UNIT 1
Environmental change and management

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1 Sustainability

Source 1.1 Alternative energy-producing technologies can reduce environmental impacts.

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Before you start

Main focus

To understand why sustainable use of natural resources and maintenance of the quality and functioning of ecosystems is critical to all life on Earth.

Why it's relevant to us

Growing populations, economic growth and changes in lifestyle are placing pressure on natural resources and ecosystems. Humans must conserve and protect the environment so that social, economic and environmental functions are not degraded. All levels of society have a responsibility to protect cultural assets and conserve natural resources for fair access by future generations.

Inquiry questions

- How can social and economic needs be met without degrading the environment?
- What are the key threats to sustainability?
- Why is intergenerational equity fundamental to the decisions we make about development?
- How can we protect the Earth's resources?
- To what extent have human actions contributed to climate change in the previous 150 years?

Key terms

- Biosphere
- Carbon dioxide
- Desertification
- Ecologically sustainable development
- Economic development
- Ecosystem functioning
- Environmental impact assessment
- Environmentalism
- Fossil fuels
- Global warming
- Greenhouse Effect
- Intergenerational equity
- Land clearing
- Renewable energy
- Stakeholders
- The Precautionary Principle

Let's begin

Earth is home to 7 billion people and countless flora and fauna. Life is sustained by healthy ecosystems that are increasingly at risk of degradation from humans modifying the environment and over-exploiting natural resources. Humans depend on the biosphere to meet basic needs, but increasing development has led to pressure on natural resources. Humans can cause widespread changes that affect all living things, but we are intelligent enough to manage the biosphere properly.

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1.1 The concept of sustainability

Sustainability generally refers to the capacity to use resources so that they are maintained for future use and managed in a way that brings about economic and social improvements without significant environmental degradation. The environment in which we live is a complex of natural and human features and includes different ecosystems that form the **biosphere**. Ecosystems are communities of flora and fauna that interact with each other and the physical components of the environment, principally soil, water and the atmosphere. All living things, including humans, depend on the interaction of the biological and physical processes that support **ecosystem functioning**.

biosphere the sum of all terrestrial and aquatic ecosystems

ecosystem functioning the interaction between the biological and physical environment

When processes or components of an ecosystem are modified by human activities, the capacity of an ecosystem to function is reduced or may cease. Throughout history humans have been responsible for the degradation of soil, water and the atmosphere, extinction of plant and animal species, and the subsequent loss of **biodiversity**. Changes in ecosystem functioning also has a negative feedback effect on humans; a loss of ecosystem functioning threatens our health, access to food to sustain our populations and our ability to prosper. As the most intelligent life form on Earth, humans have the ability to understand ecosystem functioning and modify practices to sustainably utilise natural resources and minimise environmental impacts.

biodiversity the diversity of plant and animal life in a particular habitat

Since the 1980s, governments around the world have developed strategies to sustain human populations by integrating social, economic and environmental goals and values into decisions on development. In 1987 the Brundtland Commission of the United Nations proposed the following, now widely adopted definition of sustainable development:

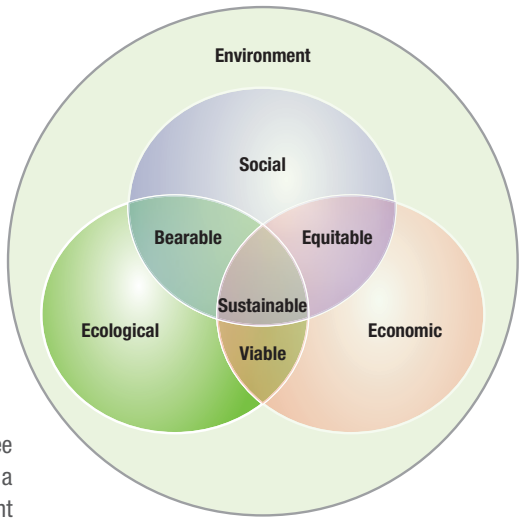
> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

This definition now commonly appears in laws, policies and guidelines for sustainable development. The Brundtland Report, from which this definition is sourced, identified three pillars for sustainable development:

- **economic growth** – promotion of **economic development** to improve the standard of living of humans, particularly those in poverty, without degrading natural resources
- **environmental protection** – to protect ecological processes and ecosystems
- **social equality** – a focus on ensuring the wellbeing of humans and raising the standard of living of all people. Central to this is equal access to resources.

economic development sustained actions of stakeholders and communities that promote an improving standard of living and a healthy economy

These three pillars are also often presented as interacting components or overlapping spheres of sustainable development. How we manage one component involves an understanding of the effect on the other two components. Environmentalists are, however, critical of the formal definition of sustainable development, arguing that it is vaguely worded and does not mention the environment. Similarly, the term 'sustainable development' itself is considered to be ambiguous and open to interpretation.



Source 1.2 A representation of the three spheres of sustainability embedded in a sphere that represents the environment

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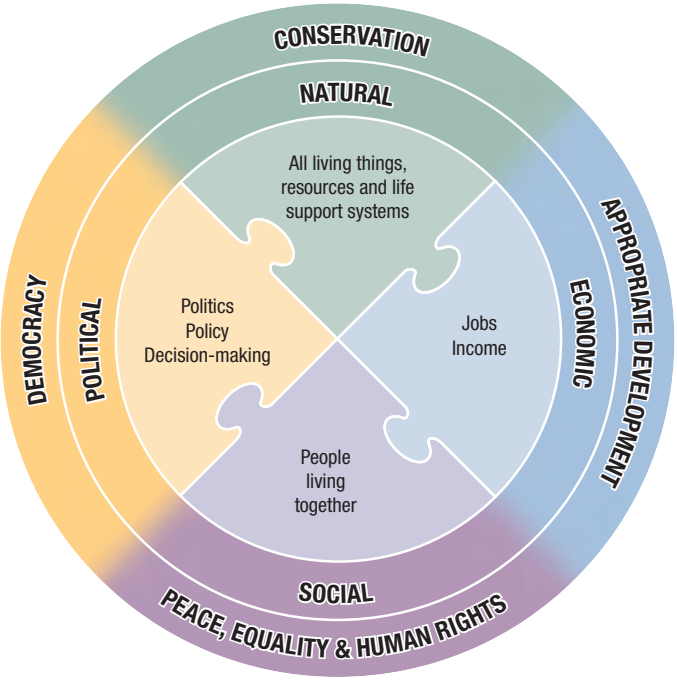
ACTIVITY 1.1

1. Identify three important environmental resources that humans and animals depend on.
2. Define social equality.
3. Analyse why the formal definition of sustainable development is criticised by environmentalists.
4. Discuss why we must manage the environment, economic growth and social needs collectively.

Geographical fact

More than 25% of the world's fish stocks are thought to be at the brink of collapse due to overfishing and habitat destruction.



Source 1.3 A four-dimensional representation of sustainability that includes political considerations

1.2 History of sustainability

The need for sustainability can be traced back to 10 000 years ago when humans established permanent settlements supported by agriculture. **Agrarian societies** that over-exploited resources and were unable to adapt to natural and human-induced changes in the environment declined or disappeared. For example, intensive farming initially provided abundant food that enabled the population of Mesopotamia to grow dramatically. Irrigation was introduced to increase crop yields to feed the growing population. Irrigation salinised the soil and extensive areas of once-productive farmland were abandoned. By 1700 BC, the population of Mesopotamia was reduced by 60% from its peak as a result of soil salinisation, climate change, and over-exploitation of other natural resources.

agrarian societies societies that are dependent on agriculture for economic growth and stability

Geographical fact

Some villages around the world are entirely sustainable. The people of Awana Kancha in Peru have no need for cash. They raise their own animals, spin their own fabric and grow their own food.

Over-exploitation of natural resources also caused population decline in predominantly hunter and gatherer societies. Deforestation on Easter Island caused soil erosion, destroyed

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habitat for birds that were important food sources, and denied the population a source of timber to build fishing boats. The loss of natural resources, and the reduced capacity to hunt and gather food, led to social conflict and cannibalism. The islanders struggled to replace their food sources through basic farming. The population declined dramatically because of unsustainable activities and was eventually wiped out by disease and slavery. By contrast, societies that used sustainable practices, whether for farming or hunting and gathering, were able to maintain their populations. Before Europeans settled in Australia, Aboriginal and Torres Strait Islander peoples maintained their populations through hunting and gathering for over 40 000 years in very harsh environments. However, there is evidence they altered vegetation communities through the use of fire. Shifting cultivators in New Guinea and parts of South America continue to farm sustainably to the present day by reducing pressure on soils and avoiding widespread deforestation for farming. There are also many examples of agricultural societies that have farmed their land continuously for centuries in Asia despite large populations. Key factors in the success or failure of societies include:

- an understanding of the **carrying capacity** of the environment
- an ability to use plant and animal food sources without loss of biodiversity
- the resilience of the environment – that is, its ability to recover from environmental impacts
- the intensity of human activities and the types of practices used to exploit resources
- the ability to conserve soil, water and air quality
- the capacity of humans to recognise and adapt to environment change.

carrying capacity the number of individuals that can be supported by the environment without causing significant harm

Source 1.4 Deforestation destroys habitat and exposes soil to erosion.

The Industrial Revolution

The Industrial Revolution, which occurred between the 18th and 19th centuries in England, Europe and the United States of America (USA), resulted in a transition from producing commodities by hand to mechanised manufacturing. This period of rapid development was significant in the history of sustainability because people were confronted by the widespread social and environmental impacts of unsustainable practices. The shift in production methods involved an unprecedented dependency on coal, timber and mineral resources. Advances in medicine and more efficient food production enabled populations to grow further and increased urbanisation in Europe and North America. Infrastructure such as roads and canals dissected farmland and natural environments, and factories began to pollute the air with smoke from burning fossil fuels. As a result of the Industrial Revolution, the population of England and many European countries doubled every 50 years. The growth in population and the associated increasing demand for water, soil and minerals led to a decline in the habitability of cities, which were often affected by pollution. Rivers became contaminated by sewage, domestic waste and chemicals, and many people were affected by lung and water-borne diseases caused by pollution. **Hinterland** resources were also progressively depleted to support growing cities and deforestation, to supply timber and create new farmland, irreversibly modified the environment.

hinterland the land behind the coast or the banks of a river, or an area of a country that is far away from cities

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RESEARCH 1.1

Search for information on the Mayan or Anasazi civilisations. Use 'environmental degradation' as a search term. Research only one of these civilisations and answer the following:

1. Identify which activities were thought to have caused environmental degradation.
2. Evaluate whether there were any natural changes to the environment that might have also been a factor in the decline of the society.
3. Explain why the society was unable to find a solution.
4. Distinguish which lessons can be learned from the experiences of the society.

Source 1.5 The wellbeing of children was not widely considered during the Industrial Revolution. They were engaged as poorly paid labourers.

Geographical fact

More than 20% of species are predicted to become extinct in the next 25 years. More than half of all current species could become extinct within 100 years.

1.3 Key concepts in sustainable development

Intergenerational equity

intergenerational equity the responsible use of natural resources to enable fair access to the same resources by future generations of humans

Intergenerational equity refers to the responsible use of natural resources to enable fair access to the same resources by future generations of humans. If today's populations deplete the Earth of critical resources, such as topsoil to grow food and fossil fuels to generate electricity and power vehicles, future generations will have less opportunity to prosper. Prosperity is intrinsically linked to consumption of resources, but it can deplete non-renewable resources or reduce access to renewable resources if they are destroyed or unable to be replenished because of over-exploitation. Accordingly, intergenerational equity is a key component of policies, laws and other management approaches that have sustainable development as a primary goal. Whether it can be achieved is highly contentious because the rate of urbanisation and growth in human population is increasing consumption of resources.

Uncertainty, risk and precaution

Sustainable development of Earth's resources involves the challenge of dealing with uncertainty and risk. In the context of sustainable development, uncertainty refers to our inability to be absolutely certain of the outcomes and risks of modifying the environment to meet our needs. Predicting the impacts of development depends on sound scientific knowledge of Earth's processes and how our actions modify them. For example, we know that humans have the potential to change climate by modifying atmospheric processes through pollution. Changing climate is a risk to the environment because it may increase sea levels, destroy temperature-sensitive ecosystems and cause local extinction of flora and fauna. Changes in temperature and water availability, along with the submergence of land from rising sea levels, can destroy habitat and lead to loss of species. The extent to which we influence climate has high levels of uncertainty. We are uncertain of

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the magnitude and the timing of climate change, and we are uncertain of how the environment will respond. Furthermore, we are uncertain over the management actions that can mitigate the negative impacts yet are compelled to develop in order to prosper. Stakeholder conflicts over development often involve debates about the level of uncertainty and environmental risks.

Geographical fact

As water heats up, it expands. Approximately half of the past century's rise in sea level is attributable to warmer oceans occupying more space.

1.4 Climate and climate change

'Weather' is what happened today or yesterday, or this year. 'Climate' is what you understand about a place when you have lived in it for 30 years or longer; but actually feeling climate change for yourself is almost impossible. The weather varies widely wherever you are, but the climate remains the same over half a lifetime, because climate is the average of all the weather's variations. From day to day and season to season the temperature change is large, but over the last 100 years **global warming** has seen Australia's average annual temperature rise by 1°C. This might appear to be a small amount, but not too small for changes to happen in the life cycle of plants, insects and animals.

global warming rise in the average temperature of the Earth's atmosphere

In climates where life pauses for the cold of winter, plants and animals respond to the warmth of spring. Trees bud, frogs spawn, birds mate and caterpillars hatch from their dormant eggs. And if spring comes early, so does the re-awakening of life. In most of Europe, Asia and North America, many plants and insects are now emerging from their winter shut-down a few weeks earlier than they did 50 years ago. This early awakening has occurred because the warmer days happen earlier than they used to.

Geographical fact

There is a swan farm in Dorset in England called the Abbotsbury Swannery. The swannery is over 600 years old, and has over 1000 white swans. By tradition, the first day of summer is proclaimed when the first cygnets hatch at Abbotsbury, which for centuries was in mid-May. In 2011 the first hatching was on May the 4th; in 2012, it was even earlier; April the 30th. The swans know the world is warming.

