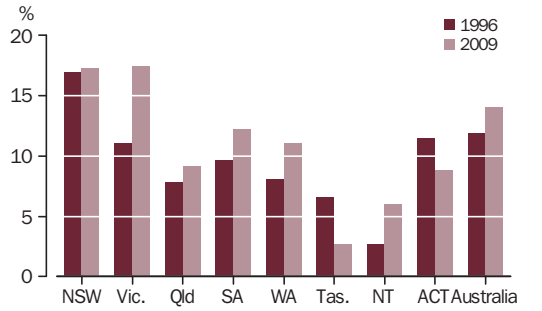
Travel to work: selected modes, 2009

Main form of transport used on usual trip to work or full-time study, March 2009	%
Private motor vehicle	79.6
Public transport	14.0
Bicycle	1.5
Walk	4.0
Other	0.9

Source: ABS, 2009, Environmental Issues: Waste Management and Transport Use, Mar 2009 (ABS cat. no. 4602.0.55.002)

In 2009, over three quarters (80%) of Australians used private motor vehicles as the main method of travel to work or study, compared to only 14% who used public transport.[56] However, the proportion of trips on public transport has risen since 1996, particularly in Victoria.

Use of public transport, 1996 and 2009

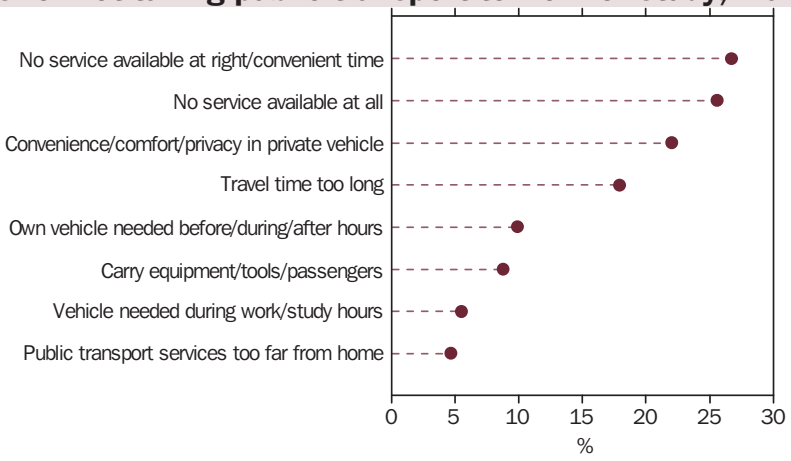


Note: Public transport used as the main form of transport on usual trip to work or full-time study
Source: ABS, 2006, *Environmental Issues: People's Views and Practices March 2006 (cat. no. 4602.0);* ABS, 2009, *Environmental Issues: Waste Management and Transport Use, March 2009 (ABS cat. no. 4602.0.55.002).*

Lack of public transport services at the right time and complete lack of services continue to be the main reasons why people in Australia do not use public transport. In 2009, over one half (52%) of people not taking public transport cited either of these reasons. The convenience/comfort/privacy of using a motor vehicle and travel time were the next most common reasons for not using public transport (22% and 18%, respectively).[57]

Relatively few people usually walked or cycled to their place of work or study (4% and 1%, respectively). The proximity of home (64%) and exercise and health (50%) were the two most commonly reported reasons why people walked or cycled. Only 7% cited environmental concerns as a reason for walking.[58]

Reasons for not taking public transport to work or study, March 2009



Note: Major reasons given by respondents
Source: ABS, 2009, *Environmental Issues: People's Views and Practices March 2006 (cat. no. 4602.0)*.

The renewable energy industry

In 2007–08, Australia produced 290 petajoules (PJ) of renewable energy, equivalent to 5% of Australia's total primary energy consumption of 5,572 PJ. Bagasse (sugar cane waste) was the largest source of renewable energy (39%), followed by wood and wood waste (33%) and hydroelectricity (15%). Other biofuels, wind and solar (including solar hot water) contributed 13%.

Australian production of renewable energy (a)

	2001–02 (PJ)	2007–08 (PJ)	% Increase
Bagasse	91.7	111.9	22
Other biofuels(b)	10.1	17.6	74
Hydroelectricity	57.5	43.4	-25
Solar hot water	2.7	6.5	141
Wind and solar photovoltaic	0.6	14.6	2333
Wood and woodwaste	95.0	96.0	1
Total	**257.6**	**290.0**	**13**

(a) Electricity and heat.
(b) Includes biogas, black liquor, crop and municipal waste.
Source: Australian Bureau of Agricultural and Resource Economics (ABARE), 2009, *Energy statistics – historical, Table A, <http://www.abare.gov.au/publications_html/data/data/data.html >, last viewed November 2009;* ABARE, 2009, *Energy in Australia 2009.*

Over the six year period from 2001–02 to 2007–08, production of renewable energy increased by 13%.[59] Very rapid growth rates in wind and solar electricity were from low bases and have been largely offset by falling hydroelectricity generation.

According to the Australian Bureau of Agricultural and Resource Economics, in the six months to April 2009, ten electricity generation projects were completed in Australia, four of which were renewables (two wind and two biomass). The new renewable energy projects have a generating capacity of 310 megawatts (MW), or 16.5% of additional generating capacity commissioned.[60]

Wind farms figure very prominently in renewable electricity projects. The recently completed Waubbra Wind Farm in Victoria is the largest in the southern hemisphere, consisting of 128 wind turbines with a generation capacity of 192 MW.[61]

In April 2009, renewable electricity projects represented 16% of capacity of all electricity generation projects[c] at an advanced stage of development.[62] In addition, the number of renewable electricity projects at less advanced stages of development is considerable and the combined capacity of these projects constitutes 41% (9,408 MW) of all less advanced electricity generation projects.[63]

[c] Projects with a total capacity exceeding 30 MW.

Sources of energy in homes

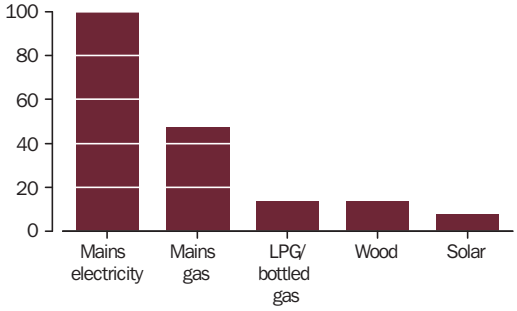
Energy consumption in the residential sector is a significant contributor to greenhouse gas emissions in Australia due to the heavy reliance on fossil fuels, notably coal, to produce electricity.

Hot water systems and space heating account for the majority of energy used in most households. In March 2008, electricity was the main energy source for hot water systems (46%), space heating (35%), ovens (75%) and cooktops (56%).[64]

Compared to electricity generated from coal, natural gas produces substantially less carbon dioxide emissions.[65] Gas is the second most common source of energy for Australian households and was used in more than half of households (61%) in March 2008, particularly in the gas producing states of Victoria and Western Australia.[66]

Use of renewable energy is still uncommon in Australian homes. Solar energy use has increased from 5% in 2002 to 8% in 2008. It is used primarily for heating water.[67]

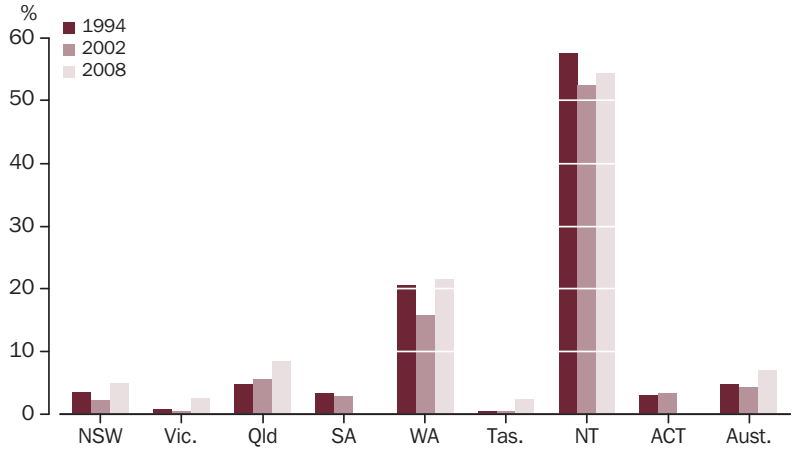
Main sources of energy in dwellings, 2008



Note: Only includes the five most common sources of energy used in residential dwellings.
Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

The use of solar hot water varies considerably between regions. In the Northern Territory and Western Australia, 54% and 21% of households, respectively, had solar hot water, compared to the national figure of 7%.[68] These higher proportions reflect numerous factors but especially high levels of solar radiation in these states and the larger proportion of remote communities lacking access to cheap mains electricity.

Solar hot water heating, Use in dwellings



Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

GreenPower is a government renewable energy accreditation program. GreenPower schemes enable consumers to pay a premium for electricity generated from sources like mini hydro, wind power and biomass which produce no net greenhouse gas emissions.

The schemes have been operating for over ten years in New South Wales, Victoria, Queensland, Western Australia, South Australia and the Australian Capital Territory. In the March quarter 2009, there were approximately 984,000 GreenPower customers in Australia, a substantial increase from 138,879 customers in March 2005.[69]

More than half of all households (52%) were aware of GreenPower in 2008 (including 5% already paying for GreenPower). This was a large increase compared with 2005 and 1999 when 29% and 19% respectively were aware of GreenPower.[70]

In 2008, one-third of households that were aware of GreenPower stated they were willing to pay more to support the scheme, up from 23% in 2005.[71]

Awareness of GreenPower scheme, March 2008

	NSW	Vic.	Qld	SA	WA	ACT	Aust.
	%	%	%	%	%	%	%
Already paying for GreenPower	5.0	7.1	5.3	5.8	*1.0	4.9	5.3
Aware of GreenPower scheme	48.9	52.9	38.4	45.3	38.4	65.9	46.7
Not aware of GreenPower scheme	42.2	35.6	53.1	45.4	59.0	26.3	44.4
Did not know	3.9	4.4	3.2	3.5	1.6	*2.9	3.6
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

* estimate has a relative standard error of 25% to 50% and should be used with caution

Note: Data covers only states and territories that are participating in the *National Green Power Accreditation Program.*

Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

Willingness to pay extra per annum on GreenPower electricity, March 2008

	NSW	Vic.	Qld	SA	WA	ACT	Aust.
	%	%	%	%	%	%	%
Willing to pay extra	30.9	30.9	34.6	30.9	37.6	36.1	32.5
Not willing to pay extra	57.7	56.0	52.3	55.3	53.1	54.0	55.4
Did not know	11.4	13.1	13.1	13.8	9.3	9.9	12.1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: Data covers only states and territories that are participating in the *National Green Power Accreditation Program.*

Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

Energy efficiency in homes

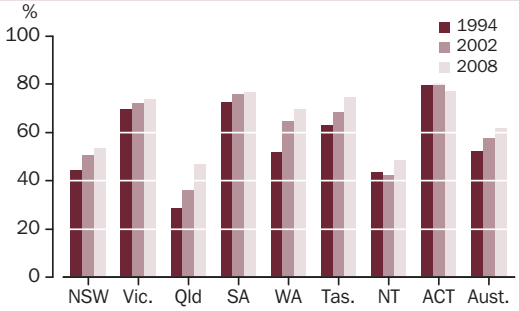
Residential buildings are responsible for a significant proportion of Australia's emissions, in both construction and use.

In 2007–08, most Australians (88%) reported that they take steps to limit their electricity use. The main reasons people gave for not taking steps to limit electricity use was that their electricity consumption was already low enough (33%) and that they had not thought about saving electricity (27%).[72]

Electrical appliances account for around 30% of energy use in the home.[73] In 2008, more than three-quarters (77%) of all households had a heater, over two-thirds (67%) had a cooler (i.e. air conditioner or evaporative cooler) and more than half (56%) had a clothes dryer. Nearly half of households had dishwashers (45%) and more than one-third had separate freezers (37%).[74]

When buying new appliances, energy efficiency was the most commonly reported factor which influenced the decision to buy a refrigerator (72%) and air conditioner (74%). Purchase price was the second most commonly reported factor for these appliances (68% and 63% respectively).[75]

Houses with insulation



Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

In 2008, 61% of households reported having insulation in their dwelling, up from 52% in 1994. The main reason given for having insulation was to improve comfort (83% of households installing insulation). While only a small proportion (4%) of households reported that they had installed insulation primarily to save energy, the installation of insulation for whatever reason leads to lower energy use.[76]

Putting a price on carbon

Sir Nicholas Stern has described climate change as the greatest example of market failure we have ever seen.[77] The failure to put a price on emissions has led to excessive emissions and the risk of dangerous climate change.[78]

Putting a price on carbon[d] through the introduction of emissions trading has been proposed as one way to reduce emissions. Under a cap and trade scheme, permits are required to emit greenhouse gases into the atmosphere. These permits can be bought and sold but the government is able to place a cap on total emissions by limiting the number of permits issued.[79]

Industries in Australia most likely to be affected by putting a price on carbon are those with: 1) a high emissions intensity; 2) limited or negligible access to substitutes to reduce their emissions intensity; 3) exposure to increased costs under an emissions trading scheme; 4) limited capacity to pass on the emissions price.

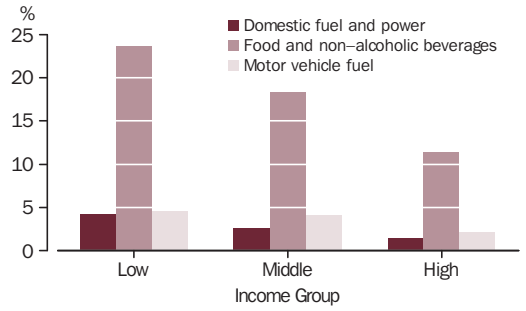
In July 2008, the Australian Government released a Green Paper on a Carbon Pollution Reduction Scheme which included options and preferred approaches relating to imposing a limit on how much carbon pollution industry can emit.

Although in the proposed scheme the cost of purchasing emissions permits would rest with certain emissions-intensive industries, such as electricity generators, the cost is expected to be passed down the supply chain.

Consumers would, therefore, pay more for a range of goods and services, particularly emissions-intensive goods and services. Low income households are particularly vulnerable to price increases as they spend a greater proportion of their incomes on items that are more likely to be impacted by higher energy prices, such as food, petrol, electricity and gas.[80]

[d] Carbon dioxide emissions.

Expenditure on selected items as a proportion of disposable income



Source: ABS, data available on request (Household Expenditure Survey, 2003–04).

Some households already struggle to purchase necessities. In 2003–04, almost 9% of households with low income and low net worth reported they were unable to heat their home. Twelve percent went without meals and 38% could not pay utility bills on time.[81]

Selected indicators of financial stress, 2003–04

	Low economic resources households (a) (%)	Other households (%)
Unable to heat home	8.9	1.2
Went without meals	11.8	1.8
Could not pay bills on time	37.8	11.5
Total households ('000)	1,050.6	6,685.2

(a) Households simultaneously in both the lowest three income deciles and the lowest three net worth deciles.
Source: ABS, data available on request (Household Expenditure Survey, 2003–04).

People living in rural or outer suburban areas may also be disproportionately affected. Higher transport costs in these areas will also be reflected in higher product prices, including food. Those who need to drive long distances to access services will be particularly vulnerable to rising fuel prices.[82]

The effects of higher fuel and power prices can be offset by a range of measures. For example, under an emissions trading scheme, revenues gained from the sale of emission permits to industry can be used to compensate households, improve access to public transport and assist households to use more energy efficient products and motor vehicles.

Impacts and adaptation

"Mitigation will come too late to avoid substantial damage from climate change"
Garnaut, 2008.[83]

Within the next few decades, it is likely that Australian households, communities and businesses will have to take actions to adapt to the impacts of climate change that cannot be avoided by mitigation.[84]

Impacts affecting society, environment and the economy

The impacts of climate change will affect the environment, society and the economy. The vulnerability of these systems will vary between regions and sectors depending on exposure to changes in the climate, sensitivity to those changes and capacity to adapt.

This section explores some of the areas considered most vulnerable to the impacts of climate change:

- Water
- Agriculture
- Biodiversity
- Coastal settlements
- Human health

While some households and businesses are already taking actions to adapt to a changing climate, some are limited in their capacity to adapt and, therefore, may be more vulnerable.

Water

In 2004–05, the distribution of water consumption in the Australian economy was:

- 65% by agriculture;
- 11% by households;
- 11% water supply industry (including losses in delivery system);
- 3% by manufacturing;
- 10% by other industries (e.g. mining, service industries).[85]

Lower rainfall and increases in evaporation will reduce runoff and stream flow in many parts of Australia, including many major cities and irrigation areas. For example, in one study a temperature increase of 1 to 2°C is projected to result in a 7 to 35% decrease in Melbourne's water supply and a 0 to 25% decrease in flow in the Murray-Darling Basin.[86]

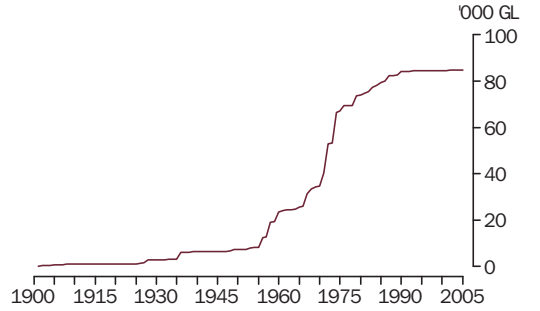
Projections suggest that across Australia the number of drought months will increase by up to 20% by 2030. By 2070, drought months are projected to increase by up to 40% in eastern Australia and by up to 80% in south-western Australia.[87]

Dams

Dams have been built in Australia since the late-1800s to provide a reliable water resource for irrigated agriculture, urban water needs and hydro-electric power generation.[88]

At the start of the 20th century the combined storage capacity of all large dams was 250 GL. This grew to 9,540 GL by 1950 and 83,853 GL in 2005.[89] Australia's 500 large dams have a total capacity equivalent to 4,000 kilolitres (kL) per person.

Total storage capacity of large dams



Note: A large dam is defined as having a height of greater than 15 metres (m), or as greater than 10 m but meeting other size criteria.
Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

In addition, there are many thousands of farm dams throughout Australia. Australia's high per capita storage capacity is needed to sustain agricultural production and potable water supplies for human use during long dry periods.

Large dam storage levels

Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

Drought conditions were reflected in an 18% fall in the water stored in large dams between 2002 and 2005. On 1 July 2002, storage levels were at 48,683 GL, falling to 39,959 GL by 30 June 2005.[90]

Comprehensive current data for all of Australia is not available. However, total public storage in the Murray-Darling Basin at the end of October 2009 was only 6,450 GL, or 28% of capacity.[91]

Water management on farms

Australia's agriculture industry is particularly dependent on irrigation water to sustain production. Whilst most agricultural water is used for irrigation of crops and pasture, water is also used for livestock drinking and washing down dairy sheds.

In 2004–05, a third of all farms carried out water-related management activities, spending a total of $314 million in that year.[92]

The most commonly reported water management activities were: earthworks, drains and water pumping; tree and shrub maintenance; and removing stock from waterways.[93]

Water issues included surface and groundwater availability, excess nutrients, clarity, toxicity and others. Of these, water availability was the water issue most frequently reported by farmers.[94]

Farms identifying water issues and water activities, 2004–05

Source: ABS, 2007, *Natural Resource Management on Australian Farms 2004–05 (cat. no. 4620.0)*.

Expenditure by the agriculture industry for water management, 2004–05

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
Total expenditure ($million)	128	^ 51	^ 85	^ 18	25	^ 5	*1	^ –	314
Average expenditure per farm ($)	9,501	^ 5,151	^ 9,241	4,836	5,095	3,833	*18,474	^ 3,405	7,351

^ Estimate has a relative standard error of 10% to less than 25% and should be used with caution.
* Estimate has a relative standard error of 25% to less than 50% and should be used with caution.
Source: ABS, 2007, *Natural Resource Management on Australian Farms 2004–05 (cat. no. 4620.0)*.

Inland waterways and wetlands

Climate change and, in particular, reduced rainfall, increased drought, more intense rainfall events, sea level rise and warming of the water column will impact on inland waterways and wetlands in many ways, including:

- reduced river flows and changes in seasonality of flows;
- changes in species composition and community structure (such as loss of cool adapted aquatic species);
- reduced area available for waterbird breeding;
- sea level rise resulting in saltwater intrusion into freshwater bodies; and
- changes in water quality, eutrophication[e] levels and incidence of blue-green algae outbreaks.[95]

In the interest of maintaining the health of rivers, a number of states and territories are allocating and providing water to the environment – generally known as 'environmental flows'.

Without sufficient flows water-dependent ecosystems may lose their capacity to provide for environmental and other public benefits outcomes. Such losses can be difficult or costly to overturn and, in some cases, may be irreversible.[96]

The ABS *Water Account Australia 2004–05* presented information on water released for the purpose of the environment in accordance with specific environmental regulations. This has been termed environmental provisions; it does not represent all environmental flows, but only the volume of water released by water suppliers. Other methods of providing water to the environment include placing limits and rules on licences for water extraction and strategic management of flows and water quality.

In 2004–05, 1,005 GL of water was supplied to the environment through environmental provisions. This is an increase of 119% across Australia since 2000–01. States with large increases were Queensland, Victoria and Tasmania.[97]

More recently, the *Water Act 2007* (Cwlth) established a management system for the Australian government's $3.1 billion Restoring the Balance in the Murray-Darling Basin program and $5.8 billion Sustainable Rural Water Use and Infrastructure program.[98]

[e] Excess nutrients in a water body, often leading to enhanced plant growth and degradation of water/habitat quality.

Environmental provisions

	NSW/ACT	Vic	Qld	SA	WA	Tas	NT	Aust.
	GL	GL	GL	GL	GL	GL	GL	GL
2000–01	200.5	253.2	4.5	0.9	–	0.4	–	459.4
2004–05	127.2	373.9	383.6	0.7	–	118.7	1.1	1,005.3

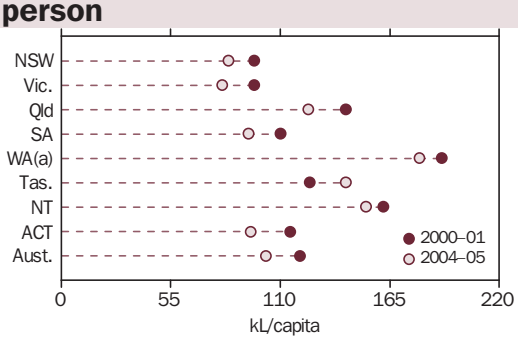
– Nil or rounded to zero (including null cells).
Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

Household water use and conservation

After years of low rainfall, Australian households are adapting to reduced water availability. Over the period 2000–01 to 2004–05, household water use per person fell 14%, from 120 kL to 103 kL. Tasmania was the only state to record an increase.[99]

Decreased household use reflects water restrictions in most states and territories since 2002, government incentives to reduce water use and improve water use efficiency, and voluntary conservation of water by households.

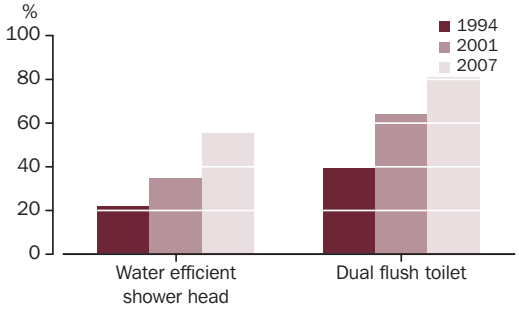
Household water consumption per person



(a) Includes unlicensed water use from garden bores.
Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

From 1994 to 2007, the proportion of households with water conservation devices more than doubled.[100]

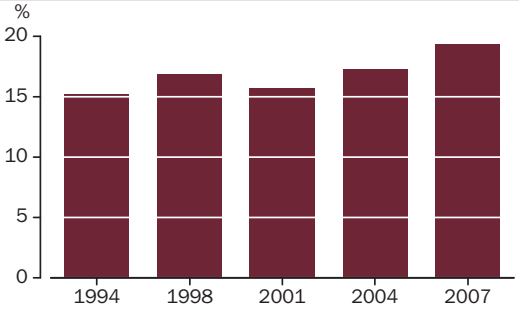
Households with water conservation devices



Source: ABS, 2007, *Environmental Issues: People's Views and Practices March 2007 (cat. no.4602.0)*.

Whilst mains/town water is overwhelmingly the principal source of water for Australian households, (93% connected in March 2007), households are reducing their reliance on mains water by increasing their use of grey water and rainwater tanks.[101]

Rainwater tanks as a source of water for households



Source: ABS, 2007, *Environmental Issues: People's Views and Practices March 2007 (cat. no.4602.0)*.

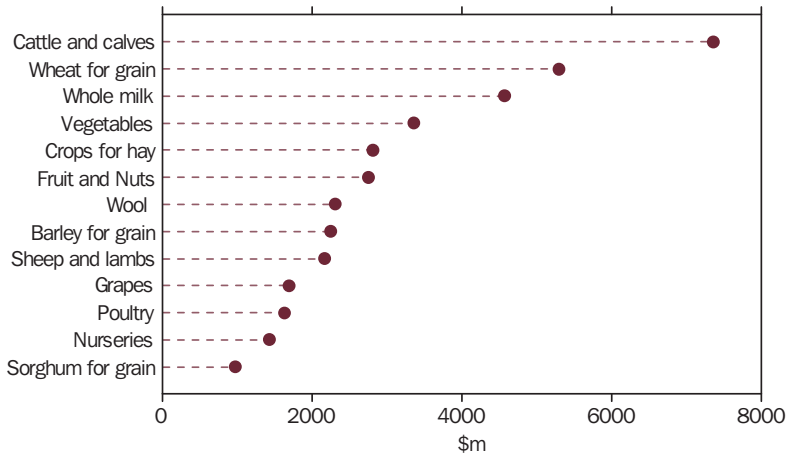
In 2007, nearly one-fifth (19%) of all households sourced water from a rainwater tank, up from 16% in 2001.[102]

Agriculture

Agriculture is an important part of the Australian economy. In 2007–08, the gross value of agricultural production was $43.3 billion[103] and in 2008–09, 318,000 people were employed in the agriculture industry.[104]

Australia's agricultural businesses are engaged mainly in beef cattle farming, dairy cattle farming, sheep farming, grain growing, or a mixture of two or more of these activities. Farm exports account for around 15% of total merchandise exports,[105] with products such as beef, wheat, and skim milk powder contributing significantly to global markets.

Gross value of agricultural commodities produced, 2007–08



Source: ABS, 2009, *Value of Agricultural Commodities Produced, Australia 2007–08 (cat. no. 7503.0)*.

