UNIT 1 ENVIRONMENTAL CHANGE AND MANAGEMENT

TOPIC 2
Introducing environmental change and management

2.1 Overview
Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

2.1.1 Introduction
Across the world there are many environmental changes that have been caused by humans, such as pollution, land degradation and impacts on aquatic environments. People have different points of view, or world views, on many of these changes. Climate change is a major environmental change as it impacts on all aspects of the biophysical environment, such as plants and animals; our land; inland water resources; coastal, marine and urban environments. It is vital that we respond intelligently to, and effectively manage, all future environmental changes to minimise negative social and economic impacts.

Human-induced climate change has led to increased severe weather events such as drought. Rivers can dry up, with consequent loss of plant and animal life.
Starter questions

1. The environment supports all life on Earth — humans, plants and animals. As a class, brainstorm examples of environmental changes people have caused, and discuss where these are occurring.
2. Choose one environmental change from the list your class created and discuss the various viewpoints different people, groups or organisations have about it.
3. Brainstorm specific examples of environmental changes people have caused that have been positive, and that have come about by people deliberately and efficiently managing the change.

INQUIRY SEQUENCE

2.1 Overview
2.2 SkillBuilder: Evaluating alternative responses
2.3 How do people interact with the environment?
2.4 Is climate change heating the Earth?
2.5 Can we slow climate change?
2.6 How can we reduce the impacts of climate change?
2.7 Is Australia’s climate changing?
2.8 SkillBuilder: Drawing a futures wheel
2.9 Review

2.2 SkillBuilder: Evaluating alternative responses

WHAT IS INVOLVED IN EVALUATING ALTERNATIVE RESPONSES?

Alternative responses are a range of different ideas or opinions on an issue. Evaluating ideas involves weighing up and interpreting your research to reach a judgement or a decision based on the information.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 Alternative responses to the question ‘Should tourist numbers on Fraser Island be limited?’

Watch this eLesson: Watch this video to learn how to evaluate alternative responses.
Searchlight ID: eles-1744

Try out this interactivity: Use this interactivity to learn how to evaluate alternative responses.
Searchlight ID: int-3362
2.3 How do people interact with the environment?

2.3.1 How much space do we need?

If you gathered together all 7.4 billion humans from around the world and gave each person a space of one square metre, the island of Cyprus, which is approximately 8000 square kilometres, would provide standing room for everyone (see figure 1). Clearly this would be impractical, and providing services to ensure human wellbeing in an area with a density of almost 1 000 000 per square kilometre would be impossible.

While this idea is unrealistic in suggesting that 0.005 per cent of the total space on Earth is sufficient for humanity, it suggests we need to think about how little personal space we actually occupy, and how greatly we impact on the Earth and its biophysical systems.

2.3.2 How do humans interact with the environment?

Over 200 years ago, an English scholar named Thomas Malthus proposed that England’s population growth would eventually outstrip agricultural production. Malthus’s earth-centred environmental worldview foretold of problems with supplies of food and warned that there would be more deaths due to famine and wars over resources. In 1798 he wrote, ‘The power of population is so superior to the power in the earth to produce subsistence for man …’. At the time Malthus wrote his thesis, England was moving into a period known as the Industrial Revolution; a time when the human-centred environmental worldview of the government and leaders of industry considered the earth’s resources as limitless and that the development of the economy should take priority over the preservation of the natural world.

Today, many environments have become overloaded with the growing demands for food, land and other resources. This pressure on biomes and ecosystems has led to land degradation, with a consequent loss of habitats and biodiversity. Further consequences of this change are a reduction in human well-being and a struggle for social justice as land becomes unproductive due to overuse. Nevertheless, it should be remembered that change can be a natural process as well as human-induced.

Some topics that can help us explore change and the need for careful management include marine environments and coasts, the land, inland waters, and urban or built environments (see figure 2).
What are ecological services?

A new view of the relationship between the environment and people is one of an ecological service or ‘what nature provides for humanity’.

Ecological services can be thought of as biological and physical processes that occur in natural or semi-natural ecosystems and maintain the habitability and livelihood of people on the planet. These services are shown in figure 3.