Source 1.6 Cygnets at the swannery in Abbotsbury, Dorset, England

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RESEARCH 1.2

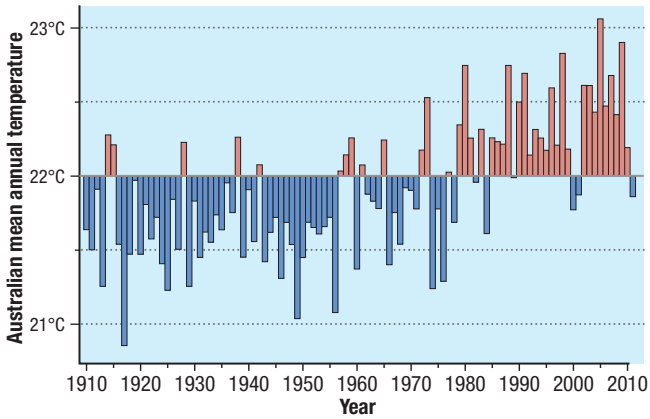
1 Investigate how global warming has affected the life cycle of the Common Brown butterfly (*Heteronympha merope*) in Victoria. Present your results in the form of a life-cycle calendar now and 60 years ago.
You can find the science of this summarised via Cambridge weblinks: www.cambridge.edu.au/geography10weblinks

2 Explain the meaning of the word 'phenology'.

Measuring global warming

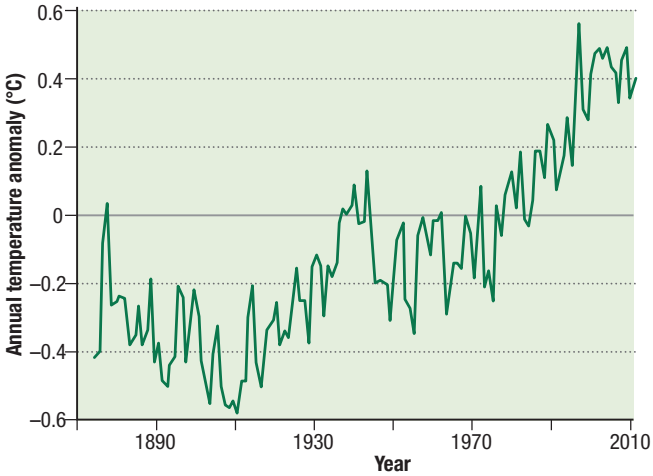
To calculate an annual average temperature for any place, meteorologists measure the daily maximum and minimum temperature for the entire year, and then average these 730 numbers (732 in a leap year).

Although temperature changes have alerted us to global warming, it is the record of temperature maintained by the world's meteorological stations that show the amount of warming that happened in the 20th century. Source 1.7 shows how Australia's average yearly temperature has changed since 1910. Australia spans the Earth's temperate and tropical zones and is clearly a warm continent. For the entire Earth, the average temperature is now approximately at 15°C.



Source 1.7 Australian mean temperature since 1910. Notice that from year to year the average temperature may vary by as much as 1°C, yet overall there is a trend towards warmer temperature. Source: Australian Bureau of Meteorology, product of the National Climate Centre

Temperature measurements taken in more than 30 000 meteorological stations around the world since 1880 have been compiled by four different groups of scientists, and they show very clearly how the world has warmed in the past 130 years (Source 1.8).



Source 1.8 The global land-based temperature anomaly (difference from the 1951 to 1980 average) drawn from data available from the Hadley Climatic Research Unit of the University of East Anglia, UK

Ice melt

Another very significant indication that global warming is happening can be seen by the changes in the amount of ice in the Arctic Ocean and on the great ice caps of Greenland and Antarctica. The warming ocean melts sea-ice from below while warmer air melts it from above. The area of Arctic sea-ice has been monitored by satellite since 1980, when the September area of ice was about 8 million square km – enough to cover Australia. Year by year more summer ice melted until by September 2012 Arctic sea-ice had shrunk to less than half its original area, to only 3.4 million square km. If this trend continues, the Arctic will be free of ice in the summer of 2030.

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ACTIVITY 1.2

1. Investigate the temperature range in your town or a nearby town between night and day in both January and July. Data for this can be found on the Bureau of Meteorology website via Cambridge weblinks: www.cambridge.edu.au/geography10weblinks
2. Research online what a Stevenson screen is and explain why it is used.
3. For the coming fortnight, record the daily maximum and minimum temperatures at your place using the newspaper, the Bureau of Meteorology's website or your own thermometer. Calculate the average temperature for the fortnight. Draw a graph showing the daily temperature anomaly (the difference between that day's average and the average for the fortnight).

RESEARCH 1.3

Investigate the history of the exploration of the North-west Passage between the Pacific Ocean and the Atlantic through the Arctic Ocean north of Canada.

Search for information in nauticapedia, Wikipedia and the Skeptical Science page via Cambridge weblinks: www.cambridge.edu.au/geography10weblinks

Use the scaffold below to help with the arrangement of your report.

- Include an introduction outlining the global warming trend and changes in Arctic sea-ice.
- Include descriptions and images of the type of boat used to explore this sea-route before 1950.
- Present a bar graph to compare the number of vessels sailing this route from the first passage until today.
- Compare the number of vessel passages with the changes in Arctic temperature since 1930.
- Re-emphasise your main point and reach a logical conclusion from the information you have presented.
- Data for temperature can be found via Cambridge weblinks (www.cambridge.edu.au/geography10weblinks) or from Source 1.8 above, though note that the latter graph is for global not Arctic temperatures.

What makes 'climate'?

To understand climate change we need to know the things that drive the weather and affect the climate.

The sun

Sunshine is made up of heat, light and ultraviolet (UV) rays, with most of its energy coming in as light. The different parts of sunshine, including the part you can see, light and the colours of the rainbow, can be described as having different wavelengths: longer wavelengths at the red end of the spectrum, shorter at the blue end. UV has the shortest wavelength and is the most energetic. Heat – also called infra-red – has longer wavelengths than UV (see Source 1.9). Heat, light and UV rays all warm the planet. You cannot specifically 'feel' UV, but it can burn your skin nonetheless.

The sun provides the energy to drive the weather. There is over 1 kilowatt (kW) of energy falling on each square metre when the sun is directly overhead – enough to power a small radiator. By the time it has passed through the atmosphere, that energy is reduced to a bit less than a kW during the Australian summer, and half a kW or less at noontime in winter.

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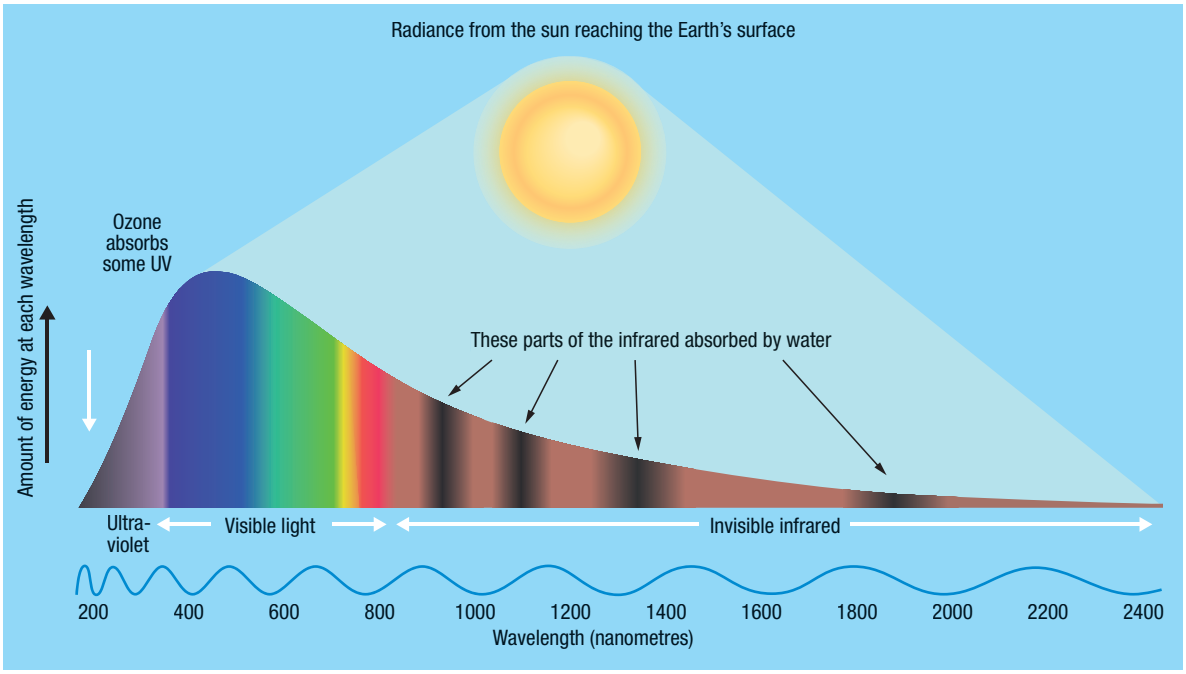


Source 1.9 The sun's radiation. Each part of the spectrum, not just the visible part as we see it in a rainbow, has its own wavelength, measured in nanometres (millionths of a millimetre). Various gases in the atmosphere, particularly ozone and water vapour, absorb different parts of the sun's radiance, as shown by the dark bands.

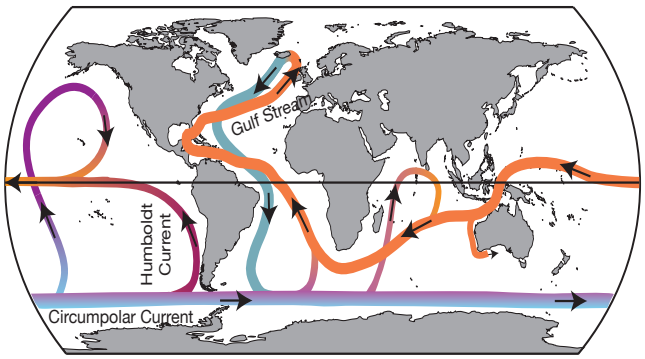
The sun is a very steady source of heat, and though minor variations of solar radiation occur, these are not enough to significantly affect climate. What can change the climate is the proportion of the sun's energy on the big landmasses of the northern hemisphere: Asia and North America. When there is slightly less summer sun there, something happens for reasons connected to the Earth's orbit and inclination of Earth's rotation axis: the winter snows do not melt as much as usual. If this lasts for thousands of years the overall amount of ice increases. Ice reflects almost all the sunshine that strikes it, and that helps cool the Earth – more area of ice means less of the sun's heat is absorbed. So the Earth cools and more ice forms. This is an important climate factor known as **feedback**. As this happens the world enters an ice age. There have been eight ice ages in the past million years. During each one the Earth's temperature fell by as much as 6°C. Astronomical calculations show we are now in a period called an **interglacial** with very slow cooling, and this should continue for approximately 50 000 years.

feedback change in one factor causing a change in a second and this then changing the first

interglacial warmer period between ice ages

Ocean currents

About 70% of the Earth's surface is ocean, and because water absorbs most of the sun's heat that falls on it, the oceans are the main store of the Earth's heat. Ocean currents encircling the globe are known as the Great Ocean Conveyor Belt (see Source 1.10). Surface currents take warm tropical waters towards the poles, and the cold, denser polar water sinks to the ocean floor and moves towards the Equator. In this way the sun's heat is distributed around the world.



Source 1.10 Main features of the Great Ocean Conveyor Belt. Note particularly the northward Humboldt Current, which carries cool Antarctic water up the South American coast before it turns west and is warmed. Note also the warm Gulf Steam, which carries warm water from the Gulf of Mexico to the North Atlantic.

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The atmosphere

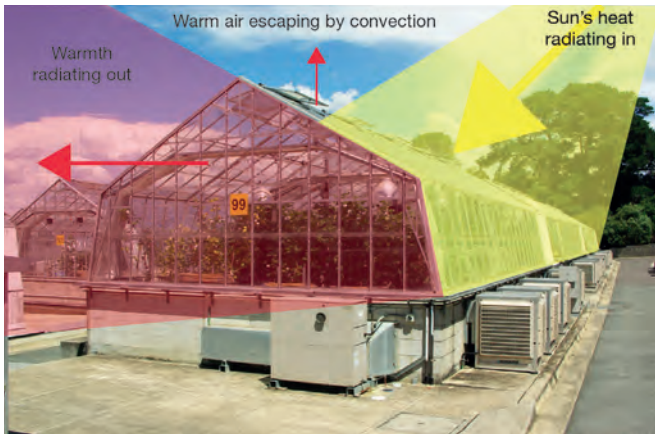
The Greenhouse Effect

A greenhouse works because incoming light and heat from the sun warm the air and plants in the greenhouse. The glass walls and roof prevent the warm air from flowing out by **convection** – warm air rises but the roof stops it escaping. Glass is not a good conductor of heat, so the warmth of the air in the glass house is taken away slowly by **conduction**. The greenhouse does lose heat by **radiation**, but enough heat is trapped inside by the glass for the greenhouse to remain warmer than the rest of the garden until sunset (see Source 1.11).

convection the transfer of heat from one place to another by the movement of liquids or gases

conduction the transfer of heat between substances that are in direct contact with each other

radiation the emission of heat energy in the form of waves travelling through space, air or anything transparent to heat

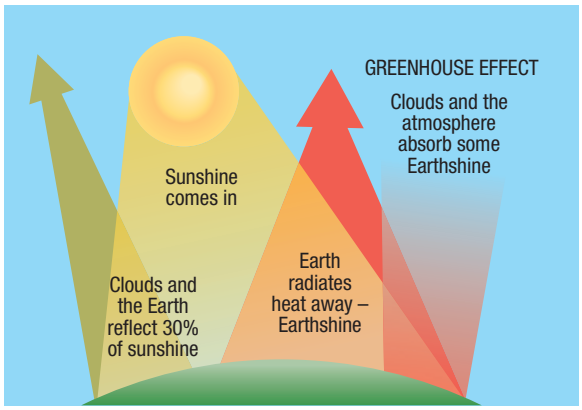


Source 1.11 How a greenhouse works. High-energy heat from the sun warms the interior, while lower-energy heat radiates out, keeping the greenhouse from overheating. Some heat escapes if a window is opened and some is conducted through the glass to the outside air.