Climate change is likely to affect agriculture in a number of ways:

- changes in rainfall and temperature will affect crop production;
- changes in the quantity and quality of pasture as well as temperature increases will affect the productivity of the livestock industries;
- severe weather events (e.g. bushfires and flooding) will affect crop yields and stock;
- changes in temperature are expected to alter the incidence and occurrence of pests and disease; and
- where there is adequate moisture, increased concentrations of CO_2 will increase growth in some plants.[106]

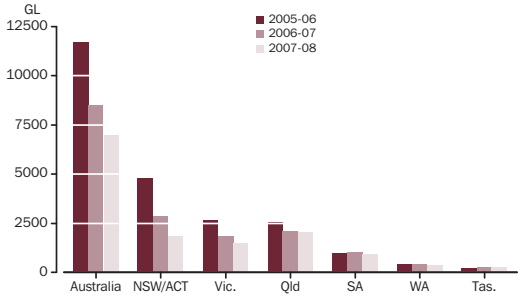
Many Australian farmers are already taking actions to adapt to what they perceive as a changing climate. In 2006–07, 66% of Australian agricultural businesses reported that the climate affecting their holding had changed and of this group 75% reported that they had changed management practices as a result of this perceived change.[107]

The most commonly reported perceived change in climate affecting the holding was a change in rainfall patterns (92%) followed by more extreme weather events (74%) and warmer temperatures (50%).[108]

The most commonly reported impact on the holding was a decreased level of production (89%) followed by an increased frequency or extent of pests, weeds or disease (56%).

In contrast, a small proportion of agricultural businesses reported a decreased frequency or extent of pests, weeds or disease (20%) and an increased level of production (15%).[109]

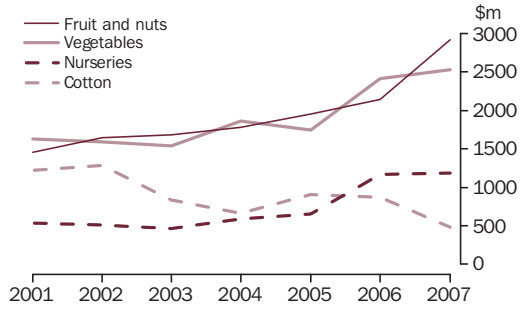
Agricultural water use on Australian farms



Note: Northern Territory data too small to display.
Source: ABS, 2008; 2008; 2009, *Water Use on Australian Farms 2005–06; 2006–07; 2007–08 (cat. no. 4618.0)*

From 2005–06 to 2007–8, agricultural water use on Australian farms fell 40% (from 11,689 GL to 6,989 GL) due to the continuing unavailability of water as a result of the drought. The largest declines occurred in NSW (61%), Victoria (44%) and Queensland (21%).[110]

Gross value of irrigated agricultural production, selected products

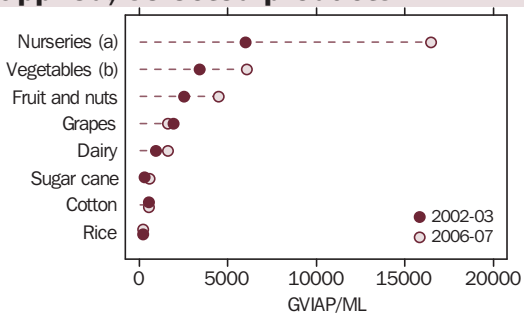


Note: Year refers to financial year eg. 2001 refers to 2000-01.
Source: ABS, 2009, *Experimental Estimates of the Gross Value of Irrigated Agricultural Production, 2000–01 to 2006–07 (cat. no. 4610.0.55.008)*.

In 2006–07, irrigated agricultural land comprised less than 0.5% of all agricultural land in Australia, yet the gross value of irrigated agricultural production (GVIAP) was $12,319 million. This represented 34% of the total gross value of agricultural production, up from 28% in 2000–01.[111]

The GVIAP generated for each megalitre of water applied (GVIAP/ML) can vary significantly between different agricultural activities and over time. The product groups with the highest GVIAP/ML in 2006–07 were: nurseries, cut flowers and cultivated turf, ($16,470), vegetables ($6,104), and fruit and nuts ($4,493). The product with the lowest GVIAP/ML was rice ($230).[112] Reductions in water availability could see a decline in low GVIAP/ML activities to higher ones.

GVIAP per megalitre of water applied, selected products



(a) Nurseries cut flowers and cultivated turf.
(b) Vegetables for human consumption or seed.
Source: ABS, 2009, *Experimental Estimates of the Gross Value of Irrigated Agricultural Production, 2000–01 to 2006–07 (cat no. 4610.0.55.008).*

Murray-Darling Basin

The Murray-Darling Basin (MDB) covers around 14% of Australia's land area[113] and is of special importance to Australia's agricultural production. In 2005–06, the gross value of agricultural production (GVAP) in the Basin was worth $15 billion or 39% of Australia's total GVAP ($38.5 billion).[114]

Agriculture dominates land use in the Basin. In 2006, 10% of the people employed in the Basin worked in agriculture, compared to only 3% Australia wide.[115]

Industries (including agriculture) and households in the MDB accounted for just over half (52%) of Australia's total water consumption in 2004–05. In terms of agricultural water consumption, the MDB is even more dominant. In 2005–06 the MDB used two-thirds (66%) of Australia's total agricultural water consumption.[116]

Irrigated agriculture in the MDB generated $4.6 billion or 44% of Australia's gross value of irrigated agricultural production in 2005–06. Dairy farming generated $938 million, fruit and nuts $898 million, cotton $797 million and grapes $722 million.[117]

Irrigated agriculture in the MDB is one area for which the impacts of climate change are anticipated to be large. Lower average rainfall and higher average temperatures are expected to significantly reduce water availability in the Basin, impacting on crop

yields and the quantity of water available for irrigation.

Without effective mitigation, by 2100, the economic production of irrigated agriculture in the Basin is projected to fall by 92%.[118]

Agriculture water consumption, 2005–06

	Murray-Darling Basin GL	Australia GL	MDB as a proportion of Aust. %
Dairy farming (a)	1,287	1,893	68
Pasture for other livestock (b)	1,284	2,042	63
Rice	1,252	1,253	100
Cereals (excl. rice)	782	894	88
Cotton	1,574	1,735	91
Grapes	515	633	81
Fruit (excl. grapes)	413	630	66
Vegetables	152	431	35
Other agriculture (c)	461	2,178	21
Total Agriculture	**7,720**	**11,689**	**66**

(a) Includes irrigated pasture for grazing, hay and seed; livestock drinking; and shed washdown.
(b) Includes irrigated pasture for grazing, hay and seed.
(c) Includes other broadacre crops, nurseries, livestock (other than dairy) drinking.
Note: Components may not add to total due to rounding.
Source: ABS, 2008, *Water and the Murray-Darling Basin, A Statistical Profile 2000–01 to 2005–06 (cat. no. 4610.0.55.007)*.

One way farmers can adapt to reduced water availability is by improving their water use efficiency. It is estimated that currently between 10 and 30 per cent of the water diverted from the rivers into irrigation systems is lost before it reaches the farm, and up to 20 per cent of the delivered water may be lost in on-farm distribution channels.[119]

Approximately two-thirds of irrigators in the MDB changed their water management practices during 2004–05. In 2004–05, the most common changes to irrigation practices in the MDB (as a proportion of total MDB irrigated farms) were:

- adopting more efficient irrigation techniques (35%)
- undertaking more efficient irrigation scheduling (27%)
- reducing area under irrigation (20%)
- laser levelling (17%)
- purchasing extra irrigation water (16%)[120]

Less common practices included: introducing reuse or recycled irrigation water (11%), installing soil moisture sensors (9%), selling irrigation water (8%), increasing the area under irrigation (8%), and installing piping or covering open channels to reduce water loss (7%).[121]

Biodiversity

Australia is one of the world's most biologically diverse countries. It is home to more than one million species, many of which are unique.

Biodiversity is particularly vulnerable to climate change because it has relatively low adaptive capacity compared to other sectors.[122]

In addition to climate change, biodiversity in Australia is under pressure from a range of other factors such as land clearing, pollution, weeds and pests. It is, therefore, difficult to know with certainty exactly what impact climate change has had on biodiversity to date. Nonetheless, numerous changes in biodiversity have been observed that are consistent with climate change. For example:

- changes in geographic ranges including expansion of animal and plant species into higher elevations and southerly latitudes;
- earlier arrival and later departure of migratory bird species;
- declines in populations of mountain pygmy possums associated with declining snow cover;
- expansion of rainforest in the NT, QLD and NSW;
- altered fire regimes; and
- more intense and frequent coral bleaching events.[123]

The capacity of natural systems to adapt to climate change will be improved if other pressures, such as land clearing, lack of environmental flows and pollution, can be eased. The resilience of natural systems can also be improved by expanding reserve systems and promoting conservation on private land.[124]

The Great Barrier Reef

The Great Barrier Reef is among the largest and most spectacular coral reef ecosystems in the world. A World Heritage Area, it is home to many organisms including six species of marine turtles, 24 species of seabirds, more than 30 species of marine mammals, 350 coral species, 4000 species of molluscs and 1500 fish species. Coral reefs are highly vulnerable to human-induced climate change.

Over the last 30 years, the waters of the Great Barrier Reef have increased in temperature by 0.4°C. This has made the Reef more susceptible to heat stress during short periods of warm sea temperature. As a result, episodes of mass coral bleaching have increased in frequency and intensity.

Over the last 25 years, heat stress has resulted in six episodes of coral bleaching within the Reef. In 1998, 50% of the coral reefs within the Great Barrier Reef Marine Park were affected by coral bleaching and in 2002, another mass coral bleaching event affected 60% of the coral reefs. About 5 to 10% of the corals affected during these events died.

Ocean chemistry has also been affected by climate change. Ocean pH has decreased by 0.1, that is, the ocean is becoming more acidic. As CO_2 concentrations increase in the atmosphere, increased amounts of CO_2 enter the ocean where it combines with water to produce a weak acid which limits the rate of coral growth. While the impacts of ocean acidification are not yet fully understood, there is consensus that ocean acidification poses a serious threat to coral reefs.

Increasing water temperatures and ocean acidity are putting this unique ecosystem at risk. Even with effective mitigation, it is expected that, by 2100, mass coral bleaching will be twice as common as it is today. Without mitigation, by 2100, the Great Barrier Reef will be destroyed.

Damage to or destruction of the Great Barrier Reef will have serious implications for the Queensland economy. Tourism is an important part of Queensland's economy and a substantial proportion of tourism in Queensland is related to the existence of the Great Barrier Reef. It is estimated that the reef interested tourism economy contributes more than $2 billion each year to Queensland's Gross State Product. Tourism in the Tropical North region is particularly dependant on the reef with over 90% of interstate and international visitor nights associated with interest in the reef.

Source: Hoegh-Guldberg, O, and Hoegh-Guldberg, H, 2008, *Garnaut Climate Change Review: The impact of climate change and ocean acidification on the Great Barrier Reef and its tourist industry.*

Eco-tourism

Australia's natural landscapes underpin much of Australia's international and domestic tourism.

Each year, millions of domestic and international visitors in Australia participate in nature activities such as:

- visiting national parks, wildlife parks, zoos, aquariums, botanical gardens and public gardens;
- bushwalking;
- whale and dolphin watching; and
- snorkelling and scuba diving.[125]

Total expenditure by domestic visitors who participated in nature activities was approximately $12 billion in 2008.[126]

Two-thirds (65%) of the 3.36 million international visitors to Australia in 2008 participated in nature activities. These visitors spent $20.2 billion.[127]

Number of visitors who participated in nature activities, 2004 to 2008

	2004	2006	2008
Domestic overnight			
No. of visitors (million)	12.62	13.15	12.94
Share of total (%)	17	18	18
Domestic day			
No. of visitors (million)	11.01	12.44	12.37
Share of total (%)	8	9	9
International			
No. of visitors (million)	3.02	3.43	3.36
Share of total (%)	63	67	65

Source: Tourism Research Australia, 2009, *Nature Tourism in Australia 2008*.

Some natural attractions would be significantly affected by unmitigated climate change, particularly the Great Barrier Reef. More generally, beaches are in danger of increasing storm damage and inundation. Ski fields will suffer from reductions in snow cover, average season lengths and peak snow depths.[128]

Popular tourist destinations may become less appealing if they face climate change related impacts such as increased incidence of bushfires, increased ultraviolet radiation, increased exposure to disease and increased extreme weather events (e.g. flooding, storm surges, heatwaves, cyclones and droughts). Climate change is also expected to lead to increased costs associated with increased need for repair,

tourist infrastructure as well as development of alternative attractions.[129]

Coastal settlements

"Australia's coastal zone is a significant national environmental asset that is also fundamentally important to our lifestyle and economy."

House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts.[130]

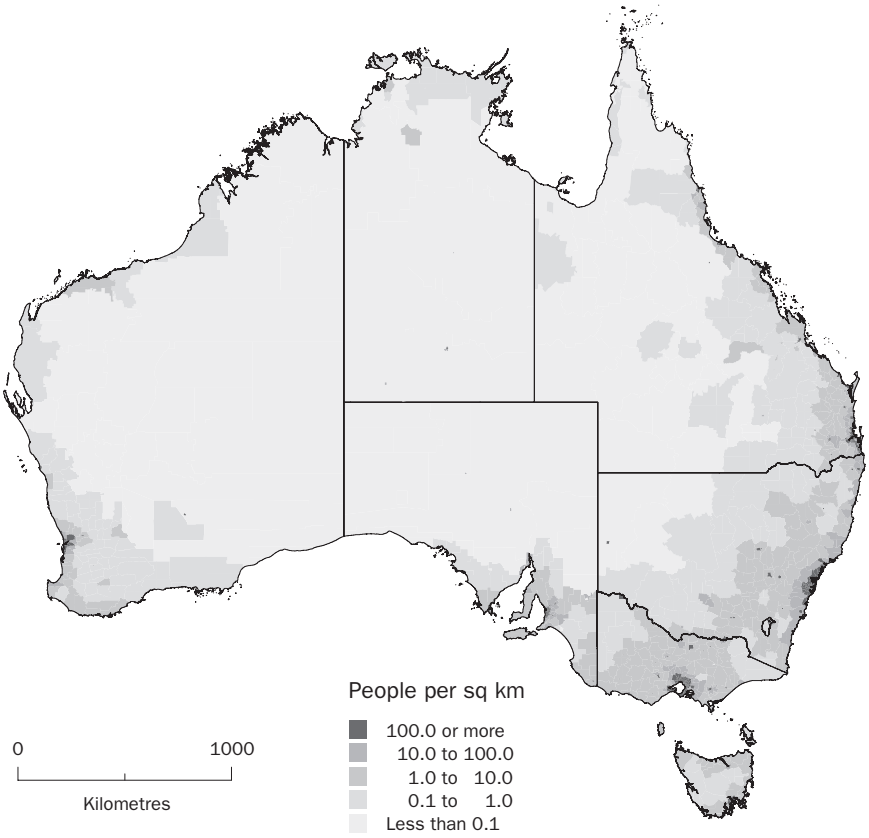
Coastal communities, their infrastructure and resources are vulnerable to a number of climate change impacts.
Sea level rise is likely to result in:

- increased risk of inundation during storm surges;
- increased coastal erosion and recession;
- loss of wetlands and mangroves saltwater intrusion into freshwater sources; and
- loss of wetlands.[131]

Extreme weather events will also impact upon coastal areas. For example tropical cyclones are expected to become more intense in northern Australia.[132]

The majority of Australians (over 80%) live within the coastal zone. About 711,000 addresses are within three kilometres of the coast and less than six metres above sea level,[133] and coastal settlements are continuing to grow. In 2007–08, outside capital cities, the largest population growth generally occurred along the Australian coast. Several local government areas on the Queensland coast had large population increases, such as the Gold Coast (up 13,000 people), Sunshine Coast (9,000), Cairns (6,000) and Townsville (5,000).[134] Other coastal centres experiencing rapid growth included Seaside Tweed in NSW, Mandurah and Busselton in Western Australia and Victor Harbour in South Australia. Areas of population decline occurred mainly in inland rural areas.

Population density, Australia, June 2008



Source: ABS, 2009, *Regional Population Growth Australia 2007–08 (cat. no. 3218.0)*.

Human health

"Climate change is a significant and emerging threat to public health, and changes the way we must look at protecting vulnerable populations"
World Health Organisation.[135]

In Australia, some health impacts attributable to climate change will be direct, such as death and disease associated with heatwaves and natural disasters. Others will occur indirectly, such as increases in mosquito borne diseases due to changes in mosquito population range and activity.[136]

Climate change will also impact upon food, water and air quality, which are the most fundamental determinants of health.[137]

Australians most 'at risk'

Some communities in Australia are more vulnerable to climate change than others. This reflects differences in exposure to risks as well as adaptive capacity. People living in remote areas, people on lower incomes, those with poor housing, the elderly and the sick are among the most vulnerable.[138]

Torres Strait islanders and remote indigenous communities are particularly vulnerable because of their relative isolation and limited access to support facilities.[139]

Climate change is expected to result in substantial increases in extreme hot weather. If no attempt is made to mitigate climate change, by 2100 the number of days over 35°C each year is projected to rise from 9 to 27 in Melbourne, 1 to 21 in Brisbane and most dramatically from 9 to 312 in Darwin.[140]

Extreme hot weather has serious impacts on health, including heat-related deaths from heatwaves. The IPCC projects increased frequency of heatwaves over this century as "very likely", with an associated increased risk of heat related deaths.[141]

Climate change and health

In 2008, the Garnaut Review identified the main health risks climate changes poses in Australia. The risks are many and varied and include:

- impacts of severe weather events (floods, storms, cyclones);
- impacts of temperature extremes, including heatwaves;
- mosquito-borne infectious diseases (e.g. dengue and Ross River virus);
- food-borne infectious diseases (e.g. those due to Salmonella and Campylobacter);
- water-borne infectious diseases and health risks from poor water quality;
- diminished food production and higher prices, with nutritional consequences;
- increases in air pollution (e.g. from bushfires);
- changes in production of aeroallergens (spores, pollens), with the potential to exacerbate asthma and other diseases; and
- mental health consequences and the emotional cost of social, economic and demographic dislocation (e.g. in parts of rural Australia, and through disruptions to traditional ways of living in remote Indigenous communities).

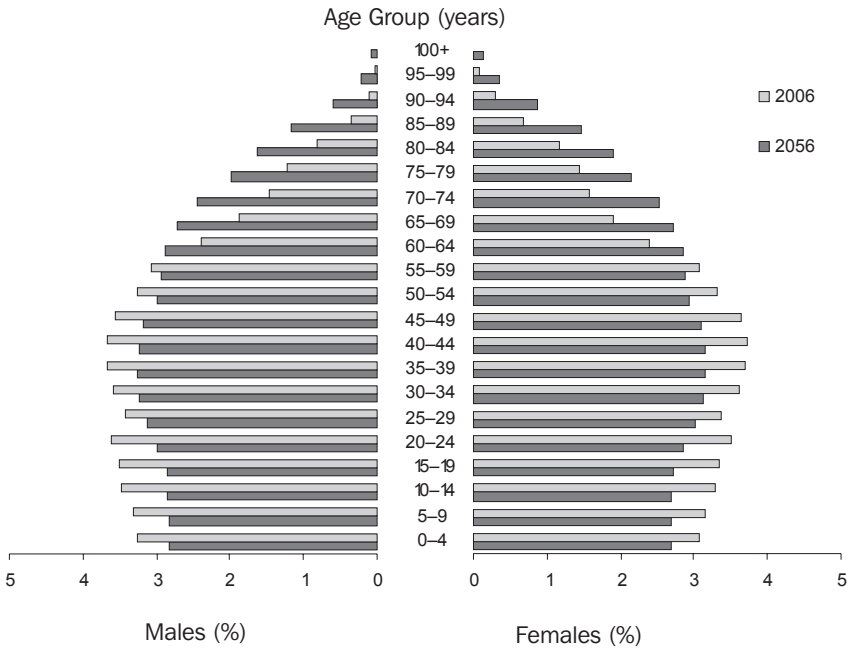
Source: Garnaut, 2008, *The Garnaut Climate Change Review;* Bambrick et al., 2008, *The impacts of climate change on three health outcomes: temperature-related motality and hospitilaisations, samonellosis and other bacterial gastroentreritis, and population at risk from dengue.*

The elderly are particularly vulnerable to extreme hot weather. A combination of factors such as chronic illness, disability, prescribed medication and social isolation reduce the capacity of elderly individuals to cope during heat waves.[142]

In this regard, the growing proportion of elderly people in Australia is of concern. Between 30 June 1989 and 30 June 2009, the proportion of Australia's population aged 65 years and over increased from 11% to 13%. During the same period, the proportion of the population aged 85 years and over doubled, from 0.9% to 1.8%.[143]

This trend is expected to continue. Projections by the ABS, based on certain assumptions about future levels of fertility, mortality and net overseas migration, indicate that by 2056 the proportion of Australians aged 65 and over may reach around 23% to 25%, while the proportion aged over 85 years may reach 5% to 7%.[144] This trend is evident in the population pyramid shown.

Population structure, Age and sex – Australia – 2006 and 2056



Source: ABS, 2009, data available on request.

Summary

In 2007–08, almost three out of four Australians were concerned about climate change.[145]

Climate change and strategies to mitigate and adapt to it will affect many facets of Australian society, including the sources of energy used to power homes and industry, town planning, modes of transport and how farmers manage the land.

If not already, over the next few decades many Australians will experience impacts associated with climate change. Reduced rainfall in many areas will affect urban water supplies and agriculture.

Biodiversity, already under pressure, is particularly vulnerable to the impacts of climate change and unique ecosystems such as the Great Barrier Reef are at risk. Coastal erosion, storm surges and increased risk of inundation will affect coastal communities. Human health will also be affected.

Improving our understanding of the complex relationships between climate and natural and human systems will be necessary to better identify and manage the many impacts of climate change on businesses, industry, individuals and communities. To this end, greater scientific knowledge of climate and statistical information on the environment, economy and society will be critical.

Endnotes

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[4] Department of Climate Change, 2009a, Australia's National Greenhouse Accounts, *National Greenhouse Gas Inventory (Accounting for the Kyoto target) May 2009*, p.4

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[10] CSIRO, 2009, *Aerosols – their part in our rainfall*, <http://www.csiro.au/news/Aerosols.html>, viewed November 2009

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[15] IPCC, 2007c, "Summary for Policymakers", in *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, p.14

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[18] Garnaut, op. cit., p.153

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[26] Department of Climate Change, 2009b, Australia's National Greenhouse Accounts, *National Inventory Report 2007 Vol. 2*, p.210; Department of Climate Change, 2008, *The Australian Government's Initial Report under the Kyoto Protocol*, p.2

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[28] Department of Climate Change, 2009a, op. cit., p.24

[29] ibid., pp.5, 24

[30] Department of Climate Change, 2009c, op. cit., p.26

[31] ibid., p.27

[32] Department of Climate Change, 2009a, op. cit., p.16

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[35] Department of Climate Change, 2009c, op. cit., p.2; Department of Climate Change, 2009a, op. cit., p.24

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[39] Department of Climate Change, 2009b, op. cit., p.190

[40] Garnaut, loc. cit., p.153

[41] ibid., p.42

[42] ibid., p.xiii

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Trends

Population and urban

Australia's estimated resident population was 21.9 million at June 2009 (based on 2006 Census data). As the population continues to increase, both in numbers and in affluence, there is more pressure on the environment.

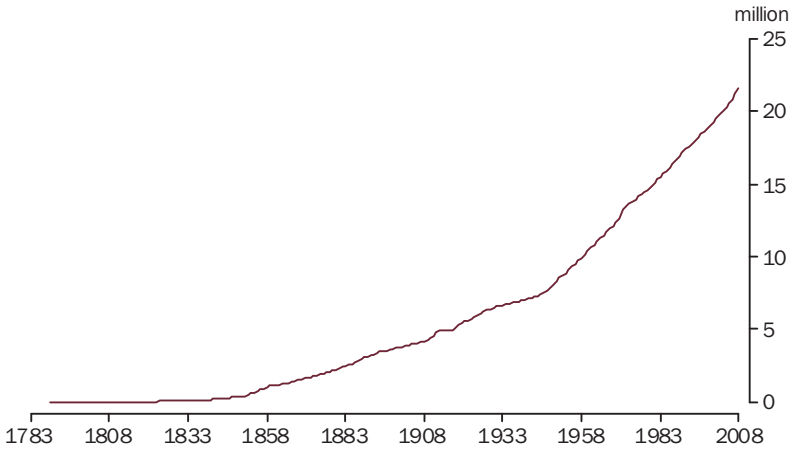
This section looks at a number of trends which are drivers of environmental change, including population growth, population structure and distribution, gross domestic product (GDP) and changes in people's expenditure.

- **Population** growth occurs as a result of natural increase (defined as the number of births less the number of deaths) and migration patterns. Trends in natural increase and migration patterns have resulted in uneven population growth and distribution across Australian states and territories. Despite the large land area of Australia, the majority of the population is located in two widely-separated coastal regions. Where people live has environmental implications for air quality, and land and water degradation. Other consequences of population growth, such as increased waste generation and energy use, can also have negative environmental impacts.

- **Economic growth** (as measured by GDP) is a key determinant of employment and, therefore, of the economic wellbeing of households. However, economic activity often has associated environmental costs. For example, economic activity, especially among the more energy-intensive industries, is associated with the creation of greenhouse gas emissions. Another example of environmental costs associated with economic activity is in the agriculture industry, where the use of irrigation can reduce water flows and quality in rivers, thereby affecting riverine flora and fauna and human health. On the other hand, higher incomes can provide resources to address environmental issues. There is a debate about how to balance economic progress, often measured by gross domestic product (GDP), against the need to maintain resources for future generations – getting this balance right is often referred to as environmental sustainability. Depletion-adjusted GDP is a way of incorporating the damage to environmental assets that is associated with economic activity.

Population

Population growth

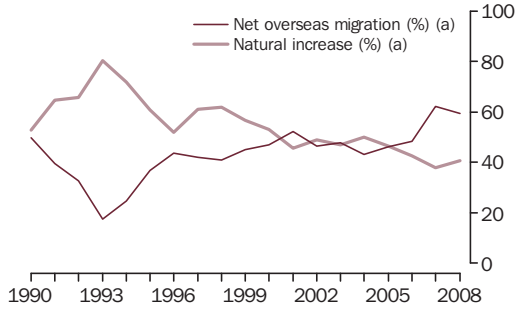


Note: Population estimates are at 31 December each year. Estimates for 2007 and 2008 are preliminary. 1788 to 2005 estimates are from ABS cat. no. 3105.0.65.001 and 2006 to 2008 estimates are from ABS cat. no. 3101.0 (see sources below).
Source: ABS, 2008, *Australian Historical Population Statistics 2008 (cat. no. 3105.0.65.001);* ABS, 2009, *Australian Demographic Statistics June 2009 (cat. no. 3101.0).*

Australia's preliminary estimated resident population was 21.9 million at June 2009. The graph above shows Australia's population growth since European settlement in 1788. Since Federation in 1901, Australia's population has increased by 18.1 million people.

The growth of Australia's population has two components: natural increase (the number of births minus the number of deaths) and net overseas migration.

