An aerial, high-angle photograph of a city at night. The city is densely packed with buildings, and the streets are illuminated with warm yellow and orange lights. A large commercial jet is flying over the city, leaving a white contrail. The overall color palette is dominated by blues, greys, and the warm glow of city lights.

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NEW SOUTH WALES

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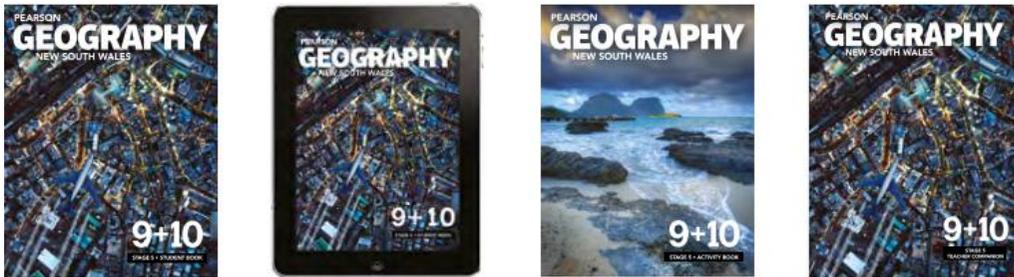
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Case studies

Case study units relate to a specific event or location. The units are written to extend students' knowledge and understanding. Case studies include examples from Australia and the world.

5.1.1
CASE STUDY: The Green and Gene revolutions

Intensification of agriculture
This has been the result of a number of factors. The main one is the increasing demand for food. The world population is growing rapidly and the demand for food is increasing. This has led to the intensification of agriculture. This means that more land is being used for growing crops and raising animals. This has led to the development of new technologies and techniques for growing crops and raising animals. This has led to the development of new products and services for the food industry.

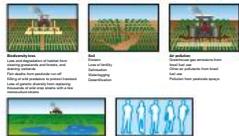
The Green Revolution
The Green Revolution was a period of rapid agricultural development that took place between 1940 and 1970. It was characterized by the use of new technologies and techniques for growing crops and raising animals. This led to a significant increase in food production and helped to feed a growing world population.

The Second Green Revolution
The Second Green Revolution is a period of rapid agricultural development that is currently taking place. It is characterized by the use of new technologies and techniques for growing crops and raising animals. This is expected to lead to a significant increase in food production and help to feed a growing world population.

Impact of the Green Revolution
The Green Revolution has had a significant impact on the world. It has led to a significant increase in food production and helped to feed a growing world population. It has also led to the development of new technologies and techniques for growing crops and raising animals. This has led to the development of new products and services for the food industry.

Environmental Impact
The Green Revolution has had a significant impact on the environment. It has led to the use of large amounts of fertilizers and pesticides, which can be harmful to the environment. It has also led to the depletion of natural resources and the loss of biodiversity.





Skills builder

Skills builders are embedded in selected units and concentrate on key geographical skills.

12.6
Access to water

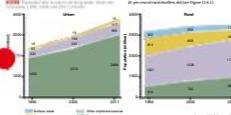
Millennium Development Goals
The Millennium Development Goals (MDGs) are a set of eight international development goals that were adopted by the United Nations in 2000. The goals are to be achieved by 2015. The goals are: 1. Eradicate extreme poverty and hunger, 2. Achieve universal primary education, 3. Promote gender equality and empower women, 4. Reduce child mortality, 5. Improve maternal health, 6. Combat HIV/AIDS, malaria and other diseases, 7. Ensure environmental sustainability, and 8. Develop a global partnership for development.

Sustainable development goals
The Sustainable Development Goals (SDGs) are a set of 17 international development goals that were adopted by the United Nations in 2015. The goals are to be achieved by 2030. The goals are: 1. No poverty, 2. Zero hunger, 3. Good health and well-being, 4. Quality education, 5. Gender equality, 6. Clean water and sanitation, 7. Affordable and clean energy, 8. Decent work and economic growth, 9. Industry, innovation and infrastructure, 10. Reduced inequalities, 11. Sustainable cities and communities, 12. Responsible consumption and production, 13. Climate action, 14. Life below water, 15. Life on land, 16. Peace, justice and strong institutions, and 17. Partnerships for sustainable development.

Improved sources of water
Improved sources of water are those that are clean, safe, and accessible to all people. This can be achieved through a variety of methods, including: 1. Building dams and reservoirs, 2. Desalination, 3. Rainwater harvesting, 4. Groundwater recharge, and 5. Water recycling.

Access
Access to water is the ability to obtain water in a safe and sustainable manner. This is a key challenge in many parts of the world, particularly in arid and semi-arid regions. Access to water is essential for human health, economic development, and environmental sustainability.

Spotlight
Waterborne disease
Waterborne diseases are those that are caused by drinking contaminated water. These diseases can be caused by a variety of pathogens, including bacteria, viruses, and parasites. Common waterborne diseases include cholera, typhoid, and dysentery. Waterborne diseases are a major public health problem in many parts of the world, particularly in developing countries.


Spotlight

Spotlight boxes focus attention on a place, an issue or a concept relating to the unit.

ONLINE RESOURCES

Extra content (online)

Chapters 14 and 15 refer to the NSW BOSTES syllabus unit 'Environmental change and management', providing two extra environments to investigate—coastal environments and marine environments. Chapter 16 refers to the NSW BOSTES syllabus unit 'Human wellbeing', and provides an investigation into human wellbeing in India.

Extension tasks

Extension tasks enable students to revise key geographical concepts, tools and skills developed in the text, and to complete higher order inquiry skill tasks.

CHAPTER 14
Coastal environments

The coastline is the area where the land meets the sea. The coastline is a dynamic feature of the Earth's surface. It is constantly changing due to a variety of factors, including sea level rise, erosion, and sedimentation. Coastal environments are those that are located along the coastline. They are characterized by a variety of features, including beaches, dunes, and mangroves. Coastal environments are important for a variety of reasons, including their role in protecting inland areas from flooding and their role in providing habitat for a variety of plants and animals.

ENQUIRY QUESTIONS

- What are the characteristics of coastal environments?
- How do coastal environments change over time?
- What are the threats to coastal environments?
- How can coastal environments be protected?

GLOSSARY

Coastline The area where the land meets the sea.

Sea level rise The increase in the average level of the world's oceans.

Erosion The process of wearing away the land.

Sedimentation The process of depositing material.

Beach A strip of land between the sea and the land.

Dune A mound of sand.

Mangrove A type of wetland.

Flooding The overflow of water onto land.

Habitat The natural home of an animal or plant.

Threat A danger or risk.

Protect To keep safe from harm.

CHAPTER 16
Human wellbeing: India

India is a large and diverse country. It is home to a variety of people and cultures. India is a developing country and is facing a variety of challenges, including poverty, inequality, and environmental degradation. However, India is also making significant progress in a variety of areas, including economic growth, social development, and environmental protection. India is a country of great potential and is expected to continue to grow and develop in the future.

ENQUIRY QUESTIONS

- What are the characteristics of India?
- How is India changing over time?
- What are the challenges facing India?
- How can India be improved?

GLOSSARY

Developing country A country that is in the process of economic development.

Poverty The state of being poor.

Inequality The state of being unequal.

Environmental degradation The damage to the environment.

Economic growth The increase in a country's production of goods and services.

Social development The improvement in the quality of life.

Environmental protection The actions taken to protect the environment.

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Productivity Commission: © Commonwealth of Australia, *Overcoming Indigenous Disadvantage: 2013 consultation paper*, p. 361.

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University of Colorado, CIRES: Dr. Conrad Steffen, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, p. 402b.

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Geographical inquiry and skills

In Geography we use an inquiry approach to make meaning of the world around us. This involves finding answers to the questions we have about the things we observe in the biophysical, managed and constructed environments.

Our developing geographical knowledge and understanding informs the investigations we undertake in Geography. Geographical knowledge is made up of the facts, generalisations, principles, theories and models developed in Geography.

This knowledge is dynamic and its interpretation can be challenged. Geographical understanding is the ability to see the relationships between elements of knowledge and construct explanations to account for these relationships. It is also the ability to apply this knowledge to new situations or to solve new problems.

When undertaking a geographical inquiry we start with geographical questions and proceed through the collection, evaluation, analysis and interpretation of information to the development of conclusions and proposals for actions. Our inquiries may vary in scale and geographical

context. Geographical skills are the techniques we use in these investigations, both in fieldwork and in the classroom.

In this chapter we focus on the analysis of topographic maps, the use of flowline maps and diagrams, population pyramids and photographs. We also examine the steps involved in undertaking a geographical inquiry.

INQUIRY QUESTIONS

- What information can we gain from an analysis of topographic maps?
- How does the drawing of cross-sections, and the calculation of gradient and local relief, enhance our understanding of relief?
- How do flowline maps and diagrams enhance our understanding of the links between places and elements of processes?
- How can photographs inform our understanding of types of agriculture?
- What do population pyramids tell us about the demographic structure of countries?
- What are the key stages in a geographical inquiry?

GLOSSARY

cross-section	a side view, or profile, of a landscape, providing a visual impression of the shape of the land	local relief	the variation in elevation or height over a relatively small, defined area
flow diagram	an illustration showing the interactions that occur within and between the biophysical, managed and constructed environments	location	the place where something is or where something is occurring
flowline maps	maps drawn using statistics of actual movements that have occurred, demonstrating the main patterns and linkages	population pyramid	a graphical representation of a population's age and sex structure
geographical inquiry	an investigation that starts with geographical questions and proceeds through the collection, evaluation, analysis and interpretation of information to the development of conclusions and proposals for actions	relief	the shape, height and steepness of the land
gradient	the steepness of a slope, road or river	topographic map	a detailed, large-scale representation of part of the earth's surface
		transect	a straight line or narrow section through a natural feature or across the earth's surface, along which observations are made or measurements taken

1.0 Geologists study a graphical display of oil- and gas-bearing rock.

Analysing topographic maps

Topographic maps

A **topographic map** is a detailed, large-scale representation of part of the earth's surface. Topographic maps show selected features of the biophysical, managed and constructed environments: the height, relief and slope of the land; drainage patterns and vegetation; and a range of human features including agricultural landuses, settlements and transport linkages.

Analysing maps

Interpreting and analysing topographic maps allows you to:

- locate and describe the biophysical environment
- recognise, describe and explain elements of the managed and constructed environments, for example settlement patterns, patterns of transport infrastructure, and the distribution of agricultural and industrial landuses
- identify, describe and explain the relationship between biophysical features and the managed and constructed elements of environments
- determine the distance between places, and the area of features such as lakes, using a linear scale.

'Reading' the landscape

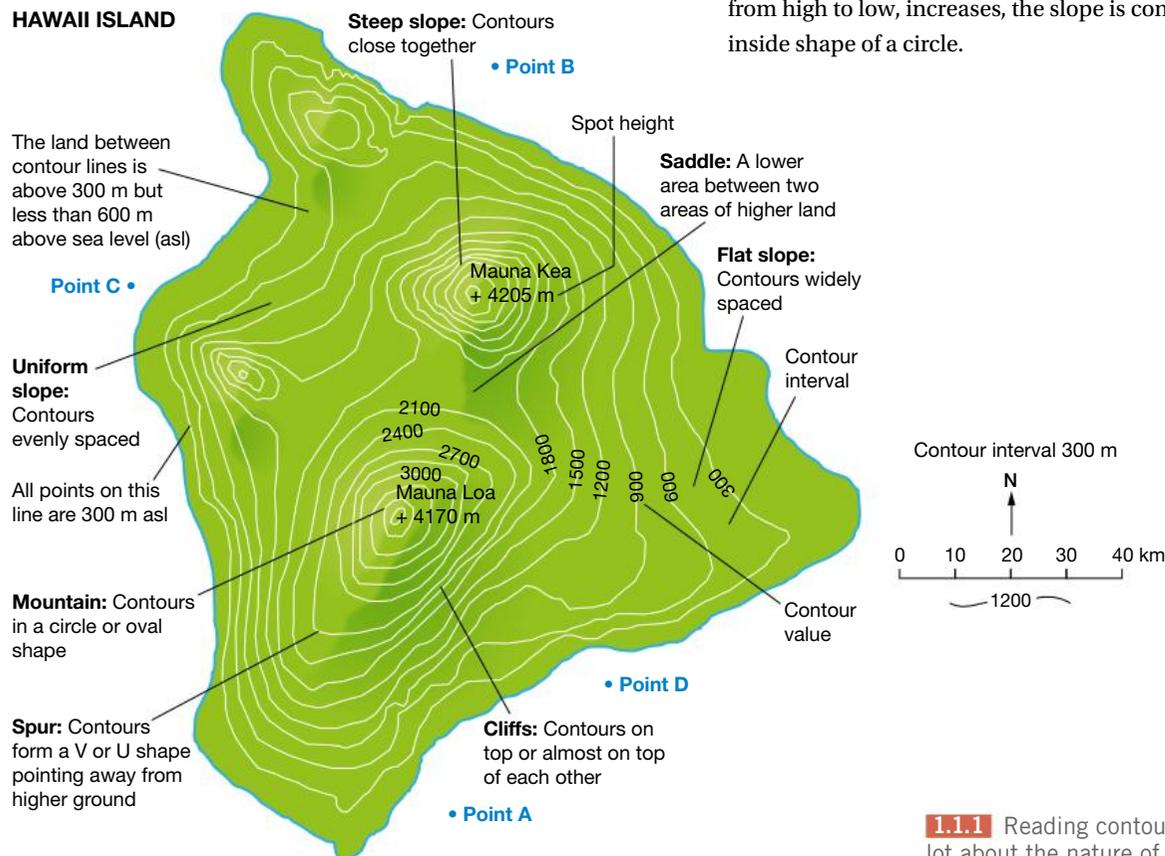
Relief is a general term describing the shape of the land, including height and steepness. The main techniques used to show relief are spot heights and contour lines and patterns. Layer colouring and landform shading are also used.

The elevation of a prominent landform feature is often shown using a spot height—a black dot or cross with the height written next to it. Spot heights give the exact height above sea level of the particular **location** or feature.

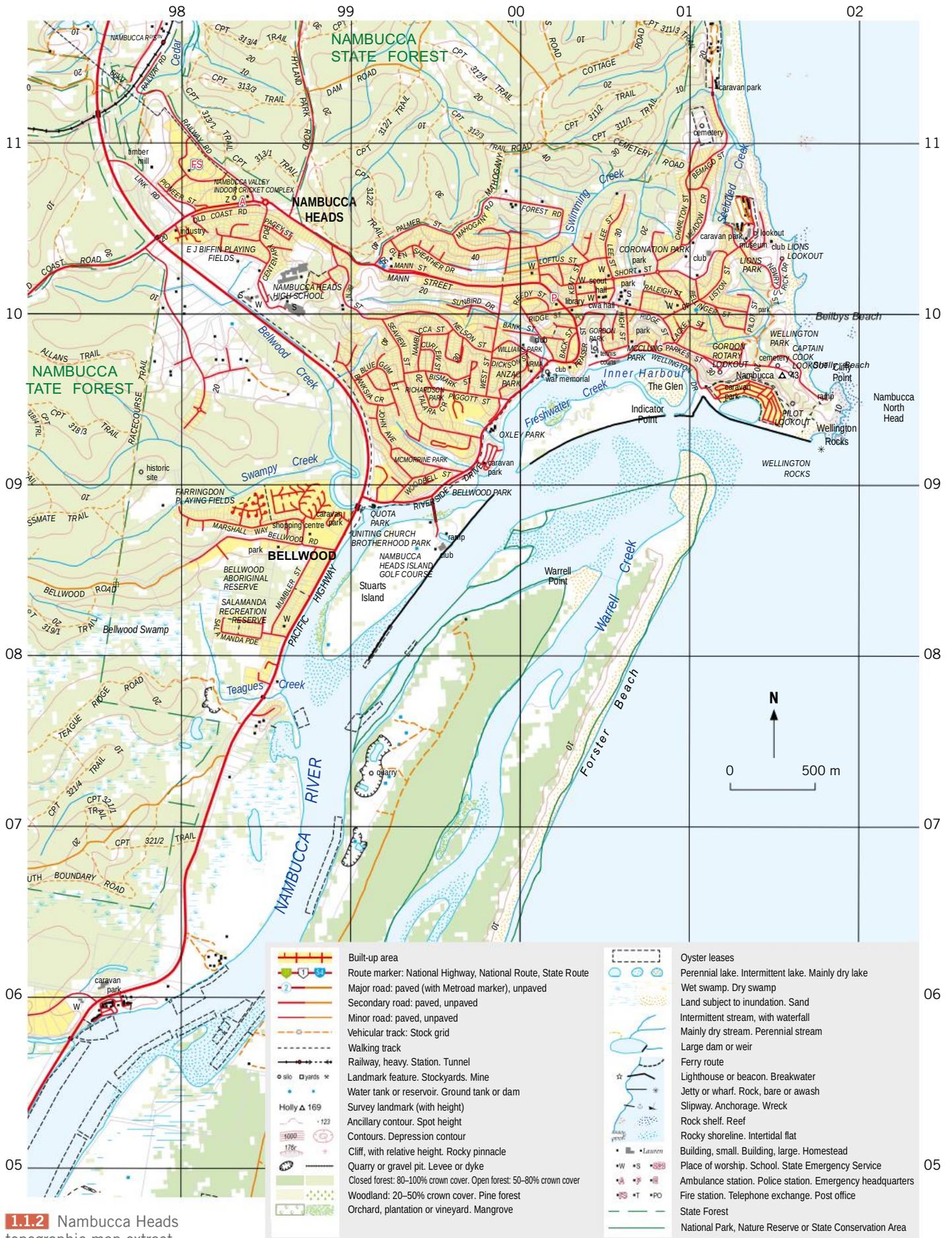
Contour lines are lines joining points of equal height above sea level. Every point along the line has the same elevation. Contour lines provide geographers with information about the shape and slope of the land and the height of features above sea level. The contour interval, or vertical interval, is the difference in height between two adjacent contour lines. This interval is normally stated in the map's legend or near the edge of the map.

Each type of topographic feature is represented by its own distinctive contour pattern, such as the shield volcano depicted in Figure 1.1.1. Figure 1.1.2 is an example of a topographic map.

When the spacing of contour lines, reading from high to low, decreases, the slope is convex; that is, curved like the outside shape of a circle. When the spacing of contour lines, reading from high to low, increases, the slope is concave; that is, like the inside shape of a circle.



1.1.1 Reading contour lines can tell us a lot about the nature of landforms.



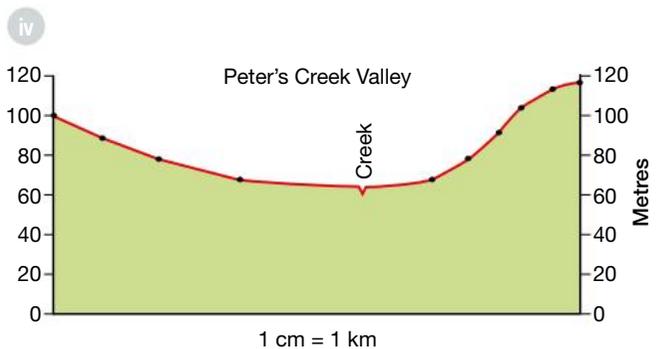
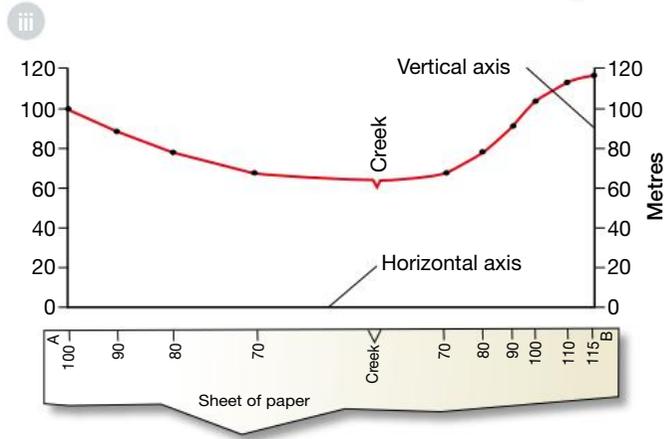
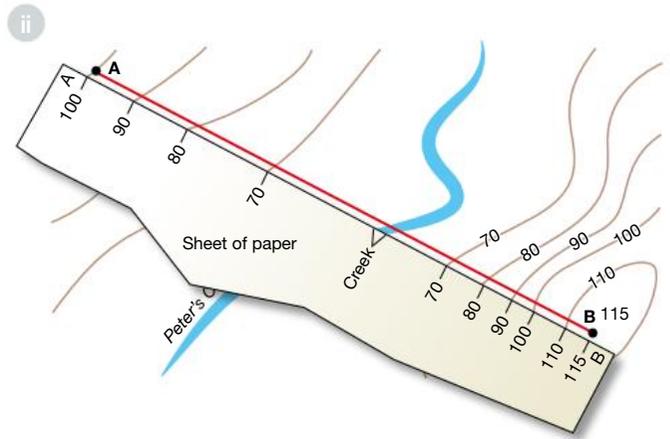
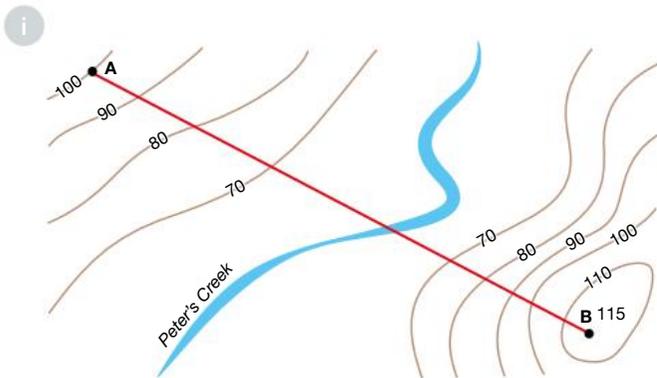
Cross-sections

A **cross-section** is a side view, or profile, of a landscape and provides a visual impression of the shape of the land. Information about landuse, settlement, drainage and vegetation can be added to cross-sections. This provides a means of seeing how the shape of the land influences these features.

Drawing a cross-section

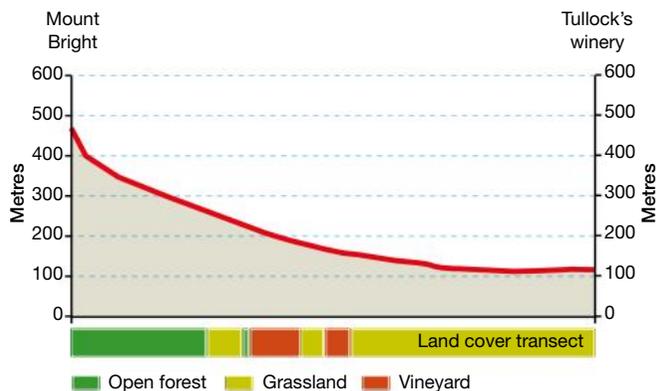
To draw a cross-section, follow the steps below and refer to Figure 1.1.3.

- 1 Locate the two points on the map between which the cross-section is to be made. Label these points 'A' and 'B' (see drawing i).
- 2 Place the straight edge of a piece of paper along an imaginary line joining points A and B. Mark points A and B on your paper (see drawing ii).
- 3 Mark the position where your paper crosses each contour line. Write the value of each contour line on your piece of paper (see drawing ii).
- 4 On graph or squared paper, draw the horizontal and vertical axes for your cross-section (see drawing iii). The length of the horizontal axis should equal the distance between A and B. The vertical axis should use a scale that does not over-exaggerate your vertical scale.
- 5 Place your piece of paper along your horizontal axis. Lightly plot, in pencil, the contour points and heights as if you were drawing a line graph (see drawing iii).
- 6 Join the dots with a fine, single, smooth curved line.
- 7 Label any features intersected by your cross-section.
- 8 Finish off your cross-section by:
 - a shading in the area below the landform
 - b labelling the scale on the horizontal and vertical axes
 - c giving it a title.



1.1.3 Steps involved in constructing cross-sections

1.1.4 A cross-section from Mount Bright to Tullock's winery (GR402704) and an associated land cover transect



Transects

Transects are used to demonstrate the relationship between different features of the biophysical, managed and constructed environments along a cross-section or line of latitude (see Figure 1.1.4).

Drawing a transect

To draw a transect, follow these steps.

- 1 Identify the two points between which you will use to construct your transect. It may be along a cross-section.
- 2 Decide on the element of the biophysical, managed or constructed environments you wish to highlight on your transect.
- 3 Place the edge of a piece of paper along the line of the proposed transect on the topographic map. Mark on the spread of the selected element.
- 4 Draw in the distribution of the feature along your transect.
- 5 Label each area or construct a legend that identifies the features numbered or shaded on your transect.
- 6 Give your transect an appropriate title.

Précis maps

A précis map (see Figure 1.1.5) shows the main features of a topographic map. By comparing précis maps it is often possible to identify the relationship between two features, for example between landform and settlement patterns. Précis maps are sometimes referred to as single-feature maps.

Drawing a précis map

To draw a précis map, follow these steps.

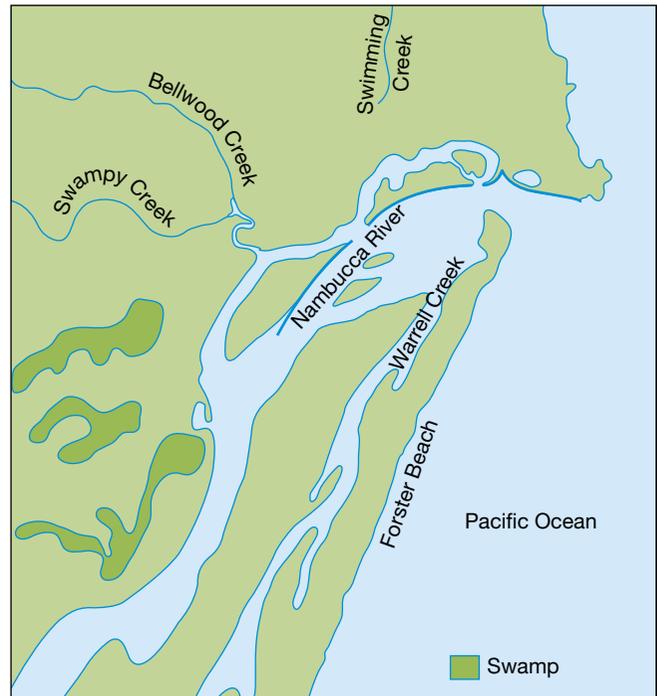
- 1 Identify the feature or pattern to be studied, for example landforms, vegetation, settlement, transport or landuse.

ACTIVITIES

Geographical skills

- 1 Study Figure 1.1.1. Construct the cross-sections A–B and C–D.
- 2 Study Figure 1.1.2 and do the following tasks.
 - a State the scale.
 - b State the contour interval.
 - c Identify the biophysical features at:
 - GR019093 • GR981076
 - GR008096 • GR017096
 - d Identify the managed or constructed features at:
 - GR986077 • GR987102
 - GR995086 • GR013096
 - e State the direction of the lookout (AR0109) from Belwood (AR9808).
 - f State the general direction in which Bellwood Creek flows in AR9809.
 - g State the bearing of the lookout (AR0109) from the bridge in AR9807.
 - h State the length of the up-stream breakwater.
 - i State the density of buildings in AR9807.
 - j State the vegetation type found in AR9909.
 - k State the elevation of the lookout in AR0109.
 - l Describe the nature of the riverine environment on the Nambucca Heads topographic map extract.
 - m Describe the nature of the coastal landscape to the north and south of the Nambucca River entrance. Identify the dominant coastal processes responsible for the formation of the landform features.
 - n Identify the main economic activity in the Nambucca River.
 - o Outline the ways in which people have modified the biophysical environment in the area covered by the Nambucca Heads topographic map extract.
 - p Construct a précis map showing the major transport links on the Nambucca Heads topographic map extract.

- 2 Examine the distribution of the features on the map and the pattern created.
- 3 Draw in the distribution of the feature.
- 4 Label each area or construct a legend that identifies the features numbered or shaded on the map.



1.1.5 Sample précis map showing the drainage pattern on the Nambucca Heads topographic map extract (drawn from Figure 1.1.2)

Working with topographic maps

Topographic maps

Aspect

Aspect refers to the direction in which a slope faces. The aspect of a particular slope can be determined by studying the height and pattern of the contour lines. For example, the slope in AR0782 on the Trial Bay topographic map extract (Figure 1.2.1) has a north-east aspect.

Gradient

It is possible, using the contour lines and scale on a map, to calculate the average **gradient** (steepness) of a slope, road or river. A gradient is typically expressed as a fraction or ratio. It is calculated by dividing the difference in height (or vertical interval) between the two points by the horizontal distance between them.

Calculating the gradient between two points involves the following steps.

1.2.1 Trial Bay topographic map extract



STEP 1

Identify the two pieces of information needed to complete the calculation.

- 1 The difference in height between the two points. This is called the *vertical interval*, or *rise*. Find this by subtracting the lowest point from the highest point.
- 2 The *horizontal distance* between the two points. This is sometimes referred to as the *run*. Find this by measuring the distance between the two points on the map and then using the scale to work out the actual distance.

STEP 2

To calculate the gradient of a slope use the following formula.

$$\text{Gradient} = \frac{\text{vertical interval (rise)}}{\text{horizontal distance (run)}}$$

Note: Because the gradient of a slope is expressed as a ratio, the unit of measurement for the rise (numerator) and the run (denominator) must be the same, for example metres.

EXAMPLE

Calculate the gradient of the slope between the summit of Big Smoky (AR0679) on Figure 1.2.1, the Trial Bay topographic map extract, and the camping ground at GR076085.

$$\text{Gradient} = \frac{\text{vertical interval (rise)}}{\text{horizontal distance (run)}}$$

$$= \frac{291 \text{ m}}{1350 \text{ m}}$$

Note that this is already expressed as a ratio. To simplify it you need a '1' on the top. To simplify the ratio, divide the denominator by the numerator.

$$= \frac{1}{4.6}$$

$$= 1 \text{ in } 4.6 \text{ (or } 1 \text{ in } 5 \text{ rounded) or } 1:4.6$$

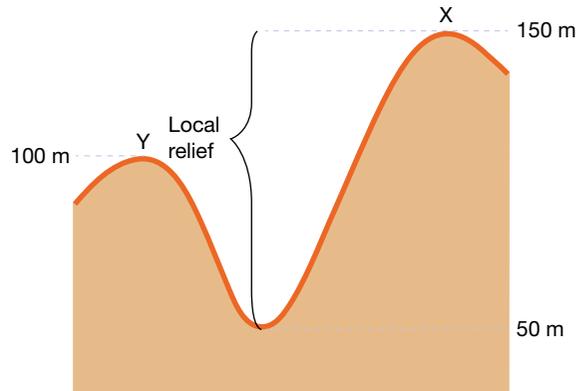
This means that for every 4.6 m travelled in a horizontal direction, you go up 1 m.

Local relief

Local relief is the variation in elevation or height over a relatively small, defined area. It is determined by working out the difference in height between the highest and lowest points in the area.

EXAMPLE

Calculate the local relief between points X and Y in Figure 1.2.2.



1.2.2 Calculating local relief

$$150 \text{ m (highest point: X)} - 50 \text{ m (lowest point)} = 100 \text{ m}$$

Note: Always ensure you include the appropriate unit of measurement with your answer.

ACTIVITIES

- 1 Study Figure 1.2.1 and do the following tasks.
 - a What type of wetland ecosystem lines Saltwater Lagoon?
 - b Name two vegetation types found in AR0681.
 - c Into what waterway does Saltwater Lagoon drain?
 - d Identify the feature of the biophysical environment found at each of the following grid references.
 - GR069797 • GR045817
 - GR074818 • GR040835
 - GR043835 • GR077813
 - e Identify the feature of the constructed environment found at each of the following grid references.
 - GR042831 • GR072828
 - GR047818 • GR062824
 - f What is the direction of South West Rocks (AR0483) from the summit of Big Smoky (AR0679)?
 - g In what direction is Saltwater Creek flowing in AR0582?
 - h What is the bearing of the summit of Big Smoky from South West Rocks (AR0483)?
 - i What is the straight-line distance between the bridge at GR042831 and the bridge at GR053826?
 - j What is the elevation of Little Smoky (AR0781)?
 - k What is the difference in elevation between Big Smoky (AR0679) and Little Smoky (AR0781)?
 - l Using information from the map, account for the existence of wetlands in the area.
 - m Construct the cross-section from GR060820 to the summit of Little Smoky AR0781.
 - n Calculate the vertical exaggeration of the cross-sections you have drawn.
 - o Construct a précis map showing land cover found on the Trial Bay topographic map extract.

Flow diagrams

Using graphics

By its nature, Geography is a visual subject. Keen observers note the spectacular interactions of the natural and human elements of landscape. Graphics tools such as flowline maps and flow diagrams help us to understand the workings of both the natural and the human world. Such graphics capture and highlight the important patterns and links that exist. They are a visual representation of what is happening.

Flowline maps

Flowline maps show movement between places, tracking the passage of goods, information and people. Lines or arrows link the place of origin with the destination, and the quantity that is moved is indicated by their width or thickness, as is illustrated in Figure 1.3.1.

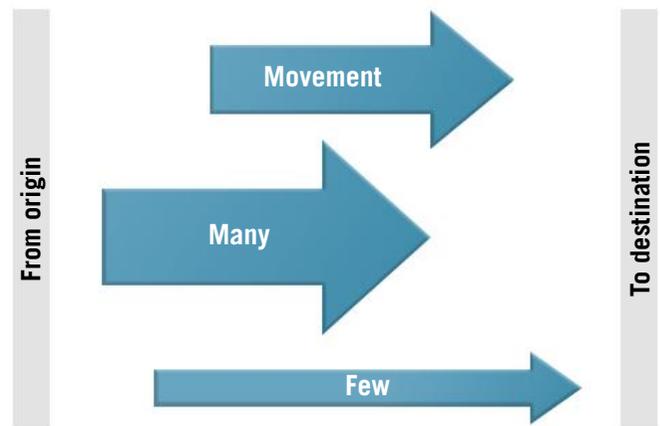
Flowline maps are drawn using statistics of actual movements that have occurred, for the purpose of demonstrating the main patterns. Trade statistics, showing the export of Australia's wheat in 2013–14, are represented in Figure 1.3.2. It is clear that the majority of it goes to feed people in East and South-East Asia.

Constructing a flowline map

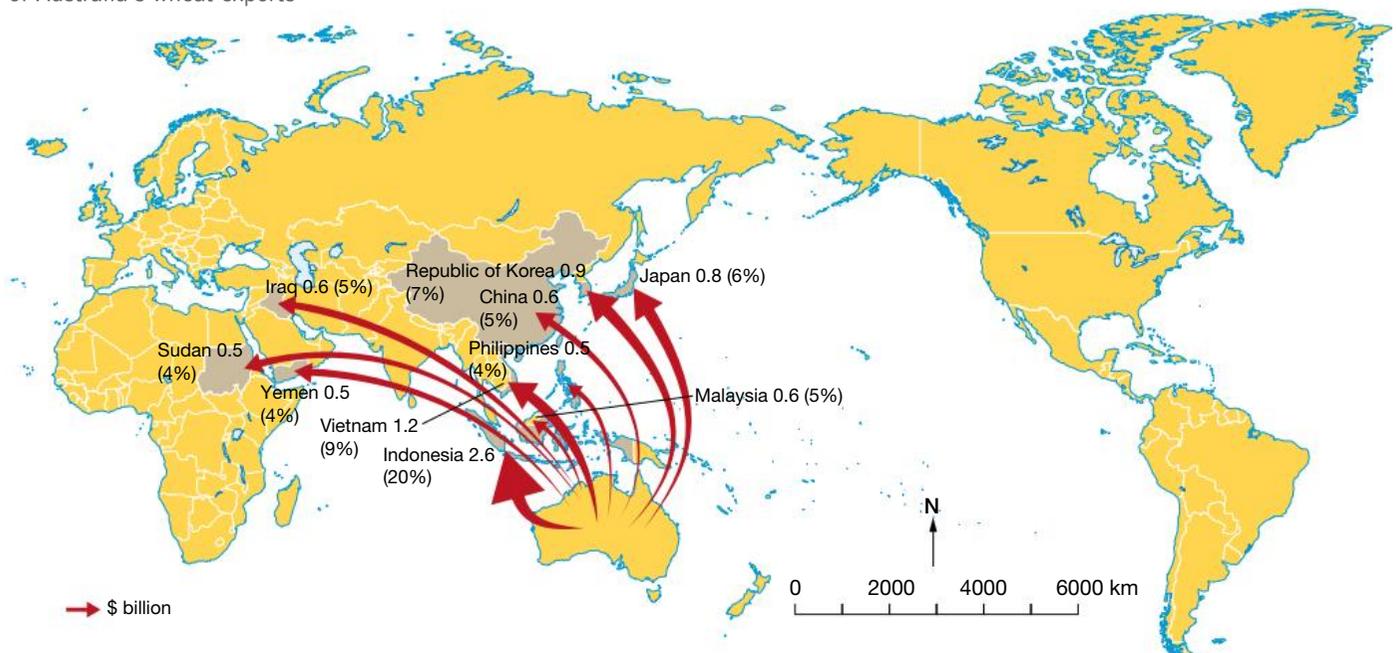
To construct a flowline map, follow these steps.

- 1 Select your statistics for flow or movement and arrange them from the smallest to the largest.
- 2 Find a suitable base map.
- 3 Decide on the various thicknesses of the lines to match the different categories of the sizes of flows that will be shown.
- 4 Draw in the lines of varying thickness and add an arrowhead to each to show the direction of the flow.
- 5 Add a key and give the map a title.

1.3.1 Flowline map lines or arrows



1.3.2 A flowline map showing the main destinations of Australia's wheat exports



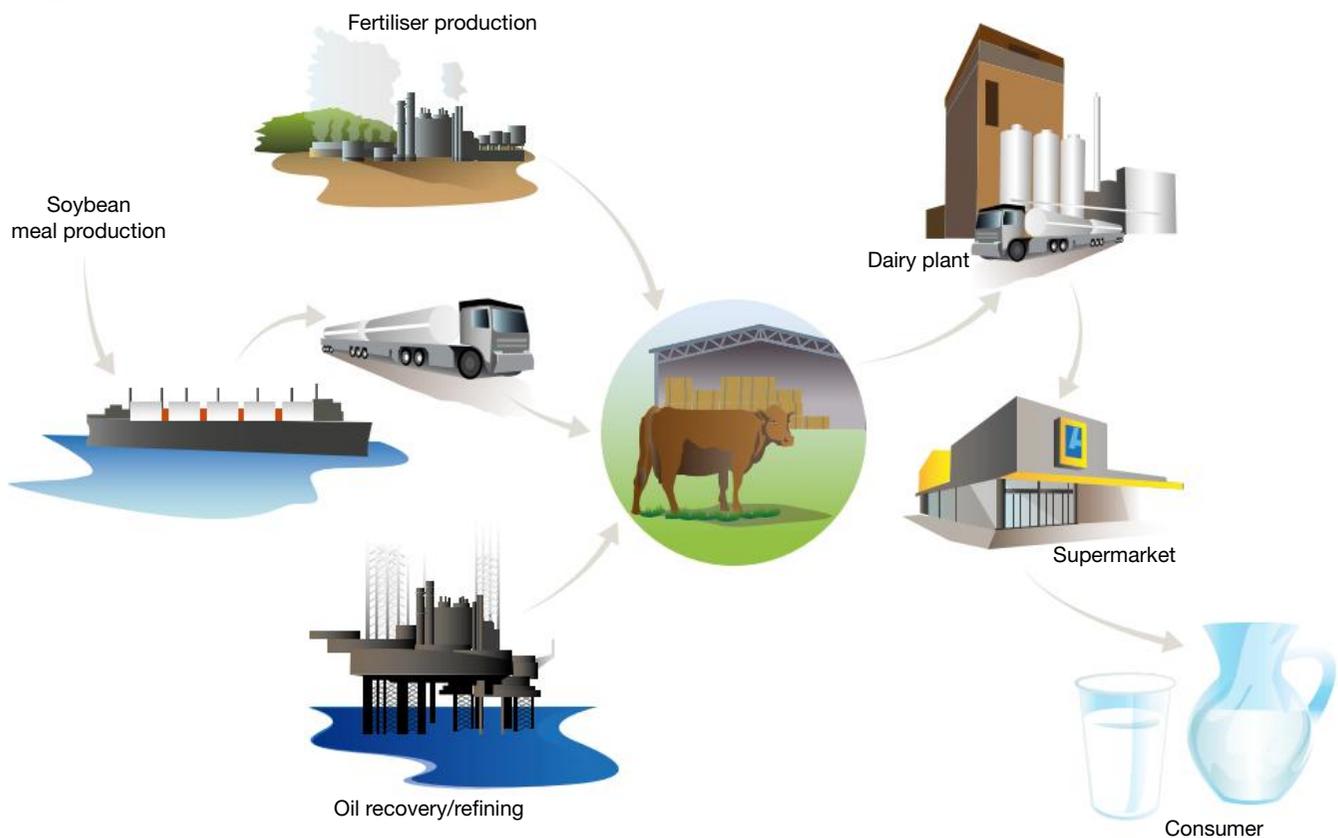
Flow diagrams

Flow diagrams are used widely in Geography to illustrate how the world functions and in particular the interactions that occur within and between the physical and human environments. While flowline maps show a record of actual movement that has occurred, **flow diagrams** tend to be more generalised. They represent common flows that can occur in many places and they emphasise the processes and links involved. Annotations are often added to the picture to provide build a clearer understanding.

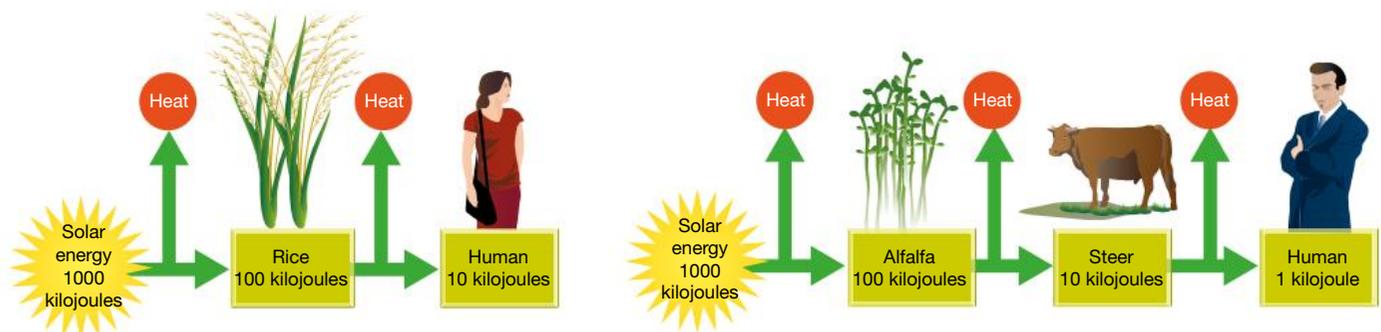
Simple

Some flow diagrams are quite simple, showing the clear stages of a process, such as the production of milk depicted in Figure 1.3.3. Others attempt to simplify the complexity of the real world by highlighting a simple progression, such as in Figure 1.3.4.

1.3.3 A flow diagram showing the production of milk



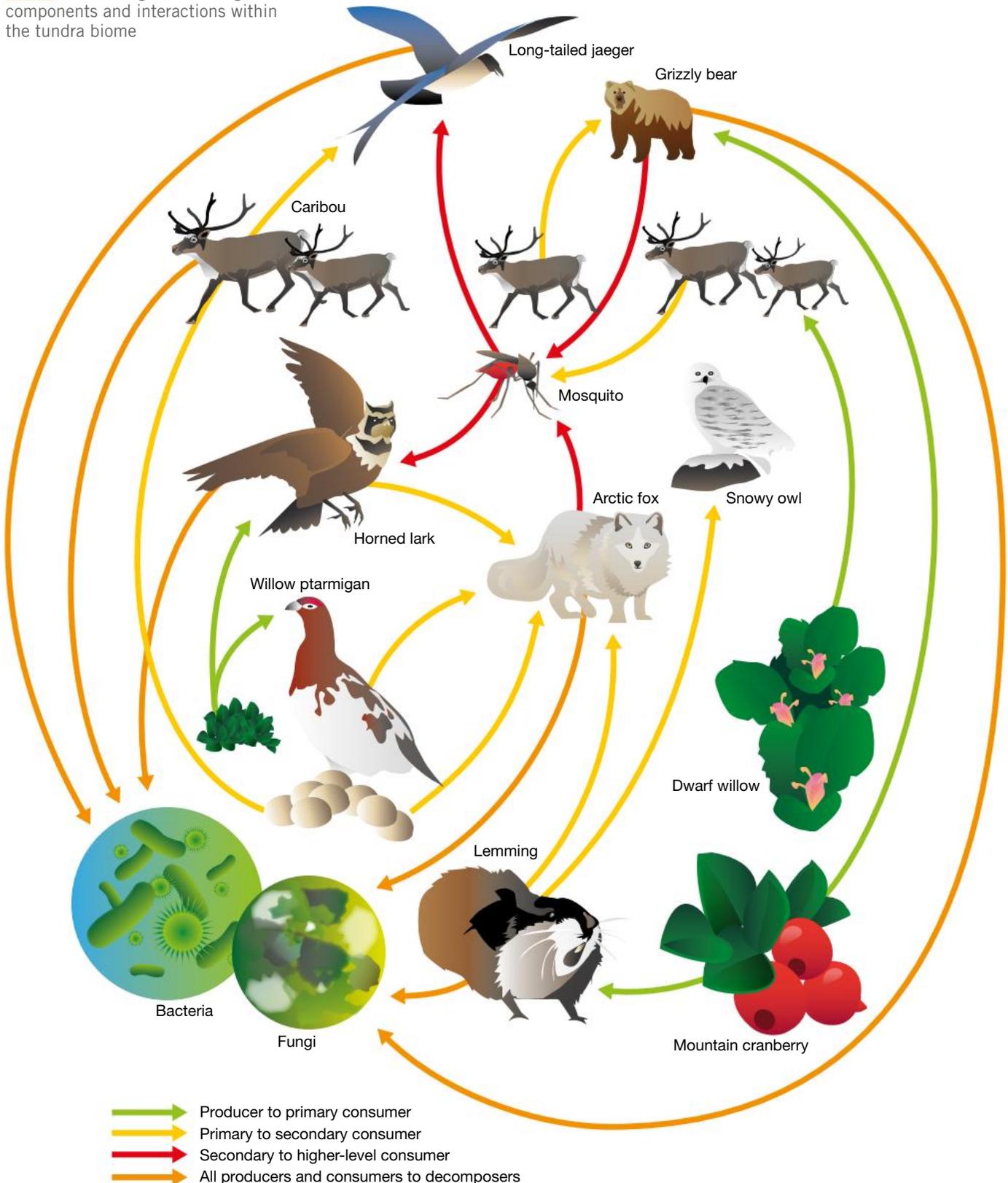
1.3.4 A flow diagram showing how the energy gained from food decreases when meat is eaten

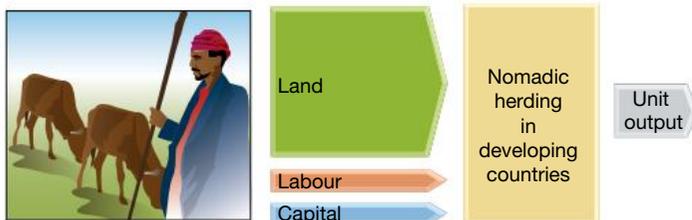
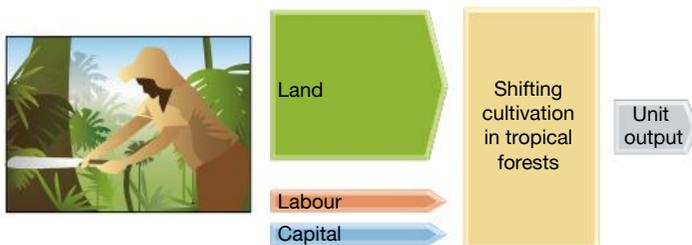
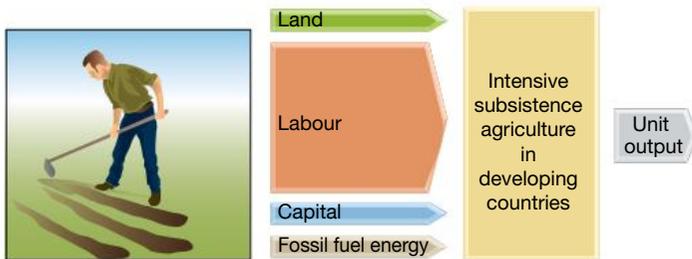
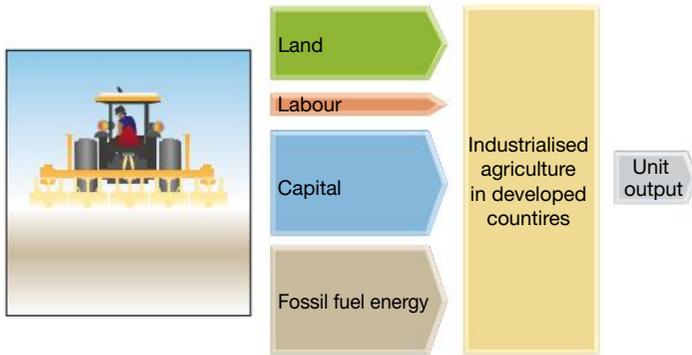


Complex

When geographers want to reveal just how complex nature is, a flow diagram, such as the one in Figure 1.3.5, does this well. They are also useful in analysing human activities, as illustrated in Figure 1.3.6.

1.3.5 A flow diagram showing some components and interactions within the tundra biome





1.3.6 A flow diagram showing the relative inputs of land, labour, capital and fossil fuel energy into major types of agricultural systems

DID YOU KNOW?

Since 1950, approximately 88 per cent of the increase in global food production has come from increased yields per hectare of land under cultivation.

ACTIVITIES

Knowledge and understanding

- 1 Give an example of when you would use a flowline map or flowline diagram.

Geographical skills

- 2 Refer to Figure 1.3.2 and answer the following questions.
 - a What was the value of exports to Vietnam?
 - b What was the value of exports to Indonesia?
 - c Suggest reasons why these countries import most of Australia's wheat.
- 3 Using the statistics below, construct a flowline map to show the destinations of Australia's beef exports in 2013–14.

Beef (fresh, chilled or frozen)	A\$ ('000)
USA	2687.5
Japan	1625.4
China	935.3
Republic of Korea	903.0
Middle East	361.2

Source: Department of Foreign Affairs and Trade, 2015

- 4 Using the following statistics, construct a flowline map to show the destinations of Australia's major agricultural export markets in 2014.

Primary products	A\$ (million)
China	8290
USA	4320
Japan	3992
Indonesia	3329
Republic of Korea	2602

Source: Department of Foreign Affairs and Trade, 2015

- 5 Conduct a survey of the suburbs/towns/areas that students in your year at school come from. Construct a flowline map to illustrate your results.
- 6 Study Figure 1.3.3. Construct a flow diagram to show the production of bread.
- 7 Study Figure 1.3.4. Explain why most of the people in the world survive on a grain diet.
- 8 Study Figure 1.3.6. Compare the relative inputs of land, labour, capital and fossil fuels to the major types of agricultural systems.

Photograph interpretation: Agriculture

Agriculture

Agriculture is the world's most important industry. It provides humans with essential supplies of food and many other raw materials. Agriculture accounts for more land than any other human activity and has a great impact on the biophysical environment. Soils, water, plants and other natural elements are important factors affecting the operation of a farming system.

Types of agriculture

Figures 1.4.1 to 1.4.6 provide examples of different types of agriculture. The type of agriculture depends on physical, human and economic factors. Agriculture is often classified as either commercial or traditional, and intensive or extensive.

Commercial agriculture uses energy (mainly fuel oil for machinery), water and chemicals to produce huge amounts of food and other agricultural products, including fibres (such as cotton).

Traditional agriculture consists of two types: subsistence and intensive.

- Traditional subsistence agriculture involves people producing just enough food to meet their family's needs. Subsistence farmers rely on human labour and animal power. Examples are shifting agriculture in tropical forests and nomadic herding.
- Traditional intensive agriculture involves farmers using increased amounts of human and draught (animal) labour, fertiliser and water to increase the amount of food produced. If there is more food produced than can be used by the family, some may be sold at market. The intensive production of rice is an example of this type of agriculture. Traditional subsistence agriculture is practised by almost half the people on earth.

Extensive agriculture involves the farming of a large area with limited use of labour and capital, or with limited labour and high investment of capital and technology.

Intensive agriculture is the farming of a small amount of land by a large labour supply with limited technology and investment (for example rice growing in Bali) or a large amount of capital, labour and technology used in a relatively small area, as in horticulture.



1.4.1 Nomads grazing their livestock in the African Sahel: an example of traditional subsistence agriculture



1.4.2 Rubber plantations are an example of commercial agriculture. Most plantation crops are found in the tropics. Other plantation crops are cacao, copra, coffee, tea, pineapples and bananas.



1.4.3 The cultivation of rice is an example of traditional subsistence agriculture. It involves farmers using human and draught labour, fertiliser and water to maximise the amount of food produced.



1.4.5 Grain production is an example of extensive commercial agriculture using high levels of capital investment and technology.



1.4.4 Cattle grazing in the United States of America is an example of extensive commercial livestock production.



1.4.6 Grape growing is an example of intensive commercial agriculture. High levels of capital investment and technology are used to produce wine.

ACTIVITIES

Knowledge and understanding

- 1 Explain why agriculture is considered to be the world's most important industry.
- 2 List the elements that are important for farming.
- 3 Explain what is meant by the term 'commercial agriculture'.
- 4 Distinguish between traditional subsistence agriculture and traditional intensive agriculture.

Applying and analysing

- 5 Create a Venn diagram comparing extensive and intensive agriculture.
- 6 Classify each of the following types of agriculture:
 - a the growing of rice in terraced paddy fields
 - b the combination of wheat and sheep production in Australia
 - c battery hen production
 - d dairying in Western Europe

- e shifting agriculture in the Amazon Basin
 - f rubber plantations in Malaysia
 - g viticulture (the growing of grapes for wine production)
 - h cotton growing in north-west New South Wales.
- 7 Analyse Figures 1.4.1 to 1.4.6 and copy and complete the following table.

Image	Type of agriculture	Scale of production
1.4.1		
1.4.2		
1.4.3		
1.4.4		
1.4.5		
1.4.6		

Population pyramids

Using population pyramids

A **population pyramid** is a graphical representation of a population's age and sex structure. Geographers study such graphs to determine the age distribution of a population. They also tell us about the potential for future population growth. India and Australia have quite different-shaped population pyramids. Being able to read these pyramids tells us a lot about the demographic characteristics of the two countries.