While the Earth is not enveloped by a glass case, it is nevertheless protected by greenhouse gases which retain the Earth's heat. However, the process is quite different; Source 1.12 shows what happens. The Earth is warmed by the sun, which makes the Earth itself a radiator; not a very hot radiator, but a heat radiator nonetheless. The Earth's radiant heat, Earthshine, heads upward towards space and has to pass through the atmosphere to get out. Most Earthshine escapes; if it did not we would boil. But some of the Earth's heat is absorbed by water vapour and **carbon dioxide (CO_2)** in the air, and to a lesser extent by methane (CH_4) and other trace gases, and this absorbed heat stays with us and keeps the Earth at about 14°C. The way the Earth's heat is kept in is called the '**Greenhouse Effect**'. If it were not for our atmosphere, the temperature would be like the moon's, literally boiling during the day in the full light of the sun then dropping to 150°C below zero (–150°C) after sunset.

carbon dioxide (CO_2) a chemical compound composed of two oxygen atoms bonded to a single carbon atom. It is a colourless odourless gas

Greenhouse Effect retention of the Earth's heat by atmospheric gases



Source 1.12 The Earth's heat budget. Clouds and the Earth's surface reflect some heat, but most (70%) is radiated back towards space. About 10% of the Earth's heat is retained by the Greenhouse Effect.

Aerosols

'Aerosol' in this context does not mean a spray can. It refers to dust and other small particles which are always present in the air. Sulfuric acid droplets from volcanic and industrial emissions can float high up into the sky where they reflect a little of the sunshine and cool the Earth. Soot, on the other hand, absorbs heat and warms the air. Changes in the amount of these particles, known as aerosols, have a fluctuating effect on the Earth's temperature. During the period from 1945 to 1975 there was much industrial pollution, causing acid rain over Europe and damage to forests. An international agreement in 1979 reduced this pollution. Global warming, occurring at a rate of approximately 0.1°C every 10 years from 1900 to 1940, was slowed by these aerosols until 1975. Since the air was cleaned of sulfuric acid droplets the global temperature rise has averaged 0.15°C every 10 years.

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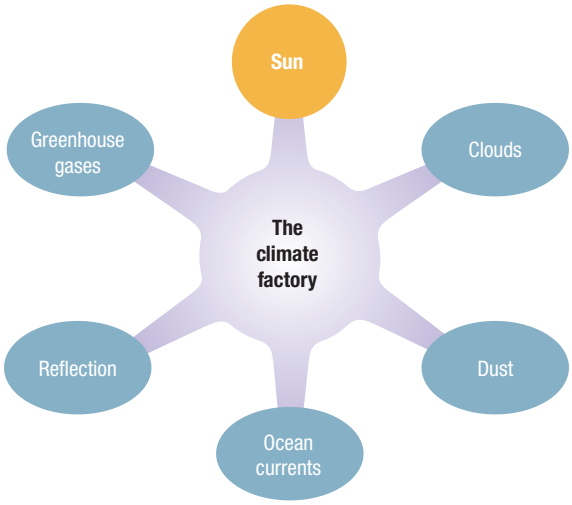


Source 1.13 Schematic of climate factors

Recent and past global warming

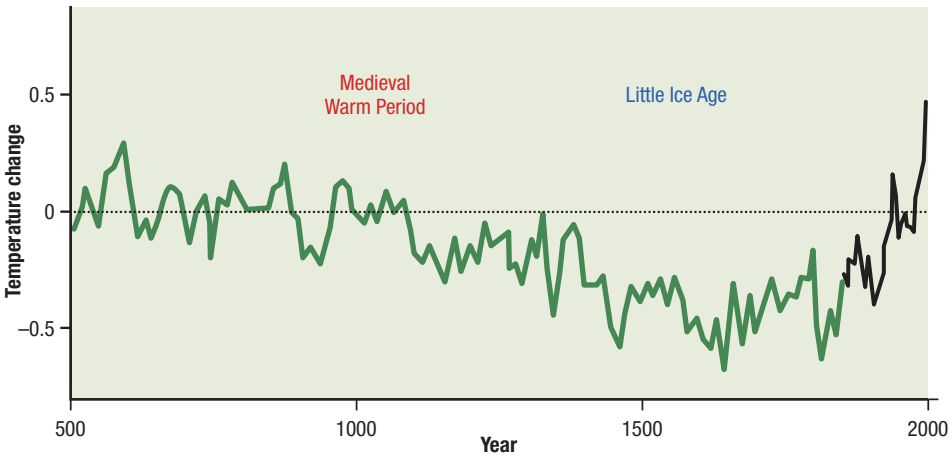
A change in the average temperature of 1°C in 100 years may not seem very much at all. To put this change in perspective we need to understand broad trends in temperature changes from past eras. Because thermometers are a recent invention, scientists have to work with what they call temperature proxies – natural phenomena that reveal the temperature by their effect on something. One proxy is the width of tree rings, because in the warmer year trees develop a slightly thicker layer of wood. Another is the composition of snow falling on Greenland and Antarctica. The detailed atomic composition of water depends on the temperature, and examination of annual ice layers can tell scientists how the temperature has changed. Putting these clues together has shown us that global temperatures cooled very slightly, with variations up and down, at least for the past 2000 years.

There are several things that can be seen in Source 1.14. One is that for 1500 years, global temperature varied by only a few tenths of a degree as it slowly declined. A second and very important thing is that since 1850 global temperature has risen extremely suddenly.

Going back as far as 400 000 years ago, global ice-age temperatures were about 6°C cooler than those of today, whereas the temperatures of the interglacial periods were not much different. What is very different is the rate at which temperature changed during the ice ages and the rate of change today. Ice-age cooling was slow – 1°C in 4000 years, with subsequent warming occurring at a rate of approximately 1°C in 1000 years. Today's rate is almost 20 times as fast: that is, 1°C in 60 years.

Geographical fact

At the height of the last ice age, 21 000 years ago, New York was covered by ice as much as 1 km deep. As the Earth warmed, starting 18 000 years ago, the edge of the ice sheet retreated at a rate of about 50 m a year. Today, the edge of the Arctic sea-ice is retreating at the rate of 8 km a year.



Source 1.14 The green line shows global temperature reconstructions for the last 1500 years. The black line shows thermometer measurements of the last 150 years. Zero on this graph represents the average temperature from 1850 to 1995.

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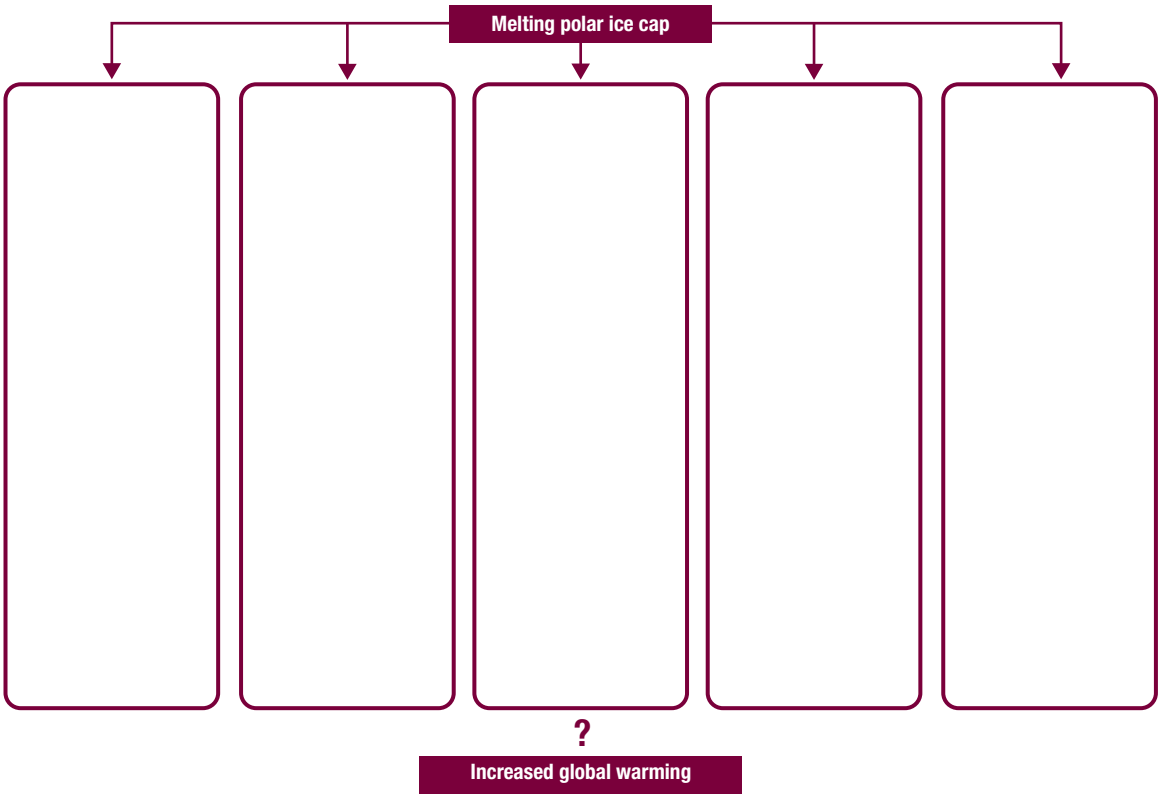
What is the cause of global warming?

We saw earlier that the Earth's climate is ruled by the sun. Some of the sun's heat is reflected, some of the heat is distributed by the ocean, and the atmosphere keeps the warmth in. If the Earth has warmed, then either the sun or the Earth's surface or the atmosphere must have changed. Astronomers are sure that the sun is not to blame; it has barely changed in the past 200 years. Similarly, there has been little change in the Earth's reflectivity. That only leaves the atmosphere, and it is a change in the Greenhouse Effect that scientists conclude is responsible for global warming.

The Earth's Greenhouse Effect is dominated by water vapour (about 60% of the effect) and by carbon dioxide (about 30%). It is water vapour that makes the air humid. In 1800 there were 280 molecules of carbon dioxide for every million molecules of air (76% nitrogen, 23% oxygen, 1% argon). You might think that 280 molecules in a million is not enough to do anything much, but it is enough to provide the carbon for all the plants on Earth. And it is enough to maintain a global temperature of about 14°C, helped by a big contribution from water vapour. Because of the way carbon dioxide can trap the Earth's heat, an increase in its amount must trap more heat. When that happens the warmer atmosphere can hold more water vapour, and that further increases the Greenhouse Effect. This is a second climate feedback just like melting polar ice – one warming factor drives another. Today the amount of carbon dioxide in the air is growing at a rate of 2 parts per million each year, and has currently reached 400 parts per million; that is, 40% more than there was in 1800. Not surprisingly, global temperatures have risen as a result.

NOTE THIS DOWN

Copy the graphic organiser below and summarise the consequences of melting polar ice. Consider also which, if any, consequences could cause further warming.



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ACTIVITY 1.3

1. Construct a table of the Greenhouse Effect of the following constituents of the atmosphere in order of their absorption of the heat radiated from the Earth (greatest to least): oxygen, water vapour, carbon dioxide, methane, ozone.
2. Research the meaning of the word 'albedo'. Construct a table of the albedo of forests, deserts, tundra, ocean, grasslands, Venus and the moon and arrange them in order of their albedo from greatest to least. (Wikipedia has data for these activities.)
3. Explain why, at least in the southern states, clear nights in winter are often frosty but cloudy nights are not.

Where did the carbon dioxide come from?

There are four sources of carbon dioxide to the atmosphere:

1. *From life itself.* As organisms live, breathe and die, their carbon is cycled from the atmosphere into plants and then into animals. When they die the carbon goes back to the atmosphere or ocean. Overall there is no significant change in the carbon dioxide content of the air.

2. *From volcanoes.* Volcanic gases contain carbon dioxide. Emissions from volcanic eruptions and fissures add approximately 300 million tonnes of carbon dioxide to the atmosphere every year. This is new carbon dioxide, but it contributes only 0.03 parts per million each year. Volcanoes are not the source of the global increase in carbon dioxide.
3. *From the ocean.* Most of the Earth's store of available carbon dioxide is dissolved in the waters of the oceans. If the ocean warms, some of the dissolved carbon dioxide comes out. Warming the oceans is certainly one way that atmospheric carbon dioxide can increase.
4. *From burning coal, oil and gas – the fossil fuels.* When a **fossil fuel** is burned, the carbon it contains combines with oxygen in the air to make carbon dioxide. Expressed as a chemical equation this statement can be written:

fossil fuels natural fuels such as coal or gas, formed in the geological past from the remains of living organisms

$$C + O_2 = CO_2$$

Coal is nearly pure carbon. Burning 1 tonne of coal produces about 3½ tonnes of carbon dioxide. Oil and gas contain both carbon and hydrogen, and when these fuels burn they produce both carbon dioxide and water. For light diesel oil the chemical equation is

$$C_{10}H_{20} + 15O_2 = 10CO_2 + 10H_2O$$

Since the beginning of the Industrial Revolution in 1750, more than a million million tonnes of carbon dioxide have been added to the atmosphere from burning coal, oil and gas. The source of the increasing amount of carbon dioxide in the atmosphere is fossil fuel burning.