Components of population change



(a) As a proportion of total population growth.
Note: Year refers to financial year, e.g. 1990 refers to 1989–90 financial year. Estimates for 2007–08 are preliminary. Estimates for net overseas migration contain a break in time series from 2006–07.
Source: ABS, 2009, *Migration 2007–08 (cat. no. 3412.0).*

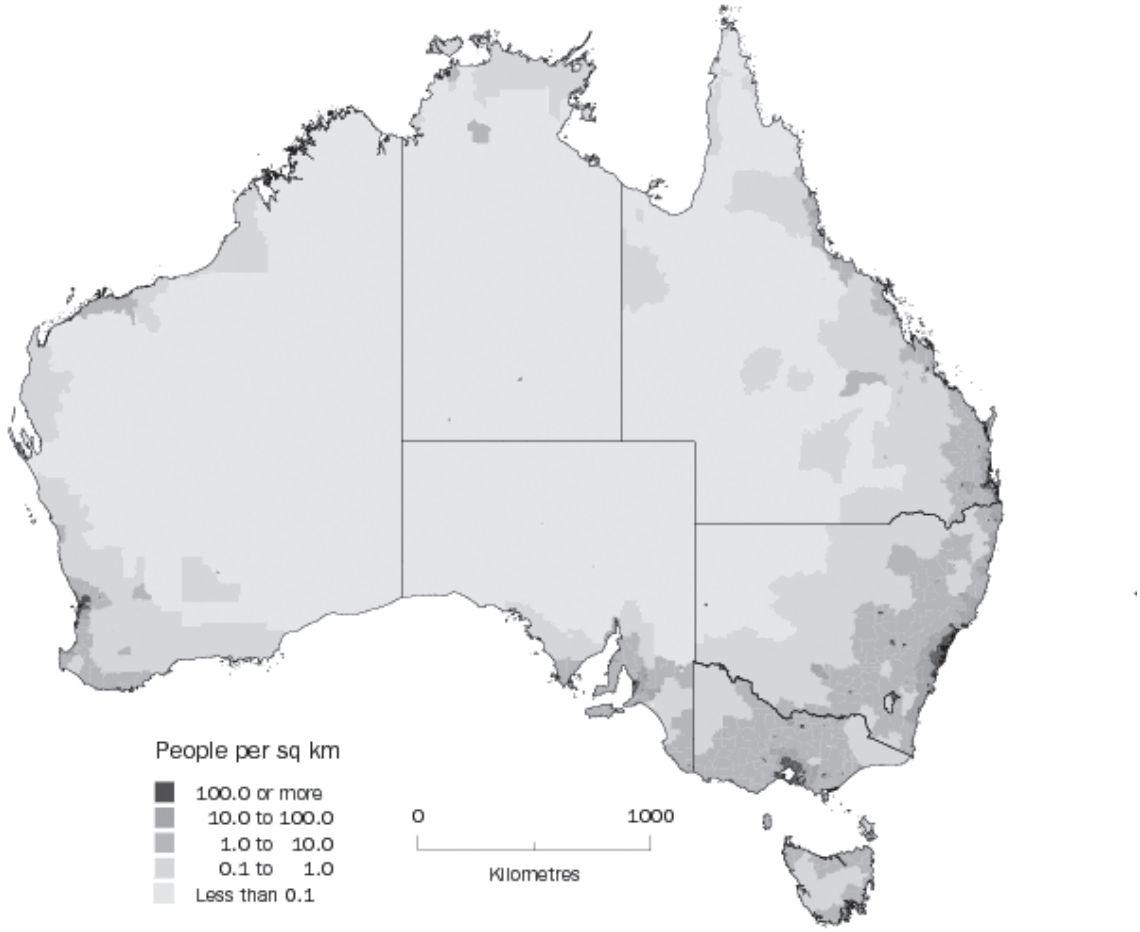
In 2007–08, 59% of Australia's population growth was due to net overseas migration. This percentage decreased slightly from 62% in 2006–07 but increased from 50% in 1989–90. By contrast, the proportion of population growth due to natural increase decreased to 41% in 2007–08.

Low fertility rates have contributed to Australia's relatively low rate of natural increase. Between 1961 and 2001, Australia's total fertility rate (TFR) declined from 3.55 babies per woman to 1.73.[1] Since then the fertility rate has trended upwards to 1.98 babies per woman in 2008–09. This TFR is still below the replacement level of 2.1 babies per woman.

1. ABS, 2007, *Australian Social Trends 2007 (cat. no. 4102.0).*

Population

Population density by Statistical Local Area



Source: ABS, 2009, *Regional Population Growth, Australia 2007–08 (cat. no. 3218.0)*.

Population density varies greatly across Australia. Australia's total population density at June 2008 was 2.8 people per square kilometre. Among the states and territories, the Australian Capital Territory had the highest population density at 147 people per square kilometre and the Northern Territory had the lowest population density at just 0.2 people per square kilometre.

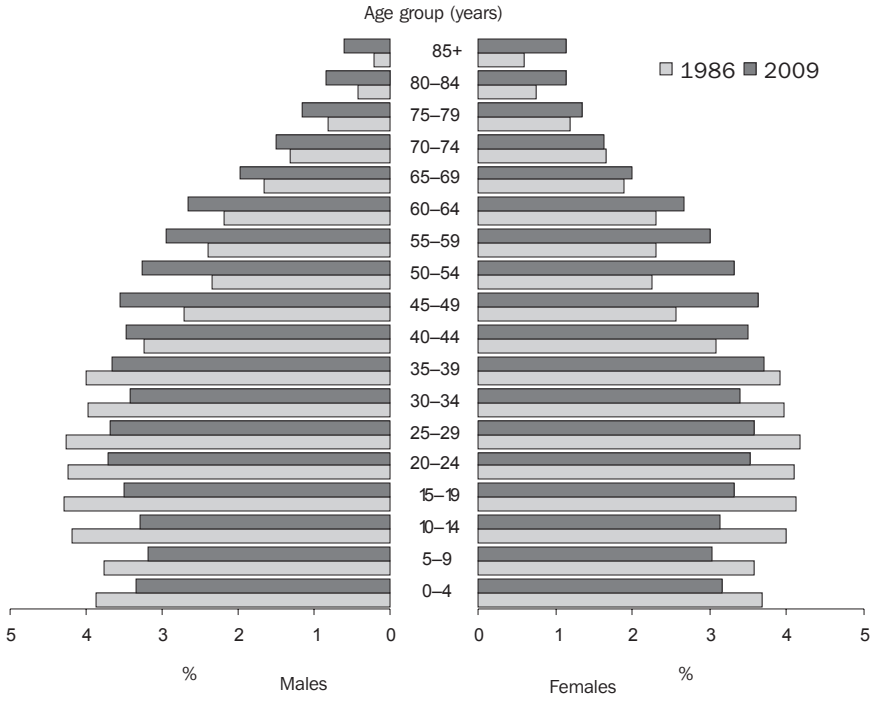
At 30 June 2008, population density was highest in the capital cities of Australia's states and territories. With the exception of Canberra, all these capital cities are located on the coast.

Population density in other coastal and surrounding areas was also relatively high, particularly in the southeast corner of the country. On the other hand, most of central and western Australia had a population density of less than one person/km^2.

Five of the top ten most densely-populated statistical local areas (SLAs) were located in Sydney, which is currently the most populous city in Australia. At 30 June 2008, the Sydney statistical division had a population of 4.4 million people.

Population

Population age and sex structure



Source: ABS, 2009, *Australian Demographic Statistics June 2009 (cat. no. 3101.0);* ABS, 2006, *Population by Age and Sex, Australian States and Territories, June 2006 (cat. no. 3201.0).*

The age structure of Australia's population has changed significantly over the past 23 years.

The graph above shows the proportions of the population by age and sex at 30 June 1986 and 30 June 2009, illustrating the ageing of Australia's population. There were proportionally fewer people aged between 0 and 39 in 2009 than in 1986, and a proportionally greater number of people aged 40 and over in 2009.

Between 30 June 1986 and 30 June 2009, the proportion of the population aged 0–14 years decreased from 23% to 19%. During the same period, the proportion of the population aged 15–64 years increased from 66% to 68%, and the proportion aged 65 or over increased from 11% to 13%.

Population

Selected population indicators, 2008

State/ Territory	Population (no.) (a)	Population growth 2007–2008 (b) (%)	Population in capital city (no.)	Proportion of population in capital city (%)	Total capital city population density (persons/km^2)	Highest SLA population density (no./km^2) (d)
NSW	6,984,172	1.1	4,399,722	63.0	362.5	8,395.4
Vic.	5,313,823	1.8	3,892,419	73.3	505.9	7,284.9
Qld	4,293,915	2.3	1,945,639	45.3	327.0	5,736.9
WA	2,171,197	2.8	1,602,559	73.8	297.5	2,594.7
SA	1,603,361	1.1	1,172,105	73.1	641.6	2,867.1
Tas.	497,529	0.9	209,287	42.1	154.2	840.7
ACT	345,551	1.3	345,257	99.9	427.4	3,055.9
NT	219,818	2.3	120,652	54.9	38.6	2,651.4
Australia (c)	**21,431,781**	**1.7**	**13,687,640**	**63.9**	**357.5**	**8,395.4**

(a) 30 June 2008 population estimates are preliminary.
(b) Population growth between June 2007 and June 2008.
(c) Includes other territories.
(d) SLA = Statistical local area.
Source: ABS, 2009, *Regional Population Growth, Australia 2007–08 (cat. no. 3218.0)*.

The major cities of Australia were home to 14.7 million people or more than two-thirds (69%) of Australia's population at 30 June 2008. Of those, 13.7 million lived in the capital city of their state or territory. In contrast, just 491,560 people, or 2% of the total population, lived in remote or very remote areas of Australia. The remaining 29% lived in regional areas (see ABS, 2009, *Australian Standard Geographical Classification July 2009 (cat. no. 1216.0)* for an explanation of the remoteness structure classification).

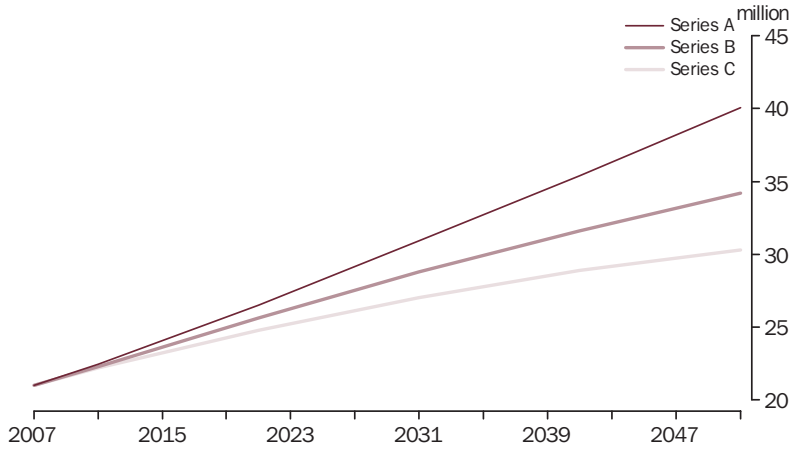
Queensland recorded the largest population increase of the states and territories between 2007 and 2008, growing by 98,000 people. Western Australia had the highest percentage growth for the year, at 2.8%. Of the 25 local government areas (LGAs) with the greatest population increases between 30 June 2007 and 30 June 2008, eight were in Queensland, seven in Victoria, six in Western Australia and four in New South Wales. The LGA with the highest growth in Australia was Brisbane, with 17,000 new residents, followed by the Gold Coast, with an increase of 13,000 people.

While Sydney was the most populous city in Australia in 2008, its large size (12,137.5 km^2) meant it was not the city with the highest overall population density. Adelaide (1,826.9 km^2) had a higher total density than Sydney, with 641.6 people per km^2 compared to 362.5 people/km^2. However, Sydney was home to the area with the highest population density in the country in 2008. The Sydney East statistical local area had a density of 8,395.4 persons/km^2.

The high concentration of people in coastal areas of south-eastern Australia has resulted in high rates of land clearing for urban development. This has caused loss of habitat for native plants and animals, reducing their numbers and geographical spread. Urban developments also need landfill sites and water and sewerage services, all of which can affect the environment.

Population

Population projections, Australia

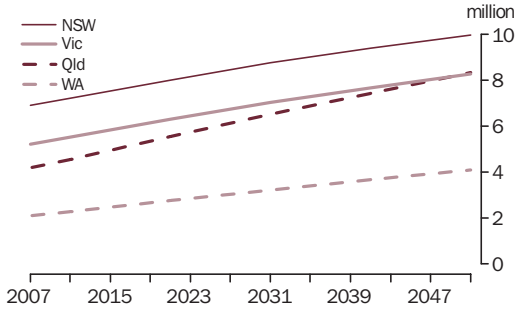


Source: ABS, 2009, *Population Projections, Australia, 2006 to 2101 (cat. no. 3222.0).*

Australia's population increased by approximately 17 million people in the 100 years between 1907 and 2007.[1] Projections based on the estimated resident population at 30 June 2007 indicate that Australia's population will increase by anywhere between 9 and 19 million between 2007 and 2051, to reach between 30 and 40 million by June 2051.

The ABS' three categories of population projections are referred to as Series A, B and C. In Series B, which assumes medium levels of fertility, mortality and overseas migration, 92% of Australia's population growth between 2007 and 2051 is projected to come from Australia's four most populous states (New South Wales, Victoria, Queensland and Western Australia).

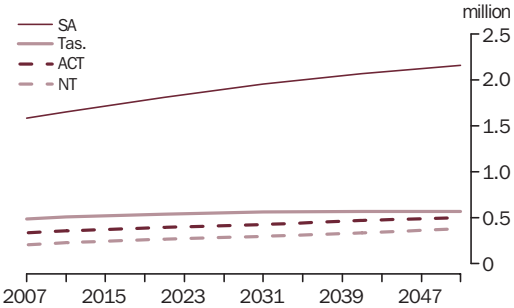
Population projections, largest states



Source: ABS, 2009, *Population Projections, Australia, 2006 to 2101 (cat. no. 3222.0).*

Queensland's population is projected to grow the most between 2007 and 2051. Series B figures project a near doubling of the state's population (from 4.2 to 8.3 million) over the 44-year period. New South Wales is projected to remain Australia's most highly populated state, with a Series B projected growth of three million people (to bring the state's population to 9.9 million in 2051).

Population projections, territories and smaller states



Source: ABS, 2009, *Population Projections, Australia, 2006 to 2101 (cat. no. 3222.0).*

Of the territories and less populated states, South Australia is projected to grow by the greatest number (580,000 persons) between 2007 and 2051 (Series B). The Series B growth projection for the Northern Territory is 170,000 persons, a 77% increase on its 2007 population.

1. ABS, 2008, *Australian Historical Population Statistics (cat. no. 3105.0.65.001).*

Population

Household and dwelling characteristics, 2007–08

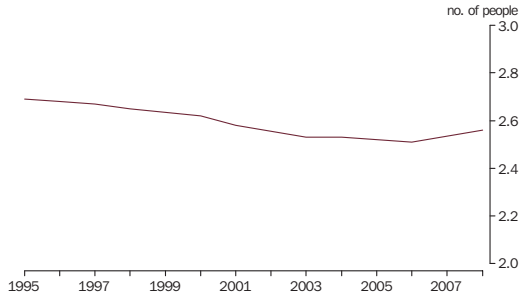
	One bedroom	Two bedrooms	Three bedrooms	Four or more bedrooms	Total households (a)	
	'000	'000	'000	'000	'000	% of total
One person	267.3	721.0	803.1	197.0	2,004.1	24.8
Two persons	58.3	619.7	1,432.7	625.2	2,735.9	33.9
Three persons	n.p.	174.0	681.1	456.7	1,314.9	16.3
Four persons	n.p.	76.3	592.3	587.9	1,258.3	15.6
Five or more persons	n.p.	18.2 (b)	230.4	514.2	764.1	9.5
Total households	**331.3**	**1,609.2**	**3,739.6**	**2,381.0**	**8,077.3**	**100**

(a) Includes bedsitters and dwellings with zero bedrooms.
(b) Estimate has a relative standard error of 25% to 50% and should be used with caution.
Note: n.p. = not published, due to estimates having a relative standard error of over 50%.
Source: ABS, data available on request (Survey of Income and Housing, 2007–08).

Environmental impacts result from the construction and renovation of dwellings, and the use of energy to heat and/or cool them. In general, a larger dwelling will consume more energy than a smaller one.

The physical size of Australian houses or apartments (dwellings) is increasing (as indicated by the number of bedrooms). Between 1975–76 and 2007–08, the average dwelling size increased from 2.8 to 3.1 bedrooms per dwelling. In 2007–08, 29% of Australia's total dwellings had four or more bedrooms. This percentage has increased substantially from 17% in 1976.[1]

Average household size



Note: Year refers to financial year, e.g. 1995 refers to 1994–95 financial year. Survey not run in 1998–99, 2001–02, 2004–05 or 2006–07. Values have been interpolated for these years.
Source: ABS, 2009, *Housing Occupancy and Costs 2007–08 (cat. no. 4130.0)*.

Despite the fact that sizes of physical dwellings have increased, household sizes (i.e. the number of people living in a dwelling) have decreased over the past 13 years. Average household size fell from 2.69 people in 1994–1995 to 2.56 in 2007–08.

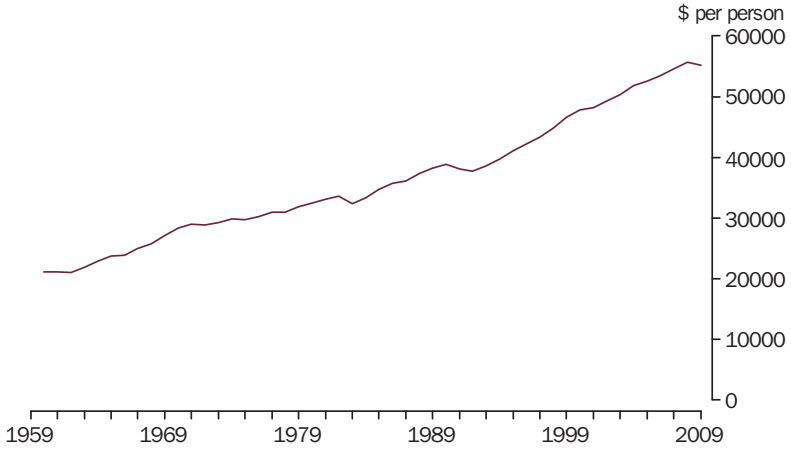
Much of this decline can be attributed to reductions in family size and the increase in numbers of one and two-person households (which together made up 59% of households in 2007–08). Between 1986 and 2006, the proportion of the population living alone grew from 9% to 12%. This increase has been attributed to delayed partnering, divorce and separation, a decrease in fertility rates and a decline in extended families.[2]

More than four in five (86%) people who lived alone in 2007–08 lived in dwellings with two or more bedrooms. Three quarters (75%) of dwellings housing two people had three or more bedrooms.

1. ABS, 2008, *2008 Year Book Australia (cat. no. 1301.0)*.
2. ABS, 2009, *Australian Social Trends December 2009 (cat. no. 4201.0)*.

Economic growth

Gross domestic product per capita



Note: Chain volume measure; reference year 2007–08. Year refers to financial year, e.g. 1960 refers to 1959–60 financial year.
Source: ABS, 2009, *Australian System of National Accounts 2008–09 (cat. no. 5204.0)*.

The performance of the economy is represented in the national accounts by measures such as gross domestic product (GDP). GDP is a measure of the overall value of economic production in Australia in a given period. Growth in the economy is a key determinant of employment and, therefore, economic wellbeing of households. The chain volume measure of GDP is an indicator of real growth in Australian production. Between 1959–60 and 2008–09, Australia's chain volume GDP increased by a factor of 4.6 (or $979,962 million, based on 2007–08 monetary value). In 2008–09, Australia's total chain volume GDP was $1,194,496 million.

GDP per capita (person) is another measure of the performance of the economy, which takes population growth into account. Between 1959–60 and 2008–09, Australia's GDP per capita grew by 161% in chain volume terms. Based on the value of money in 2007–08, Australia's chain volume GDP per capita in 2008–09 was $55,195.

Economic activity is often associated with depletion and/or degradation of natural resources. For example, the degradation of water quality, due to land clearing for agricultural production or urban development, can adversely affect native plants and animals in freshwater ecosystems.

Similarly, air quality can be adversely affected by economic activity, particularly by the more energy-intensive manufacturing industries and transport, which rely on fossil fuels. The air pollution created can damage human health and the environment.

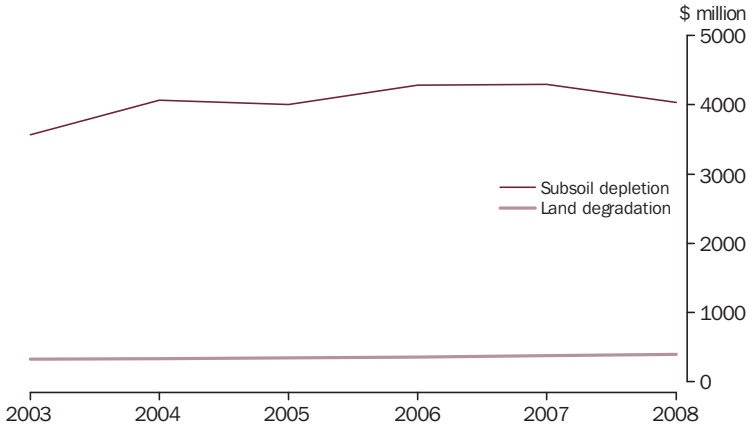
Decoupling indicators have emerged as a way to measure whether economic growth is occurring without corresponding pressures on the environment. Decoupling has been described as breaking the link between economic growth and environmental degradation. An example of decoupling is when a developed nation experiences economic growth without an equivalent increase in its greenhouse gas emissions. Decoupling indicators are one way to make an assessment of whether levels of growth are sustainable in the longer term. Appendix A contains more information about decoupling indicators.

Economic growth

Depletion-adjusted gross domestic product (a)

	2002–03	2003–04	2004–05	2005–06	2006-07	2007-08
	$ million	$ million	$ million	$ million	$ million	$ million
GDP	804,361	864,955	925,864	1,000,787	1,091,327	1,181,750
Depletion-adjusted GDP (b)	800,474	860,556	921,510	996,144	1,086,647	1,177,321
Subsoil depletion	3,567	4,068	4,008	4,281	4,302	4,034
plus Land degradation	320	331	346	362	378	395
equals Net depletion	3,887	4,399	4,354	4,643	4,680	4,429

(a) Estimates based on current prices.
(b) Estimates are experimental, therefore use with caution.



Note: Estimates are experimental, therefore use with caution. Year refers to financial year, e.g. 2003 refers to 2002–03 financial year.
Source: ABS, 2009, data available on request (Australian System of National Accounts).

While gross domestic product (GDP) reflects the value added arising from the use of environmental assets, it does not reflect the associated depletion and degradion of those assets.

Degradation of environmental assets occurs when the value of the stock is reduced through a decline in quality. For example, land degradation can result from land clearance and deforestation, agricultural depletion of soil nutrients, poor irrigation practices and pollution.

Depletion of environmental assets occurs when the value of the stock is reduced through use in a productive activity. For example, the extraction and use of subsoil assets through mining activity depletes the total stock of these assets available for future use.

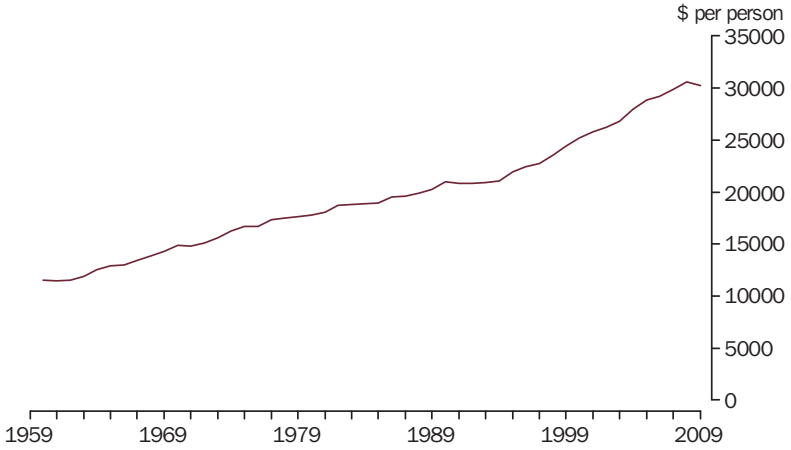
A depletion-adjusted GDP attempts to incorporate the environmental damage and depletion associated with economic activity. This is achieved by deducting depletion and degradation from the conventional GDP measure.

It must be noted that the table above only includes estimates for subsoil depletion and land degradation. There are many other forms of depletion and degradation that occur as a result of economic activity, however limitations on data and valuation methods prevent a more comprehensive account at this stage.

The estimates shown are experimental and should therefore be regarded as indicative only.

Economic growth

Household final consumption expenditure (HFCE) per capita



Note: Chain volume measure; reference year 2007–08. Year refers to financial year,
Source: ABS, 2009, *Australian System of National Accounts 2008–09 (cat. no. 5204.0);* ABS, 2008, *Australian Historical Population Statistics 2008 (cat. no. 3105.0.65.001);* ABS, 2009, *Australian Demographic Statistics June 2009 (cat. no. 3101.0).*

	1985–86		2008–09	
	$ millions	% of total HFCE	$ millions	% of total HCFE
Rent and other dwelling services	56,978	17.0	115,786	17.5
Recreation and culture	26,062	7.8	74,753	11.3
Transport	42,014	12.5	74,388	11.3
Food	47,069	14.0	70,898	10.7
Finance and insurance services	34,872	10.4	68,772	10.4
Hotels, cafes and restaurants	25,127	7.5	44,829	6.8
Furnishings and household equipment	13,024	3.9	34,248	5.2
Health	15,728	4.7	35,450	5.4
Alcoholic beverages and tobacco	22,911	6.8	23,462	3.6
Clothing and footwear	13,689	4.1	22,830	3.5
Education services	10,149	3.0	22,079	3.3
Communication	3,030	0.9	18,685	2.8
Electricity, gas and other fuel	6,680	2.0	13,427	2.0
Personal care	4,746	1.4	11,297	1.7
Miscellaneous goods and services	14,006	4.2	29,333	4.4

Note: Chain volume measure; reference year 2007–08.
Source: ABS, 2009, *Australian System of National Accounts 2008–09 (cat. no. 5204.0).*

Per capita household consumption expenditure, expressed in chain volume (real) terms, rose 54% between 1985–86 and 2008–09, equivalent to 1.9% compound growth per year.

In both 1985–86 and 2008–09, rent and other dwelling services consumed the highest percentage of total household expenditure, about 17%. The proportion of total expenditure spent on food decreased substantially (14.0 to 10.7%) between 1985–86 and 2008–09 and the proportion spent on recreation and culture increased by a large percentage (from 7.8% to 11.3%) during that period. The share of expenditure on transport decreased slightly (12.5% to 11.3%).

Generally, an increase in the quantity or quality of goods and services consumed by people is regarded as progress. However, increased consumption of certain goods and services can indicate movement away from social and environmental goals such as improved health and cleaner air. For example, the increase in mobile phone usage and turnover since the mid-1990s may cause an issue for waste disposal.

Human activities

This section focuses on major trends in energy and waste and their environmental impacts.

- **Energy** is a vital input into all sectors of a modern economy. As well as powering industry and households, the production and supply of energy generates employment, investment and significant export earnings, all of which contribute substantially to the material standard of living of Australians.