Understanding the link (interconnection) between ecological services and human action is important as it can lead to more sustainable practices. The idea of ecological management takes an earth-centred environmental worldview, promoting stewardship or custodial management. This view considers caring for the land and the ecological services it provides as paramount. By applying this earth-centred viewpoint to human uses and management of the environment, future options for human wellbeing will be sustainable. The question is, ‘how do we evaluate human impacts on the environment and what management strategies can be implemented to reverse damage and create a sustainable future?’ As such, we need to consider the costs and benefits, or more simply, the advantages and disadvantages of changes we make to the environment, as there will be consequences in terms of economic viability and social justice.
What is the ecological footprint?

The ecological footprint is one means of measuring human demand for ecological services. The footprint takes into account the regenerative capacities of biomes and ecosystems, which are described as the Earth’s biocapacity. The footprint is given as a number, in hectares of productive land and sea area, by measuring a total of six factors, as shown in Figure 4. The ecological footprint is a useful indicator of environmental sustainability.

Figure 5 compares the ecological footprint with biocapacity. The elephants represent each region’s footprint (per capita) and the balancing balls represent the size of the region’s biocapacity (per capita). The dark green background represents the gross footprint of regions that exceed their biocapacity, and the light green background represents those regions that use less than their biocapacity.

In 2014 the total ecological footprint was estimated at 1.5 planet Earths, which means that humanity used ecological services at 1.5 times the biocapacity of the Earth to renew them. The 1.5 ecological footprint figure represents an average for all regions of the Earth. However, the United States and Canada, which have an ecological footprint of 7.9, are well above this average. This level of resource use is not sustainable into the future, and raises questions of economic viability, environmental benefit and social justice. Figure 6 shows a map of the Earth’s ecological debt. Note that there is a strong relationship between ecological footprint and a country’s wealth and/or population. For example, the USA and much of Europe and Japan are wealthy countries with large ecological footprints and small biocapacities. China and India are highly populated countries with large ecological footprints and small biocapacities. Australia and New Zealand have minimal ecological footprints because they have relatively small populations and high biocapacities.
What is a sustainable world?

A range of indices have been developed in recent years to examine the link between ecological services, human wellbeing and sustainability. These include the Human Development Index (HDI), the Sustainable Society Index (SSI) and the Happy Planet Index (HPI), and each gives a slightly different perspective on human activity and/or sustainability.

The Sustainable Society Index says that sustainable human action must:

(a) meet the needs of the present generation yet not compromise the ability of future generations to meet their own needs

(b) ensure that people have the opportunity to develop themselves in a free, well-balanced society that is in harmony with nature.

It is worthwhile studying these indices as they put forward many sound ideas about human wellbeing and the sustainability of the ecological services of the natural world.

The Sustainable Society Index gives values to 21 factors across a range of social, political, economic and environmental considerations. Australia rates, for example, highly in clean air and sufficient food and lowly in renewable energy and consumption. For further details see figure 7.
2.3 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Explain

1. Figure 7 represents Australia's situation based on the Sustainable Society Index. Values increase from the centre of the circle outwards. Use the Sustainable Society Index weblink in the Resources tab to find out more about the Index. Then answer the following questions.
   (a) Divide the various factors shown around the circle into the categories human wellbeing, environmental wellbeing and economic wellbeing.
   (b) Explain how these factors are interconnected.
   (c) List the factors that Australia needs to change to be a more sustainable nation. Consider environmental, social and economic criteria from the index to inform your recommendations.
   (d) Suggest reasons why Australia rates poorly in some of these factors.
   (e) In what factors with respect to human wellbeing does Australia rate highly? Why would this be so?

2. Refer to figure 5.
   (a) What reasons can you suggest for the very high environmental or ecological footprint for the United States and Canada?
   (b) How might the three regions with the dark green very high gross footprint improve their biocapacity?
   (c) Why is Australia in such a good position in terms of ecological footprint compared to biocapacity?