Interpreting population pyramids

A population pyramid is a special type of bar graph. The vertical axis of the graph shows the various age groups of the population, while the horizontal axis shows either the actual number or the proportion of the population for both males and females. Because each population pyramid represents 100 per cent of a particular population group, comparisons can be made with the population pyramids of other populations and of the same population over time.

The shape of a population pyramid is also important because it tells us a lot about the particular population. For example:

- if the base of the pyramid is wide, then the population is said to be 'young'
- if the upper part is relatively wide, then the population is said to be 'old' or 'ageing'

- fewer people than expected in a particular age group might indicate events such as war, famine, disease or large-scale emigration
- more people than expected in a particular age group might indicate the impact of a baby boom and/or immigration.

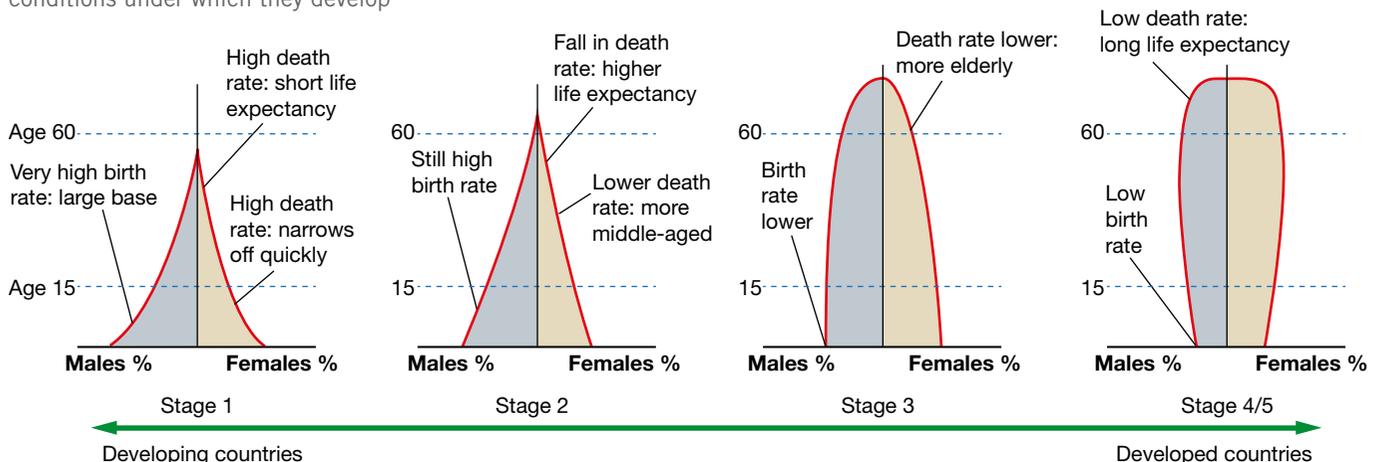
Figure 1.5.1 shows a series of pyramid shapes, with an explanation of conditions under which such population structures develop.

Populations are often divided into broad age groups based on their level of independence. The dependent parts of the population are usually defined as the '14 years and under' age group and the '65 years and over' age group. The changing proportion of the population in each age group provides us with valuable information about future population trends. If the proportion of the population aged 65 years and over is growing, the population is said to be ageing. If the proportion of the population aged 14 years and under is decreasing, the birth rate is declining, as is the rate of population increase.

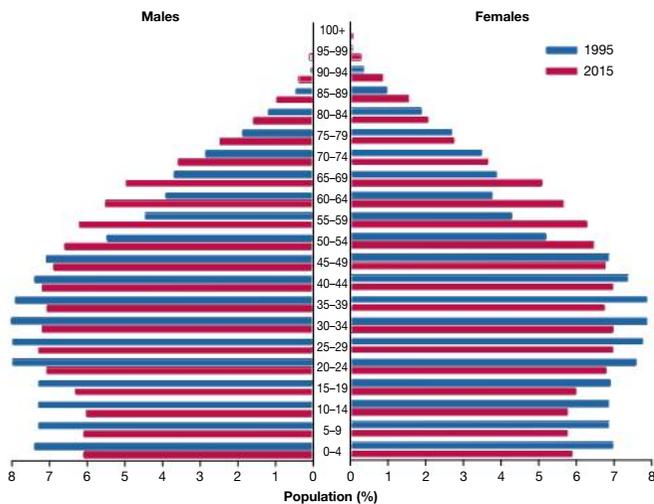
Population pyramids: Australia and India

The populations of India and Australia are different; the population structures are also different, as is illustrated in Figures 1.5.2 and 1.5.3. The projected population statistics in Figure 1.5.4 also show continued differences.

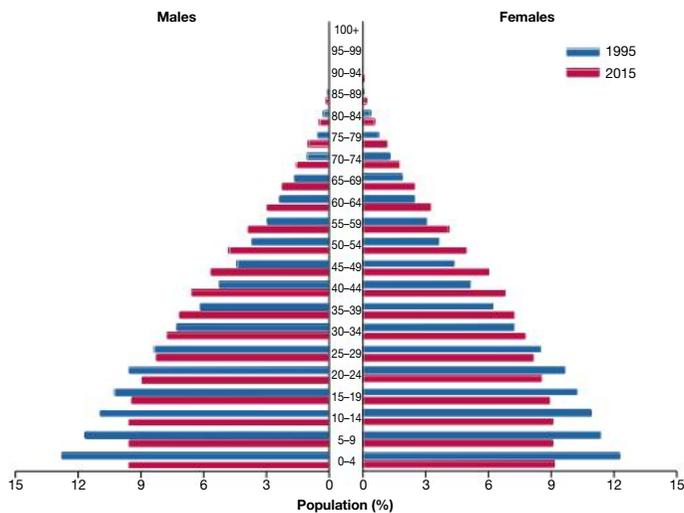
1.5.1 Common population pyramid shapes and the conditions under which they develop



1.5.2 Population pyramid of Australia, 1995 and 2015 (%)



1.5.3 Population pyramid of India, 1995 and 2015 (%)



1.5.4 Projected age–sex data for Australian and India, 2050 (%)

	Australia		India	
	Males	Females	Males	Females
0–4	5.3	5.1	6.6	6.5
5–9	5.4	5.1	6.6	6.6
10–14	5.5	5.2	6.7	6.6
15–19	5.7	5.3	6.8	6.7
20–24	6.1	5.8	6.9	6.7
25–29	6.5	6.2	7.0	6.7
30–34	6.6	6.3	7.0	6.6
35–39	6.7	6.3	7.0	6.6
40–44	6.6	6.2	7.0	6.6
45–49	6.5	6.1	6.9	6.5
50–54	6.4	6.1	6.7	6.4
55–59	6.4	6.1	6.1	5.9
60–64	5.9	5.8	5.3	5.4
65–69	5.4	5.4	4.5	4.9
70–74	4.6	4.8	3.6	4.1
75–79	4.0	4.5	2.6	3.3
80–84	3.0	3.8	1.5	2.1
85–89	2.0	2.9	0.7	1.1
90–94	1.0	1.9	0.2	0.5
95–99	0.4	0.9	0.0	0.1
100+	0.1	0.4	0.0	0.0
Population	29012740		1656553632	

Source: US Census Bureau

ACTIVITIES

Knowledge and understanding

- 1 State what population pyramids show.

Geographical skills

- 2 Study Figures 1.5.2 and 1.5.3 and complete the following tasks.
 - a Estimate the proportion of the population under the age of 15 in Australia in 1995 and 2015.
 - b Estimate the proportion of the population under the age of 15 in India in 1995 and 2015.
 - c Estimate the number of Australians under the age of 15 in 2015.
 - d Estimate the number of Indians under the age of 15 in 2015.
 - e Estimate the proportion of the Australian population over the age of 64 in 2015.
 - f Estimate the proportion of the Indian population over the age of 64 in 2015.

- g Using data from the graphs, contrast the population structure of Australia and India in 2015.
 - h Using Figure 1.5.1, classify the structure of the Australian and Indian populations in 1995 according to stage of demographic transition.
- 3 Study Table 1.5.4. Construct the population pyramids of Australia and India using the 2050 population projections. Compare the 'under 15 years of age' and 'over 64 years of age' populations with the structure of the two countries' populations in 2015.

Investigating

- 4 Using the US Census Bureau's international population database, generate a population pyramid for a selected developing country in Africa (1995, 2015 and 2050). Compare your selected population pyramid with those of Australia and India.



Biomes

CHAPTER

2

The earth's major ecosystems are often referred to as biomes. Biomes are defined by factors such as plant types (for example trees, shrubs and grasses), leaf type (broadleaf or needle-like), plant spacing (forest, woodland or savanna) and climate (for example deserts). The main world biomes are deserts, forests (equatorial and tropical rainforests; deciduous and evergreen forests; and coniferous forests), grasslands and tundra.

In this chapter we examine the distribution and characteristics of biomes as regions in terms of climate, soil, vegetation and productivity. We also examine human alterations to biomes, especially those related to agriculture.

INQUIRY QUESTIONS

- What factors determine the spatial distribution and physical characteristics of the earth's biomes?
- What factors determine the productivity of biomes?
- How do energy and matter flow within biomes?
- How have humans altered biomes and what are the environmental effects of these alterations?
- What is the relationship between biomes and food security?

GLOSSARY

annual	a plant that completes its life cycle in one year; this means it goes from seed to seed and then dies off, during the course of one year	photosynthesis	a process by which green plants make carbohydrates such as sugar, using water, carbon dioxide and sunlight
aquatic ecosystem	a water-based community of plants and animals	primary productivity	the rate of energy accumulation, usually through photosynthesis
biome	a vegetation community occupying a large area of the earth's surface	producer	an organism (plant) that produces its own food via the process of photosynthesis
commercial agriculture	the use of energy, water and chemicals to produce food and other agricultural products for sale	resilience	the capacity of an ecosystem to respond to a disturbance by resisting damage and recovering quickly
consumer	an organism that gains its energy requirements by eating plant or animal matter	shifting cultivation	a farming system that involves moving from site to site as soil fertility declines due to leaching
decomposer	an organism that breaks down the remains of other living things	terrestrial ecosystem	a land-based community of plants and animals
ecosystem	a community of interacting plants and animals and their physical surroundings	traditional agriculture	subsistence and intensive forms of agriculture (such as intensive rice cultivation) practised in many developing countries
estuary	an area near a river's mouth where the tide ebbs and flows		
nomadic	a way of life that involves moving across a territory seasonally in search of food and water		

Biomes: Ecosystems and biomes

Elements of life

Life can be created and sustained only in the presence of moisture, sunlight and nutrients. These elements occur together only on or near the surface of the land and in the sea. No organism can live in isolation, including humans. Yet the ecosystems that we depend on for survival are being significantly altered by our actions.

The biosphere

The **biosphere** encompasses all living things, from the creatures on the ocean floor and the animals burrowing into the soil to the plants anchored to the earth's surface and the insects floating high in the atmosphere. It includes all the living organisms and their excrement (waste) and dead remains. It also includes the non-living environment, which is made up of rocks, water and air. The levels and components of the biosphere are shown in Figure 2.1.1 and outlined in Table 2.1.2.

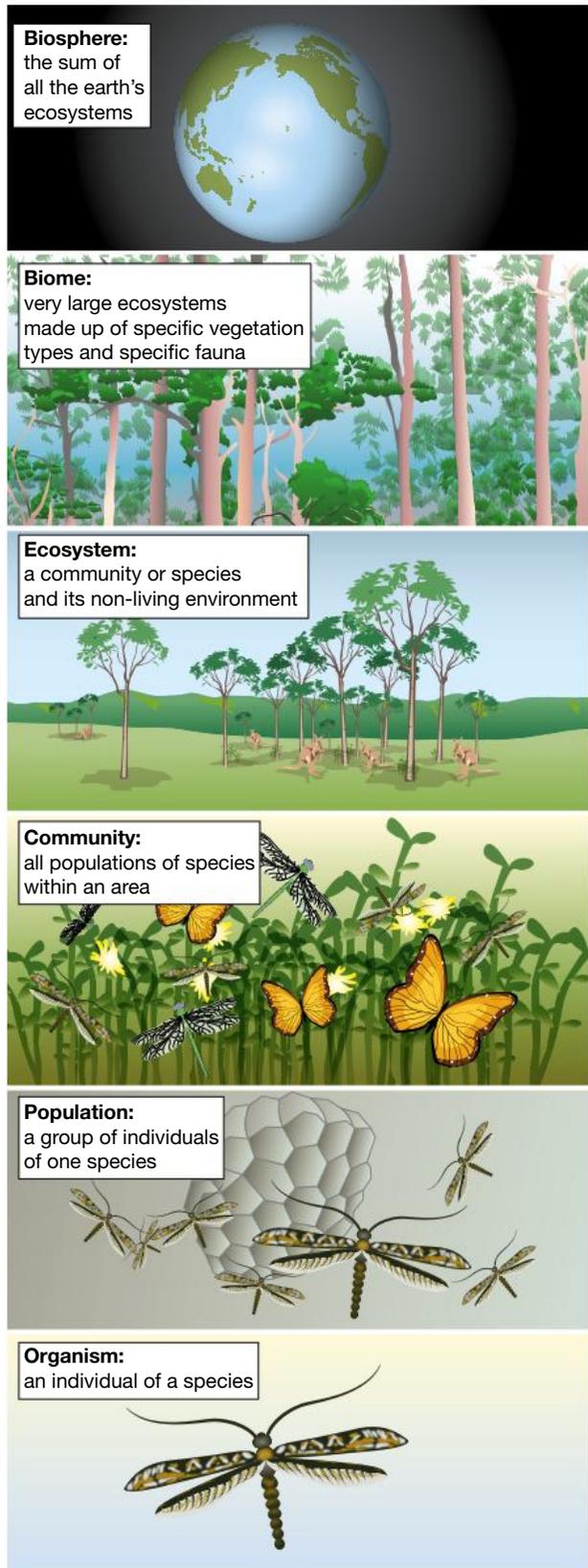
Ecosystems

An individual of a **species** is intimately related to others of the same species and the environment in which it lives. Individuals must come together and usually touch in order to mate and nurture their young. Feeding territories are established, with different species sharing the available resources (water and nutrients). These species interact in many curious and interdependent ways. There is also competition and predation, as some animals hunt and feed on others for survival, but this is all part of the natural balance.

Each individual is a member of a population, which in turn forms a part of a larger community. A community, together with its non-living environment, forms an **ecosystem**.

A tidal pool on a rock platform or a huge expanse of tropical rainforest stretching across thousands of kilometres represents an ecosystem, although the two are on different scales. Each ecosystem has a characteristic community of plants and animals that has adapted to that ecosystem.

Ecosystems can be divided into two broad groups: aquatic and terrestrial. Those associated with water are known as **aquatic ecosystems** and the major land ecosystems are called **terrestrial ecosystems**.



2.1.1 Levels within the biosphere

2.1.2 Main components of the biosphere

Component	Characteristics
Organism	Simply any form of life. There are a number of ways of classifying organisms, but a very important distinction needs to be made between producers (plants), consumers (most animals) and decomposers (bacteria and fungi that break down organic matter for recycling). Plants range from microscopic single-cell phytoplankton that float in water to the giant sequoia trees growing along the coast of California. Animals range in size from microscopic zooplankton, also living in water, to the 30-metre blue whale. While most decomposers such as bacteria are microscopic, others can grow to a metre in diameter, such as the rafflesia (also known as the 'corpse flower' because it smells like rotting meat).
Species	A single type of organism that is able to reproduce its own kind. The majority of species on earth are insects, mites and nematodes (worms). So far, only 2 million have been identified and named. Scientists estimate that there could be anywhere between 5 and 100 million species on the planet.
Population	A group of organisms of the same species living together in the same area. As the environmental conditions change in this area, so do the number of organisms. In good times, when plenty of food and water are available, populations soar, and when they are scarce, numbers drop.
Habitat	The area within which an organism or population lives.
Community	Several populations that live together within a particular habitat. Caves, for example, will often have several species of spiders, moths and bats.
Environment	The non-living or physical attributes of an area, such as temperature, precipitation, soils and topography on land, or the temperature, clarity and salinity of water.
Ecosystem	A community of organisms that interact with each other and their non-living environment.
Biome	Very large ecosystems made up of specific vegetation types and associated fauna.
Biosphere	The zone of habitation containing all the earth's ecosystems.

Biomes

Within terrestrial ecosystems, the largest recognisable subdivision is the **biome**, a very large ecosystem made up of specific vegetation types and their associated fauna. Biomes occur on different continents in areas with similar climates.

Although the biome includes all organisms interacting within the biosphere, the vegetation with its enormous biomass forms the most visible part of the biome. Biomes are classified according to the characteristic vegetation within the ecosystem, which is a response to the availability of soil, water and heat:

- forest—abundant soil, water and heat
- savanna—transitional between forest and grassland
- grassland—moderate shortage of soil and water; adequate heat
- desert—extreme shortage of soil and water; adequate heat
- tundra—insufficient heat to sustain vegetation growth throughout the whole year.

Just as climates across the earth transition from one type to another, so do vegetation types. The concept of biomes is an attempt to describe on a global scale how similar climates in different places support similar vegetation types.

One of the most well-known examples of a biome is the tropical rainforest, which grows in hot, wet climates such as those found in Brazil, the Democratic Republic of the Congo, Kalimantan in Indonesia and parts of coastal Queensland.

Changes to the natural world

Humans possess intelligence and through technology have sought to control nature, perceiving their needs as paramount, no matter what the cost to other species. The imprint of humans is evident and growing. In their efforts to exploit resources and secure water and food supplies, they have altered many ecosystems and biomes.

ACTIVITIES

Knowledge and understanding

- 1 Describe the biosphere.
- 2 Explain why no organism can live in isolation.
- 3 Identify the two main identifiable features of a biome.
- 4 Explain why biomes alter in response to changes in climate.

Applying and analysing

- 5 Study Figure 2.1.1. Select a different organism and draw your own annotated diagram showing levels within the biosphere.
- 6 Working in pairs, consider the following question and then share your thoughts with the rest of the class.

Why do plants and animals change when they move from one biome to another?

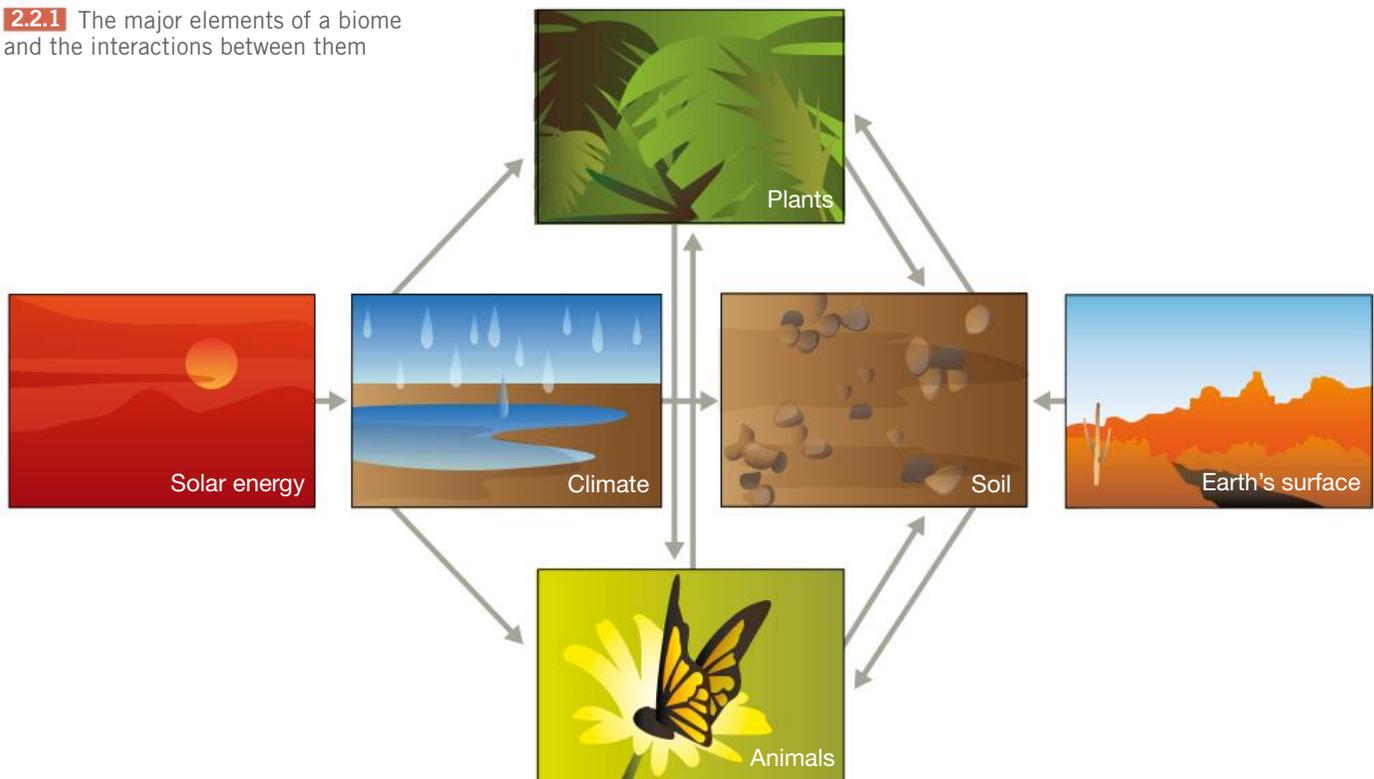
Energy flows within biomes

Energy flows

Figure 2.1.1 shows the links between climate, plants, animals and soil, as well as with solar energy and the earth's surface. Each arrow in this illustration represents one set of interactions, and shows the effect that one element has on another. Plants influence the type of soil found in an area. In turn, the soil type found in an area may favour certain plants and particular plant communities. A biome may also include birds that distribute the seeds of a plant, which, in turn, provides food and shelter for other species of birds.

Living organisms interact with each other and with their non-living environment. The nature of these interactions determines the variety of biomes. Each biome has its own characteristic community of plants and animals that are adapted to a particular set of environmental conditions. Ecosystems exist on a local scale, for example a small area of wetland. Biomes occur on a global scale, for example a forest community dominated by a particular type of tree, such as conifers or eucalypts.

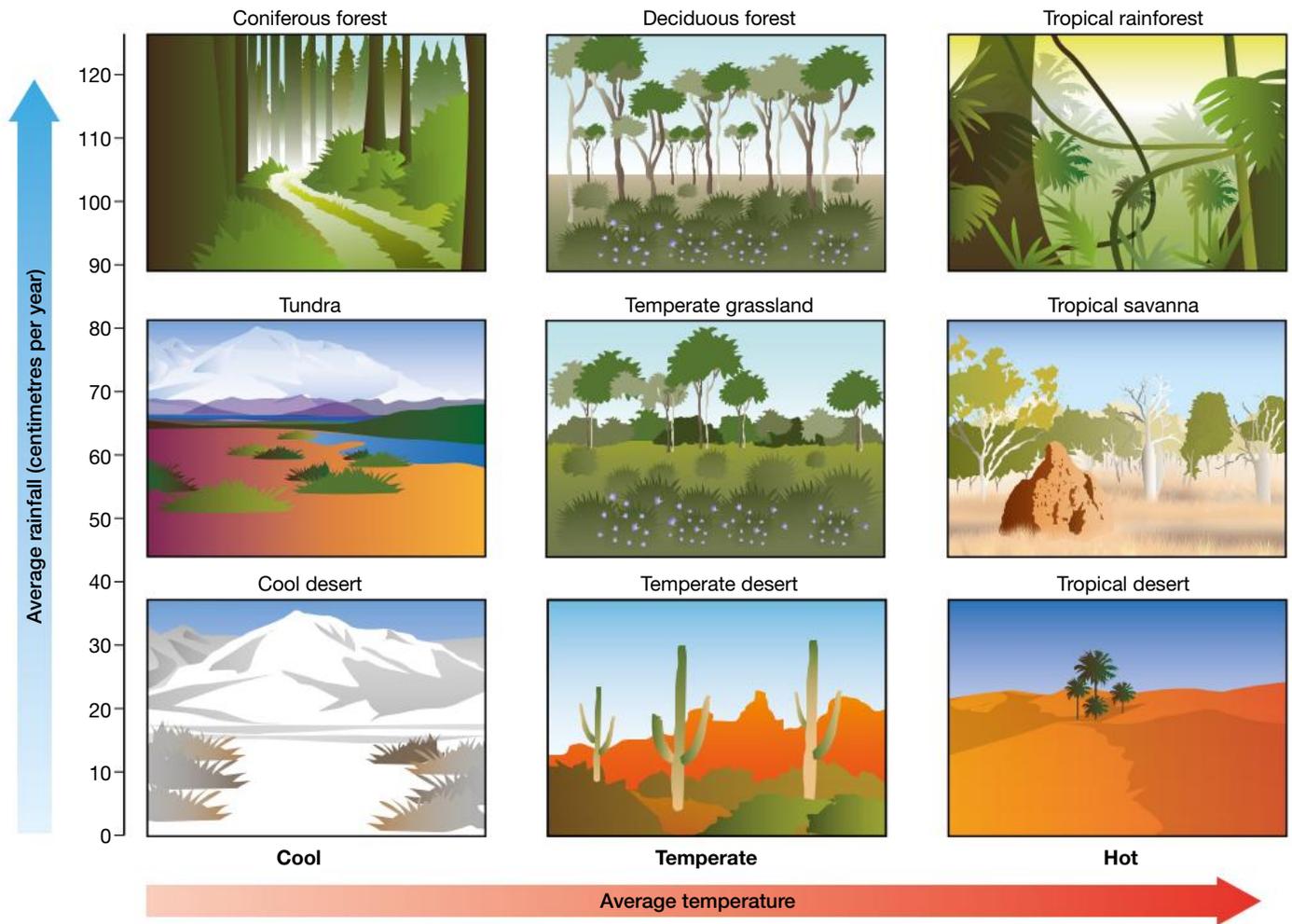
2.2.1 The major elements of a biome and the interactions between them



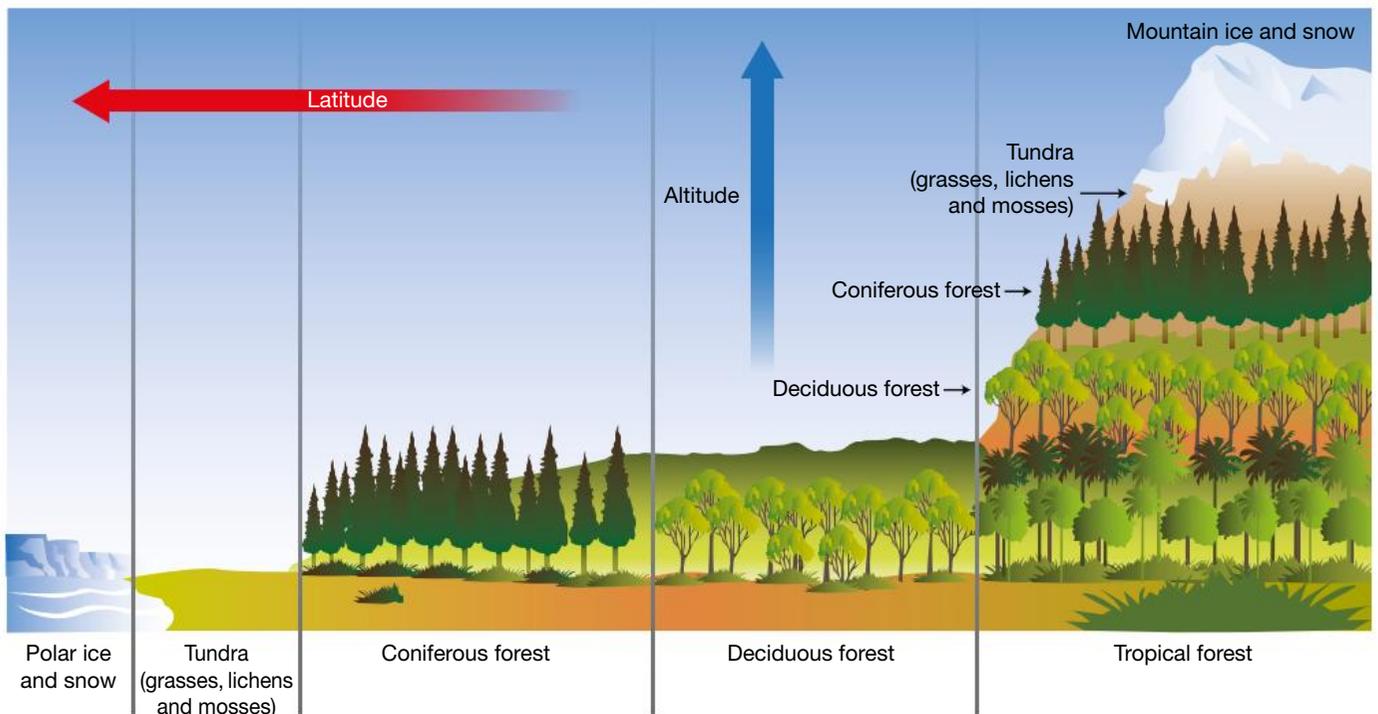
The variety of biomes on the earth's surface depends mostly on climatic differences. The main types of biomes on land are forests, grasslands and deserts. In general, areas of high rainfall have forest, areas of medium rainfall have grasslands and areas of low rainfall have deserts. Figure 2.2.2 shows how rainfall and temperature interact to produce different types of biomes. Figure 2.2.3 shows how latitude and height above sea level influence biomes and ecosystems.

DID YOU KNOW?

Aquatic environments, such as coral reefs, estuaries, swamps and marshes, and terrestrial environments, including tropical rainforests, tropical seasonal forests, temperate evergreen forests, and temperate deciduous forests have the highest levels of primary productivity.

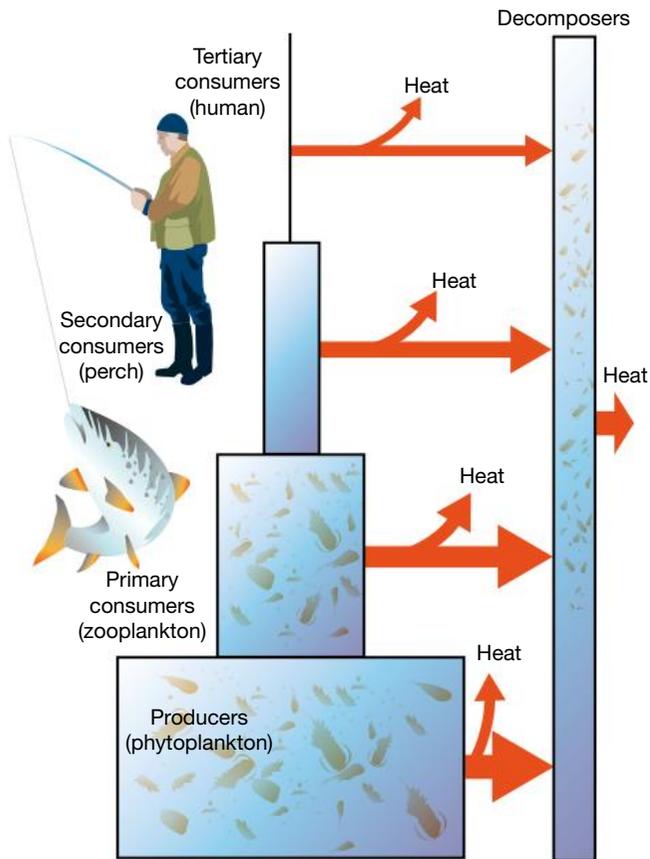


2.2.2 Temperature and rainfall interact to produce different types of biomes.



2.2.3 Latitude and height above sea level are important factors in producing different biomes.

Heat is lost during movement in animals and in the production of energy in mammals and birds



Smaller and smaller amounts of energy are available at each level of the food chain

2.2.4 This food chain shows the transfer of energy and nutrients. The sun is the source of energy for all the levels of the biosphere, including the decomposers, which return the minerals to the producers.

Food chains

Within every biome and ecosystem there are food chains, made up of **producers, consumers and decomposers**. A food chain, such as the one shown in Figure 2.2.4, indicates the flow of energy from the sun through to the various kinds of animals in the ecosystem.

Producers

Plants are called the producers in a biome because they produce their own food. They do this by **photosynthesis**. They use energy from the sun to convert carbon dioxide and water into sugars, starches and cellulose (carbohydrates), producing oxygen as a by-product.

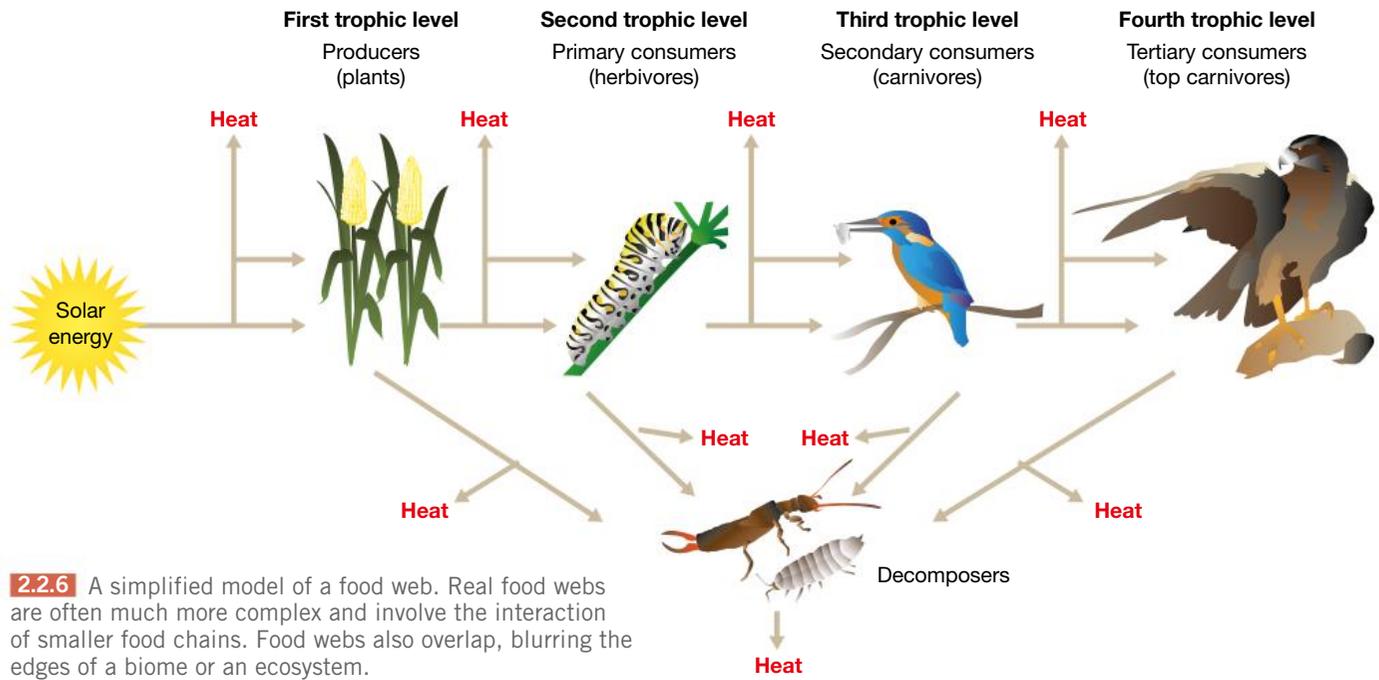
Only plants and a few bacteria can produce their own food. All other organisms are either consumers or decomposers. Animals and humans are the most obvious examples of consumers.

Consumers

Herbivores are primary consumers—they eat only plants. Herbivores include animals that graze on grass, birds that eat seeds, and animals that browse on leaves. These herbivores are eaten by the secondary consumers—carnivores (meat eaters). Some carnivores eat only herbivores; others eat only other carnivores. Those animals and birds that feed on other carnivores are called higher-level, or tertiary, consumers. Examples of these are sharks, hawks and lions. They are said to be at the top of the food chain. This is because the energy from the sun has worked its way through the producers, the herbivores and the lower-order carnivores before it reaches them.



2.2.5 An owl eating a mouse



2.2.6 A simplified model of a food web. Real food webs are often much more complex and involve the interaction of smaller food chains. Food webs also overlap, blurring the edges of a biome or an ecosystem.

Some animals (including pigs, cockroaches and humans) are both herbivores and carnivores. They eat a mixture of plants and animals and are called omnivores.

Decomposers

Decomposers include many kinds of bacteria and fungi. Their function in the food chain is to break down (decompose) the wood, leaves and dead bodies of other living things, so that every living thing is recycled. This recycling means that there is no waste in a biome or an ecosystem. For example, a mouse eats grains; an owl eats the mouse (see Figure 2.2.5); a fox eats the owl. Other grains, owls and foxes die naturally and their remains are broken down by decomposers.

Food webs

Although a food chain shows in a simple way how energy moves through different feeding levels in a biome or an ecosystem, it does not show all the relationships. Each animal does not eat one type of plant or one type of animal only. A food web shows the more complex interactions between different food chains within a biome or an ecosystem. Figure 2.2.6 shows a simplified model of a food web.

At each level of the food chain or food web, energy passes from one organism to another. The energy for plants comes from the carbohydrates produced by photosynthesis; the energy for animals comes from eating plants and other animals. Most of the energy taken in by an animal is used in the process of living, but a small percentage is passed on to the next-level consumer when the animal is eaten, or to the decomposers when the animal dies.

At each level of the food chain, most of the energy is used up in living; only a little goes to the next level. This means that less energy is available at each higher level of the food chain. For

example, of 100 units of energy produced by plants, only 0.1 unit is available to humans, who are at the top of the food chain and eat carnivores that have eaten herbivores that have eaten plants. More people can be supported if they eat grains and vegetables than if they feed grains and vegetables to animals and then eat the animals.

ACTIVITIES

Knowledge and understanding

- 1 Outline the factors that interact to produce the variety of ecosystems on earth.
- 2 Explain how ecosystems get their energy.
- 3 Explain the difference between a producer and a consumer in a food chain.
- 4 Outline how green plants manufacture their own food.
- 5 a Explain the difference between a herbivore and a carnivore.
b What is an omnivore?
- 6 Outline the role of decomposers in the food chain.

Applying and analysing

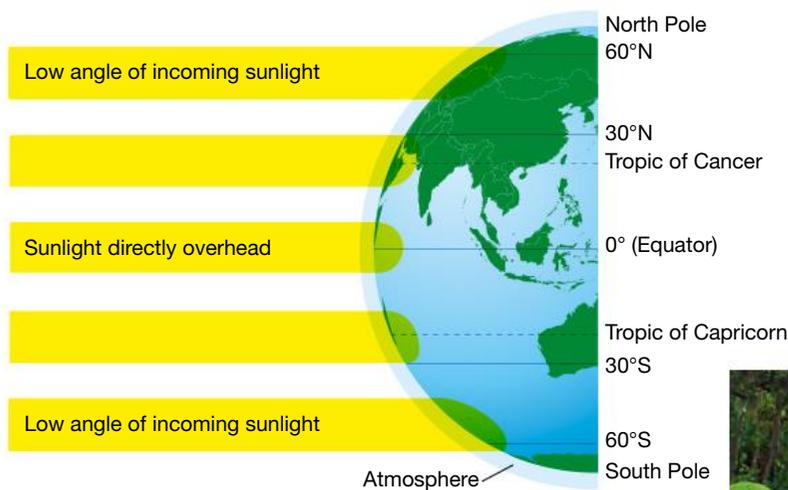
- 7 Discuss why there is no waste in an ecosystem.
- 8 Differentiate between a food web and a food chain.
- 9 Explain what happens to the energy that is taken in by an animal when it eats some grass.
- 10 Study Figure 2.2.4. Write a short report describing the flow of energy within an ecosystem.

The global distribution of biomes

Factors and location of biomes

There are many factors that affect the types of biomes or ecosystems found across the earth's surface. These factors operate on both local and global scales. The type of ecosystem at the bottom of a steep-sided valley is usually different from the ecosystem at the top due to factors such as shade, wind and moisture. At the global level, climate factors have the most significant impact on the distribution of biomes.

2.3.1 Solar insolation is the amount of solar energy that reaches the surface of the earth. It is greatest at the Equator.



Latitude

Latitude plays a crucial role in determining climate on a global scale. Latitude is a measure of the distance from the Equator—the imaginary line that runs around the earth at its widest circumference. At the Equator the earth presents the greatest landmass towards the sun, as shown in Figure 2.3.1. The amount of solar energy that reaches a particular part of the earth is referred to as solar insolation. Solar energy is greatest at the Equator and lowest at the poles. Table 2.3.2 shows the relationship between latitude and the amount of solar insolation.

Solar insolation is important to ecosystems because it is from the sun that ecosystems derive their energy. Without the sun, plants are unable to photosynthesise and therefore are unable to produce the energy to grow and survive. Without plants, there could be no animals, and ecosystems could not function. Ecosystems close to the Equator have the most amount of energy and are therefore able to support the greatest diversity of life. Tropical rainforests, such as the one shown

in Figure 2.3.3, grow in the world's equatorial region and are thought to contain about 50 per cent of all the plants and animals on earth.

2.3.2 Impact of latitude on solar insolation

Latitude (°)	Insolation (%)
0 (Equator)	100.0
10	98.6
20	94.5
30	88.0
40	79.2
50	68.5
60	57.0
70	47.4
80	43.0
90 (poles)	41.6



2.3.3 Tropical rainforests grow at the Equator and are the most productive of biomes.

At the other extreme, the polar regions receive the least amount of solar insolation. They have almost 24 hours of total darkness in winter. Such ecosystems are the harshest places of all to survive in and have the least diverse ecosystems. Antarctica, shown in Figure 2.3.4, is the coldest, driest and windiest place on earth.



2.3.4 Along with the Arctic, Antarctica receives the least amount of solar energy and therefore has little energy to support diverse life.

Precipitation and temperature

Rainfall is the main component of precipitation (sleet, snow, hail and dew are the other forms). Water is critical for plant growth and is essential for animals. In areas with low levels of precipitation, such as deserts, life is limited. Plants and animals have to become highly specialised and diversity is limited, as shown in Figure 2.3.5.

Temperature is another key factor in determining the distribution of ecosystems on a global scale. Most plants prefer

a temperature range of between 10°C and 35°C. Outside this range, photosynthesis is more challenging and plant growth is limited. Less plant growth means less food available for animals.

There is a strong link between precipitation, temperature and latitude. Solar energy is a key factor in determining temperature, and the Equator has the most constantly warm temperatures. Precipitation is also affected by solar insolation. When solar energy is high, the amount of evaporation increases and rain is more likely.



2.3.5 Desert plants have had to adapt to a lack of precipitation.

ACTIVITIES

Knowledge and understanding

- 1 State what solar insolation is.
- 2 Explain the importance of solar insolation to biome formation.
- 3 Describe the importance of precipitation on biomes.
- 4 What is the optimum temperature range for plant growth?

Applying and analysing

- 5 Examine Figure 2.3.1 and Table 2.3.2. Demonstrate how latitude affects solar insolation.
- 6 Write a short report explaining the importance of latitude in determining the global distribution of biomes.
- 7 Using the information in the text, create a Venn diagram comparing polar and tropical rainforest biomes. Are there any similarities? Explain.
- 8 Using Table 2.3.2 and an atlas or online map, find the latitude where you live and the nearest solar insolation percentage.

The world's major biomes

Ecosystems

One way to classify the earth's biophysical environments is to look at the different types of biomes found on the earth's surface.

The many ecosystems that exist can be divided into two groups: aquatic ecosystems and terrestrial ecosystems.

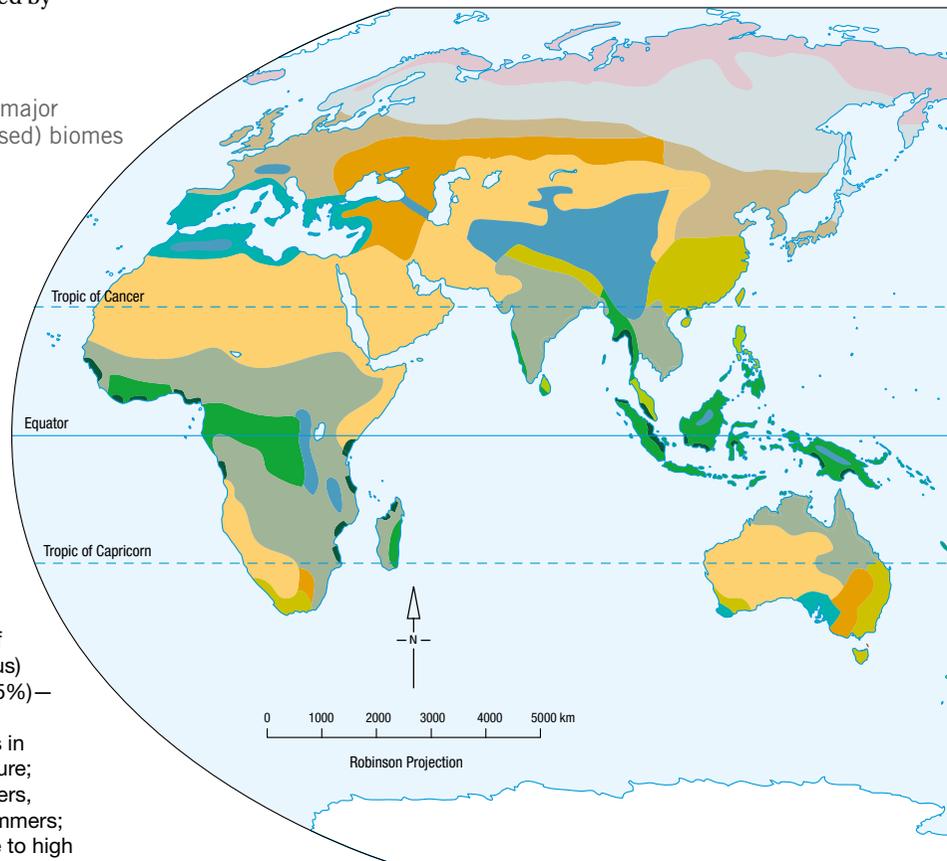
Aquatic ecosystems are water-based ecosystems. They include open oceans, river **estuaries** (the part of a river influenced by the sea) and coastal wetlands.

Terrestrial ecosystems are land-based ecosystems. The earth's major terrestrial ecosystems are shown in Figure 2.4.1. The earth's biomes are usually named after the type of vegetation that dominates the area. The type of vegetation, in turn, depends mainly on climate.

 Deserts (21%)—very dry, low humidity, both hot and cold; large daily range in temperatures



2.4.1 The earth's major terrestrial (land-based) biomes



 Broadleaf (deciduous) forest (1.5%)—seasonal variations in temperature; cold winters, warm summers; moderate to high precipitation

 Mediterranean shrubland (1%)—wet winter, dry summer



 Tundra (5%)—long severe winters, short cool summer



 Mountains (alpine) (11%)—temperatures decrease with elevation



 Tropical rainforest (2%)—warm to hot temperatures throughout the year; high rainfall



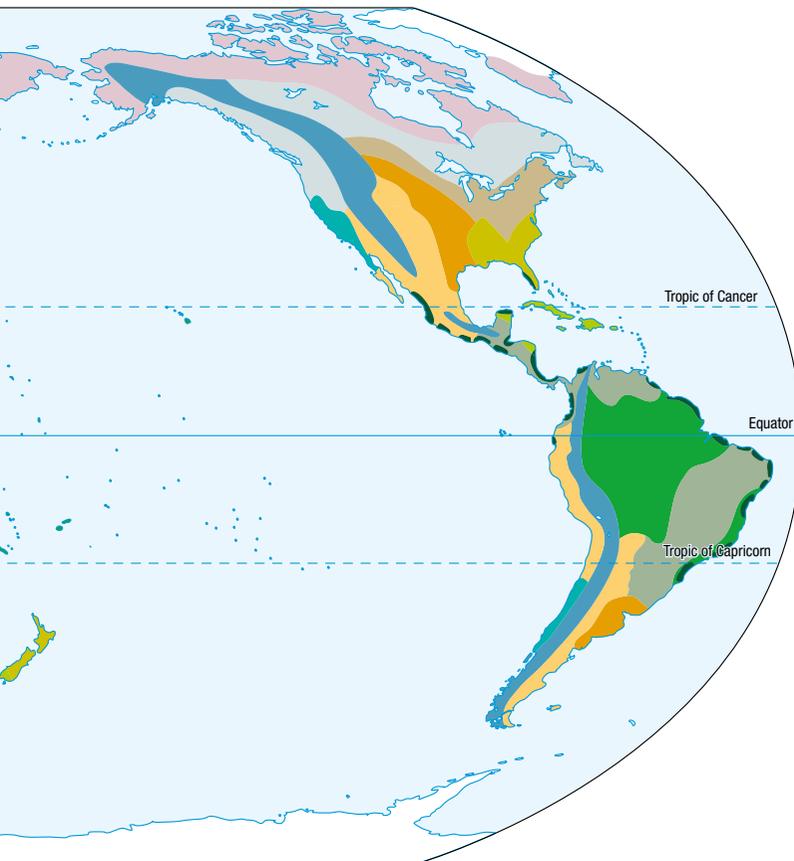
 Tropical savanna (24%)—distinct wet and dry seasons; high temperatures in summer



 Temperate grassland (9%)—warm to hot summers, cold winters; relatively low rainfall



 Broadleaf (evergreen) forest (9%)—cool wet winters and dry mild summers



 Polar (11%)—very cold, low precipitation



 Coniferous (taiga/boreal) forest (14%)—long cold winters, short cool summers



 Mangroves (<1%)—variable rainfall, temperate climates

ACTIVITIES

Knowledge and understanding

- 1 Distinguish between aquatic and terrestrial ecosystems.
- 2 After what characteristic are most terrestrial biomes or ecosystems named?
- 3 Explain the role of climate in determining the type of biomes that exist in an area.

Geographical skills

- 4 Study Figure 2.4.1. With the aid of an atlas, write a report describing the distribution of the earth's major terrestrial biomes.

Australia's major ecosystems and biomes

Diverse biomes

Australia has a diverse selection of highly valued aquatic and terrestrial ecosystems. The immense diversity found on and around the continent is a product of its size, latitudinal extent and long coastline, as well as a long geological history. This is reflected in the particular combinations of plants and animals found within the different ecosystems.

Australia is one of the earth's seven continental landmasses. Among the continents, Australia is unique in many ways and possesses a remarkable wealth of life, despite the harsh natural environment.

Aquatic ecosystems

Australia's aquatic ecosystems are found in marine and freshwater environments. These are illustrated in Tables 2.5.1 and 2.5.2

2.5.1 Australia's marine aquatic ecosystems

Marine

With such a long coastline, there are many highly specialised marine ecosystems found around Australia.



a Rottnest Island, Perth, Western Australia

Coastal zone: the warm, nutrient-rich, shallow waters that extend from the high-tide mark on land, to the gently sloping, shallow edge of the continental shelf (the submerged part of the continent). This water is disturbed by wind (producing waves at its surface) and ocean currents. Copious amounts of seaweed float in the water, supporting animals such as sea snails, crabs and lobsters. Fish abound and larger animals, such as turtles and whales, move through on their migration routes.

Along the shoreline of the coast there are beaches and rock platforms under the cliffs of headlands, where tidal pools are found.



b Gippsland Lakes, Victoria

Estuaries and their associated coastal wetlands: where sea water mixes with fresh water and nutrients from rivers and surface run-off. It includes inlets, bays, river mouths and the fringes of land that are inundated by the changing tides. Many of these sheltered areas are covered with mangrove forests. In northern Australia the tidal range is quite substantial and so the tidal reach inland is considerable. This is the habitat of the freshwater crocodile.



c Great Barrier Reef

Coral reefs: occur in shallow seas along much of north-eastern Australia, where the Great Barrier Reef (the largest coral reef system in the world) is found. Scattered reefs, such as Ningaloo Reef, are found along the Western Australian coast. Coral reefs are one of the most complex ecosystems on earth and support immense biodiversity.

Freshwater

Despite being such a dry continent, Australia does have distinct and valuable freshwater ecosystems.

a Finke River, Northern Territory



Watercourses: across the surface of Australia, there are a number of watercourses that mostly drain towards the sea, though inland rivers such as the Diamantina and Barcoo empty into Lake Eyre in rare outback rain events. While river flow in Australia is characteristically quite low, it is also highly variable. A riverbed can become merely a chain of waterholes in a dry spell and then transform into a torrent after heavy rain. The ecosystem supports a multitude of life forms, from microscopic organisms in the mud on the bottom of the channel to large populations of freshwater fish.

b Kakadu National Park, Northern Territory



Freshwater wetlands: associated with rivers, flood plains, lakes and groundwater discharges. Some bodies of still water are only linked to the main river by floodwaters, but they are very productive ecosystems rich in life forms. Many are like a rich soup of micro-organisms that young fish, such as the Murray cod fry, rely on to survive. The diversity of algae found in these wetlands ensures their continuing productivity.

c Cradle Mountain and Dove Lake, Tasmania



Lakes: large natural bodies of still or standing fresh water in depressions on the earth's surface. They are not common in Australia, but they do support characteristic life forms in different layers, depending on the depth of the water and the amount of sunlight available.

Terrestrial ecosystems

Spanning almost 33° of latitude, Australia's climate ranges from the hot, wet tropical far north, to a cool temperate (with snow) south. Australia is the driest inhabited continent in the world, with the Lake Eyre region in South Australia averaging

only 100 millimetres of rainfall a year. Tully, in northern Queensland, has an annual average rainfall of 4204 millimetres. The responses to so many different climate regimes across such a vast continent underpin the diversity found in Australia's terrestrial ecosystems, which are outlined in Table 2.5.3.