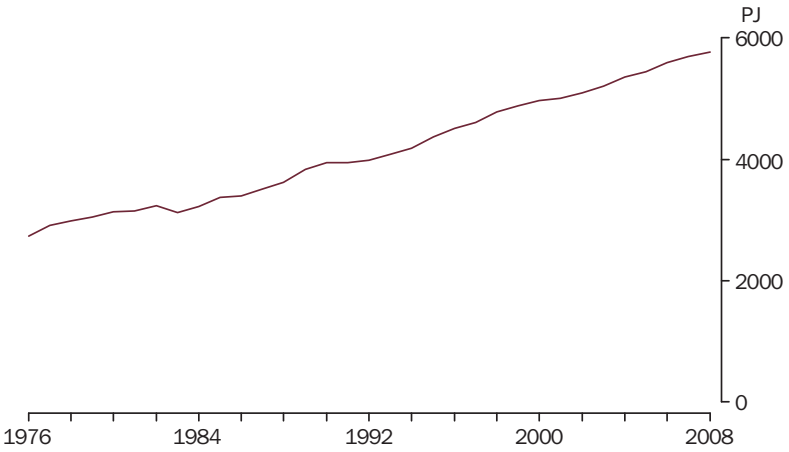
  Energy sources are divided into two groups – renewable (energy sources for which the supply is essentially inexhaustible) and non-renewable (energy sources with a finite supply). Renewable energy includes well-established sources such as hydro-electricity, biomass and solar hot water and "newer" forms such as wind, solar (photovoltaic and thermal), geothermal, wave and tidal. Most of Australia's energy comes from non-renewable fossil fuels, which include oil, natural gas and coal. Australia exports significant amounts of uranium oxide for nuclear power, but there are no plans for nuclear power generation in Australia. Although energy use by industry constitutes the bulk of total energy use, the amount and type of energy used by households (notably electricity and petroleum products) also has important implications for the environment, especially greenhouse gas emissions, air pollution and depletion of natural resources.

  In order to aggregate and compare energy statistics from different energy sources, statistics presented in this publication are in energy units (petajoules) rather than physical units (tonnes or megalitres). A petajoule (PJ) is a very large unit of energy, commonly used to express energy production or consumption at the industry or country level.

- **Waste** is a by-product of many human activities. Sustained growth in Australia's population and in real per capita income has created a large increase in the volume and diversity of redundant goods and materials. The environmental and health threats from waste depend not just on the volumes involved but also on the type of waste and the way it is managed. A combination of environmental and cost pressures associated with the appropriate disposal of various wastes has stimulated greater action, especially from local and state governments, to limit the growth in waste disposal and increase recycling rates.

Energy

Total energy use



Note: Year refers to financial year, e.g. 1976 refers to 1975–76 financial year.
Source: Australian Bureau of Agricultural and Resource Economics (ABARE), 2009, *Energy statistics – historical, Table C, <http://www.abare.gov.au/publications_html/data/data/data.html>, viewed Nov. 2009.*

In 2007–08, Australia's total domestic energy use was 5,772 petajoules (PJ). Over the 32 years from 1975–76 to 2007–08, total energy use in Australia rose by 111%, up from 2,731 PJ in 1975–76. This represented a compound annual growth of nearly 2.4%.

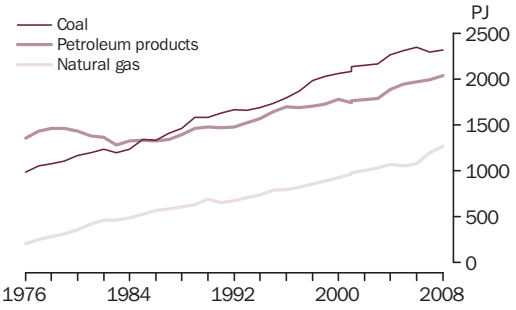
Growth rates were highest in the period from 1983–84 to 1989–90 (averaging 3.3%). From 1990–91, growth rates have averaged 2.1% annually.

Over the last 30 years, energy use by industry has tended to grow more slowly than growth in GDP, reflecting declining energy intensity (energy used to produce a unit of economic output).

The decline in energy intensity of the Australian economy has been attributed to two main factors. One is an increase in energy efficiency due to technological advances. The other is the more rapid growth of less energy intensive sectors, such as the services sector, relative to lower growth rates in more energy intensive sectors such as manufacturing and mining.

Of the 5,772 PJ of energy used nationally, the state or territory with the highest energy use was New South Wales (27%), followed by Victoria (24%), Queensland (23%) and Western Australia (16%). Those with the lowest use were South Australia (6%), Tasmania (2%) and the Northern Territory (2%).[1]

Energy use by selected fuel



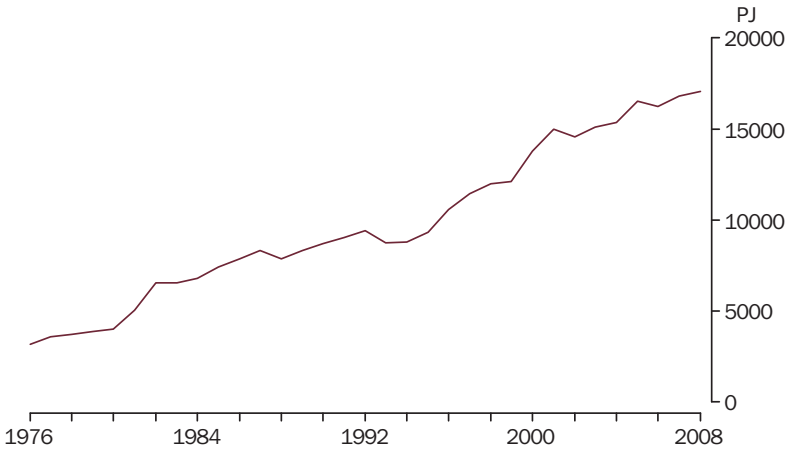
Note: Year refers to financial year, e.g. 1976 refers to 1975–76 financial year.
Source: ABARE, 2009, *Energy statistics – historical, Table C, <http://www.abare.gov.au/publications_html/data/data/data.html>, last viewed November 2009.*

The mix of fuels used to provide energy has changed little since 2000–01. In 2007–08, black and brown coal accounted for 40% of primary energy consumption (down from 42% in 2000–01). The shares of petroleum products (e.g. automotive gasoline, diesel, aviation turbine fuel, and fuel oil) and natural gas both rose slightly, to 35% and 22%, respectively.

1. ABARE, 2009, *Energy statistics – historical, Table B, <http://www.abare.gov.au/publications_html/data/data/data.html>, last viewed November 2009.*

Energy

Production of non-renewable fuels

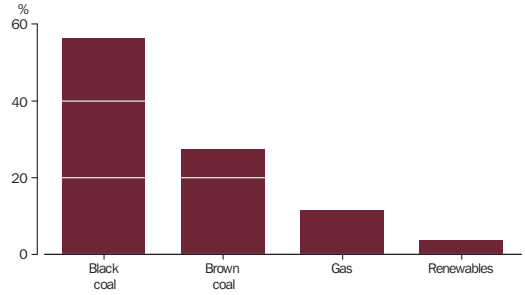


Note: Year refers to financial year, e.g. 1976 refers to 1975–76 financial year.
Source: ABARE, 2009, *Energy statistics – historical, Table J, <http://www.abare.gov.au/publications_html/data/data/data.html>, viewed Nov. 2009.*

In 2007–08, Australia's total primary energy production was estimated at 17,360 petajoules (PJ), nearly all of which was from non-renewables. Black and brown coal accounted for 54% of energy production, followed by uranium (27%), natural gas (11%) and crude oil (6%).[1]

From 1975–76 to 2007–08, the production of non-renewable fuels grew from 3,158 PJ to 17,070 PJ, an increase of 441%. This increase was driven more by overseas demand than domestic consumption.

Fuels used in electricity generation, 2006–07



Note: Oil excluded because figures too small to show (1%).
Source: ABARE, 2009, *Energy in Australia 2009.*

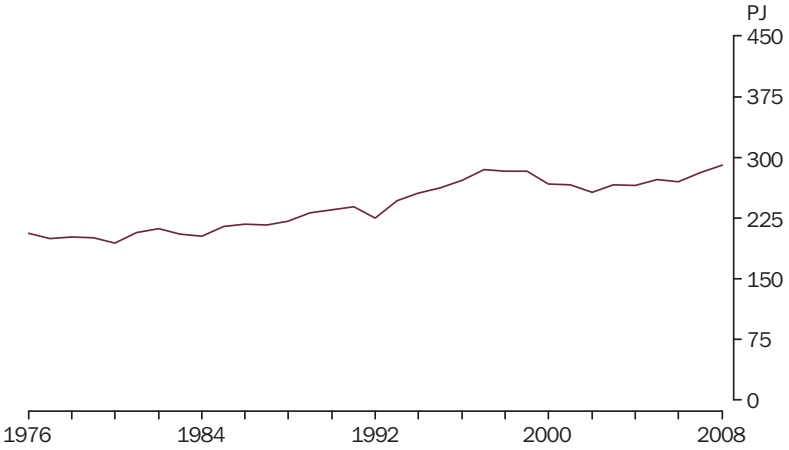
Over 96% of fuels used to generate electricity in Australia's are non-renewables. Black and brown coal alone account for 84%. Consequently, the electricity sector is a major emitter of greenhouse gases, accounting for one-third of Australia's net greenhouse gas emissions in 2007.[2]

There is a wide variation in the estimated greenhouse gas emissions intensities of electricity generation technologies currently used in many countries. The emissions intensity of fossil fuels (such as coal and gas) is much higher than for renewable fuels (especially wind and hydro) or nuclear power.

1. ABARE, 2009, *Energy Update 2009.*
2. Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009.*

Energy

Production of renewable fuels



Note: Year refers to financial year, e.g. 1976 refers to 1975–76 financial year.
Source: Australian Bureau of Agricultural and Resource Economics (ABARE), 2009, *Energy statistics – historical, Table J, <http://www.abare.gov.au/publications_html/data/data/data.html>, viewed Nov. 2009.*

Growth in Australia's production of renewable energy (hydro-electricity, biomass, biofuels, wind and solar) increased by 41% from 1975–76 to 2007–08 (from 206 PJ to 290 PJ).

Production of renewable energy (a)

	2001–02 (PJ)	2007–08 (PJ)	Increase %
Bagasse	91.7	111.9	22
Other biofuels (b)	10.1	17.6	74
Hydro-electricity	57.5	43.4	-25
Solar hot water	2.7	6.5	141
Wind and solar photovoltaic	0.6	14.6	2,333
Wood and wood waste	95.0	96.0	1
Total	257.6	290.0	13

(a) Electricity and heat.
(b) Includes biogas, black liquor, crop and municipal waste.
Source: ABARE, 2009, *Energy statistics – historical, Table A, <http://www.abare.gov.au/publications_html/data/data/data.html >, last viewed November 2009;* ABARE, 2009, *Energy in Australia 2009.*

Renewable energy production is heavily dominated by bagasse, wood and hydro-electricity. Bagasse is a sugar cane residue used to power sugar mills and to generate electricity. Bagasse, wood and hydro-electricity accounted for 39%, 33% and 15%, respectively, of renewable energy production in 2007–08. Hydro-electricity generation was restricted due to continued drought conditions in many areas.[1]

Although hydro-electricity generation fell, overall renewable energy production increased by 13% between 2001–02 and 2007–08, due largely to strong growth of bagasse and wind energy.

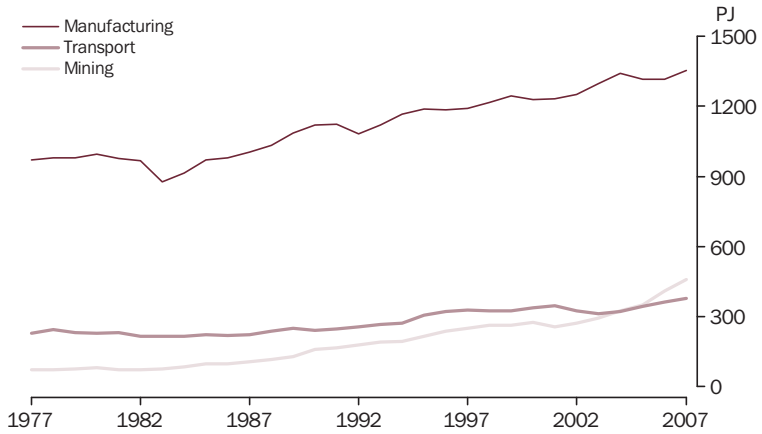
Large-scale wind power projects have been completed in recent years, with more planned or under construction. The recently completed 192 megawatt Waubra Wind Farm in Victoria is the largest capacity renewable energy project completed so far and is the largest wind farm in the southern hemisphere. As at April 2009, nearly 13% of committed electricity generation projects were wind power.[2]

Electricity generation from solar photovoltaic (PV) cells is growing very quickly, but from a very low base. Government subsidies for installation and the payment of feed-in tariffs for electricity produced from PV units have been instrumental in encouraging the take-up of this technology. However, small scale applications in residential and commercial buildings still dominate this sector.

1. ABARE, 2009, *Energy Update 2009.*
2. ABARE, 2009, *Electricity Generation – major development projects – April 2009 listing.*

Energy

Energy consumption by selected industry

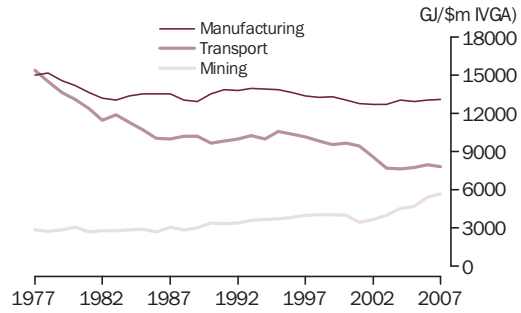


Note: Year refers to financial year, e.g. 1977 refers to 1976–77 financial year.
Source: ABS, data available on request (Energy Account Australia).

The proportion of total energy consumption by industry changes slowly over time. In 2006–07, manufacturing accounted for 36%, followed by electricity, gas and water (31%), transport (6%) and mining (5%). Households accounted for 12% of energy consumption. While energy consumption has grown with population and economic growth, the rate of growth in energy consumption has generally been slower than growth in economic output.

Energy intensity is a measure of energy used per unit of economic output. Here it is expressed as gigajoules per million dollars of Industry Gross Value Added (GJ/$m IGVA). From 1976–77 to 2006–07 energy intensity fell for all major industries, except mining and agriculture. Energy intensity in mining and agriculture increased by 99% and 41%, respectively. By contrast, energy intensity in the transport and construction industries decreased by 49% and 74%, respectively.

Energy intensity by selected industry

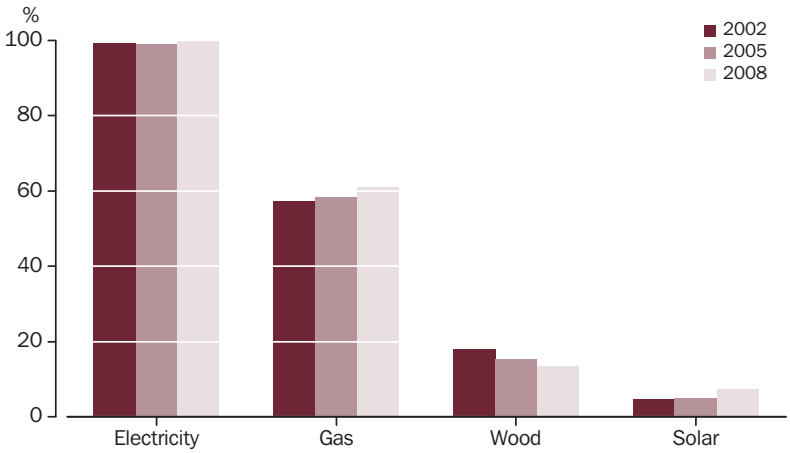


Note: Year refers to financial year, e.g. 1977 refers to 1976–77 financial year.
Source: ABS, data available on request (Energy Account Australia).

Care should be exercised in interpreting changes in energy intensity. For example, mining is increasingly dominated by the low value per tonne commodities iron ore and coal. Open cut mining is the preferred method of extraction because total costs are generally lower than for underground mining, even though open cut mining is more energy intensive. In contrast, fuel costs have always constituted a large portion of total costs in the Transport industry, and significant falls in energy intensity have been achieved in response to sustained increases in fuel costs.

Energy

Household energy use by type



Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001)*

The amount and type of energy used by households has considerable implications for the environment, including depletion of natural resources, greenhouse gas generation and air pollution.

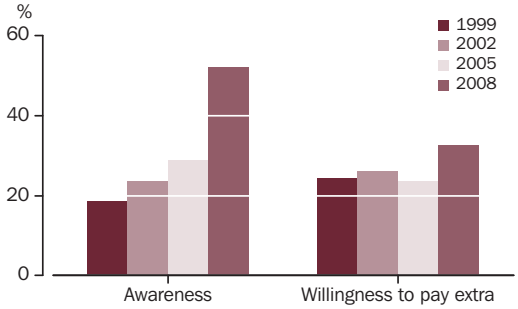
In March 2008, 99.9% of Australian households used electricity for power and/or heating. However, the availability and use of mains gas and bottled LPG gas is increasing. In March 2008, 61% of households had mains or bottled gas as an energy source (up from 57% in 2002). The proportion of households using wood as an energy source decreased to 14% in 2008 (down from 18% in 2002).

The main source of energy for cooktops was electricity (56%), with almost all the remainder coming from mains or bottled gas. For room heating, electricity and gas were almost equally preferred (35% and 31%, respectively).

Solar energy is primarily used by households for heating water and was used by 7% of Australian households for this purpose in 2008. The Northern Territory had the largest proportion of households (54%) using solar energy to heat water.

GreenPower refers to electricity generated from approved renewable energy resources such as solar, wind, biomass and hydroelectricity commissioned after 1 January 1997. GreenPower enables consumers to pay a premium for electricity generated from renewable sources. As at March 2009, there were 945,491 household and 38,533 commercial customers paying for GreenPower.[1]

Household awareness of GreenPower and willingness to pay extra



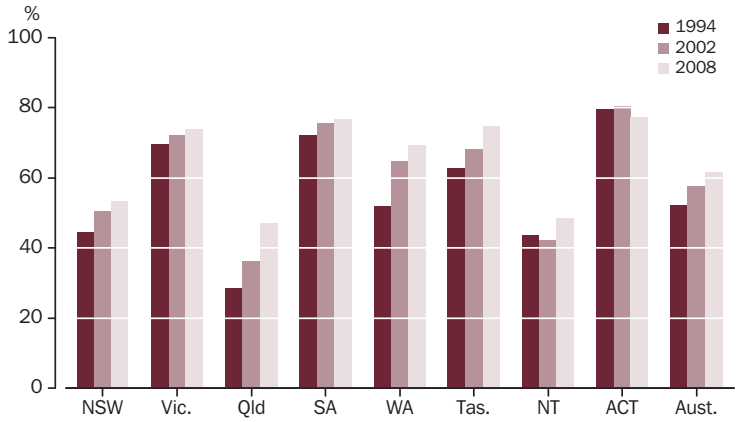
Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

The graph shows that while household awareness of GreenPower increased to 52% in 2008, only 33% were willing to pay extra for green power. 5% of households were already paying extra for GreenPower in March 2008.

1. NSW Department of Water and Energy, 2009, *National GreenPower Accreditation Program Status Report, Quarter 1 2009.*

Energy

Dwellings with insulation



Source: ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

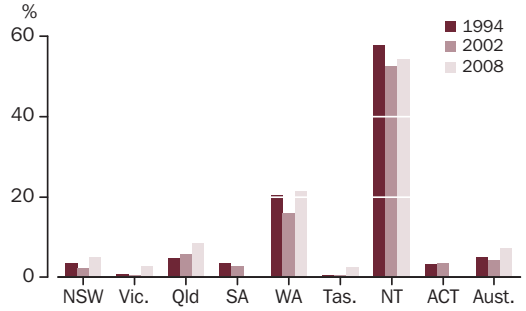
Installing insulation and solar hot water heating help reduce household energy consumption and greenhouse gas emissions. Effective insulation reduces overall energy consumption and helps to limit spikes in electricity demand associated with extreme weather conditions.

The proportion of Australian homes with insulation grew from 52% in March 1994 to 62% in March 2008. This figure is set to rise further in response to the Commonwealth Government's Energy Efficient Homes Package, which commenced in 2009. This scheme subsidises the installation of ceiling insulation and solar and heat pump hot water systems to replace electric storage systems.[1]

The proportion of homes with solar hot water heating rose from 5% in 1994 to 7% in 2008, with nearly all this growth occurring between 2005 and 2008. Commonwealth and state government rebates on solar hot water systems may have helped contribute to their increased use.

While solar hot water systems usually require some boosting (electric or gas), they produce significantly less greenhouse gas emissions than electric systems, which depend largely on coal-fired electricity.

Solar hot water use in dwellings



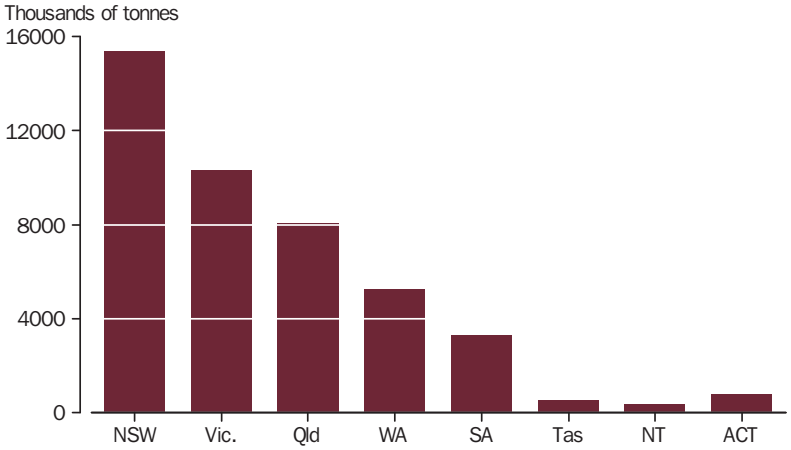
Note: SA and ACT data not published for 2008.
Source: ABS, 2002, *Environmental Issues: People's Views and Practices March 2002 (cat. no. 4602.0):* ABS, 2008, *Environmental Issues: Energy Use and Conservation March 2008 (cat. no. 4602.0.55.001).*

The proportion of households using electric hot water systems fell from 51% in 2005 to 46% in 2008. Mains and bottled gas' share of hot water heating peaked in 2005 (39%) and declined slightly by 2008, to 37%. In 2008, the proportion of households using gas hot water was greater in capital cities (47%) than in other areas (20%), reflecting greater access to reticulated (mains) gas in capital cities. Victoria had the highest proportion of households using gas hot water (two-thirds).

1. Department of the Environment, Water, Heritage and the Arts, *Energy Efficient Homes Package, <http://www.environment.gov.au/energyefficiency/index.html>, last viewed October 2009.*

Waste

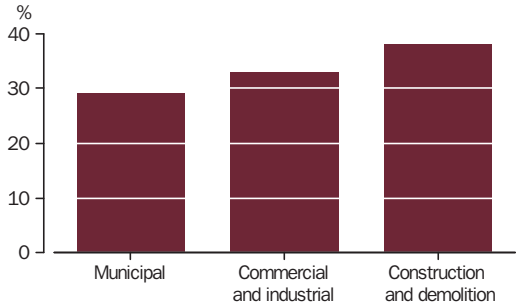
Waste generation by state, 2006–07



Source: Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009.*

Australians generated approximately 43.8 million tonnes of waste (approximately 2,080 kilograms of waste per person) in 2006–07. The states responsible for the largest proportions of the country's waste generation in 2006–07 were the three most populous states: NSW (35%), Victoria (23%) and Queensland (18%).

Solid waste generation by source, Australia, 2006–07



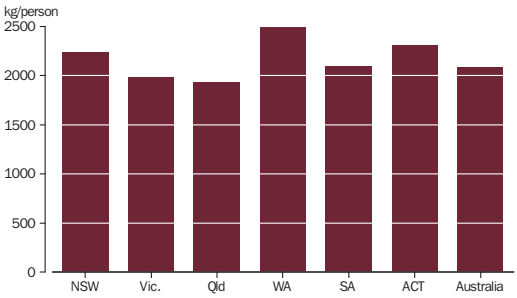
Source: Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009.*

Of the 43.8 million tonnes of waste generated in Australia in 2006–07, 29% came from municipal sources, 33% from the commercial and industrial sector, and 38% from the construction and demolition sector. Municipal waste includes domestic waste and council waste.

Growth in the amount of waste generated per person in Australia has been driven by a number of economic and demographic factors. A consequence of Australia's fast-growing, materially intensive economy is the production of large quantities of waste. International evidence suggests that economic growth contributes to growth in waste generation per person.[1]

Population demographics can also influence waste generation volumes. Australians tend to live in smaller household groups than they have in the past.[2] A possible consequence of this is an increase in the consumption of smaller-serve goods that have more packaging.

Per capita waste generation by state, 2006–07

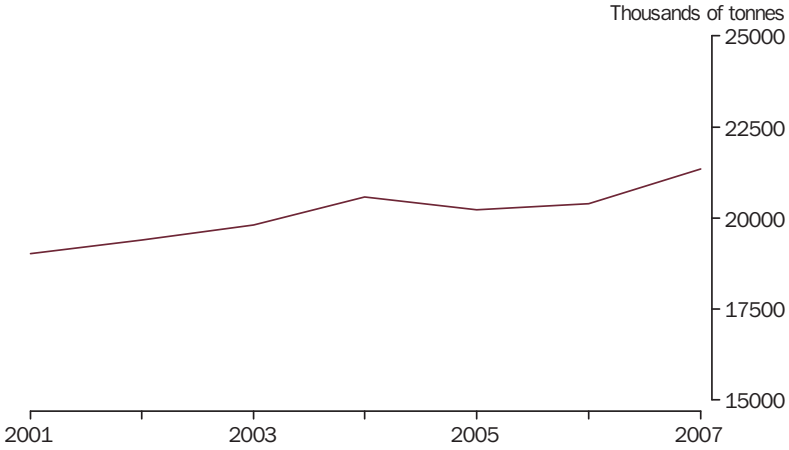


Source: Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009.*

1. Productivity Commission, 2006, *Inquiry Report No. 38: Waste Management*.
2. ABS, 2006, *Measures of Australia's Progress 2006 (cat. no. 1370.0)*.

Waste

Total waste disposed to landfill



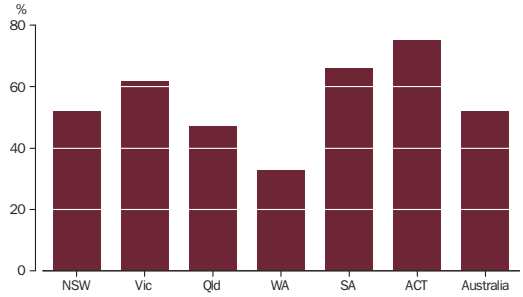
Source: Department of Climate Change, 2009, *National Inventory Report 2007 Volume 2*.