Think

3. Use the Forest depletion weblink in the Resources tab to explore information on this topic.
   (a) What aspects of sustainability and the concept of stewardship can you draw from this information?
   (b) Make a list of nations that have an unsustainable level of forest depletion.
2.4 Is climate change heating the Earth?

2.4.1 Climate change and global warming

The world’s climate has been changing for millions of years, but more recently there has been an increase in the concentration of greenhouse gases in the atmosphere, leading to **global warming**. It is believed that human activity, particularly the burning of fossil fuels such as coal and oil, have led to what is known as the **enhanced greenhouse effect**, which is heating the Earth and its atmosphere. The wider consequences of global warming will lead to environmental change across a wide range of biophysical systems. See figure 1.

Climate, which can be defined as the yearly changes in the Earth’s atmosphere, is highly variable over the Earth’s surface. As such, climates in the tropics contrast markedly with climates near the poles.
also varies over extensive periods of time, and scientists have described these changes, which date back millions of years, long before the emergence of the human species, as warm periods and ice ages. Currently the Earth is in a warm period, having moved out of ice age conditions as recently as 6000 years ago. Today it is realised that human activity is increasing the rate of global warming leading to climate change, particularly in the past few hundred years, and this can have serious consequences for the planet (see figure 2).

The greenhouse effect

The greenhouse effect is the mechanism whereby solar energy is trapped by water vapour and gases in the atmosphere, thereby heating the atmosphere and helping to retain this heat, as in a glasshouse. The three most important gases responsible for the greenhouse effect are carbon dioxide, nitrous oxide and methane. Without this greenhouse effect the atmosphere would be much cooler, and ice age conditions would prevail over the planet, making life as we know it impossible (see figure 3).

Human activity and the enhanced greenhouse effect

Changes in the balance of the greenhouse gases are a natural event, leading to the different climatic conditions on the planet as experienced over geological time. The issue today is how much impact human activity is having on the natural cycle of events, and how this activity is leading to climate change and global warming.

The term ‘the enhanced greenhouse effect’ has been developed to show that heating of the atmosphere is moving at a rate that is above what could be expected by natural processes of change (see figure 4). Recent research by government and non-government organisations has indicated that all parts of the world are
vulnerable to the impacts of the enhanced greenhouse effect and associated climate change. Six key risks that have been identified in Australia alone include higher temperatures, sea level rise, heavier rainfall, greater wildfire risk, less snow cover, reduced run-off over southern and eastern Australia, and more intense tropical cyclones and storm surges along the coast.

2.4.2 What can we do?

A switch to renewable energy sources such as solar, wind, water (hydro) and geothermal (heat from inside the Earth’s crust) will lead to sustainable energy use in the future, reduce carbon emissions into the atmosphere and thereby reduce the enhanced greenhouse effect. At the household level, using energy-efficient light bulbs and appliances and purchasing solar panels to produce hot water and electricity can lead to a significant reduction in greenhouse gas emissions. You could even think of purchasing a new motor vehicle that uses electricity or has a higher fuel efficiency rating.

**FIGURE 3 How the greenhouse effect works**

**FIGURE 4 The enhanced greenhouse effect**

1. Heat from the sun
2. Heat trapped by greenhouse gases
3. Heat radiating back into space
4. Greenhouse gases produced by power stations burning fossil fuels
5. Greenhouse gases produced by industry burning fossil fuels
6. Greenhouse gases produced by transport burning fossil fuels
7. Greenhouse gases released by logging forests and clearing land
8. Methane escaping from waste dumps
9. Methane from ruminant (cud-chewing) livestock, e.g. cattle, sheep
10. Nitrous oxide released from fertilisers and by burning fossil fuels
2.4 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What are the differences between climate change and global warming?
2. What is the greenhouse effect and what are the three atmospheric gases responsible for this effect?
3. What would happen to the Earth if there was no greenhouse effect?

Explain
4. What changes have occurred to the Earth’s climate over geological time?
5. Why would sea levels be much lower in an ice age period?