2.5.3 Australia's terrestrial ecosystems

a Rainforest in Queensland



Rainforests are only found in isolated pockets on the well-watered eastern side of the Great Dividing Range where annual rainfall exceeds 1200 to 1500 millimetres. Tropical rainforests are found in the hot climate of northern Queensland, but as the temperatures decrease towards the south, subtropical rainforests take over. In the cooler states of Victoria and Tasmania, cool temperate rainforests are found. Rainforests are characterised by a closed canopy of tree crowns and a large diversity of species of plants, animals and insects.

b Forest in Southern Australia



Sclerophyll forests are dominated by eucalypt trees, which have hard leathery leaves that are able to survive in the poor, phosphate-deficient soils of Australia. Wet sclerophyll forests have tall eucalypt trees sheltering an understorey of moisture-loving shrubs. They generally occupy moist gullies on the shaded southern side of highland areas and on the wetter eastern coast. Dry sclerophyll forests have smaller trees that are well spaced, allowing the sun to reach the understorey, where hardy plants, such as banksias and grevilleas, thrive. Such forests burn fiercely, but then regenerate.

c Eucalypt woodlands near Horsham, Victoria



The eucalypt woodlands have fewer and shorter trees scattered among grasses and shrubs. In the semi-arid fringes, the mallee tree survives droughts and fires because it has a large lignotuber that is protected underground. The temperate grasslands have no trees but are dominated by extensive perennial grass tussocks such as kangaroo grass, which dominate the landscape.

d The Kimberley, Western Australia



Large, generally flat areas covered by extensive grasslands (such as Mitchell grass) with a few low, scattered trees are found across northern Australia. The climate has distinct wet and dry seasons, with fires common in the dry season. Marsupials dominate the animals of the savanna.

e Uluru-Kata Tjuṯa National Park



Two-thirds of Australia is desert or semi-desert (receiving less than 250 millimetres or between 250 and 300 millimetres of annual rainfall respectively). Some desert surfaces are covered with sand or stones. Others have tussock and hummock grasslands containing spinifex grasses, with acacias and low shrubs such as saltbush. Animals such as the bilby and reptiles such as goannas survive by burrowing underground to avoid the extreme heat.

f Snowy Mountains, Kosciuszko National Park, New South Wales



Mountains of sufficient height have unique ecosystems. The highest parts of the Snowy Mountains in southern NSW are too cold for trees to grow. The alpine area only occupies 100 square kilometres around Mt Kosciuszko. The alpine area is a mosaic of heathland, alpine grasses, herbfields and bogs, interspersed by protruding rocks. Highly specialised plant and animal communities are adapted to the extreme cold, such as the marsh marigold, which flowers under the snow, giving it enough time to spread seed in the brief summer.

ACTIVITIES

Knowledge and understanding

- 1 List the reasons why Australia has such diverse aquatic and terrestrial ecosystems.

Applying and analysing

- 2 Study Tables 2.5.1, 2.5.2 and 2.5.3 and do the following tasks.
 - a Create a three-column table, label the columns with the following headings and fill in the table:
 - photograph letter (name of place)
 - type of ecosystem (select from the tables)
 - dominant features (include information about climate where available)

- b Individually rank the photographs, from the environment that appeals to you the most to the environment that appeals to you the least.
- c List the criteria you used.
- d In groups of four, compare your individual rankings and criteria. Then as a group, rank the photographs. What criteria did the group use?
- e Share your group's rankings with the rest of the class. How much agreement was there?

Productivity of biomes

Process of primary production

All life on earth depends on the production of new organic matter within ecosystems. This production is carried out by the primary producers, which form the base of the food chain. Various ecosystems differ in their primary productivity and this is significant as it determines the food supply for humans and other animals.

The earth's organisms either produce their own food or consume it after others have made it. The organisms responsible for primary production are known as primary producers or autotrophs (self-feeders). They alone are able to capture and store the energy from the sun through photosynthesis.

Producers

On land the producers are mostly green plants. In fresh water and marine ecosystems near the shoreline, algae and green plants are the major producers. However, in the open water of the oceans of the world, the dominant producers are phytoplankton. They are microscopic organisms that float or drift in the sunlit upper layer of vast stretches of sea water.

Process of photosynthesis

During photosynthesis, the producers convert the light energy of the sun into chemical energy that is stored within plant tissues. Using this sunlight, as well as carbon dioxide, water and nutrients, the producers create new organic compounds or simple sugars, such as glucose, which hold chemical energy. In the process of making their own food, plants also provide oxygen to the atmosphere.

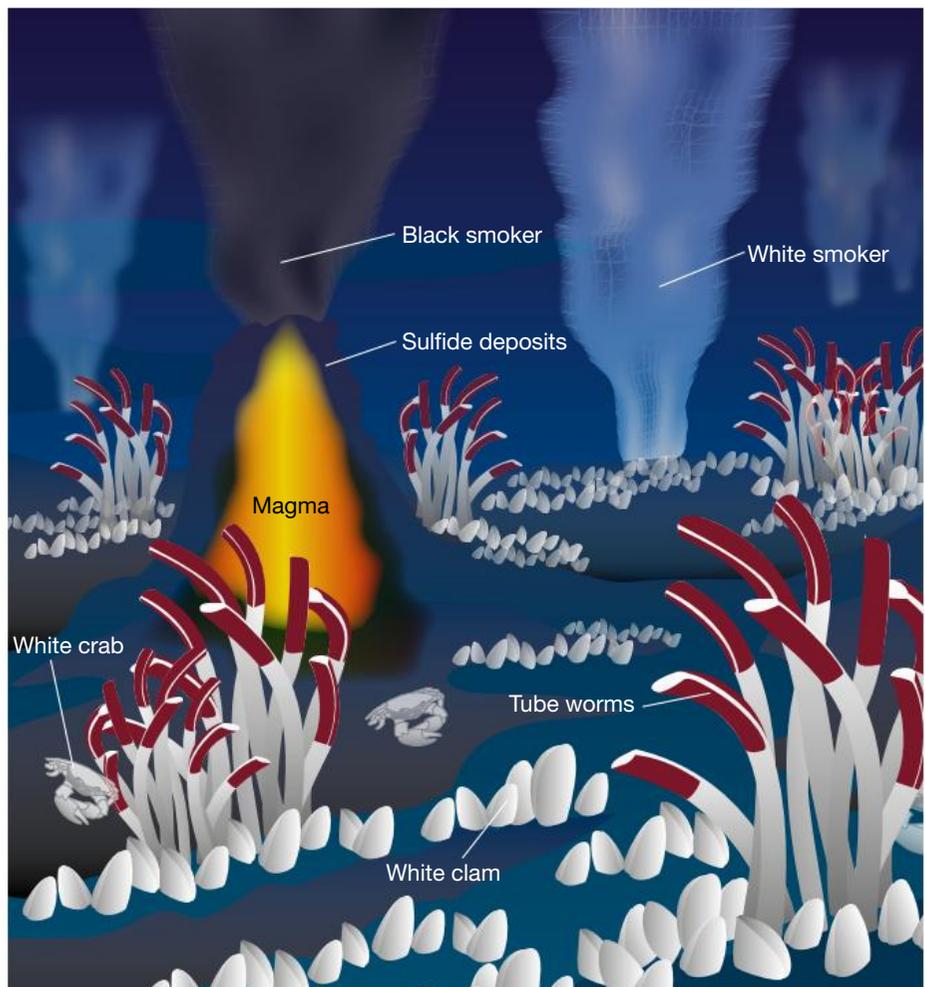
The chemical energy within the plant supports it as it grows in size. Over time this primary production results in the

2.6.1 The sun's energy penetrates only about 200 metres below the surface of the water. Exploration of the deep ocean floor as recently as 1977 resulted in the totally unexpected discovery of abundant and unusual sea life around black smokers, 2.5 kilometres below the surface.

addition of new biomass to the biome. Consumers derive their energy from these primary producers.

Chemosynthesis in the dark ocean depths

There are only a few producers, mostly highly specialised bacteria, that can convert simple compounds from their environment into food without any sunlight. They are found deep within the ocean near the deposits that form when superheated water shoots out of vents on the ocean floor near some tectonic plate boundaries. As the water mixes with the cold sea water, black particles precipitate out and accumulate as chimney-like structures known as black smokers. A variety of rare and exotic life forms, including giant clams, 2-metre tubeworms and eyeless prawns exist in the dark depths around these black smokers. These life forms are supported by bacteria that produce food through chemosynthesis from the minerals discharged by the vents. Figure 2.6.1 illustrates how life forms are supported by chemosynthesis.



Types of primary productivity

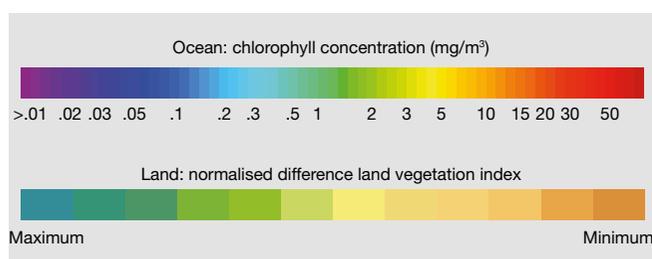
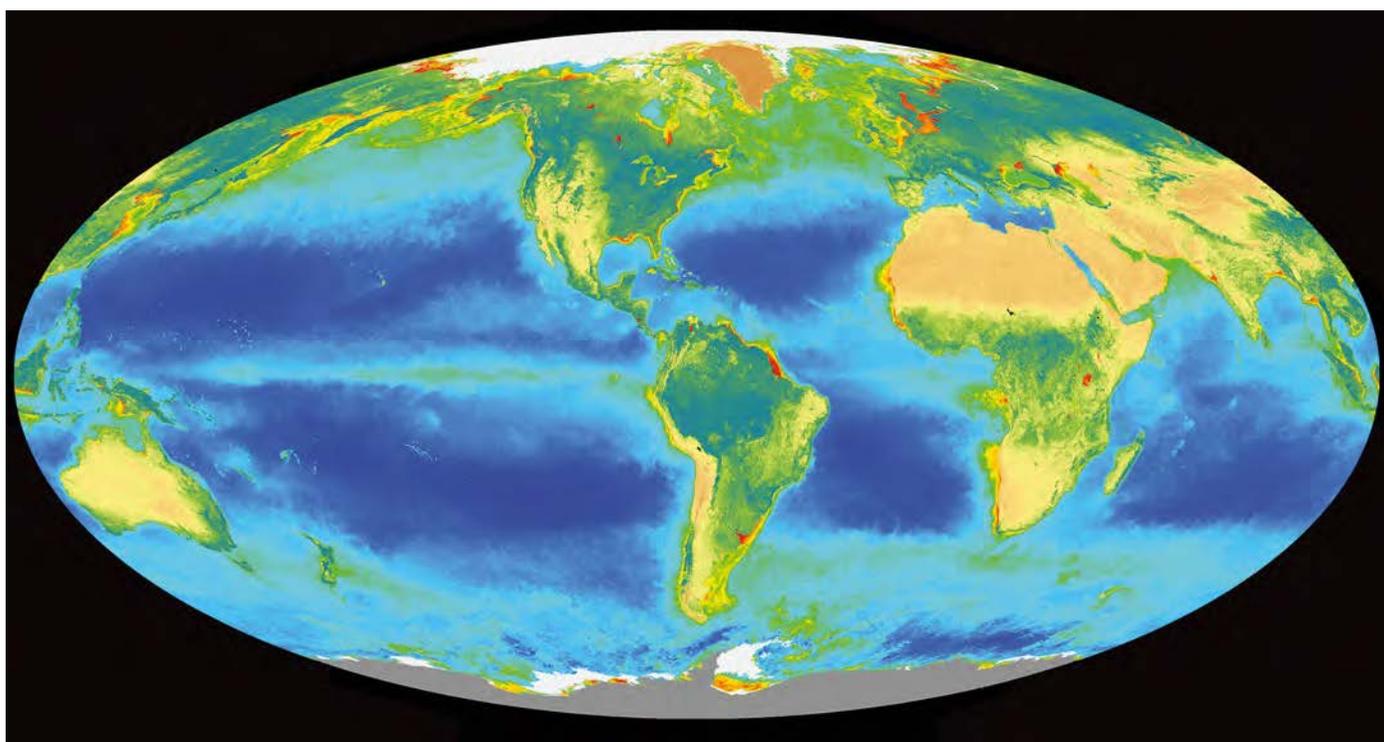
The rate at which photosynthesis occurs determines the rate at which biomass increases within a biome. It is identified as the **primary productivity** of that biome. When comparing the primary productivity of different biomes it is important to consider the different types of primary productivity.

Gross primary productivity

Gross primary productivity (GPP) is the rate at which the primary producers in an ecosystem convert the sun's energy into chemical energy in the form of biomass found in their tissues. GPP is measured in terms of the energy produced

per unit of area over a given time span, such as kilocalories per square metre per year ($\text{kcal}/\text{m}^2/\text{yr}$). Figure 2.6.2 shows satellite data of the earth's GPP in terms of ocean and land concentrations of chlorophyll. Note that ocean chlorophyll concentration is often measured in milligrams per cubic metre (mg/m^3). On land, rainforests and other highly productive areas are dark green, and the least productive (mostly deserts) are brown. Note that the colours are the opposite in the oceans, with red, orange and yellow representing the highest values and dark blue the lowest values of the chlorophyll found in phytoplankton. The highest values are in the cooler waters near the polar regions, as cold water holds more oxygen.

2.6.2 Image of the earth's GPP. All plant life contains the primary photosynthetic pigment chlorophyll 'a'.



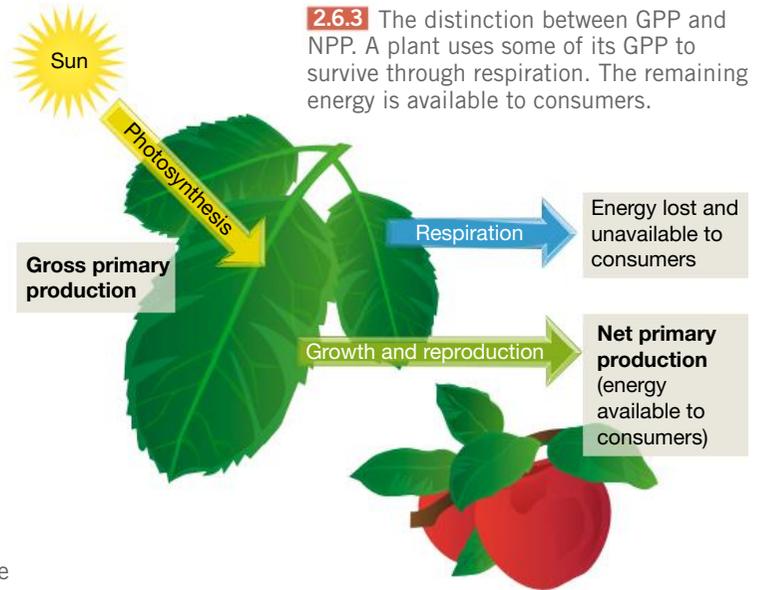
DID YOU KNOW?

Biomass is the dry weight of all the organic matter contained within the organisms of an ecosystem. The more productive an ecosystem is, the bigger its biomass.

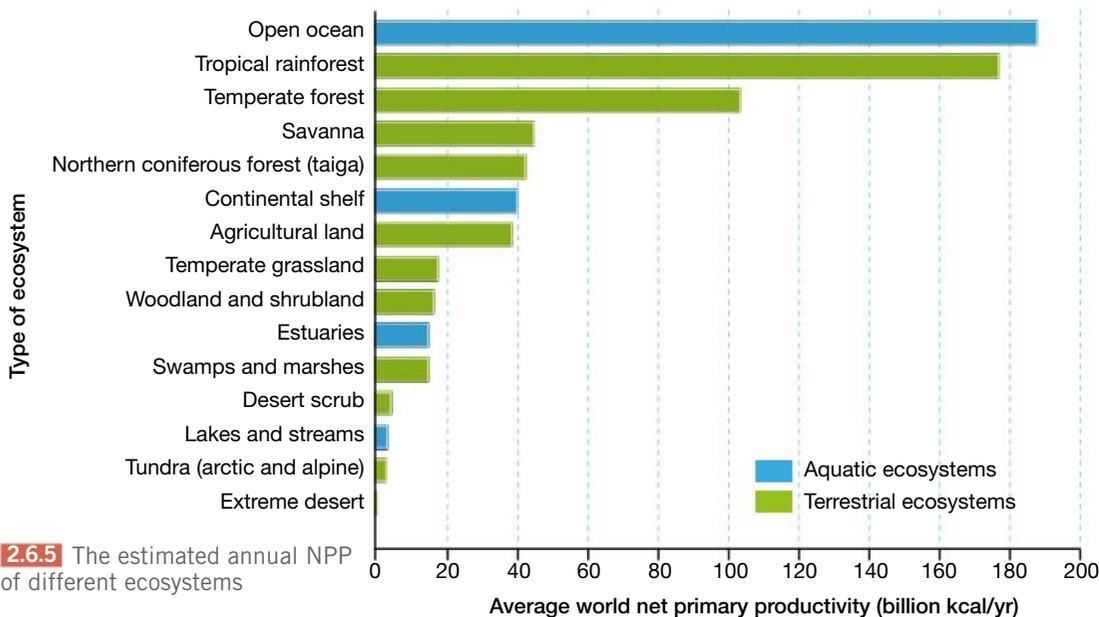
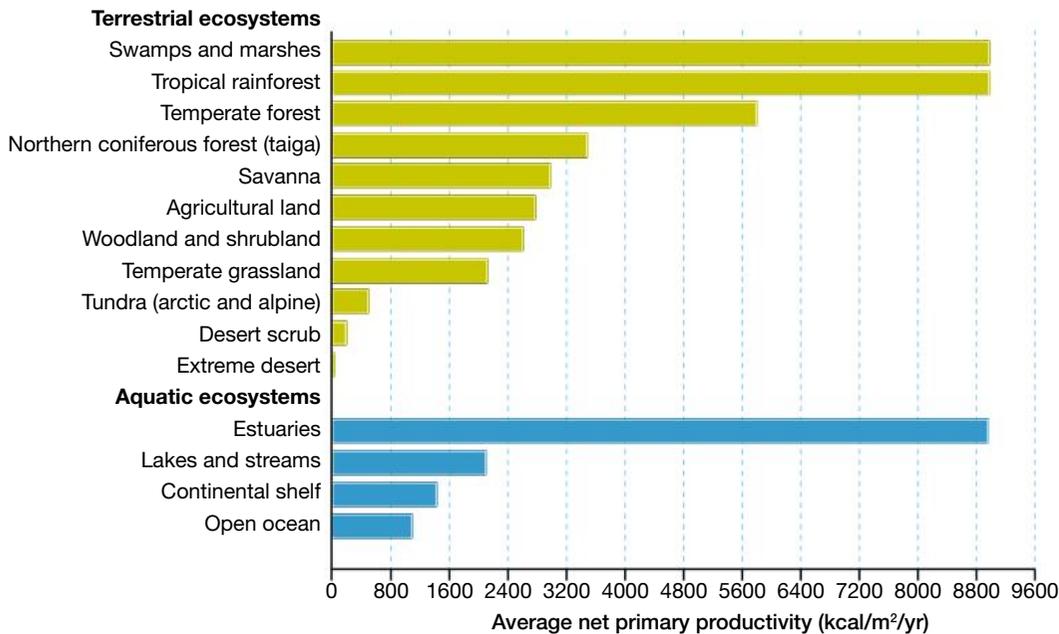
Net primary productivity

Not all of the chemical energy produced is available to others in an ecosystem. The producers must use some of it for their own respiration in order to stay alive, grow and reproduce. Net primary productivity (NPP) is the rate at which producers use photosynthesis to produce and store chemical energy minus the rate at which they use some of this for their own respiration. This is depicted in Figure 2.6.3.

NPP is a measure of how quickly producers can make the chemical energy they store in their tissues that potentially becomes available to the consumer organisms within the biome. NPP is the base of the food supply for humans and other animals.



2.6.4 The estimated annual average NPP per square metre



2.6.5 The estimated annual NPP of different ecosystems

Primary productivity of biomes

The biomass within a particular biome is determined by how much solar energy its producers are able to capture and store as chemical energy, and how quickly they do it. Terrestrial and aquatic ecosystems differ in their NPP, as is illustrated in Figure 2.6.2. The highest NPP rates are in swamps and marshes, tropical rainforests and estuaries, while the lowest rates are found in the desert, tundra and open ocean.

On land, NPP per square metre decreases between the Equator and the poles in response to the amount of solar radiation available to producers. It is highest at the Equator, as is evident in tropical rainforests, and lowest towards the poles, in tundra and arctic ecosystems.

In aquatic ecosystems, the highest NPP per square metre is found in estuaries, swamps and marshes, which are rich in the nutrients found in the sediments carried in by rivers. The open ocean has a very low NPP per square metre, as it is usually low in nutrients, except in locations where there is an upwelling of water from the bottom depths to the surface that brings nutrients with it. As can be seen in Figure 2.6.5, the open ocean produces more of the earth's biomass than any other biome, simply because there is so much open ocean—71 per cent of the world's surface. Even though estuaries (see Figure 2.6.6) are very productive, their total area is small.

Primary productivity for humans

Primary producers are the source of all food available for every other organism within a biome. Furthermore, only the biomass represented by the NPP is available to support consumers. It is the planet's NPP that ultimately limits the number of species (including humans) that are able to survive on earth.



2.6.6 Estuaries are coastal bodies of water that are a mixture of fresh and salt water.

SPOTLIGHT

Humans and the NPP

Peter Vitouseck, Stuart Rojstaczer and other ecologists estimate that humans now use, waste or destroy about 27 per cent of the earth's total potential NPP and 10–55 per cent of the planet's terrestrial ecosystems. They contend that this is the main reason why we are crowding out or eliminating the habitats and food supplies of so many other species.

Physicist Paul MacCready estimates that humans, their livestock and pets now make up 98 per cent of the earth's total vertebrate biomass. This means that wild vertebrates make up only 2 per cent of the planet's vertebrate biomass, as humans have overtaken much of the planet. Many of the remaining tigers, elephants, birds and small mammals face extinction as the human footprint becomes heavier.

G Tyler Miller, *Living in the Environment*, fifteenth edition, Thomson Brooks/Cole, Belmont, 2007

ACTIVITIES

Knowledge and understanding

- 1 Explain why the primary producers of ecosystems are so important.
- 2 Distinguish between GPP and NPP.
- 3 Compare photosynthesis with chemosynthesis.
- 4 Describe the differences in the NPP per square metre of ecosystems from the Equator to the poles.

Applying and analysing

- 5 Model your family's weekly budget on the concepts of GPP and NPP.
- 6 Study Figure 2.6.4 and write a short response to the following statement:
As swamps and marshes and estuaries are the most productive biomes, they should be protected before all other biomes.

Geographical skills

- 7 Study Figure 2.6.2. Compare the gross primary productivity (on land) of Australia, South America and Africa.

Biodiversity's impact on energy and matter

Biodiversity

Biodiversity is found in the variety of the earth's genes, species, ecosystems and ecosystem processes. It is vital in sustaining the flow of energy and cycling of matter that supports life. Humans, like all other species, are dependent upon the maintenance of this biological wealth. Biodiversity is of great value and it must be protected to ensure our future wellbeing.

Components of biodiversity

Biological diversity, or biodiversity, is illustrated in Figure 2.7.1 and includes:

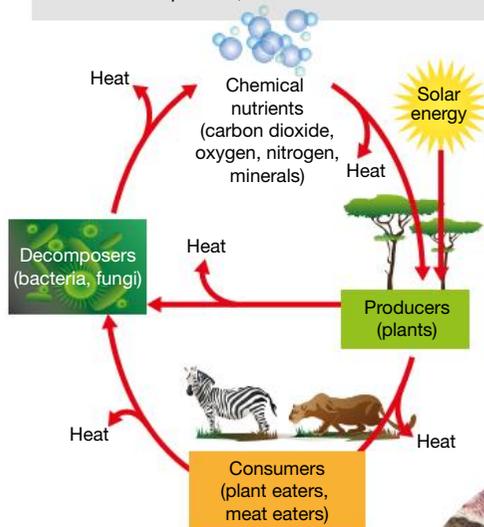
- **species diversity**—the number of species within particular communities

- **ecosystem diversity**—the variety of aquatic and terrestrial ecosystems/biomes
- **functional diversity**—chemical and biological processes such as the flow of energy and cycling of matter needed for the existence of species, communities and ecosystems
- **genetic diversity**—the inherited variation that occurs within species populations as a result of different genes or biochemical packages.

2.7.1 Major components of the earth's biodiversity

Functional diversity

The biological and chemical processes such as energy flow and matter recycling needed for the survival of species, communities and ecosystems



Genetic diversity

The variety of genetic material within a species or population

Ecosystem diversity

The variety of terrestrial and aquatic ecosystems found in an area on the earth



Species diversity

The number and abundance of species present in different communities

Biodiversity in biomes

Within a biome there are many interrelationships between numerous species whereby energy flows through the food chain and matter is constantly recycled, sustaining life. Should a disturbance occur, such as a storm or a fire, a biome rich in diversity is more able to recover and restore functioning and so has greater **resilience**.

Feeding pathways

Feeding pathways are the means by which energy and matter move through a biome. When biodiversity is high, there are many pathways, so if a few are destroyed, others can be used and the biome is able to continue to function. However, in biomes lacking biodiversity, the impact of disturbances can be catastrophic. A reliance on limited food pathways means that, if they are lost, the flow of energy in the food chain is halted, resulting to the demise of dependent species.

Tropical rainforests are renowned for their immense biodiversity. If a particular fruit tree favoured by a fruit-eating bat dies, the usual feeding path is lost. However, in the rainforest, the bat will simply turn to another source in the abundance of fruit on offer. The Jamaican fruit-eating bat shown in Figure 2.7.2 thrives on the number and variety of fruit-bearing trees in the rainforest.

Functional diversity for food production

Grasslands are the biome that is most heavily relied upon for food production. Seeds from grasses such as wheat and barley provide the cereal grains that are staple foods. Throughout the temperate latitudes there has been widespread clearing of native grasses, which have been replaced with a monoculture of a cereal crop. Most significantly, the grassland biome overlies deep, fertile soils. With continued cultivation, the flow and cycling of energy has generally been maintained by good farming practices, and with it the productivity of the land.

Tropical rainforests have a much higher productivity than grasslands, but they are a fragile biome and not suited to clearing for food production. They are also highly valued for their immense diversity, as they contain up to half the world's plant and animal species, many as yet undiscovered. Their continued productivity can be maintained only if rainforests remain intact, as the soil underneath is quite impoverished. The soil depends on all the decaying organic matter that reaches the ground from above to provide nutrients, and the rainforest biome is very efficient at recycling nutrients that would be otherwise leached out by the heavy rain.



2.7.2 The Jamaican fruit-eating bat lives in the tropical rainforest. Its favourite fruits are mangoes and bananas.

Genetic diversity for future food production

Biomes provide a bank of genetic material that our future existence may well depend upon. Currently, 75 per cent of the world's food is provided by just seven staple crops, so it is important that genetic material from wild stocks of plants is kept for use if needed. Genetic diversity will be vital in developing new crops if environments change with global warming.

ACTIVITIES

Knowledge and understanding

- 1 Outline the components of biodiversity.
- 2 Explain why biodiversity is important in ecosystem functioning.
- 3 Discuss why resilience is important.

Applying and analysing

- 4 Compare the suitability of grasslands and rainforests for food crops.
- 5 Explain why genetic diversity is important for future food production.

Human alterations to biomes

Humans and their place in the natural world

While humans are only one of millions of species living on earth, they have, more than any other, altered the world's biomes. Like all species, they have sought to meet their immediate needs of food, water and shelter—but humans have gone further. From the beginning of civilisation the scale of their alterations to biomes has increased. Recent technological advances have accelerated the process.

For thousands of years many indigenous peoples lived in harmony with nature. While they used their environment to support their way of life, and altered it to some extent, most acted as stewards of their environment.

As human society became more sophisticated, the relationship with nature changed. In the scramble to develop, nature became a casualty.

Humans have several traits that set them apart from other species.

- They desire to control or master nature, and they perceive their success in doing so as progress, which they consider good no matter what the cost to other species. The extent of this control can be seen in Table 2.8.1.
- They believe that the satisfaction of human needs is paramount. Any disturbance or even destruction of the natural world is usually discounted, ignored or deemed necessary.
- They possess intelligence, and by developing new technologies they have managed to achieve greater control over their environment. They have power far beyond their numbers in comparison to other species.

Why humans alter biomes

Civilisations emerged when adequate food was produced to support them. Food production has continued to be of fundamental importance and, as the world's population has grown, more and more land has been needed for this purpose. As the world has industrialised and modernised, even greater demands have been placed on the natural environment to provide the fibres, fuels and all the raw materials needed. Many of the world's biomes have been affected by human activities in the scramble or competition for resources.

How humans alter biomes

The imprint of humans has spread across the earth's surface as natural habitats have been lost to agriculture, mines, dams, transport routes, canals, cleared tracts for power transmission lines and settlements. Such features of the built environment stand out as evidence of the impact of humans. Humans alter their environment to make it more suitable to their purposes. This is done in a number of ways.

Vegetation clearance

Land clearing, primarily for agriculture, is probably the most widespread cause of damage to biomes. The biome most affected has been the temperate grasslands, which have been either removed or modified on every inhabited continent of the world. The absence of trees, flat terrain and the deep rich soil made them attractive for farmland as well as urban settlements.

In 2013, the International Union for Conservation of Nature (IUCN) reported that the temperate grasslands are one of the world's great biomes—but they have mostly disappeared. Indigenous temperate grasslands are now, according to the IUCN, the most altered ecosystem on the planet. The temperate grasslands biome occupies 9 million square kilometres or 8 per cent of the earth's terrestrial surface. Of this 8 per cent, only 5 per cent is currently protected within the global system of protected areas. Indigenous temperate grasslands are now the earth's most endangered ecosystem.

Globally, about 80 per cent of the original forest cover has also been cleared, fragmented, degraded or turned into plantations for commercial crops. About half of this area has been completely cleared and the loss of habitat of a biome rich in biodiversity has resulted in the demise of many species. Early casualties were the rainforests that covered the Ivory Coast of West Africa. The same trend of deforestation continues in South America and South-East Asia.

DID YOU KNOW?

Due to land clearing, particularly in Queensland, koalas have been listed as vulnerable to extinction by the Federal Environment Department. Approximately 40312 hectares of forest has been cleared. It is estimated that between 1990 and 2010 koala numbers declined by 42 per cent across Queensland and NSW, but on the Koala Coast, south-east of Brisbane, a Queensland Government survey has shown a 68 per cent decline.

2.8.1 Extent of human control of ecosystems

Type of control	Examples
Direct physical control	<ul style="list-style-type: none"> • Confinement of animals or plants by enclosures of any kind • Exclusion of animals or plants by devices of any kind • Physical support given to organisms (mainly plants), such as stakes and trellising • Pruning, trimming and mowing • Weeding • Persecution of organisms by physical means, such as shooting, buffeting and scarring • Performance of minor operations on a routine basis, such as shearing, dehorning, docking, castration and hoof care • Cropping/harvesting: removal of all or part of certain plants or animals and their transfer from the system to the point of consumption
Chemical control	<ul style="list-style-type: none"> • Poisoning unwanted organisms, whether plant, animal, insect, fungus or bacteria • Stimulating growth by adding nutrients • Chemically inducing changes in organism behaviour or characteristics, such as through the use of defoliants, colourants, hormones, attractants or repellents
Habitat control	<ul style="list-style-type: none"> • Ploughing or other modifications to soil, earth or rock • Provision of special environments, such as glasshouses, greenhouses and beehives • Provision of shelters such as windbreaks • Microclimatic modification to deter unwanted organisms • Introduction or exclusion of fire • Habitat deconstruction (such as deforestation, swamp draining and filling), leading to local or global extinctions
Biological control	<ul style="list-style-type: none"> • Spread of disease to unwanted species, such as myxomatosis in Australian rabbits • Introduction of predator or parasite specific to unwanted species, such as cactoblastis on Australian prickly pear • Introduction of species to niche, such as marram grass for sand dune stabilisation in south-eastern Australia
Genetic control	<ul style="list-style-type: none"> • Regular importing of strains of organisms with special characteristics (usually high yield) • Importing genetic material, such as use of artificial insemination • Control of plant or animal breeding within the system, such as use of selective breeding, selective hybridisation • Scientific interventions to bring about genetic changes that act as a means of controlling and perhaps eliminating unwanted species
Behaviour control	<ul style="list-style-type: none"> • Subjugation, such as 'breaking' of horses • Training of animals to respond to stimuli, such as to attack unknown humans and to feed at sound of buzzer to facilitate harvest • Stimulating inherent responses of organisms to light/dark, heat/cold, high/low humidity, etc., such as by extending day lengths with lamps and by refrigeration to simulate winter and induce 'spring' behaviour on removal from refrigeration
Water-cycle control	<ul style="list-style-type: none"> • Supply or removal of water by any means • Weather modification

Source: P Chapman and S Codrington, *Understanding our Earth*, Pitman, Carlton

Table 2.8.2 illustrates the extent of human influence on the main biomes of the world.

2.8.2 How people have influenced biomes

Biome	Percentage of the world's land	Vegetation	Effect of people on the ecosystem
Equatorial and tropical rainforest	8	Many different types of trees; dense layers of plants: adapted to high rainfall throughout the year.	The effect depends on the type of use: <ul style="list-style-type: none"> • hunters and gatherers: very little effect • shifting cultivators: large short-term effect, when forest is cleared; after fields are abandoned, forest regrows; that is, medium-term effect • timber-cutting: large effect over large areas • clearing for farming: large effect as forest is totally removed.
Temperate forest	7	Forests of different trees, many of which are deciduous; trees adapted to moderate rainfall and cool winters, warm summers.	Many of the world's temperate forests have been cleared and the land used for crop growing. People have had a major effect on this ecosystem.
Coniferous (or boreal) forest	14	Forests of evergreen trees, mainly conifers; trees adapted to cold winters and low rainfall.	People have changed some areas more than others. In Canada and the eastern part of Russia, some forests have not been used. In the USA and Norway, they are used for grazing and herding. In western areas of Russia, the effect of people is higher as the forests have been cleared for crop growing.
Savanna (grassland)	24	Areas near Equator have trees and grasses; closer to deserts, grasses dominate: grasses adapted to a wet and dry season.	Major effect of people: <ul style="list-style-type: none"> • herding and ranching: fires have been used to clear trees and encourage grasses • areas of overgrazing: high stock numbers cause erosion • grasslands ploughed for crops: danger of erosion.
Temperate grassland	7	Tall grasses in wetter areas, and scattered trees; shorter grasses where drier.	Most of these grasslands have been cleared and ploughed for crop growing. Areas of grassland have been improved, or replanted with better grasses, for livestock grazing.
Mediterranean	1	Shrubs and trees adapted to summer drought and winter rains.	Most vegetation has been cleared and soil ploughed for tree crops and other crops; some grazing.
Hot desert	21	Sparse cover of shrubs and grasses: plants adapted to low rainfall and long periods without rain.	Areas in Africa and Asia are used for nomadic herding. In the USA, Australia and South America, they are used for ranching (cattle/sheep). Very fragile ecosystem; although stock numbers are low, many areas are overgrazed and erosion is a problem.
Tundra	5	Mosses, lichens and plants adapted to cold temperatures and low rainfall.	People have had very little effect, although tourism can destroy the vegetation.
Polar	11	Ice caps: no vegetation.	People have had little direct impact on ice caps, but fishing of krill and other marine life is having an effect on polar ecosystems. Also, pollution from water areas is starting to affect marine life.
Cities and industrial areas	2	Natural vegetation cleared and people build new environment (houses, roads, and factories).	Major impact, as people change the nature of the ecosystem. Pollution of air and water is having a major impact on all the world's ecosystems.

Source: P Chapman and S Codrington, *Understanding our Earth*, Pitman, Carlton



2.8.3 Mountainous areas are farmed using terraces. They are common in China, the Philippines and Bali.

Sourcing water supplies

Water is a vital resource for humans. Irrigated agriculture has been the backbone of increased food production and water is necessary to run stock. It is also needed in large quantities to serve the daily needs of the concentrations of people living in urban centres. Many industries need water for cooling, washing and the chemical processes involved in manufacturing. Humans have found a number of ways to tap into the water cycle to secure an adequate supply of water for their needs, such as:

- constructing large engineering projects such as dams to store water. Currently, there are around 40 000 large dams that obstruct the world's rivers. They can have a major environmental impact upstream (such as loss of habitat in drowned river valleys) and downstream (such as blocking fish migrations, changing temperature and reducing the level of dissolved oxygen in water released from the dams)
- using canals and pipelines to transport water
- sinking wells and bores to extract groundwater, which can lead to its depletion and a lowering of the water table
- using large bodies of water to dilute pollutants, such as by dumping sewage into oceans.

Terracing

Terracing is an ancient farming technique that has existed in China, and elsewhere, for as long as two thousand years. It involves reducing the steepness of a slope by building structures such as earthen ridges or stone walls that divide

the slope into small flat or gently sloping sections. It has enabled rice to be grown on hillsides, where water flows downhill continuously through successive levels, flooding the paddy fields so the rice can be planted. As the plants mature, the fields are allowed to dry out. By harvest time the hillsides resemble a stairway of golden grain, as seen in Figure 2.8.3.

ACTIVITIES

Knowledge and understanding

- 1 Explain why humans have had more of an impact on biomes than any other species.
- 2 Identify the features that stand out as evidence of the impact of humans on biomes.
- 3 Describe how the forest biome has been affected by humans.
- 4 Outline the reasons why water supplies are very important to humans.
- 5 Explain how terracing enables the cultivation of steep slopes.

Applying and analysing

- 6 Study Figure 2.8.1. Rank each type of control from having the most negative impact to the least. Justify your ranking.
- 7 Study Figure 2.8.2. Create a pie graph that shows how the different ecosystems make up the world's land.

Biomes and food security

Biomes

The vegetation of biomes is vital for the survival of other species on earth, as plants are the basis of all food chains. They capture the sun's energy and through photosynthesis convert it into compounds that keep organisms alive and serve as food for others. Biomes sustain life, and humans, like other species, depend upon them for food.

Food for humans

Humans eat to live. Daily nourishment from food provides our bodies with fuel and the nutrients essential for vital body functions that maintain good health. A well-balanced diet contains vegetables, fruit, meat, fish and dairy products as well as grains such as rice, wheat, rice, nuts and seeds. Such a diet is much more diverse than that of any other animal.

Humans are omnivores, as they eat both plant and animal products. This has enabled them to live in a range of environments, many of which are very harsh.

Some humans are able to survive the extreme aridity of deserts or in the icy lands of the Arctic. They could not do this if they were unable to obtain sufficient food. The availability of food often determines the number of people that can be supported in a region. The fertile river valleys of South-East Asia support some of the highest rural population densities in the world, as the rich alluvial soil is capable of producing up to three rice crops a year—plenty of food to support plenty of people. Table 2.9.1 shows some of the food crops produced in various regions around the world.

2.9.1 Selected food crops across the world

Region	Main crops
Chinese–Japanese region	Bamboo, <i>millet</i> , mustard, orange, peach, rice, soya bean
Indochinese region	Bamboo, coconut, grapefruit, mango, <i>rice</i> , sugar cane, <i>yam</i>
Australian region	Macadamia nut
Hindustani region	Banana, bean, chickpea, citrus, cucumber, eggplant, mango, mustard, <i>rice</i> , sugar cane
Central Asian region	Apple, apricot, bean, carrot, grape, melon, onion, pea, pear, plum, <i>rye</i> , spinach, walnut, <i>wheat</i>
Near Eastern region	Almond, <i>barley</i> , fig, grape, lentil, melon, pea, pistachio, <i>rye</i> , <i>wheat</i>
Mediterranean region	Beetroot, cabbage, fava bean, grape, lettuce, <i>oats</i> , olive, radish, <i>wheat</i>
African region	Coffee, <i>millet</i> , oil, palm, okra, <i>sorghum</i> , <i>teff</i> , <i>wheat</i> , <i>yam</i>
European–Siberian region	Apple, cherry, chicory, hops, lettuce, pear
South American region	Cacao, <i>cassava</i> , groundnut, lima bean, papaya, pineapple, <i>potato</i> , squash
Central American and Mexican region	French bean, <i>maize</i> , pepper, chilli, <i>potato</i> , squash
North American region	Blueberry, sunflower

Note: Staple crops are shown in italics.

Source: FAO Corporate Document Repository, *Dimensions of Need—An Atlas of Food and Agriculture*

SPOTLIGHT

History of food production

For most of human history, people collected food from the wild by gathering fruits, nuts and seeds, or by hunting wild animals for their meat. These nomadic hunters and gatherers wandered across the land, taking advantage of food where they found it and moving elsewhere when it ran out.

About 8000 years ago, people began to grow food by planting the seeds of plants that they ate most often. Farming had begun, and with it the skills of tilling the land and nurturing crops until they could be harvested. The earliest evidence of cultivation has been found in the Middle East, where wheat and barley were sown in fields. People also began to domesticate wild animals by collecting them in herds and then breeding them.

Once a reliable food supply was secured, people were able to live in settlements (such as towns and cities) and populations thrived.

Staple foods

A staple food is one that is eaten regularly by a community or society and in such quantities so as to make it the main part of their diet. It is often eaten at every meal or each day. Staple foods vary from place to place, but usually they are easily grown in that region and so are readily available and quite cheap. Staple foods are shown in italics in Table 2.9.1. Staples are well adapted to the biophysical environment of their source regions; for example, they may be tolerant to drought or nutrient-poor

soils. Farmers rely on staple crops, as they are more resilient and therefore lower the risk of crop failure and a resulting food shortage.

Grains

Most staple foods are cereal grains, such as wheat, barley, maize, rice, rye, oats and triticale. They are all grasses and their seeds are harvested to provide grain foods that can be stored for a long period of time without spoiling. Such crops are **annuals** and their seeds must be replanted each year. Cereals are the main food for most people in the world. Rice, maize and wheat are the staples of over 4 billion people and rice feeds almost half of humanity.

Rice is usually eaten once it has been cooked as a whole grain. Most other cereals are refined; that is, they are milled or ground into a finer substance. Flour from wheat and maize are used to make bread and pasta. Maize, barley, oats and millet are often boiled for porridge or baked as flat cakes. Other staple foods include starchy root vegetables such as cassava, potatoes, yams and taro. Over a billion people in developing countries depend on roots and tubers as their staple food. Roots and tubers are especially important in Sub-Saharan Africa (see Figure 2.9.2). Although they may provide carbohydrates, they are poor in protein and nutrients.

As people drift to cities, they tend to replace roots and tubers with cereals, as these are easier to obtain. With increasing affluence, the more varied a diet becomes, the more meat and dairy products are consumed. However, one billion of the poorest people in developing countries still rely on roots and tubers.

2.9.2 What people eat

Cassava



The main staple foods in the average African diet are (in terms of energy intake) cereals (46%), roots and tubers (20%) and animal products (7%).

Bread and grains



In Western Europe, the main staples in the average diet are (in terms of energy intake) animal products (33%), cereals (26%) and roots and tubers (4%).

Traditional food crops gaining popularity

Cassava is a woody shrub that is grown in tropical and subtropical areas for its large, starchy, tuberous root. The root can be eaten only after it is carefully prepared, as it contains cyanide. It is poisonous unless it is cooked or grated and left in the open. Cassava is grown globally, as it is a very hardy plant that survives well in poor soils and can withstand drought. It has become one of the most important staples in developing countries.

Quinoa is becoming increasingly popular, notably in wealthy countries, because of its high nutrient content. It is rich in essential amino acids such as lysine, as well as iron and calcium. Quinoa is grown for its edible seeds and with improved processing it is now also made into bread.

Biomes and food production

The productivity of biomes in terms of the amount of food that can be gained from them varies greatly.

Deserts

The extreme aridity of deserts really limits land use. **Nomadic** pastoralists such as the Tuareg and the Bedouin of the Sahara survive in this inhospitable environment (where the vegetation is sparse) by moving around to find new sources of pasture for their stock.

Tundra

The extreme cold and permafrost (permanently frozen layer of the soil) of the tundra result in a very harsh environment that supports only nomadic reindeer herders such as the Nenets, shown in Figure 2.9.3, who live in northern Russia.

2.9.3 The Nenets of Siberia have migrated across their lands for thousands of years.





2.9.4 Temperate grasslands, Australia. Temperate grasslands are very productive ecosystems because their soils are so fertile.

Tropical savanna

The dry season restricts the amount of vegetation that can grow in the tropical savanna, so the land is really only suitable for grazing, and very large areas are needed to support stock. Cattle properties in the tropical north of Australia are thousands of square kilometres in size.

Tropical rainforests

Early hunter-gatherer societies managed to survive in tropical rainforests by hunting animals and birds, catching fish and collecting fruits, nuts and berries. Other groups, such as the Amerindians of the Amazon, engaged in **shifting cultivation**, clearing small patches of forest for gardens that yielded food for four to five years before abandoning them once the fertility of the soil was lost. The impoverished soils are the biggest limitation on food production in rainforests, as soils rely on decaying material from the forest above to maintain nutrient levels. Heavy rainfall leaches nutrients from the soil and also causes erosion if the vegetation is removed.

Temperate grasslands

As they overlie some of the richest soils in the world, grasslands in the temperate zone have been heavily utilised for food production. They have been ploughed up and planted with cereal crops such as wheat in the Canadian prairies and Australia, as well as pastures for beef cattle, such as those in Figure 2.9.4.

ACTIVITIES

Knowledge and understanding

- 1 Explain why the vegetation in biomes is so important to life on earth.
- 2 Outline the history of food production.
- 3 Describe a staple food.
- 4 Describe how the diet of people changes as they shift from rural to urban areas.
- 5 Explain why cassava has to be carefully prepared before eating.

Applying and analysing

- 6 Working in groups of five, prepare a newspaper headline that captures the issue of feeding the growing urban population of the world. Add a few sentences to convey the thoughts behind the headline (hint: consider how the types of food eaten change).

Investigating

- 7 Study Table 2.9.1 and do the following tasks.
 - a On an outline map of the world, add text boxes locating the different food crops in the regions shown.
 - b Select three crops from regions that you are unfamiliar with and prepare an illustrated report on how each food crop is grown and prepared for consumption.

Global pattern of agriculture

Importance of agriculture

Agriculture sustains people. It remains a way of life for many and a daily struggle for some. Even those living in urban-industrial societies, far removed from the agricultural environment, depend on the food surplus it generates. Today, agriculture remains one of the most important economic activities in the world, as it has done through most of recorded history.

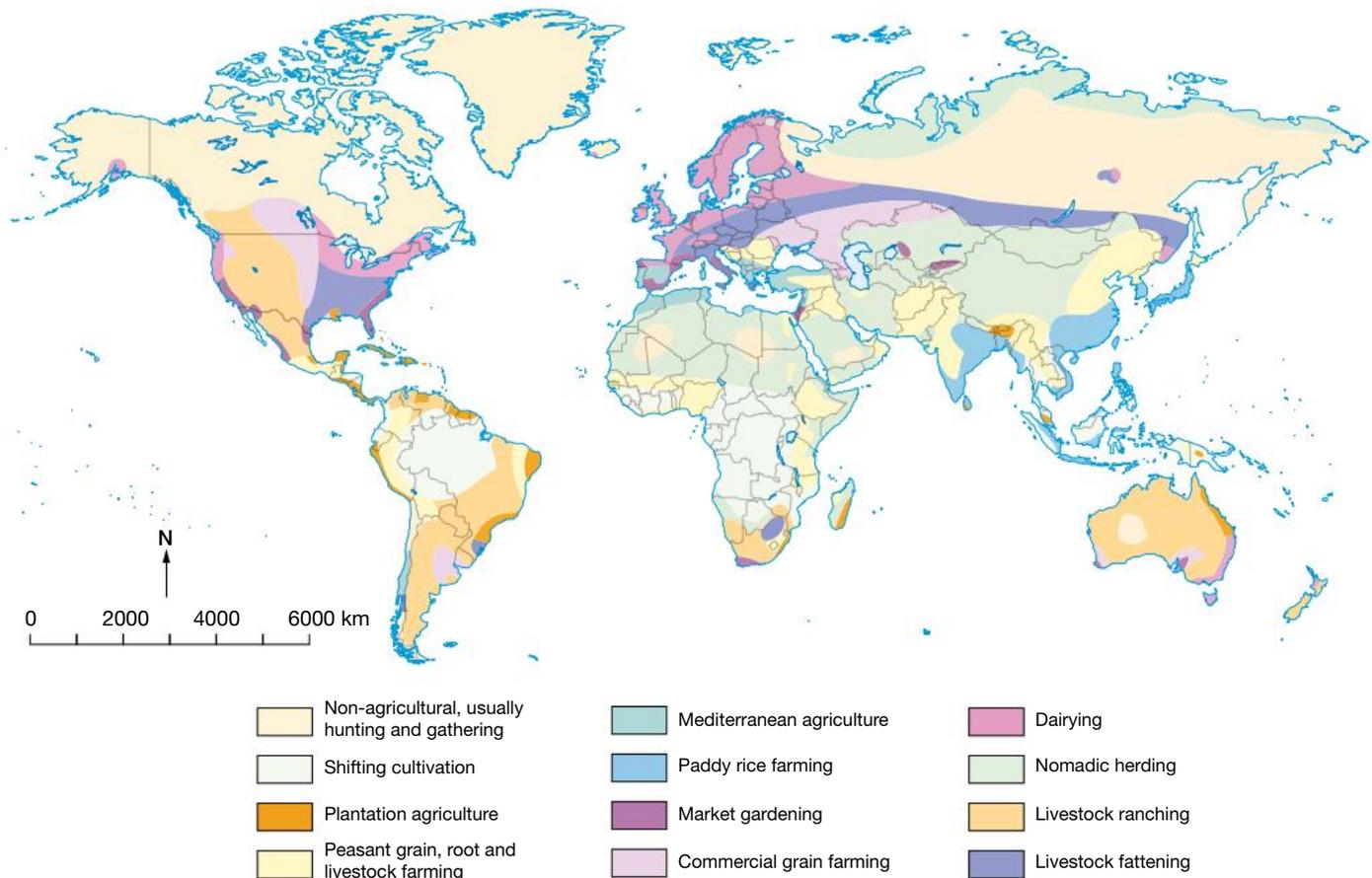
Development of agriculture

Humans are believed to have been on earth for somewhere between 90 000 and 195 000 years. For most of that time they survived by hunting and gathering. Eventually, however, they learnt how to grow and breed plants and animals that could nourish them. People were then able to settle in one place, secure in the knowledge that they would have enough to eat.

By the seventeenth century, **commercial agriculture** emerged in Europe, and profit became the motive for production of food and fibre crops. This spread to the colonies as plantations became established.

As population levels rose, more food was needed and, increasingly, the earth's surface became transformed by agriculture. Over time, distinct global patterns of agriculture have emerged, which can be seen in Figure 2.10.1. These reflect regional variations in the biophysical environment and human interactions with it.

2.10.1 Agricultural regions of the world



Types of agriculture

Crops

Table 2.10.2 outlines how agriculture is practised across the world in growing crops.

2.10.2 Types of agriculture (crops)

Type of agriculture	Where it is practised	How it is practised
Shifting cultivation	Tropical lowlands and hills in the Americas, Africa and South-East Asia	Essentially a land rotation system. Small patches of rainforest are cleared and when the vegetation has dried, it is burnt (hence known as 'slash-and-burn' agriculture). Farmers use digging sticks to plant a variety of crops (taller plants protecting lower, more fragile ones from the tropical downpours). No fertiliser applied and little tending of plants until harvest. Same clearing only used for 4 to 5 years until soils lose fertility. Plot is abandoned for 10 to 20 years.
Plantation agriculture	Tropical and subtropical regions of the Americas and South-East Asia. Today the greatest concentration is in the American tropics.	A huge landholding devoted to specialised, large-scale production. Used to rely on large amounts of labour (most workers living on the plantation), but now many are mechanised. Started in colonial times as Europeans sought spices, tobacco, cotton and rubber. Today coffee, tea, sugar cane and bananas are the main crops.
Peasant grain, root and livestock farming	Colder, drier Asiatic farming regions, river valleys of the Middle East, parts of Europe and Africa, mountain highlands of Latin America and New Guinea.	Based on grains such as wheat, barley, maize and millet. Some cash crops such as flax, hemp, coffee and tobacco are grown. Livestock such as cattle, sheep and pigs raised for milk, meat and wool. Llamas and alpacas raised in South America.
Mediterranean agriculture	Regions bordering the Mediterranean Sea and in Chile.	Based on grains such as wheat, barley, maize and millet. A few areas still practise the traditional system of wheat and barley production, with sheep and goat herding on rocky slopes. Drought-resistant vine and tree crops grown: grapes, olives and figs. Irrigation has led to expansion of citrus fruits.
Paddy rice farming	Humid tropical and subtropical parts of Asia, monsoon coasts of India, hills of south-eastern China, warmer parts of Japan.	Tiny, mud-dyked, flooded rice fields, many perched on terraced hillsides. Draught animals such as water buffalo used to plough the fields. Mechanised in Japan. Small sprouts carefully transplanted by hand from seedbeds to paddy fields. Large amounts of organic fertiliser used (more recently, chemical fertiliser). Double and triple cropping on same parcels of land (2 to 3 crops a year).
Market gardening	Located on fertile land in developed countries, usually close to large cities.	Specialises in intensively cultivated non-tropical fruits, vegetables and vines such as grapes (no livestock). All produce sold.
Commercial grain farming	Wheat belts stretch through Australia, America's Great Plains region, the steppes of the Ukraine and the pampas of Argentina.	Market-oriented type of agriculture. Farmers grow wheat or, less frequently, rice or corn. Large properties in excess of 400 hectares. Agribusiness involvement—huge corporations. Highly mechanised. Uses agrichemicals such as fertilisers, pesticides and herbicides, as well as hybrid seeds.



2.10.3 Shifting cultivation, Suriname. The area of rainforest cleared for cultivation can be seen.

2.10.4 Types of agriculture (animals)

Type of agriculture	Where it is practised	How it is practised
Dairying	Large dairy belts in the United States of America from New England to the upper Midwest, Western and northern Europe, south-eastern Australia and northern New Zealand.	Generally found close to markets—large cities. Farmers use pastures and fodder crops (such as hay). New Zealand produces butter and cheese, as it is a long way from markets. Large feedlot systems on the fringes of large cities are common in the USA.
Nomadic herding	The deserts, steppes and savannas of Africa, Arabia and the interior of Eurasia.	Graze cattle, sheep, goats and camels. Continually move stock in search of feed. Some migrate to mountains in summer. Only survives in remote areas and may soon completely vanish.
Livestock ranching	Interior of North America, Brazil and northern Australia.	Ranchers run stock on huge properties on vast grasslands. Cattle are sold for meat or exported live.
Livestock fattening	Corn belt of the mid-western United States of America, Europe, Australia, Brazil and South Africa.	Farmers grow fodder crops and raise/fatten cattle and pigs for sale. Maize and soybeans are used as feed in the USA; oats and potatoes in Europe. Feedlots have become common in the USA and Australia.

Animals

Table 2.10.4 outlines how agriculture is practised across the world in raising animals.