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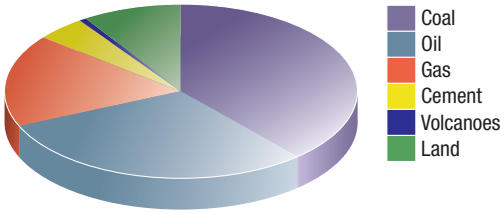
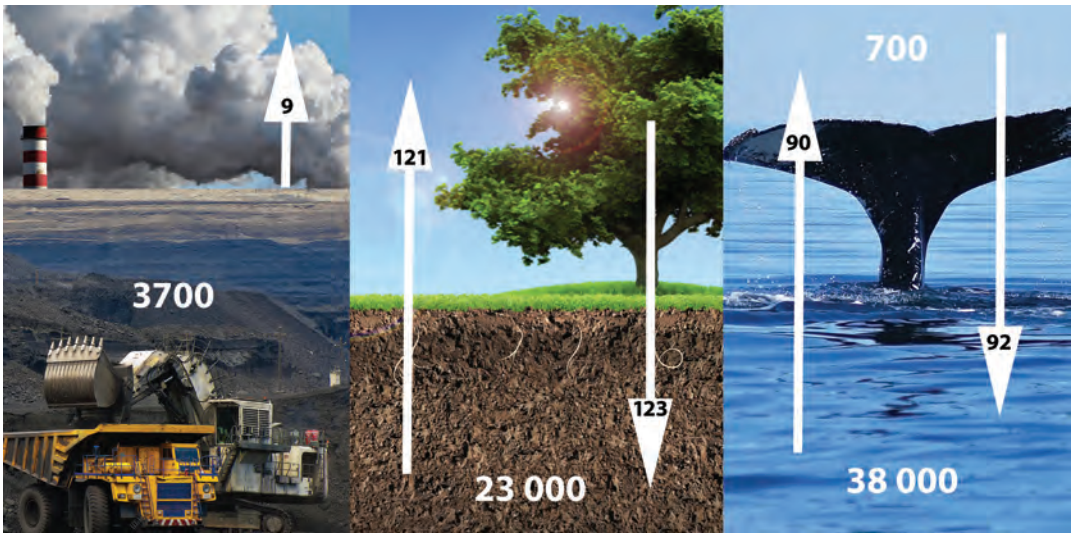
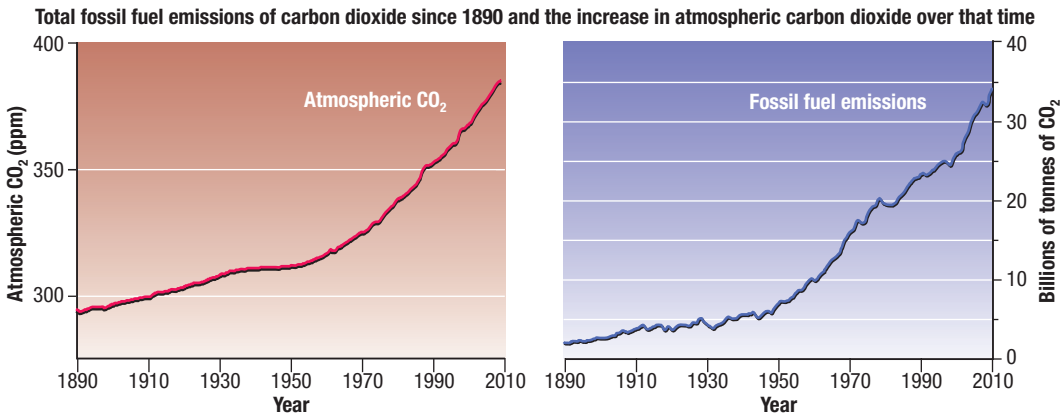
ACTIVITY 1.4

1. Research how the atmospheric carbon dioxide content has changed over the last 12 months at Mauna Loa Hawaii (see www.cambridge.edu.au/geography10weblinks) and at Cape Grim in Tasmania.
2. Explain the month-by-month variation at each locality.
3. Identify the change in the average atmospheric carbon dioxide content measured at Cape Grim, Tasmania, from 1955 to last year. (Go to the website of the World Data Centre for Greenhouse Gases and click the box Data-Quickplot. Under 'Station name' click the entry for Cape Grim – Australia – CSIRO. In the first column headed 'Parameter' click CO_2 flask. At the end of the third row headed 'Monthly data' click under 'Quick plot', either png or pdf)
4. Describe what has been happening to produce the extra carbon dioxide over this time.
5. Discuss (geographically) from where you think most of the increase in carbon dioxide has come.







Source 1.15 Summary of the way carbon dioxide is produced and cycled in the Earth

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1.5 What will climate change do?

We can understand what the future holds in terms of climate and weather firstly by looking at recent changes. An important effect of global warming is that the amount of water vapour in the air must increase simply because warmer air can hold more water. Indeed, this has been found: atmospheric water vapour has risen by 4% since 1970. More water vapour means more rain, though not necessarily everywhere, and this too has been seen. Northern Australia has had more rain since 1970. Record heavy rain, leading to floods, happened in eastern Australia in the summers of 2010 and 2011. Climate scientists point out that while no individual weather event can be attributed *to* climate change, every weather event is affected *by* climate change because the world is warmer, the air has more moisture, the Arctic is warmer and ocean currents are being affected. A storm can be stronger because of these changes, hot days can become more frequent and droughts may be longer and drier.

By looking at the geological record of past climates and levels of carbon dioxide, scientists have concluded that if the amount of carbon dioxide in the atmosphere doubles, the global temperature will rise by approximately 3°C. This is not an exact figure though and estimates by different scientists range between 2°C and 4.5°C, with 3°C as the most likely prediction at present.

For the next 20 years, we can expect the following small changes:

- global temperature will rise by at least another 0.3°C by 2030
- heat waves will be longer and more intense
- rainfall globally will be higher, though in eastern Australia it will be lower and more intense
- droughts will become more frequent
- sea-level will rise a further 6 cm
- alpine glaciers will retreat further and many will vanish
- arctic sea-ice will retreat, possibly vanishing in the summer
- the Antarctic and Greenland ice caps will become thicker from more snow, but with continued melting at lower altitudes
- the oceans will become more acidic
- hurricanes will be stronger and wetter.

If greenhouse gas emissions continue to increase as they have for 50 years, by the year 2100:

- Australia will be 4°C hotter
- the Arctic will be 8°C hotter
- sea level will be at least 30 cm higher; some say a metre is not too fanciful a prediction.

Case study 1.1

A British academic has warned that complacency could prove disastrous

Vast areas of regional Queensland, South Australia and Western Australia have been identified as among the most vulnerable in the world because of poor climate change policy and a failure to recognise the need to adapt to rising temperatures.

University College London's International Energy Policy Institute director Stefaan Simons said South Australia had already been identified as the driest state in the driest continent, but the failure of the federal and state governments to enact stable climate change policies, such as long-term **carbon pricing**, left it vulnerable to minor increases in temperature.

Regional cities including Whyalla, Port Augusta and Port Pirie, as well as the Eyre Peninsula's western communities, were particularly at risk because of their ageing populations, the exodus of young people and poor access to services.

'If this inaction continues, then South Australia could find itself in very deep trouble,' Professor

carbon pricing placing a price on carbon put into the atmosphere as carbon dioxide through either subsidies, a carbon tax, or an emissions trading ('cap and trade') system

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Simons said. He said sectors including agriculture, employment and fisheries could potentially be affected.

'If the temperatures increase, grapes will ripen more quickly, quality of wine goes down, people stop buying it around the world, there's a huge impact then on the economy,' he said.

Source: Verity Edwards, *The Australian*, Education Supplement, 5 December 2012.

1. Recall by how much the global temperature is predicted to rise if the carbon dioxide content of the atmosphere doubles from its pre-industrial level.
2. Research the value to the Australian economy of the South Australian grape harvest.
3. Investigate the change in the age distribution of the population of Port Augusta since 2001.

Source 1.16 Consequence of global warming

1.6 Can climate change be stopped?

Reducing carbon dioxide emissions

The **Kyoto Protocol** committed many countries, including Australia, to a reduction in their carbon dioxide emissions, but the biggest emitters, the United States of America and China, did not ratify this agreement. Since then a series of international meetings has failed to achieve much in the way of a reduction in the use of fossil fuels. After the Global Financial Crisis of 2010 there was a slight decrease in emissions, but 2011 and 2012 were years of increasing carbon dioxide emission.

Kyoto Protocol an international agreement created under the United Nations Framework Convention on Climate Change in Kyoto, Japan in 1997, which aimed to reduce the collective greenhouse gas emissions of developed country parties by at least 5% below 1990 levels during 2008 to 2012

Carbon dioxide from power stations can be trapped and stored underground – this is called carbon capture and storage. This would slow the increase of carbon dioxide to the atmosphere. But because carbon dioxide emissions have not decreased since 2008, **geoengineering** could buy time for alternative energies to be built. One idea is to mimic large volcanic eruptions by putting reflective aerosols such as sulphuric acid into the atmosphere. Because this is a known, natural process, the hope is it would not have too many unknown and possibly negative, effects.

geoengineering the deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming

Some governments, including those of Australia and several European countries, have accepted that energy generation will have to change from using fossil fuels to using **renewable resources** such as wind, solar, tidal and geothermal energy. New Zealand, with its large sources of volcanic activity, already generates much of its electricity from **geothermal heat**. South Australia has invested heavily in wind power.

renewable resource any natural resource (such as wood or solar energy) that can be replenished naturally with the passage of time

geothermal heat heat from hot rocks

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Case study 1.2

Alternative energy sources in South Australia

Energy is fundamental to the way we live, our economy and our future. Like Australia's other states and territories, South Australia has relied mainly on gas and coal to produce its electricity. Burning of fossil fuels is the main source of greenhouse gases that are triggering the changes we are seeing in the global climate.

To avoid the most damaging consequences of climate change, we need to use energy more efficiently and harness low-emissions energy technologies, including renewable energy.

renewable energy natural energy which does not have a limited supply

South Australia reached its target of generating 20% of electricity from **renewable energy** in 2011, three years ahead of schedule. South Australia now has a target of producing one-third of its electricity from renewable energy by 2020.

Wind

South Australia's wind farms contributed about one-quarter of the state's total electricity production in 2011/12. Wind farms can provide employment and other economic benefits for regional communities.

Solar

About one in five South Australian homes have **rooftop solar photovoltaic (PV) systems** installed, producing the equivalent of 2.4% of South Australia's annual energy in 2011–12 (Australian Climate Commission, 5 Dec 2012).

rooftop solar photovoltaic (PV) systems energy generation equipment that works by converting sunlight directly into electrical power

1. Investigate from where South Australia gets its coal and gas.
2. Research and compare the cost of electricity generated by coal, by gas and by wind.
3. Analyse some reasons why the USA and China did not ratify the Kyoto Protocol.

RESEARCH 1.4

Prepare a poster to illustrate *one* of the *two* following topics:

- The impact of rising temperature and increased atmospheric carbon dioxide on the ocean.

Aspects you might include are:

1. causes of coral bleaching on the Great Barrier Reef
2. the effect of rising CO_2 on ocean acidity and marine life
3. the implications for a sustainable fishing industry in northern Australian waters as the global temperature rises

or

- how the Earth might be cooled by geoengineering.

Investigate such possibilities as injecting stratospheric sulfuric acid, ocean spray, mirrors in space, reflective surfaces on Earth, CO_2 scrubbers.

Sources for these topics can be found in 'A Short Introduction to Climate Change' and many internet sites.

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Case study 1.3

Sub-Saharan Africa – the Sahel

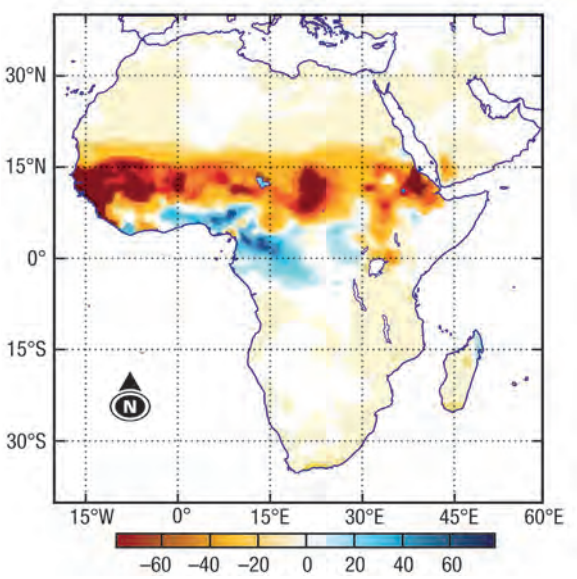
Major climate changes have taken place to the south of the Sahara Desert in a regional band known as the Sahel. The region includes the countries of Niger, Chad, Senegal, Sudan, Mali and several smaller countries. Source 1.17 shows the land near Timbuktu in Mali. Across the Sahel, the climate of the past 50 years has been disastrous. Rainfall – never abundant and once averaging between 100 and 400 mm annually – in some parts declined by 40% between 1950 and 1980.

Source 1.17 Near Timbuktu in the northern Sahel, Mali. The annual rainfall here has declined from 225 mm to 175 mm since 1950.

Changes in rainfall across the Sahel during the wet season for the 50 years from 1950 to 2000 are shown in Source 1.18. As rainfall has dwindled, so has the agricultural productivity of the Sahel, falling 1% every year from 1970 to 2000. In parallel, **desertification** has intensified. Although some improved farming practices have started to reverse the declining food production of the late 20th century, the region is still highly susceptible to drought. By early 2010, failure of the rains in the previous year had led to a 30% decline in cereal production in Chad. Neighbouring Niger had its worst crops in two decades. According to the United Nations Children's Fund (UNICEF), in the Sahel 300 000 children under age five die each year from **malnutrition.** The drying of the Sahel is attributed to an increased Atlantic sea-surface temperature difference north and south of the Equator, as well as warming of the Indian Ocean.

desertification the change of dry land to desert

malnutrition illness caused by inadequate food



Source 1.18 Wet-season rainfall changes in millimetres across Africa from 1950 to 2000

1 Reports from the Sahel shown here are only up to 2010. What has happened in the Sahel since then?

Points to consider:

- Has the drought broken?
- What are the main crops of the Sahel? Have they succeeded?
- International aid was needed in 2012. Did that aid eventuate?
- Did civil war or other conflict limit access to international aid?

Possible sources: Food and Agriculture Organization of the United Nations, Syngenta Foundation for Sustainable Agriculture, Wikipedia, UNICEF.

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Case study 1.4
Latin America

Latin America spans a vast region of the Earth, from the tropics almost to the Antarctic. Along the length of South America there are many different landscapes and climate zones, and each will be impacted by climate change in its own way.