Discover
6. What role do trees play in the carbon cycle and in controlling the level of greenhouse gases?
7. What impacts will global warming, and in particular higher water temperatures, have on a marine ecosystem such as the Great Barrier Reef?

Predict
8. Refer to figure 2, which shows average global temperatures.
   (a) What is the time period shown in the graph?
   (b) In which year did the highest average temperature and lowest average temperature occur?
   (c) What is the projected temperature in 2100?
   (d) What is the general trend shown by the graph?

Think
9. In groups, prepare a report that explains how the enhanced greenhouse effect operates, based on the information in figure 4. Prepare a presentation for the class that includes your suggestions about what we can do to reduce the impacts of the enhanced greenhouse effect.

2.5 Can we slow climate change?

2.5.1 Global action
Climate change is a global phenomenon. The greenhouse gases produced in one country spread through the atmosphere and affect other countries. Action by only a few countries to reduce greenhouse gases will, therefore, have little impact — it requires international cooperation, especially by the largest polluters.

Since the 1990s, countries have met at United Nations Intergovernmental Panel of Climate Change (IPCC) conferences and agreed to take steps to reduce emissions of greenhouse gases. An early conference developed the Kyoto Protocol, an agreement that sets targets to limit greenhouse gas emissions, and 128 countries have agreed to this Protocol. Further conferences in 2009 in Copenhagen, Denmark, 2010 in Cancun, Mexico, and Paris 2015 led to an important new direction, with all countries agreeing to contain global warming within 2 °C. This means that emissions of CO₂, which were at 395 parts per million (ppm) in 2013, must be kept below 550 ppm to reach this target. If no actions (mitigation measures) are taken, temperatures could increase by 5 °C, as shown in figure 1. To date, 192 of the world’s 196 countries have signed the Kyoto
Protocol, however close to half have modified their commitment to reach targets for greenhouse emission reductions set for 2020. The USA has signed the Protocol but has not ratified emission targets and Canada has withdrawn from the Protocol.

To meet the greenhouse gas emissions targets defined by these agreements, countries must make changes that reduce their level of emissions. They can also meet the targets in two other ways:

1. A country can carry out projects in other countries that reduce greenhouse gas emissions and offset these reductions against their own target.
2. Companies can buy and sell the right to emit carbon gases. For example, a major polluter, such as a coal power station, is allowed to emit a certain amount of greenhouse gases. If it is energy efficient, and emits less than its limit, it gains carbon credits. It has the right to sell these credits to another company that is having difficulty reducing its emissions. Companies can also gain credits by investing in projects that reduce greenhouse gases (such as renewable energy), improve energy efficiency, or that act as carbon sinks (such as tree planting and underground storage of CO₂).

2.5.2 Australia’s action

The Garnaut Report 2011 and the findings of the IPCC state that it is in Australia’s national interest to do its fair share in a global effort to mitigate climate change (see table 1). The findings of this report were confirmed at the IPCC meeting in Paris in 2015. The introduction in 2012 by the Australian Government of an emissions trading scheme with a fixed price on carbon for three years and then a floating price led to the introduction of a carbon tax set at $23 per tonne of carbon dioxide emissions. Big businesses and industries that use large amounts of fossil fuels have complained that the tax will affect profits and force the price of goods and commodities higher. In 2015, the new Australian government reversed the decision to support the previously established emissions trading scheme, based on social and economic criteria stating that the carbon tax had increased costs of power to households and businesses.

<table>
<thead>
<tr>
<th>TABLE 1 Potential impacts for each of the three emissions cases by 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions case</td>
</tr>
<tr>
<td>Likely range of temperature increase from 1990 level</td>
</tr>
<tr>
<td>Percentage of species at risk of extinction</td>
</tr>
<tr>
<td>Area of reefs above critical limits for coral bleaching</td>
</tr>
<tr>
<td>Likelihood of starting large-scale melt of the Greenland ice sheet</td>
</tr>
<tr>
<td>Threshold for starting accelerated disintegration of the West Antarctic ice sheet</td>
</tr>
</tbody>
</table>

2.5.3 Taking personal action

Australian households produce about one-fifth of Australia’s greenhouse gases through their use of transport, household energy and the decay of household waste in landfill. This amounts to about 15 tonnes of CO₂ per household per year. (A tonne of CO₂ would fill one family home.) The Australian Conservation Foundation has suggested a 10-point plan (see figure 2) that every Australian household can follow to reduce its level of greenhouse gas pollution.