Traditional agriculture

Despite the global dominance of commercial agriculture today, some forms of **traditional agriculture** continue. In many developing countries, traditional agriculture is practised by 2.7 billion people on roughly three-quarters of the world's cultivated land. There are two main types of traditional agriculture:

- traditional subsistence agriculture—usually found in difficult environments such as tropical rainforests (see Figure 2.10.3), where it is practised by shifting cultivators, or in the tundra and the desert fringes, where the nomadic herders roam. People live off the land, relying on their own labour to produce enough food for their families. The area covered by this form of landuse is becoming smaller with deforestation in the tropics, and many nomadic herders are abandoning their traditional life.
- traditional intensive agriculture—in the more fertile areas of South-East Asia, paddy rice farming has been practised for thousands of years. This labour-intensive form of agriculture produces high-yield crops and in good seasons there may be enough produce to sell.

Industrial agriculture

Since the 1960s, there has been a staggering increase in agricultural production as a result of technological advances. This has occurred in what is known as industrial agriculture,

or the large-scale production of single crops (monocultures) or livestock in the more favourable temperate environments of developed countries. Industrial agriculture is now responsible for the production of 80 per cent of the world's food. Investments in machinery, fossil fuels, agrichemicals and irrigation water have raised yields and made profits.

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'agriculture'.
- 2 Describe the development of agriculture.
- 3 Compare traditional subsistence agriculture and traditional intensive agriculture.
- 4 Explain how industrial agriculture dominates food production today, given that it occupies only a small percentage of cultivated land.

Geographical skills

- 5 Study Figure 2.10.1 and answer the following questions.
 - a Identify the main agricultural regions of Australia and New Zealand.
 - b What two types of agriculture dominate South-East Asia?
 - c What continent has the greatest variety of agriculture in a small area?



Food and fibre production

Food security, population growth, environmental stability and economic wellbeing are all critical to our future. However, they cannot be viewed in isolation, and they cannot be considered without recognising the role of food and fibre production. We need to know where the food and fibre that sustain our lives come from, and resources are needed to produce the products we consume and use.

Food, industrial materials and fibre production are big business. The food industry is especially complex. It includes the diverse range of businesses that participate in the supply chain that provides much of the food energy consumed by the world's population. These businesses involve farmers and ranchers; processors; those involved in research and development; food processors; the transport and logistics industry; farm machinery suppliers; and the food distributors, marketers, wholesalers and retailers. Only subsistence farmers—those who survive on what they grow—fall outside the scope of the modern food industry.

Industrial materials and fibre production include commonly used products such as cotton, hemp, jute, flax and sisal. Plant fibres are used in the manufacture of textiles and paper.

In this chapter we study the human alteration of biomes to produce food, industrial materials and fibres, and the environmental effects of these alterations. We also investigate the environmental, economic and technological factors that influence agricultural yields; the environmental challenges to food production; and the capacity of the world's biomes to achieve sustainable food security.

INQUIRY QUESTIONS

- How do humans alter biomes to produce food, industrial materials and fibres, and what are the environmental effects of these alterations?
- What are the environmental, economic and technological factors that influence agricultural yields?

GLOSSARY

agribusiness	businesses collectively associated with the production, processing and distribution of agricultural products
agrochemical	a chemical used in agriculture, such as a pesticide or a fertiliser
commercial agriculture	the use of energy, water and chemicals to produce food and other agricultural products for sale
crop yield	a measurement of the amount of a crop harvested per unit of land

Green Revolution	an increase in food production, especially in developing countries, resulting from the introduction of high-yielding crop varieties and application of modern agricultural techniques
milled rice	rice from which the husk, bran and possibly even the germ layers have been removed
pore space	the space between individual soil particles

Global food and fibre production

Changes in agriculture

In the past, the types of crops and pastures grown were largely dependent on the biophysical environment, and the choices farmers made were limited. Today, however, the genetic engineering of plant species and the use of irrigation have allowed agriculture and fibre production to expand into areas once considered to be marginal.

Importance of agriculture

Agriculture sustains people. It is a way of life for many and a daily struggle for some. Even people living in urban-industrial societies, far removed from the agricultural scene, depend on the food and the fibres generated by agriculture. Today, agriculture is one of the most important economic activities in the world, as it has been through most of recorded history.

Food and fibre crops

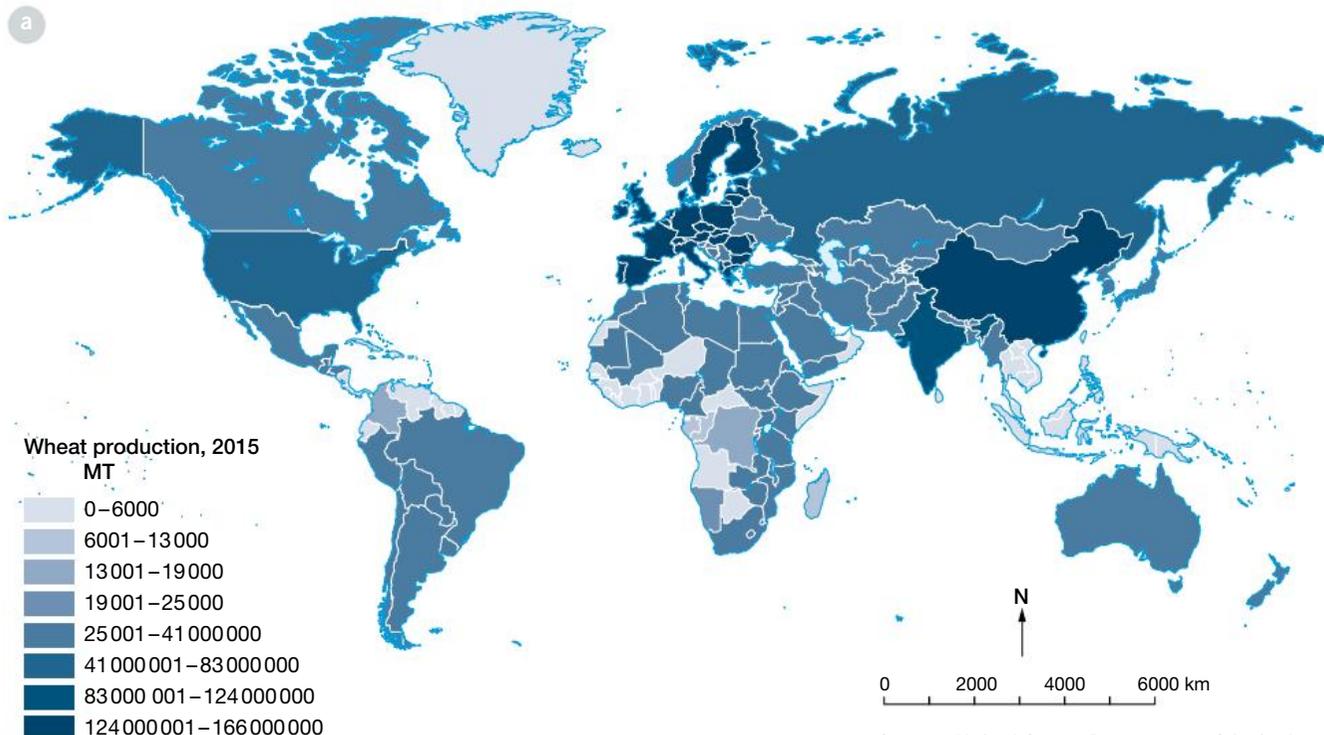
It is thought that there are 50 000 plant species on earth that people can eat. Since agriculture began, about 10 000 of these species have been used as a direct source of food or as feed for livestock that provide meat and milk. It is estimated that 90 per cent of the global energy intake is provided by just four plant species and eight terrestrial animal species. Of this 90 per cent, 60 per cent comes from just three grain crops—wheat, rice and corn. Figure 3.1.1 shows the spatial distribution of wheat, **milled rice** and corn production around the world.

Plants yielding fibres are second to food plants in terms of their worth to humans and the development of civilisation. They have been used in weaving and filling, and made into textiles (cloth) and paper.

Types of plants

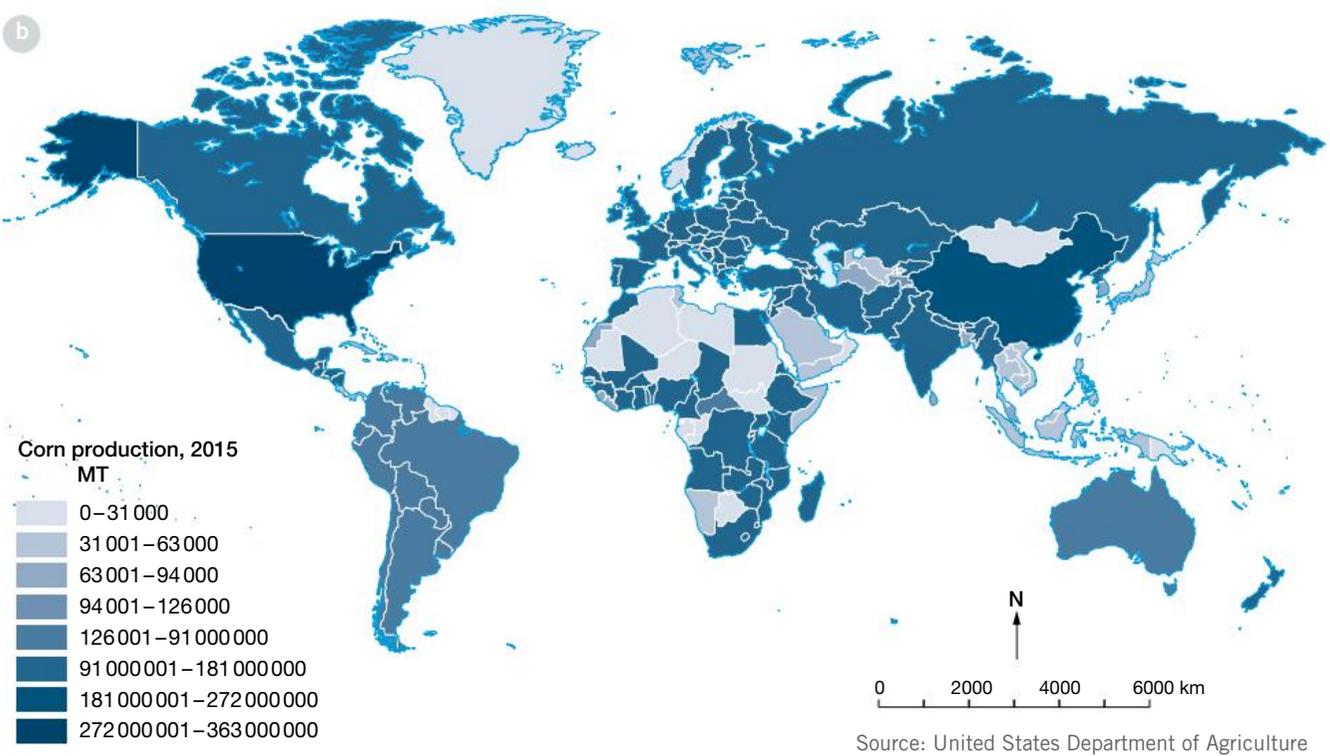
It is impossible to estimate the number of species of fibre plants, but over a thousand species have yielded fibres in America alone, and over 800 in the Philippines. Plant fibres of commercial importance are relatively few, however, most being native species used in traditional agriculture.

3.1.1 Global production of the main grain crops

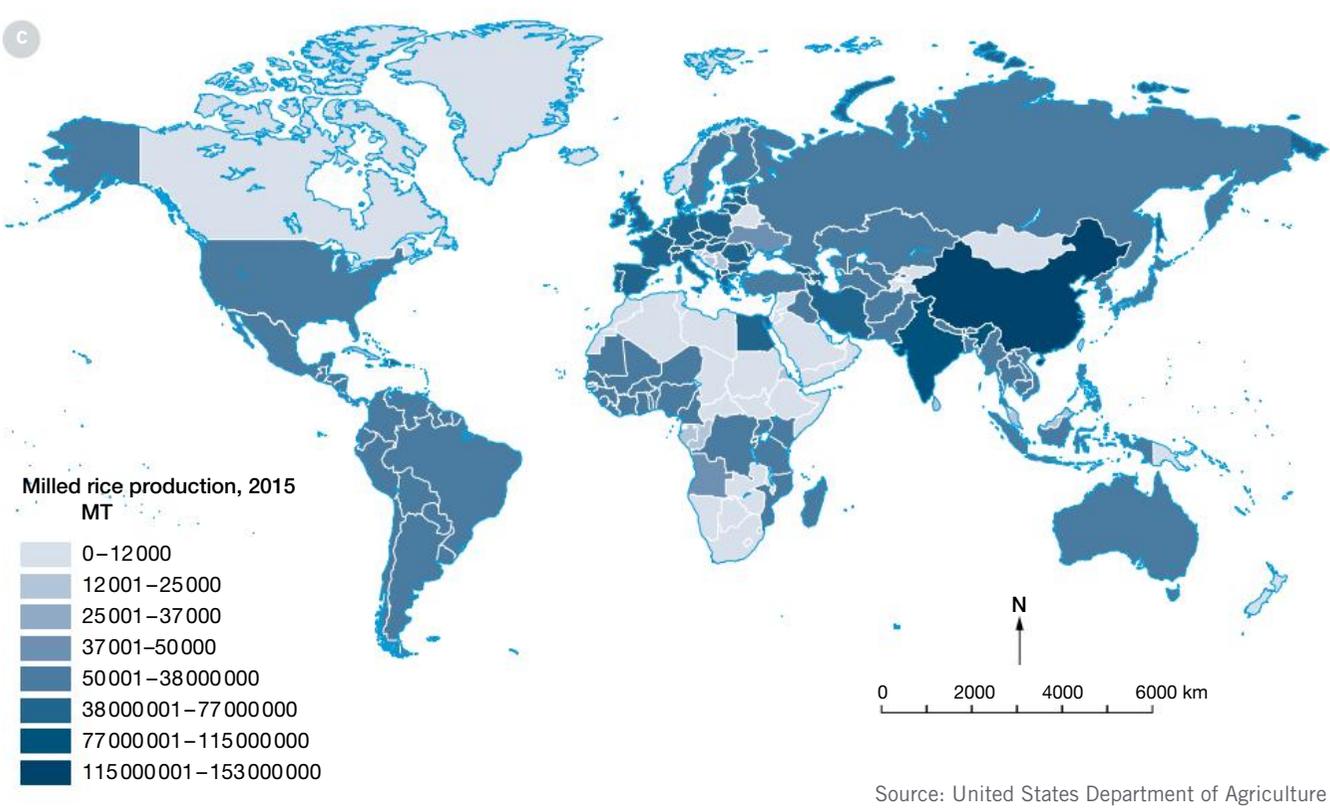


Source: United States Department of Agriculture

b



c



Global pattern of agriculture

The suitability of a region for agriculture has always been heavily dependent on the biophysical environment, as natural elements affect plant and animal growth. Crops have certain requirements, such as temperature, availability of soil moisture, soil fertility and the length of the growing season, that must be met for them to grow and flourish. Some plants are intolerant of frosts or high winds, which cause damage that reduces yields and so restricts their distribution. Table 3.1.2 outlines the climate regimes that are associated with the world's major food and fibre crops.

Agriculture is a deliberate attempt by humans to modify natural processes for their own advantage. While agriculture relies on the natural environment, human elements determine how these natural elements are organised. The level of civilisation; cultural, social and political organisation; management skills; and available technology all affect how the land is used. Distinct global patterns of agriculture have emerged which reflect regional variations in both the biophysical environment and human interactions with it.

Since the 1960s, there has been a large increase in agricultural production as a result of technological advances. This has occurred in what is known as industrial agriculture or the large-scale production of single crops (monocultures) or livestock in the more favourable temperate environments of developed countries. Industrial agriculture now produces 80 per cent of the world's food. Investments in machinery, fossil fuels, agrochemicals and irrigation water have raised yields and generated profits.

Global food production

Globally, more land is taken up for the growth of wheat than for any other grain. On average, wheat yields only 3 tonnes per hectare, whereas corn yields are generally much higher and are close to 5 tonnes per hectare. In the United States of America, corn yields in the most productive areas can exceed 10 tonnes per hectare when conditions are favourable.

Nearly half the world's grain is produced in just three countries: China, the United States of America and India. China produced an estimated 431 million tonnes of grain in 2013—compared with the United States of America's 436 million tonnes. India harvested 264 million tonnes. The countries in the European Union produced 334 million tonnes.

3.1.2 Climate regimes associated with the world's major food and fibre crops

Grain or fibre	Suitable climate
Wheat	Wheat can be grown in a wide range of climates, but is best suited to the dry, mild climates of the temperate zone, as it is susceptible to diseases such as rust that thrive in very hot, humid climates. It generally requires between 110 and 130 days from planting to harvesting. It grows best in climates with temperatures between 21°C and 24°C, with annual precipitation totals between 310 and 380 millimetres. Wheat also needs plenty of sunshine for the heads of grain to fill.
Corn	Maize can also be grown in a range of climatic conditions, so long as the night-time temperatures do not fall below 15.6°C, as it stops growing then. It cannot survive frost at any stage of its growth. So corn is a crop that loves warm weather, where the mean summer temperature is above 23°C. It thrives in bright sunshine. It also needs at least 600 millimetres of precipitation annually, as inadequate soil moisture results in poor yields because of shrivelled grains.
Rice	Rice is best suited to regions that experience high temperatures and prolonged sunshine. The optimum average temperature during its life cycle is between 20°C and 38°C. While rice may be tolerant of a range of temperatures, it is very demanding of water (with both the amount and timing). It cannot be grown successfully if the annual total precipitation is below 1000 millimetres and during the growing season 125 millimetres is needed each month. Once ripening of the rice is underway, dry weather should prevail until harvesting.
Oilseeds	Palm oil is grown in hot, wet tropical climates, where temperatures remain around 26°C all year and between 1700 millimetres and 3000 millimetres of precipitation falls annually.
	Soybeans grow best in climates with hot summers where mean temperatures range between 20°C and 30°C, and only need between 500 and 600 millimetres of annual precipitation.
	Olive oil is suited to the Mediterranean climate of long, hot, dry summers, where monthly average temperatures are above 26°C. The winters are mild and annual average precipitation is between 250 and 430 millimetres.
Cotton	Cotton is a warm-climate crop, requiring temperatures between 11°C and 25°C and 6 months free of frost. Throughout the plant's growing period it needs between 600 and 1200 millimetres of precipitation, followed by dry weather and abundant sunshine while the crop matures.
Wool	Fine wool sheep are raised in arid and semi-arid climates where the annual rainfall totals are very low, whereas long-wool breeds are suited to the cool, wet climates, where up to 1600 millimetres of precipitation is received annually.
Silk	The mulberry trees that support sericulture (silk farming) can be grown in a range of climates from cool temperate to subtropical where there is ample rainfall.



3.1.3 Bales of wool, ready for export. The wool trade continues to be important to the Australian economy.

Global fibre production

Cotton is produced in many parts of the world, the largest growers being China, India and the United States of America. Australia is the leading global producer of wool (see Figure 3.1.3), although China has more sheep.

The history of production and trade

By the seventeenth century **commercial agriculture** emerged in Europe and profit became the motive for production of food and fibre crops. Commercial agricultural practices spread to the colonies as plantations became established. During the colonial era an extractive relationship developed between wealthy nations and the rest of the world that would last for centuries, whereby the less developed nations became the suppliers of food and the raw materials that fuelled the growing wealth and power of Western capitalism. In Australia, after European settlement was firmly established, commercial agriculture began. The two main commodities were wheat and wool. These products were sent mainly back to the United Kingdom and helped make Australia a wealthy country.

During the twentieth century, production levels soared as agriculture became industrialised, supported by technological innovations and the use of agrochemicals that lifted crop yields. World trade in food and fibre products increased as multinational corporations became heavily involved in both the production and distribution of goods.

ACTIVITIES

Knowledge and understanding

- 1 Identify the factors that determine how the land in a particular region is used for agriculture.
- 2 Describe the different forms of agriculture practised today.
- 3 Explain why global trade has shifted.

Applying and analysing

- 4 Prepare an annotated visual display of the climate regimes associated with the world's major food and fibre crops.

Geographical skills

- 5 Study Figure 3.1.1 and answer the following questions.
 - a Which grain has the highest production levels?
 - b Which were the top six wheat-producing countries in 2015?
 - c How much rice was produced in Indonesia in 2015?
- 6 Create a large wall map of the world. Identify the main types of agriculture practised in each of the inhabited continents by using symbols or images. Using text boxes, account for their location.

Changing food and fibre production

Changing food production

Until 2007, the world enjoyed a surplus in food production, and food was generally freely available at relatively cheap prices for those who could afford it. The wealthy developed countries continued to dominate global trade flows. Since 2007, however, there have been quite dramatic shifts in both the production and distribution of food.

The shock of a food shortage

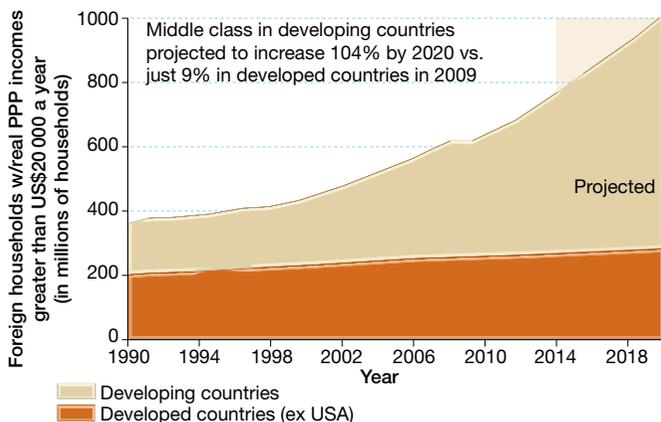
During the world food crisis of 2007–08, world grain reserves dipped to their lowest level ever, at only 54 days supply, and, as a result, prices soared. Maize doubled in price, wheat prices rose by 50 per cent and rice increased by 70 per cent. While this had an impact on food supplies across the world, the poorest people were the worst affected, especially those living in Sub-Saharan Africa, as they could not afford to pay the higher prices.

Emerging economies

Both the origin (production) and destination (consumption) of grains and oilseeds are shifting. This is in response to the accelerating demand for crops and oilseeds of one billion new middle-class consumers in countries such as China, India, South Korea, Poland and Mexico (see Figure 3.2.1).

The higher demand for grain that has resulted from increasing meat consumption and the use of biofuels is occurring at a time when productivity (or yield) is not rising as quickly. These competing demands for crops put pressure on prices, especially for corn, which is used for both animal feed and biofuel.

3.2.1 Middle-class households, 1990–2020



CAR OWNERSHIP AND MEAT CONSUMPTION

Car ownership and meat consumption are the symbols of affluence in the emerging economies. The soaring demand for these two commodities has led to rising demand for biofuels and feed crops for livestock, causing their prices to increase. As a result, more farmers are replacing food crops with biofuel and feed crops.

Continued volatility in prices

The upward pressure on food prices is largely a result of accelerating demand for grains and oilseeds, and in particular corn. The growing regions have not been able to keep up supplies and stocks have dwindled, resulting in extraordinary pressure on prices. Figure 3.2.2 illustrates the volatility of the global price of crops in comparison with their relatively stable levels of production.

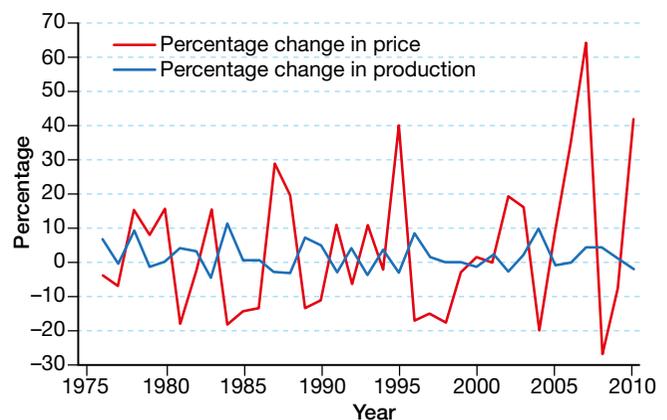
Trade in oilseeds overtakes grains

Such is the demand for oilseeds to feed livestock and for use in the production of processed food that the volume of oilseeds traded overtook grains for the first time in 2010–11. The total value of grain and oilseed trade flows have trebled in the last six years, from US\$70 billion to US\$210 billion, as a result of the higher prices.

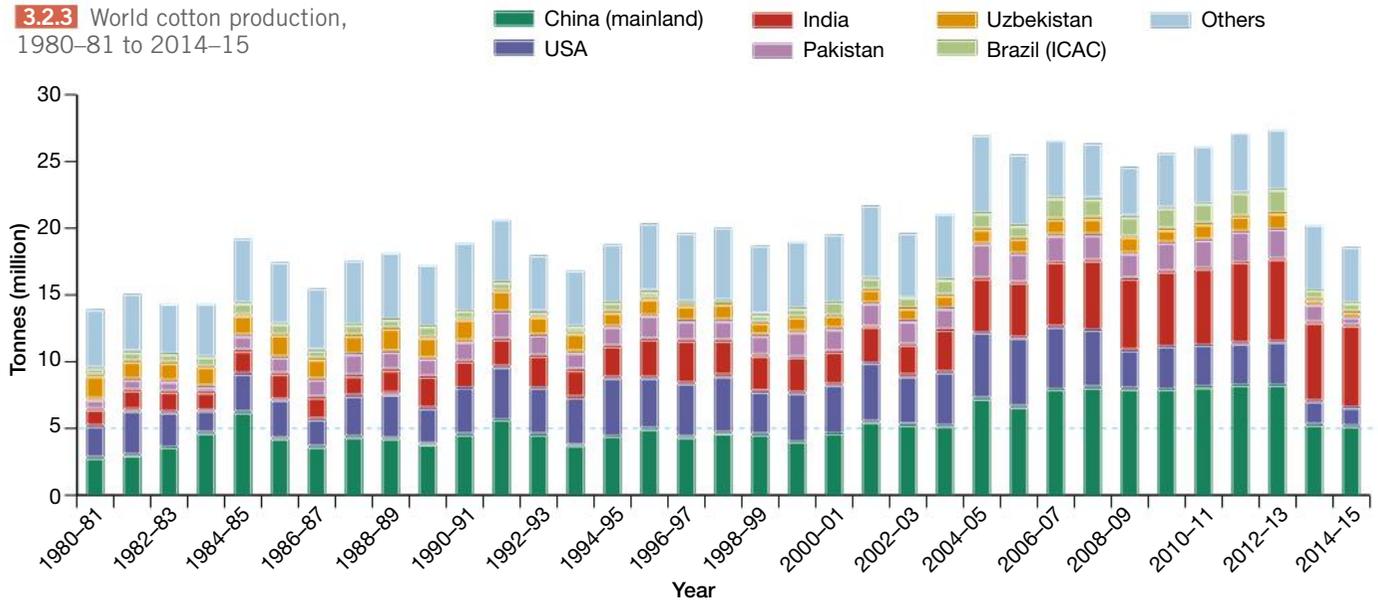
Changing fibre production

Since the 1960s, natural fibres have come under increasing competition from cheaper synthetic substitutes such as nylon and polyester. Cotton remains the most important natural fibre

3.2.2 Prices for food crops are becoming increasingly volatile.



3.2.3 World cotton production, 1980–81 to 2014–15

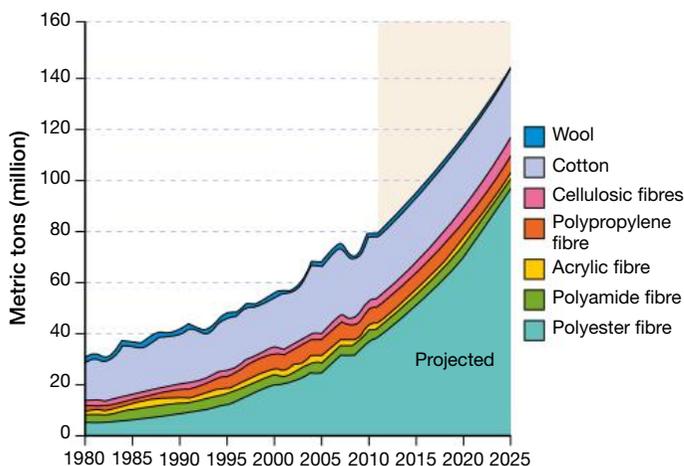


Source: UNCTAD Secretariat

and its production continues to grow, as shown in Figure 3.2.3. As the global demand for wool has declined, so too has its production. Heavier fibres such as jute, once used to make the bags to transport agricultural products, are no longer needed, as large supertankers and container ships are now used. Figure 3.2.4 shows how the increase in the use of synthetics in the clothing industry has resulted in the natural fibre industry losing much of its market share.

Synthetic fibres are popular because they are cheaper. Demand for natural fibres is increasingly correlated with income. People on higher incomes seek out the highest quality fibres such as silk and cashmere. Various trade associations promote and brand their fibres such as '100% Pure Sea Island Cotton' or 'Pure Wool'.

3.2.4 World fibre production and projected production, 1980–2025



ACTIVITIES

Knowledge and understanding

- 1 Describe what happened to the price of maize, wheat and rice during the food crisis of 2007–08.
- 2 Outline why the prices for food crops have become so volatile.

Geographical skills

- 3 Study Figure 3.2.1 then answer the following questions.
 - a What was the number of households with incomes greater than US\$20 000 a year in developed and developing countries in 1990 and 2020?
 - b Compare the growth between developed and developing countries. Suggest reasons for the difference.
- 4 Study Figure 3.2.3 and answer the following questions.
 - a Which country has consistently been the largest producer of cotton?
 - b Which country has increased its market share the most?
- 5 Study Figure 3.2.4 and outline the trends in fibre production. Suggest reasons for the change.

The agricultural trade

When agricultural trade began

With the spread of civilisation and the growth of populations, emerging societies began to look beyond their immediate regions for resources. International trade developed between societies, cultures and nations. As the world industrialised, the range and volume of products expanded, particularly during the colonial era, when the European nations secured materials for themselves.

Increasing trade flows

Populations throughout the world rely increasingly on agricultural and fibre-based products not grown within their own country. Trade has resulted because of the differences between countries that determine their ability to provide for themselves. These differences include:

- the quality of the biophysical environment: some have long growing seasons, ample fresh water and deep fertile soils, while others have to contend with arid and inhospitable terrains
- the level of economic development within a nation: this determines the quality of the workforce (in terms of health, education and skills); the infrastructure available (such as dams for irrigation and transport to move produce); and the level of research and development to provide new technologies.

As the world has become more economically integrated through globalisation, goods have flowed more freely and in greater volumes between countries. These flows are a simple transfer of products from countries with a surplus of produce to those with a deficit.

Agriculture becomes internationalised

The process of globalisation has been accompanied by unprecedented growth in trade. As multinational corporations came to control an increasing proportion of the production and distribution of agricultural and fibre-based products, both the volume and range of goods flowing around the world increased.

Large **agribusinesses** have extended their operations into many countries, taking advantage of cheap labour costs and a range of environments for different crops. They have diversified their product base by planting different types of crops, bought out competitors in numerous countries and placed the produce on the global market. The size of flows and the number of countries involved have both risen.

Technological advancements

Computers and communication technologies have enabled multinational corporations to coordinate their operations overseas. Advances in transport technologies have resulted in more goods being traded than ever before.

As 90 per cent of global trade is by sea, advances in shipping and cargo handling, such as the development of container ships and specialised bulk carriers like the one shown in Figure 3.3.1, have been central to the expansion of international trade. Refrigeration and new packaging systems, such as vacuum sealing, extend the freshness of produce and enable products to be moved great distances.

Matching consumer expectations

Rising standards of living, particularly in the emerging economies of the world, have increased the flows of meat, dairy products, feed crops for livestock and processed food. Consumers now seek affordable and fresh produce all year round. To meet their needs, multinational corporations keep agricultural products in cold storage and move them to countries where they are out of season.

PRODUCE ALL YEAR ROUND

Green asparagus is a summer crop in Australia, yet it can be found in supermarkets in the middle of winter, as it is now imported from Mexico. Like many Central and South American countries, Mexico supplies fresh fruit and vegetables to the United States of America, but it now also sends its produce as far afield as Japan.

SPOTLIGHT

Food miles are the number of miles over which a food item is transported during the journey from producer to consumer. Food miles also calculate the amount of fuel used to transport a food item. People are choosing to buy local produce to reduce their food miles and carbon footprint. There are arguments for and against buying local produce to reduce food miles.

For:

- reduces carbon footprint
- supports local producers
- promotes national food security.

Against:

- only measuring carbon dioxide ignores the other environmental impacts of food production
- damages economies reliant on food exports
- restricts eating choices.



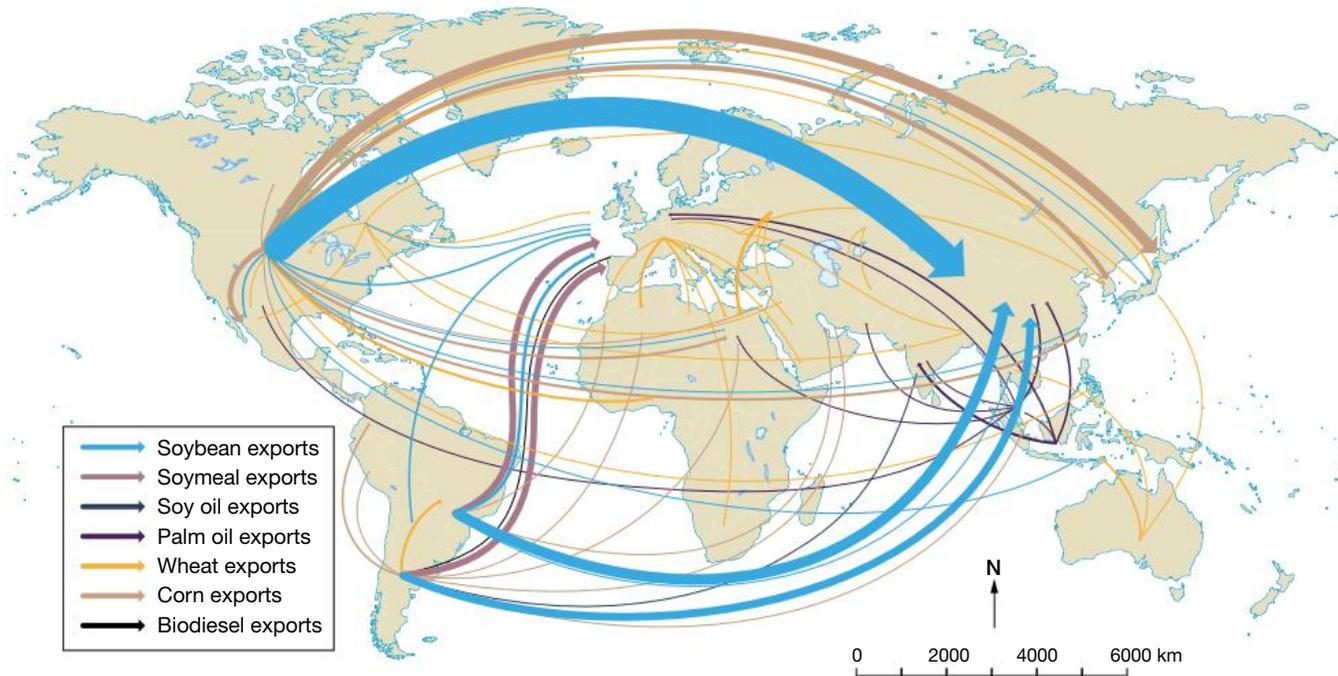
3.3.1 A specialised bulk carrier loading a cargo of grain

The pattern of flows

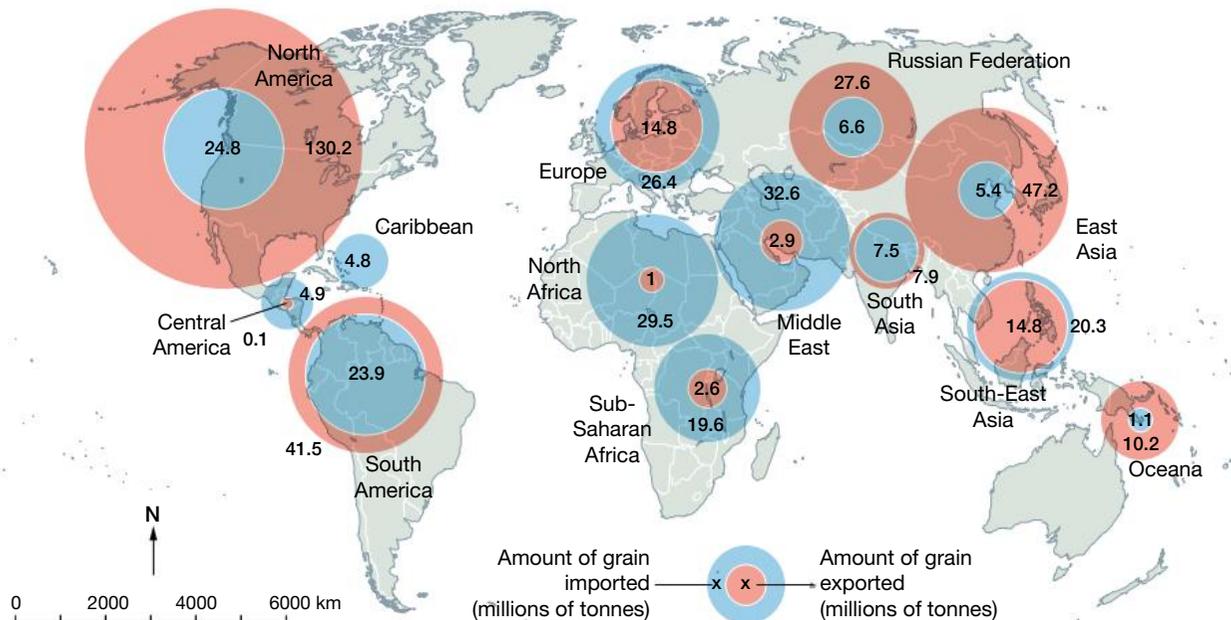
Historically, trade flows focused on the high-income countries of Europe, and they still are the recipients of a substantial proportion of trade flows, as is shown in Figure 3.3.2. However, there has been rapid economic development in Asia since 2000, and a massive expansion of exports to China. An enormous transformation is underway in the world economy and it will continue over the next 20 years.

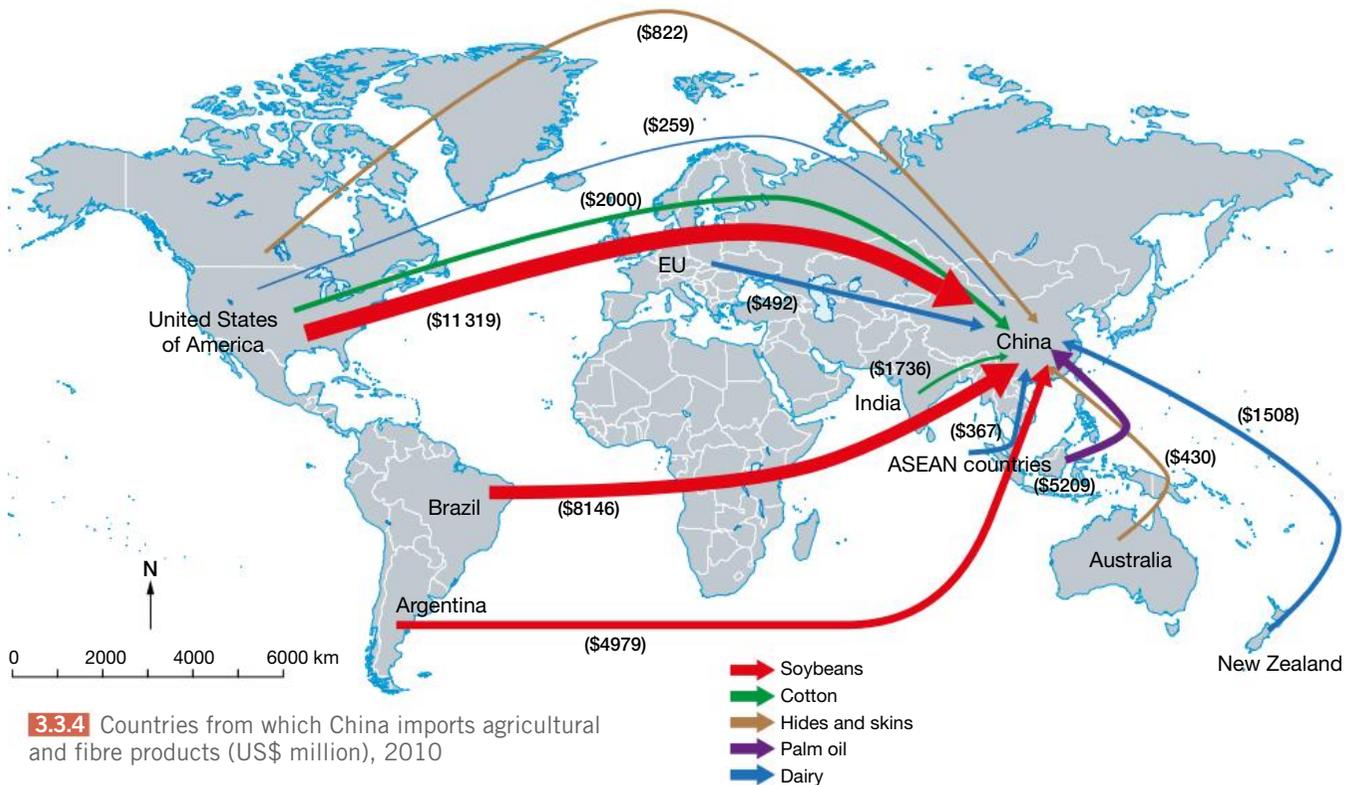
The United States of America helps feed the world, supplying about half of global grain exports, as shown in Figure 3.3.3. It is also a major exporter of cotton, the world's most commonly used natural fibre. Before 2000, Europe was its largest market, but exports to Europe have declined and agricultural trade flows have switched to middle-income countries such as China and Mexico, which now account for the largest share of US agricultural exports. China has become a major importer of agricultural products, as is illustrated in Figure 3.3.4. China is the world's largest producer, consumer and importer of cotton.

3.3.2 Global flows of grains and oilseeds



3.3.3 Global imports and exports of grain





3.3.4 Countries from which China imports agricultural and fibre products (US\$ million), 2010

SPOTLIGHT

The USA and China: The world's largest producer and consumer of soybeans

Soybeans are China's largest agricultural import. In 2011, by volume, the USA exported 60 per cent of its soybeans to China. Imports of soybean and soybean oil from Brazil and Argentina also account for the majority of agricultural trade between China and the two South American countries. In China, soybeans are typically processed into soybean meal for animal feed and cooking oil for human consumption.



3.3.5 Soybean products

ACTIVITIES

Knowledge and understanding

- 1 Explain why countries trade.
- 2 Outline how agriculture became internationalised and identify the technological advancements that accompanied this.
- 3 Describe the changing pattern of global trade flows and the role played by the United States of America and China.

Geographical skills

- 4 Study Figure 3.3.3 and answer the following questions.
 - a What region is the largest importer of grains?
 - b What continent is the smallest exporter of grains?
- 5 Study Figure 3.3.4 and do the following tasks.
 - a List the agricultural and fibre-based products that the United States of America exports to China.
 - b Where does China get its cotton imports from?

Factors affecting crop yields

Crop yields

Crop production provides food for humans, fodder for livestock and fibres used for making cloth and paper. It involves exploiting plants to produce high yields from the land on which they are grown. While nature does set limits on what can be accomplished, humans have altered the environment within which selected plants are grown. This has affected crop yields and also has implications for the future.

Measuring crop yield

Crop yield is a measure of the amount of a crop that is harvested per unit area of land and is usually expressed in tonnes per hectare. It reflects the amount of seed or grain generated by the plant. Increasing the yield of a cereal grain requires the production of more grains or larger grains on the head of the plant. Figure 3.4.1 shows heads of wheat that are densely packed with grains.



3.4.1 The heads of wheat are densely packed with grains. Increasing the size or number of the grains increases yields.

Determining crop yields

All crops require basic resources from the biophysical environment in order to grow. These are:

- solar radiation—the sun's energy provides light to plants and determines temperature regimes that are favourable for their growth
- carbon dioxide from the atmosphere
- soil water, which is contained in the **pore spaces** between soil particles

- mineral nutrients, which are dissolved in soil water
- oxygen above and below the ground
- nitrogen within the soil, which is contained in soil air.

Crop productivity depends on adequate quantities of these resources being available. They enable plants to grow and yield a successful harvest. In their endeavours to produce good, high-yielding crops, humans have manipulated this environment. They can, for example:

- determine the amount of soil water available to plants through irrigation
- improve the quality of the soil through the addition of fertilisers, increasing the availability of nutrients. Growing legumes also increases the level of nitrogen in soils, as legumes have nitrogen fixation nodules attached to their roots
- improve the supply of oxygen to plant roots by aerating soils. When soil is cultivated it turns over, and large dirt clods break down into a fine soil that is an ideal environment for seed germination.

New technologies

The adoption of new farm technologies has raised crop yields in a number of ways:

- **Mechanisation** has improved the speed and efficiency of cultivating large areas of land and harvesting the crop quickly.
- **Plant breeding** has provided new high-yielding varieties of plants that grow vigorously, are more resistant to diseases or are able to do well in a wider range of conditions.
- **Agrochemicals** have been developed to protect plants and improve growth rates. These include herbicides, pesticides, insecticides, fungicides, fertilisers and growth hormones.
- **Irrigation** has become highly sophisticated. Piezometers use soil probes to measure soil moisture and, when needed, irrigation water is applied to meet plant needs.

Maintaining high yields

The success of an agricultural enterprise in raising crop yields depends on how the crop is managed and how well the environment is protected. Some interventions in agriculture have come at a cost. If the resource base of the agricultural system is damaged through land degradation, then the practices are unsustainable and crop yields eventually fall.

3.4.2 Improved irrigation and more intelligent use of fertilisers could increase agricultural production by as much as 70 per cent.

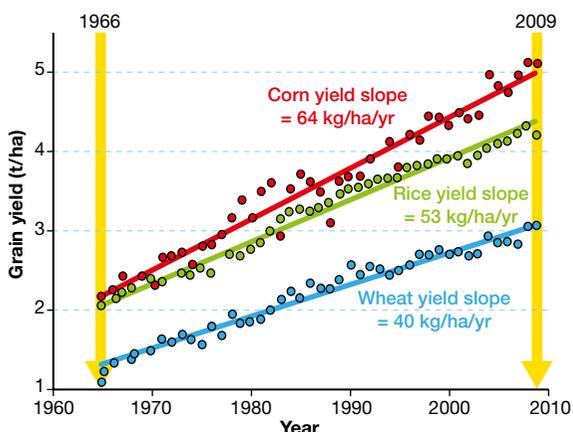


High crop yields

In the past, technology was very important in generating the growth in food output (see Figure 3.4.2). Despite this success, the world remains vulnerable to food shortages. As most suitable land is already under cultivation, the real challenge in the coming decades is to expand food production without significantly increasing the amount of land used.

There are concerns that crop yields are rising more slowly than they did some decades ago. There is an urgent need for new crop varieties that offer higher yields but use less water, fertiliser and other inputs. It is important that crops are grown in an ecologically sustainable manner to protect the resource base that supports them.

3.4.3 Grain crop yields, 1966–2009. The rate of increase in grain crop yields has fallen from 2.9 per cent of average yields in 1966 to 1.3 per cent in 2009, which is not fast enough to meet expected food demand without a large expansion of crop production area.



ACTIVITIES

Knowledge and understanding

- 1 Describe how crop yield is measured.
- 2 Outline the basic resources that crops need to grow.
- 3 Explain how new technologies have raised crop yields.

Applying and analysing

- 4 Create a mind map explaining how new technologies increased crop yields.
- 5 Demonstrate why the world is vulnerable to food shortages.

Geographical skills

- 6 Study Figure 3.4.3 and answer the following questions.
 - a Which crop has had the greatest increase in yield over the period from 1966 to 2009?
 - b What was the yield for corn, rice and wheat in 1980?

Investigating

- 7 Select a food crop to investigate and prepare an annotated visual display of its specific resource requirements.

Environmental factors affecting crop yields

Constraints within the biophysical environment

Most of the crops we rely on have quite specific environmental requirements for growth and performance. Increasingly though, other influences, which of course include humans, are affecting the actual yields realised. This is especially important when global food security may be put at risk. Crops rely on the air above and the soil below to grow and prosper.

Aerial environment

Crops extend their stalks and leaves up into the atmosphere, taking in carbon dioxide and oxygen, and trapping solar energy. Temperature and precipitation are both very important and determine the types of crops that can be grown within a region. Most crops have a certain temperature and precipitation regime within which they grow well.

Soil environment

The roots of plants anchor them into the ground and also provide the means by which they absorb water, mineral nutrients and oxygen. The type and condition of soils can place significant restrictions on the productivity of crops. The nutrient level, water-holding capability and structure of soils are natural variables that either support or hinder growth. Fertile soils provide crops with all they need, but infertile soils impose limitations on growth and development.

Topography

The shape of the land surface can also restrict land use, and is often related to soil type. Slope generally determines if the land can be cultivated safely. The most arable land, suitable for unrestricted agricultural use, is usually found on flat valley bottoms or plains where soils are deep and fertile. Typically, such areas are used to produce high-yielding crops such as those shown in Figure 3.5.1. Steep slopes and ridge tops are unsuitable for cultivation as they have thin, stony soils and are an erosion hazard if the land is disturbed. Terracing is one method people have developed to turn steep sloping land into crop-supporting land.



3.5.1 The fertile Canterbury Plains of New Zealand

Inputs from the human environment

Historically, the major increases in crop yields have taken place as humans have intervened to overcome the physical limitations on crop production.

Technology has been particularly important in generating the growth in the output of food and it has brought about an intensification of agriculture. Conventional crop-breeding techniques have led to genetic engineering. New strains of high-yielding crops have been developed. Large inputs of agrochemicals and irrigation have been used to maintain these yields.

Economic and cultural constraints

While the feasibility of growing a crop in a particular area is determined by the suitability of the biophysical environment, the actual choice of a crop type is based on economic and cultural factors.

The choice between crops being grown for commercial purposes depends on the perceived profit to be made. This is dependent on price stability, which will determine the return on production; the cost of inputs such as agrochemicals, machinery, storage and transport; and distance to the market.

3.5.2 Cultivation of marginal land in Sub-Saharan Africa. Crop yields are very low in a difficult biophysical environment and the land can become unproductive if it is overexploited.



In some developing nations, culture exerts a strong influence over agriculture. Rules of inheritance and gender inequality are the core determinants of access to the land for farming, and women are generally disadvantaged.

Pressures from humans

The push for higher yields in resource-intensive agriculture has resulted in environmental degradation in some areas. Erosion, the contamination of soil and water by agrochemicals, and the depletion of surface and groundwater supplies have resulted from unsustainable land practices and must be addressed. Population pressure and overexploitation of the land in poor nations also limit improvements in agricultural production. In their desperation to feed their families, people overuse marginal land—and the damage can be irreversible (see Figure 3.5.2).

DID YOU KNOW?

The environment is the total surroundings. It includes the living and non-living features of the natural world as well as all those features that are created or altered by humans.

ACTIVITIES

Knowledge and understanding

- 1 Outline the constraints that the biophysical environment places on crop production.
- 2 Assess the importance of technology in raising crop yields.
- 3 Identify the pressures people put on the land that then affect crop productivity.

Applying and analysing

- 4 Study Figure 3.5.2. Brainstorm and list the circumstances under which people might be forced to exploit the land even when they know that what they do is unsustainable.

Geographical skills

- 5 Study Figure 3.5.1 and draw an annotated photo sketch. Highlight the relationship between topography and landuse in the region.

Climate and crop yields

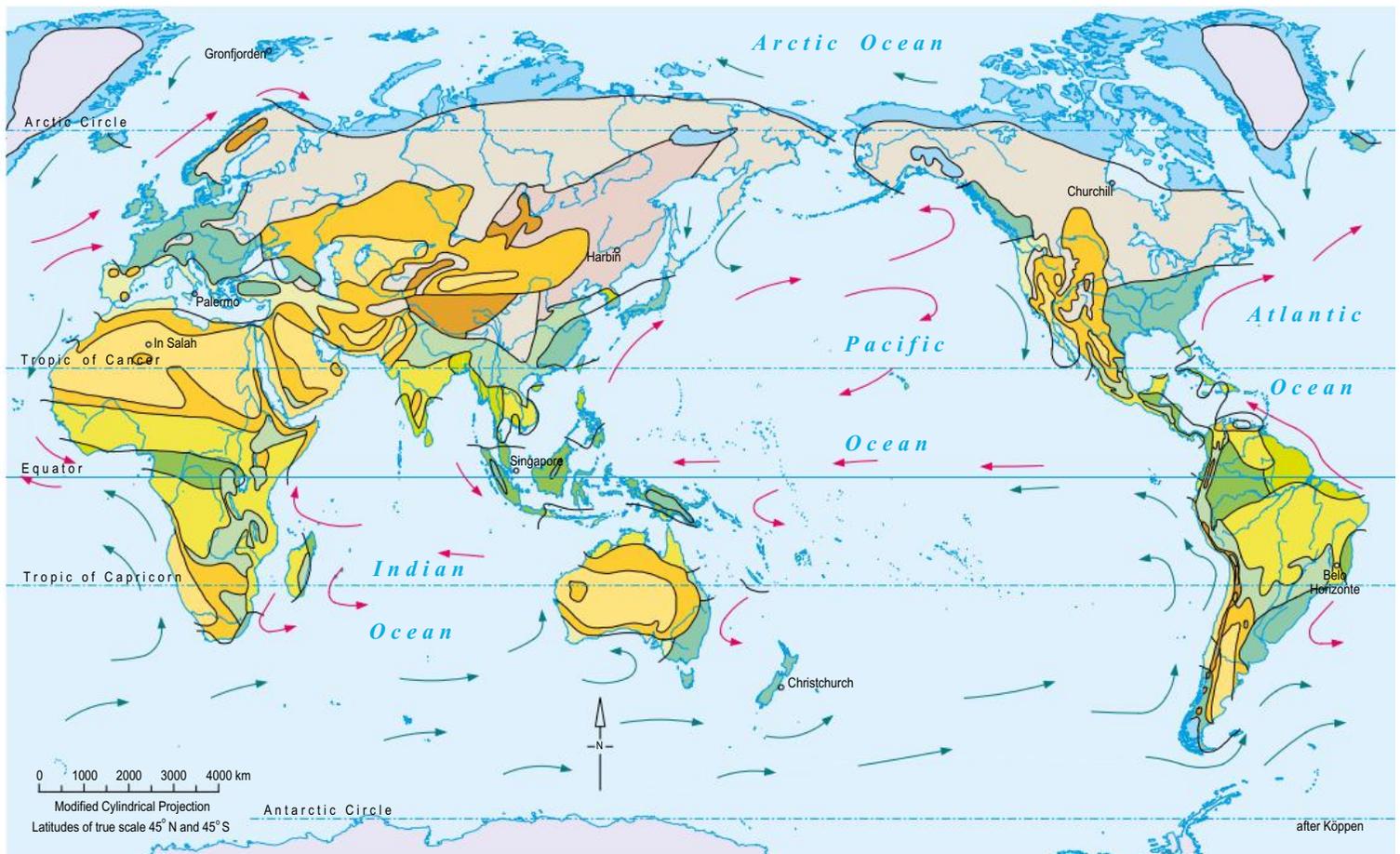
Climate

Climate is the most important factor in determining the viability of cropping and grazing. Most crops are suited to certain regimes of temperature and rainfall in which their seeds germinate and subsequent growth produces the desired grains and fibres. The actual yield of a crop at harvest reflects the seasonal conditions that have been experienced while the crop has been growing.