Running along the whole western coast of the continent is the huge mountain range of the Andes. In the high Andes valley glaciers are important water sources, but through global warming these are melting and water supplies may be jeopardised.

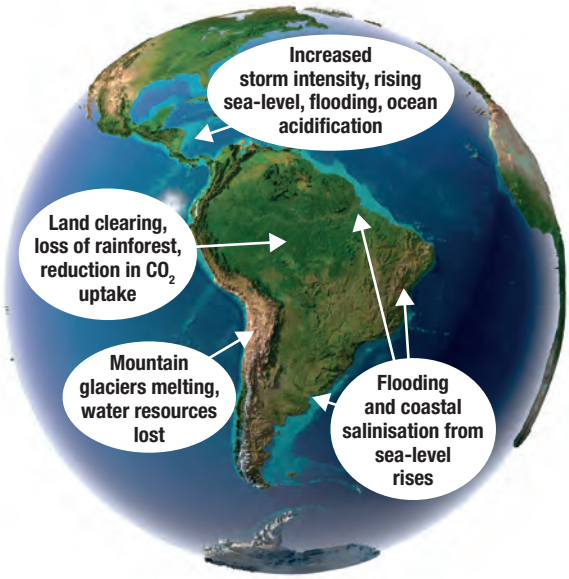
The Amazon Basin carries the world's largest rainforest with an area of 5.5 million square km, almost as big as Australia (7.7 million sq. km). Already a combination of **land clearing**, rising temperatures and changing rainfall is affecting the forest. Rainforests are the land's largest sink for atmospheric carbon dioxide.

land clearing is defined as the direct human-induced removal of vegetation cover from forested areas, in order to allow the land to be used for other purposes such as agriculture

In the Caribbean, higher rainfall, increasing storm intensity, floods, an increase in ocean acidity and sea level rise can all be expected to have a significant impact on property, the environment and coral reefs.

According to the Inter-American Development Bank:

> Latin America and the Caribbean contribute only 11 per cent of the emissions that cause global warming. However, some countries are especially vulnerable to its effects, given the region's dependence on natural resources, an infrastructure network that is susceptible to climate events, and the presence of bio-climate hotspots such as the Amazon basin, the Caribbean coral biome, coastal wetlands and fragile mountain eco-systems.
>
> Estimated yearly damages in Latin America and the Caribbean caused by the physical impacts associated with a rise of 2°C over pre-industrial levels are of the order of $100 billion by 2050, or about 2 per cent of GDP.
>
> The study cites climate impacts in areas such as agriculture, exposure to tropical diseases and changing rainfall patterns, among others. For instance, the report cites recent work estimating the loss of net agricultural exports in the region valued at between $30 billion and $52 billion in 2050.
>
> In Mexico and Brazil alone, almost one million hectares of land lie within 10 metres of sea level, making those countries vulnerable to rising sea levels. A rise of one metre in the sea level could affect 6700 km of roads and cause extensive flooding and coastal damage. A 50% loss of the coral cover in the Caribbean from coral bleaching would cost at least $7 billion to the economies in the region.



Source 1.19 Expected impact of climate change in Latin America

According to the World Bank (November 2012):

> Even today the global climate is changing, and so regions must adapt to it in order to maximise their resilience to the changes…
>
> For Latin America, this resilience means:
>
> - ensuring the region's infrastructure can withstand the new climatic 'extremes'
> - growing a wider variety of crops, which perform well in droughts, floods and heat, as well as guaranteeing future crops through seed-banksprioritising land use to preserve and manage multiple threats

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- implementing emergency response plans and early-warning alert systems
- developing social safety nets and insurance to protect the region's most vulnerable groups
- sharing best practices and information systems between countries
- monitoring the region's weather and climate.

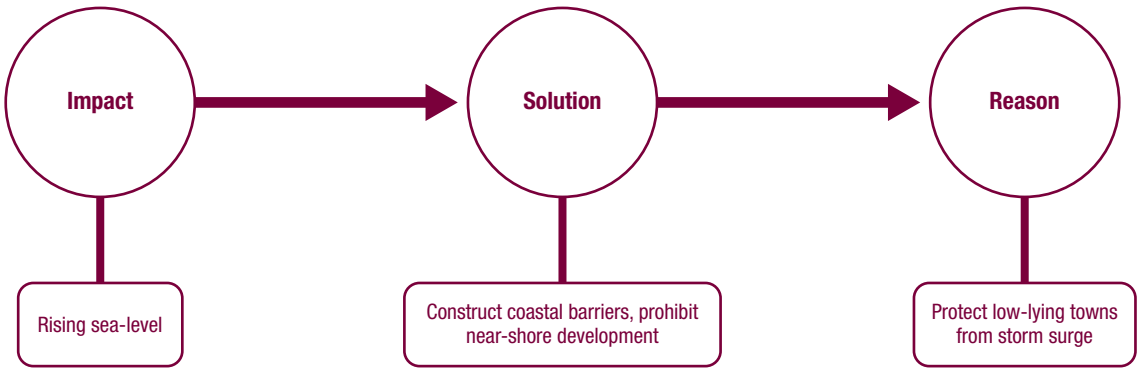
Source: Inter-American Development Bank, *The Climate and Development Challenge for Latin America and the Caribbean: Options for Climate Resilient Low Carbon Development*, 5 June 2012; World Bank, *Climate Change: Is Latin America prepared for temperatures to rise 4 degrees?*, 19 November 2012

1. Draw up a graph of the loss of Amazon rainforest since 1970. (Sources: Wikipedia – search for 'Deforestation of the Amazon Rainforest' – and also National Geographic (see www.cambridge.edu.au/geography10weblinks).
2. List four major agricultural exports from Latin America, and explain how climate change might affect these.
3. Explain what particular threats are caused by climate changes that could cause the collapse of the coral **biome**?
4. Discuss your thoughts on what 'prioritising land use to preserve and manage multiple threats' means?

biome the main groups of plants and animals living in areas of certain climate patterns

NOTE THIS DOWN

Copy the graphic organiser below and list the expected impacts of climate change. Suggest steps that could be taken to mitigate these impacts and explain why these steps should be taken.



Is it all doom and gloom?

Many of the scientists and engineers who advise governments about the impacts of climate change emphasise the bad things that might happen, such as longer droughts or more violent storms. This is perfectly sensible because governments need to prepare for weather that is likely to be damaging. But there is another side to climate change, and it might also be sensible to plan for the good things.

Plants need carbon dioxide to grow. If the atmosphere contains more carbon dioxide, plants grow larger and produce bigger crops, though not all such crops have better nutritional value. Another consequence is they may become more drought-tolerant and so extend **arable** land further into the dry country.

arable suitable for farming

The Arctic is known to be warming twice as fast as the rest of the world. As the snow melts and as the permanently frozen ground (permafrost) of Siberia and northern Canada warm up, these areas will become open to agriculture, benefiting those who live there.

Australian politicians agree that some control on carbon emissions is required, but they disagree about how to achieve this. Any mechanism designed to reduce dependence on fossil fuels will have the added benefit of extending their availability for longer.

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Prediction

Humans rely on prediction to guide environmental decision-making, which may be influenced by our understanding of past impacts and emerging scientific knowledge. This knowledge is the basis for estimating risks to the environment. Environmental impacts are not always immediate and there can be interactions between impacts over time that can have a cumulative effect on the environment. Indeed, many environmental impacts can occur decades or even centuries after development has altered processes. A lack of understanding of time frames of impacts can challenge our ability to conserve resources for future use. However, our capacity to predict and avoid impacts associated with development is improving as our scientific knowledge increases.

RESEARCH 1.5

In a class group, discuss what you might like to have at a party. What drinks, what food would you want? It is only a party, so maybe 'healthy eating' can be forgotten for this. Or maybe not. If you want Tim Tams and someone else says 'Yuck, too sweet, let's have chips,' would you say they are wrong, or 'OK, that's your opinion,' or 'Sor-ry!'?

Now discuss why the climate is changing. After all, this is a topic that gets much discussion in the media and the internet, but who has actually experienced it? Politicians are divided over it, and you might read that scientists are divided over it. In much of daily life there are two, sometimes more, sides to an argument. Is climate change a topic that should be resolved by debate?

To do this, have your teacher divide the class up into small groups, each to tackle one of the points below.

- Is 400 parts in a million of carbon dioxide trivial?
- Do you think the climate scientists who have studied this topic are dishonest, and report untrue but amazing results in order to scare governments into giving them more money to do their research and keep their jobs?
- How authoritative and reliable is the Intergovernmental Panel on Climate Change?
- Besides thermometer measurements, what evidence is there for global warming?
- What proportion of climate scientists doubt that global warming is happening as a result of burning fossil fuels?
- Some assert the world cooled since 1998. Do the data support that?
- Are you in a position to have an opinion on the science? An opinion about the scientists?
- Why do you think Australian politicians argue over this?
- Over the long term, do you think global warming will benefit or harm human wellbeing?

Bring all these topics, and others you might think of, together at a Forum on Climate Change. Perhaps invite other classes, invite a climate scientist, invite the Australian Youth Coalition for Climate Change.

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NOTE THIS DOWN

Copy the graphic organiser below and create a SWOT analysis on the process of relying on prediction to guide environmental decision-making. An example has been done for you.

Relying on prediction to guide environmental decision making	
Strengths	**Weaknesses**
A safe approach due to the uncertain nature of the environment	
Opportunities	**Threats**

The Precautionary Principle

In the absence of sufficient scientific knowledge, reliable predictions of human impacts on the environment are difficult. A lack of predictive capacity can result in development that causes irreversible harm and unrecoverable loss of resources. Governments have recognised that, in the absence of scientific knowledge, precautionary approaches to resource management are required to prevent irreversible harm to the environment and ensure that unsustainable practices are averted. A precautionary approach to development is highly contentious because pro-development groups consider precautionary decisions to be a hindrance to development. The **Precautionary Principle** has been introduced to the legislation of many countries to guide decisions on developments that might cause irreversible harm. The most widely adopted definition of the Precautionary Principle is based on Principle 15 of the Rio Declaration:

Precautionary Principle a precautionary guide in the legislation for decisions on developments that might cause irreversible harm

> Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In this definition, 'measures' refers to the powers of governments, through legislation, to refuse developments that could cause irreversible environmental damage.

ACTIVITY 1.5

1. Discuss why developers are wary of the Precautionary Principle.
2. Provide an example of environmental harm caused by past decisions that lacked an understanding of risks.
3. Explain why we need to consider time frames when predicting environmental impacts.
4. In your opinion, is sustainability achievable in Australia? Explain your answer.

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RESEARCH 1.6

Search the internet and your school library for information on nuclear energy production and the Fukushima Daiichi nuclear disaster.

1. Is nuclear energy production a better environmental choice than coal-based energy production? Explain your answer.
2. Summarise in a series of short bullet points the Fukushima Daiichi nuclear disaster.
3. Reflect on the events at Fukushima. Discuss how they could have been avoided.
4. Identify one social, economic and environmental impact of a nuclear disaster. How do these impacts affect sustainability?

Source 1.20 Are nuclear power stations a sustainable alternative to coal-fired power stations?

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Human impacts

There are many human activities that degrade resources and threaten our capacity to achieve sustainability. The most common impacts are summarised in the table below:

Human activity	Immediate impacts	Short- to medium-term impacts	Long-term impacts
Deforestation	Loss of vegetation cover; increase in run-off; loss of habitat	Soil erosion and soil salinisation; degradation of streams through sedimentation and high turbidity	Reduced environmental quality for humans, plants and animals; desertification; reduced biodiversity.
Manufacturing and heavy industry	Contamination of soil, air and water; noise pollution; loss or degradation of cultural sites	Degraded habitats; accumulation of toxins in plants and animals; increase in acute diseases	Climate change; reduced biodiversity; extinction of species; increase in chronic diseases
Impoundment of water (dams and weirs)	Reduced river flows; degradation of water quality; changes in flood regimes; inability for fish to migrate	Erosion of downstream river; 'river chilling' from cold water releases; habitat degradation; reduced recruitment of aquatic organisms; reduced nutrient levels in flood plain soils	Loss of fish and other aquatic organisms; reduced productivity of agricultural land
Mining	Habitat loss or fragmentation; loss or contamination of groundwater resources	Weed infestation; reduced natural food resources; soil acidification and salinisation	Loss of biodiversity; low agricultural productivity; land subsidence
Over-fishing and harmful fishing practices	Loss of breeding population; damage to habitat	Habitat degradation; loss of seagrasses and coral; changes in food chain, changes in biodiversity	Extinction of species; reduced number of fish populations; changes in food web; loss of recreational and commercial fisheries and destruction of marine and freshwater systems
Urbanisation	Increased run-off; decreased infiltration; contamination of soil, air and water; stakeholder conflicts	Loss or degradation of habitat; downstream pollution of rivers; increase in invasive species; fragmented habitats	Extinction of species; loss of biodiversity; reduced food resources
Agriculture	Loss of natural vegetation; increased run-off; increased soil erosion; pollution of waterways	Habitat fragmentation; loss of habitat; sedimentation in nearby streams; water quality degradation in downstream areas	Reduced or loss of biodiversity; chronic soil salinisation

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1.7 Environmental worldviews

A worldview is a set of beliefs about what is real, what is valuable and what it means to be a human being. People hold different worldviews about the environment. People's worldviews affect their willingness to protect landscapes for aesthetic, cultural or spiritual reasons. Some worldviews are about benefits to the individual and some are more about ecological wellbeing. All worldviews are based on a set of values.

Value judgements are drivers for how we use and manage the environment. Our value judgements influence our decisions on whether we find environmental impacts acceptable or unacceptable, and also influence political positions on sustainability. Our environmental values are shaped by our exposure to environmental impacts and the influence of the media and education. The following ideologies influence how humans perceive environmental risks:

- *Ecocentrism* – places a focus on nature rather than humans. Ecocentrism proposes that we should consider humans as part of the biotic community and that we should modify our behaviour to protect the ecosystems to which we also belong. Sustainable development must consider our place in the ecosystem and build environmental goals rather than solely focus on meeting human needs.
- *Anthropocentrism* – places a focus on meeting human needs and recognises humans as the dominant species on Earth. Ecocentrics consider this ideology as the cause of unsustainable development.
- *Technocentrism* – proposes that environmental problems can be solved using science and technology. Ecocentrics are in conflict with technocentrics due to a lack of faith in technological solutions and a view that nature should not be controlled through technology.
- *Biocentrism* – endorses ethical treatment of all living things. Biocentrics consider that humans are not superior to other species and promote biodiversity. It differs from ecocentrism because it focuses on living organisms rather than the physical environment.