**FIGURE 2** The Australian Conservation Foundation Plan

1. **Switch to green power**
Choose renewable energy from your electricity retailer and support investment in sustainable, more environmentally friendly energies. Make sure it is accredited GreenPower [electricity produced using renewable resources] — see www.greenpower.gov.au for a list of who qualifies.

![GreenPower](image)

2. **Get rid of one car in your household**
A car produces seven tonnes of greenhouse pollution each year (based on travelling 15,000 kilometres per year). This does not include the energy and water used to build the car — 83,000 litres of water and eight tonnes of greenhouse pollution. So share a car with your family.

3. **Take fewer air flights**
A return domestic flight in Australia creates about 1.5 tonnes of greenhouse emissions (based on Melbourne to Sydney return). A return international flight creates about 9 tonnes (based on Melbourne to New York return). Holiday closer to home.

4. **Use less power to heat your water**
A conventional electric household water heater produces about 3.2 tonnes of greenhouse pollution in a year. Using less hot water will reduce your pollution. Using the cold cycle on your washing machine will save 3 kg of greenhouse pollution. Switching off your water heater when you’re away will also reduce your energy use.

5. **Eat less meat**
Meat, particularly beef, has a very high environmental impact, using a lot of water and land to produce it, and creating significant greenhouse pollution. If you reduce your red meat intake by two 150-gram serves a week, you’ll save 20,000 litres of water and 600 kg of greenhouse pollution a year.

6. **Heat and cool your home less**
Insulate your walls and ceilings. This can cut heating and cooling costs by 10 per cent. Each degree change can save 10 per cent of your energy use. A 10 per cent reduction is 310 kg of greenhouse pollution saved.

7. **Replace your old showerhead with a water-efficient alternative**
This will save about 44,000 litres of water a year and up to 1.5 tonnes of greenhouse pollution from hot water heating (on average).

8. **Turn off standby power**
Turning appliances off at the wall could reduce your home’s greenhouse emissions by up to 700 kg a year.

9. **Cycle, walk or take public transport rather than drive your car**
Cycling 10 kilometres to work (or school) and back twice a week instead of driving saves about 500 kg of greenhouse pollution each year and saves you about $770. Besides, it’s great for your health and fitness!

10. **Make your fridge more efficient**
Ensure the coils of your fridge are clean and well ventilated — that will save around 150 kg of greenhouse pollution a year. Make sure the door seals properly — this saves another 50 kg. Keep fridges and freezers in a cool, well-ventilated spot to save up to another 100 kg a year. If you have a second fridge, turn it off when not in use.
2.6 How can we reduce the impacts of climate change?

2.6.1 Fossil fuels

It has been recognised by climate authorities that global warming is possibly the most important issue impacting on life on Earth at this time and into the future. The burning of fossil fuels, which generate greenhouse gases, is causing the atmosphere to heat up, and it is believed that a sustainable future, in terms of energy use, can be achieved only by reducing the consumption of energy and/or switching to renewable energy forms. While use of fossil fuels is a significant factor in global warming, it should also be realised that there are a number of other human activities that lead to greenhouse gas emissions.
Fossil fuels have been widely used for energy production by human societies since the Industrial Revolution. Burning of wood in fires was the earliest use of fuels, and today coal, oil and gas are the fossil fuels of choice. Much of the energy used in society today for transport, domestic use and all forms of industry is from electricity generated by power stations that are fired by fossil fuels (see figures 1 and 2).

2.6.2 Renewable energy

The alternative and environmentally friendly option to fossil fuels is renewable energy. This includes hydro-power, solar, wind, wave and tidal, geothermal, and bioenergy sources to generate electricity. These sources do not produce greenhouse gases and are replenished in relatively short periods of time (see figure 3). These actions represent a significant change from a human-centred to an earth-centred worldview. This change will lead to a more sustainable use of energy with a significantly lower impact of greenhouse gas emissions on the environment.