Climate and crop choice

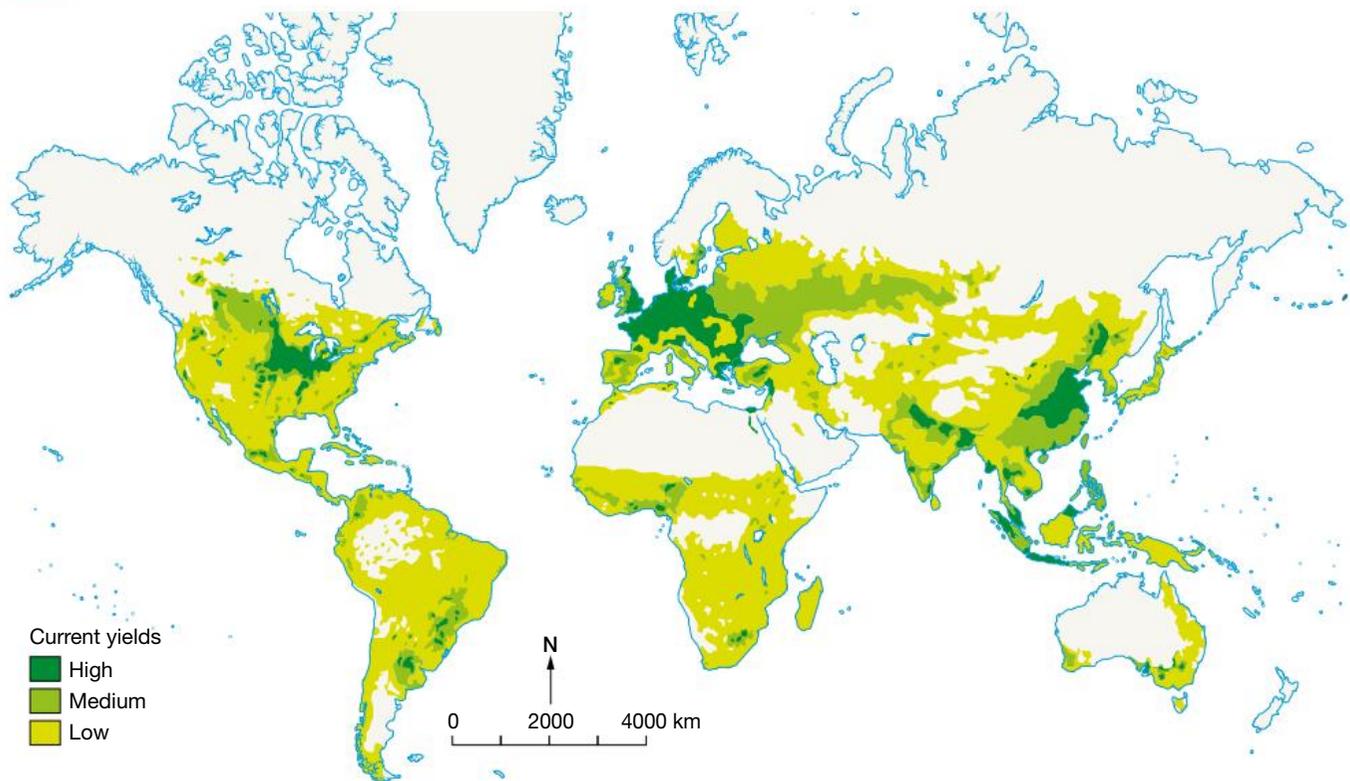
The climate experienced in any area determines the types of crops that can be grown there. Crops vary in their yields and these differences closely reflect the growing conditions found within the various climate belts across the world (see Figures 3.6.1 and 3.6.2). The key climate variables are the temperature and precipitation ranges to which some crop types have quite specific tolerances.

3.6.1 World climates



- | | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|  Hot and rainy all year |  Warm to mild months, wet all year |  Cold most months with a short summer |
|  Hot and rainy most of the year |  Warm to mild months, dry in winter |  Cold all year |
|  Hot all year, rainy most months but with a definite dry season |  Hot dry summer, mild wet winter |  Climate strongly affected by altitude |
|  Hot and mostly dry all year; unreliable rainfall |  Warm to mild summer, cool to cold winter; wet all year |  Cold ocean current |
|  Hot and dry all year; unreliable rainfall |  Warm to mild summer, cool to cold and dry winter |  Warm ocean current |

3.6.2 Global crop yields



Temperature

The limits for crops being introduced to any region are set by a number of factors.

- **Daily maximum and minimum temperatures** Wheat tolerates temperatures as low as 3°C and up to 32°C. Corn, however, is a warm-climate crop and its ideal temperature for germination is 21°C. It is frost sensitive, but can withstand temperatures up to 40°C. Rice also requires high temperatures from 21°C to 37°C throughout the lifespan of the crop.
- **Soil temperature** This is crucial for many of the processes that enable seeds to germinate and crops to grow and mature. Adequate heat is necessary to support the billions of micro-organisms active in the soil. If the soil water freezes it then becomes unavailable to plants, as it cannot move into the roots.
- **The length of the growing season** This is set by the number of frost-free days from the last frost of spring to the first frost of autumn. This is usually the amount of time required for a crop to complete its life cycle and produce an economic yield. Cotton, for example, needs 200 days to be ready for harvest, so it cannot survive in a cold climate.

DID YOU KNOW?

Rice is the main crop in the tropics because it requires both consistently high temperatures and substantial rainfall. It is particularly high-yielding as three crops can be grown in a year.

SPOTLIGHT

Harvested when frozen

Icewine is an intensely sweet and very expensive dessert wine that is produced from grapes grown in the cool climate of southern Canada. The grapes stay on the vine and become dehydrated, which intensifies their flavour. The moment they freeze they are harvested by hand, usually when the temperature reaches -13°C.



3.6.3 The grapes must be just frozen through before they are picked to make icewine.

3.6.4 Excessively high and low temperatures hinder crop yields.

Excessively high temperatures	Excessively low temperatures
Increases the rate of evaporation of soil moisture.	Results in poor growth and low yields because photosynthesis is slowed down.
Increases the rate of transpiration from the leaf pores of plants.	Causes the plant to go into dormancy; that is, it stops growing because plant processes shut down.
Causes the plants, leaves and stems to droop or wilt and halts the growth of new shoots.	Reduces the germination of seeds.
Can cause the pollen to become unviable and so flowers do not grow, which means that there will be no seed or grain to harvest.	Kills the flowers, which also stops seed and grain being produced. If frosts hit plants that have just flowered, they can wipe out the entire crop for a season.
Can kill the plant as it frizzles up.	Causes death of many plants if temperatures drop below zero. When the water freezes, it expands, which can kill the plant tissue by tearing its cell membranes. Plants often turn black after they have been hit by a frost overnight.

TEMPERATURE EXTREMES

Temperatures are especially important for crop production and any extremes that are experienced can have an undesirable effect on crop yields, as is shown in Table 3.6.4. Crops are influenced by temperature in the following ways.

- Their growth depends on the combined processes of photosynthesis and respiration, which increase with temperature. For example, the rate at which photosynthesis occurs in corn increases until the temperature reaches 30°C, and then it levels off, even if the temperature increases further.
- Optimum temperatures mark the upper and lower limits at which a crop performs best. This is where they accumulate the maximum amount of dry matter in the form of cereal grains or fibres.
- Adequate night-time temperatures must be maintained to enable the growth of new shoots on the plants.
- Temperature affects the amount of water a crop needs to stay alive and function properly. On hot days, crops need more water to sustain plant processes.

Precipitation

Without water, crops cannot grow. Given that they are 85 per cent water, it is easy to understand the importance of rainfall to crop growth. The individual water requirements of the main food and fibre crops are shown in Table 3.6.6.

The lack of water is a major constraint on productivity in much of the world's arable lands. If rainfall is inadequate, water must be supplied to crops from other sources, such as irrigation water. Too much water is also not good for many crops, especially when the soil becomes saturated. When this happens, all the pore spaces in the soil fill with water and there is no air available. Rice is the only crop that demands such conditions; it is grown in flooded paddy fields.



3.6.5 Drones are increasingly being used in agriculture to monitor crops and manage water use.

Seasonal variations

While climate largely determines crop choice, more than 50 per cent of the variation in crop yields is determined by seasonal variations in the climate. Both the extremes of drought (when precipitation is insufficient to meet crop needs) and floods (when excessive precipitation drowns crops) can be disastrous. Australia often experiences the variability of seasonal rainfall.

There are increasing concerns that climate change could bring more frequent and extreme weather events that will affect crop production in the future.

3.6.6 Crop water needs and sensitivity to drought

Crop	Crop water need (mm/total growing period)	Sensitivity to drought
Alfalfa	800–1600	low–medium
Banana	1200–2200	high
Barley/oats/wheat	450–650	low–medium
Bean	300–500	medium–high
Cabbage	350–500	medium–high
Citrus	900–1200	low–medium
Cotton	700–1300	low
Maize	500–800	medium–high
Melon	400–600	medium–high
Onion	350–550	medium–high
Peanut	500–700	low–medium
Pea	350–500	medium–high
Pepper	600–900	medium–high
Potato	500–700	high
Rice (paddy)	450–700	high
Sorghum/millet	450–650	low
Soybean	450–700	low–medium
Sugar beet	550–750	low–medium
Sugar cane	1500–2500	high
Sunflower	600–1000	low–medium
Tomato	400–800	medium–high

Source: FAO

ACTIVITIES

Knowledge and understanding

- 1 Describe how temperature limits what crops can be grown in a region.
- 2 Assess the impact of temperature extremes on crop productivity.
- 3 Explain why water is crucial to crop growing.
- 4 Identify what determines the actual crop yield realised in any particular season.

Geographical skills

- 5 Study Table 3.6.6.
 - a Identify the three crops that need the most water and are the most sensitive to drought.
 - b Identify the three crops that need the least water and are the most tolerant of drought.
- 6 Study Figures 3.6.1 and 3.6.2, and Table 3.6.6, and do the following tasks.
 - a Describe and account for the crop yields across the Australian and African continents.

- b Explain why many farmers in Africa choose to grow sorghum and millet.
- c Explain why the banana and sugar cane farms in Australia are located on the east coast of Queensland and northern New South Wales.

Investigating

- 7 Research the crops that are most commonly grown in either the USA or China. Prepare a multimedia presentation identifying:
 - the choice of crops
 - where they are grown
 - the suitability of the climate to these crops
 - the productivity of these crops
 - any limitation on farming imposed by climate in parts of the country.

Significance of soils

Not just dirt

Unless you are a farmer, you probably think of soil as just dirt—something you do not want on your hands, clothes or carpet. While you are very aware of your need for air and water, you may be unaware that your life, and the lives of other living organisms, depend on soil, especially the upper layer known as topsoil.

Soil is the foundation for life on land. It provides the nutrients needed for plant growth and also sustains the animals that feed on these plants. Historically, the fertility of soils has strongly influenced the distribution and activities of people. It has determined agricultural patterns, settlement locations and the numbers of people living in an area.

The nutrients in the food you eat come from soil. Soil also provides you with wood, paper, cotton, and the many other vital materials people use on a daily basis. It also helps purify the water you drink.

As long as soil is held in place by vegetation, it stores water and releases it in a nourishing trickle instead of a devastating flood. The decomposer organisms of soils recycle the key chemicals humans and most other forms of life need. Bacteria in the soil

decompose degradable forms of rubbish you throw away. The buildings, roads, infrastructure and waste treatment plants we use are all built on and supported by soil. Soil is truly the basis of life and civilisation, as is shown in Table 3.7.1.

Soils influencing agriculture

Soil is fundamental to agriculture. Food and fibre crops, as well as pasture for the grazing of animals, depend on the nutrients and water available in soil. The suitability of soil depends on a number of characteristics, such as fertility, texture, water-holding capacity and aeration (air content).

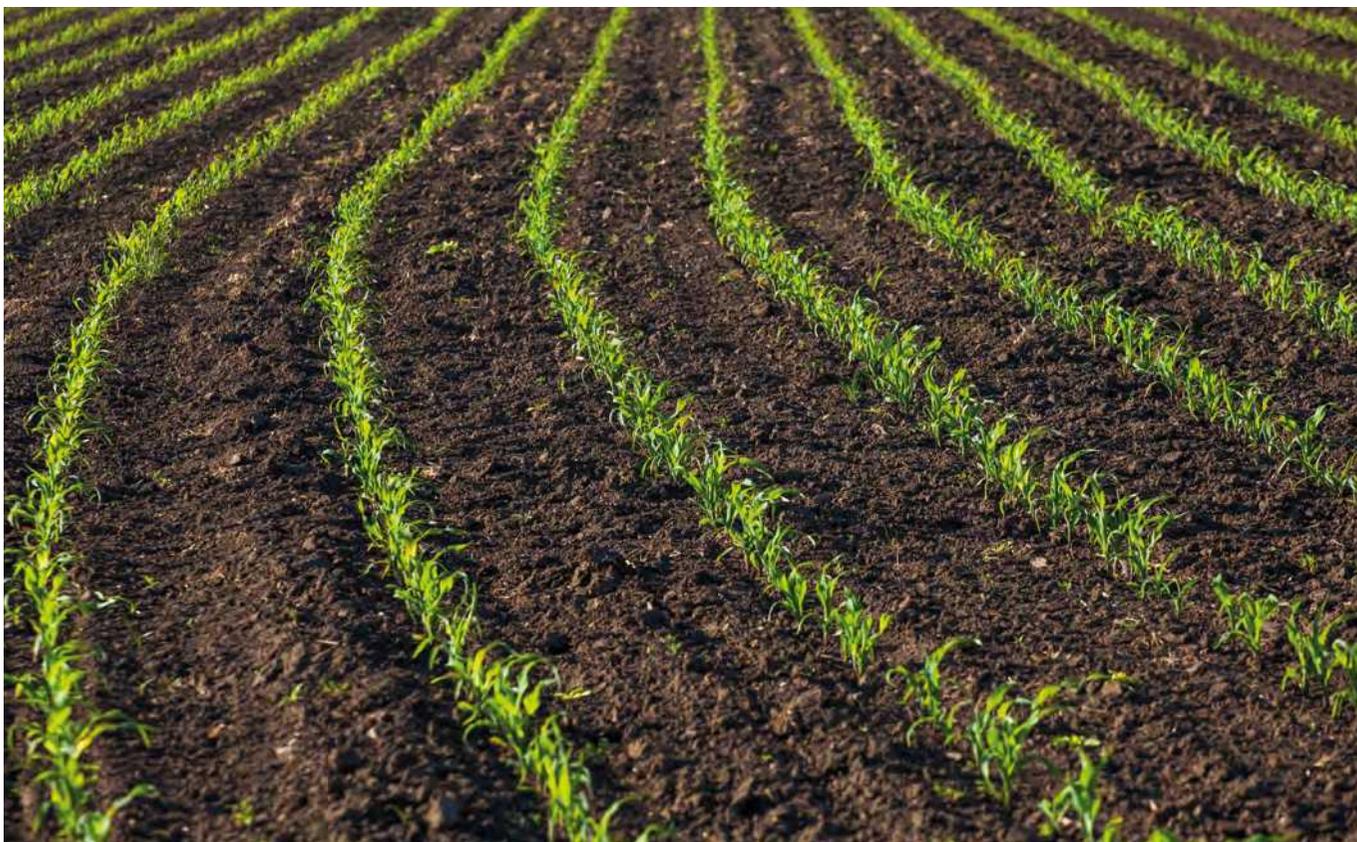
Colour

The colour of the topsoil is an indicator of how good the soil is for agriculture. If the topsoil is dark brown, then it is rich in organic matter and nutrients (see Figure 3.7.2). Most of the world's crops are grown on land that has been cleared of grasslands and deciduous forests, as these are the soils that are fertile because of their high humus content and good texture. Soils that are a pale colour or grey, yellow or red in colour are generally low in organic matter and not as fertile.

3.7.1 Importance of soil to different people

	Importance of soil to wellbeing/livelihood
Gardener	A home gardener wants to use the dirt in the yard to grow flowers, herbs, vegetables, ornamental shrubs and trees to beautify the living environment and supplement food supplies.
Farmer	A farmer is interested in the complex factors that contribute to a soil's productivity to maximise production and income from crops and livestock. Knowing the capabilities and limitations of different soils is fundamental to successful farming.
Builder	A builder uses the soil as a foundation for construction. It should provide a stable base that is free from waterlogging. Soil is also an important source of clay that is the basic material for brick making.
Engineer	An engineer is concerned with the properties of soil that will contribute to a stable, long-lasting structure that will not crack or collapse. Soil is also used as a construction material for dams and road bases.
Hydrologist	A hydrologist is involved in determining how quickly and to what extent soils will absorb rainfall after a storm event and how this water moves across a landscape.
Urban planner	Urban planners are responsible for appropriate development within an urban area that entails knowledge of soil capabilities and any problems with drainage.
Conservationist	Conservationists are bound to protect soils, as they are a fragile resource that is subject to degradation when used beyond capacity. Soil is vital for the maintenance of biodiversity above and below the ground. With much of this activity hidden from view, conservationists work to increase awareness of the importance of soil and its myriad micro-organisms in sustaining landscapes.

3.7.2 Fertile, dark-brown topsoil is highly productive.



Texture

The texture of the soil also determines its suitability for agriculture.

- Sandy soils contain large, angular sand grains that are loose and so water passes through them very easily. While the soils are light, well drained and aerated, which makes them easy to cultivate, they are not very fertile. They have little organic matter and the water quickly leaches out any minerals, so they require a lot of fertiliser to remain productive. Sandy soils tend to be used for growing vegetables and fruit. The roots of crops such as carrots find the soil easy to penetrate.
- Clay soils are the opposite to sandy soils, as nutrients cling to the tiny clay particles. Such soils are very fertile and usually high in organic matter, making them especially productive. However, if the clay content is too high, they are considered heavy soils that are hard to cultivate, especially after rain. Heavy clay soil areas are often left under permanent grass as pasture for stock.
- The best soil for agriculture is a loam, which has enough clay to retain moisture and nutrients, sufficient sand to be well drained and aerated, and enough silt to hold the clay and sand together. These fertile soils are highly favoured for food and fibre crops.

ACTIVITIES

Knowledge and understanding

- 1 Describe how soils have influenced the activities of people throughout history.
- 2 Identify the characteristics of soil that determine its suitability for agriculture.
- 3 Given that sandy soils are not very fertile, explain why they are good for growing vegetables.
- 4 State the landuse that clay soils are most suitable for.
- 5 Explain why loam soils are favoured for cropping.

Applying and analysing

- 6 Use the 'think, pair, share' strategy to complete the following statements.
 - a 'I used to think soil was just dirt ...'
 - b 'Now I think soil is ...'
- 7 Study Table 3.7.1 and the section 'Not just dirt' Make a list of all the ways your family depends on soil.

Australia's soils

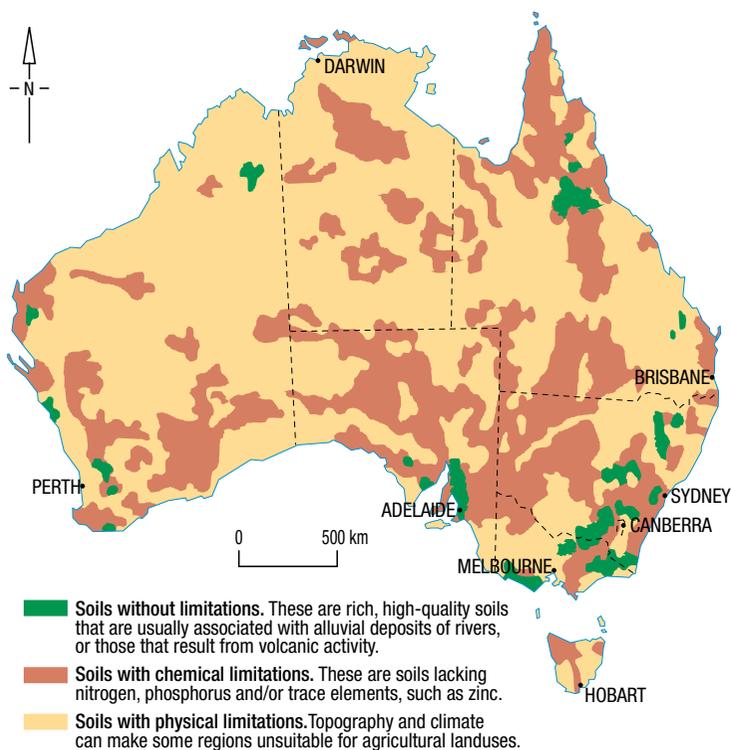
Australia's ancient soils

Australia is often described as an ancient land because it has been stable over a very long period of geological time. This means that the surface of the continent has been exposed to the processes of weathering and erosion for millions of years. As a result, the continent has one of the world's flattest and most ancient landscapes, with soils that are among the world's oldest and least fertile.

Australia's soils, shown in Figure 3.8.1, are ancient because deep chemical weathering and the leaching of the continent's ancient rocks have resulted in the loss of many minerals. When the rocks break down into sediment, the soils that result tend to lack the nutrients needed to support agriculture.

Volcanic activity, which produces new volcanic rock, from which rich volcanic soils are formed, has been largely absent from the continent. The volcanic activity that did occur millions of years ago was mainly concentrated along the eastern edge of the continent. Here it poured out basalt, which formed the basis of the rich basaltic soils found in areas along the length of the Great Dividing Range. The absence of large-scale tectonic mountain building meant that there was little erosion rapid enough to expose and transform bedrock into sediment.

3.8.1 Australian soils. Only 6 per cent of Australia's soils are suitable for agricultural industries.



Unlike Europe and North America, which have quite fertile soils, Australia was not covered by an ice sheet during the Pleistocene Ice Age (that is, 1.8 million to 11 700 years ago). Moving ice sheets grind up unweathered rock, transforming it into fertile soil. Ice sheets last covered Australia more than 300 million years ago.

Impacts of European settlement

The European settlers found the soils of Australia difficult to manage. Their knowledge of agriculture had been gained in temperate lands with deep, productive soils and predictable weather patterns. Their farming practices, which had proved highly effective in Europe, were applied in Australia. The result was the widespread degradation of the land, such as the land shown in Figure 3.8.2.

Many Australians are just beginning to realise that the degradation of their life-supporting resources of soil and water has reached a crisis point. Government authorities and community-based groups, such as Landcare and Greening Australia, are tackling the problem of land degradation through the promotion of sustainable landuse practices.

Agricultural potential of Australian soils

The potential of the land to support agriculture depends on the soil type and associated properties, especially its fertility and water-holding capacity. Areas of land with poor soils in the agricultural zone of Australian are generally left uncleared. Agriculture in Australia is supported by a great range of soils.

The arid and semi-arid expanses of the continent have ancient, very weathered and infertile soils lacking not only nutrients but also organic material and soil moisture. At best this land in northern Australia and the drier western margins of Queensland and New South Wales can only support extensive cattle grazing, as the land cannot carry much stock.

Other soils are younger, deeper and more fertile, especially the alluvial soils found in river valleys, particularly along the east coast. They are used for more intensive forms of agriculture, such as growing vegetables and fodder crops for haymaking, and dairying. The rich red volcanic soils are also very productive. In Queensland they support the growth of peanut crops, as well as sugar cane and tropical fruits.



3.8.2 The heavily eroded landscape west of Charters Towers, Queensland

The red-brown soils (which have a sandy loam topsoil over a clay subsoil) and black cracking clay soils support the wheat-growing regions of Australia, where summer crops such as sorghum, sunflowers and soybeans are also grown. Such soils

are also irrigated to grow cotton and rice. The valuable grazing lands of the tablelands that produce fine wool are mainly on red soils that are predominantly sandy and porous.

ACTIVITIES

Knowledge and understanding

- 1 Explain why Australia's soils are described as being ancient.
- 2 List the factors that contributed to the comparative infertility of Australia's soils.
- 3 Explain the impact European arrival had on Australian soils.
- 4 Outline what is now being done to address the impact that Europeans had on the land.
- 5 Identify the properties of soil that are needed to support agriculture.
- 6 Describe the range of soils that support agriculture in Australia.

Geographical skills

- 7 Study Figure 3.8.1. Describe the distribution of Australia's high-quality soils (soils without limitations).

Investigating

- 8 Select one of the following organisations involved in improving soils: Landcare or Greening Australia.
 - a Investigate the organisation and include the following information in your oral report:
 - when the organisation was established and the main aim of the organisation
 - where in Australia the organisation works
 - with whom the organisation works.
 - b Select one program and describe the work of the organisation.
 - c Evaluate the work of the organisation.

Soil erosion in Australia

Land clearing

When the British first arrived in Australia in 1788, forests covered about 10 per cent of the Australian continent. Woodlands occupied a further 23 per cent. Today, the area covered by eucalypt forests has been halved and the area of rainforest has been reduced by 75 per cent. More than 35 per cent of woodlands have been cleared or severely modified, as shown in Figure 3.9.1. The forests that remain are disappearing at a rate of 1 per cent each year. In some places, particularly south-east Queensland, the rate of land clearing exceeds that being experienced in the Amazon Basin in South America. Once the native vegetation cover is removed, the soil is exposed to the processes of erosion.

DID YOU KNOW?

Between 2000 and 2004, 1.5 million hectares of forest (which includes native and non-native vegetation) were cleared across the continent. After forest regrowth, the total loss was 287 000 hectares.

Water erosion

Figure 3.9.2 shows that the most widespread type of land degradation affecting Australia's soils is water erosion. This process involves the removal of soil particles by heavy rainfall or running water. The loss of soil is greatest in places where the vegetation cover is thinnest. Plant roots bind the soil, while leaves protect it from the impact of heavy rain. A layer of humus (leaf matter) helps to absorb rainfall and reduce the run-off that can carry away soil in small rivulets. Any sort of slope makes water erosion more severe, because water flowing downhill has enough force to dislodge more soil particles.

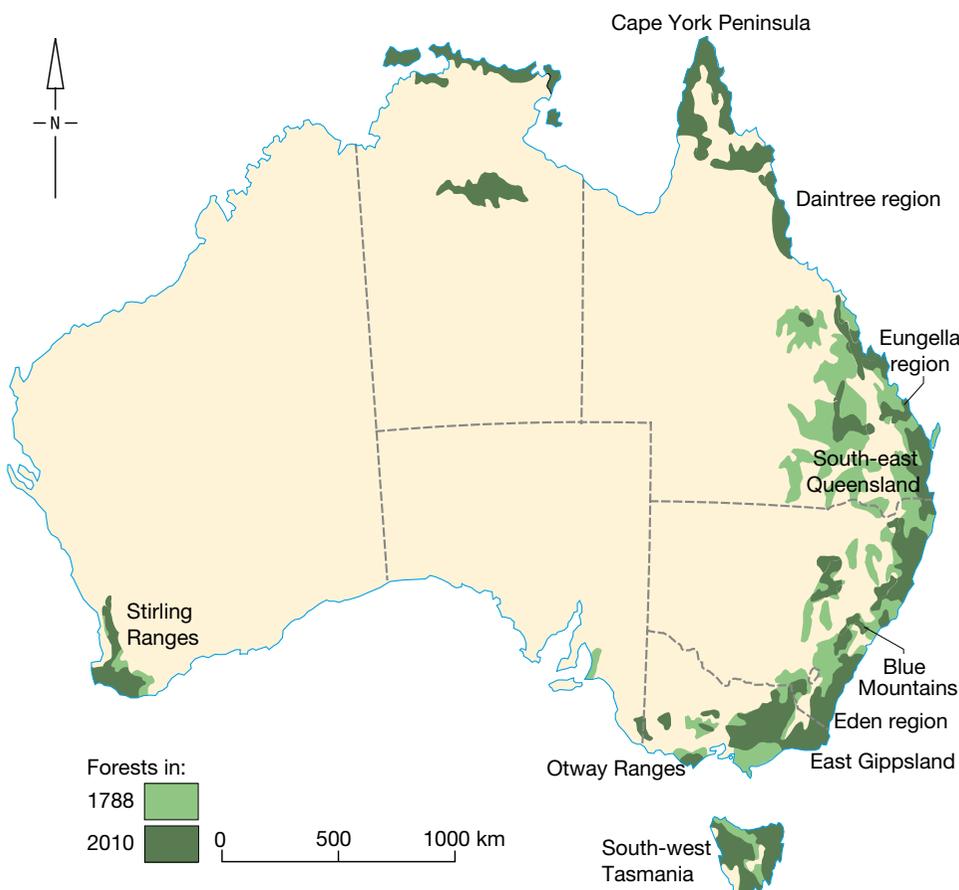
SHEET EROSION

Figure 3.9.3a shows the process of sheet erosion. Sheet erosion occurs if the water moves evenly, stripping soil across a broad front. An example of sheet erosion can be seen in Figure 3.9.4.

RILL AND GULLY EROSION

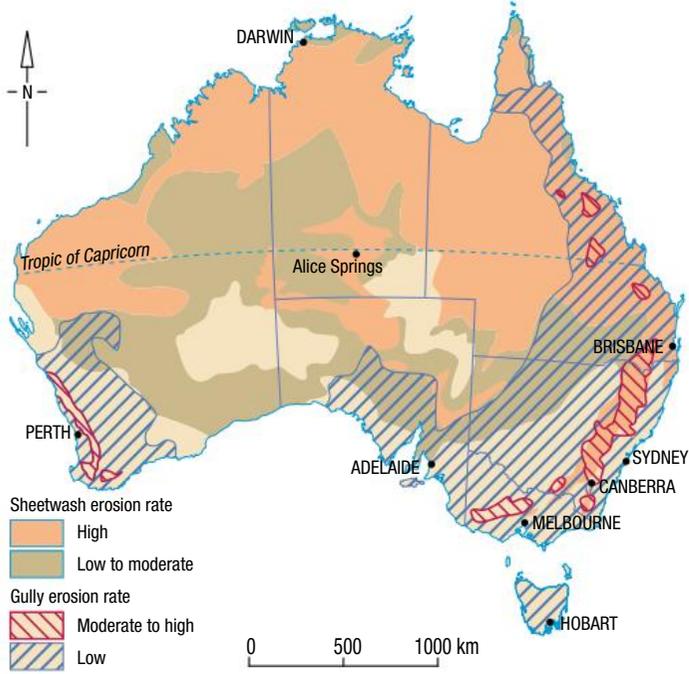
Figure 3.9.3b shows how rill and gully erosion occur. If water flows into channels or rivulets, the soil will be washed away along these lines, forming furrows or rills. This is called rill erosion. Sometimes, even larger channels (called gullies) develop. This is called gully erosion.

The eroded material will eventually be deposited elsewhere, usually at the bottom of a valley. Some is washed into river systems, where it clogs channels and increases the turbidity (muddiness) of the water. Silt may also build up in dams, shortening their useful life. Eventually, most of the eroded material enters the sea.

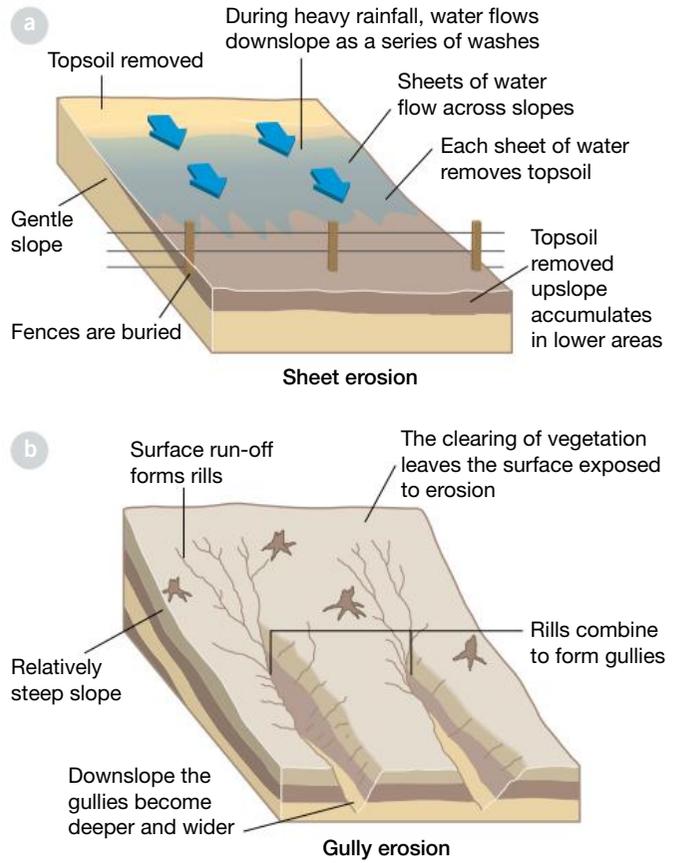


3.9.1 Australia forest cover, 1788 and 2010

3.9.2 Areas of Australia affected by water erosion



3.9.3 Sheet (a) and gully (b) erosion



3.9.4 Sheet erosion in a corn field





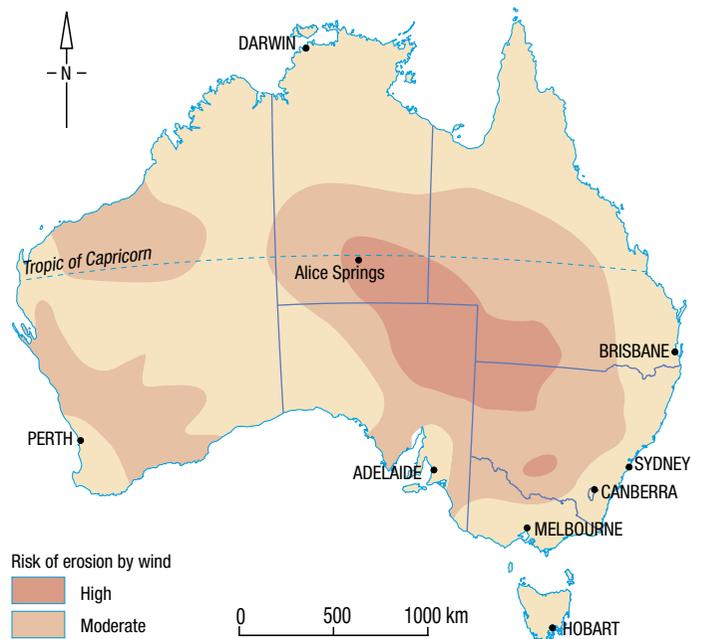
3.9.5 Dust storm at the outback town of Alice Springs, Northern Territory

Wind erosion

Wind erosion occurs when soil particles are detached from the soil surface and blown away by the wind (see Figure 3.9.5). The areas of Australia that are most affected by wind erosion are those where soils are sandy and rainfall is low. Figure 3.9.6 shows the areas of Australia that are affected by wind erosion.

DID YOU KNOW?

Every year, tens of thousands of hectares of Australian bushland are bulldozed, chained or poisoned to prepare land for forestry and agriculture.



3.9.6 Areas of Australia affected by wind erosion

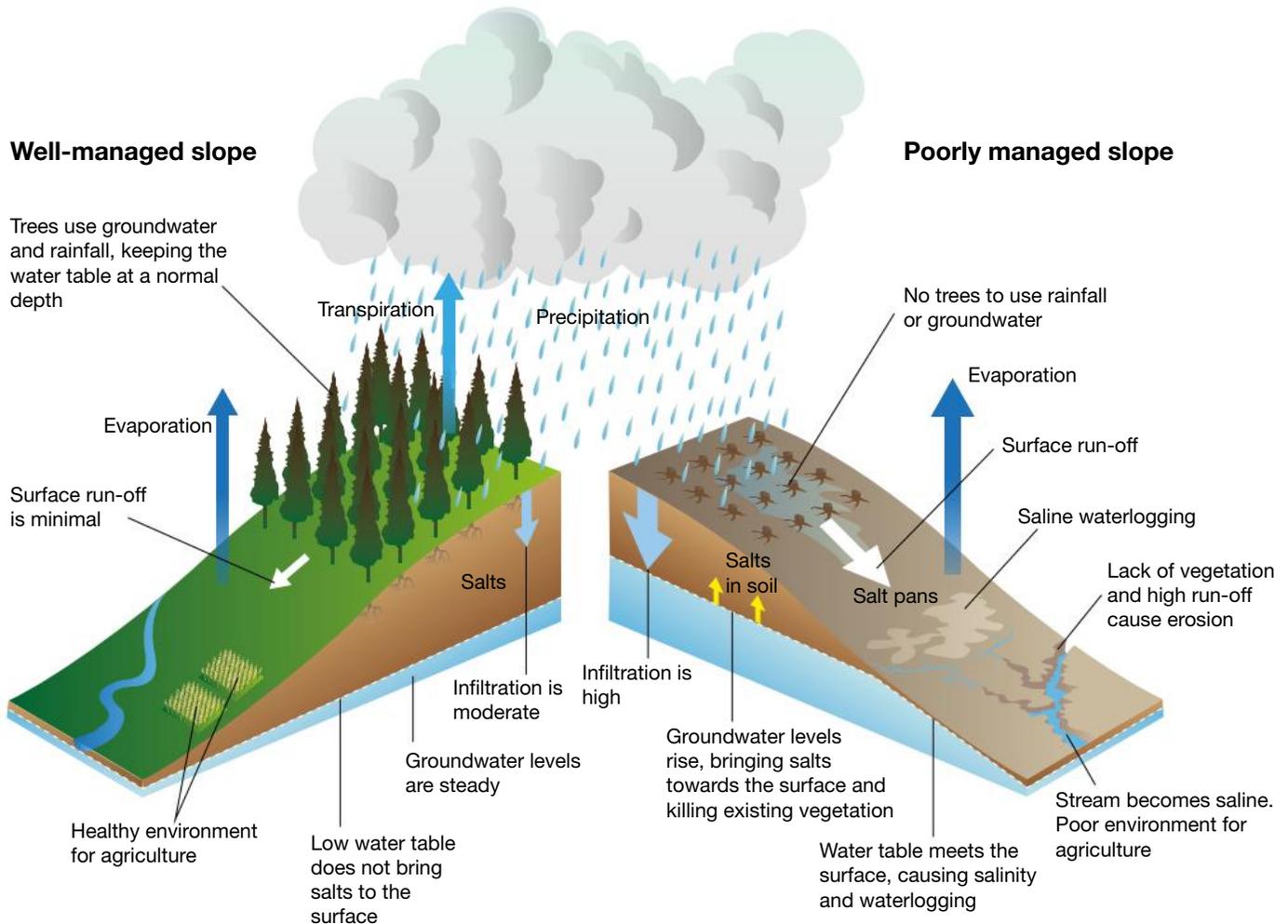
Reducing soil erosion

Strategies for reducing soil erosion include:

- minimising the length of time that soil is left bare, particularly in areas where strong winds and drought occur
- maintaining plant cover by reducing the amount of stock (animals)
- eliminating pests, such as rabbits, which can strip an area of its vegetation

- building raised areas of soil, called contour banks, across slopes to reduce the movement of water down slopes
- ploughing across, not down, slopes, or avoiding the cultivation of sloping land
- planting trees to form windbreaks.

Land clearing can also result in salinity. Figure 3.9.7 compares a well-managed slope, on which there is a forest, and a poorly managed slope, from which forest cover has been removed.



3.9.7 Managing a slope to minimise salinity

ACTIVITIES

Knowledge and understanding

- 1 Explain what water erosion is. Where is the problem most severe?
- 2 Distinguish between sheet, rill and gully erosion.
- 3 Describe what happens to the eroded material.
- 4 Explain the causes of wind erosion. Where is the problem most severe?

Applying and analysing

- 5 Study Figure 3.9.7. Prepare a brochure for farmers explaining how erosion of a slope can be minimised.

Investigating

- 6 Investigate land clearing in Australia. Access the websites of the Australian Conservation Foundation and the Wilderness Society. Use the information available on these websites to develop a multimedia presentation highlighting the extent and impacts of land clearing in Australia. Outline the campaigns mounted by these organisations and evaluate their effectiveness. What successes have these organisations had? How do they seek to influence the decision-making processes of governments?

Innovations in agriculture

Overcoming the limitations on crop yields

The majority of the world's food comes from agriculture—the deliberate cultivation of plant and animal species. Agriculture exploits the processes of growth and reproduction that occur within nature. The amount of food (the yield) that can be obtained from the land depends on the efficiency of these processes. Overcoming any limitations on these processes increases yields.

In Ancient Egypt, irrigation was used to water the crops in a dry land; by 2500 BC an ox-drawn plough was being used to break up the ground for seeds to be planted. When the horse collar was invented in AD 1000, horsepower came to dominate agriculture in the Western world. The invention of the tractor and the introduction of machinery designed to till the land and harvest the crops greatly improved agricultural output.

Rapid improvements in productivity

The development of new technologies and the growing knowledge base and skills of farmers have resulted in spectacular improvements in productivity over the last 50 years. This progress has been underpinned by three factors: new breeding technologies, the expansion of land under irrigation and the widespread use of agrochemicals.

NEW BREEDING TECHNOLOGIES

Scientific research into new varieties of crops and breeds of animals uses genetics to shape strains that are more suitable for human needs. New hybrid crops have much higher yields, ripen more quickly during shorter summers and are disease resistant. For example, investments in cocoa research in Nigeria led to the introduction of a hybrid seed and effective control of the pests capsid (an insect) and black pod (a fungus), producing increases in annual returns of more than 40 per cent. Breeding programs using artificial insemination have boosted livestock productivity, with more meat or milk and more offspring.

EXPANSION OF LAND UNDER IRRIGATION

About 20 per cent of arable land is now irrigated, overcoming the limitation of water shortages. Irrigated land is very productive, providing 40 per cent of global food. It has been especially important in China and India, where the high yields have helped feed their growing populations. In India, the area of crop production under irrigation grew from less than 20 per cent to over 40 per cent between 1961 and 2004. Over that same period, India's cereal production rose from 87 to 230 million tonnes.

WIDESPREAD USE OF AGROCHEMICALS

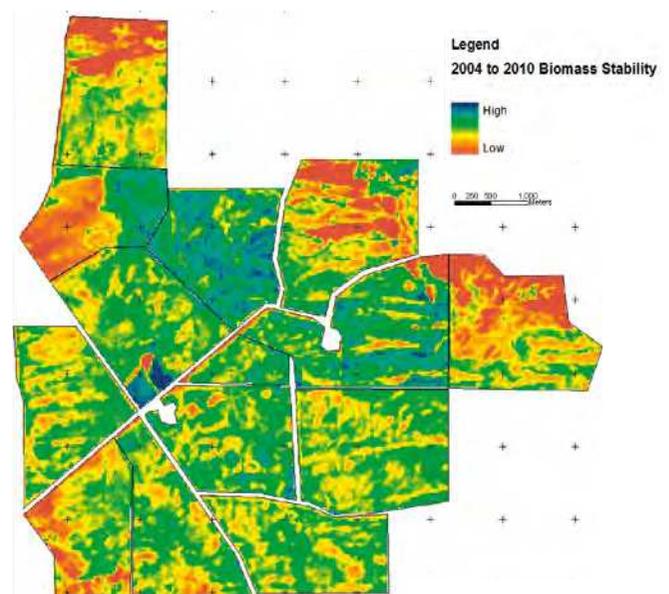
The cultivation of modern varieties of crops has necessitated the intensive use of chemical fertilisers to retain nutrient levels in the soil and chemicals to control weeds and pests that damage the crop or compete with it for water and nutrients.

New research

Biotechnology and precision agriculture are emerging technologies that are becoming increasingly important.

PRECISION AGRICULTURE

Agricultural land is variable and consequently productivity is variable. Farmers have always been aware of this, but without any means of recording or tracking variations, they have been limited in overcoming the issue. The development of precision agriculture, involving new technologies such as soil sensors, yield monitors, global positioning systems (GPS) and geographical information systems (GIS), has given farmers the sophisticated tools they need to recognise the variations within their paddocks. They are then able to manage the land differently and more efficiently. Figure 3.10.1 shows an example of the new technologies used in precision agriculture.



3.10.1 After a satellite image of a property is captured, sophisticated GIS tools are used to compare it with yield data and determine the response of the crop to certain treatments.

PLANT BIOTECHNOLOGY

In addition to traditional research from agricultural scientists, plant biotechnology research has improved productivity and enabled advances in overcoming environmental limitations such as drought and salinity. Biotechnology includes genetic engineering and the transfer of genes from unrelated plants and micro-organisms to develop crops with desirable traits. While improvements in production have been realised, there is some consumer concern about the effects of genetically modified food.

Future challenges

Scientific advances have underpinned yield improvements in crops to date but the development and delivery of breakthrough innovations is required to ensure that enough food is produced (see Table 3.10.2) in the future. Future productivity gains will rely on removing inefficiencies in production and investing heavily in research. Above all, the resource base that supports crops needs to be protected for future production. Ecological sustainability must be a priority.

3.10.2 Crop technology breakthrough predictions in 2020 and effects on crop production in China

Technology	Expected effects on crop production (percentage of those expecting a breakthrough in the technology)				
	Likelihood of significant technological progress	Increases in yields and efficiency	Allows increase in sown area	Allows increase in cropping intensity	Other effects (e.g. on nutrition or pollution)
Conventional plant breeding	97	49	17	10	24
Genetic engineering	97	43	23	6	28
Precision technology	71	56	11	15	18
Information technology	76	41	8	13	38
For use in water-short areas	97	49	31	10	10
Labour-saving technologies	76	53	16	14	18
For increasing nutrition	82	30	2	2	66
For sustaining productivity	85	54	14	16	16

ACTIVITIES

Knowledge and understanding

- 1 Outline the early efforts undertaken to overcome the limitations to food production.
- 2 Explain how innovations in agriculture have lifted productivity in the last 50 years.
- 3 Describe plant biotechnology and precision farming.
- 4 Identify the growing concern about future global food production and the role innovations will have in addressing this.

Applying and analysing

- 5 Prepare a T-chart to show the arguments for and against producing genetically modified food.

Investigating

- 6 Use the internet to investigate the various forms of controlled environment agriculture, including greenhouses, hydroponics, aeroponics and vertical farming. Present your findings on a poster with illustrations and text boxes.
- 7 Investigate the research into precision agriculture that is being undertaken by the CSIRO in Australia. Present your findings in an oral report.

CASE STUDY: The Green and Gene revolutions

Intensification of agriculture

Since the 1950s, there has been an intensification of agriculture. Advances in farming technology have raised the productivity of land in what is often referred to as the Green Revolution. Scientists have developed genetically improved varieties of crops and animals through genetic engineering.

The Green Revolution

The **Green Revolution** in agricultural production began in Mexico in 1943 with US scientists trying to solve Mexico's reliance on imported wheat. Strong winds, heavy rain and associated diseases such as rust had damaged crops and lowered productivity. New varieties of wheat and maize were successfully introduced. Yields of wheat and maize tripled and doubled, respectively, between 1944 and 1967, with Mexico producing a surplus and subsequently able to export food crops.

The First Green Revolution

Between 1950 and 1970, crop yields in most developed countries increased dramatically. This is shown in Figure 3.11.1. There were a number of key advances.

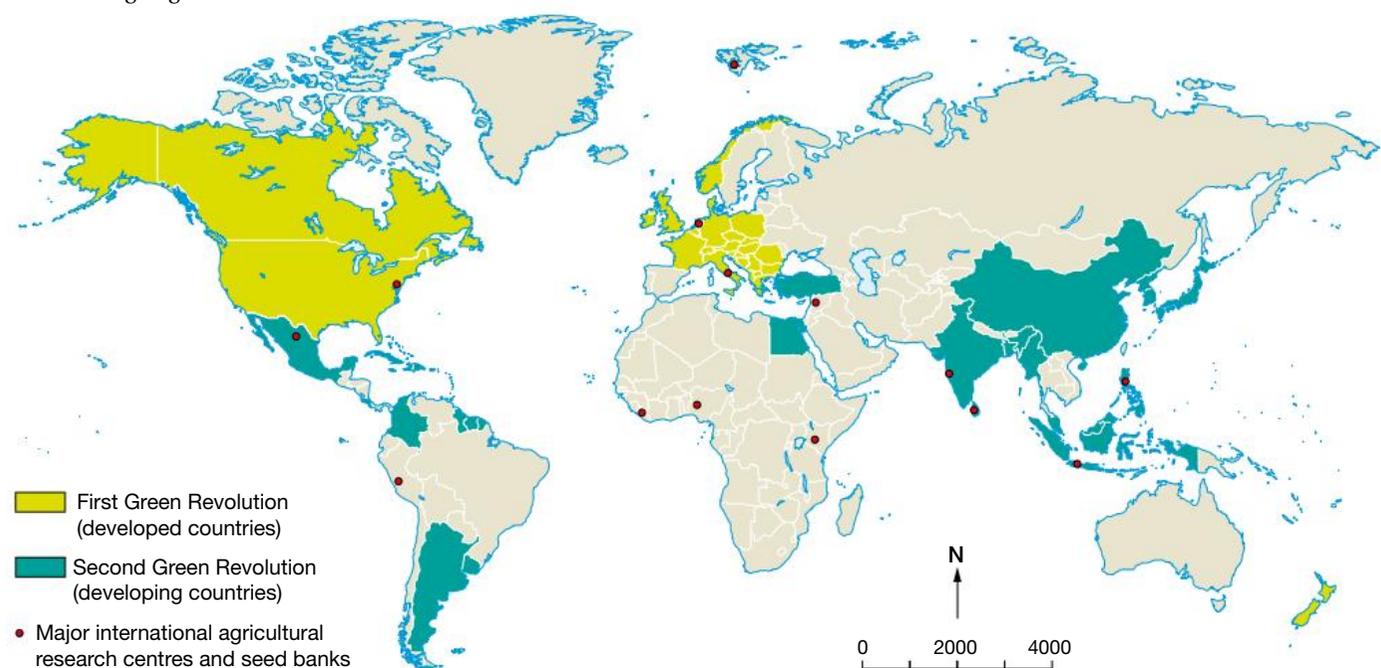
- New high-yield varieties of key food crops such as wheat, corn and rice were selectively bred or genetically engineered. Monocultures dominated, with single crops covering large areas of land.

- Large inputs of a range of agrochemicals maintained the high yields.
 - Artificial fertiliser continually provided nutrients to plants.
 - Herbicides removed weeds that otherwise would compete with crops for both water and nutrients in the soil.
 - Pesticides combated insects, which thrive in a monoculture where there is so much for them to eat.
 - Fungicides protected crops from fungal attack when it became humid.
- Irrigation met the water demands of the crops grown or guarded against drought.
- Multiple cropping was achieved by increasing the number of crops grown on a plot of land each year.

This high-input industrialised agriculture produced bumper crop yields in developed countries.

The Second Green Revolution

When research first began in Mexico, there was no consideration of the need to transform agriculture in other developing countries. However, when thousands of people died in India during the drought of the mid-1960s, their government started importing seed stock of the high-yielding crops from



3.11.1 Countries whose crop yields increased during the First and Second Green revolutions

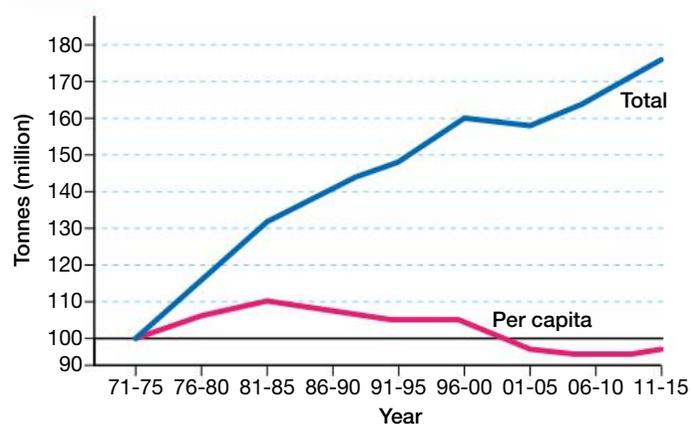
Mexico in 1967. New varieties of rice and wheat were bred for tropical and subtropical climates and the Second Green Revolution spread to India, China and countries of Central and South America.

The new varieties were dwarf plants with strong, stiff stalks that could hold up larger heads of grain and not fall over. Adding irrigation water, fertilisers and other agrochemicals boosted yields up to five times those of traditional varieties. Having such fast-growing crops meant that multiple cropping was possible, with two or even three crops being grown on the same land in one year.

Impact of the Green Revolution

Global grain production has tripled since 1950, mostly because of the Green Revolution; Figure 3.11.2 shows grain production since 1960. Both India and China are now mostly self-sufficient in food. The Green Revolution is credited with saving millions of people from hunger and starvation. Unfortunately, it has not spread to Africa, where population growth rates are the highest in the world and food shortages are the most acute. The limitations of poor soils and water shortages, as well as the chaos of civil unrest and war, have limited the adoption of new technologies.

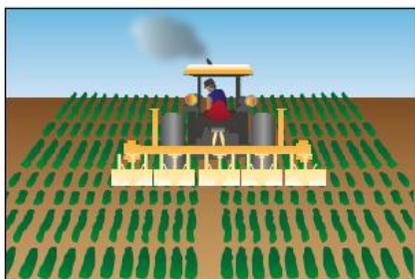
3.11.2 Global grain production, 1971–2015



Environmental impacts

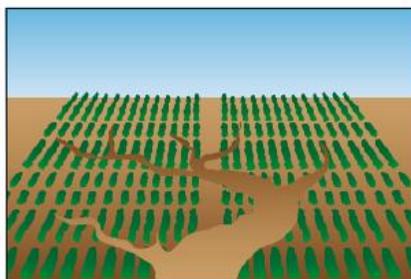
The problem with intensive farming methods is the damage that can occur to the environment. The impacts of farming are shown in Figure 3.11.3.