Australia has a strong dependence on landfill for waste management. Between 2001 and 2007, the volume of waste deposited into landfill increased markedly. In 2001, 19 million tonnes of waste were disposed to landfill, and by 2007 this figure had grown to 21.3 million tonnes (a 12% increase)[1] Increases in Australia's population and per capita income over the period are likely to have contributed to the rise in waste production.

During 2006–07, nearly half (48%) of all waste was disposed to landfill. Approximately 60% of municipal waste, 44% of commercial and industrial waste and 43% of construction and demolition waste went into landfill in 2006–07.[2]

The chief environmental concerns associated with modern landfills are emissions of greenhouse gases, particularly methane, and the possible long-term pollution of the environment through leaching of heavy metals, household chemicals, consumer electronic products and earlier generation rechargeable batteries, such as ni-cads.[3]

Recycling, percentage of total waste, by state, 2006–07



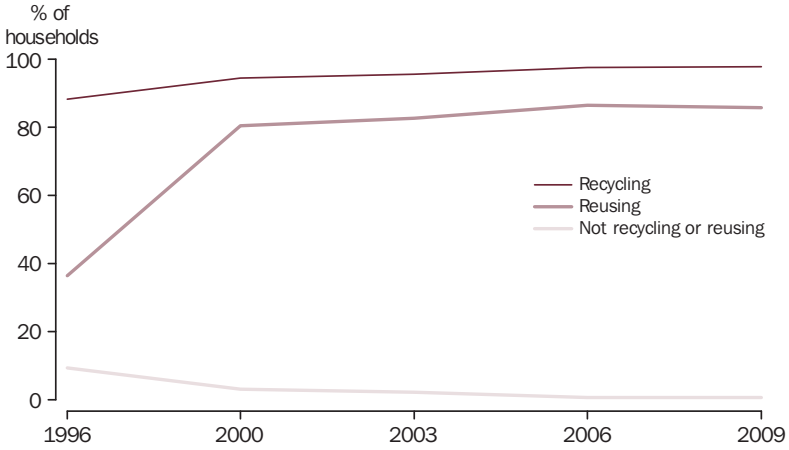
Source: Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009*.

Recycling of waste materials reduces the volume of waste disposed in landfills. The estimated recycling rate in Australia for 2006–07 was 52%. However, the recycling rate varied between states and territories. The Australian Capital Territory recycled three-quarters of the waste it generated, while Western Australia recycled only one-third (33%).

1. Department of Climate Change, 2009, *National Inventory Report 2007 Volume 2*
2. Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009*
3. ABS, 2006, *Australia's Environment: Issues and Trends 2006 (cat. no. 4613.0)*.

Waste

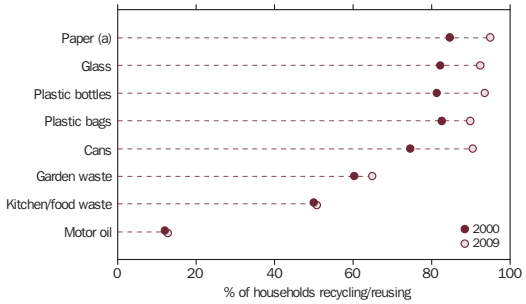
Recycling and reuse of waste in households



Source: ABS, 2009, *Environmental Issues: Waste Management and Transport Use March 2009 (cat. no. 4602.0.55.002).*

The recycling activities of households grew extensively between 1996 and 2009. In March 1996, 91% of Australian households said they practised some form of waste recycling and/or reuse activity. By March 2009, almost all households (99%) reported that they recycled and/or reused. There is a disparity in recycling between rural and urban areas, which may be due to limited implementation of kerbside recycling schemes in rural areas due to higher costs.[1]

Waste items recycled and/or reused by households



(a) Includes cardboard and newspapers.
Source: ABS, 2009, *Environmental Issues: Waste Management and Transport Use March 2009 (cat. no. 4602.0.55.002).*

In 2009, paper products were recycled and/or reused by 95% of Australian households, 94% of households recycled or reused plastic bottles, 93% recycled or reused glass, 91% cans and 90% plastic bags. In 2000, 85% of households recycled or reused paper, 81% recycled or reused plastic bottles and 82% recycled or reused glass. Only 13% of households recycled motor oil in 2009 (12% in 2000).

The proportion of households recycling organic waste (e.g. garden waste and kitchen or food waste) has also increased over time. Nearly two-thirds (65%) of households recycled garden waste in 2009, up from 60% in 2000.

Australians are among the highest users of new technology in the world. Waste from obsolete electronic goods, or "e-waste", is one of the fastest growing waste types.[1]

In 2007–08, 31.7 million new televisions, computers and computer products were sold in Australia. Another 16.8 million units reached the end of their life that year. Of these, 88% ended up in landfill.[2]

1. ABS, 2006, *Australia's Environment: Issues and Trends 2006 (cat. no. 4613.0).*
2. Hyder Consulting and Pricewaterhouse Coopers, 2009, *Environment Protection and Heritage Council – Consultation Regulatory Impact Statement: Televisions and Computers.*

Atmosphere

The atmosphere is an essential component of all ecological systems on Earth. Nitrogen and oxygen comprise 99% of the atmosphere. Small amounts of other gases and particles make up the balance. The atmosphere plays a critical role in regulating global, regional and local climate and is essential to supporting life on Earth. Oxygen is required for life, stratospheric ozone protects us from harmful solar radiation and greenhouse gases help maintain a temperature range suitable for life.

This section focuses on the following topics:

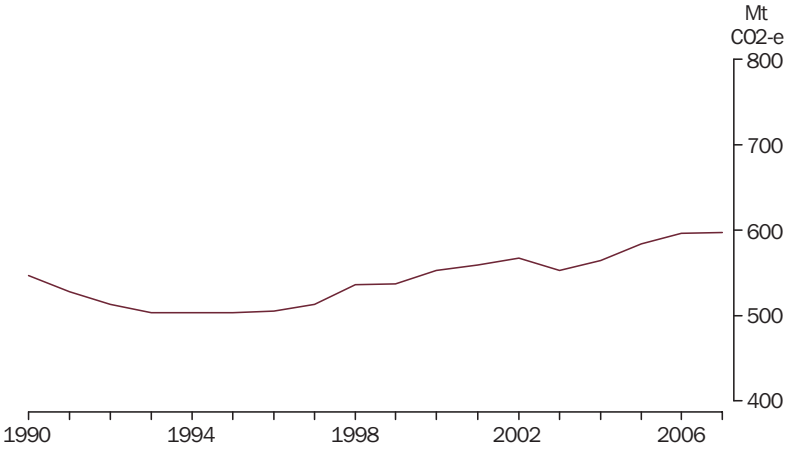
- **Greenhouse gases** are a natural part of the atmosphere. They trap the sun's warmth and maintain the earth's surface temperature at levels able to support life. However, human actions – particularly burning fossil fuels (coal, oil and natural gas) and land clearing – are increasing the concentrations of these gases which mean they trap more heat and change the climate. This is known as the enhanced greenhouse effect, which contributes to global warming. Global warming is widely perceived as one of the most significant international environmental issues. Different greenhouse gases have different effects and remain in the atmosphere for different periods of time. A tonne of methane, for example, contributes as much to global warming as 21 tonnes of carbon dioxide (CO_2). To assess the overall impact of different greenhouse gases, emissions of each gas are converted to a common CO_2 equivalent (CO_2-e) scale and added together.

- **Climate change:** According to meteorological records, the global average surface temperature has increased over the past 100 years. In Australia, annual average (mean) temperatures have increased, although this has not been uniform throughout the country. The effects of global warming are very difficult to predict. It is likely Australia will be hotter and drier in coming decades according to climate change projections. For most of the last decade, rainfall over south-eastern Australia has been lower than average.

- **Air quality** is an important factor in the quality of life in Australian cities. The main source of air pollution is motor vehicle emissions. Trends in pollution by fine particles and ozone (a component of photochemical smog) are presented for Australia's three largest cities. Sulphur dioxide and lead can be emitted in relatively large quantities by mineral ore processing activities, and hence can become a health hazard over some regional centres. Trends in sulphur dioxide pollution over the mining towns of Port Pirie in South Australia and Mt Isa in Queensland are presented.

Greenhouse gases

Net greenhouse gas emissions, Kyoto accounting



Year	Base year	1995	2000	2004	2005	2006	2007
Net emissions (Mt CO_2-e)	547.7	503.5	552.7	564.7	584.2	596.1	597.2
% of base year emissions	100	91.9	100.9	103.1	106.7	108.8	109.0

Note: Kyoto-based estimates of Australia's net greenhouse gas emissions, expressed in millions of tonnes (Mt) of carbon dioxide equivalent (CO_2-e). CO_2-e provides the basis for comparing the warming effect of different greenhouse gases.
Source: Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009;* Department of Climate Change, 2008, *The Australian Government's Initial Report under the Kyoto Protocol: Revised Submission to the UNFCCC Secretariat.*

By signing the Kyoto Protocol in 2007, Australia agreed to stabilise its emissions (for the five-year commitment period of 2008 to 2012) at no more than 108% of its 1990 (base year) emissions level.

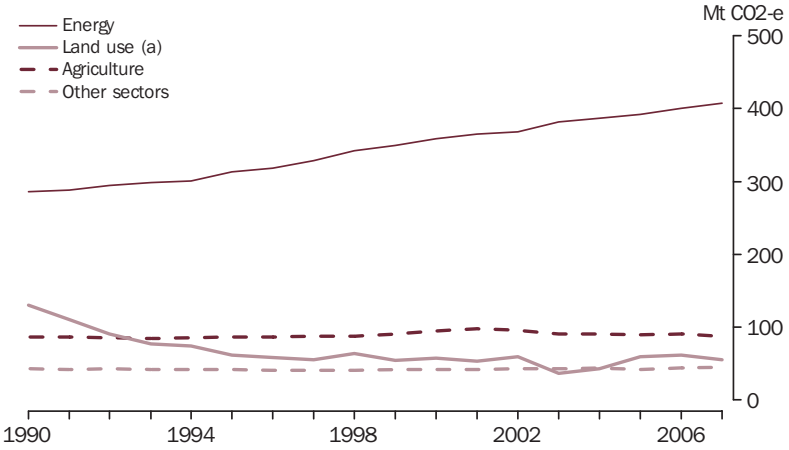
Based on the 1990 emissions estimate, Australia's Kyoto target was set at 591.5 Mt CO_2-e/yr.

Australia's net greenhouse gas emissions in 2007 totalled 597.2 million tonnes (Mt) carbon dioxide equivalent (CO_2-e). Therefore, in order to meet its Kyoto target for 2008 to 2012, Australia will have to lower its emissions slightly from the 2007 level.

Australia's Department of Climate Change also produces national greenhouse gas emissions estimates according to the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC emissions reporting differs from Kyoto Protocol reporting because the UNFCCC method includes all emissions from the land use, land use change and forestry (LULUCF) sector, while the Kyoto method excludes LULUCF emissions that result from natural events.

Greenhouse gases

Net greenhouse gas emissions by sector



Note: "Other sectors" includes industrial processes, waste and solvent and other product use.
(a) Land use, land use change and forestry (Kyoto-accounting).
Source: Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009.*

The greenhouse gases regulated under the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Emissions of different greenhouse gases may be compared by converting them to carbon dioxide equivalents (CO_2-e).

Of all the greenhouse gases, carbon dioxide is the one Australia emits in the largest quantities. In 2007, Australia's net greenhouse gas emissions were 597.2 million tonnes (Mt) CO_2-e. Carbon dioxide accounted for 75% of that total. Methane accounted for 20%, nitrous oxide for 4% and HFCs, PFCs and SF_6 for 1%.[1]

The energy sector was the primary source of greenhouse gases emitted by Australia in 2007, accounting for more than two-thirds (68%) of Australia's total greenhouse gas emissions (by the Kyoto accounting method). Emissions from this sector rose by 43% between 1990 and 2007. Of the energy sector's total emissions in 2007, 91% were CO_2. This represented 83% of Australia's total CO_2 emissions for 2007.[1]

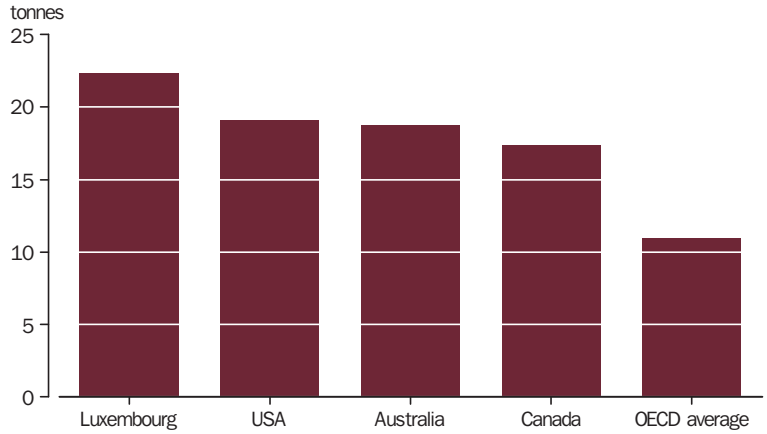
The agriculture sector provided the second-greatest contribution to Australia's net greenhouse gas emissions in 2007. Emissions from this sector totalled 88.1 Mt CO_2-e, or 15% of Australia's net emissions. The agriculture sector emitted 57% and 81% of Australia's CH_4 and N_2O emissions, respectively, in 2007.[1]

The land use, land use change and forestry (LULUCF) sector was responsible for a net total of 56.0 Mt CO_2-e (or 9% of Australia's total emissions) in 2007. This was a decrease of 57% compared to 1990.

1. Department of Climate Change, 2009, *National Inventory Report 2007 Volume 1.*

Greenhouse gases

Carbon dioxide emissions per capita, selected OECD countries, 2007



Source: International Energy Agency, *Key World Energy Statistics 2009*.

Carbon dioxide (CO_2) was Australia's most common greenhouse gas in 2007, accounting for 75% of national net emissions.[1]

While Australia only accounts for around 1.4% of global emissions of CO_2,[2] its emissions per person are relatively high compared with other OECD countries. In 2007, 18.75 tonnes of CO_2 were emitted for every Australian, compared with an OECD country average of 10.97 tonnes per person. Many large economies, including Japan (9.68 tonnes/person) and the United Kingdom (8.6 tonnes/person), had significantly lower per capita CO_2 emissions than Australia in 2007.

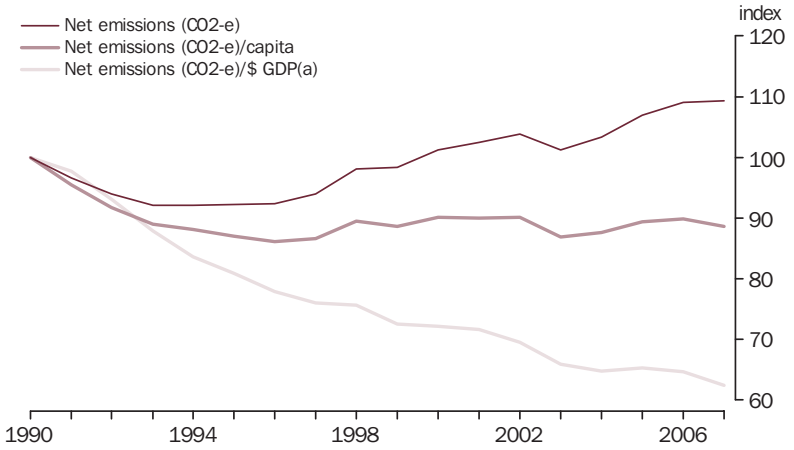
Of the OECD countries, only Luxembourg (22.35 tonnes/person) and the United States (19.1 tonnes/person) had higher per capita CO_2 emissions than Australia. However, some of the major oil exporting nations such as the United Arab Emirates (29.91 tonnes/capita) also had very high per capita emissions.

Australia's relatively high per capita emissions rate can be attributed to factors such as the high usage of coal in electricity generation, the energy intensive aluminium smelting sector, and the high dependence on motor vehicles and trucks for transport.

1. Department of Climate Change, 2009, *National Inventory Report 2007 Volume 1; National Greenhouse Gas Inventory May 2009.*
2. Carbon dioxide emissions only (excluding other greenhouse gases).

Greenhouse gases

Greenhouse gas emissions indexes; total, per capita and per $GDP



Note: Index displays emissions as a percentage of emissions in 1990 (Kyoto Protocol base year).
(a) GDP is a chain volume measure; reference year 2007–08.

	Emissions (Mt CO_2-e)	Tonnes CO_2-e/capita	kg CO_2-e/$GDP
1990	547.7	32.1	0.83
1993	503.2	28.5	0.73
1996	504.9	27.6	0.65
1999	537.0	28.4	0.60
2002	567.0	28.9	0.58
2005	584.2	28.6	0.54
2007	597.2	28.3	0.51

Source: ABS, 2008, *Australian Historical Population Statistics 2008 (cat. no. 3105.0.65.001);* ABS, 2009, *Australian Demographic Statistics June 2009 (cat. no. 31010.0);* ABS, 2009, *Australian National Accounts, National Income, Expenditure and Product September 2009 (cat. no. 5206.0);* Department of Climate Change, 2009, *National Greenhouse Gas Inventory May 2009.*

The greenhouse gas emissions intensity of the Australian economy, expressed as emissions per dollar of GDP, declined by 38% over the period 1990 to 2007, from 0.83 to 0.51 kg of carbon dioxide equivalent emissions (CO_2-e). The falling trend in emissions per unit of GDP reflects:[1]

- specific emissions management activities across sectors
- a decline in net land use, land use change and forestry (LULUCF) emissions over the period
- stronger growth in the services sector of the Australian economy, as opposed to the more energy-intensive manufacturing sector.

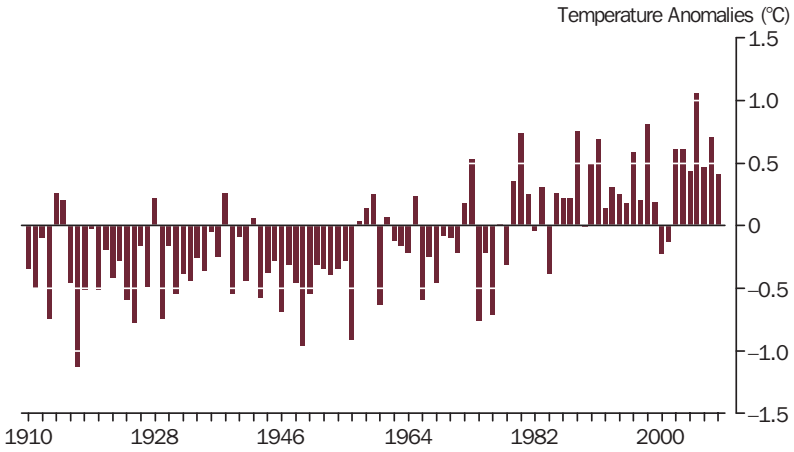
Australia reduced its per capita greenhouse gas emissions by 12% over the period 1990 to 2007 (from 32.1 tonnes CO_2-e per capita in 1990 to 28.3 tonnes CO_2-e per capita in 2007). Despite this reduction, Australia continues to emit a large volume of greenhouse gases per capita, in comparison to other OECD countries (see previous page for CO_2 emissions comparisons). Australia's high per capita emissions reflect a number of factors:[1]

- the dominance of coal as a fuel in the electricity industry
- the presence of net emissions from the LULUCF sector
- the production in Australia of many goods with high associated emission levels, which are later exported.

1. Australian Greenhouse Office, 2007, *National Greenhouse Gas Inventory 2005.*

Climate change

Annual average temperature anomalies, 1910 to 2008



Note: Anomalies are based on 1961 to 1990 average of 21.8°C.
Source: Bureau of Meteorology, 2009, *Australian Climate Change and Variability, <http://reg.bom.gov.au/silo/products/cli_chg>, last viewed October 2009*.

Australia experienced its 14th warmest year on record in 2008 following its 6th warmest year on record in 2007[1,2]. The annual average temperature for 2008 was 0.41^{0}C above the 1961 to 1990 average. Australia's annual average (mean) temperatures have increased by approximately 0.9^{0}C since 1910.[1]

2008 marked Australia's 7th consecutive warmer-than-average year. Despite this, Australia's average temperature in 2008 was slightly lower than mean temperatures over the previous six years.

Above-average global temperatures have also been recorded in recent years. The global mean temperature for 2008 was approximately 0.31°C above the worldwide average (for 1961 to 1990).[1] The last year that recorded a worldwide average temperature below the global average was 1985.[1]

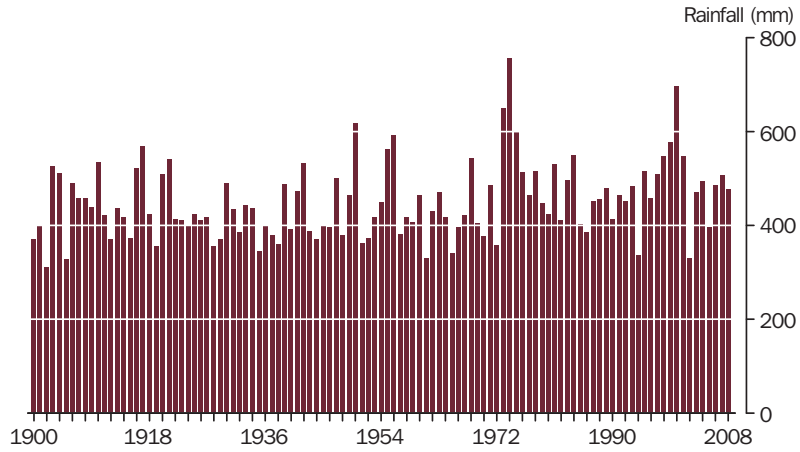
Most climate scientists from the Intergovernmental Panel on Climate Change (IPCC) agree that a significant proportion of global temperature increases over the last 50 years have been caused by human-induced greenhouse gas emissions.[1]

Despite the apparent overall warming trend, Australian annual temperatures are expected to continue to vary from year-to-year.[1]

1. Bureau of Meteorology, 2009; 2008; 2007, *Annual Australian Climate Statement 2008; 2007; 2006, <http://www.bom.gov.au/announcements/media_releases/climate/change/>, last viewed October 2009.*

Climate change

Annual rainfall, 1900 to 2008



Note: 1961 to 1990 annual average rainfall is 472.2 mm.
Source: Bureau of Meteorology (BoM), 2009, *Australian Climate Change and Variability, <http://reg.bom.gov.au/silo/products/cli_chg>, last viewed October 2009*.

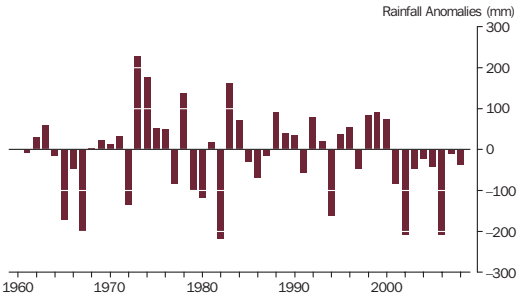
The two El Niño–Southern Oscillation (ENSO) phases are El Niño and La Niña. El Niño refers to a warming of surface water over the central and eastern tropical Pacific Ocean. This sea surface temperature (SST) increase is accompanied by changes in the atmosphere measured by the Southern Oscillation Index.

ENSO cycles affect weather patterns across Australia and much of the Pacific Basin. In Australia, El Niño is often associated with reduced rainfall.[1] La Niña refers to the cooling of the waters that warm up during El Niño periods, and the associated changes in the Southern Oscillation Index. La Niña periods are often associated with increased rainfall across Australia.[2]

Rainfall across Australia in 2008 was 478.1 mm, which was only just above the long-term annual average. Above average rainfall was recorded across the Top End (of the Northern Territory), eastern Queensland, northeast New South Wales and far western areas of Western Australia.

Rainfall was below average in other parts of the country. South-eastern Australia, much of which is incorporated in the Murray-Darling Basin, received below average rainfall for the eighth consecutive year in 2008.

Murray-Darling Basin rainfall anomalies, 1961 to 2008



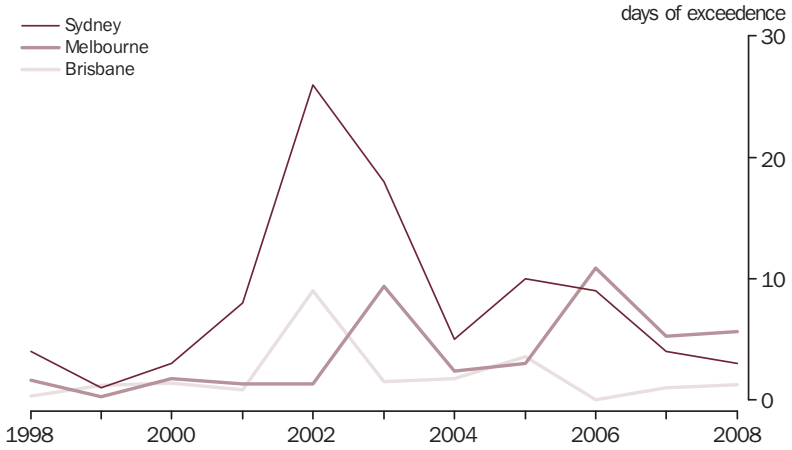
Note: 1961 to 1990 annual average rainfall is 483.2 mm.
Source: BoM, 2009, *Australian Climate Change and Variability, <http://reg.bom.gov.au/silo/products/cli_chg>, last viewed December 2009*.

Projections indicate that dry conditions will persist across southern Australia in the coming decades.[3] Therefore, gaining an understanding of the factors driving the long-term drought is particularly important in the context of Australia's future climate.

1. Bureau of Meteorology, *About El Niño and La Niña, <http://www.bom.gov.au/climate/enso/about-el-nino-la-nina.shtml>, last viewed October 2009.*
2. Bureau of Meteorology, *Climate Glossary - La Niña, <http://www.bom.gov.au/climate/glossary/lanina>, last viewed October 2009.*
3. Bureau of Meteorology, 2009; 2008; 2007, *Annual Australian Climate Statement 2008; 2007; 2006 <http://www.bom.gov.au/announcements/media_releases/climate/change/ >, last viewed October 2009.*

Air quality

Particulate concentrations, daily 24-hour PM_{10}, selected cities



Note: "Days of exceedence" refers to the number of days in which average PM_{10} concentrations exceeded the NEPM standard. Each city contains several PM_{10} monitoring stations. The data presented are an average of exceedence days across each PM_{10} monitoring station in each city. Melbourne averages only consider stations with data available for at least 75% of days in a given year.
Source: New South Wales Department of Environment, Climate Change and Water; Queensland Department of Environment and Resource Management; Victoria Environment Protection Authority.