Many countries throughout the world are now using or developing sustainable energy industries. The USA, for example, has established the Clean Energy Plan and currently produces 0.54% of its energy needs from solar power, with renewable energy sources comprising 13% of its total electricity generation. In Europe, Germany has made great progress in harnessing renewable energy sources, which today provide 78% of its power needs. Solar energy alone provides 50% of this amount.

In Australia, with expansive desert regions, there is huge potential to generate solar power. In recent years, the installation of solar panels for domestic households has increased, and this has been supported by a Federal Government subsidy scheme, however, currently solar energy accounts for only 0.1% of Australia’s total energy requirements. In other renewable energy fields, wind farms have become more widespread in southern Australia, and there are companies investigating the potential for geothermal energy production.
2.6.3 What can be done in the future?

In 2015, the United Nations Intergovernmental Panel on Climate Change (IPCC) confirmed the 2007 recommendations to reduce greenhouse gas emissions. The recommendations cover a wide range of human activities, with suggestions for management to mitigate global warming (see table 1).

For each of the mitigation actions shown in table 1 there are economic, social and environmental consequences. For example, considering the ‘developing safer and cleaner nuclear energy’ action, there may be positive economic consequences, such as the creation of energy security and job opportunities, but also negative consequences, such as the cost of waste disposal. Similarly, the social and environmental consequences may be positive, such as reduced air pollution, and negative, such as nuclear accidents.

### TABLE 1 Reducing greenhouse gas emissions

<table>
<thead>
<tr>
<th>Ways to reduce greenhouse gas emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy supply</strong></td>
</tr>
<tr>
<td>• Switching from coal to gas</td>
</tr>
<tr>
<td>• Developing safer and cleaner nuclear energy</td>
</tr>
<tr>
<td>• Increasing use of renewables such as hydro-power, solar, wind, wave and tidal, geothermal and bioenergy</td>
</tr>
<tr>
<td>• Carbon Capture and Storage (CCS) at fossil fuel electricity generating facilities</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
</tr>
<tr>
<td>• More fuel-efficient vehicles such as electric, hybrid, clean diesel and biofuels</td>
</tr>
<tr>
<td>• Changing from road to rail and bus transport systems</td>
</tr>
<tr>
<td>• Promoting cycling and walking to work</td>
</tr>
</tbody>
</table>

(Continued)
Ways to reduce greenhouse gas emissions

Buildings
- Installing more efficient lighting and day-lighting systems and electrical appliances for heating and cooling, cooking, and washing
- Increased use of photovoltaic (PV) solar panels
- Improved refrigeration fluids including the recovery and recycling of fluorinated gases

Industry
- More efficient electrical equipment
- Heat and power recovery
- Material recycling and substitution
- Control of gas emissions

Agriculture
- Improved crop yields and grazing land management
- Increased storage of carbon in the soil and reduction of methane gas emissions from livestock manure
- Restoration of cultivated soils and degraded lands
- Improved nitrogen fertiliser application techniques to reduce nitrous oxide emissions
- New bioenergy crops to replace fossil fuels

Forestry/forests
- Planting new forests
- Better harvested wood management
- Use of forestry products for bioenergy to replace fossil fuel use
- Better remote sensing technologies for analysis of vegetation and mapping land-use change

Waste
- Landfill methane recovery
- Waste incineration with energy recovery
- Composting of organic waste
- Controlled waste water treatment
- Recycling and waste minimisation


### 2.6 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**
1. What is meant by the term fossil fuel?
2. List some major renewable energy sources.

**Explain**
3. What would be the negative impacts if all fossil fuels were banned tomorrow?

**Discover**
5. How is ethanol produced as a renewable energy source for power production, and is it sustainable as a renewable energy source?
6. Use the internet to find out about geothermal energy and its potential as a future energy source.