3.11.3 Major environmental impacts of food production



Biodiversity loss

- Loss and degradation of habitat from clearing grasslands and forests, and draining wetlands
- Fish deaths from pesticide run-off
- Killing of wild predators to protect livestock
- Loss of genetic diversity from replacing thousands of wild crop strains with a few monoculture strains



Soil

- Erosion
- Loss of fertility
- Salinisation
- Waterlogging
- Desertification



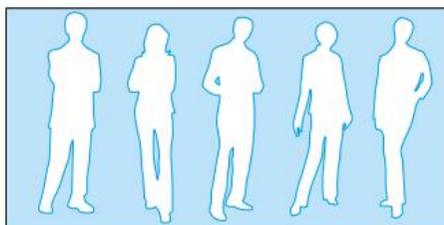
Air pollution

- Greenhouse gas emissions from fossil fuel use
- Other air pollutants from fossil fuel use
- Pollution from pesticide sprays



Water

- Water waste
- Aquifer depletion
- Increased run-off and flooding from land cleared to grow crops
- Sediment pollution from erosion
- Fish deaths from pesticide run-off
- Surface and groundwater pollution from pesticides and fertilisers
- Eutrophication of lakes and slow-moving rivers from run-off of nitrates and phosphates from fertilisers, livestock wastes, and food-processing wastes



Human health

- Nitrates in drinking water
- Pesticide residues in drinking water, food and air
- Contamination of drinking and swimming water with disease organisms from livestock wastes
- Bacterial contamination of meat

FERTILISERS AND CHEMICALS

Boosting and maintaining high levels of production are heavily dependent upon the use of artificial fertilisers and other agrochemicals, which can accumulate within the soil and disrupt natural processes. They can also have adverse impacts on the wellbeing of people living in the area.

Fertiliser use has tripled since the 1960s and it continues to rise. The over-application of fertilisers (mostly nitrates and phosphates), in excess of what is taken up by the crops, leads to nutrient-rich water washing into waterways with irrigation water or following rain. Here the fertilisers encourage algae growth, limiting the survival of other aquatic species.

The use of agrochemicals can have serious implications when residues enter soils or waterways. The increasing concentration of dangerous chemicals such as DDT and PCBs in the tissues of organisms at successively higher levels of the food chain can damage human health. Fish deaths have occurred in Asian waterways, denying the people an important source of protein in their diet.

FOSSIL FUELS

The increases in agricultural output that have been achieved by the Green Revolution have relied on the use of fossil fuels in making and applying the fertiliser and agrochemicals, pumping the irrigation water and running machinery such as tractors. Industrial agriculture has become addicted to oil.

Changing diets

Increases in grain production are not necessarily feeding more people, either. As incomes grow, people tend to include more meat in their diet. As production intensifies, grain is fed to livestock rather than to people. Grains are also being used to produce biofuels for cars.

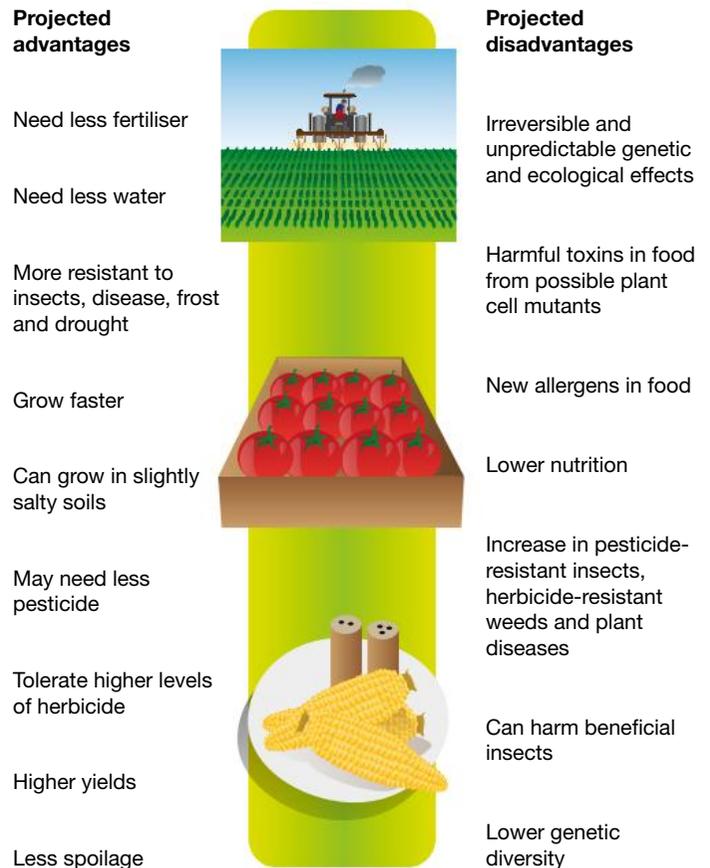
Social impacts

The Green Revolution gave many countries an improved level of food security and helped lift large numbers of people out of poverty. However, it also increased inequalities in many countries, as not all farmers could afford all the necessary inputs. In India, farmers with less than one hectare of land have become poorer, while those with larger holdings have usually become richer.

The Gene Revolution

Scientists are using genetic engineering to develop improved strains of crops and animals. This enables a gene with desirable characteristics to be transferred to another species. This technology is advancing rapidly and its supporters believe that genetically modified food has the potential to end global food shortages. However, critics are wary of this new technology

3.11.4 Projected advantages and disadvantages of genetically modified crops and food



SPOTLIGHT

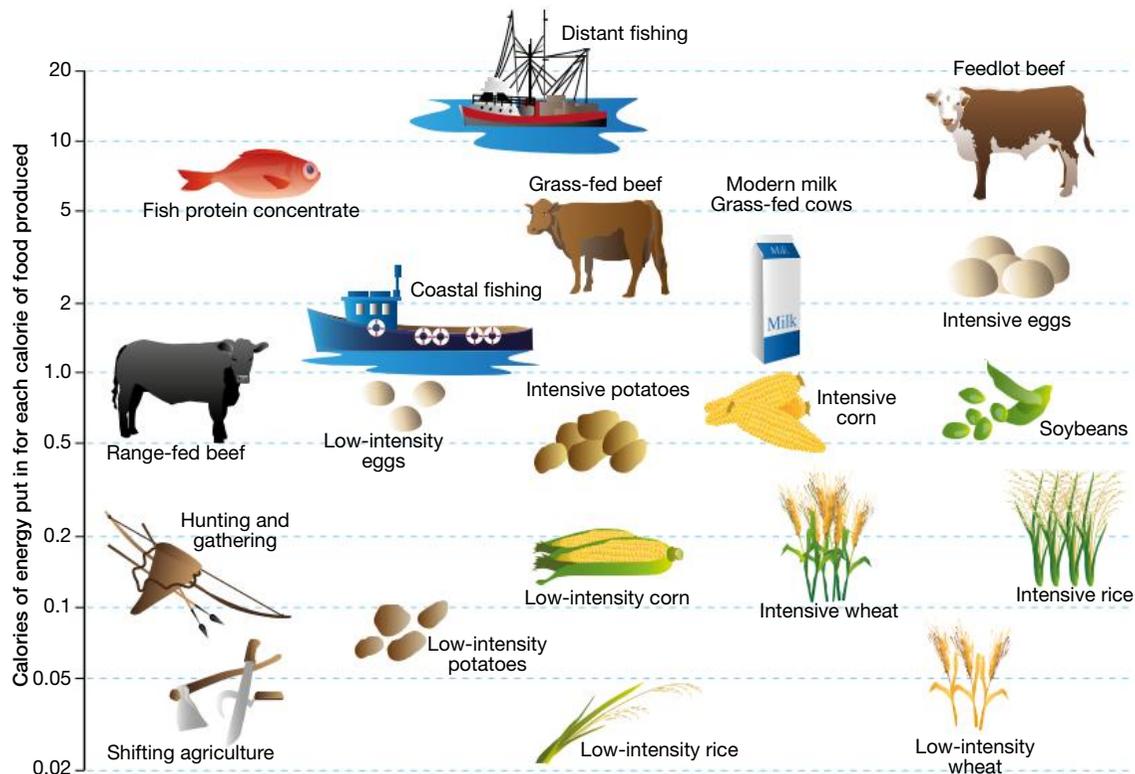
Golden rice and edible cotton plants

Genetic engineers used genes from ordinary daffodils and a soil bacterium to produce golden rice. This rice contains beta-carotene, a substance the body can convert to Vitamin A, which prevents blindness and common childhood infections.

Scientists have also genetically altered normally inedible cotton plants (grown in more than eighty countries worldwide) so that their cottonseeds can be ground into flour and made into bread and other foods that could potentially meet the protein requirements of a billion people a year.

Source: G Tyler Miller and S Spoolman, *Environmental Science*, Brooks Cole, Belmont, 2008

and warn that, as yet, the long-term impacts on human health and ecosystems are unknown. The projected advantages and disadvantages of genetically modified crops and food are shown in Figure 3.11.4.



3.11.5 The amount of energy needed in food production varies with the intensity of land use.

The way forward

Figure 3.11.5 illustrates the amount of energy required to produce a range of food products. Agricultural research will be important in further increasing production to meet the growth in demand for food in developing countries.

By building on the strengths of the Green and the Gene revolutions, while seeking to avoid their weaknesses, progress may be made in achieving sustainable global food security.

ACTIVITIES

Knowledge and understanding

- 1 Outline the key advances of the first Green Revolution.
- 2 Describe the Second Green Revolution in agriculture.
- 3 Explain why the Green Revolution has not benefited all farmers in developing countries.
- 4 Describe recent advances in the Gene Revolution.

Geographical skills

- 5 Study Figure 3.11.1. With the aid of an atlas, identify the countries where the First and Second Green revolutions occurred and where the major international agricultural research centres and seed banks are located.
- 6 Study Figure 3.11.5 and describe and account for the calories of energy put into range-fed beef and feedlot beef.

Applying and analysing

- 7 Complete the following table with arguments for and against the following statement.

Genetically modified food is 'Frankenfood' and should be banned.

Hint: 'Frankenfood' is a reference to the monster created by the fictional character Victor Frankenstein.

For banning GM foods	Against banning GM foods

- 8 Write an extended response on the following topic.
The intensification of agriculture has been of great benefit to the world.

Investigating

- 9 Investigate the scientific advances that led to the Green Revolution with reference to Norman Borlaug; the International Maize and Wheat Improvement Centre in Mexico; and the International Rice Research Institute in the Philippines. Prepare a multimedia presentation.



Challenges to food production

Our wellbeing depends on having access to affordable food. But a complex combination of increasingly unreliable harvests (a consequence of climate change), competition for agricultural lands from biofuels, higher energy prices, the surging demand for food in China and India, and distortions in world trade, are driving food prices up worldwide. Some countries, especially in Africa, are facing an increasingly dire situation, while even consumers in wealthy nations are being forced to make adjustments to their food budgets.

In the future, food shortages have the potential to destabilise governments, ignite street riots and send a new wave of hunger rippling through the world's poorest nations.

The issue of food security is likely to dominate the international policy agenda for decades, especially as the world's population heads towards 9 billion.

In this chapter we study the challenges to food production, including land and water degradation, shortage of fresh water, competing landuses, and climate change, for Australia and other areas of the world.

INQUIRY QUESTIONS

- What are the principal challenges to food production?
- How will climate change affect food production?

GLOSSARY

acidification	the build-up of hydrogen in soil, which reduces the soil pH	land (or soil) degradation	the downgrading of soils and their productive capacity
algal bloom	a high concentration of microscopic aquatic plant life	mixed farming	agricultural practices that mix arable farming with the raising of livestock or that involve growing two or more diverse crops on the same piece of land
biodiversity	the variety of all life forms—plants, animals and micro-organisms, the genes they contain, the ecosystems of which they form a part and the processes that link them	monoculture	the cultivation of a single crop on a farm
biofuel	a solid, liquid or gas fuel derived from biological material	soil compaction	the process in which a weight applied to a soil causes air to be displaced from the pores between the soil particles
cash cropping	the growing of agricultural crops for sale and profit	water degradation	the contamination of water bodies with pollution
desertification	the expansion of deserts due to overgrazing, soil erosion, climate change or prolonged drought		

Threats to global food production

Food security

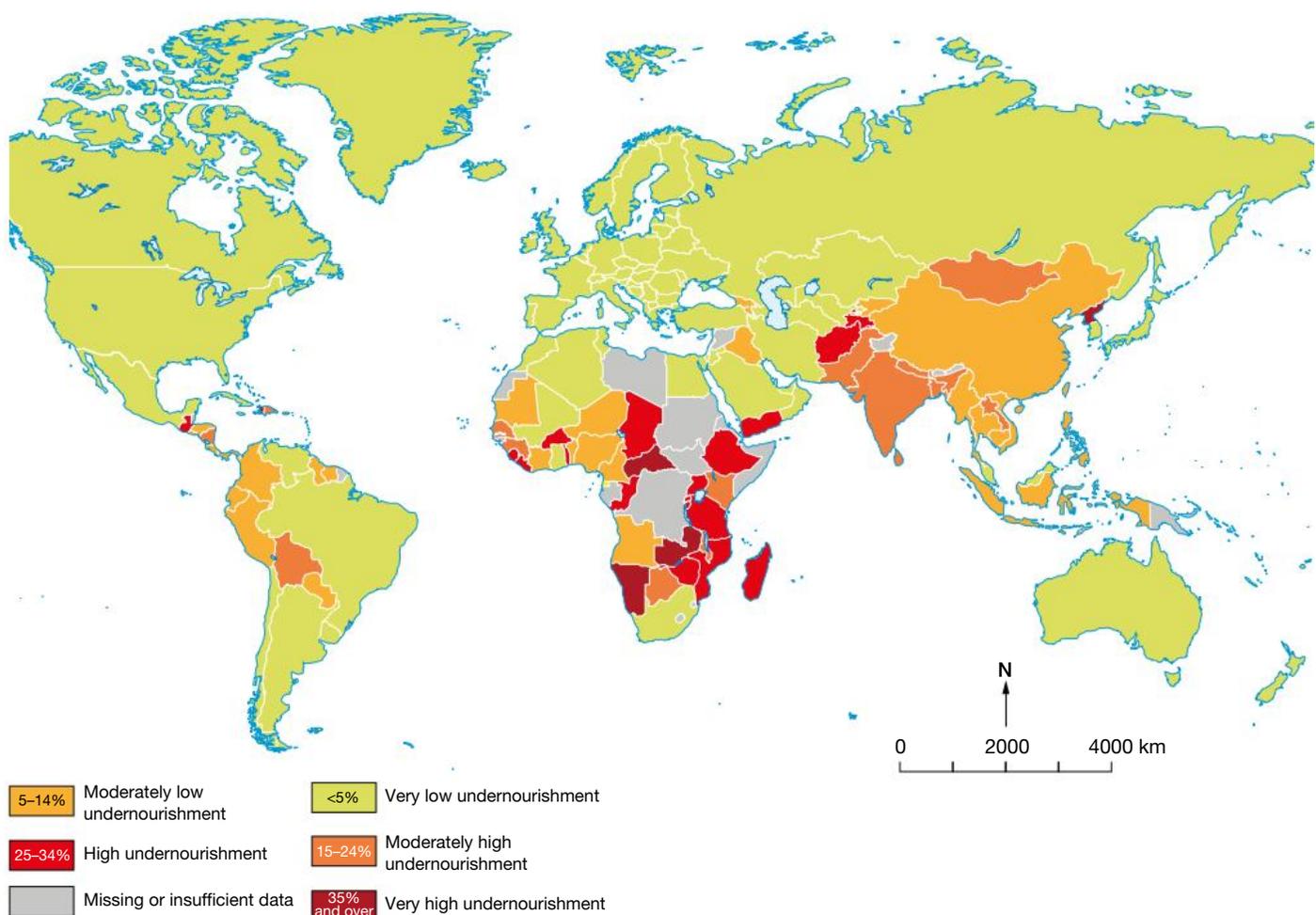
The UN's Food and Agriculture Organization (FAO) notes that food security is achieved when all people at all times have physical and economic access to sufficient, safe, nutritious food to meet dietary needs and food preferences for a healthy and active life.

Food security means that the following conditions are met.

- Enough good quality food is available. Food supplies can be affected by adverse weather (hailstorms, heatwaves), natural hazards (droughts, floods, tropical cyclones and tsunamis), conflict (civil unrest, wars), population growth, unsuitable agricultural practices, environmental degradation, trade barriers and inequalities within societies.
- Food is affordable and within the reach of all. When food supplies are interrupted and become expensive, wealthy people can still afford to buy them, but poorer people do not have the means to do so.
- The food available is the right sort of food. A variety of food types is essential for a balanced diet that ensures normal growth and development and good health. Such food needs to be stored safely and prepared hygienically.

Enough food is currently produced to adequately feed all of the world's people, yet one billion are undernourished (see Figure 4.1.1 and Table 4.1.2). It is the desperately poor who are going hungry because they lack the means to acquire even the bare minimum of food. The desperately poor will often spend up to 80 per cent of their household budgets on food.

4.1.1 World Hunger Map 2015, showing the proportion of the global population who are undernourished



4.1.2 Countries containing the highest percentage of undernourished people as a percentage of their total population in 2011–13

Rank	Country	Percentage of total population of country
	Global	13.0
1	Burundi	67.3
2	Comoros	65.3
3	Eritrea	61.3
4	Haiti	49.8
5	Zambia	43.1
6	Sudan	38.9
6	Timor Leste	38.3
7	Ethiopia	37.1
8	Mozambique	36.8
9	Tanzania	33.0
10	Congo	33.0

Food shortages

When food shortages occur, it is the poor who suffer the most. This was evident when the prices for staple grains soared in 2008 as people and governments panicked because the global stockpile had shrunk. Public unrest and riots spread across the developing world and 1.5 billion people were put at risk by the food crisis. Violent food riots broke out in some thirty countries throughout the world in 2007–08, including India, Peru, Morocco, Egypt and Bangladesh. Figure 4.1.3 shows a scene from food riots in Haiti.

While the situation has eased, there are grave concerns that more food shortages are inevitable. This would cause instability and major disruptions in many countries and there could well be a humanitarian catastrophe across some of the poorest regions of the world. When food shortages resulted in famines in the 1960s, the Green Revolution delivered the big surge in food production needed to lift crop yields. This has now largely fizzled out. The issue of food security has become more complex. There are now multiple threats that tend to amplify each other and compound the problem.



4.1.3 Food riots in Haiti, 2008

Increasing demand for food

A combination of population growth and higher consumer expectations means that the global requirement for food by 2050 will be 70 to 100 per cent greater than it is today.

Population growth

While the rate of growth of human numbers is slowing, about 100 million people are still being added to the world's population each year. This upward trend is expected to result in the global population reaching 9.1 billion in 2050. Every year there are simply more mouths to feed.

Changing consumption patterns

As people move out of poverty, they improve their diets by eating different foods, particularly those that are rich in protein, such as meat, milk and eggs. Livestock are being fed vast quantities of corn, wheat, soybeans and barley, which are no longer then available as grain foods. As these grains are converted into meat, they lose as much as 95 per cent of their kilojoule value.

Limitations on food production

Population and demand for food are together rising at about 2 per cent a year, whereas food output is now increasing at only about 1 per cent a year. There are a number of potential threats that could prevent food production from rising as much as needed to achieve global food security.

Crop yields

Although total yields for grain crops continue to increase on a global basis, there has been a disturbing slide in the yield advances being made. This has been detected in many of the major cereal crops, such as corn, wheat and rice. Where yields were once rising by 5–10 per cent each year with the sharing of the skills and technologies of the Green Revolution, they have now dwindled to only 1 per cent a year, as shown in Figure 4.1.4.

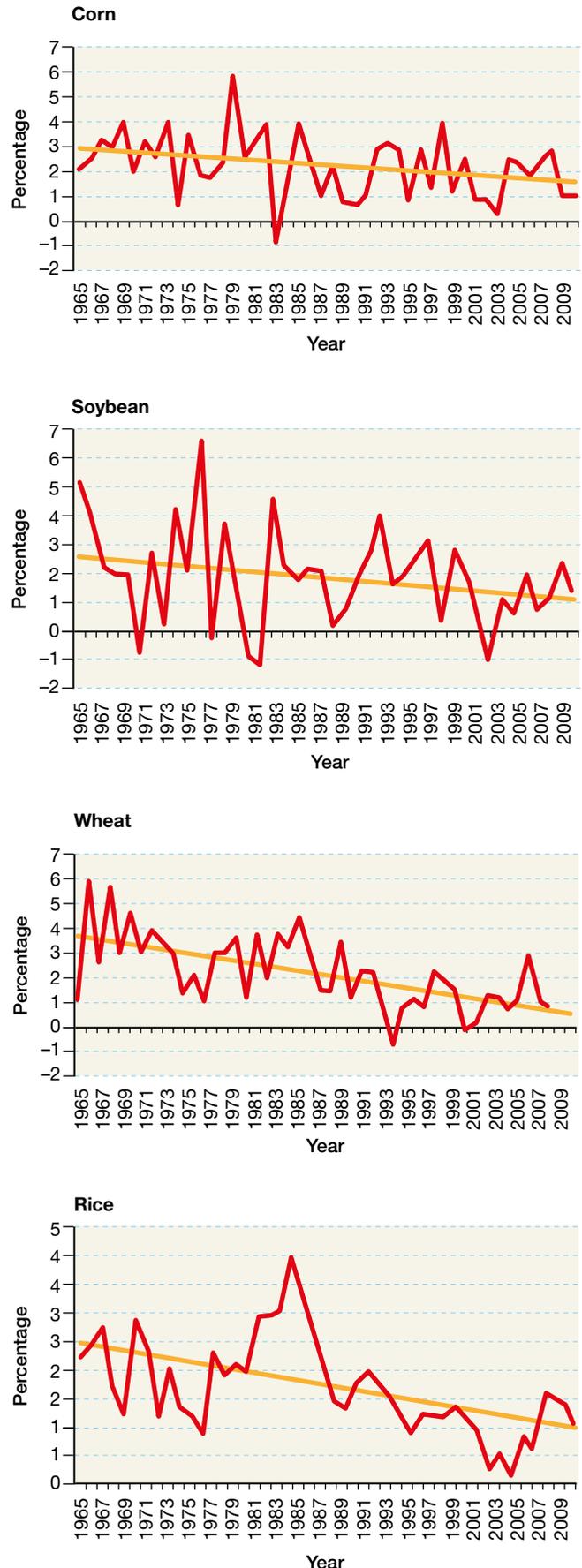
Competing uses of the land

As large amounts of cereal grains are being used to feed livestock and to produce **biofuels**, land is diverted away from food production. Similarly, arable land is being lost as cities expand outwards.

Globalisation

Food has become a commodity and the profit motive now dominates global food production, as huge agribusinesses have taken control of all aspects of food production. The physical resource base that supports agriculture is being put at risk by this industrial agriculture. Farmers are getting lower returns for their produce, as they are locked into supplying the big corporations. International trade in food products has also soared and many poorer countries are disadvantaged by trade restrictions.

4.1.4 Global crop yield change, 1965–2009



Shortages of fresh water

Water is crucial to food production and some of the most intensive food emergencies have been associated with severe water shortages. The increasing overuse of both surface and groundwater supplies, and declining water quality, are threatening the availability of fresh water. Dwindling supplies will affect agriculture and put at risk the world's food supply.

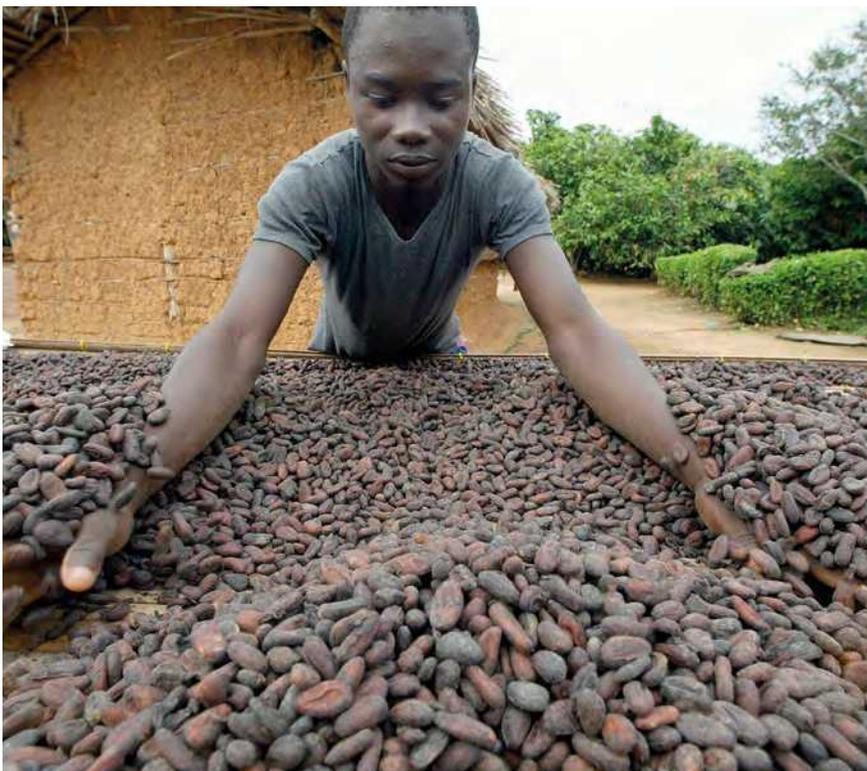
Climate change

Climate change will add to the existing and substantial pressures on global food security. Higher temperatures, shifting rainfall patterns and more frequent extreme weather events may change the environment that crops and animals have to grow in.

SPOTLIGHT

The chocolate industry may be melting

More than half of the world's chocolate comes from cocoa produced by smallholders in Ghana and Côte d'Ivoire. Research undertaken by the Centre for Tropical Agriculture predicted a 1°C temperature rise by 2030, increasing to 2.3°C by 2050. Such an increase could be catastrophic for this heat-sensitive crop. A rise in temperature of this extent is enough to inhibit the growth of cocoa pods. This would send yields crashing, depleting supplies of cocoa and causing prices to soar.



4.1.5 Cocoa production, Ghana

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'food security'.
- 2 Describe what happened in 2008 when food shortages occurred.
- 3 Explain why the demand for food is increasing.
- 4 Outline the threats to food production.

Applying and analysing

- 5 Working in pairs, consider the following statement and share your thoughts with the rest of the class.
Poverty pushes population growth; however, its elimination impairs food availability.
- 6 To what extent do you agree with the following statement?

Improvements in technology will ensure global food security in the future.

Discuss.

Geographical skills

- 7 Study Table 4.1.2 and construct a column graph showing the percentage of undernourished people for the countries represented.
- 8 Study Figure 4.1.4 and answer the following questions.
 - a Which two crops have had the most notable deceleration in crop yield improvements?
 - b Which crop has experienced the most volatile changes in crop yield improvements?

Land and water degradation

Land degradation

One-quarter of the earth's lands are highly degraded. Another 8 per cent are moderately degraded, 36 per cent are stable or slightly degraded and 10 per cent are ranked as 'improving'. The remaining shares of the earth's land surface are either bare (around 18 per cent) or covered by inland water bodies (around 2 per cent). The extent of land degradation is shown in Figure 4.2.1.

Land (or soil) degradation is any change in the land that reduces its existing or potential productivity. It occurs wherever the natural balance in the landscape is changed by human activity, through misuse or overuse. It is the result of using land beyond its capability.

The United Nations estimates that 1.5 billion people—one-quarter of the world's population—depend directly on land that is being degraded.

The causes of land degradation are environmental and economic.

Environmental causes, shown in Figure 4.2.2, include:

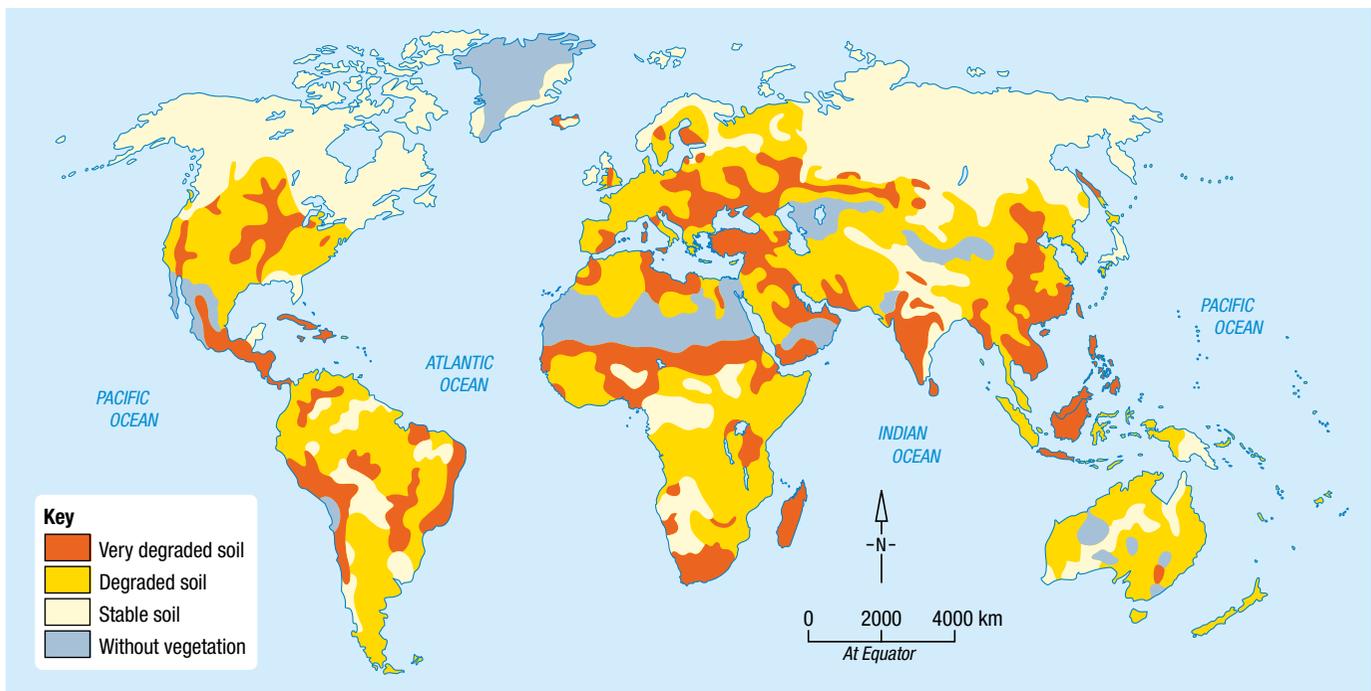
- overgrazing of livestock, especially in times of drought
- deforestation (removal of trees for industry or farming)
- land clearance for fuelwood collection

- agricultural practices
 - reduction in soil nutrients through poor farming practices
 - excessive irrigation, resulting in salinity
 - **soil compaction** by animals and vehicles
 - exposure of soil to wind and water erosion during cultivation
- bio-industrial activities (soil contamination by toxic substances such as pesticides and heavy metals).

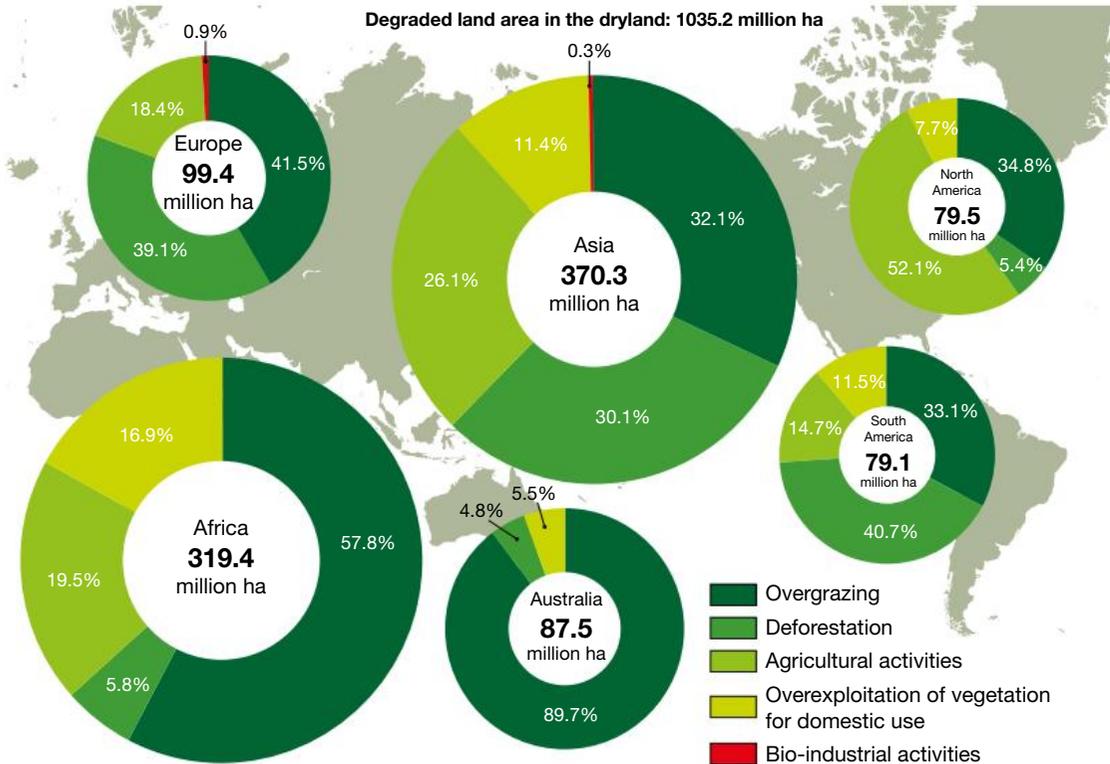
Economic causes include:

- poverty (forcing people to abandon more sustainable land use practices, as is illustrated in Figure 4.2.3)
- urban sprawl.

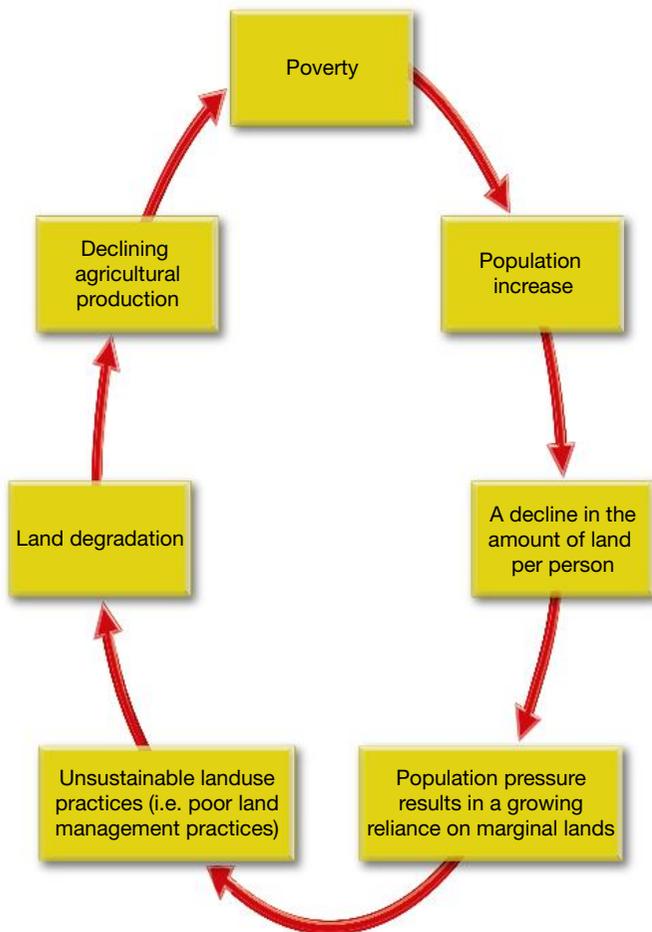
Land degradation leads to reduced productivity, forced migration (environmental refugees), food insecurity, damage to basic resources and ecosystems, and loss of **biodiversity** through changes to habitats. Figure 4.2.4, which shows the trends in land degradation around the world, indicates that only 18 per cent of land is improving.



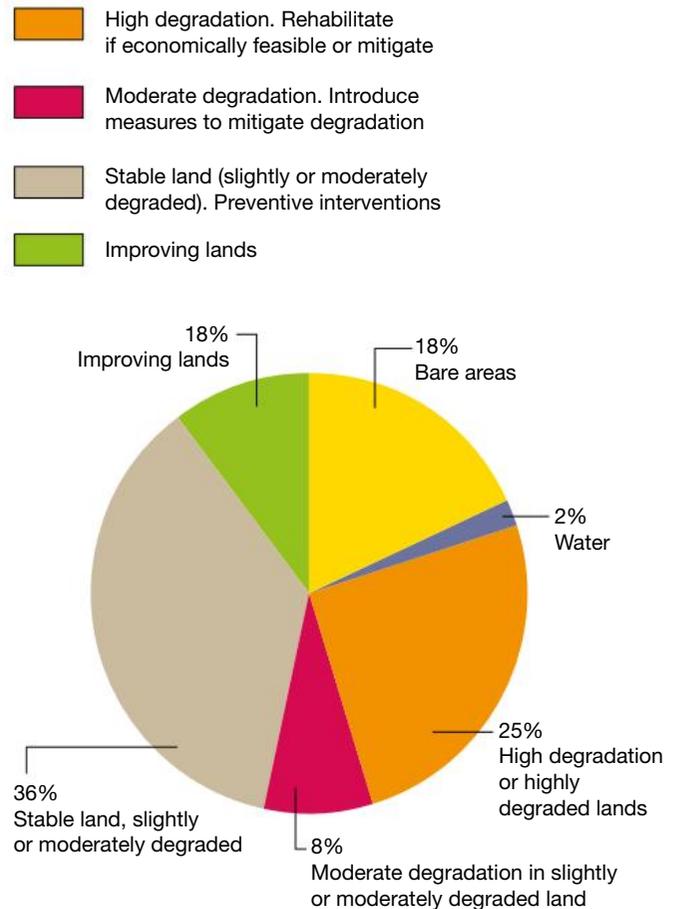
4.2.1 Soil degradation



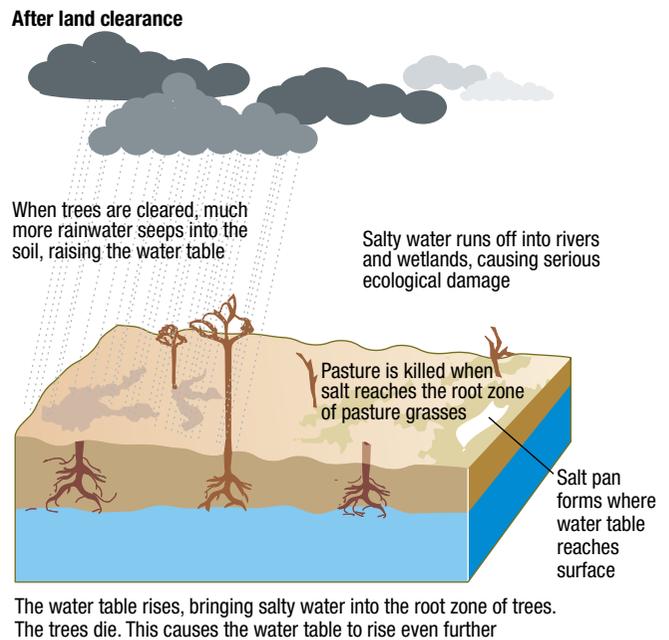
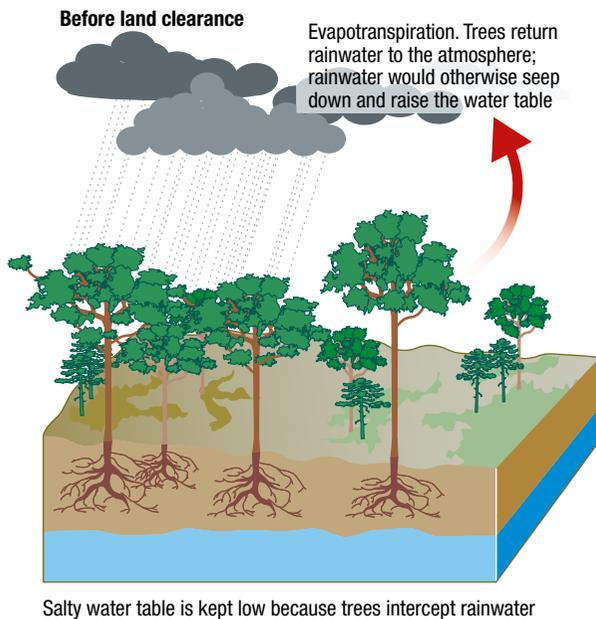
4.2.2 Extent and causes of land degradation by continent



4.2.3 Poverty and the cycle of degradation



4.2.4 Trends in global land degradation



4.2.5 Land clearance is the main cause of soil salinity.

Types of land degradation

The productive capacity of soil can be damaged, or degraded, in four main ways: through salinity, erosion, compaction or **acidification**.

Soil salinity

Increasing levels of salt in soils are common in some parts of the world, including Australia. This increase is caused by salty groundwater (water that is stored in rock and soil below the surface) reaching the surface of the soil. Normally, this groundwater level (known as the water table) is controlled by large trees, which pump water from the soil as they transpire. However, when trees are cut down, salty water may rise to the surface, as shown in Figure 4.2.5. The water evaporates, leaving a salty crust.

Soil erosion

Soil erosion is the removal of topsoil by water or wind. This happens wherever the soil is unprotected by plant cover. Once the original plant cover is removed, soil can be carried away easily by strong winds or heavy rain. Winds can strip the land of its topsoil and carry it hundreds of kilometres. Heavy rain and run-off can cut deep gullies in the soil.

Soil compaction

Soil can be compacted by the weight of heavy machinery or the trampling of hard-hoofed animals. Both of these can compress the air spaces in the soil so that it develops a hard layer on top. This reduces infiltration and makes it difficult to use the land for crops or pasture.

Soil acidification

Soil can be made acidic by the overuse of chemical fertilisers. Often, the use of some fertiliser is essential to ensure that the soil keeps producing crops. When used over a long period of time, however, fertilisers can also harm the soil.

Water degradation

Widespread **water degradation** has placed a number of key food production systems around the globe at risk, posing a major challenge to the task of feeding a growing world population.

Water scarcity is growing, as are the salinisation and pollution of groundwater and surface water bodies. Water-related ecosystems are also being degraded. Large inland water bodies are under pressure from a combination of reduced inflows and higher nutrient loading—the excessive build-up of nutrients such as nitrogen and phosphorus. Many rivers do not reach their natural end-points and wetlands are disappearing.

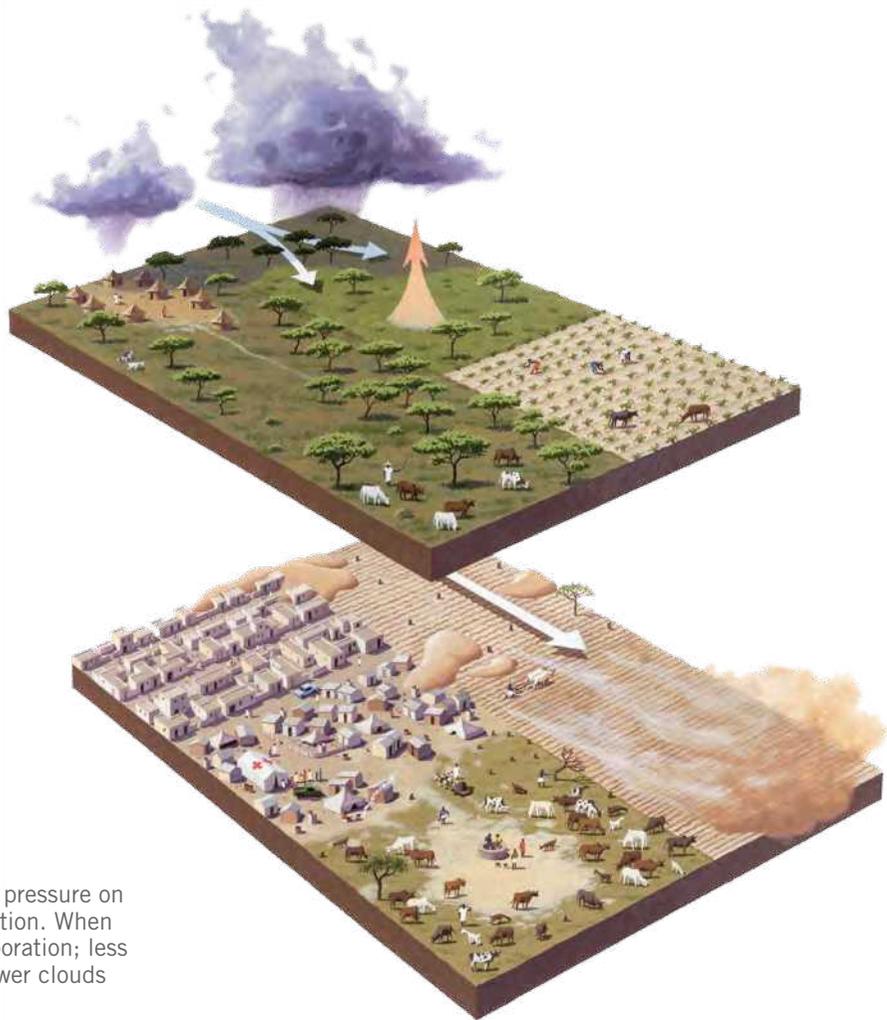
In key cereal-producing regions of the world, intensive groundwater withdrawals have resulted in a lowering of aquifers. This, in turn, has reduced the accessible groundwater stores that many rural communities rely on.

Algal blooms are a growing water-quality issue. A bloom results from a rapid increase or accumulation in the population of algae in a waterway. Some of these are toxic and can render the water unfit for use. Freshwater algal blooms are the result of an excess of nutrients, especially phosphates. The excess of nutrients may originate from fertilisers used in agriculture.

SPOTLIGHT

Desertification

One of the most serious forms of land degradation in the world is **desertification**, which means the creation of deserts. Desertification is a problem in parts of Africa, where the desert is steadily advancing over what used to be good farming land. Desertification in northern Africa has occurred at the edges of the Sahara. These marginal lands have variable rainfall and can only be used with great care. A mixture of overuse and periodic change in the rainfall has destroyed the productive ability of the land. The results are creeping desert sands and salty water holes.



4.2.6 Population growth increases the pressure on agricultural land, leading to its degradation. When the trees are removed there is less evaporation; less evaporation means fewer clouds and fewer clouds means decreased rainfall, or drought.

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'land degradation'.
- 2 Outline the causes of land degradation.
- 3 Outline the various types of soil degradation.
- 4 Define the term 'desertification'.
- 5 Identify the various ways in which water supplies are degraded.

Applying and analysing

- 6 Study Figure 4.2.5. Explain how land clearance can cause salinity-related land degradation.
- 7 Study Figures 4.2.3 and 4.2.6. Write two to three paragraphs explaining the relationship between population increase and the process of land degradation.

Geographical skills

- 8 Construct a block diagram illustrating the various causes of land degradation.
- 9 Study Figure 4.2.2 and answer the following questions.
 - a Which continent has the largest area of soil degradation?
 - b On which continent is overgrazing the major contributor to soil degradation?
 - c On which continent is deforestation the major contributor to soil degradation?
 - d On which continent are agricultural activities the major contributor to soil degradation?

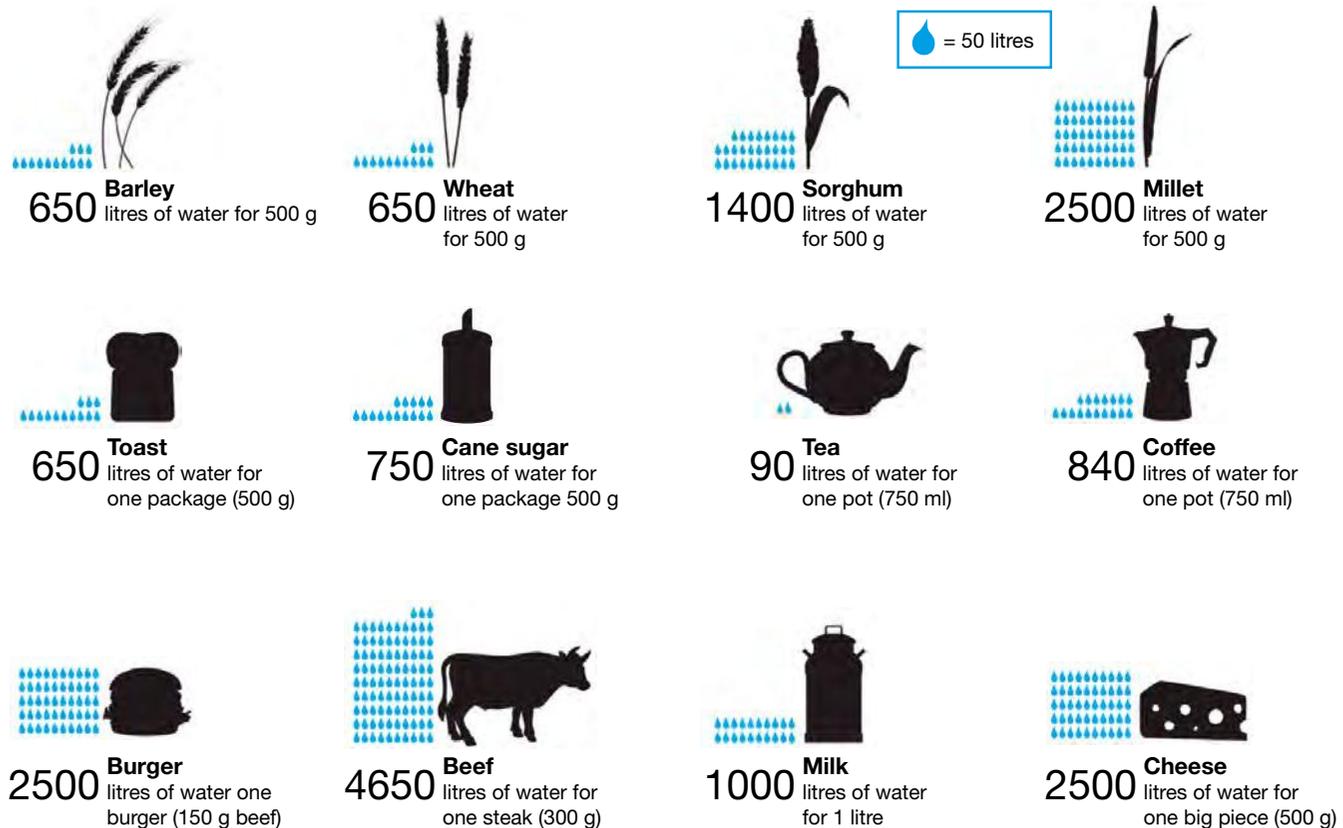
Shortages of fresh water

Water usage in food production

All food sources—from crop and livestock production to aquaculture and inland fisheries—require adequate quantities of water. Freshwater resources are central to the challenge of achieving global food security. Yet water scarcity is growing, and many of the world's key food-producing systems are being stressed by unprecedented demand for surface and groundwater supplies. Declining water quality is compounding the problem.

Producing adequate food supplies is directly related to the availability of sufficient water. Agriculture consumes 85 per cent of the world's fresh water. To produce a kilogram of rice needs 3400 litres. Figure 4.3.1 shows the 'water footprint' of a range of foods.

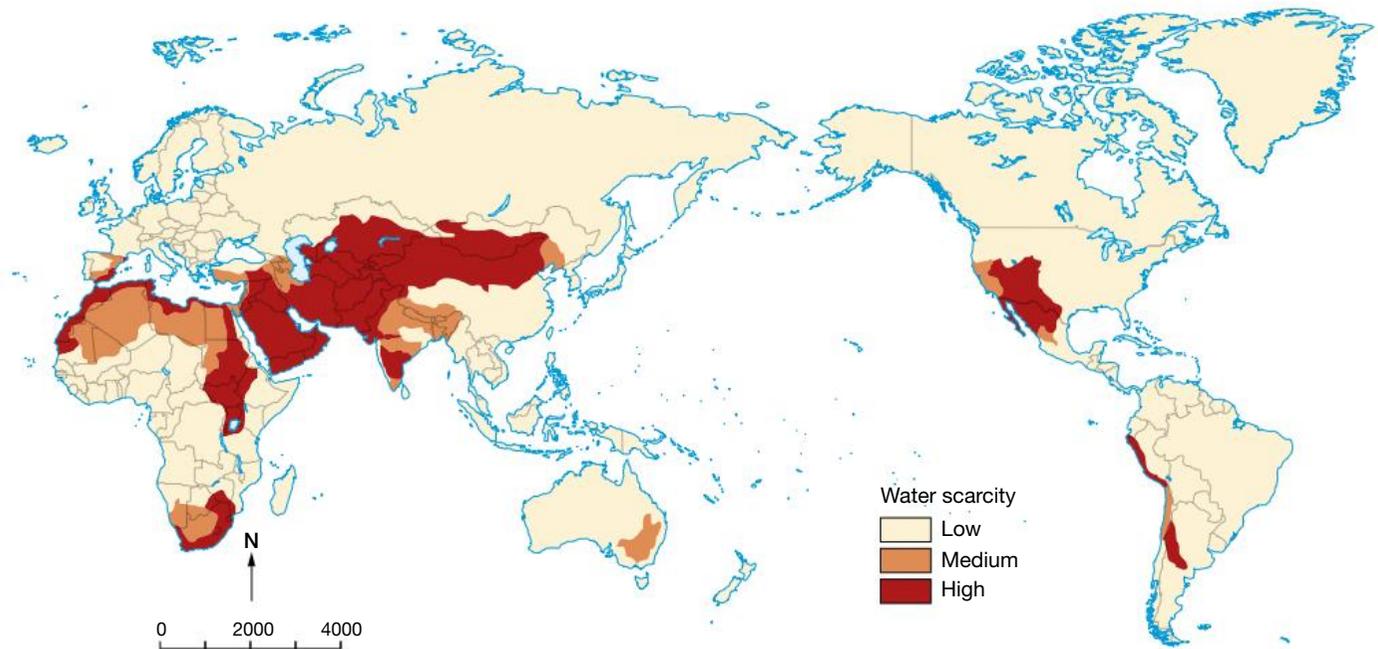
4.3.1 The water footprint of food produced includes the volume of water taken to produce the food from the land as well as all the water needed in the various stages of the production process, such as washing and processing.



Rain-fed agriculture

Globally, over 80 per cent of cultivated land relies on rainfall and moisture stored in the soils to support crops and pastures. If rainfall is erratic, or below average, crop yields drop. When prolonged or severe droughts occur over wide regions, crops may fail altogether, raising prices and triggering major food emergencies such as the 2008–09 crisis resulting from droughts occurring across China, the United States of America and Australia.

Those hardest hit by rainfall deficiencies are smallholders who make up the majority of the world's rural poor. They often occupy marginal land in arid and semi-arid regions such as Sub-Saharan Africa, where there is great climatic variability.