RESEARCH 1.7

Search the internet and a dictionary for the term 'NIMBY' and Nimbyism.

1. Spell out the acronym for NIMBY and explain what the term means.
2. Examine whether the term is used in a negative or positive context.
3. Identify three examples of developments in your city or town that triggered Nimbyism.

Source 1.21 An environmental protest supporting clean energy in Brisbane

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NOTE THIS DOWN

Copy the graphic organiser below and use it to summarise the different views of sustainability. An example has been provided.

Biocentrism				
The ethical treatment of all animals				

Sustainability worldview

From a sustainability worldview, we seek to combine rather than trade off ecological, cultural, social and economic values. This means creating technologies and livelihoods for people that also protect the environment, strengthen society and respect cultures.

The role of the whole community is very important in sustainability for several reasons. Involving the community in environmental management can lead to creative strategies and decisions that reflect the values and interests of the community, sometimes including spirituality. Sustainability is most likely to be achieved when the community has sound ecological knowledge and a strong sense of place and belonging.

In working towards sustainability, community discussions about the varying worldviews on the environment can help to gain a shared understanding of all values and how to combine them.

Where we can successfully combine ecological, cultural, social and economic values, we are beginning to tread lightly on the Earth and move towards sustainability.

For example, rather than locating industrial development, nature conservation, social activity and cultural heritage at different points of the landscape, we could make these activities more compatible so they can support each other and exist together in the landscape. Here are some examples of where we are starting to do this:

- Miners can rehabilitate a mine site to restore its ecological value and can also provide recreational infrastructure like a swimming pool to the local community.
- A farmer can plant a variety of native trees as windbreaks on his or her farm. The windbreaks provide ecological diversity but also increase the productivity of the farm by protecting the pasture and the livestock. The trees can also add visual appeal to the landscape.
- National parks can be jointly managed by a government conservation agency and Traditional Owners to support both ecological conservation and Aboriginal and Torres Strait Islander peoples' empowerment. Renewable energy and passive solar design can be used for the park facilities. Tourism can develop as a result of joint management practice. Community education and the local economy can then also improve.

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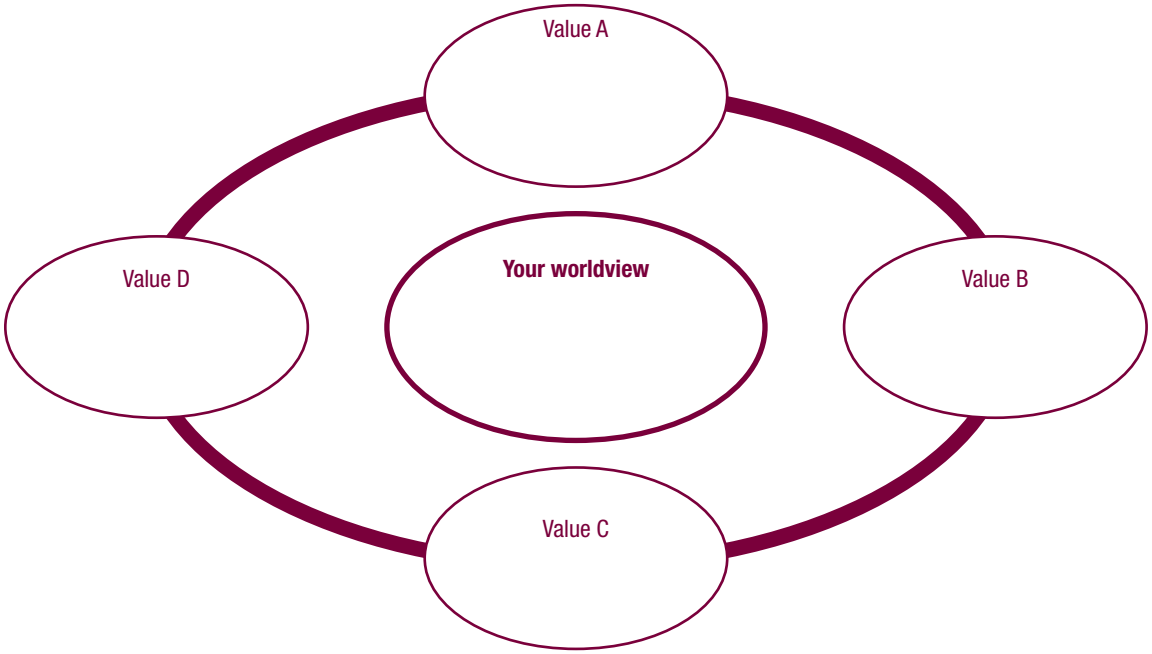
NOTE THIS DOWN

Copy the graphic organiser below and answer the following questions:

1 What do you value most about your environment? Write down your main values in the outside circles.

2 What do you conclude your worldview might be? Write it down in the centre circle.



Australian law

Ecologically sustainable development (ESD) is embedded in environmental decision-making in Australia. Legislation provides a legal framework for decision-making, guidelines for developers, processes for public participation and consistent measures to enforce compliance. **Environmental impact assessment** and planning laws were enacted during the 1970s following growing environmental activism that saw the public having a strong influence on environmental decision-making in this country. The Federal Government enacted the *Environmental Protection and Biodiversity Conservation Act* (EPBC) in 1999 to replace a number of environmental Acts from the 1970s and to streamline environmental decisions. The EPBC Act addresses the following matters of national significance:

- World Heritage sites
- National Heritage places
- nationally protected wetlands (Ramsar wetlands)
- nationally listed threatened species and ecological communities
- listed migratory species
- nuclear actions (including uranium mines)
- Commonwealth marine areas
- land owned by the Commonwealth
- activities by Commonwealth agencies.

Responsibility for environmental management and sustainable development is divided between all levels of government in Australia. If a development involves any of the previously mentioned matters of national significance, then the developer must seek approval from the Federal Minister for the Environment. This may require the submission of an Environmental Impact Statement.

ecologically sustainable development (ESD) the environmental component of sustainability that is embedded in environmental decision-making in Australia. It also considers the need to meet economic and social development goals

environmental impact assessment an assessment of positive and negative impacts an action or project will have on the environment

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Role of the public

Australian federal and state laws include opportunities for the public to make comment or to submit objections to developments. Major developments trigger the need for an **Environmental Impact Statement (EIS)** in most states and under the EPBC Act if there are matters of national significance. An EIS outlines the main activities of the development, predicts the potential impacts and describes strategies to minimise or prevent environmental impacts. The developer or proponent, who may also be the government, is required to produce an EIS that is subjected to review by **stakeholders**. Local government (councils) is also empowered to make decisions on development.

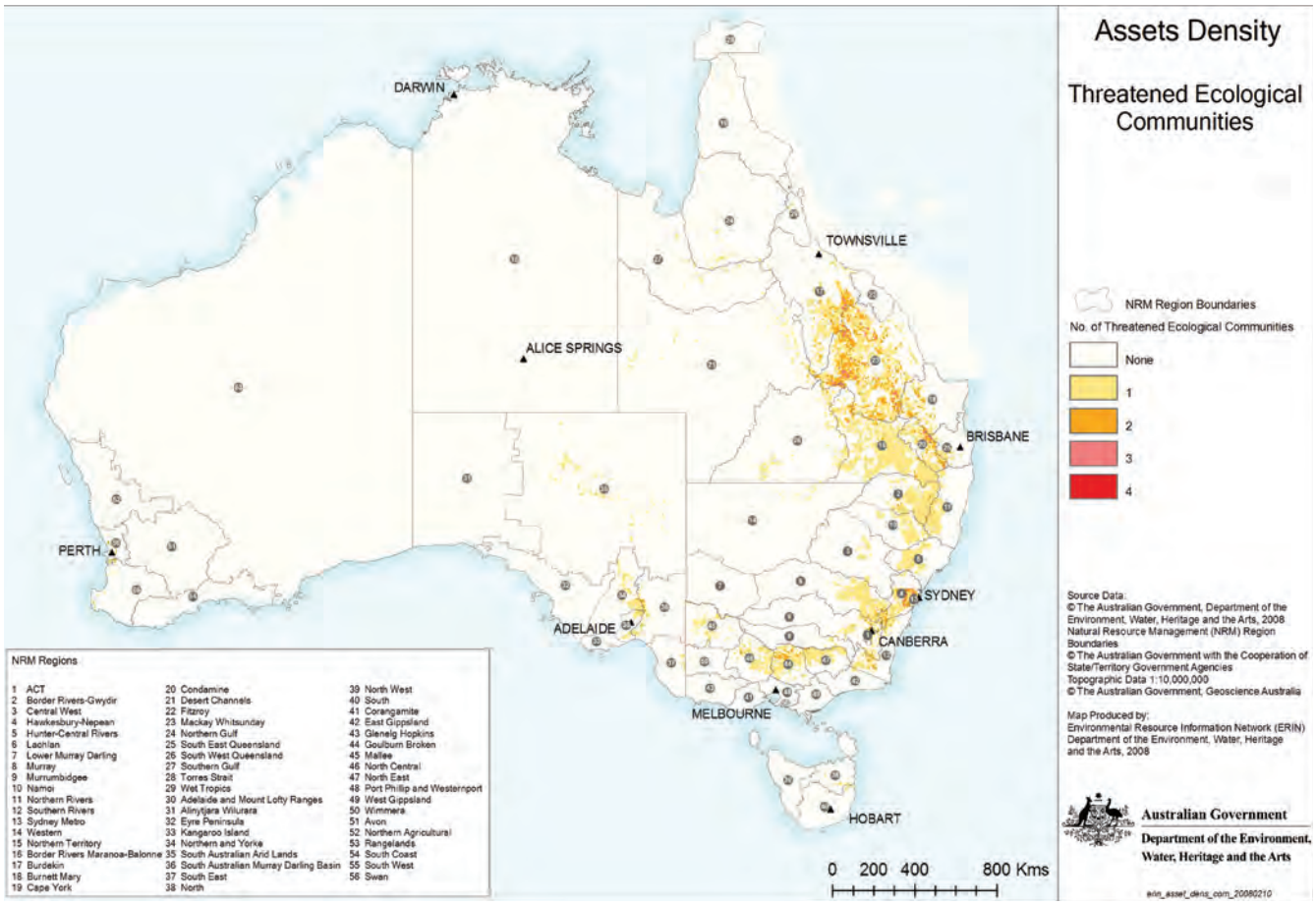
Environmental Impact Statement (EIS) a document that outlines the main activities of a development, predicts the potential impacts and describes strategies to minimise or prevent environmental impacts

stakeholder a party or person with an interest or concern in an organisation and its actions

Many Australian planning policies and environmental laws traditionally focused on approving single developments in an independent manner. That is, decisions were once made on the sole effects of one development at one location without considering the interactions with, and the sum of impacts of, other developments. There is now greater recognition of cumulative impacts and the importance of planning development strategically so that the effects of multiple projects can be predicted and considered. Although single developments can be considered sustainable, the environment may not be resilient to the effects of multiple developments. There can also be cumulative social impacts when multiple developments are approved separately. For example, truck movements to a single factory might cause acceptable noise levels. However, if there are multiple factories at a location, the increase in noise from trucks might become unacceptable. To address cumulative environmental impacts, environmental managers must consider the following:

- the spatial extent of the potential impacts of a development or activity; understanding the spatial extent enables decision-makers to determine who, what and where will be impacted and where interactions with other developments might occur

Source 1.22 Map of threatened ecological communities in Australia. Mapping is a useful tool for environmental decision-makers.



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Source 1.23 Coal seam gas exploration in Sydney's suburbs has triggered public objection and calls to apply the Precautionary Principle.

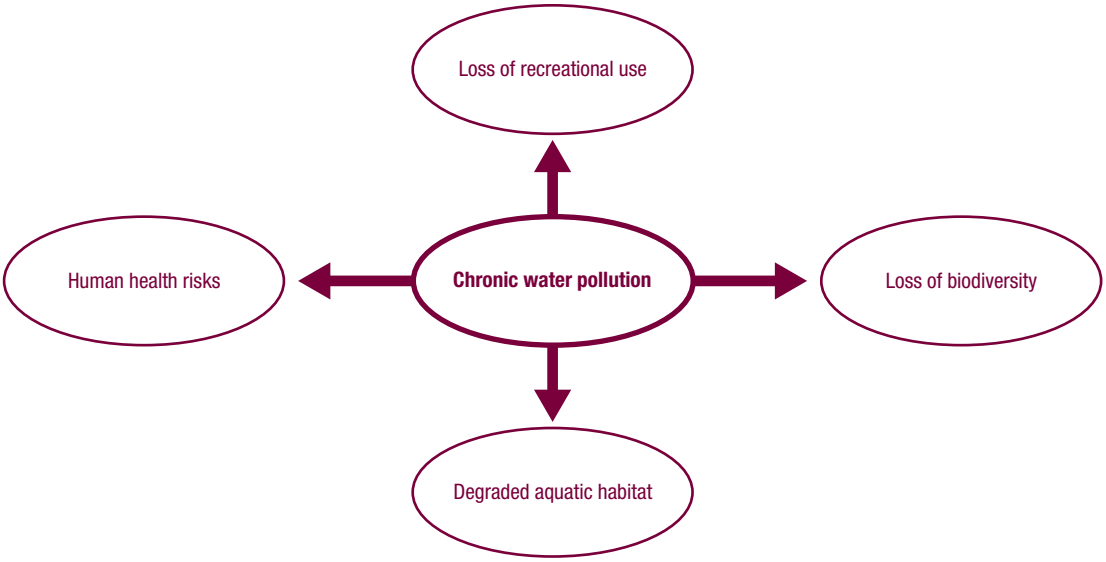
- the time over which an impact might occur and the length of time required to monitor; understanding the time frame for impacts enables decisions to be made about future impacts, future needs to be considered and projections on interactions between the current and future use of the environment to be made
- the interaction of impacts from past, present and future developments and activities; this knowledge is essential because decision-makers can more accurately predict if the impacts from a single development will add to or amplify the impacts from other developments
- the use of contingency plans and environmental monitoring to address impacts, over time, that were not accurately predicted; a lack of scientific knowledge or errors in past and current decisions on development can lead to cumulative impacts. Contingency plans and monitoring enable managers to quickly respond to negative changes in the environment by modifying development or implementing remediation strategies.