**Predict**
7. Refer to figure 2. What percentage of Australia’s energy currently comes from renewable sources, and by how much is this projected to change by 2019–20?
8. Considering the range of nuclear power plant accidents in the past and their impacts on the environment, how might nuclear energy be managed as a safe energy source into the future?

**Think**
9. Why isn’t the use of fossil fuels sustainable?
10. Select examples of recommendations from the UN IPCC Report in Table 1 that you think you could apply in your everyday living to reduce global warming by greenhouse gas emissions.
2.7 Is Australia’s climate changing?
2.7.1 Impacts of climate change in Australia

Research by government and non-government organisations such as the Bureau of Meteorology (BOM); the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the United Nations Intergovernmental Panel on Climate Change (UN IPCC) in 2014–15 has indicated that Australia is particularly vulnerable to climate change. The consequent changes that will affect all Australian biophysical systems have been identified as eight key risks, which are outlined in figure 1.

The challenge for the future is how to manage these risks to minimise negative consequences for the Australian environment, economy and social systems.

2.7.2 How has Australia’s climate changed and what will it be like in the future?

Australia’s climate is quite variable from one year to the next, and floods and droughts have always occurred. The concern raised by global warming and climate change is the degree of climate variability and the likelihood of more extreme weather events. For instance, will we experience worse floods and droughts...
and more bushfires and severe cyclones, tornadoes and the like? Scientific evidence supports the view that there have been more extreme weather events in recent years and that the climate of Australia has undergone significant regional change. See Figure 2.

FIGURE 2 State of the Climate 2014 report

The State of the Climate 2014 report, produced by the BOM and CSIRO made the following summary points.

- Australia’s climate has warmed by 0.9 °C since 1910, and the frequency of extreme weather has changed, with more extreme heat and fewer cool extremes.
- Rainfall averaged across Australia has slightly increased since 1900, with the largest increases in the northwest since 1970.
- Rainfall has declined since 1970 in the southwest, dominated by reduced winter rainfall. Autumn and early winter rainfall has mostly been below average in the southeast since 1990.
- Extreme fire weather has increased, and the fire season has lengthened, across large parts of Australia since the 1970s.
- Australian temperatures are projected to continue to increase, with more extremely hot days and fewer extremely cool days.
- Average rainfall in southern Australia is projected to decrease, and heavy rainfall is projected to increase over most parts of Australia.
- Sea-level rise and ocean acidification are projected to continue.

FIGURE 3 Climatic records broken in Australia

2.7.3 Recent severe weather events

Each year, climatic records are being broken and severe weather is seen to be on the increase. The general consensus is that these events are due to global warming and climate change impacting on regional weather patterns. From November 2012 to March 2013 alone, more than 120 records were broken. Figure 3 outlines a number of these.
In 2015–16, a number of serious floods occurred after torrential downpours. Places that experienced these extreme events included the east coast of Australia, including Sydney; Bendigo, Victoria; the Kimberley region’s Fitzroy Valley and the Dampier Peninsula in Western Australia; and Oodnadatta and Marree, in northern South Australia. **Figure 4** shows the floodwaters experienced in Bendigo in 2015.

In 2015–16 drought prevailed in many regions throughout Australia and this, combined with heatwaves, created conditions conducive to bushfires in places such as Wye River and Separation Creek, Victoria; the Hamley Bridge area and Mt Compass, South Australia; and Rockingham, Western Australia. See **figure 5**.

2.7.4 How will climate change impact on the environment, economy and social systems?

Some of the impacts of climate change that will require management by governments and communities include:

- impacts on fragile and diverse biomes and ecosystems, for example the Great Barrier Reef, where warming of 1°C is expected to have significant impacts on biodiversity, with losses of species and associated coral communities and the potential for up to 97% of the reef to be subject to coral bleaching
- changed temperatures and rainfall regimes affecting the potential of agriculture and forestry to maintain crop yields such as wheat, and timber yields from forests
- reduced river flows in the Murray Darling Basin with significant impacts on agriculture, industry and urban household use
- more extreme weather events such as heatwave conditions, with an increase in the number of days when the forest fire index rating is very high or extreme
- more severe tropical cyclones, with associated property damage due to strong winds and flooding
- spread of tropical diseases such as dengue fever and malaria to southern regions.
2.7.5 How can the impacts of severe weather be managed?