4.3.2 Global distribution of water scarcity by major river basin

Irrigated agriculture

An adequate and reliable supply of water can be ensured by withdrawing water from watercourses, lakes and aquifers and using it to irrigate crops. Irrigation lifts the yields of crops by 100 to 400 per cent. Although only 20 per cent of global cropland is irrigated, this land is very productive and contributes 40 per cent of the total food supply.

Water scarcity

Water scarcity often has its roots in water shortages and the problems are most severe in marginal areas. Water scarcity has become an issue of global concern, as water use has been increasing at twice the rate of population growth. With excessive amounts of water being withdrawn, groundwater and river levels have dropped, placing agricultural regions at risk all around the world. Global distribution of water scarcity is shown in Figure 4.3.2. It is estimated that 10 per cent of all food harvested is produced by depleting groundwater supplies, which are being used at a faster rate than they can be replaced.

The North China Plain, for example, is running out of water. Water scarcity also threatens food production in Australia's Murray-Darling Basin. In North Africa, Lake Chad, once one of the largest freshwater lakes in the world, is rapidly disappearing. As 20 million people live in the region and depend on the lake for irrigation, watering livestock, fishing and drinking water, conflicts have already erupted between competing water users. In parts of India, groundwater tables are falling by more than 1 metre a year. Future agricultural production is under threat.

DID YOU KNOW?

By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water-stressed conditions. The lack of water limits farmers' ability to produce enough food to eat or earn a living. South Asia, East Asia and the Middle East are already close to their resources limits, and their populations are still growing.

Water pollution

Despite food production relying heavily on water, inappropriate agricultural practices are fouling this water and making it unusable. Excess nutrients from over-fertilisation end up in water bodies, leading to toxic algal blooms. Agrochemicals such as pesticides contaminate the water and accumulate in living organisms. The more intensive the land use becomes, the greater the risk to freshwater supplies.

ACTIVITIES

Knowledge and understanding

- 1 Justify the importance of fresh water for food production.
- 2 Describe the sources of water used in agriculture.
- 3 Explain why Africa is so vulnerable to water shortages.
- 4 Outline the impact of agricultural practices on water quality.

Geographical skills

- 5 Study Figure 4.3.1. Identify the most water-demanding foods and the most water-efficient foods.
- 6 Study Figure 4.3.2 and describe the location of the regions experiencing the highest water scarcity.

Competing landuses

Urbanisation and agriculture

Increased competition for land and water resources is a major threat to global food security. As the world urbanises, cities spread across arable land and consume a larger share of available water supplies. There is also competition within the agricultural sector. Alternative forms of agricultural landuses—staple crops, livestock, non-food crops and biofuel production—compete for the arable land.

The impact of urban growth

The world is running out of good arable land, as some of the most productive land is lost to cities. Historically, cities occupied fertile river basins and coastal plains in better-watered areas close to food supplies. With increasing urbanisation and associated urban growth, cities have sprawled outwards, covering the rich soil with concrete and asphalt. Farmers often sell their land to developers (see Figure 4.4.1). By 2010, the total of the world's built-up areas was 4.75 million square kilometres, which is the equivalent to half the size of the United States of America or China. These areas occupy some of the world's best farmland.

The demand for water generated by population and economic growth is increasing much more quickly than the demand from agriculture. There is, as a result, increased competition for a resource that has a finite supply. City dwellers want water in their homes, as do industry and waste treatment facilities. These are expected to grow, crowding out the allocations to agriculture. Yet urban dwellers need food and rely on agriculture to provide it. By 2050, urban centres could swallow half or more of the world's available fresh water at a time when many rivers, lakes and aquifers will be drying up.

Competition for land and water

Staple grain crops, livestock, non-food crops (including biofuels), inland fisheries and aquaculture already compete for land and water resources. With profit being the driver of commercial agriculture, market forces are determining what the land is used for.

Cash cropping

Governments in developing countries often focus on **cash cropping** as a driver of economic growth. The prospect of generating revenue and export sales can blind them to the effect on other competing landuses, especially food production. The Pakistani government, for example, has promoted cotton farming as the country's biggest cash crop. As a result, the production of sunflower seeds, which are used to make edible oil, has almost disappeared from the country's fertile golden triangle. Pakistan now has to import edible oil, at a cost that is second only to what they pay for imported petroleum products. The problem has been compounded by falling prices for cotton exports.

Biofuels

As the world has become concerned about diminishing oil supplies and the need for a greener and more secure transport fuel, large amounts of land have been used to grow crops for biofuels such as ethanol and biodiesel. Ethanol can be made from plants such as sugar cane and corn, whereas biodiesel is produced from oilseeds such as soybeans, canola and sunflower seeds.



4.4.1 Rich farming country once used to grow canola in the United States of America is lost to a new housing subdivision.



4.4.2 The aquaculture industry uses vast quantities of water to incubate fish eggs and rear juvenile fish. Fish farms can also pollute waterways with nutrients, antibiotics and fungicides.

Aquaculture

Fish and fishery products are among the world's most traded food commodities, and aquaculture has become the fastest-growing animal-producing sector. While it is heavily dominated by the countries in the Asia-Pacific region, aquaculture is developing, expanding and intensifying in almost all regions of the world.

Fish farming (see Figure 4.4.2) makes heavy demands on the land. As it takes more than 5 tonnes of wild-catch marine fish stocks to feed a single tonne of farmed fish, they are fed grain. This imposes another strain on available grain stocks, which are also being fed to livestock. The availability of staple grains as human food diminishes even further.

Water wars

The fiercest competition for water is over that withdrawn from watercourses and storages to water stock and irrigate crops. Local disputes are common, and fighting can break out, as it did between farmers and herders in 2005 in the arid regions of western Sudan after the rains failed to arrive. In recent years, Africa, the Middle East and Central Asia have been the regions drawn into conflict over water. Such disputes could well lead to war this century, if tensions increase as climate change takes hold.

ACTIVITIES

Knowledge and understanding

- 1 Describe the impact of urban growth on the land and water resources traditionally used for agriculture.
- 2 Explain why governments favour cash cropping and how it can affect food production.
- 3 Outline the competition for land and water from biofuels and aquaculture.

Applying and analysing

- 4 Create a cartoon highlighting how competing landuses threaten global food security.
- 5 Read the following statement and complete the table.

To protect Australia's and the world's food security, the selling of farmland for housing should be stopped.

Arguments for	Arguments against

Investigating

- 6 Select the topic of biofuels or aquaculture to investigate. Research the nature of its production and how it may continue to affect food production. Present your findings in a T-chart showing arguments for and against.

Population growth

The pattern of population growth

For most of human history, the world's population grew quite slowly. Over the last 200 years there has been an explosive increase in numbers as a result of:

- settlement expanding across the planet, opening up new land for exploitation
- the development of modern agriculture, which has enabled increased food production
- better sanitation, health care and medical advances such as immunisation, all of which have helped to control the spread of diseases and resulted in death rates dropping sharply.

While the rate of population growth has slowed down considerably, the population is still rising. The United Nations predicts that 2.3 billion people will be added to the world's population by 2050, taking the total to 9.1 billion (see Figure 4.5.1). Most of this growth will occur in developing countries, because poverty is a major cause of continuing population growth.

Implications for global food security

While more people means that there are more mouths to feed, the security of food supplies is at its most tenuous where rates of population growth are greatest.

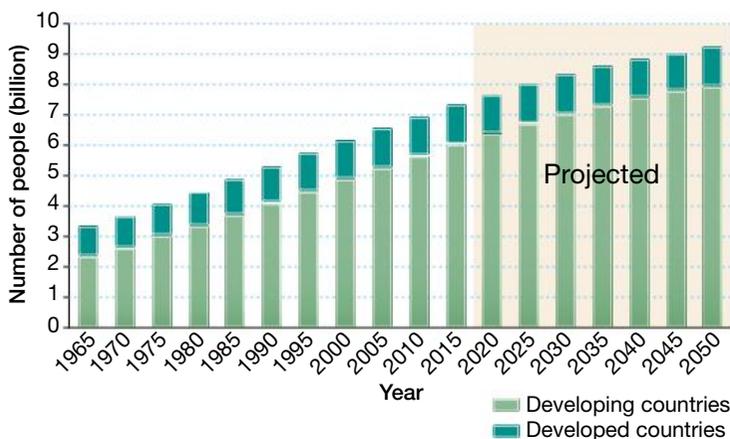
Within cities

While rural areas will still be the home of the majority of the poor and hungry for quite some time, increasing numbers of people are moving to cities. By 2050, more than 70 per cent of the world's population is expected to be urban. This growing concentration is already affecting consumption patterns: there is a growing preference for meat, dairy products, fish, fruit and vegetables and processed products, at the expense of more traditional foods such as pulses, roots and tubers. Figure 4.5.2 illustrates this change in food consumption.

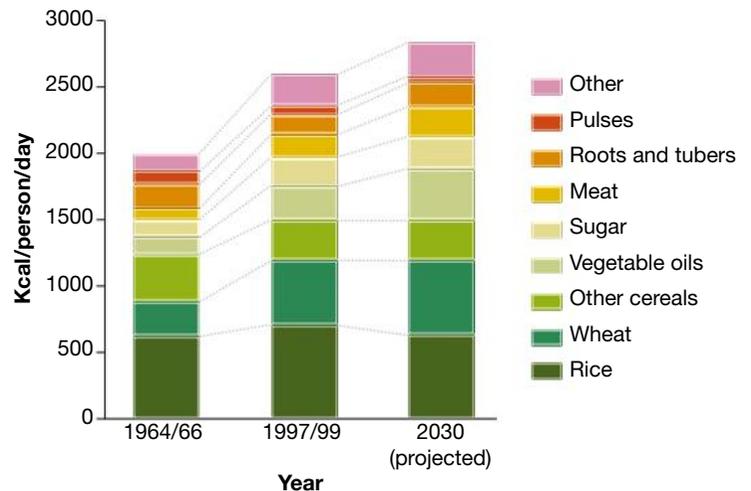
Within developing countries

If current trends continue, almost all future population growth will occur in developing countries, as shown in Figure 4.5.3. Countries such as the Democratic Republic of the Congo, Uganda and Yemen are expected to have populations in 2050 that are four to five times greater than they are now. Yet these countries already struggle with food and water shortages because of the limitations of their biophysical environments, as well as chronic poverty, a lack of education and conflict. These countries are also losing large areas of their arable fields and pastures through erosion and desertification.

4.5.1 World population, 1965–2050

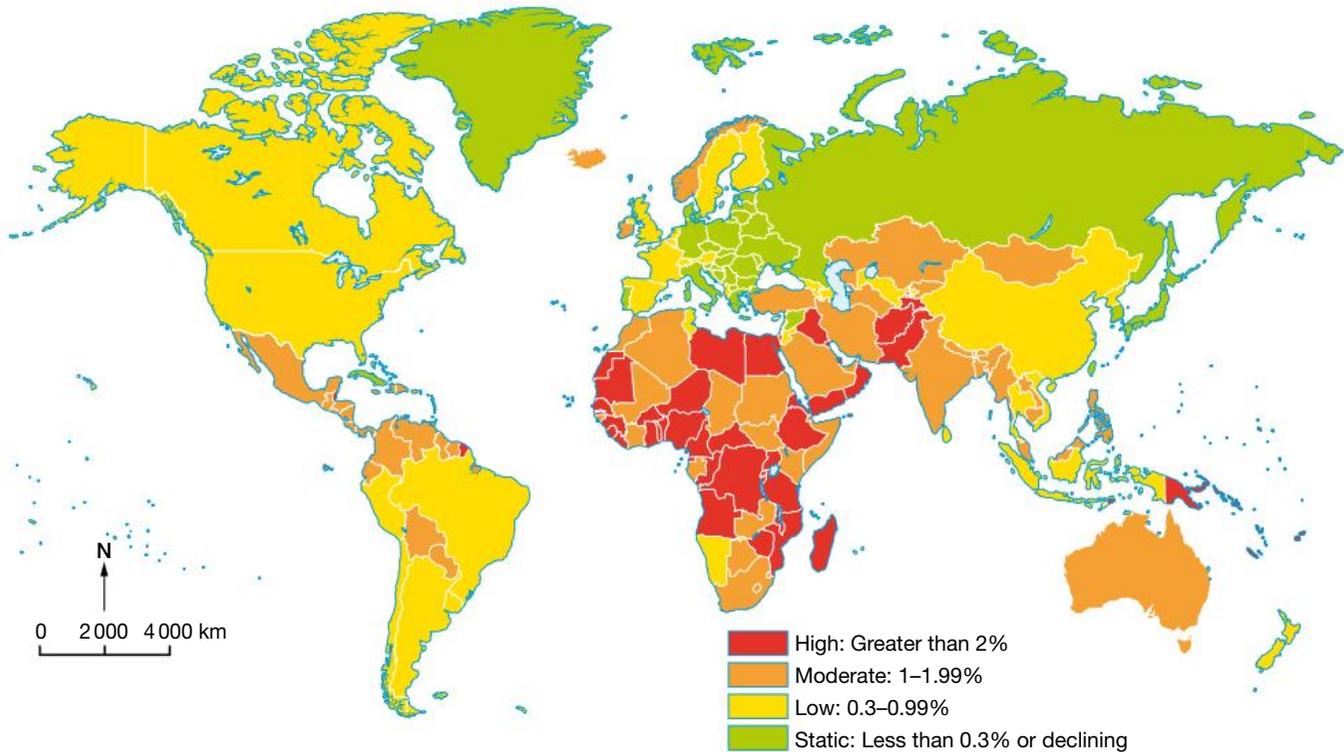


4.5.2 Global changes in food consumption



DID YOU KNOW?

On average, two people are added to the world's population every time your heart beats.



Source: CIA Factbook

4.5.3 Global rates of population increase, 2015

ACTIVITIES

Knowledge and understanding

- 1 Explain why there has been such a large increase in the world's population in the last 200 years.
- 2 Outline the United Nations prediction for the world's population in 2050.
- 3 Identify those countries that are expected to more than quadruple their total population by 2050 and explain why this will pose problems for them.
- 4 Describe what is happening to the percentage of people living in urban centres and how this will affect food consumption patterns.

Geographical skills

- 5 Study Figure 4.5.1 and complete the following table.

	Total population	Percentage in developed countries	Percentage in developing countries
1965			
1990			
2010			
2030			
2050			

- 6 Study Figure 4.5.2 and answer the following questions.
 - a What was the energy value of wheat consumed in 1997–99?
 - b What will be the energy value of wheat consumed in 2030?
 - c The consumption of which food will have decreased the most from 1964–66 to 2030?
 - d The consumption of which food will have increased the most from 1964–66 to 2030?
- 7 Study Figure 4.5.3 and answer the following questions.
 - a Which continent has the greatest number of countries with the highest rates of population increase? Explain this.
 - b Identify the continent that has the greatest number of countries with static rates. Explain this.
 - c For each category on this map, name two countries that are the largest in terms of total area.

Climate change

Climate change and farming

Climate affects almost every aspect of food production. It determines what can be grown and where. Climate influences both the quality of the produce and, most importantly, the yield. It follows then that if the climate changes then the nature of food production will also change and, most significantly, so will the amount of food that is actually produced.

Understanding climate change

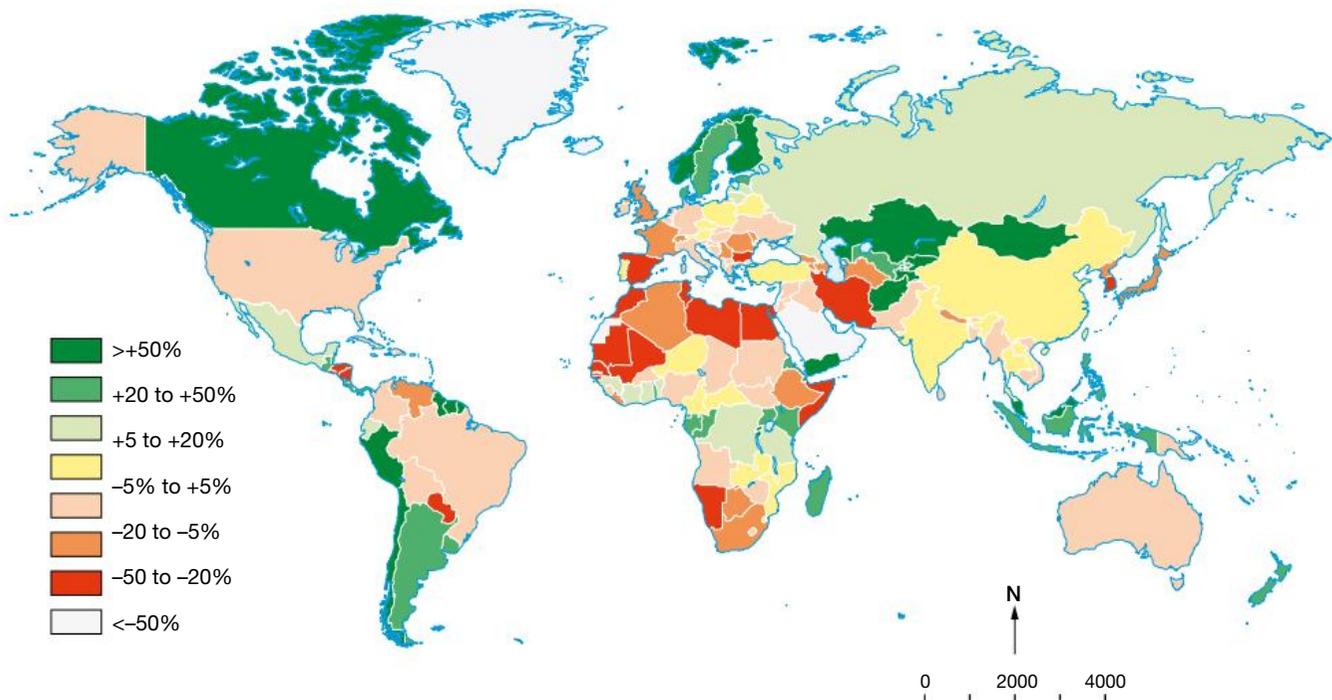
According to the 2013 report by the Intergovernmental Panel on Climate Change (IPCC), there is a 95 per cent belief that the atmospheric concentrations of greenhouse gases such as carbon dioxide, methane and nitrous oxide are rising as a result of human activity. These gases trap additional heat in the atmosphere, keeping it warmer than it would otherwise be. There is strong evidence that such changes in the composition of the atmosphere are affecting global climates. The global mean surface temperature is expected to rise between 1.8°C and 4.0°C by 2100.

Food production in a warmer world

Climate change may have disturbing consequences for food production due to an increased incidence of extreme weather events and greater climatic variability. Data collected by the IPCC strongly points to a worldwide decrease in productivity if global temperatures rise by more than 2.7°C—which is well within the range of current predictions. Rain-fed agriculture could be hit hardest, with yields halving as soon as 2020 because of prolonged and severe droughts.

While there is wide consensus among scientists that climate change is already happening, the extent of the change in various parts of the world is less clear. The geographical distribution of the impacts of climate change on food production is very uneven. An example of the impact on grain and cereal production can be seen in Figure 4.6.1.

4.6.1 Projected percentage gains and losses in rain-fed cereal production potential by 2080





4.6.2 Due to prolonged drought, the water storage level in Sempor reservoir, near Kebumen in Central Java, Indonesia, has dropped to 8.5 million cubic metres. The capacity of the reservoir is 39.9 million cubic metres.

Winners

Some aspects of climate change are positive. Rising carbon dioxide levels may increase the efficiency of photosynthesis in crops and lead to marginally higher yields. According to the IPCC report, crop productivity is projected to increase slightly in the middle to high latitudes if there is moderate warming, but then decrease if warming goes too far, which is likely to occur in the second half of this century. Most of the land found in these latitudes is in the Northern Hemisphere. Here, higher temperatures would lengthen the growing season and open up more land for cereal production. Russia and Canada could expect to benefit from moderately warmer temperatures and increased precipitation.

Losers

Although the countries of the Southern Hemisphere are not the main originators of the emissions responsible for climate change, they may suffer the most from extreme weather events, such as the droughts (see Figure 4.6.2) and floods that accompany climate change. Those areas that will first be hit hardest by climate change are those in which the poorest people live, such as Indonesia.

The IPCC predicts that rising temperatures will decrease the yields in forty developing countries, mainly in Sub-Saharan Africa, and that a 3°C increase in warming will increase the price of food by 40 per cent. This will exacerbate food insecurity in the world's poorest regions. Scientists warn that between 200 and 600 million of the world's most vulnerable people could face malnutrition and even starvation due to the effects of projected climate disruption.

Productivity is expected to decline in the coastal tropical and subtropical regions, which will experience flooding and damage caused by higher seasonal rainfall and severe storms. Rising sea levels would cover river deltas and disturb fish production in aquaculture ponds. Saltwater intrusions are already contaminating water supplies.

ACTIVITIES

Knowledge and understanding

- 1 Explain why climate is important to food production.
- 2 Outline the findings of the 2013 IPCC report.
- 3 Identify the positive aspects of climate change for food production and those parts of the world that may benefit.
- 4 Identify those parts of the world that are most at risk from climate change and explain why a drop in food production would be difficult for people living there.

Geographical skills

- 5 Study Figure 4.6.1 and do the following tasks.
 - a Identify the continent most at risk of reduced grain production due to climate change.
 - b Identify five countries that are likely to have gains in rain-fed cereal production. Explain why this would be the case there.

Agricultural expansion and intensification

Farmland

Globally, the amount of land available for agriculture is limited and most of the best quality farmland is already being used. So, increasing food production will require more intensive use of land already under cultivation. The only alternative is to expand into marginal areas that are vulnerable to land degradation and unlikely to be able to sustain adequate yields over the long term.

Forests for food

The world's most productive agricultural regions were once covered with temperate forests and grasslands. However, the forests that remain today are mainly in the tropical zone and they do not hold the same potential for supporting agriculture, as their soils quickly become impoverished once the rainforest itself is cleared. Claims that the clear-felling of the Amazon and the Congo rainforests is the answer to global food shortages cannot be justified.

Land suitability

It would appear that the world has plenty of spare land but, like water, it is not always where people need it. More significantly, not all land is suitable for agriculture. Table 4.7.1 shows the amount of suitable land by region around the world. Those parts of the world that will experience the biggest increases in food demand (as a result of rising populations) are where most of the suitable land is already under cultivation. Food demand is likely to more than double in Asia (see Table 4.7.2), yet there is only room for a modest 25 per cent expansion in cultivated land. Land shortages are even more acute in West and North Africa, where only 13 per cent more farmland is available, yet the region needs to provide one and a half times the food by 2050.

Latin America and Sub-Saharan Africa have more land available, but much of this land may never be farmed, and probably should not be.

- The tropical rainforests of Latin America were the primary source of new croplands during the 1980s and 1990s. High rates of deforestation were condemned globally, as tropical rainforests are valued for their immense biodiversity. Annual rates of deforestation and land clearing have since declined.

- The land in Sub-Saharan Africa is marginal and prone to degradation and desertification, as droughts strike often and overuse pushes the land beyond recoverable limits.

4.7.1 Usage of land suitable for agriculture, by region

Region	Cultivated area (millions of hectares)	Area suitable for agriculture (millions of hectares)	Percentage of suitable land in cultivation
Asia	439	585	75
Latin America	203	1066	19
OECD	265	497	53
Russia	387	874	44
Sub-Saharan Africa	228	1031	22
West Asia and North Africa	86	99	87
World	1600	4152	39

Source: Ghislain de Marsily, 'Water, Climate Change, Food and Population Growth,' *Revue des Sciences de l'Eau*, 21, no. 2 (2008), pp. 111–28

4.7.2 Food needed in 2000 and 2050, by region

Region	Cereals needed in 2000 (millions of tonnes)	Cereals likely to be needed in 2050 (millions of tonnes)	Growth factor
Asia	1800	4150	2.34
Latin America	272	520	1.92
Sub-Saharan Africa	262	1350	5.14
West Asia and North Africa	154	390	2.5

Source: Ghislain de Marsily, 'Water, Climate Change, Food and Population Growth,' *Revue des Sciences de l'Eau*, 21, no. 2 (2008), pp. 111–28



4.7.3 Battery chickens. Domesticated chickens (*Gallus gallus*) in a large poultry house. These birds are being intensively bred for meat production. Some of them have lost feathers from their plumage. Photographed in south west Iowa, USA.

Intensification of agriculture

Most of the future growth in food production is likely to result from the intensification of existing agriculture. The objective of the intensification is to increase the yield per hectare. This is achieved with more inputs into the land, such as irrigation water, fertilisers, herbicides and pesticides, as well as planting high-yielding seeds. Increasing high-input farming on land that is most suitable for cropping will take the pressure off agricultural expansion and encroachments into forests and marginal land.

Agriculture has changed significantly in recent decades. The first noticeable shift followed World War II, when intensive **monoculture** (the cultivation of a single crop) was favoured over **mixed farming** (a variety of crops and livestock) that had been the norm for centuries. As farming industrialised, most farmers took advantage of the high-yielding crops and the agrochemicals of the Green Revolution. Mechanisation improved their efficiency and irrigation lifted yields.

Factory farming methods were extended to livestock production as meat and dairy products became popular in the daily diet. Livestock production is becoming an industrial-scale process, whereby tens of thousands of cattle or pigs, or over 100 000 chickens, are held in a single facility and fed grains to fatten them, as shown in Figure 4.7.3. Such intensive but large-scale facilities are favoured as they are considered more efficient. So-called ‘vertical farming’ is already used in Japan to fatten cattle.

City farming

A recent innovation in intensive agriculture is city farming. There are currently rooftop gardens producing fruit and vegetables in many large cities, such as Sydney and New York. It is anticipated that whole vertical garden skyscrapers could

be used to grow food. It is estimated that a 30-storey skyscraper could feed 40 000 to 50 000 people a year. Realistically, skyscrapers would probably not be suitable for growing grains, as more extensive areas are needed for such crops.

ACTIVITIES

Knowledge and understanding

- 1 Identify the two ways in which land can be used to lift global food production.
- 2 Explain why tropical rainforests are not suitable for continual cropping.
- 3 Identify those regions of the world that face the greatest challenge in increasing food production because most of the land suitable for agriculture is already in use.
- 4 Explain how the intensification of agriculture has lifted crop yields.
- 5 Describe the intensification of livestock production.

Geographical skills

- 6 Study Table 4.7.1 and do the following tasks.
 - a Identify the region that has the lowest percentage of arable land still available for cultivation. Give reasons for your answer.
 - b Identify the region that has the highest percentage of arable land still available for cultivation. Give reasons for your answer
- 7 Study Table 4.7.2 and do the following tasks.
 - a Identify the region that needs the highest rate of increase to provide enough cereals in 2050. Give reasons for your answer.
 - b How many extra million tonnes of cereals will be needed in Asia in 2050 compared with 2000?



Food security

CHAPTER

5

Increasing population and consumption are placing unprecedented demands on agriculture and the earth's natural resources. Today, approximately a billion people do not have enough to eat, while our agricultural processes and other landuses are, in some cases, degrading the land, water resources, biodiversity and climate on a global scale. To meet the world's future food security, food production must grow significantly while, at the same time, agriculture's environmental footprint must shrink.

Strategies used to address the issue include halting agricultural expansion into areas now occupied by natural ecosystems, increasing yields on underperforming lands, increasing cropping efficiency and reducing waste. If done properly, these strategies could double food

production while reducing the environmental impacts of agriculture.

In this chapter we study the capacity of the world's environments to sustainably feed the projected future population and so to achieve food security for Australia and the world.

INQUIRY QUESTIONS

- What is the capacity of the world's biomes to achieve sustainable food security for Australia and the world?
- What are the barriers to expanding food production?
- What are the opportunities for increasing food production?
- What is meant by sustainable agriculture?

GLOSSARY

agrobiodiversity	a subset of general biodiversity that includes all forms of life directly relevant to agriculture: rare seed varieties and animal breeds; it also includes other organisms such as soil fauna, weeds, pests, predators, and all of the native plants and animals (wild biodiversity) existing on and passing through the farm	natural systems	cropping systems based on processes found in nature
agro-energy	the production of renewable energies through agriculture	net primary production	the capacity of the earth to support life through its biophysical processes
ecological footprint	a measure of the load imposed by a given population on nature	organic food	food that is produced using methods that do not involve the use of modern synthetic inputs such as synthetic pesticides and chemical fertilisers
environmentalism	advocacy for, or work towards, protecting the natural environment from destruction or pollution	perennial crops	crops that live for more than two years
		sustainable agriculture	environmentally friendly farming methods that preserve an ecological balance by avoiding depletion of natural resources

Population growth and food production

Feeding a growing population

The growth of the human population has been accompanied and supported by substantial increases in crop and animal production. The extraordinary spike in food prices in 2008, however, raised people's awareness of a number of long-term trends that had been at work for decades and which threaten global food security. Securing future global food supplies will depend on our capacity to address these issues.

While the rate of population growth has slowed, the number of people on earth is projected to continue to increase for most of this century and this will affect food availability.

Annual increases in population

Adding even more people to the planet and satisfying all their needs may well be at the expense of valuable agricultural land and involve the use of huge amounts of water and energy, both of which are needed for the production of food. By 2050, agriculture will need to produce another one billion tonnes of cereals and 200 million tonnes of livestock products each year to feed everyone.

Population growth alone will push up the price of grain. Coupled with climate change, the trends are disturbing for the countries that grow the world's three most important food crops—wheat, corn and rice.

Increasing urbanisation

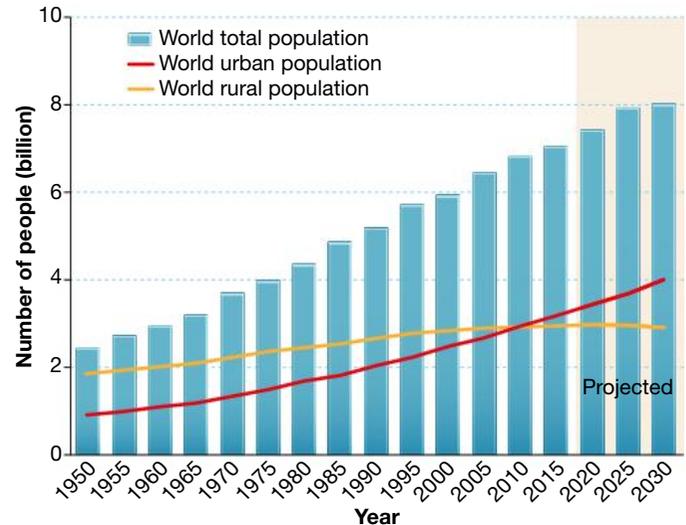
Figure 5.1.1 shows that the majority of the world's population now live in urban areas. In Latin America, Asia and Africa, the urban population will have doubled between 2000 and 2025. Ninety-five per cent of future population growth will occur in the urban areas of developing countries.

So the movement of people from rural areas to towns and cities is a trend set to continue. As rural dwellers, many families grew their own food, but as urban dwellers they must rely on buying food grown elsewhere.

Trends in food production

With the number of malnourished people increasing in the world, future agricultural production is going to have to rise faster than the rate of population growth if global food security is to be assured. The potential for expanding food supplies may well be limited by some emerging trends.

5.1.1 The urban and rural populations of the world, 1950–2030



Source: World Vision, *Get Connected*, 2009

Environmental degradation

Land and water resources and the ways in which they are used are crucial to the challenge of achieving global food security. The resource base that supports food production has been put at risk by the rapid intensification of agriculture through mechanisation, irrigation and the application of agrochemicals. Land degradation and declining water quality and quantity have become issues of real concern, especially when agricultural productivity needs to be increased but is actually falling in many areas.

The need to address the adverse environmental impacts of agriculture and restore the functioning of the natural ecosystems that support crop and livestock production is increasingly recognised. The idea that agriculture must be sustainable to meet human needs in the future is becoming widely accepted.

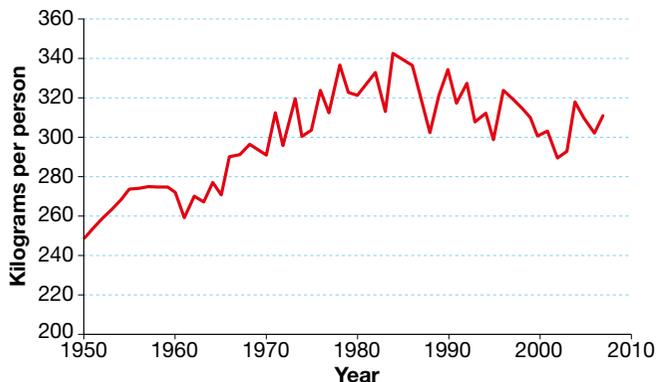
DID YOU KNOW?

According to the FAO, the number of hungry people in the world has increased, with almost 870 million people chronically undernourished in 2010–12.

Trends in crop yields

The gains in global grain production per capita that resulted from higher yields from the Green Revolution started in the 1960s, plateaued during the 1980s, and have since been in decline, as can be seen in Figure 5.1.2. As a consequence, the global grain reserve has shrunk; this triggered high prices and food riots in 2008. The slide in crop yield advances has continued and this does not bode well for future grain reserves.

5.1.2 Per capita world grain production, 1950–2010



Source: F Magdof and B Tokar, 'Agriculture and food in crisis', *Monthly Review Press*, New York, 2010

Diversion of crops to other uses

Both traditional and newly emerging demands for agricultural produce are putting pressure on already scarce resources. By 2050, the global demand for food and fibre crops is anticipated to grow by 70 per cent, but increasingly crops may be used for bio-energy and other industrial purposes rather than food.

The rush to produce biofuels has been driven by the desire of governments in Europe and the United States of America to reduce their dependence on foreign oil. They have subsidised programs to grow corn to produce ethanol and soybeans for biodiesel. The competition for land and water resources that has arisen between crops for food and biofuels has resulted in scarcities and higher prices for food.

This represents a shift in land use away from food production to **agro-energy**. It poses a risk to global food security as farmers seek higher monetary returns by using their land to grow the crops to make biofuels rather than to provide food. New arable land is also being used to provide for this rapidly expanding liquid biofuel industry. The grain that is used to produce biofuels in the United States of America in one year could feed 350 million people.

Shortage of arable land

With most of the suitable agricultural land already in production, there are growing concerns about having enough arable land available to secure food supplies.

SPOTLIGHT

Inside the meat lab: The future of food

The Dutch government is funding food-innovation research into the production of artificial meat. Behind such research is a recognition that nine billion people cannot go on eating food, especially meat, produced in the traditional way. The planet just cannot take it. While consumers may be reluctant to eat artificial meat, ethical reasons could speed up its approval. Taking stem cells from a pig, rather than killing millions of pigs in abattoirs, may be more acceptable. Furthermore, it would take only 1–2 per cent of the land and water resources that pasture or grain-fed production of meat takes.



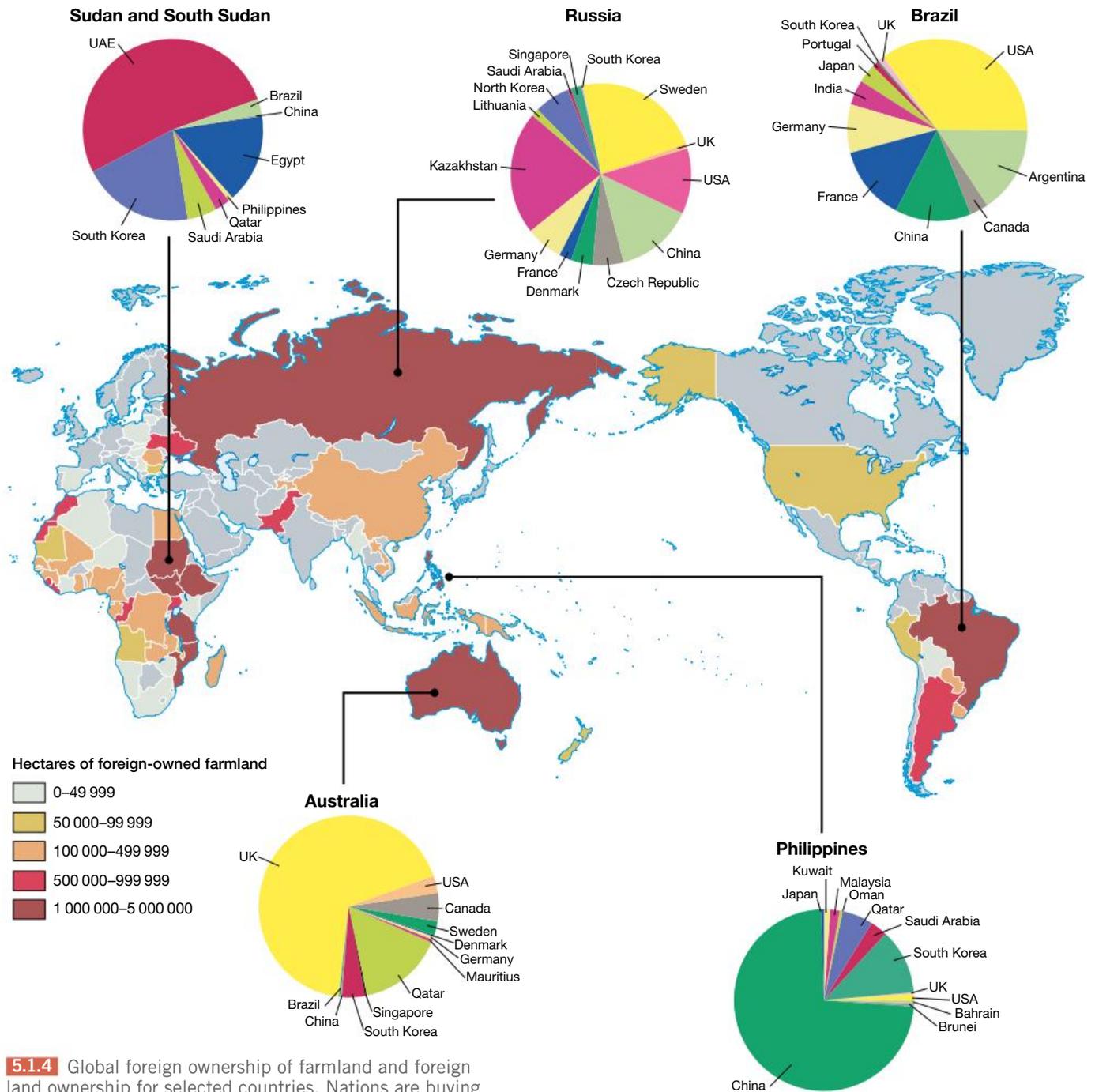
5.1.3 Dish of the day: breeding and mutating food species may be the only convincing plan anyone has for feeding the world.

The international scramble for land

A further pointer to approaching global land scarcity is the rate at which certain countries are now buying up land in others. China has proposed foreign land acquisition as a strategy, similar to its acquisition of global energy resources. China has land in Algeria and Zimbabwe. Saudi Arabia has purchased land in Ethiopia and is in negotiations with other Arab nations to purchase over 400 000 hectares of farmland in Pakistan. The world land grab is shown in Figure 5.1.4.

Control of food production

Corporations, intent on maximising profits, are increasingly controlling all aspects of food production, from seeds and fertilisers to processing and distribution. The global trade in food commodities is now dominated by a few large companies. Small producers in developing countries face many trade barriers, such as tariffs imposed by the developed countries. The developing countries do not really get a fair return for their produce.



5.1.4 Global foreign ownership of farmland and foreign land ownership for selected countries. Nations are buying farms across the world to ensure access to biofuels and fibre production, and food security.

Source: Grain Org is original source of data. Grain Org gathers data by monitoring online sources about land deals.



5.1.5 As much as half of all the food produced in the world—equivalent to two billion tonnes—ends up as waste every year.

Waste of food

An unacceptable amount of food is thrown away. This often happens in households where the food simply spoils before it can be used. Australians waste more than \$5 billion worth of food each year. Figure 5.1.5 provides a snapshot of common

food wastage. The corporatisation of agriculture also generates a lot of waste, particularly with fresh produce—fruits and vegetables are rejected if they do not meet the exacting requirements of retailers, for example if they have blemishes. Food is commonly discarded after its ‘use-by date’ is reached.

ACTIVITIES

Knowledge and understanding

- 1 Describe the pressure that population growth will put on global food security.
- 2 Explain how environmental degradation may affect future food supplies.
- 3 Describe how new demands for agricultural produce are affecting food production.

Applying and analysing

- 4 Create a PMI chart about the following statement.
Artificial food must become acceptable if the human population is to adequately feed itself in the future.

- 5 Study Figure 5.1.4.

- a With the aid of an atlas, list the countries with the highest levels of foreign-owned farmland.
- b Compare foreign ownership in Australia, the Philippines, Brazil, Russia, Sudan and South Sudan.
- c Can you suggest reasons for this pattern?

Investigating

- 6 Investigate the foreign acquisition of agricultural land in Australia. Present your findings in a feature newspaper article.

Potential for expanding food production

Meeting the needs of a growing population

In the period following World War II, which ended in 1945, the world's population began to grow rapidly. There were fears that the world might run short of food but this did not happen.

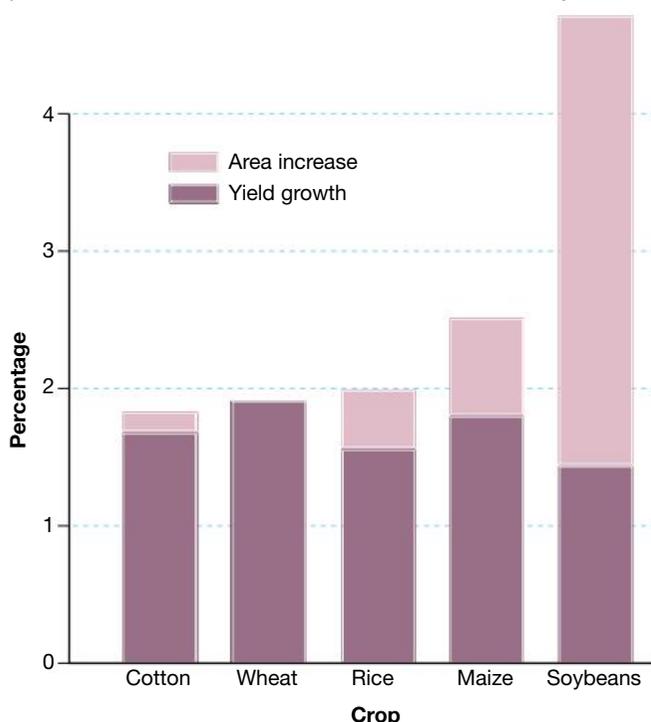
Today the world's population is well over seven billion. Estimates based on statistics from the United Nations Food and Agricultural Organization are that about 925 million people are malnourished—meaning that they do not receive enough food. The developed world, on the other hand, is facing a problem of obesity. While the population of the developing world continues to grow there is a need to expand global food production.

Green Revolution

In the 1940s, US scientist Norman Borlaug began research into improved agricultural techniques that would allow expanded food production. By the 1960s, Borlaug's research was being put into place around the world in what became known as the 'Green Revolution.'

Figure 5.2.1 shows the impact of the Green Revolution on production on the world's major crops throughout the second half of the twentieth century.

5.2.1 Impact of the Green Revolution on global crop production in the second half of the twentieth century



Expanding food production

The potential to expand food production in the twenty-first century is likely to come from four main factors:

- enhanced technologies—in particular, genetically modified (GM) crops and irrigation techniques
- improvements in the efficiency of growing meat
- decreasing food wastage
- dietary changes—especially reducing intake of animal-based food products, particularly meat and dairy.

GM CROPS

Genetically modified food is one of the most debated issues in agriculture. Many scientists believe that it holds the answer to improving food production. Modifying the genes of plants can increase production by reducing the crop losses to pests and natural events, such as drought. However, many people fear the environmental consequences and unintended health effects of such modifications.

MEAT

Meat is an increasingly important source of protein for much of the world's population. However, production of meat is a fairly inefficient process, as it requires considerable inputs in the form of land, water and energy. Improving the efficiency of these inputs will enable an increase in meat production. For example, some agricultural scientists believe that by more intensively using aquaculture (fish farming, as shown in Figure 5.2.2), we can eat more fish protein, which tends to grow more efficiently than traditional meat sources such as cattle and pigs. A more radical proposal put forward by some groups is to promote a vegetarian diet, or at least one that contains less meat and other animal-based products.

REDUCED WASTE

In 2013, a study conducted by the British Institution of Mechanical Engineers found that almost half of all the food produced in the world is wasted. Figure 5.2.3 provides an example of enormous food wastage. A study in New South Wales found that, on average, families throw away more than \$1000 worth of food each year. Reducing the amount of wasted food is a simple but highly effective strategy for ensuring the world has enough food. Education programs designed to help consumers preserve and conserve food are being developed in many countries. There is also pressure on food producers to reconsider their labelling regimes.



5.2.2 Intensive farming, as practised in these fish farms, offers possibilities for increasing protein production.

Many people argue that producers place unnecessarily short ‘best before’ dates on food in order to promote more sales by having consumers and retailers throw away the food more quickly than is required. In many countries, charitable organisations collect food from retailers to distribute to communities in need rather than allow it to be thrown away.

CHANGING DIETS

Meat and dairy production uses resources such as water and fodder. Fields are being used to grow grains to feed animals; these fields could be used to grow crops consumed by people. There are also negative environmental outcomes from animal farming, such as the methane gas produced by cattle, which accounts for about 20 per cent of the world’s methane.



5.2.3 This tomato mountain on the Spanish island of Tenerife was created after the price of tomatoes fell below the cost of exporting them.

ACTIVITIES

Knowledge and understanding

- 1 Explain why increasing food production is so important.
- 2 Describe the Green Revolution.
- 3 Describe the strategies proposed for meat production.
- 4 Outline the extent of food wastage.
- 5 Describe the strategies proposed to reduce food wastage.

Investigating

- 6 Copy and complete the following table.

Strategy	Advantages	Disadvantages
Grow GM crops		
Adopt a vegetarian diet		
Reduce consumption		
Reduce waste		

Geographical skills

- 7 Study Figure 5.2.1 and answer the following questions.
 - a By what percentage did rice and wheat production increase in the second half of the twentieth century?
 - b How much extra land was being used for soybean production by the end of the twentieth century?
 - c Describe the relationship between the amount of land used and the increase in yields.

Barriers to increasing world food production

Use of chemical agents

During the 1950s and 1960s there was a massive increase in the use of chemical agents in agriculture (see Figure 5.3.1). Pesticides, chemical fertilisers and herbicides were all widely used, allowing food production to boom. However, many of these chemicals had disastrous side-effects. For example, the chemical DDT (dichlorodiphenyl-trichloroethane) was used to control insect pests throughout the world. But DDT poisoned wildlife and is suspected of causing a number of cancers, which led many countries to ban its use. The extensive use of chemicals to control pests has also led to many insect and weed species becoming increasingly resistant to chemicals. This has the potential to decrease food production, as pests reduce productivity.



5.3.1 The extensive use of chemicals to control pests has led to many pest species becoming resistant to the chemicals.

Changing attitudes

In addition to the earth's systems simply not being able to support an ever-increasing human population, there are also important social factors that act as barriers to increased food production: the rise of **environmentalism** and the **organic food** movement.

Rise of environmentalism

Since the second half of the twentieth century there has been an increasing awareness of the impact of human activities on the earth's environment. This awareness has meant that society expects the needs of the environment to be considered along with the need for increased food production. For example, here in Australia the percentage of water available for irrigation has gradually declined in recent years as the need of river ecosystems for the water— so-called 'environmental flow'—has become more apparent. Many communities in the irrigation districts of the Murray–Darling Basin have argued that, as environmental flows are increased, their capacity to grow food has declined. Environmentalists argue that without the environmental flows the entire river system could collapse.

Organic food movement

Many scientists believe that modifying the genes of major food crops to increase their yields could be the answer for increasing world food production. However, there are considerable social barriers to this. Many people fear that genetically modified food may cause disease and other problems in the same way that chemicals such as DDT did in the past. Figure 5.3.2 shows a Greenpeace protest against the production of genetically modified foods.



5.3.2 Anti-GM protest, Berlin

SPOTLIGHT

Net primary production

Net primary production refers to the capacity of the earth to support life through its biophysical processes, for example through the capacity of soils to support plant growth. Human appropriation of net primary production (HANPP) is a measure of the extent to which humans have taken over the earth's systems to support themselves. Estimates of HANPP vary widely. Some studies have found that it is as high as 83 per cent while others put it as low as 35 per cent. Most researchers, however, believe that HANPP is 50–60 per cent of the total net primary product of the earth.

Even at the lowest estimate, the extent to which humans are consuming the world's resources is staggering, leaving less and less for the rest of the planet's species. Ultimately there is a limit to HANPP—and that limit is approaching. The world's fish stocks are an example. Over the last few decades the total number of fish caught has been in steady decline, despite the fact that fishing technology has improved considerably. There are simply fewer fish to catch, as humans have overfished many key species and fishing grounds.

5.3.3 Overfishing has seen global fish stocks decline. The total number of fish caught globally is in decline.



ACTIVITIES

Knowledge and understanding

- 1 Explain how food production was increased throughout the second part of the twentieth century.
- 2 Outline the cause of chemical resistance among pest species.
- 3 Describe the concept of net primary production.
- 4 Explain why environmentalism can be seen as a barrier to world food production.

Applying and analysing

- 5 As a class, discuss the concept of whether humans have the right to appropriate net primary production. What are the implications of this for the world? Following your discussion, write an exposition outlining your views on the topic.
- 6 Discuss the following topic with a partner.
Feeding the world's population is more important than protecting the environment.
List the views that you and your partner discussed.

Sustainable agriculture

Sustainability

Sustainability is central to the future of food production because it is aimed at meeting of the needs of the present generation without compromising the ability of future generations to meet theirs. This involves farmers understanding the ecological processes that support their production of crops and livestock, and working with nature rather than against it.

Importance of sustainable agriculture

Sustainable agriculture is the growing of crops and raising of livestock in ways that mimic and support natural ecological processes. It involves the use of farming practices that utilise organic fertilisers and biological pest controls, as well as minimise disturbance of the land surface, water use and the reliance on non-renewable fossil fuel energy.

The future of agriculture and the ability of the world's food system to provide food security for a growing population are closely linked to the improved stewardship of natural resources. Major reforms and investments are needed in all regions to cope with rising scarcity and degradation of land, water and biodiversity, with added pressures resulting from rising incomes, climate change and energy demands. There is a need to develop and implement the incentives needed to harness agriculture's environmental services, to protect watersheds and biodiversity, and to ensure food production using sustainable technologies.

More sustainable production

The world faces some serious long-term challenges to food production. These come from limits to the resources that support it, including land and water as well as energy. The onset of climate change adds even more uncertainty. What is clear is that a strong natural resource base is crucial to the planet's capacity to produce food. This productive capacity must be maintained in order to provide the food security necessary for future generations.

Environmental costs of industrial agriculture

The main environmental impacts of industrial agriculture come from the conversion of **natural systems** to agricultural production systems. Modern industrialised agriculture is

considered unsustainable because it violates a number of important principles that are considered fundamental to ensuring the future well-being of humans.

- It relies heavily on the use of fossil fuels to power farm machinery and for transport and food processing. Many of the agrochemicals that are used are petroleum-based. This adds greenhouse gases to the atmosphere, which is driving climate change.
- It reduces biodiversity, as natural habitats are cleared for farming. **Agrobiodiversity** is also being lost, which will limit the potential strains of crops that may be needed in the future, especially as climate change affects agriculture.
- As crops are harvested and removed for consumption elsewhere, the cycling of plant nutrients back to the topsoil is halted. This results in the need to use artificial fertilisers to support continued cropping.

Sustainability experts agree that future food supplies can only be assured if there is a determined shift to more low-input agricultural systems over the next few decades. Figure 5.4.1 lists the major components of more sustainable agriculture. Compared to the high-input industrial farming, low-input agriculture uses less energy per unit of yield and has lower carbon dioxide emissions. It also lifts topsoil fertility, can often be more profitable for the farmers and is especially helpful to poor farmers trying to feed themselves.

Sustainable farming practices

Sustainable agriculture is an approach to managing farming practices that will protect and enhance the resource base of the biophysical environment, thereby enabling continued productivity. This generally occurs through small-scale diversified farming systems that imitate nature and therefore need fewer inputs from outside the farm. It involves:

- minimal soil disturbance
- permanent ground cover
- a variety of crop/pasture species grown in rotation and/or association to retain soil fertility and guard against pests and weeds.

Sustainable agriculture encompasses a wide range of techniques, including organic, free-range (increasingly popular in egg production), low-input and biodynamic farming.

Organic farming

Organic farming emphasises a holistic farm management approach, the benefits of which are shown in Figure 5.4.2. Crop rotations and animals play an important role in the

production system. This approach to farming involves growing crops without any synthetic pesticides, synthetic fertilisers or genetically modified seeds. Livestock are raised without any feed additives or synthetic growth promoters.

5.4.1 More sustainable low-input agriculture is based mainly on mimicking and working with nature.

More

- high-yield polycultures
- organic fertilisers
- biological pest control
- integrated pest management
- efficient irrigation
- perennial crops
- crop rotations
- water-efficient crops
- soil conservation
- subsidies for sustainable farming



Less

- soil erosion
- soil salinisation
- water pollution
- aquifer degradation
- overgrazing
- overfishing
- loss of biodiversity and agrobiodiversity
- fossil fuel use
- greenhouse gas emissions
- subsidies for unsustainable farming

Source: G Tyler Miller and C E Spoolman, *Living in the Environment*, 2012

5.4.2 Benefits of organic farming

Organic farming

- improves soil fertility
- reduces soil erosion
- retains more water in soil during drought years
- uses about 30 per cent less energy per unit of yield
- lowers CO₂ emissions
- reduces water pollution by recycling livestock wastes
- eliminates pollution from pesticides
- increases biodiversity above and below ground
- benefits wildlife such as birds and bats



Source: G Tyler Miller and C E Spoolman, *Living in the Environment*, 2012

SPOTLIGHT

Ladybirds—friends to farmers

Ladybirds help farmers protect crops, as they consume plant-eating insects such as aphids. On organic farms, planting systems can place suitable habitat for ladybirds on the edges of paddocks. The ladybirds have been known to travel over 80 metres into adjacent crops to feed on insects. Field tests

have demonstrated the benefit of strip harvesting a crop rather than clear-cutting an entire field. Strip harvesting leaves part of the plant behind, which the ladybirds can then feed on. This allows the ladybirds to survive.

5.4.3 The ladybird is a good insect to have within a crop. As soon as ladybirds hatch, they begin to feed, taking out 5000 aphids in their brief 3–6 weeks of life.



FERTILITY AND PEST CONTROL

The fertility of the soil is enhanced with manure, compost or nitrogen-fixing legumes that replenish the soil in crop rotations. Harmful pests are kept at bay

by planting crops that repel harmful bugs or attract good bugs, which then eat harmful bugs, as shown in Figure 5.4.4.