Airborne particles may be solid matter (such as dust, dirt or soot) or liquid droplets. These particles result from both natural and human sources. Natural sources include bushfires, dust storms, pollens and sea spray. Human activities that create airborne particles include motor vehicle emissions, industrial processes, use of unpaved roads and woodheater use.[1]

Particle pollution reduces visibility on roads, which can cause a safety issue. It has also been linked to respiratory illnesses and cardiovascular disease.[1]

Not all airborne particles are large enough to be seen by the human eye. PM_{10} and $PM_{2.5}$ are two examples of particles that can only be detected with a microsope. PM_{10} particles are those less than 10 micrometres (μm) in diameter. For comparison, the diameter of a human hair is approximately 70 μm.[1]

In June 1998, the National Environment Protection Council created the ambient air quality National Environment Protection Measure (NEPM), which set uniform standards for outdoor air quality. The one-day standard for PM_{10} is 50 $\mu g/m^3$ (micrograms per cubic metre).[2]

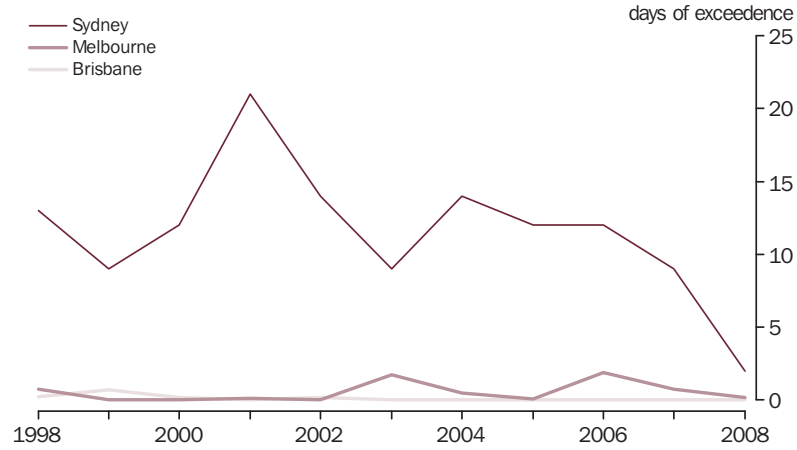
In most years since 1998, the average number of PM_{10} exceedence days in Australia's three most populated cities has been below 10. However, there was a sharp rise in Sydney's number of exceedence days in 2002, mainly due to severe forest fires and dust storms in the area.[3]

The National Environment Protection Measure (NEPM) was varied in 2003 to include advisory reporting standards for $PM_{2.5}$ (particulate matter with a diameter of less than 2.5μm), as well as PM_{10}. The NEPM one-day standard for $PM_{2.5}$ is 25 $\mu g/m^3$.[2]

1. Department of the Environment, Water, Heritage and the Arts, 2005, *Particles – Air quality fact sheet*, *<http://www.environment.gov.au/atmosphere/airquality/publications/particles.html>, last viewed November 2009.*
2. Environment Protection Heritage Council, *Reports from jurisdictions on the implementation of the Ambient Air Quality NEPM 2007–08.*
3. Bureau of Meteorology, 2002, *Weather diary for year 2002, <http://www.bom.gov.au/announcements/media_releases/nsw/year2002.shtml>, last viewed November 2009.*

Air quality

Daily peak 4-hour ozone, selected cities



Note: "Days of exceedence" refers to the number of days in which average peak 4-hour ozone concentrations exceeded the NEPM standard. Each city contains several ozone monitoring stations. The data presented are an average of exceedence days across each ozone monitoring station in each city. Melbourne averages only consider stations with data available for at least 75% of days in a given year.
Source: New South Wales Department of Environment, Climate Change and Water; Queensland Department of Environment and Resource Management; Victoria Environment Protection Authority.

The smog found in Australian cities during the warmer months of the year is caused by photochemical oxidants, such as ozone and other chemicals like formaldehyde.[1]

Ozone and other photochemical oxidants are created when sunlight falls on a combination of chemicals in the air. Cities that receive a lot of sunshine, high temperatures and moderate winds for extended periods of time are likely to experience relatively high concentrations of photochemical oxidants.[1]

The chemicals that react to form ozone are nitrogen oxides and reactive organic substances. These chemicals are produced by motor vehicle exhaust, oil refining, printing, petrochemicals, lawn mowing, aviation, bushfires and burning off. Motor vehicle exhaust fumes produce up to 70% of the nitrogen oxides and up to 50% of the reactive organic substances that form ozone.[1]

Ozone occurs naturally in the lower atmosphere in concentrations of about 0.04 parts per million (ppm) and that amount is not harmful to human health. However, in higher concentrations ozone can irritate the nose, airways and lungs. The National Environment Protection Measure (NEPM) standard for ozone measured over a four hour period is 0.08 ppm.

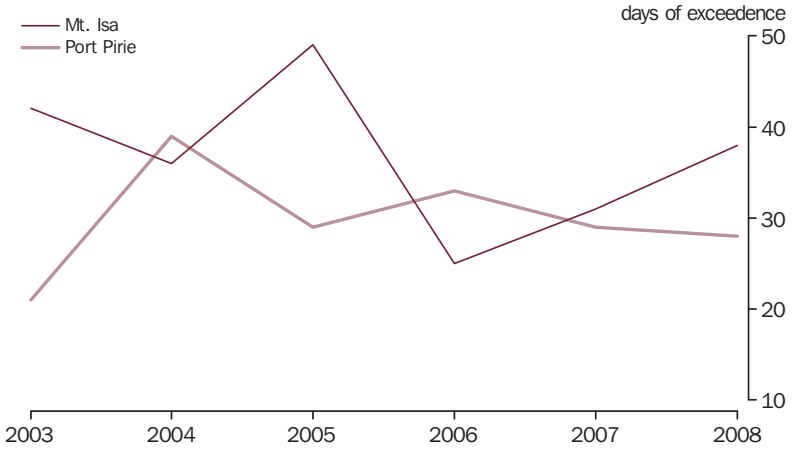
In most Australian towns and cities, the level of ozone in the air does not exceed the NEPM standard.[1] Even large cities like Melbourne and Brisbane averaged less than two days of exceedence in each year between 1998 and 2008.

Of Australia's three most populous cities, Sydney recorded the most four-hour ozone NEPM exceedences between 1998 and 2008. Sydney's second-warmest year on record was 2001,[2] and this was reflected in its average number of ozone exceedence days that year, which was higher than 20.

1. Department of the Environment, Water, Heritage and the Arts, 2005, *Ground-level ozone – Air quality fact sheet, <http://www.environment.gov.au/atmosphere/airquality/publications/ozone.html>, last viewed November 2009.*
2. Bureau of Meteorology, 2002, *Fiery December ends Sydney's second-warmest year on record, <http://www.bom.gov.au/announcements/media_releases/nsw/20020102.shtml>, last viewed November 2009.*

Air quality

Daily peak 1-hour sulphur dioxide, selected regional centres



Note: The National Environment Protection Measure (NEPM) standard maximum concentration for one-hour SO_2 is 0.2 parts per million. The graph shows days in which exceedences occurred, not total number of exceedences per year (as there may be more than one exceedence per day).
Source: Queensland Department of Environment and Resource Management; South Australia Environment Protection Authority.

Sulphur dioxide (SO_2) is a colourless, irritating and reactive gas with a strong odour. Emissions of sulphur dioxide are primarily from industrial operations that burn fuels such as coal, oil and gas. It is also emitted by vehicles. It irritates the nose, throat and airways, and people with asthma or similar conditions are at risk of exacerbating these existing health problems.[1]

Ambient (outdoor) sulphur dioxide concentrations are generally low in Australian towns and cities. The highest concentrations are found around petrol refineries, chemical manufacturing industries, mineral ore processing plants and power stations.[1]

In recent years, one-hour SO_2 concentrations have been below the National Environment Protection Measure (NEPM) standard levels at Gladstone, the Lower Hunter and La Trobe Valley (power generation areas using coal).[2]

Sulphur dioxide pollution is still an issue in some mining/minerals processing centres, such as Port Pirie (about 200 km north of Adelaide in South Australia) and Mount Isa (in northwest Queensland). However, other centres, such as Kalgoorlie and Kwinana in Western Australia, have reduced their SO_2 levels since the early 1990s and are now meeting the National Environment Protection Measure (NEPM) standard. These changes have been attributed to improved regulation and best practice industry technology.[3]

1. Department of the Environment, Water, Heritage and the Arts, 2005, *Sulfur dioxide (SO_2) – Air quality fact sheet*, *<http://www.environment.gov.au/atmosphere/airquality/publications/sulfurdioxide.html>, last viewed November 2009.*
2. State environmental protection agencies.
3. Western Australia Environmental Protection Authority, *State of the Environment Report 2007: Atmosphere – Sulfur dioxide, <http://www.soe.wa.gov.au/report/atmosphere/sulfur-dioxide.html>, last viewed November 2009.*

Water

Water supply and use in Australia needs to be viewed in the context of Australia's climate. Australia's long-term annual average rainfall is the lowest of all the continents (except Antarctica). Rainfall in Australia is also highly variable, not only from region-to-region but also from year-to-year and from season-to-season.

This section is divided into four main parts:

- **Water consumption**: In recent years, below-average rainfall in many parts of Australia has resulted in urban water restrictions and reduced availability of water for farmers.

  Agriculture accounted for 65% of total water consumed in 2004–05. Household water use, which includes water for drinking, cooking, cleaning and outdoors, accounted for about 11% of total water consumed in Australia.

  Within the agricultural sector in 2007–08, 90% of water used was for irrigation. More than a quarter (26%) of irrigation water was used for pasture and crops for grazing, 15% for cereals (excluding rice) and 14% for sugar cane.

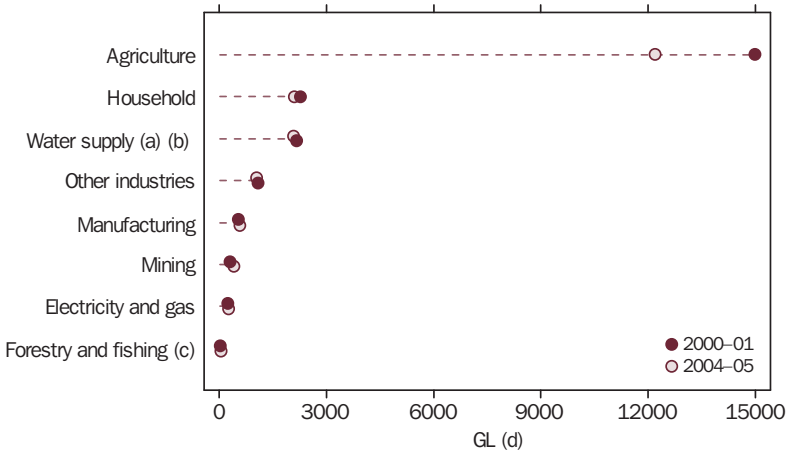
- **Water conservation** The recent drought and ensuing water restrictions have firmly focused attention on the need to conserve water. While mandatory water restrictions in many parts of Australia limit household outdoor water use, many Australians have been voluntarily conserving water by adopting water saving practices and installing water saving devices (such as dual flush toilets and reduced flow shower heads).

- **Water management**: Continuing low rainfall levels in parts of the Murray-Darling Basin in 2008–09 created strong demand for water transfers, which resulted in about 32,000 water trades during the year, totalling $2.2 billion and almost 4,000 gigalitres.

- **Marine and coastal waters:** The marine environment is important for Australia's society, economy and ecology. Many people like to live on or near the coast and take holidays at the beach. Economic benefits flow from marine industries such as shipping, tourism, fisheries, and offshore oil and gas extraction. The coastal and marine regions support a large range of species, many of them found only in Australian waters. The preservation of the marine environment is vital for the benefit of future generations.

Water consumption

Water consumption by sector



(a) Includes sewerage and drainage services.
(b) Includes water losses.
(c) Includes services to agriculture; hunting and trapping.
(d) 1 GL = 1 Gigalitre = 1,000,000,000 Litres
Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

	2000–01		2004–05	
	Volume (GL)	% of total	Volume (GL)	% of total
Agriculture	14,989	69.1	12,191	65.0
Household	2,278	10.5	2,108	11.2
Water supply (a) (b)	2,165	10.0	2,083	11.1
Other industries	1,102	5.1	1,059	5.6
Manufacturing	549	2.5	589	3.1
Mining	321	1.5	413	2.2
Electricity and gas	255	1.2	271	1.4
Forestry and fishing (c)	44	0.2	51	0.3
Total	**21,703**	**100**	**18,767**	**100**

(a) Includes sewerage and drainage services.
(b) Includes water losses.
(c) Includes services to agriculture; hunting and trapping.
Source: ABS, 2006, *Water Account Australia 2004–05 (cat. no. 4610.0)*.

The most recent comprehensive data available for Australia-wide water consumption by sector is the ABS *Water Account Australia 2004-05.*

Water consumption in Australia in 2004–05 was 18,767 gigalitres (GL), a decrease of 14% from 2000–01, in which it was 21,703 GL.

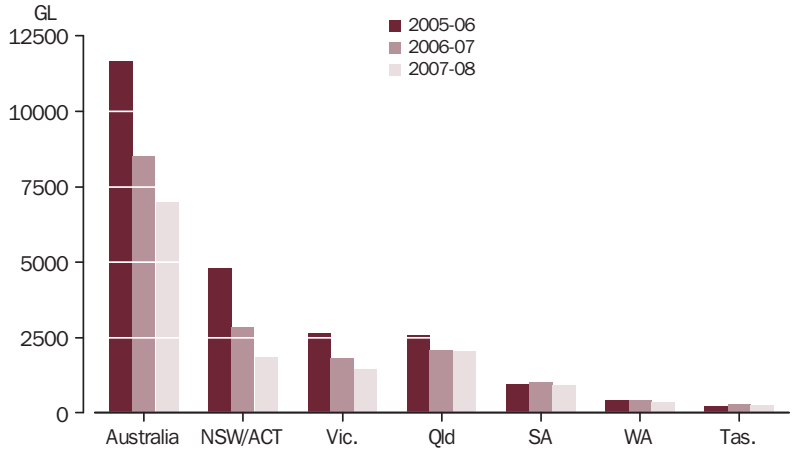
Many parts of Australia experienced below average rainfall in 2004–05, with drought conditions occurring in some areas, including parts of the Murray-Darling Basin. These dry conditions have led to urban water restrictions and reduced availability of water for irrigators.

Although the agriculture industry had the highest water use in 2004–05 (12,191 GL, or 65% of total water consumption), water use by this sector decreased by 19%, or 2,798 GL, between 2000–01 and 2004–05.

Households accounted for 2,108 GL of water in 2004–05, or 11.2% of Australia's total water consumption. Household water use also decreased between 2000–01 and 2004–05, by 7% or 170 GL.

Water consumption

Water consumption by agriculture



(a) NT values are too small to show on graph.
Source: ABS, 2009, *Water Use on Australian Farms 2007–08 (cat. no. 4618.0)*.

	2005–06		2006–07		2007–08	
	Volume (GL)	% of total	Volume (GL)	% of total	Volume (GL)	% of total
NSW & ACT	4,796	41.0	2,845	33.4	1,856	26.6
Vic.	2,641	22.6	1,823	21.4	1,471	21.0
Qld.	2,581	22.1	2,084	24.5	2,039	29.2
SA	976	8.3	1,035	12.1	934	13.4
WA	428	3.7	412	4.8	370	5.3
Tas.	230	2.0	288	3.4	271	3.9
NT	38	0.3	34	0.4	49	0.7
Total	**11,689**	**100**	**8,521**	**100**	**6,989**	**100**

Source: ABS, 2008; 2008; 2009, *Water Use on Australian Farms 2005–06; 2006–07; 2007–08 (cat. no. 4618.0)*.

The agriculture industry is the largest consumer of water in Australia (see previous page). Nearly all (90%) of the water used for agriculture in 2007–08 was used for irrigation.

Water consumption by the agriculture industry is very much influenced by climatic conditions and this must be taken into account when assessing changes in water use. For large parts of southern and eastern Australia, dry conditions have persisted since 2001. For the majority of the agriculturally important Murray-Darling Basin, October 2008 marked the seventh consecutive year of lower-than-average rainfall totals.[1]

In 2007–08, the agriculture industry consumed 6,989 gigalitres (GL), nearly one-fifth (18%) less water compared with 2006–07 (8,521 GL), and 40.2% less than in 2005–06 (11,689 GL).

New South Wales (including the ACT) was responsible for the majority of this decrease, dropping its agricultural water consumption by 35% or 989 GL between 2006–07 and 2007–08. This followed a drop of 1951 GL (41%) between 2005–06 and 2006–07. Victorian agriculture also lowered its water consumption, by a total of 44% (1,170 GL) between 2005–06 and 2007–08. Farmers in Queensland, South Australia and Western Australia also decreased the amount of water they used during the period, but their percentage share of the country's total increased. Tasmania and the Northern Territory increased their agricultural water consumption slightly between 2005–06 and 2007–08.

1. Bureau of Meteorology, 2008, *Special Climate Statement 16*.

Water consumption

Water used for irrigation, 2007–08

Pasture / crop	Area under pasture or crop '000 ha (c)	Area irrigated '000 ha	Application rate ML/ha (d)	Volume of water applied GL (e)	% of total irrigation water
Pasture and crops used for grazing	66,667	544	3.0	1641	26.1
Cereals for grain or seed (excludes rice)	19,660	340	2.8	955	15.2
Sugar cane	381	187	4.6	863	13.7
Fruit trees, nut trees, plantation and berry fruits (a)	187	131	4.3	560	8.9
Grapevines	175	168	3.1	517	8.2
Pasture and crops used for hay	2,677	147	3.4	502	8.0
Vegetables for human consumption	123	114	3.8	431	6.9
Cotton	69	58	5.3	310	4.9
Other broadacre crops (b)	3,773	58	3.2	185	2.9
Pasture and crops used for silage (includes lucerne)	na	65	2.5	162	2.6
Nurseries, cut flowers and cultivated turf	17	14	4.4	62	1.0
Rice	2	2	12.9	27	0.4
Other pastures or crops not elsewhere classified	na	23	3.0	70	1.1
Total	**na (>93,731)**	**1,851**	**3.4**	**6,285**	**100**

(a) Excludes grapevines.
(b) Excludes cereals, sugar cane and cotton.
(c) 1 ha = 1 hectare = 10,000 m^2; 100 ha = 1 km^2.
(d) 1 ML = 1 Megalitre = 1,000,000 Litres.
(e) 1 GL = 1 Gigalitre = 1,000,000,000 Litres.
Note: na = Not available
Source: ABS, 2009, *Water Use on Australian Farms 2007–08 (cat. no. 4618.0)*.

The vast majority (90%) of the water used for agricultural production is for irrigation of crops and pastures, with the rest used for other agricultural purposes such as drinking water for stock and dairy/piggery cleaning.

Climatic conditions affect both availability of water for irrigation and the need to irrigate in order to supplement rainfall. Some crops such as rice, cotton and grapevines are highly dependent on irrigation. For other production, including grazing pasture and most broadacre crops, irrigation water supplements natural rainfall or provides moisture at critical periods of plant growth.

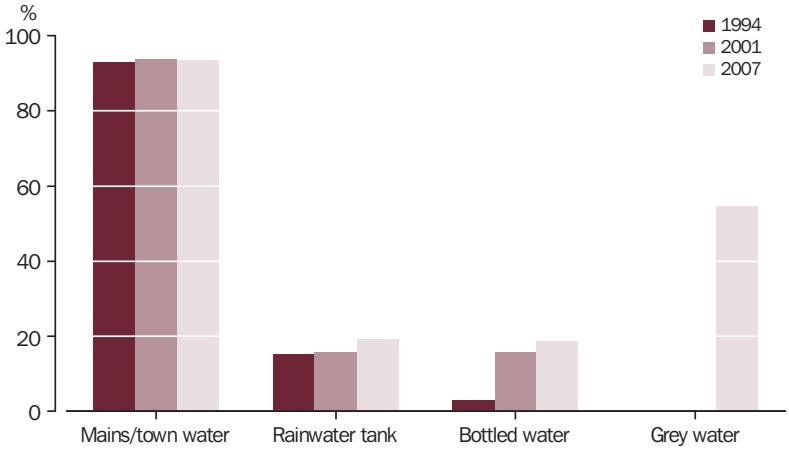
In 2007–08, the total volume of water used for irrigation was 6,285 gigalitres (GL). 'Pasture and crops used for grazing' used the most water in Australia in 2007–08. It accounted for more than a quarter (26.1%) of the total volume of irrigation water and for 29% of the total area irrigated nationally.

Rice was the most heavily irrigated crop in 2007–08, in terms of the volume of water applied per unit area. The application rate for rice was almost four times the national average rate across all crops and pastures. Cotton was the crop with the second-highest irrigation rate.

Rice growers reported a substantial drop in irrigation water use in 2007–08 (down 89% on 2006–07), as did cotton growers (down 64%). The area of cotton crop irrigated in Australia fell by 57%, compared to the previous year.

Water conservation

Sources of water for households



Note: No data available for collection of grey water as a source of water in 1994 or 2001.
Source: ABS, 2007, *Environmental Issues: People's Views and Practices, March 2007 (cat. no. 4602.0).*

The majority of Australian households (93%) had access to mains water in March 2007. Other households relied on rainwater tanks, bores or wells or water from rivers, creeks and dams.

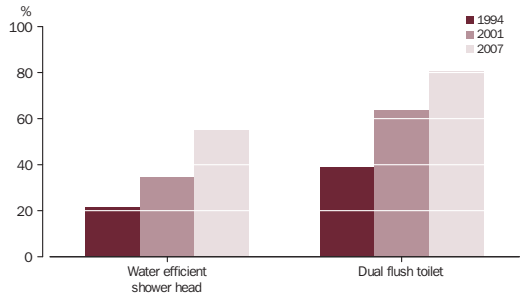
Some households supplemented their water supply by collecting water in containers or by using rainwater. Many Australian households also reported using grey water (54%) and bottled water (19%).

Household water use and conservation has been a widely discussed issue in recent years due to drought conditions and water restrictions in many parts of Australia.

In addition to mandatory water restrictions in many parts of Australia, many Australians have been voluntarily conserving water by adopting water saving practices and installing water saving devices, such as dual flush toilets.

In 2007, the majority of Australian households had some type of water conservation device installed in their home. In June 1994, only 39% of households had a dual flush toilet. In 2007, 81% of households had a dual flush toilet. The percentage of dwellings using water-efficient shower heads rose from 22% in 1994 to 55% in 2007.

Households with water conservation devices

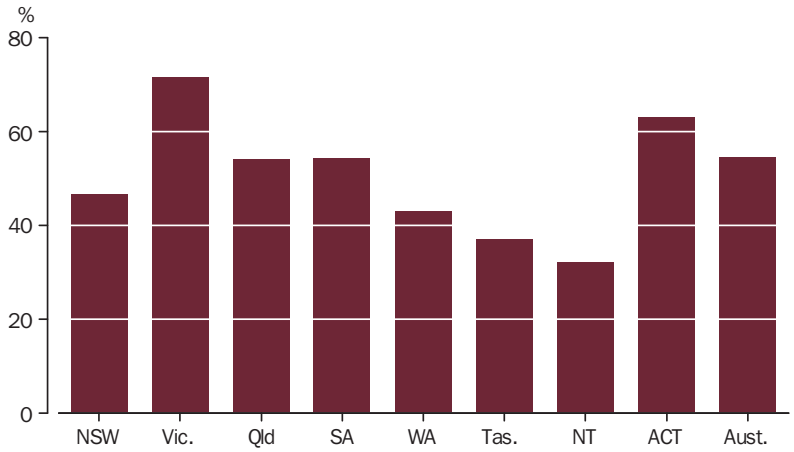


Source: ABS, 2007, *Environmental Issues: People's Views and Practices, March 2007 (cat. no. 4602.0).*

In 2007, 96% of dwellings less than one year old had only dual flush toilets (rather than "regular" toilets), and 74% had water-efficient shower heads in each shower. When the dwelling was more than 30 years old, these figures fell to 64% for dual flush toilets and 46% for water-efficient shower heads.

Water conservation

Household use of grey water, 2007



Note: NT and ACT data refers to the whole territory.
Source: ABS, 2007, *Environmental Issues: People's Views and Practices, March 2007 (cat. no. 4602.0)*.

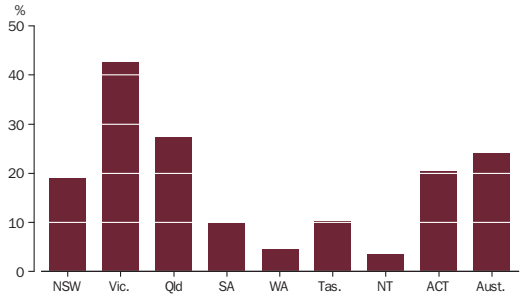
Grey water is used water from the shower/bath, laundry or kitchen that households collect for re-use. In 2007, grey water was the second most common source of water for households, after mains/town water. More than half (54%) of Australian households reported grey water as a source.

Victoria had the highest percentage of households reporting grey water as a source (72%), followed by the Australian Capital Territory (63%). The Northern Territory had the lowest reported use of grey water, but this was still substantial at almost a third of households (32%). In Tasmania, just over a third (37%) of households reported using grey water.

Water restrictions since 2002 have affected households primarily by changing their use of water in the garden. In 2007, nearly a quarter (24%) of Australian households reported grey water as their primary source of water for the garden. More than four in ten households reported mains/town water (42%) as their primary source of water for the garden.

In Victoria and Queensland grey water was the most common main source of water for the garden (43% and 27% respectively). The Australian Capital Territory (21%) and New South Wales (19%) also reported high proportions of grey water use in the garden. The Northern Territory (4%) and Western Australia (5%) had the lowest proportion of households reporting grey water as their main source of water for the garden.

Grey water as the main source of water for the garden, 2007

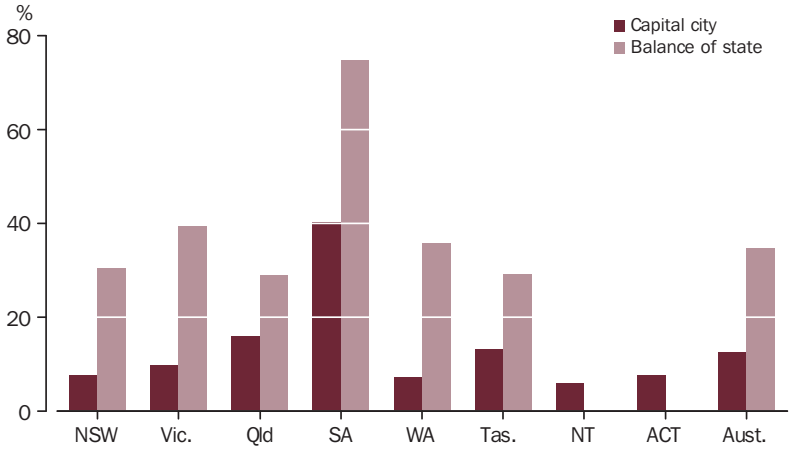


Note: Includes only households that have a garden. NT and ACT data refers to the whole territory.
Source: ABS, 2007, *Environmental Issues: People's Views and Practices, March 2007 (cat. no. 4602.0)*.

In March 2007, 83% of Australian households had their own garden. More than a quarter (26%) of households with a garden did not water or relied on rainfall only. In Brisbane, nearly half (48%) of households did not water or relied on rainfall only, compared to a third (33%) in the rest of Queensland.

Water conservation

Households with a rainwater tank, 2007



Note: NT and ACT data refers to the whole territory.
Source: ABS, 2007, *Environmental Issues: People's Views and Practices March 2007 (cat. no. 4602.0)*.