Scientific experts agree that environments will change due to global warming and climate change and there will be a range of economic and social consequences, to which society will need to adapt. Where particular industries such as agriculture and forestry may be impacted, there could be a need for governments and other agencies to encourage and facilitate the development of employment opportunities in alternative industries, such as renewable energy for example.

In dealing with the potential impact of severe weather events, a number of approaches may be taken. The redesign of urban infrastructure to improve storm water drainage is a management strategy to reduce the threat of flooding. If redesign is not able to solve the problem, there may be a need for some people to consider relocating away from the flood-prone coastal and riverine locations in which they currently live.

Successful management strategies in relation to events such as cyclones and bushfires include the development of improved tropical cyclone warning systems, with monitoring conducted and warnings issued by the Bureau of Meteorology, and bushfire warnings, issued by relevant state fire authorities. National and state-based agencies such as Emergency Management Victoria, Emergency New South Wales and the Department of Community Safety in Queensland provide a range of information and resources aimed at minimising the impacts on communities of severe weather events, and assisting with management strategies such as emergency evacuation planning. Improved building design to withstand these severe weather events is another successful form of management strategy.

Government Disaster Relief programs that offer financial and other assistance to individuals and communities to recover after events such as flood, fire and drought are further examples of impact management.

Perhaps most importantly, the root causes of severe weather events as a consequence of global warming and climate change need to be addressed. The Australian Conservation Foundation’s 10-point plan (see figure 2 in section 2.5.3) suggests a range of personal energy use management strategies that aim to minimise individuals’ contribution to greenhouse gas emissions, such as switching to solar energy and other renewables. If adopted by businesses and the general community, these strategies will go a long way towards reducing the environmental impacts of climate change and global warming, thereby mitigating the social and economic impacts.

2.7 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. How are Australia’s temperatures expected to change due to climate change?
2. Name three extreme weather events that are expected to increase in frequency due to climate change.

Explain

3. Study figure 3, which outlines climatic records broken in Australia. Describe the general pattern of temperature and rainfall extreme weather events for the 2012–13 period outlined.
4. What types of temperature and rainfall changes were experienced where you live?

Discover

5. Develop an evacuation plan to save life and property for a house or town in a bushfire prone area.
6. Use the internet to find out about Pacific Island nations that are threatened by rising sea levels due to climate change.
Predict
7. How might climate change impact tourism in the Snowy Mountains region of Australia?
8. How will rising sea levels impact Australia’s state capital cities that are located on the coast?

Think
9. How might people who live in tropical cyclone-prone areas cope with increased severe weather events?
10. List three positives, or benefits, of climate change to a particular region of Australia.

2.8 SkillBuilder: Drawing a futures wheel

WHAT IS A FUTURES WHEEL?
A futures wheel is a series of bubbles or concentric rings with words written inside each to show the increasing impact of change. It helps show the consequences of change.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 Possible responses by the ski and alpine resort industry to climate change

Predict
7. How might climate change impact tourism in the Snowy Mountains region of Australia?
8. How will rising sea levels impact Australia’s state capital cities that are located on the coast?

Think
9. How might people who live in tropical cyclone-prone areas cope with increased severe weather events?
10. List three positives, or benefits, of climate change to a particular region of Australia.

2.8 SkillBuilder: Drawing a futures wheel

WHAT IS A FUTURES WHEEL?
A futures wheel is a series of bubbles or concentric rings with words written inside each to show the increasing impact of change. It helps show the consequences of change.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 Possible responses by the ski and alpine resort industry to climate change

Predict
7. How might climate change impact tourism in the Snowy Mountains region of Australia?
8. How will rising sea levels impact Australia’s state capital cities that are located on the coast?

Think
9. How might people who live in tropical cyclone-prone areas cope with increased severe weather events?
10. List three positives, or benefits, of climate change to a particular region of Australia.