Geographical fact

In 2006–07, Australians generated approximately 48 million tonnes of waste. Only 52% of that waste was recycled.

NOTE THIS DOWN

Copy the graphic organiser below and show links between human activities and resulting impacts. You can add arrows to show interactions between impacts. An example has been completed for you below.



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Case study 1.5

The Green Bans: saving Sydney's historical sites

A green ban is strike action by a trade union or other group of labourers to protect the environment from development. The term originates from Black Bans, which involve strike or industrial action organised by unions. The term 'green ban' was coined to emphasise action taken to protect the environment from development. Until the mid-1970s, historical and cultural sites in Sydney were being demolished and redeveloped without passing through a rigorous process of planning decisions that involved public input. Communities were increasingly outraged by planning decisions that excluded them. Trade unions entered the public debate over redevelopment in the early 1970s when a group of women from Hunters Hill, a suburb of Sydney, sought help to stop the redevelopment of Kelly's Bush, the remaining bushland in the suburb. Union members working on the site of the redevelopment went on strike in what was the first of the green bans. Kelly's Bush was eventually preserved but a precedent was set and public groups continued to call on the trade unions to help protect areas of historical and cultural significance.

Source 1.24 Jack Mundey, who led union involvement in the green bans, being escorted by police during a protest. Jack Mundey coined the term 'green ban'.

Green bans helped to protect historical buildings in Glebe, The Rocks and Kings Cross, all parts of Sydney, and the redevelopment of the Royal Botanical Gardens and Centennial Park. Over 100 buildings of significant historical value were saved, and urban green space was preserved. The Sydney green bans inspired similar actions in other states and the practice was adopted internationally.

The green bans in Sydney, Melbourne and other cities triggered changes in federal and state environmental planning processes. Revisions to planning decisions, policies and environmental and planning laws included steps to protect historically and culturally valuable sites. The bans also led to a greater appreciation of public participation in development approvals. In 1975, the New South Wales State Government, aware of growing activism and changes in community attitudes, introduced the *NSW Heritage Act*, the *Environmental Protection and Assessment Act* and the *Land and Environment Court Act*, bringing to an end haphazard redevelopment of historic and cultural areas. These Acts ensured that proposals for redevelopment were carefully scrutinised by the public and state government and disputes could be addressed through the Land and Environment Court. The green bans also influenced politics in Europe where, as a result of the movement in Australia, the term 'green' was adopted to describe environmental issues and new 'green' political parties had formed. The preservation of historical and cultural sites is now embedded in environmental laws around the world to ensure that future generations have access to these assets.

1. Discuss one law that was enacted by the NSW Government that helped to protect the environment.
2. Explain in your opinion how effective green bans can be today. Can they still play a role in protecting the environment?
3. Reflect on the impact of 'people power' on environmental decisions. Besides green bans, what other ways can people influence bureaucrats to change how the environment is managed?
4. Analyse why the protection of historical and cultural sites is relevant to sustainable development.

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RESEARCH 1.8

Locate an online ecological footprint calculator; there are many, so choose a calculator that is most relevant to Australia. Prepare a list of your daily activities and record data on your use of resources such as electricity, water and food, fuel and paper and plastic products. Calculate your ecological footprint for one typical day using the online resource.

1. Explain which daily activity had the greatest energy demand.
2. Discuss what you can do to reduce your daily consumption of renewable and non-renewable energy sources.
3. Summarise the key activities that directly polluted the environment.
4. Describe how you might have impacted the environment outside the area where you conducted your activities.

1.8 Aboriginal and Torres Strait Islander peoples' approaches to custodial responsibility and environmental management

For tens of thousands of years, Aboriginal and Torres Strait Islander peoples have lived across Australia in hundreds of distinct groups with their own unique languages and cultural practices. All Aboriginal and Torres Strait Islander peoples held central to their beliefs and culture an ancestral Creation time now known to non-Indigenous people as the 'Dreaming' or 'Dreamtime'. During this time ancestral creatures moved across the landscape and created landforms, plants and animals, laws and customs, and people. Before European settlement, Aboriginal and Torres Strait Islander peoples modified the environment

Source 1.25 The Yarra River, which runs through Melbourne, has sadly attained poor water quality, impacting the ecosystem of the river.

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with fire but over a timescale that enabled the environment to reach a new balance. It is thought that through the use of fire, Aboriginal and Torres Strait Islander peoples had a major impact on Australia's landscape. Australian historian Bill Gammage published a book in 2011, *The Biggest Estate on Earth: How Aborigines made Australia*, that describes how important he thinks Aboriginal and Torres Strait Islander peoples' land management was for the Australian continent. Gammage draws upon the writings and paintings of early Australian settlers, who would often describe the landscape as looking like an English gentleman's park with large, widely spaced trees and undulating grassy slopes underneath. Often, they could not explain why one area appeared like a well-maintained parkland, whereas next to it, with the same soil, landforms and climate, was woodland or forest. It seems that this landscape was not coincidental; rather it had been created by long-term and deliberate burning by Aboriginal and Torres Strait Islander peoples to create a landscape that was easy to walk through and promoted abundant and easily accessible plant and animal resources.

The role of Aboriginal and Torres Strait Islander peoples in the extinction of megafauna is not fully understood. There is evidence that supports several theories for the extinction of Australian megafauna, which include changes in vegetation communities that were essential for food, hunting, climate change and the evolution of megafauna, through adaptation, to smaller, modern species. Nevertheless, Aboriginal and Torres Strait Islander communities were able to sustain their populations and not exhaust sources of food.

Although other scientists and land managers have known about 'fire-stick farming' for many years, Gammage presents a new hypothesis which emphasises how this use of fire created the entire landscape that early settlers encountered. After European colonisation, many traditional cultural practices of Aboriginal and Torres Strait Islander peoples, including burning, were interrupted or stopped completely. It is possible that by stopping this traditional method of burning, many grasslands disappeared and were replaced by shrubs, trees and even rainforest, the type of environments Australians are familiar with today. Unfortunately, it is also possible that without traditional burning, the landscape today is more prone to large, destructive wildfires that can damage property and endanger people and wildlife due to the build-up of vegetable litter and foliage that was once burnt regularly.

The First Fleet, which arrived in Botany Bay on 18 January 1788, soon realised the challenge of supporting a new settlement due to the poor-quality soils and limited water resources. On 26 January, Captain Arthur Phillip established a colony at Sydney Cove in Sydney Harbour where water resources and soil fertility were more suitable. Early farmers found they were unable to sustainably farm the shallow, sandy and low fertility soils of Sydney. European soils, by contrast, were deeper and more fertile. Recurrent crop failures forced settlers to move agricultural activities to the more fertile alluvial soils of the upper Parramatta River. The growing settlement also faced further environmental pressure when the main water supply, the Tank Stream, became polluted due to effluent from domestic activities and cottage industries. The pollution of the Tank Stream was potentially Australia's first example of a failure to control development and protect the sustainability of a water resource. In 1826, 38 years after English settlers occupied Sydney, the Tank Stream was abandoned as a source of potable water. The stream, which once provided water and food resources for Indigenous peoples, had become a toxic watercourse with no economic or environmental value.

The degradation of watercourses was repeated in many areas in Australia settled by Europeans. Degradation of naturally infertile and shallow soils also followed soon after settlement. Deforestation exposed the shallow soils to erosion, which was exacerbated by farming technologies imported from Europe. Since European settlement, more than half of Australia's forests have been cleared. Soil salinisation was caused by irrigation and tree clearing. Irrigation artificially raised water tables and, through evaporation, concentrated salt in the shallow topsoils. Tree clearing altered the water balance and increased the discharge of saline water in the landscape. Invasive species

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such as prickly pear and rabbits further degraded the land and jeopardised the food and income security of people. In New South Wales, the *Soil Conservation Act* was passed in 1938 and the NSW Soil Conservation Service was established to manage the declining soil resources. Other states soon followed with similar agencies.

Traditionally, Aboriginal and Torres Strait Islander peoples had an intimate knowledge of the plants, animals, water, and landforms that existed on their country. This knowledge was not written down but rather was held in many forms including songs, ceremonies and Creation stories. This knowledge was passed down through generations and many Aboriginal and Torres Strait Islander peoples continue to hold traditional knowledge and pass it down to their next generations, an important cultural responsibility. Aboriginal and Torres Strait Islander peoples held, and continue to hold, detailed knowledge about plants and animals and how they interact together. This allows people to use clues from the landscape to understand what is happening in their environment, such as when particular food resources are ready to eat. For example in northern Australia some people know that when the red kapok flower blooms, freshwater crocodiles are laying their eggs, a source of food.

Aboriginal and Torres Strait Islander peoples used, and continue to use, a range of methods that help to ensure food resources remain plentiful. This includes techniques like seasonal hunting of animals and types of farming. For instance, the Gunditjmara people from Lake Condah (350 km west of Melbourne) farmed eels through a system of channels and ponds.

Aboriginal and Torres Strait Islander peoples' natural resource management

The land rights movement has seen many Aboriginal and Torres Strait Islander peoples move back to their traditional lands and focus on sustaining their culture. In the last few decades programs have been developed that involve Aboriginal and Torres Strait Islander peoples working as rangers to care for their own country, protecting their environmental and cultural resources. These programs provide Aboriginal and Torres Strait Islander peoples with the ability to obtain an income, often in very remote areas while harnessing their knowledge and skills to provide important services.

Source 1.26 A red kapok flower, which in northern Australia signals that freshwater crocodiles are laying their eggs

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Language is a very important part of Aboriginal and Torres Strait Islander peoples' culture because it is only through language that people can express their culture, which includes caring for country. Many programs today, including ranger programs, use Indigenous language and names to express how Aboriginal and Torres Strait Islander peoples conduct environmental management. As non-Indigenous land managers increasingly recognise the importance of Aboriginal and Torres Strait Islander peoples' ecological knowledge, they are seeking to collaborate and work together with Aboriginal and Torres Strait Islander peoples to find the best ways to protect Australia's ecosystems, plants and animals. Special reserve areas, called 'Indigenous Protected Areas' (IPAs), are being created on parts of Aboriginal and Torres Strait Islander peoples' land and sea country. These are areas where traditional owners agree to promote the protection of environmental and cultural resources. IPAs recognise that the continued existence of Aboriginal and Torres Strait Islander peoples on their traditional lands across Australia provides great value in protecting the environment and its ecosystems.

ACTIVITY 1.6

1. Recall what 'fire-stick farming' is.
2. Discuss why early European farmers found they were unable to sustainably farm the shallow, sandy and low-fertility soils of Sydney.
3. List some of the programs that provide Aboriginal and Torres Strait Islander peoples with the ability to obtain an income in often very remote areas by harnessing their knowledge and skills.

Australian states and territories have engaged Aboriginal and Torres Strait Islander peoples' communities in catchment management and by establishing consultative reference groups. In most states and territories they are known as Aboriginal Reference Groups (ARGs). In Queensland they are known as Aboriginal and Torres Strait Islands Reference Groups to include island communities in Torres Strait. In New South Wales, for example, the Catchment Management Authority for the Central West established an ARG to:

Source 1.27 Guanaba IPA, at the foot of Mt Tamborine, Queensland, is one of the many Aboriginal and Torres Strait Islander peoples' Protected Areas in Australia.

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- maximise the participation of Aboriginal and Torres Strait Islander peoples in all levels of natural resource management within the Central West area
- maximise the protection and maintenance of Aboriginal and Torres Strait Islander peoples' cultural heritage
- maximise opportunities for relevant skills development and capacity building in natural resource management
- maximise the opportunities for Aboriginal and Torres Strait Islander peoples' economic development in natural resource management
- maintain and enhance the integrity of Aboriginal and Torres Strait Islander peoples' intellectual property in traditional ecological knowledge and cultural and spiritual knowledge.

The ARGs are consulted in matters of natural resource management and the protection of cultural heritage. They are responsible for developing relationships between environmental decision-makers and other stakeholders, and participate in developing and implementing catchment management plans.

The Australian Government recognises the importance of Aboriginal and Torres Strait Islander peoples' knowledge in catchment management as well as the rights of native titleholders. Accordingly, laws and policies have been developed or amended to ensure that Aboriginal and Torres Strait Islander peoples' communities are fully engaged in natural resource management without detriment to livelihood opportunities or the loss of cultural heritage. A network of Indigenous Land Management Facilitators was established to help communities develop partnerships with government agencies and organisations involved in sustainable development. Under the Natural Heritage Trust, Aboriginal and Torres Strait Islander peoples' groups are able to apply for grants to support programs that manage rivers, protect threatened species, conserve cultural assets and improve the productivity of the land. The federal government has also established the Indigenous Land Corporation to enable Aboriginal and Torres Strait Islander peoples' communities to acquire and manage land according to sustainability principles. The goal of the Indigenous Land Corporation is to enable Aboriginal and Torres Strait Islander peoples' communities to meet their socio-economic needs and fund and facilitate programs that protect cultural and environmental assets for the benefit of all Australians.