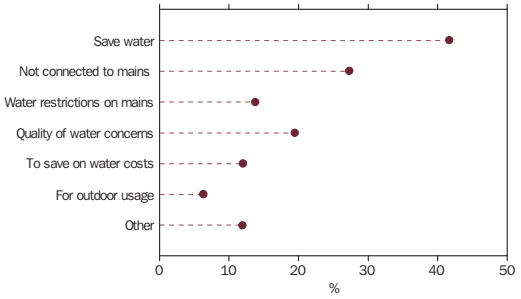
In 2007, 21% of all households reported that their dwelling had a rainwater tank.

South Australia had the highest proportion of dwellings with a rainwater tank (49% total). The Australian Capital Territory and the Northern Territory had the lowest proportion of dwellings with a rainwater tank: 8% and 6% respectively.

In 2007, rainwater tanks were much more prevalent outside capital cities (35%) than within capital cities (12%). In capital cities, the most commonly reported reason for installing a tank was to save water. In the rest of the state, the most common reason was that the dwelling was not connected to mains water. Overall, 42% of households with a rainwater tank reported saving water as a reason for installing a tank, and 27% reported that their household was not connected to mains water.

More than 60% of households without a rainwater tank (but which had a dwelling suitable for a tank and which were home owners or purchasers) had considered installing one. Cost was the most common reason reported for not installing a rainwater tank (48%).

Reasons why household installed a rainwater tank, 2007



Source: ABS, 2007, *Environmental Issues: People's Views and Practices March 2007 (cat. no. 4602.0)*.

Water trading

Volumes of water traded, 2008–09

	Permanent trades	Temporary trades		
	Total volume traded (GL)(a)	Trades within state (GL)	Outgoing (interstate) trades (GL)	Total volume traded (GL)(a)
NSW	1,286	871	560	1,431
Vic	252	344	30	374
Qld	75	248	0	248
SA	74	92	4	96
WA	8	9	0	9
Tas	104	0	0	0
NT	0	0	0	0
ACT	0	0	0	0
Australia	**1,800**	**1,564**	**594**	**2,158**
Percentage of total volume of temporary trades		**72**	**28**	**100**

(a) 1 GL = 1 Gigalitre = 1,000,000,000 Litres. Total volume traded includes trades within each state/territory and outgoing interstate trades.
Source: National Water Commission, 2009, *Australian Water Markets Report 2008–09.*

Australia is one of a small number of water-scarce countries that has instituted markets for trading water.

The National Water Commission (NWC) considers water trading important because it allows this vital resource to be transferred for productive and environmental uses.

Trading can occur on a temporary or permanent basis. Temporary transfers, where water entitlements are leased for a specified period of time (usually one year), are the most commonly used method of trading water in Australia. This market depends mainly on how much rain has fallen and how hot the season has been.

In 2008–09, a large portion of the Murray-Darling Basin experienced below-average rainfall. Many regions also suffered from an extreme heatwave in January and February 2009, which increased evaporation and, therefore, reduced water availability. This created a strong demand for water transfers, which resulted in about $2.2 billion of water trades in 2008–09, up 75% from the previous year (while the volume traded increased by 57%).

The NWC recorded 5,766 permanent and 26,285 temporary water trades in Australia in 2008–09. These trades totalled 3,958 GL of water, of which 2,158 GL changed hands temporarily and 1,800 GL were traded permanently. Nearly three-quarters (72%) of temporary trades occurred internally (within states). Interstate trades accounted for 28% of temporary trades during 2008–09, up from 15% in 2007–08. All the water traded permanently was traded within states.

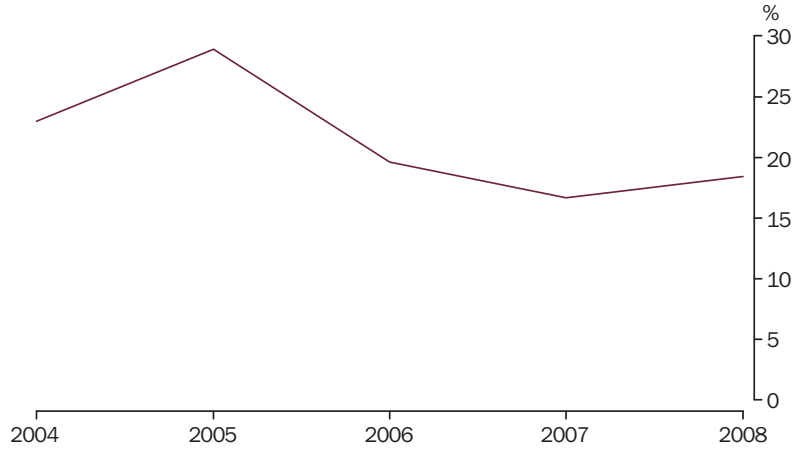
New South Wales traded the largest volume of water during 2008–09. Within the state, 1,286 GL were traded in permanent trades and 871 GL in temporary trades. New South Wales also traded 560 GL to other states in 2008–09.

Victoria was also a major water trader in 2008–09. Within the state, 252 GL of permanent trades occurred, as well as 344 GL of temporary trades. Victoria also traded 30 GL to South Australia during the year.

The Australian government also purchases water entitlements, through the Restoring the Balance in the Murray-Darling Basin program, which aims to protect or restore the environmental assets of the basin. By 30 June 2009, the program had purchased 64 GL of water, and the government had exchanged contracts for a further 382 GL.

Marine and coastal waters

Australian fish stocks overfished and/or subject to overfishing



Source: Australian Bureau of Agricultural and Resource Economics (ABARE) and Bureau of Rural Sciences (BRS), 2009, *Fishery Status Reports 2008*; BRS, 2008; 2007, *Fishery Status Reports 2007; 2006.*

Australia's coastal and marine regions support a large variety of species, many of which are only found in this country's waters.

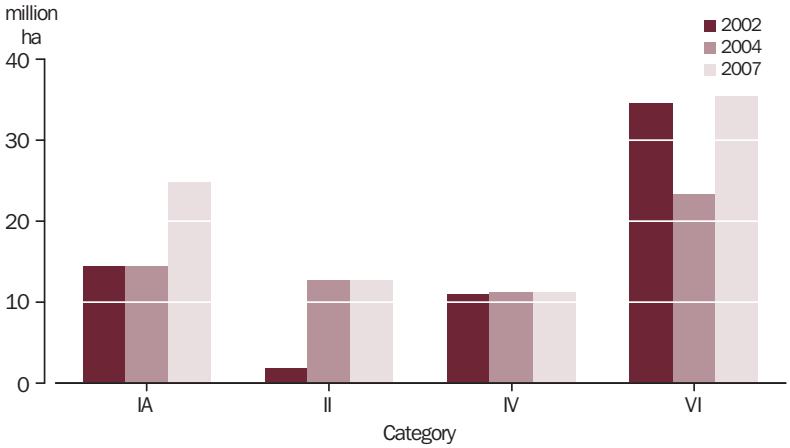
The Bureau of Rural Sciences has produced fishery status reports for those fish stocks managed wholly or in part by the Australian Fisheries Management Authority (AFMA) since 1992. Between 1992 and 2003, reports were not compiled each year, and reports were compiled for the 2000–01 and 2002–03 financial years, rather than calendar years within this period.

The fishery status report for 1996 reported that 6% (three of 48 surveyed stocks) of fish stocks were overfished (referring to the number of fish left within a stock) and/or subject to overfishing (referring to the amount of fishing a stock is experiencing) during that year. Between 1996 and 2005, the status reports showed a trend of increasing overfishing, with the proportion of fish stocks overfished and/or experiencing overfishing peaking at 29% (24 of 83 stocks) in 2005.

Since 2005, the number of stocks overfished and/or experiencing overfishing has decreased, to 18 of a total of 98 surveyed stocks (18%) in 2008.

Marine and coastal waters

Commonwealth marine parks and protected areas



Note: Categories IB, III and V are not shown because there were no Commonwealth marine Protected areas in these categories in 2002, 2004 or 2007.
Source: Department of the Environment, Water, Heritage and the Arts (DEWHA), *Collaborative Australian Protected Area Database 2002 and 2004;* DEWHA, *Commonwealth marine protected areas estate, <http://www.environment.gov.au/coasts/mpa/commonwealth/manage/index.html>, viewed Oct 2009.*

Efforts to preserve Australia's marine environment include the establishment of a system of protected areas and guidelines to select and manage protected areas. Australia uses the International Union for the Conservation of Nature's (IUCN) seven-category system to classify its protected areas. The seven categories are[1]:

- Category IA – Strict Nature Reserve: Protected Area managed mainly for science.
- Category IB – Wilderness Area: Protected Area managed mainly for wilderness protection.
- Category II – National Park: Protected Area managed mainly for ecosystem protection and recreation.
- Category III – Natural Monument: Protected Area managed for conservation of specific natural features.
- Category IV – Habitat/Species Management Area: Protected Area managed mainly for conservation through management intervention.
- Category V – Protected Landscape/Seascape: Protected Area managed mainly for landscape/seascape conservation and recreation.
- Category VI – Managed Resource Protected Areas: Protected Area managed mainly for the sustainable use of natural ecosystems.

The graph above only relates to marine reserves managed by Australia's federal (Commonwealth) government. Australia manages other marine protected areas through its state governments.

The total number of Commonwealth marine reserves in Australia and its external territories increased from 17 in 2002 to 28 in 2007. This equated to an area increase of 37% or 22.6 million hectares (ha), to a total of 84.3 million hectares in 2007.

Each marine reserve may be split up into two or more "management zones", so that a single reserve can be classified under more than one IUCN category.

Australia's largest marine reserve managed by the Commonwealth government is the Great Barrier Reef Marine Park, which has four management zones and encompasses a total area of over 34 million hectares.

1. IUCN, 2000, Application of IUCN Protected Area Management Categories: Draft Australian Handbook.

Landscape

Australia's population continues to increase, both in numbers and in affluence, putting great pressure on land and resources. Since European settlement in 1788, the way in which people use the land has significantly changed Australia's natural systems and landscapes. Some land management practices place enormous pressures on the land which can result in damage to ecosystems, reductions in biodiversity and degradation of soils and waterways.

This section is divided into three main parts:

- **Land**: Australia's landscape has been highly modified since European settlement. Native vegetation, which provides a protective cover for the land, has been removed or degraded in many areas due to urbanisation, agriculture, mining, pastoralism and infrastructure development. Altering land from its natural state inevitably results in changes to soil health and landscape functionality. If persistent, these changes can lead to environmental problems and rapid deterioration of both aquatic and terrestrial ecosystems, which can also have economic and social impacts.

- **Forest:** Land clearing has caused a dramatic decrease in Australia's native forest since European settlement. Although the clearing of native forests can be useful for the purposes of agriculture or urban development, native forests provide valuable services including:

    - contributing to global carbon cycling
    - conserving and maintaining soil and water resources
    - providing habitat for animals and other plants
    - providing recreational areas for human use
    - providing income for the forestry industry.

    In order to be sustainable, native forest management must consider all of the above factors. Plantations allow Australia's forest industries to expand, while preserving native forest resources. Australia's total hardwood plantation area has expanded significantly over recent years.

- **Biodiversity**: Australia is home to more than one million species, many of which are endemic – that is, they are found only in Australia. Globally, Australia is recognised as one of 17 "mega-diverse" countries, with ecosystems of exceptional variety and uniqueness. Changes to the landscape and native habitat as a result of human activity have put many of these unique species at risk. Ideally, the trends included in this section would consider all Australian biodiversity – the abundance and diversity of micro-organisms, plants and animals, the genes they contain and the ecosystems which they form. To measure change as comprehensively as this would be difficult, if not impossible, and so here we focus on four trends. These trends are closely linked to the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) and include: Parks and protected areas, threatened fauna, threatened flora and threatened ecological communities.

Land

Land use 2001–2002

	Area (km^2)	% of total
Conservation and natural environments	2,684,877	34.92
Production from relatively natural environments		
Grazing natural vegetation	4,194,721	54.56
Production forestry	133,064	1.73
Production from dryland agriculture and plantations		
Plantation forestry	16,879	0.22
Dryland agriculture and grazing	466,445	6.07
Production from irrigated agriculture	30,535	0.4
Intensive uses	15,984	0.21
Mining	1,366	0.02
Water	134,869	1.75
No data	9,763	0.13
Total	**7,688,503**	**100**

Source: Bureau of Rural Sciences, 2006, *2001–2002 Land Use of Australia, Version 3.*

Almost two-thirds of land in Australia has been modified for human uses, primarily grazing of natural vegetation. Clearing of native vegetation continues to occur for agriculture, plantation forestry, and urban development.[1]

The loss of native vegetation and habitat is a major threat to Australia's environment.

Land uses vary in the degree of pressure they place on the environment. Generally environmental impacts increase as land use intensifies – from grazing natural vegetation to dryland agriculture and plantations and irrigated agriculture. Intensive uses such as mining and urban development involve the greatest level of modification and thus generally have the greatest environmental impact.

Intensive uses account for less than 1% of total land use. However, their impact is often highly concentrated. For example, the environmental impacts of urban development are a major concern in coastal areas near capital cities where growing populations are increasing demand for housing near the coast.[1]

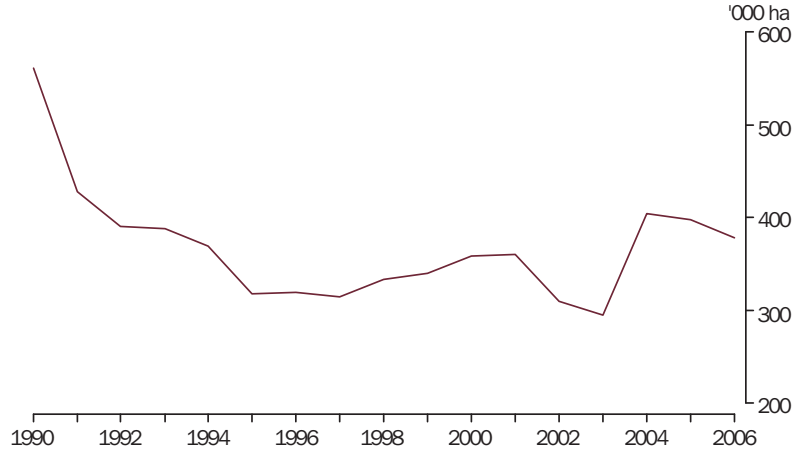
Grazing accounts for just over half of all land use. Environmental issues associated with sheep and cattle grazing include habitat loss, surface soil loss, salinity, and soil and water quality issues. Drought condition in 2002–03 exacerbated soil loss, leading to the highest dust storm activity since the 1960s.[1]

Land classified as "conservation and natural environments" accounts for just over a third of Australia's area. About 12% is formally protected in reserves or protected areas.[2]

1. Department of the Environment, Water, Heritage and the Arts, 2006, *Australia State of the Environment 2006.*
2. See page 86 of *Australia's Environment: Issues and Trends 2010.*

Land

Land clearing



Source: Department of Climate Change, 2009, *National Inventory Report 2007 Volume 2*.

Vast areas of native vegetation have been cleared since Europeans first settled in Australia in 1788.

Since 1990, although land clearing has continued, the rate of forest land conversion has decreased by more than one-third or 182.6 thousand hectares. The figures do not distinguish between the clearance of native or non-native vegetation.

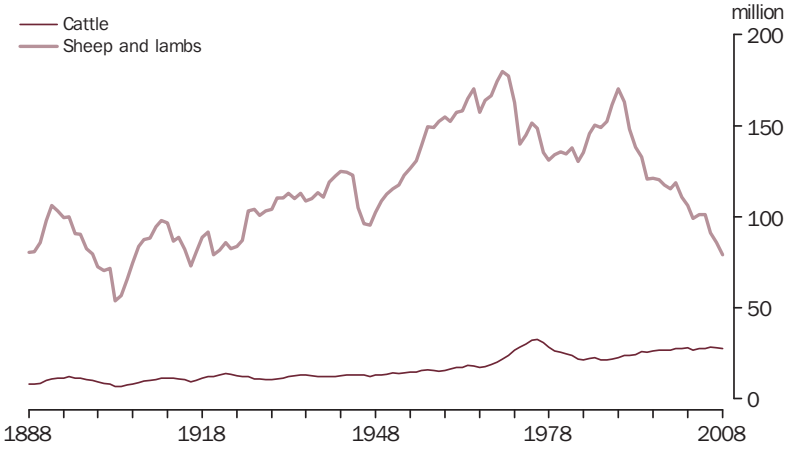
The clearance of native vegetation is a significant threat to terrestrial biodiversity. Other threats to biodiversity include deterioration of soil and water quality, increased prevalence of dryland salinity, the spread of weeds and feral pests and climate change.

Australia's biodiversity is unique and globally significant, with Australia being home to many endemic plants and animals, that is, they are found nowhere else in the world. Australia is recognised as one of only 17 'mega-diverse' countries, with ecosystems of great biological significance. This group of mega-diverse countries covers less than 10% of the global surface, but supports more than 70% of the earth's biological diversity.

Land clearing also has implications for greenhouse gas emissions. Refer to pages on greenhouse gases in the Atmosphere section.

Land

Livestock grazing pressures, 1888 to 2008

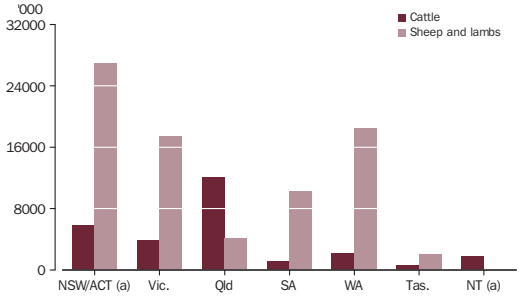


Source: ABS, 2008, *Historical Selected Agriculture Commodities, by State (1861 to Present) 2007 (cat. no. 7124.0);* ABS, 2008, *Principal Agricultural Commodities 2007–08 (cat. no. 7111.0).*

Agriculture is the most extensive form of land use in Australia. Livestock grazing accounts for the largest area of land use in agriculture. Grazing pressures can also result from feral and native animals such as goats, camels, rabbits and kangaroos.

At June 2008, sheep and lamb numbers were reported as 79.2 million, about 8% less than in the previous year. This is the lowest reported estimate since 1920.

Livestock grazing pressures, 2008



(a) Milk cattle and sheep and lamb data not available for NT; Milk cattle data not available for ACT.
Source: ABS, 2008, *Principal Agricultural Commodities 2007–08 (cat. no. 7111.0).*

In 2008, New South Wales had the highest number of sheep (26.8 million), followed by Western Australia (18.4 million) and Victoria (17.5 million). Queensland had the highest number of cattle (12.2 million), followed by New South Wales (including the Australian Capital Territory) (5.8 million), and Victoria (3.9 million).

Meat cattle were reported as 25.3 million in 2008, less than 1% fewer than for 2007. Milk cattle were reported as 2.5 million, a 10% decrease on 2007 numbers. Victoria continued to dominate the dairy industry with 62% of Australia's total dairy herd.

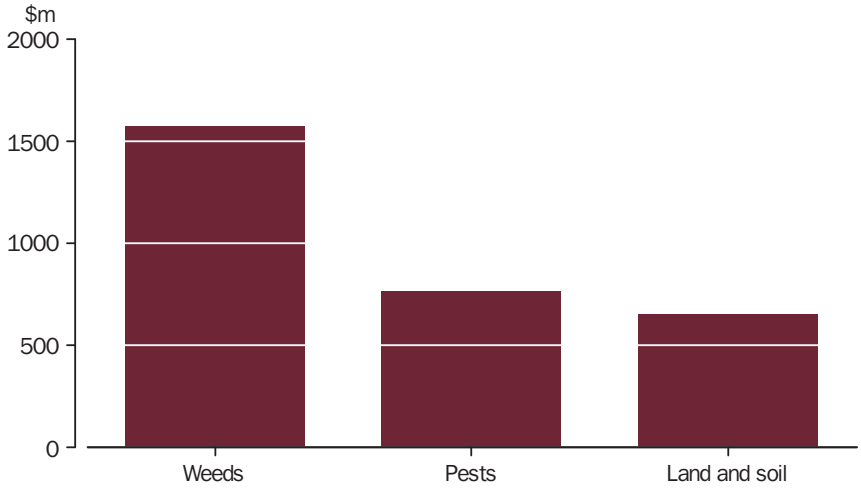
Although the numbers of cattle and sheep have not increased in recent times, they continue to place pressure on the land.

The impact of grazing varies in different parts of Australia. In the higher rainfall and irrigated areas, livestock grazing has led to the replacement of large areas of native vegetation with more productive introduced pastures and grasses. Grazing also modifies soil structure and leads to soil compaction.

In the arid and semi-arid areas of Australia, despite lower stock densities, the impact of grazing on biodiversity can be greater than in high rainfall zones. The low productivity of arid and semi-arid areas limit resources and stock compete with native animals for food and water. The provision of water through bore holes, earth tanks and dams has resulted in grazing occurring in areas previously unsuitable for livestock.

Land

Farm expenditure on Natural Resource Management, 2006–07



Source: ABS, 2008, *Natural Resource Management on Australian Farms 2006–07 (cat. no. 4620.0).*

Australian farmers reported spending almost $3 billion on Natural Resource Management (NRM) during the 2006–07 financial year. More than half ($1.57 billion) was spent on management of weed related issues. Animal and insect pest management was the next highest category of spending, followed by management of land and soil.

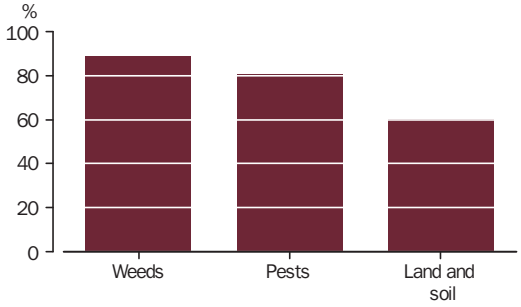
The primary weed-related problem reported by farmers in 2006–07 was decreased value of production. Decreased value of holding and increased fire risk were two other major weed-related concerns reported.

To prevent or manage weed issues, almost 89% of farmers undertook activities such as application of herbicides, pulling, manual removal or chipping, slashing, cutting or mowing, crop or grazing management, cultivation or burning.

Animal and insect pest management on farms accounted for a total of $768 million in 2006–07. Decreased crop production (including crop damage) and decreased livestock production were the two major pest-related problems reported by farmers.

More than 80% of farmers reported undertaking activities to prevent or manage pest-related issues. The most common management practices were use of pesticides or insecticides, shooting or trapping, baiting and crutching.

Farms reporting NRM activities, 2006–07

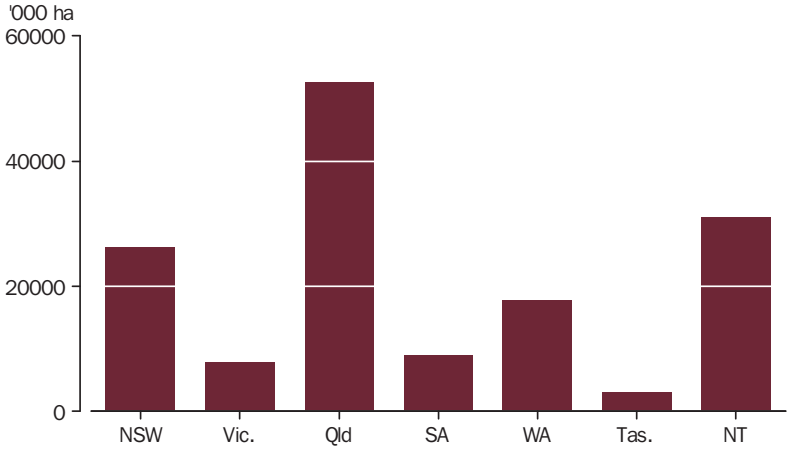


Source: ABS, 2008, *Natural Resource Management on Australian Farms, 2006–07 (cat. no. 4620.0).*

The major issues affecting the condition of soil and land on Australian farms in 2006–07 were erosion, soil compaction, soil acidity and surface waterlogging. In that year, farmers spent $649 million to prevent or manage such issues.

Forest

Area of native forest by state, 2006



Note: ACT native forest area (123,000 ha) too small to show.
Source: Bureau of Rural Sciences, 2008, *Australia's State of the Forests Report 2008.*

Forests are classified as land with trees with an actual or potential height greater than two metres and 20% crown cover.

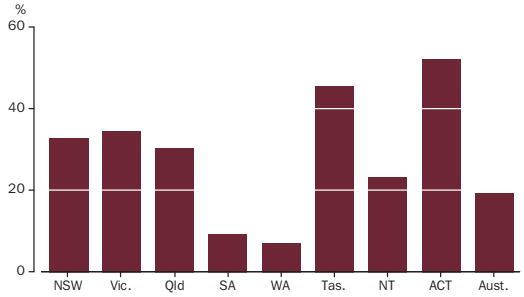
It is estimated that when Europeans settled Australia in 1788, forests covered one-third of the continent. This had fallen to less than one-fifth (19%) in 2006.

In 2006, Australia's forested area totalled 149.2 million hectares (ha). Native forests accounted for 147.4 million ha and plantation forests covered 1.8 million ha.[1]

One of the most important uses of native forests is their significance for biodiversity conservation. More than 16,500 plants and 3,800 animals have been identified as forest-dependent[2], and 1287 forest-dwelling species are listed as threatened (i.e. vulnerable, endangered or critically endangered) under the Australian *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act).[3] Sixteen per cent of Australia's native forests were formally protected in nature conservation reserves in 2006.[4]

Another value of native forests is their economic worth to the forestry and wood products manufacturing industries.

Native forest cover as a proportion of area, 2006



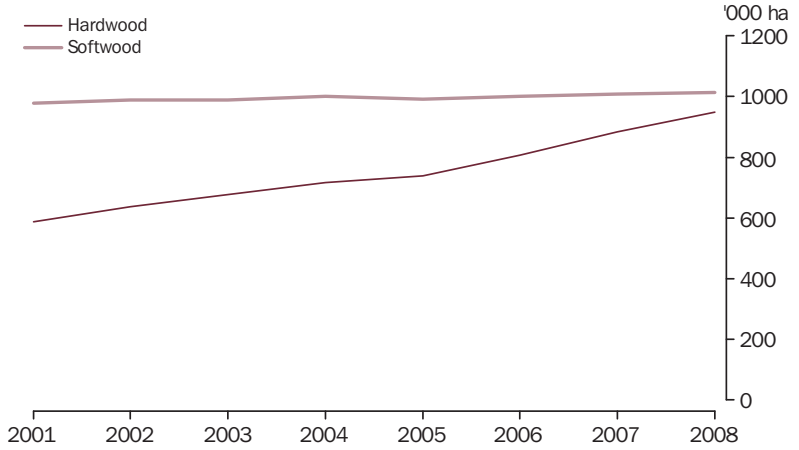
Source: ABS, 2008, *2008 Year Book Australia (cat. no. 1301.0);* Bureau of Rural Sciences, 2008, *Australia's State of the Forests Report 2008.*

The Australian Capital Territory and Tasmania had the smallest area of total native forest of all states and territories in 2006, but the largest area of native forest as a proportion of the state/territory area (52% and 46%, respectively).

1. One hectare (ha) = 10,000m^2. 100 ha = 1 km^2. Australia's land area is approximately 768,800,000 ha.
2. Bureau of Rural Sciences, 2007, *Australia's Forests at a Glance 2007.*
3. Bureau of Rural Sciences, 2009, *Australia's Forests at a Glance 2009.* See pages 87 and 88 of *Australia's Environment: Issues and Trends 2010* for more information about Australia's threatened faunal and floral species.
4. Bureau of Rural Sciences, 2008, *Australia's State of the Forests Report 2008.*

Forest

Hardwood and softwood plantation forest, 2001 to 2008



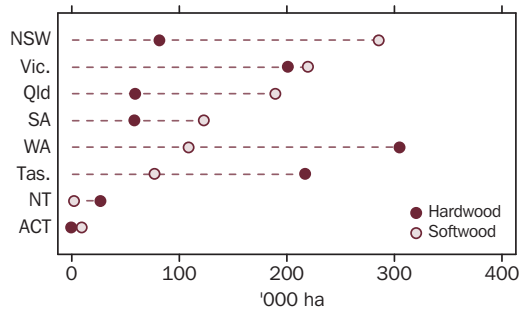
Source: Bureau of Rural Sciences, *National Plantation Inventory Australia, 2002, 2004 and 2005;* Bureau of Rural Sciences, *Australia's Plantations 2006, 2007 and 2009;* Bureau of Rural Sciences, 2003, *Australia's State of the Forests Report 2003.*

Plantations are "intensively managed stands of trees of either native or exotic species, created by the regular replacement of seedlings or seeds".[1] Hardwood plantations are chiefly composed of eucalypt species, while softwood plantations are mainly pine species.

In 2006, plantations accounted for only 1.2% of Australia's total forest cover. However, new hardwood plantations are being established. Between 2006 and 2008, the area planted to hardwood species increased by nearly 18%.

The area planted to hardwood and softwood species varies greatly between states and territories. In most states and territories the area planted to softwoods is greater than that planted to hardwoods. However, in Western Australia, Tasmania and the Northern Territory, the reverse is the case.

Hardwood and softwood plantations by state, 2008



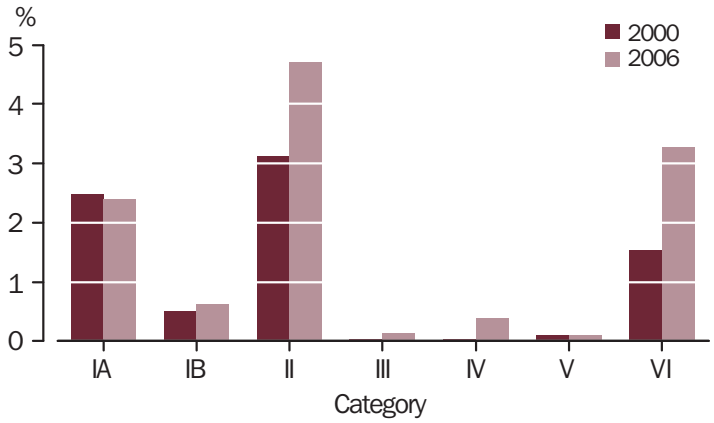
Source: Bureau of Rural Sciences, 2009, *Australia's Plantations 2009 Inventory Update.*

Although the major purpose of plantations is to produce wood for harvest, plantations do have a range of environmental benefits, just like native forests. They can help improve water quality, mitigate dryland salinity and contribute to carbon sequestration (removal of atmospheric CO_2 for use in photosynthesis). They can also provide important habitat for Australia's native plants and animals.[2]

1. Bureau of Rural Sciences, 2009, *Australia's Forests at a Glance 2009.*

Biodiversity

Parks and protected areas as a percentage of Australia's area



Note: 2000 data for Categories III and IV too small to show.
Source: Department of the Environment, Water, Heritage and the Arts, *Collaborative Australian Protected Area Database, <http://www.environment.gov.au/parks/nrs/capad/index.html>, last viewed October 2009.*

Australia employs the International Union for the Conservation of Nature (IUCN) protected area classification scheme. This system groups protected land into the following seven categories[1]:

- Category IA – Strict Nature Reserve: Protected area managed mainly for science.
- Category IB – Wilderness Area: Protected area managed mainly for wilderness protection.
- Category II – National Park: Protected area managed mainly for ecosystem protection and recreation.
- Category III – Natural Monument: Protected area managed for conservation of specific natural features.
- Category IV – Habitat/Species Management Area: Protected area managed mainly for conservation through management intervention.
- Category V – Protected Landscape/Seascape: Protected area managed mainly for landscape/seascape conservation and recreation.
- Category VI – Managed Resource Protected Areas: Protected area managed mainly for the sustainable use of natural ecosystems.

From 2000 to 2006, Australia's terrestrial protected areas expanded by 28 million hectares. In 2006, Australia's 8,780 terrestrial parks and protected areas extended across 89.5 million hectares or 12% of the country's land area. In 2006, most of Australia's terrestrial protected areas were owned by state governments. Only six were managed by Australia's federal (Commonwealth) government, but these included the ecologically and culturally significant Kakadu and Uluru-Kata Tjuta National Parks.

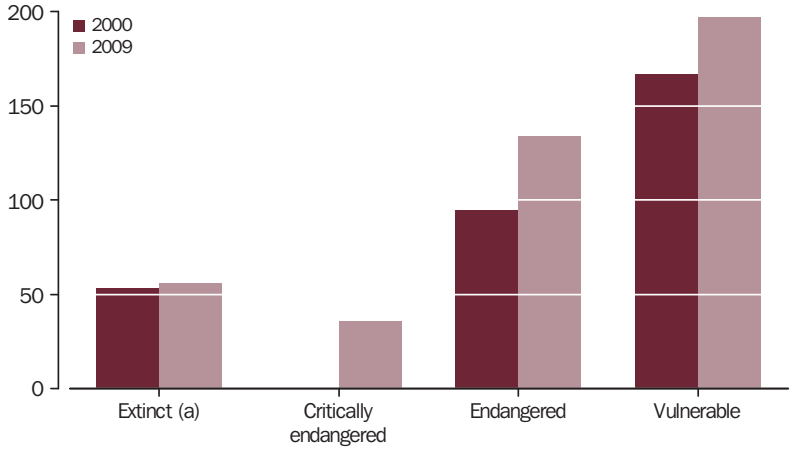
Of the 2013 protected areas not owned by government, 21 were Indigenous Protected Areas and 1992 were privately owned. However the privately owned areas covered only 0.3% of Australia's area while the Indigenous Protected Areas covered 1.9%[2].

Category VI areas showed the largest area increase between 2000 and 2006, with 13.5 million hectares of new protected area. This increase was equivalent to almost 1.8% of Australia's total area. Category II areas also showed a substantial increase between 2000 and 2006, of 12.2 million hectares, about 1.6% of Australia's total area. The majority of this increase (6.4 million hectares) occurred between 2004 and 2006.

1. IUCN, 2000, *Application of IUCN Protected Area Management Categories: Draft Australian Handbook.*
2. Department of Environment, Water, Heritage and the Arts, *Ownership of protected areas, <http://www.environment.gov.au/parks/nrs/about/ownership.html>, last viewed October 2009.*

Biodiversity

Threatened fauna species



(a) Includes the category 'extinct in the wild'.
Note: The category 'conservation dependent' is not shown since figures are too small to show. There were 0 conservation dependent species on the threatened fauna list in 2000 and 3 in 2009
Source: Department of the Environment, Water, Heritage and the Arts, *EPBC Act List of Threatened Fauna, <http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna>, viewed Sep 2009.*

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) classifies listed threatened species into six categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and conservation dependent.

At the commencement of the EPBC Act in 2000, the list of threatened fauna consisted only of those previously listed under the Endangered Species Protection Act 1992. Since that time, more species have been added to the list.

Since the introduction of the EPBC Act, the number of threatened fauna has risen by 35%, from 315 to 426 in 2009. In 2009, almost half (47%) the species on the list were vulnerable, 40% were endangered or critically endangered, and 13% were extinct or extinct in the wild.

Together, birds and mammals accounted for the majority of vulnerable and endangered species, and almost half the extinct species were mammals.

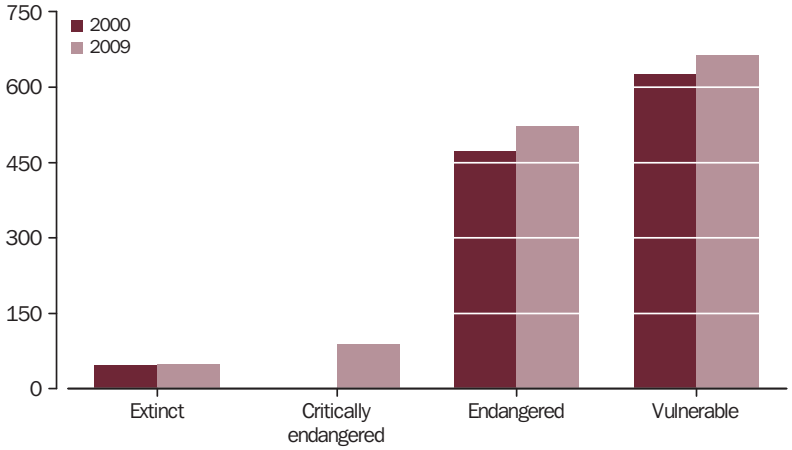
It is important to note that changes to the threatened species list since 1990 may reflect taxonomic revisions, curation of collections, data-basing information and field investigations and do not necessarily represent a change in the conservation status of the fauna.

List of threatened fauna, 2009	
Extinct	Frogs (4)
	Birds (23)
	Mammals (27)
	Other animals (1)
Extinct in the wild	Fishes (1)
Critically Endangered	Fishes (3)
	Frogs (2)
	Reptiles (2)
	Birds (6)
	Mammals (4)
	Other animals (19)
Endangered	Fishes (16)
	Frogs (14)
	Reptiles (14)
	Birds (41)
	Mammals (35)
	Other animals (14)
Vulnerable	Fishes (25)
	Frogs (12)
	Reptiles (38)
	Birds (61)
	Mammals (54)
	Other animals (7)
Conservation dependent	Fishes (3)
Total	**Fauna (426)**

Source: Department of the Environment, Water, Heritage and the Arts, *EPBC Act List of Threatened Fauna, <http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna>, last viewed September 2009.*

Biodiversity

Threatened flora species



Note: The categories 'extinct in the wild' and 'conservation dependent' are not shown since 0 species fell into these categories in 2000 or 2009.
Source: Department of the Environment, Water, Heritage and the Arts, *EPBC Act List of Threatened Flora, <http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora>, last viewed September 2009.*

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) classifies listed threatened species into six categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and conservation dependent.

Since the commencement of the EPBC Act, the number of listed threatened flora has risen by 15%, from 1,147 in 2000 to 1,324 in September 2009. In 2009, there were 24 eucalypt species listed as endangered and 49 listed as vulnerable. Two species of wattle were listed as extinct, three as critically endangered, 29 as endangered and 44 as vulnerable.

Variations to the list under the EPBC Act can be made by the Australian Government Minister for the Environment, Water, Heritage and the Arts following consideration of their conservation status by the Threatened Species Scientific Committee.[1] Thus, changes need to be treated cautiously. Species can be removed or added because of improved knowledge or sometimes new species are discovered, or those thought to be extinct are rediscovered.

To assist the conservation of listed threatened species, the EPBC Act provides for the identification of key threatening processes, the registration of threatened ecological communities and the creation of recovery plans and threat abatement plans.[1]

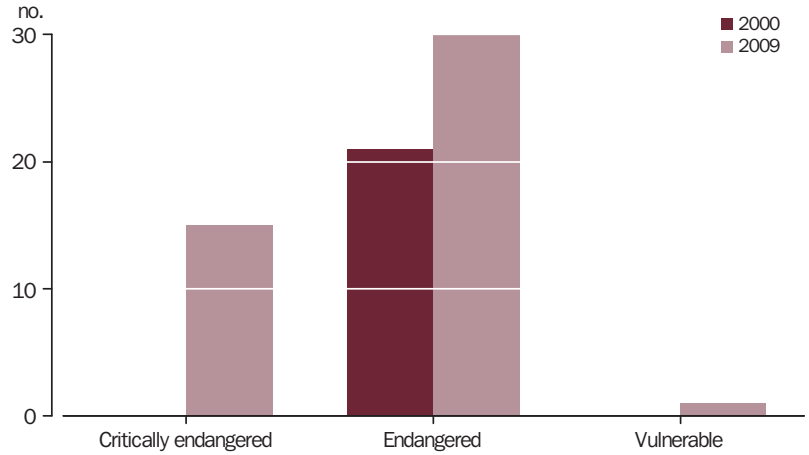
List of threatened flora, 2009	
Extinct	48
Extinct in the wild	0
Critically endangered	89
Endangered	523
Vulnerable	664
Conservation dependent	0
Total	**1,324**

Source: Department of the Environment, Water, Heritage and the Arts, *EPBC Act List of Threatened Flora, <http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora>, last viewed September 2009.*

1. Department of the Environment, Water, Heritage and the Arts, *Threatened Species Scientific Committee, <http://www.environment.gov.au/biodiversity/threatened/committee.html>, last viewed November 2009.*

Biodiversity

Threatened ecological communities



Source: Department of the Environment, Water, Heritage and the Arts (DEWHA), *EPBC Act List of Threatened Ecological Communities, <http://www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl>, last viewed Sep 2009.*

Another measure of environmental condition includes recording the number of ecological communities[1] threatened with extinction. Scientific committees examine the case for listing ecological communities. The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) classifies listed threatened communities into three categories: critically endangered, endangered and vulnerable.

The listed communities are not necessarily the only ones in danger of extinction. To be listed a community must undergo significant investigation and survey work as part of the assessment of the scientific committee, but it is likely that other communities are also under threat of extinction.

The number of threatened communities rose from 21 in 2000 to 46 in 2009. However, these increases may reflect improved information and field investigations and do not necessarily represent a change in conservation status of ecological communities. Of those listed as critically endangered three are in New South Wales, two in Queensland, three in South Australia, three in Victoria and one in Tasmania. Of those listed as endangered five are in New South Wales, one each in Victoria and Queensland and 16 in Western Australia. The only community listed as vulnerable is in Tasmania. Additionally, seven endangered communities and three critically endangered communities cross state borders.

List of threatened ecological communities, 2009	
Critically endangered	15
Endangered	30
Vulnerable	1
Total	**46**

Source: DEWHA, *EPBC Act List of Threatened Ecological Communities, <http://www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl>, viewed Sep 2009.*

The EPBC Act protects Australia's native species and ecological communities by providing for[2]:

- identification and listing of species and ecological communities as threatened
- development of conservation advice and recovery plans for listed species
- recognition of key threatening processes, and
- where appropriate, reducing the impacts of these processes through threat abatement plans.

[1] Unique and naturally occurring groups of plants and animals.

[2] DEWHA, *Biodiversity conservation, <http://www.environment.gov.au/epbc/protect/biodiversity.html>, last viewed November 2009*

Appendix A – Frameworks and indicators

Environmental reporting involves a range of physical, chemical, biological and/or socioeconomic indicators that represent the key elements of complex ecosystems or environmental issues.

Selecting which indicators to focus on depends on which model or framework is used to examine environmental issues or progress. Many different approaches are used to observe environmental trends depending on the context and purpose. There is no universal set of environmental indicators and the selection of different indicators varies by country and by region. For example, a country whose economy relies heavily on fisheries will focus on trends such as level of fish stocks and marine pollution levels, while a landlocked country will be more interested in trends such as agricultural land use and air pollution.

Environmental indicators are often grouped into different types including:

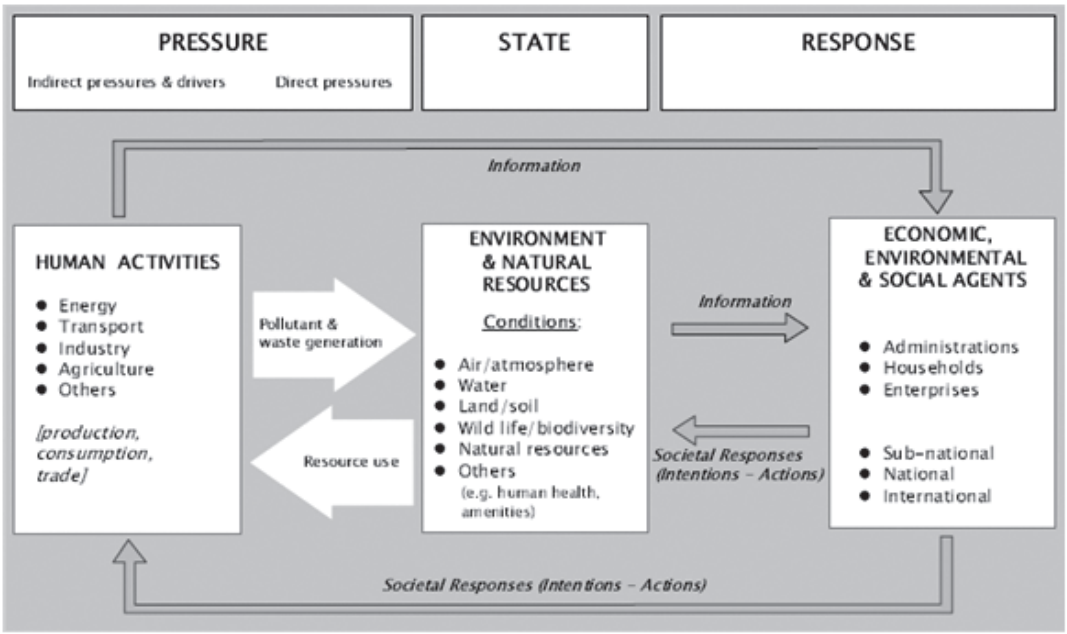
- state of the environment indicators, which reflect the quality of the environment
- sustainable development indicators, which are long-term measures
- environmental economic and accounting indicators, which evaluate cost-benefits.

Some of the most common approaches are outlined below.

Pressure–state–response model

A popular environmental model is the Organisation for Economic Co-operation and Development's (OECD's) pressure–state–response (PSR) framework. The PSR framework is based on the linkages between human activities, the state of the environment and the societal and economic responses to environmental change.

OECD Pressure-State-Response model



Source: OECD (2003)

Using this approach, indicators are classified according to whether they signal:

- Pressure indicators – which describe the pressures from human activity that affect the natural environment.

- The state (or condition) indicators – which measure the quality of the environment and the functioning of important environmental processes.

- Response indicators – which identify the efforts by society to address the pressures.

The OECD warns that the PSR model tends to suggest linear relationships in the human activity-environment interaction, which may obstruct the view of more complex relationships in ecosystems and in environment-economy interactions.

State of the Environment reporting

The OECD's PSR model provides the basis for the Australian Government's State of the Environment (SoE) reporting. Described as a national stocktake of the Australian environment, SoE reports have been released five-yearly since 1996. SoE 2006 features a comprehensive suite of key environmental indicators, developed by independent experts, for each of its environmental themes – Atmosphere, Land, Inland Waters, Coasts and Oceans, Biodiversity, Human Settlements, Natural and Cultural Heritage, and Australia's Antarctic Territories. Most state and territory governments in Australia prepare SoE reports on a regular basis and it is a legislative requirement in New South Wales, Victoria, the Australian Capital Territory, Tasmania, Queensland and South Australia. SoE reports can be found at: <http://www.environment.gov.au/soe/index.html>.

Sustainability Reporting Frameworks

The indicators used for sustainability reporting differ from SoE reporting as they are based on different models that combine social, economic and environmental trends, and the inter-relationships between these systems. The OECD has taken special responsibility for leadership in sustainable development reporting. Most OECD governments have national sustainable development strategies in place, prepared as part of the United Nations Programme for Action for Sustainable Development, Agenda 21, signed at the Rio Earth Summit in 1992.

Australian Headline Sustainability Indicators

Australia developed its National Strategy for Ecologically Sustainable Development (NSESD) in 1992 to address many key areas for action identified in Agenda 21. The NSESD defines ecologically sustainable development as "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased".

In 2001, Commonwealth Ministers endorsed a set of headline sustainability indicators for Australia, selected to collectively measure its national performance against the core objectives of the NSESD. The 2002 publication *Are We Sustaining Australia: A Report Against Headline Sustainability Indicators* was the first report against these headline sustainability indicators. Comparing successive sets of indicators will help to determine Australia's progress towards sustainability. The report is available from the Department of the Environment, Water, Heritage and the Arts website at: <http://www.environment.gov.au/esd/national/indicators/report/index.html>.

Other sustainability reporting frameworks include The Natural Step (discussed below), as well as those developed for specific industries and agendas such as The Montreal Process for the Conservation and Sustainable Management of Temperate and Boreal Forests (<http://www.mpci.org>), and Agricultural Sustainability Indicators for Regions of South Australia (<http://www.pir.sa.gov.au/pirsa/communities>).

The Natural Step

The Natural Step (TNS) Framework is a science and systems-based approach to organisational planning for sustainability. It provides a practical set of criteria that can be used to direct social, environmental, and economic actions. More information is at: <http://www.naturalstep.org>.

Decoupling indicators

Decoupling indicators monitor the extent to which economic growth is becoming decoupled from pressures on the environment, in order to make an assessment of whether levels of growth are sustainable in the longer term. An example of this might be when a developed nation experiences economic growth without a corresponding increase in its greenhouse gas emissions. This sort of assessment is relatively straightforward in some cases, such as the sustainability of fish stocks. In other cases, such as the emission of air pollutants, government targets can be used as a proxy for the environmental limit. In other cases, such as resource use, further research is needed before either limits or targets can be established. Caution is required when reporting on decoupling indicators, which may appear to convey a positive message although in practice the cumulative impact of the pressure on the environment is unsustainable at a national, local or seasonal level. For example, the link between water use and its impact on the environment is extremely sensitive to when and where the water is extracted, as well as the total amount extracted. For example, taking water out of the Murray-Darling Basin, which lowers the water level at certain times can affect the breeding patterns of fish and birds that live in or near those rivers. The OECD Environment Program has published a report on "Indicators to measure decoupling of environmental pressure from economic growth" (<http://www.oecd.org/dataoecd/0/52/1933638.pdf>).

Community environmental reporting – Local Agenda 21

In 1992, the United Nations released a ground-breaking action plan for sustainable development called Agenda 21. Agenda 21 is a blueprint that sets out actions we can contribute to global sustainability in the 21st century. It recognises that most environmental challenges have their roots in local activities and therefore encourages Local Governments to promote local environmental, economic and social sustainability by translating the principles of sustainable development into strategies that are meaningful to local communities (<http://www.idrc.ca/en/ev-9322-201-1-DO_TOPIC.html#begining>). A guide has been prepared in Australia to provide local councils and communities they represent with guidance and direction in planning and implementing a Local Agenda 21 approach (<http://www.environment.gov.au/esd/la21/manual/pubs/manual.pdf>).

In South Australia, councils have developed a practical guide for using community indicators to monitor the strategic directions of a local government area or region or to measure progress and sustainability of a local council. See <http://www.onkaparingacity.com/web/page?pg=2718>.

Measures of Australia's Progress model

The ABS' *Measures of Australia's Progress* (MAP) provides 14 headline indicators to measure economic, social and environmental progress.

MAP 2006 environmental headline indicators are:

- threatened birds and mammals
- annual area of land cleared
- salinity, assets at risk in areas affected, or with a high potential to develop salinity
- water management areas, proportion where use exceeded 70% of sustainable yield
- fine particle concentrations, days health standards exceeded, selected capital cities
- net greenhouse gas emissions.

The headline indicators are concerned with assessing dimensions of Australia's progress, rather than explaining the underlying causes of change. MAP's supplementary indicators are intended

to supplement the information provided by the headline indicators. For the environment, they included trends in threatened species, mammalian extinctions, species-threatening invasive animals, weeds of national significance distribution, native forest area, water diversions in the Murray-Darling Basin and days when ozone concentrations exceeded guidelines.

Composite (or aggregated) indicators

Composite indicators combine disparate measures of progress into just one number. For example, to measure the quality of life in a nation, approaches such as the Genuine Progress Indicator (GPI), attempt to adjust traditional measures of economic activity, such as gross domestic product (GDP), to account for changes to environmental and social capital. For example, a GPI might begin with GDP and then make allowances such as taking out spending to offset social and environmental costs and accounting for longer term environmental damage and the depreciation of natural capital. The Australia Institute has calculated a Genuine Progress Indicator for Australia. The full report can be accessed at the following website: <https://www.tai.org.au/documents/dp_fulltext/DP14.pdf>.

Composite indicators are valued for their ability to integrate large amounts of information into a single ranking that can be easily understood. However, because their construction is not straightforward they can provide misleading information.

The Ecological Footprint

The Ecological Footprint is another example of a composite indicator. It varies from SoE reporting and sustainability reporting in that it acknowledges ecological limits by suggesting whether a population is living within its ecological means. It also places less emphasis on the social and economic aspects of sustainability. Expressed as an area of land, the Ecological Footprint is a measure of how much individuals, organisations, cities, regions and nations, or humanity as a whole, consumes and compares this amount to the available resources.

The more natural resources consumed per head of population and the more waste that is produced, the larger the 'footprint' (area of land). Ecological footprint estimates are based on assumptions that may not be applicable to all places. World Wide Fund (WWF) - Australia has created a Footprint calculator to find out how you can reduce your family's and your own ecological footprint (<http://www.wwf.org.au/footprint/calculator/>).

Accounting frameworks

SEEA and SESAME

The *System of National Accounts* (SNA) is an international framework for economic accounting. Australia's national accounts record the essential elements of the Australian economy: production; income; consumption; assets and liabilities; and wealth. The *System of Integrated Environmental and Economic Accounting* (SEEA) complements the SNA by providing an international standard for incorporating environmental and social effects into a national accounting framework. SEEA describes techniques for valuing environmental goods and services that are not part of the market economy, for example, accounting for stocks and flows of natural resources.

The Dutch Government has compiled a System of Economic and Social Accounting Matrices and Extensions (SESAME), which is also an extension to the standard national accounts framework. Key features are data integration and multiple classifications, which provide links (both conceptual and numerical) between monetary and non-monetary units. SESAME can be used to analyse the links between the structure of an economy, people and the environment. Countries such as Canada and Norway use a "capital" approach to measure sustainability where the focus of measurement is on the stocks and flows of different national assets.

Triple bottom line

Triple Bottom Line (TBL) became popular in the late 1990s and describes reporting that goes beyond a financial "bottom line" to also include assessing and reporting environmental and social outcomes. This notion of reporting against economic, social and environmental performance is directly tied to the concept of sustainable development. A number of companies in Australia produce TBL reports.

The CSIRO report, *Balancing Act,* applies the principle of triple bottom line reporting at a national economic sector level for 135 sectors of the Australian economy. The analysis merged the System of National Accounts input-output tables published by the ABS, with a range of social and environmental indicators. More information is available at: <http://www.csiro.au/resources/BalancingAct.html>.

The Department of the Environment, Water, Heritage and the Arts publishes Australian guidelines for environmental reporting of organisations in *Triple bottom line reporting in Australia: a guide to reporting against environmental indicators (2003)*, available at: <http://www.environment.gov.au/sustainability/industry/publications/index.html>.

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