Source 1.28 Ayers Rock Resort at Yulara, where the Indigenous Land Corporation has established a National Indigenous Training Academy

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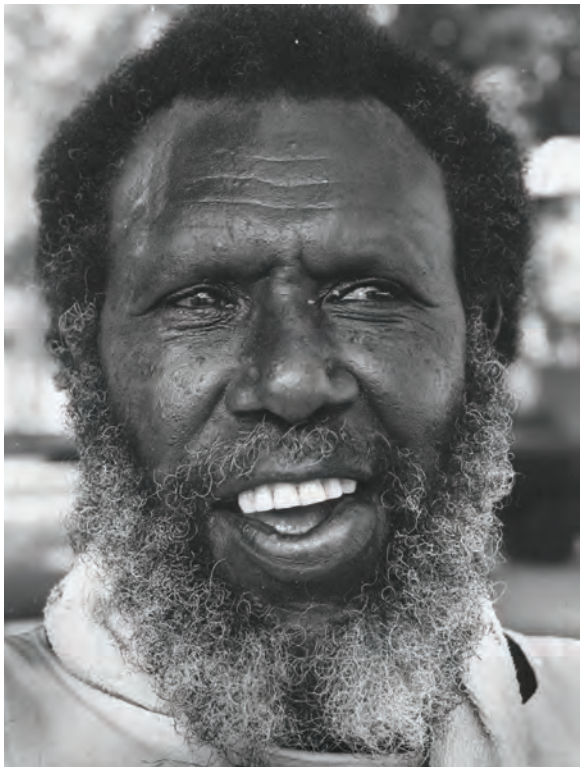
Case study 1.6

Mer – also known as Murray Island

Mer is a small volcanic island with a population of around 450 located at 9°and 144° in the eastern section of the Torres Strait Islands. Meriam people have inhabited this island for thousands of years and have a strong affiliation with the land. However, when Europeans arrived and started to settle on the island, the Queensland government claimed control in 1879.

Source 1.29 Location of Mer (Murray Island) with the Torres Strait between Queensland and Papua New Guinea

The sacred bond between its Aboriginal and Torres Strait Islander peoples, their traditional lives and the island has been the catalyst for a momentous decision in Australian history. Eddie Koiki Mabo, a native of Mer, who was working as a gardener at James Cook University in Townsville, spoke to two academics, Henry Reynolds and Noel Loos, at the university about traditional ownership or title of land on the island. They informed him that he had no legal ownership as the land was owned by the government as a result of *terra nullius*. *Terra nullius* is a Latin phrase meaning 'land belonging to no one'. When the British came to Australia they tried to identify a political system or settlement system of the Aboriginal and Torres Strait Islander peoples, and since they were not able to identify any system, they claimed the land as *terra nullius* and enforced British rule and law onto Australia.



Source 1.30 Eddie Mabo

In 1981 Eddie Mabo made a speech at James Cook University outlining the land ownership and inheritance system on Mer. A lawyer at the conference suggested there should be a test case on claiming land rights through the court system. Central to the case was challenging the concept of *terra nullius* – that land claimed by the Europeans was uninhabited. In 1982 Eddie Mabo, Sam Passi, David Pass, Celuia Mapo Salee and James Rice made a legal claim for ownership of their lands on Mer.

In 1985 the Queensland Government passed the *Queensland Coast Islands Declaratory Act* in an attempt to negate any claims Torres Strait Islanders had to the land. In 1988 the High Court found that the *Queensland Coast Islands Declaratory Act* contravened section 10 of the *Federal Racial Discrimination Act 1975* (Cth) and was therefore invalid.

Under the Constitution, federal acts of parliament take precedence over state acts of parliament. (This is to ensure that the federal parliament has the ultimate decision-making power.)

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In 1992 the High Court rejected the notion of *terra nullius* and recognised the Meriam people as the native title holders of traditional lands on the island. The ruling found that native title exists separate from Crown claims to the land, as long as a connection to the land for people claiming native title remains. It was hailed as a momentous victory by the Aboriginal and Torres Strait Islander peoples rights movement, but within the mining and pastoral sectors unease grows over the implications of the ruling. Sadly, Eddie Mabo was not present to celebrate the victory; he had died of cancer five months earlier, aged 56.

Source 1.31 The High Court of Australia in Canberra

The case was successful because it established that:

- the Meriam people have had continuous occupation of the islands
- anthropological evidence showed that the present inhabitants of the Islands were descended from the people in occupation at sovereignty
- the people lived in groups of huts strung along the foreshore or strand immediately behind the sandy beach. The cultivated garden land was and is in the higher central portion of the island
- the people used sub-tidal fish traps that would capture fish as the tides changed, allowing the Meriam to spear the fish easily. This demonstrates the Aboriginal and Torres Strait Islander peoples had a permanent part of the urban environment (rock pool fish traps) on their land.

Legacy of Mabo

In addition to rejecting the doctrine of *terra nullius*, the High Court also ruled that the common law of Australia recognised a form of native title that reflected the entitlement of the Aboriginal and Torres Strait Islander peoples to their traditional lands, in accordance with their laws and custom. In response to Mabo, the Australian Government enacted the *Native Title Act 1993* (the Act). The Act recognises and protects native title and sets up processes by which claims for native title can be determined and future activity impacting on native title may be undertaken. To May 2012, there have been 139 determinations recognising the existence of native title, and determined native title covers approximately 16% of Australia's landmass.

1. Explain why central to the case was challenging the concept of *terra nullius*.
2. Describe why, under the Constitution, federal acts of parliament take precedence over state acts of parliament.
3. Discuss why, this ruling was hailed as a momentous victory by the Aboriginal and Torres Strait Islander peoples rights movement, but was met with unease by the mining and pastoral sectors.

RESEARCH 1.9

View the ABC *Four Corners* episode titled 'Judgement Day', 3 May 2012 (for the link, see www.cambridge.edu.au/geography10weblinks)

Complete the following question after viewing 'Judgement Day':

Explain the importance of Mabo 20 years on. How has it impacted on Aboriginal and Torres Strait Islander peoples and non-Indigenous people?

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FIELDWORK 1.1 SUSTAINABLE CITIES

Aim

To identify land use and/or specific activities that cause environmental impacts, determine what measures that are being or could be used to mitigate impacts, and to determine if your city or town is following the principles of sustainability.

Method

Students will compile information on the inputs and outputs required for a city or town area to function, and to predict potential impacts on the environment from various activities. Form groups of three to five students to share the workload. This activity involves collecting information on key activities (e.g. transport, construction, disposal of domestic and industrial waste, energy use, water supply, stormwater drainage) and estimating what is required for the city or town to function. You will also investigate how resource use and waste disposal affect the local and off-site environments. General predictions are only required. You will use skills in observation and data collection.

Preparations

Locate a map of your city or town and download a satellite image at the same scale. You can utilise websites such as Google Earth or Google Maps to produce both. Download and print a second map showing the catchment area of your city or town. This catchment-level map will help you to predict off-site impacts. On this second map, draw a boundary of the city area where you will focus your investigation. On your city/town map, annotate stops for the field trip so you can locate where you are during the visit. Your teacher will advise you of the stops and the path you will take. Before the field trip, investigate and note the location of:

1. major roads
2. housing areas
3. industrial areas
4. retail and office areas
5. canals and natural waterways
6. parklands and natural areas
7. any other landscape features of importance.

You can pencil in boundaries around these features, or use highlighting or coloured pens to label key features.

Before commencing the field trip, each group should discuss key inputs (e.g. food, energy, water) and outputs (e.g. exhaust, garbage, stormwater) for the known activities, as well as consider the effect of landscape features. Use the table below to add information. You will continue to fill this table during your field trip.

Data collection

Location	Type of environment	Major activities	Inputs	Outputs	Potential environmental impacts
E.g. Queen Street Mall, Brisbane	Entertainment, retail and office space	Restaurants, shopping, commercial/ financial, pedestrian and vehicle traffic	Electricity, water, food, mineral resources, paper products	Car exhaust, run-off from hard surfaces, wastewater from shops, recyclable and non-recyclable waste	Air pollution, noise pollution, water pollution, loss of habitat, loss of land for garbage disposal

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1 Use the table to record information at each stop. You might have already partially completed the information from your maps, but use the field visit to expand information and capture photos of activities to use in your report.

2 Identify what activity at each location presents the greatest risk to the environment. Circle this activity in your table for future reference.

3 Discuss where the inputs are likely to be sourced, and where the likely destination of the outputs are.

4 Is there any evidence of environmental impacts at the location? If so, record the impacts in a notebook and rate them in terms of their magnitude (e.g. low, moderate, severe). What are the likely impacts of activities in areas outside of the city or town? Note where these impacts occur on your catchment map.

5 Is there any evidence of strategies to minimise impacts from activities at each location? Examples include: educational signs, trash traps, recycling bins, buffer zones around canals and streams and noise barriers.

6 Discuss how the environment has altered environmental processes that cause your identified impacts. Refer to hydrological, atmospheric and biological processes. For example, hard surfaces such as roads can reduce infiltration of rainwater and increase run-off. The increased run-off can transport pollution to nearby canals.

7 On return to the classroom, share your findings with other groups. Discuss the key activities that could significantly impact the environment. Which land use and its activities present the greatest risk to the environment? Propose new strategies that could be used to improve management and minimise impacts. Discuss the possible cumulative impacts on the environment; refer to your table and information provided by other groups. Synthesise information from your table and discussions and draw a conclusion on whether your city or town is sustainable.

8 Complete a group or individual report using the following presentation layout as a guide. Create section headings based on the layout:

Fieldwork presentation layout

Front page	Tile and name (or name of group)
Contents page	Complete this last so your page numbers match your section headings.
Page 1	Aims and methods
Page 2	Location map (include your local area and your catchment map)
Page 3	Introduction – brief description of the study site
Pages 4 and 5	Major activities – describe the major activities at each stop.
Page 6	Table of activities and impacts (use your data collection table. Be sure to update the information based on class discussions.)
Pages 7 and 8	Describe the observed or predicted impacts of the activities. Refer to the processes affected by the activities and how these have led to local and downstream impacts. Ensure you cover social, economic and environmental impacts.
Page 9	Discuss observed and potential strategies to minimise the impacts.
Page 10	Table or written description of management strategies
Page 11	Photos of observed strategies or sketches of proposed strategies
Page 12	Conclusion – in this section rate your city or town's sustainability status.
Page 13	Appendix (this may include photos or data you have not embedded in the main text but supported your written work), bibliography, glossary

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Chapter summary

- Sustainability refers to our capacity, actions, decisions and strategies to achieve prosperity and meet social needs without compromising the natural environment.
- The three pillars or spheres of sustainability are social needs, economic growth and environmental protection.
- Intergenerational equity is a key component of sustainability and requires humans to manage their activities and resource use today to ensure fair and reasonable access to future generations.
- Soil, water, the atmosphere and biodiversity are important for ecosystem functioning.
- An inability or reluctance to apply sustainable practices and/or adapt to environmental change, whether it is natural or human-induced, can lead to the decline of societies.
- Environmentalism is a social movement that involves lobbying and other forms of activism to influence and educate others, particularly governments and developers, to conserve or protect the environment.
- Sustainable development is a recognised global issue. Inter-governmental organisations have set global sustainability goals and recommended actions to enable all humans to prosper without significant environmental losses.
- Governments rely on laws and policies to create consistent and formal approaches to environmental management.
- Australia has embedded the principles of ecologically sustainable development in federal and state laws, and local government planning policies.
- The weather and the climate are driven by the sun. Global temperature is set by a balance between the sun's energy radiating in and the heat from the Earth radiating out.
- Earth's heat is partly retained through the absorption of heat by the two main greenhouse gases, water vapour and carbon dioxide.
- Climate change results from a change either in the sun or in the amount of heat absorbed in the atmosphere. When atmospheric carbon dioxide rises, so does the Earth's temperature and that makes the climate change.
- Burning fossil fuels has increased the atmosphere's carbon dioxide content by 40% since 1850, and this has caused global warming.
- Global warming might be slowed by reducing dependence on fossil fuels for energy, and reversed by removing some carbon dioxide.
- Climate change can be expected to increase Australia's temperature, change rainfall patterns and increase storm intensity. In low-lying places, such as the Amazon Delta, much of Bangladesh and small island communities, sea level rise and storm surges pose significant threats to livelihood.
- Already some of these effects are evident in the form of desertification, storm damage, heat-waves and the loss of Arctic ice in the summer.
- Aboriginal and Torres Strait Islander peoples continue to identify with their ancestral, or traditional lands, now commonly referred to as 'country', which refers to all of the landforms, water and living things in an area.
- Today, the Aboriginal and Torres Strait Islander peoples who are the 'custodians' or care-takers for their traditional lands are known as 'traditional owners' and 'managers'.
- Mer, or Murray Island, is a spiritual and cultural place for the Aboriginal and Torres Strait Islander peoples of the island. This led them to challenge the ownership of the island all the way to the High Court of Australia in a case they won.

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End-of-chapter questions

Multiple choice

1 The formal definition of sustainability encompasses:
   - **A** maintenance of a stable economy
   - **B** conservation of environmental resources
   - **C** meeting the needs of society
   - **D** all of the above

2 The biosphere is:
   - **A** the air we breathe
   - **B** all the vegetated areas of the earth
   - **C** the sum of all terrestrial and aquatic ecosystems
   - **D** a green buffer zone around developments

3 Where does carbon dioxide come from?
   - **A** Volcanoes
   - **B** The ocean
   - **C** Burning coal, oil and gas
   - **D** All of the above

4 Aboriginal and Torres Strait Islander peoples' used fire as a method of:
   - **A** clearing land to make it easier to hunt animals
   - **B** creating new growth shoots to attract animals
   - **C** changing the types of plants living in an area
   - **D** all of the above

5 The EPBC Act deals with environmental matters that:
   - **A** relate only to government-funded developments
   - **B** only involve stakeholder conflicts
   - **C** are nationally significant
   - **D** relate only to privately-funded developments

Short answer

1 Identify what the role of the government is in achieving sustainability.

2 Explain why the Arctic and Antarctic warm faster than the rest of the Earth during periods of global warming.

3 Briefly explain the purpose of precautionary approaches in environmental decision-making.

4 State and briefly describe the three main pillars of sustainability.

5 List the factors that determine carrying capacity.

Extended response

Reflect on the following statement: 'Sustainability can never be achieved. Human populations will keep growing and consume resources at a rate which will one day exceed the carrying capacity of the Earth.' Comment on this statement using either a technocentric, anthropocentric or ecocentric position.

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