5.4.4 Fennel is planted alongside other crops to ward off insects and rodents, which are deterred by its smell.

How to feed a hungry world sustainably

The real challenge in coming decades is going to be how to expand agricultural output on existing agricultural land. The critics of industrial agriculture insist on a return to low-input, small-scale agriculture, but this would most likely lead to mass starvation. The reality is that both types of agricultural production are needed in order to feed the world through the mid-century peak in food demand.

High-input agriculture will be necessary to grow the far bigger volumes of food for the huge urban-based populations. Low-input agriculture will not be able to achieve the higher yields in the staple grain crops that will be needed. However, there are a billion subsistence farmers in developing countries who could improve their output using organic farming. A 2008 study by the United Nations Environment Programme surveyed 114 small-scale farms in twenty-four African countries and found that yields more than doubled when organic farming practices were used.

The way forward may be a sustainable intensification of agriculture that makes more effective use of land and water resources without causing them any harm. This will require agricultural research into crop varieties that provide

higher yields using fewer inputs such as water and fertiliser. Innovations used in precision agriculture are a move in the right direction to address adverse environmental impacts.

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'sustainable agriculture'.
- 2 Outline the main principles that modern industrialised agriculture violates.
- 3 Describe the approach of organic farming.

Applying and analysing

- 4 Create a PMI chart about organic agriculture.

Investigating

- 5 Insectary plants are those that attract insects such as ladybirds. Investigate the role of insectary crops. Prepare an annotated visual display of a selection of such crops.
- 6 Investigate one of the following types of sustainable agriculture: free-range, low-input or biodynamic farming. Prepare a feature article for a rural publication to inform farmers about the benefits of this type of agriculture.

The environmental impacts of agriculture

Industrialised agriculture

The shift towards large-scale industrialised agriculture in the search for higher yields has damaged the environment, thereby restricting the resource base that supports it. The implication of this damage for the security of the global food supply is obvious and has prompted efforts to repair the damage done by agriculture and to develop strategies for making it more sustainable.

Threatened ecosystem

Many of the earth's natural resource bases show worrying signs of degradation. According to the Millennium Ecosystem Assessment, fifteen out of twenty-four ecosystem services examined are already being degraded or used unsustainably. These include the world's fisheries and water supply. In addition, actions to intensify other ecosystem services, such as those associated with food production, often cause the degradation of others. Soil nutrient decline, erosion, desertification, depletion of freshwater reserves, loss of tropical forest and declining biodiversity are clear indicators. Unless investments in maintenance and rehabilitation are increased and landuse practices are made more sustainable, the productive potential of land, water and genetic resources (the diversity of plant and animal life) will continue to decline at alarming rates.

Environmental management

In too many places, increased production has been coupled with management practices that have degraded the land and water systems on which the production depends. Exposure of the damage done by chemical pesticides was a major factor in the rise of the environmental movement. Modern agriculture has moved well beyond the practices of industrialised agriculture that were justifiably criticised in the 1960s, and the worst of the chemicals have been banned. They have been replaced by chemicals that are just as effective when applied at lower concentrations and are less persistent in the environment. Today, many chemicals are inert once they hit the ground. Total chemical use on farms in the United States of America peaked in the 1970s and has since declined.

Innovations that reduced the environmental impact of agriculture gained momentum during the 1970s and have continued to be developed. Responsible farmers embrace the importance of addressing the adverse impacts of their practices because they realise that the success of their future production

lies with the ability of their land to continue supporting crops and pastures. Without such awareness their profits decline and the viability of their farms is put at risk.

Repairing the damage

Reducing the impact of agriculture on the wider environment has involved the adoption of farming techniques that protect soil cover and return its fertility, and that use water resources efficiently and do not load them with pollutants.

Land used for agriculture must have fertile topsoil, which takes thousands of years to form. So the single most important aspect of achieving more sustainable agriculture is to stop soil erosion and repair the land. Soil conservation strategies include a variety of measures that reduce topsoil erosion by slowing down the rate of flow of water that carries away the soil particles, as well as helping retain the water within the soil for the crops to use (see Table 5.5.1).

DID YOU KNOW?

Precision agriculture in the future might involve small solar-powered robots moving through the paddocks digging out weeds, picking off insects and harvesting crops, without needing any agrochemicals or fossil fuels.

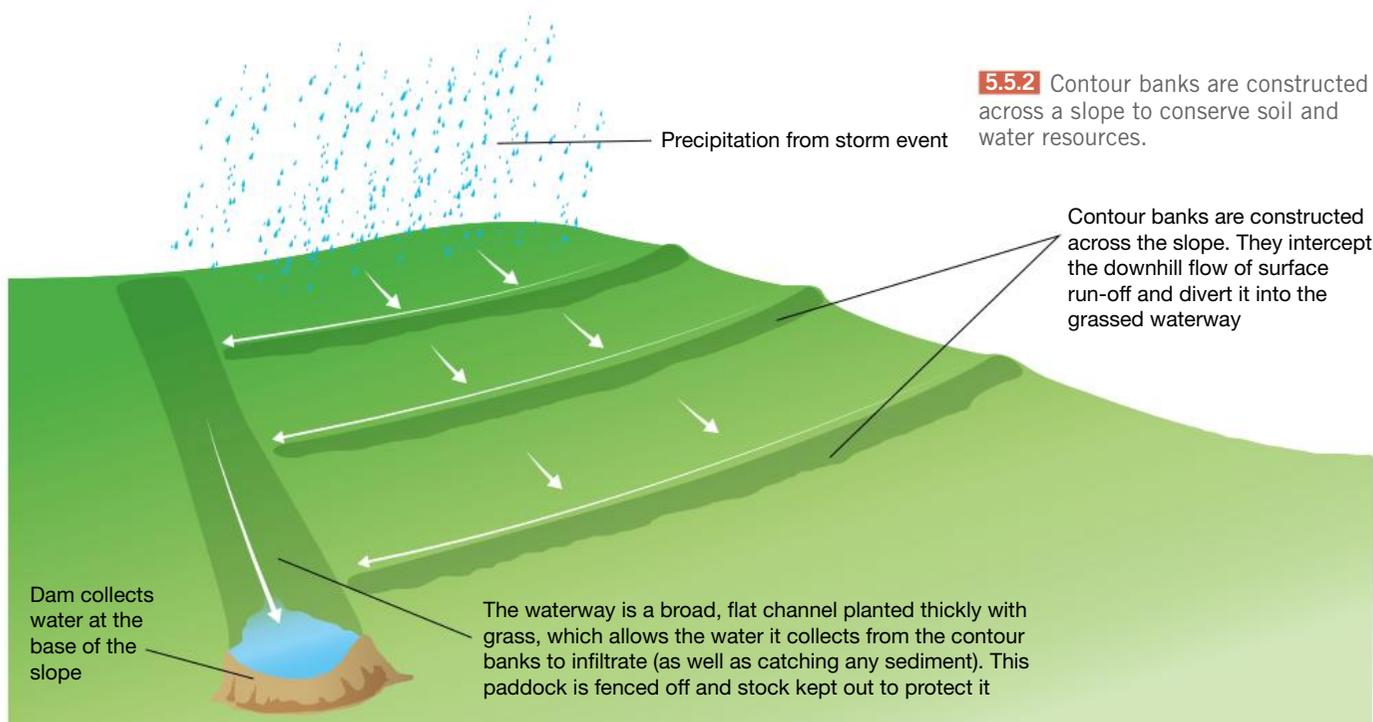
SPOTLIGHT

The greening of agriculture

The greening of agriculture does not rule out technologies or practices on ideological grounds. If a technology works to improve farmers' productivity and does not cause undue harm to society and/or the environment, then it is very much part of the efforts for making agriculture more sustainable. Although natural methods of pest and weed management are an example of green agriculture, the highly efficient and precise use of inorganic fertilisers, pest controls and technological solutions may also be included in the broad range of sustainable farming practices. So the greening of high-input agriculture, which has a high **ecological footprint**, could start by making use of inputs that are the most precise and efficient, gradually moving towards farming practices that have low or no ecological footprint.

5.5.1 Conservation strategies used to repair and protect the land used for agriculture

Conservation strategies		
Terracing		Terracing enables steep slopes to be cultivated by converting the slope to a series of broad, nearly level steps that run across the contour of the land. Small banks on the outer edge of each terrace also catch the water and retain it for the crop to use.
Contour planting		Running water can quickly cut into and erode a slope if it runs straight downhill. Ploughing and planting a crop across the slope, following the contours of the land, helps to slow run-off and reduce erosion. Farmers also construct contour banks that effectively divert the water across the slope. The water runs into broad, flat, grassed waterways that safely discharge the water into a dam at the bottom of the slope.
Strip cropping		Strip cropping involves planting alternating strips of crops in various stages of growth. When one crop is harvested, or the soil is cultivated for planting, another crop that covers the ground will catch excess water running off. This will then infiltrate the ground and the plant cover will trap any soil particles being carried along by the water. The inclusion of nitrogen-fixing cover crops lifts soil fertility.
No-till farming		When crop residue or stubble is left lying on the ground after harvesting, it not only holds onto the topsoil, but as it decomposes it returns nutrients to the soil. New technologies enable the farmer to direct-drill the seeds into the undisturbed topsoil without any cultivation or tilling, which leaves the land bare to wind or water erosion. No-till farming also reduces water pollution from sediments and agrochemicals in solution that may flow off unprotected, ploughed paddocks.
Alley cropping		With alley cropping, one or more crops are grown together in rows or alleys between orchard trees or fruit-bearing shrubs. The trees provide shade, help retain water and provide mulch and nutrients for the crops.



5.5.3 Selected evidence on benefits and costs of soil management strategies

Strategy	Crop and country	Costs	Benefits	Trends in revenues and profits after including additional costs of greening
Use of nitrogen-fixing fodder and cultivating green manure	Cultivation of maize in Spain and rice in India, Indonesia and the Philippines.	Costs varied depending on methods and country. Rice straw use (for green manure) costs ranged from US\$18/ha in Indonesia and the Philippines to \$US40/ha in India. Azolla (type of fern) for nitrogen fixing and green manure meant additional costs ranging from US\$34/ha in India to US\$48/ha in the Philippines.	Maize crop yields increased approximately 40% in the first year, 5% in the second year and 20% in the third year. No significant increases in yields were observed in rice crops compared to the use of inorganic fertilisers but there were long-term soil improvements.	Revenues increased even though there was no difference in the costs of using green manure or inorganic fertiliser for rice crops.
No-tillage practices	Maize in Mexico, wheat in Morocco and cereal grain crop in England. Sorghum and maize in Botswana. Maize, sorghum and cowpea in Nigeria. Soybean in Australia.	The capital costs for a small-scale no-tillage planting system are estimated to be US\$25 000 to \$50 000. No-tillage system was cheaper by US\$156/ha when rented from a contractor in England, compared to renting tilling systems. In Botswana, cost per household of tractor was US\$218.	Maize yields increased by 29 per cent; wheat yields by 44 per cent. No impact on total cultivated areas, crop yields and total crop output in traditional tillage systems vs. animal power or manual usage (Botswana and Nigeria). An average yield increase in soybean yields of 27% over 14 years in no-tillage vs. till systems.	No-tillage systems are economically profitable, even after incorporating the costs of installing them.
Biochar use	Cultivation of maize intercropped with soybean (Columbia) and wheat (USA).	Biochar production costs range between US\$87 and \$350/tonne depending on source of inputs and mode of production.	Maize crop yields increased after the first year, by 28%, 30% and 140% in the last 3 years of the study. No impact was seen on soybean crop yields.	In the USA, wheat production increased sufficiently to generate a profit of US\$414/acre, but only while using low-price biochar. Higher-cost biochar reduced profits.

5.5.4 Auto-steer tractors are guided by GPS systems.



FARMING STRATEGIES

Table 5.5.1 and Figure 5.5.2 illustrate different strategies used by farmers to repair the land and conserve both water and soil resources. Evidence of the benefits and cost of such soil management strategies can be seen in Table 5.5.3.

Precision farming

Improvement in food security across the world will come from the sustainable intensification of agriculture on existing land. It will involve practices that make effective use of land and water resources without causing any damage. Environmental gains have been made by the emergence and acceptance of low-impact and precision farming (see Figure 5.5.4). Practices such as installing drip-irrigation systems in laser-levelled fields, where peizometers (soil probes) are linked to computers that switch them off when optimum soil water levels are achieved, have improved water efficiency and prevented excess run-off. Infra-red sensors that assess the greenness of a crop enable farmers to then apply the correct amount of additional fertiliser needed.

ACTIVITIES

Knowledge and understanding

- 1 Assess the state of the resource base that supports agriculture.
- 2 Explain why concern for the environmental impact of agriculture arose.
- 3 Describe how this affected the use of fertiliser.
- 4 Identify the most important aspect of sustainable agriculture.

Applying and analysing

- 5 List the arguments for and against the following statement.
Agricultural production should return to natural methods that do not harm the environment.
- 6 Study Table 5.5.1 and draw photo sketches of each of the conservation strategies. Annotate each sketch to show how they are designed to conserve soil and water resources.

Restoring the functioning of ecosystems

Annual crops

When humans started cultivating wild plants 10 000 years ago, they went for annuals, as they were fast-growing and, importantly, had large seeds. Since then, the seeds of the most productive plants have been replanted year after year. Now, all the grains that feed billions of people—wheat, rice, corn and soybeans—come from annual plants. They last only for a single season, as they will not regrow after the grain has been harvested. Seeds must be resown to regenerate new plants every year.

While annual varieties have given big yields, the land used for growing them has suffered since agriculture began. Conventional methods of planting seeds for a new crop require the ground to be broken up, using ploughs, to create a fine seedbed. Every time a paddock is ploughed to plant an annual crop (and also when the crop is harvested), the land is left unprotected, and valuable topsoil is washed or blown away.

The problem is made worse by the shallow root systems of annuals. They occupy only the top 0.3 metres of the soil and die after harvest. The top layer of the soil is quickly depleted of nutrients, forcing farmers to apply large amounts of fertilisers to maintain yields. The plants usually take less than half of this up, with the rest washing into waterways. Annual crops need the frequent input of many resources to remain productive and fend off pests and diseases. Such agriculture is heavily dependent on fossil fuels, not only to power farm machinery, but also to manufacture many of the petroleum-based fertilisers and agrochemicals.

Reinventing agriculture

There is growing recognition of the merits of developing grain-cropping systems that will function much more like the natural ecosystems that agriculture displaced. The push is coming from agronomists, plant breeders and ecologists, who are seeking a more ecologically sustainable approach to agriculture that works with, rather than against, nature.

Maintaining annual monoculture is the problem in many places, and the solution may lie in restoring the functioning of ecosystems. This involves copying nature by growing a variety of **perennial crops** in diverse ecosystems that replicate nature. The key to sustainable food production may involve developing grain-cropping systems of perennials that can live for many years and develop deep root systems.

Perennial grains

Perennials may start off at a disadvantage when compared with annuals, as there is little to be harvested in the first year. Once they become established, however, the benefits soon become evident, as illustrated in Figure 5.6.1.

- They have deep root systems that protect soils. The massive underground root mat can extend to over 2 metres below the ground. This holds the soil particles in place and increases the infiltration of water. As perennial plants are long-lived, the land surface remains covered with vegetation and does not have to be ploughed for planting each year.
- They are efficient managers of water and nutrients. Perennials can capture both water and nutrients to a great depth, enabling the plants to cope with weather extremes. The roots host numerous micro-organisms that are critical to maintaining a healthy soil, as can be seen in Figure 5.6.2, and restore efficient nutrient cycling within the ecosystem.
- They exclude weeds and pests. As weeds find it difficult to get a hold in the dense cover of plants, herbicides are generally not needed. With the diversity of plants there is not a proliferation of the pests that are attracted to monocultures.

DID YOU KNOW?

Maize, or corn, originated in the Americas and was taken to Europe in the 1400s. The maize plant was first grown about 10 000 years ago in what is now Mexico. On average, an ear of corn has 800 kernels in 16 rows and will always have an even number of rows on each cob.

Ongoing research

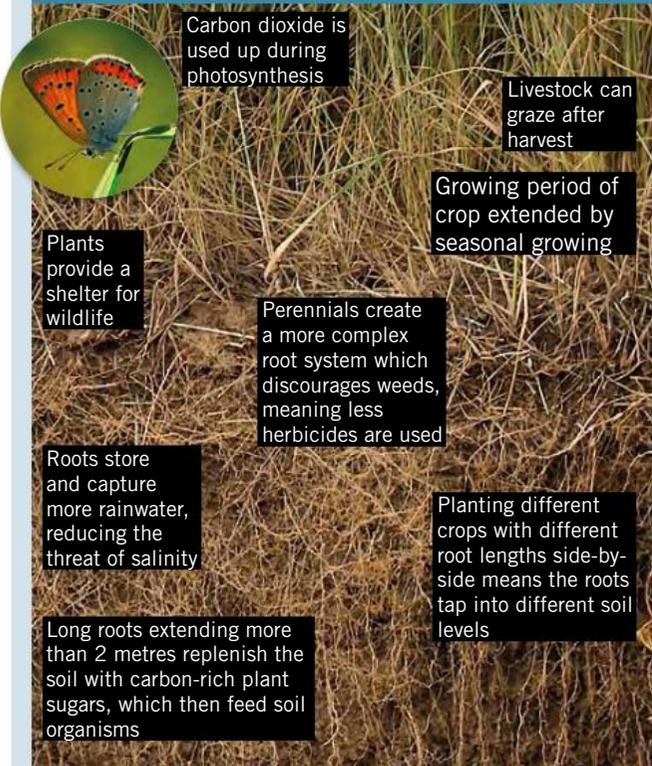
The idea that the future of farming may well lie in returning to cropping that mimics natural ecosystem functioning using perennial crops is decades old; however, it is still in the experimental stage. Significant advances are being made in the plant-breeding science to improve the yield of different varieties of perennial crops.

SUSTAINABLE FARMING: NEW VS NOW

The following diagrams compare growing a perennial grain crop (left) and annual wheat (right). By growing perennial crops, farmers can use resources more effectively and be

more productive in the long term. While annual, short-lived and short-rooted crops result in water and soil nutrient loss; perennial crops benefit their ecosystem.

Perennial



Carbon dioxide is used up during photosynthesis

Livestock can graze after harvest

Growing period of crop extended by seasonal growing

Plants provide a shelter for wildlife

Perennials create a more complex root system which discourages weeds, meaning less herbicides are used

Roots store and capture more rainwater, reducing the threat of salinity

Planting different crops with different root lengths side-by-side means the roots tap into different soil levels

Long roots extending more than 2 metres replenish the soil with carbon-rich plant sugars, which then feed soil organisms

Annual



Many inputs by farmer: machinery to plough and sow seeds, to fertilise the soil and apply herbicides. All this uses fossil fuels and generates carbon dioxide

Topsoil not bound by deep roots is subject to wind and water erosion

Fields are often barren most of the year

Herbicides and fertilisers run off into waterways

Shallow and small roots do not access water deep in the soil

Nitrogen from soils and chemical run-off creates dead zones in waterways

Short growing season means crops do not capture sunlight, nor enrich the soil with carbon-rich plant sugars

5.6.1 Sustainable farming: new vs now



5.6.2 Roots in the soil sample on right, collected more than 1 metre deep in a meadow of perennial prairie plants, feed the soil's many living organisms. The teeming life in turn builds dark healthy soils. The lighter soil on the left was collected at the same depth from an adjacent annual crop field.

ACTIVITIES

Knowledge and understanding

- 1 Define both annual and perennial crops.
- 2 Explain why the first farmers chose to domesticate annual plants.
- 3 Outline why the cultivation of annual crops may be responsible for the problems being experienced in agriculture today.

Applying and analysing

- 4 Study Figure 5.6.1 and assess how each approach to agriculture supports ecosystem functioning.
- 5 Why do you think large agribusinesses that produce seeds, fertilisers and agrochemicals oppose the development of perennial crops? Should more government funding be directed toward researching such sustainable technologies?
- 6 Conduct a class discussion before writing a letter to the editor of a national newspaper with your opinion of perennial cropping and its place in modern agriculture.

Australia and the global food chain

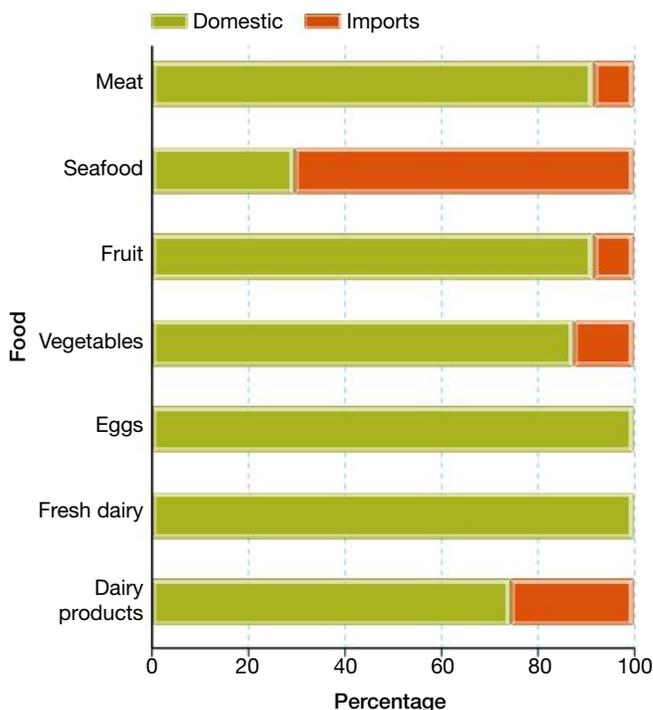
Food production in Australia

Food production in Australia makes an important contribution to international food supplies. Our open and export-oriented economy ensures that our food producers are competitive in the global market. Our agricultural land currently feeds 60 million people globally. It is in our interests to improve global food security, as it is fundamental to political and social stability, especially in our region.

Australia's food supply

Australia is in the fortunate position of having an abundant and diverse food supply and the capacity to maintain this for decades. As an affluent country, we can also afford to import additional food as desired, as is shown in Figure 5.7.1.

5.7.1 The various sources of food as a proportion of the total food volumes consumed in Australia



Australia has a long history of producing food on a commercial scale and does so on the driest inhabited continent on earth, where fertile soils are limited and the weather is variable. Despite these limitations, Australia is an efficient and surplus food producer. Over 90 per cent of all the fresh produce (milk, meat, eggs, fruit and vegetables) eaten by Australians is produced within the country.

The economic value of food production in Australia

The total gross value of farm and fisheries production (excluding non-food production such as timber, wool, cotton, fibres and pearls) in 2012–13 was \$42.8 billion. The major components were grains and oilseeds (\$14.1 billion), meat (\$13.2 billion), fruit and vegetables (\$7.7 billion), milk (\$4.2 billion), seafood (\$2.1 billion) and other food (\$1.5 billion). Figure 5.7.2 shows the economic value of food in Australia.

Importing food

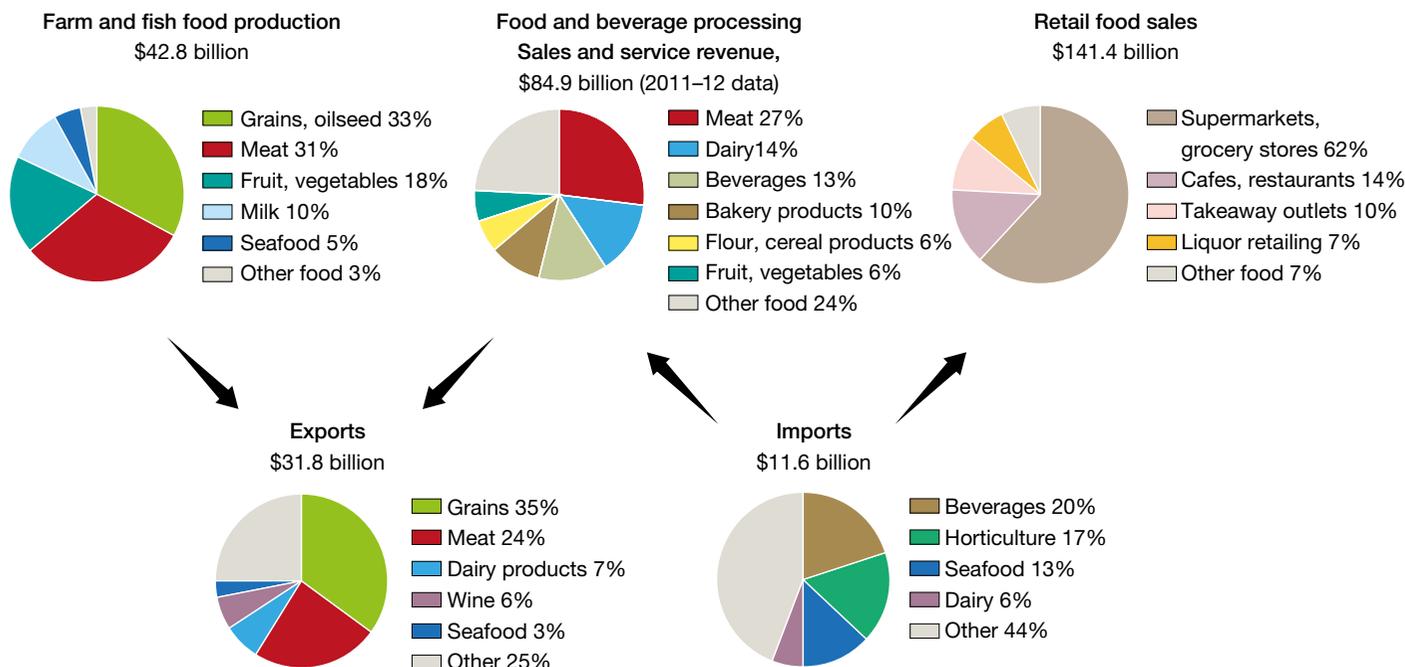
While Australia has ample food supplies, it is not entirely self-sufficient. No country is able to achieve full food security at all times. There are risks associated with food production and there are times when a natural disaster or a crop failure necessitates food to be imported. Imports are also necessary to provide consumers with produce that is out of season and to keep up the inputs of food processors.

Food consumption patterns in Australia have also changed, reflecting the growing cultural diversity of the population. Supermarket shelves and specialty stores carry a variety of international fresh and processed food products. The surge of interest in food following the growing popularity of reality cooking shows has also contributed to more diverse tastes, which often require ingredients that are sourced overseas.

SPOTLIGHT

The changing cherry scene in supermarkets

Cherries are picked in Australia over a period of 100 days in spring and early summer, which used to be the only time Australians could enjoy fresh cherries. The official start of the stone fruit season is traditionally marked with an auction of the first box of cherries at the Sydney markets, which in 2013 raised \$50 000 for charity. Nowadays, cherries can also be bought in the fruit section of a supermarket all year round, as they are shipped in from the United States of America in a near-frozen state.



5.7.2 Value chain for food in Australia, 2012–13

Australia's trade advantages

Australia is well placed to be a major player in the global trade in food, especially as we possess a number of significant advantages over our competitors.

Climatic diversity

As Australia extends so far from the tropical north to the cooler, temperate latitudes of the south, there is a great variety of climates across the continent. This enables a diverse range of produce to be grown, from bananas in northern Queensland to apples in Tasmania.

Locational advantages

As most of the lucrative international markets for food are in the Northern Hemisphere, Australia is in the fortunate position of having a counter-seasonal advantage, in that our seasons are the opposite of theirs. This enables Australia to provide produce that is out of season in the Northern Hemisphere countries.

Australia is also in a favourable geographic location to take advantage of the likely surge in demand for food in the fastest-growing economies of the world. The rise of an Asian middle-class has been accompanied by a change in food consumption patterns towards high-value products such as meats, seafood, vegetable oils and dairy products. Food and beverages, especially wine, have become symbols of wealth and status.

The Chinese government is encouraging people to drink wine instead of spirits, as wine is considered a better health option and does not rely on processing precious grains and cereals that are needed to feed the growing population. Consequently, China offers enormous potential for Australian wine producers.

SPOTLIGHT

Seizing new market opportunities

A growing world population—and changing consumption patterns in Asia—will provide new opportunities for Australia's export food industry. The value of the world's food demand is expected to rise by 77 per cent by 2050 (in real terms). Most of this growth will occur in Asia, where demand is expected to double. This gives our food sector strong prospects over the long term, given our proximity to Asia and strengths in key growth commodities such as beef, wheat, dairy products, sheep meat and sugar. Growth opportunities will not be limited to food commodities; strong growth in the demand for processed food is also expected.

Australia's role in global food security

Australia may contribute less than 3 per cent of global food trade, but we are one of the net food-exporting countries in the world and have the capability to substantially increase food production in the future. The key to ensuring global food may well be innovation, and this is where Australia is at the forefront, as we now rank among the best in the world for research and development. Australia has also built strong partnerships with developing countries within our region in delivering technological advancements and supporting their implementation.

5.7.3 Main exports of the Ord River region and their destinations

Legumes: Chickpeas, borlotti beans, dark red kidney beans and cannellini beans

Australia, New Zealand, Italy, Spain



Chia

Australia, North America, Middle East, Europe



Cotton

Queensland, China, India



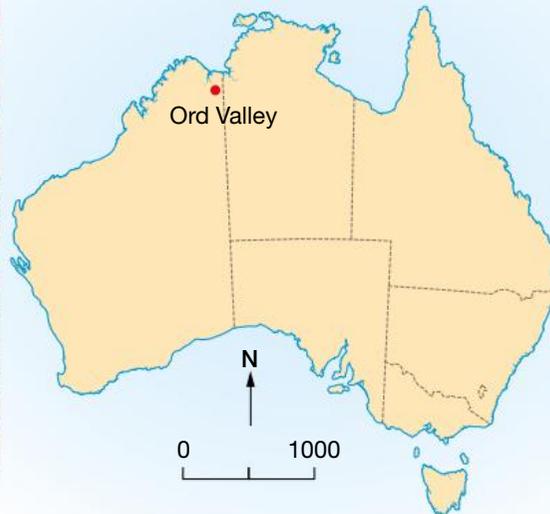
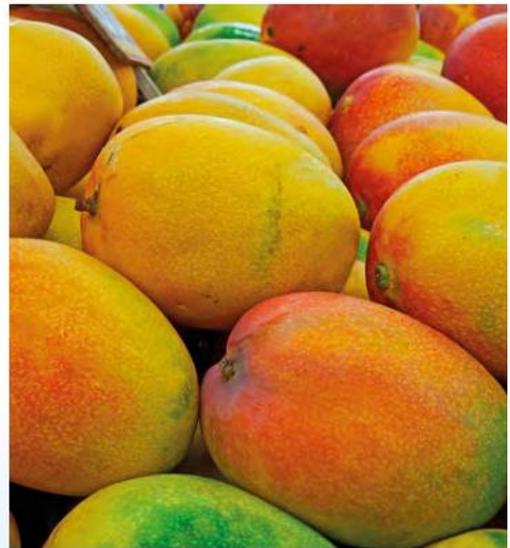
Sandalwood oil

Australia, Asia



Mangoes

Australia, Middle East, Europe, New Zealand



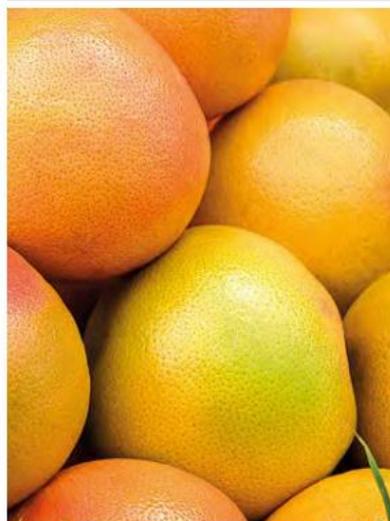
Pumpkins and melons

Perth, Adelaide, Melbourne, Sydney, Darwin, Brisbane



Red grapefruit

Australia, Europe, Japan and China



Hybrid seeds

Forage sorghum—Australia, Kimberley region, Middle East, Asia, New Zealand
 Grain sorghum—Australia
 Maize—Kimberley region, Northern Territory, Asia, New Zealand
 Millet—Australia
 Sunflower—Australia

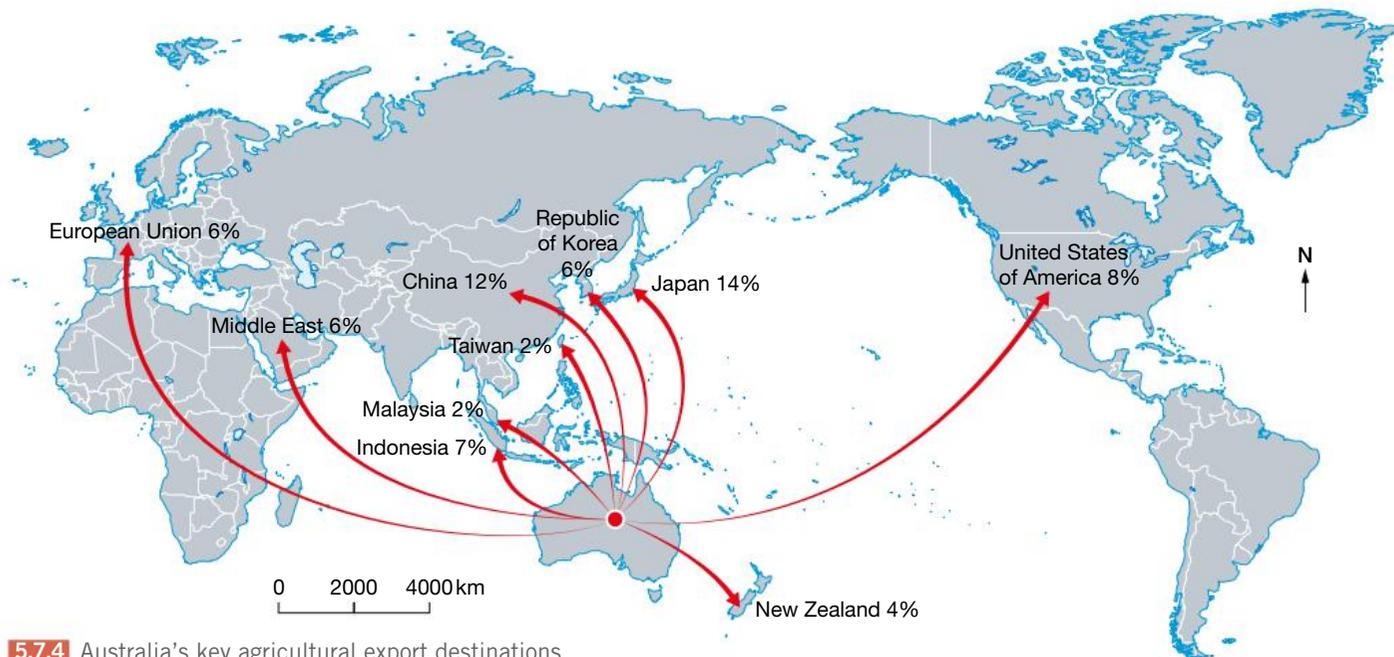


Exporting food

As Australia produces much more than it consumes, a significant proportion of the food it produces is exported. These exports contribute to the global food supply and can help countries with food security problems. In recent years, between 28 and 42 per cent of wheat shipments have been sent to countries in which more than 10 per cent of the population is undernourished. The Ord River Valley in northern Western Australia, shown in Figure 5.7.3, produces a wide variety of

produce that is predominantly exported to South-East Asia, due to its close proximity.

Most Australian producers seek markets that will return the highest value for their produce. Traditionally, these markets have been within the wealthy developed economies. Increasingly, however, there are substantial opportunities emerging in the rapidly developing economies of Asia. Figure 5.7.4 shows Australia's key agricultural export destinations.



5.7.4 Australia's key agricultural export destinations

ACTIVITIES

Knowledge and understanding

- 1 Explain why Australia is in a fortunate position when it comes to securing a food supply for the nation.
- 2 Describe Australia's food trade advantages.
- 3 Australia produces a food surplus, but it must also rely on imports. Explain.
- 4 Outline Australia's role in global food security.

Geographical skills

- 5 Study Figure 5.7.1 and answer the following questions.
 - a Which products are entirely sourced from domestic production?
 - b Which imported products does Australia most heavily rely on?
 - c What percentage of meat is sourced from domestic producers?
 - d What percentage of dairy products is imported?
- 6 Study Figure 5.7.2 and do the following tasks.
 - a Calculate the \$ value of meat production in Australia.

- b At what stage of the food supply chain is the most value added?
 - c Calculate the \$ value of seafood imports and exports in Australia.
- 7 Study Figure 5.7.4 and answer the following questions.
 - a What percentage of Australia's food exports goes to the United States of America?
 - b What percentage of Australia's exports goes to Asia?

Investigating

- 8 Conduct a survey of your local supermarket and prepare a report outlining the countries from which the following foods are sourced.
 - a seafood (fish and prawns)
 - b fresh fruit
 - c frozen vegetables
- 9 Prepare menus for the following themes and indicate where the food for the ingredients would be sourced.
 - a a reflection of the local region or state
 - b an adventure in multicultural cuisine

Food production in Australia

History of production

Australia's agricultural industries have undergone significant change in recent decades. Productivity has improved, more than doubling the agricultural output of the nation. However, this growth has been uneven. Some of the most notable trends that have emerged have been in the size of properties and the intensity of landuse.

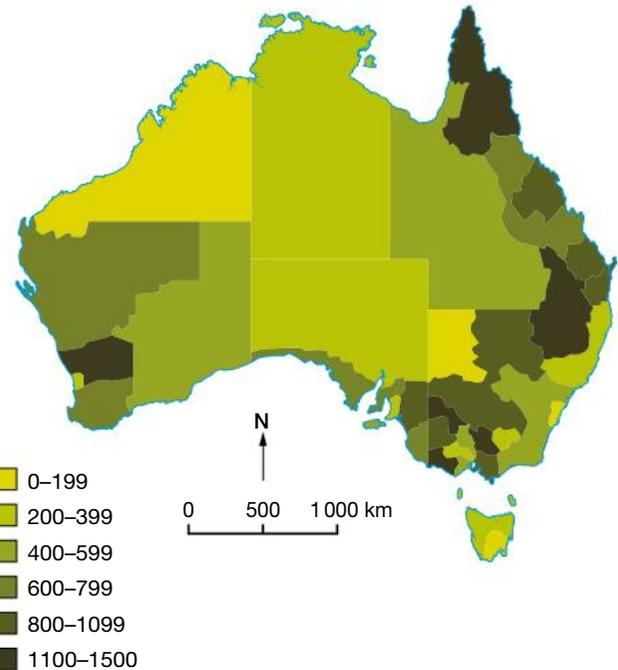
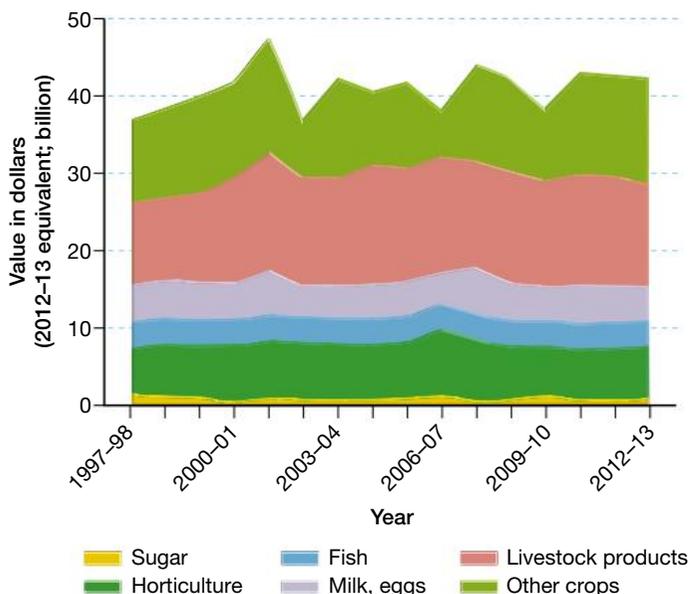
Where food has been produced

Figure 5.8.1 shows the value of Australian farm and fisheries production since 1995. Their growth has been uneven. The value of agricultural food production in Australia is shown in Figure 5.8.2. The difference in value between regions is usually a reflection of the quality of the biophysical environment. Constraints such as climate, landforms and soils limit which landuses can be undertaken and also determine the yields gained. The availability of irrigation water has enabled some water-deficit regions to be brought into production.

Within Australia, three broad zones of distinctive agriculture can be identified.

- The pastoral zones are in the semi-arid inland and tropical north, where beef cattle are grazed on sparse native pastures. The stocking rates are very low and the properties are huge—some over a million hectares in size.

5.8.1 Value of Australian farm and fisheries production, 1997–98 to 2012–13



5.8.2 Value of agricultural food production in Australia, 2009–10 (\$ million)

- The high-rainfall coastal zone is in a narrow strip of highly productive land along the east coast of the continent, as well as in Tasmania and the south-west corner of Western Australia. Dairying, fruit and vegetable growing are predominant in the south, while sugar cane, tropical fruits and vegetables are important in the north. Beef cattle are also fattened on permanent sown pastures and this land has the highest stocking rates. With such intensive landuse, the properties are small.
- The wheat belt is between the well-watered coast and the arid interior. It produces most of Australia's cereal grain, often in combination with raising livestock. Wheat is grown throughout, with barley, oats and sheep in the south. Further north, where it is warmer, sorghum and oilseeds are also grown, cattle are common and cotton is grown under irrigation.

DID YOU KNOW?

The Murray–Darling Basin produces almost 95 per cent of Australia's orange crop and 54 per cent of its apples.

Drivers of change in food production

In the past, changes occurred as producers grappled with and overcame the challenges associated with water availability and reliability, as well as soil fertility and pests. The adoption of new technologies and farming methods has led to an expansion of agriculture. The volume of food produced has been growing progressively over time, as more land has been brought into production. The key drivers of change in recent decades have been globalisation, changing consumer tastes, technological advances and environmental concerns.

Globalisation

Australian producers operate within a global food market, where they must compete with other countries. Agriculture has become increasingly export-oriented over the last 20 years, with two-thirds of the food produced for export. There has been a shift to a diverse range of processed products; wine and cheese have sold strongly overseas.

Globalisation has also meant that producers face more competition from imported food on the domestic market. Overseas interests can also influence production as large corporations or agribusinesses extend their interests into Australia.

The impact of globalisation can be seen in Western Australia's Ord irrigation scheme in the Kimberley region. A large Chinese conglomerate, Shanghai Zhongfu, won the sole right to

develop all the available land in the second-stage expansion of the scheme in 2012. Shanghai Zhongfu is going to turn the region into a new Asian food bowl, growing sugar cane across the entire region. The cane will be processed into sugar and ethanol biofuel for export.

Consumer trends

As food production in Australia is commercially based, meeting consumer expectations of diversity, quality and value is fundamental to profitability. Consumers are increasingly conscious of their health and wellbeing and this affects their food choices.

Technological advances

Experimentation, research and innovation have been used to help overcome limitations to food production and lift productivity. New technologies provide opportunities to convert, intensify or develop new landuses. Computers have moved on from being novelties to commonplace tools on properties.

Environmental concerns

Some of Australia's agricultural lands are fragile and degraded, and careful management is necessary to ensure sustainable food production. There is also uncertainty regarding the impact of global warming, which could affect not only productivity, but also where crops can be grown in the future.

SPOTLIGHT

Ancient grain becomes a modern superfood

It's not often that you can find an obscure product, see its potential and in a few short years become the world's leader in marketing and selling it. Western Australian farmer John Foss has revived an ancient, little-known plant grown in Central and South America and turned Australia into the biggest producer of its grain in the world, all within a decade.

Chia is a plant once grown by the Mayan, Aztec and Inca civilisations as early as 3500 BC. It produces seeds about 1 millimetre in diameter, which are high in dietary fibre, omega-3 fatty acids, protein and antioxidants. While its nutritive powers were no secret to the Mayans, Aztecs and Incas, it is only in recent decades that chia has become known to modern civilisation as a 'superfood'.

Source: Peter Hemphill, *Weekly Times*, 2010



5.8.3 A chia plant looks similar to lavender and produces an oilseed that is highly nutritious.



5.8.4 New housing encroaches on market gardens in Clyde, near Cranbourne, Victoria.

SPOTLIGHT

The fertile fringe

A substantial proportion of Australia's most fertile farmland now sits within Melbourne's expanded urban growth boundary. It has been argued that the sandy loam soils that produce much of Melburnians' daily greens should be set aside for growing food, not houses. Ongoing sprawl threatens 70 per cent of Victoria's fresh vegetable production, which still occurs in and around Melbourne.

Two of Melbourne's most productive horticultural areas, Werribee on the city's western fringe and the Cranbourne area to the south-east, are now facing mounting pressure from development. From these areas, trucks deliver freshly picked fruits and vegetables such as spinach, celery, leeks and herbs to the distribution centres of the two major supermarkets in the city.

Source: Royce Millar and Melissa Fyfe,
The Age, Melbourne, 26 May 2012

Current trends in food production

Larger farms

Farms in Australia have typically been run as family businesses and passed on from one generation to the next. However, the impact of new technologies and globalisation has made large farms more economically viable than small ones. The average size of farms has increased and, as a result, the number of farming families has declined. The increase in farm size has been most evident in the grain and cotton industries.

Intensification of landuse

Farmers use more intensive production techniques, such as the increased use of irrigation, feed and chemicals to produce more food per hectare. This is common on cotton and poultry farms, and in nurseries and vineyards. Farmers are seeking to improve profitability, particularly as they face increasing international competition.

DID YOU KNOW?

There are approximately 134 000 farm businesses in Australia, 99 per cent of which are family owned and operated. Each Australian farmer produces enough food to feed 600 people—150 at home and 450 overseas. Australian farmers produce almost 93 per cent of Australia's daily domestic food supply.

Organic foods

As consumers have become increasingly concerned about the environment and more interested in knowing about how their food is produced, organic foods have become popular. The basic principle of organic farming is that no agrochemicals are used and that environmental quality is maintained. There are now a substantial number of certified organic producers in Australia across a broad range of industries such as viticulture, meat and horticulture.

Loss of agricultural land to urban areas

Most of the best agricultural land in Australia is found on the coastal fringe, which is also where most of the population growth is occurring. As large cities spill over into the rural areas, their market gardens are buried under new housing subdivisions (see Figure 5.8.4).

ACTIVITIES

Knowledge and understanding

- 1 Outline the biophysical constraints on food production.
- 2 Describe the main food production zones in Australia and explain why they differ in productivity.
- 3 Identify the current trends in food production.

Geographical skills

- 4 Study Figure 5.8.1 and answer the following questions.
 - a In what year did food production peak?
 - b What type of production increased the most over the period shown?
 - c What was the value of fisheries production in 2012–13?

Applying and analysing

- 5 Conduct a class debate on the following topic.
The second stage expansion of the Ord River lease should have been given to Australian interests.

Investigating

- 6 Study Figure 5.8.2. Identify the high-value production areas of Queensland. Prepare a report on their location, the biophysical environment and the nature of the food production.

CASE STUDY: Alternative food supplies

Changes in food production

When communities became increasingly urbanised, technological advances in refrigeration, snap freezing and the development of food preservatives meant that food could be moved over long distances and food could be traded on a global scale.

The production of food is now dominated by large multinational corporations that rely on complex supply chains to source raw materials and to produce and market food products around the world (see Figure 5.9.1).

Such changes have meant that consumers are now far removed from the producers of their food. The oranges that go into your breakfast juice may be grown in Brazil and the juice processed in Florida before being sent across the Pacific Ocean in shipping containers. The concept of seasonality in food is also something of the past. When a crop such as strawberries is out of season in one area, suppliers are now able to import the product from elsewhere.

In recent years, there has been an increasingly popular movement against large-scale industrialised food

production, and a small but growing number of people are beginning to look at alternative ways to source their food supplies.

Farm gate trails

Farm gate trails have taken the concept of food provenance to another level. The trails combine food supplies with a tourism experience. The concept is that local agricultural producers join together to establish a trail that brings people to their farms to buy produce directly from them. In many cases the consumers can even pick their own.

Farm gate trails use the same concept that the wine industry has used for many years in popular wine districts, such as the Barossa Valley in South Australia. The trails are well signposted and participating farms display the trail symbol. Maps are provided for consumers via websites and local information centres. One of the largest and most established trails is found in the Hawkesbury region in Sydney's north-west. The trail, called Hawkesbury Harvest, was established in 2000 and now has dozens of participating farms.

5.9.1 The Sydney wholesale fruit and vegetable market in Flemington is the largest fresh produce market in Australia. Produce from across Australia and around the world comes to the markets, most of it to be sold to retailers.





5.9.2 A roadside vegetable and fruit stall, an alternative source of fresh food

Farmers markets

Farmers markets have become increasingly popular in developed countries. Farmers markets bring producers and consumers together directly, allowing consumers to get their fresh food directly from the farmers that produce it. There are now around 150 farmers markets operating throughout Australia. In many developing countries, many farmers continue to sell their surplus produce in local markets, as farmers have done for centuries.

Research completed in 2011 by the Australian Farmers' Markets Association found that a desire to know where their food was coming from was the main reason most consumers shopped at farmers markets. This is known as 'food provenance' and is becoming more important as people have greater concerns about food safety. For example, many consumers express concern about lax environmental regulations in some developing countries.

Broader environmental concerns are another reason for the popularity of farmers markets. The environmental impact of processing, preserving, storing and transporting food over long distances can be considerable. Purchasing food at the farmers market, where the producers tend to be local, helps to reduce such impacts. There is also a social and community element to many markets.

DID YOU KNOW?

Despite being Australia's biggest urban area, there is still more than \$500 million worth of agricultural produce grown in Sydney.

Benefits for farmers

For farmers, the markets are an opportunity to earn higher returns on their produce by cutting out the retailers, who often force down the prices they pay to farmers in order to maximise their own profits. At the markets, farmers are able to set their own prices. When they sell to large wholesalers and retailers, the price they receive is set by the buyer. Farmers markets allow the producer to be a 'price maker' not a 'price taker', which is seen as fairer for the farmers.

There have been reports that some market stallholders may not be food producers but instead purchase their produce at supermarkets and then resell it at farmers markets for inflated prices. In response, some markets are now beginning to certify the stallholders and their produce.

The locavore movement

In March 2007, *Time* magazine put 'local food' on its front cover and since then, a huge interest has developed in local food, with even some major retailers, especially in the United States of America and Europe, pledging to

DID YOU KNOW?

Australian families typically throw away about 20 per cent of the food they purchase.

sell more locally produced food. Supporters of the local food movement have become known as locavores. They attempt to eat only food that is grown within 100 miles (160 kilometres) of where they live. Locavores argue that by eating locally sourced food they are reducing the carbon footprint of their food. This footprint, which has become known as the 'foobon footprint', is measured in the distance taken to move food from where it is grown to where it is sold, and is usually measured in 'food miles'. The environmental impacts of storing and transporting food can be enormous, especially when foods are transported from overseas. For example, some recent research found that the food in a shopping trolley of an average Melbourne family had travelled more than 70 000 kilometres in total to reach the supermarket.

Farmers markets are one way that locavores source their food. However, there are a growing number of food retailers, and indeed restaurants, that sell locally produced food. The environmental and social organisation Do Something has launched a website called Foodwise. The site provides information on local food as well as on reducing your family's foobon footprint by reducing food waste.

There are others who argue that the local food movement may result in increased environmental impacts. A key argument is that local food production is generally small-scale, which is less efficient. As a consequence, the amount of land required to produce the same amount of food is far greater than in more industrialised farming. Furthermore, it is argued that contemporary industrialised farming allows for specialisation. For example, one region may specialise in citrus production, another in stone fruits and another in cereal grains. This allows for further efficiency and helps to reduce costs, which is ultimately good for consumers.

Community gardens

Even today, many people around the world rely on growing their own food in order to survive. However, as communities become increasingly urbanised, this is not always possible. Even small vegetable gardens are not an option for people living in apartments, as increasing numbers of Australians do.

Community gardens, like the garden shown in Figure 5.9.3, are becoming increasingly popular in Australia and other developed nations. In Australia, many of the gardens are established on land owned by local councils. The gardens are often built on land that is vacant and serving no real purpose.



5.9.3 Community gardens provide opportunities for people in built-up city areas to grow their own food.

For example, Rushall Garden in North Fitzroy, an inner Melbourne suburb, was established on unused land owned by the railway authority. Community gardens have also been established on many public housing estates, especially in Victoria. In some gardens there are individual plots that each person cultivates, but in others everyone shares in the work of growing crops and also in the harvest.

Such gardens have the benefit of allowing people to grow at least some of their own food. They also have important social benefits and assist in promoting healthier lifestyles by promoting exercise. Many schools have now established their own gardens as part of the school kitchen garden program. Such gardens help to educate students about healthy eating habits.

ACTIVITIES

Knowledge and understanding

- 1 Explain why seasonality is no longer an issue for consumers.
- 2 Describe the concept of farmers markets.
- 3 Define the term 'food provenance'.
- 4 Explain the link between food provenance and the growth in farmers markets.
- 5 Describe the concept of a farm gate trail.
- 6 Define the term 'locavore'.
- 7 Describe the concept of food miles.
- 8 Explain the benefits of community gardens.

Applying and analysing

- 9 Adopt the perspective of a farmer who produces fresh vegetables. Draft a submission to the local council, requesting help to establish a farmers market in your area. You will need to outline the benefits to farmers and the community of your plan.
- 10 Develop a plan for a school-based community garden in your school.
 - a Where would you site the garden?
 - b What would you plant?
 - c What rules would you put in place? Explain your reasons.
- 11 Write a short report outlining the environmental arguments for and against the locavore movement.



Urbanisation

The world has never before experienced urbanisation at the scale and speed that we see now in the countries of the developing world. Megacities are emerging from Jakarta to Istanbul, São Paulo to Cairo. Poor rural families are flooding into the world's urban centres, bringing challenges that have never before been seen—or met. Even the large cities of the developed world are facing challenges.

In this chapter we look at the process of urbanisation and its causes and consequences. We also look at the economic, environmental and social advantages and disadvantages of living in large cities.

INQUIRY QUESTIONS

- What are the causes and consequences of urbanisation in Australia and China?
- What are the economic, environmental and social advantages and disadvantages of living in large cities?
- What are the differences in urban settlement patterns between Australia and the United States of America?

GLOSSARY

commute	to travel regularly between home and work, school or university	quality of life	the happiness, wellbeing and satisfaction that a person experiences
developing world	the poor and middle-income countries of the world	regional centre	a rural city that supports smaller surrounding towns with services
exurban region	a semi-rural region lying just beyond the suburbs of a city	sea change	a relocation from the city to the coast
formal economy	economic activities that are regulated and taxed by government	squatter settlement	an informal, often illegal, settlement, built by the poor using material from the streets
global economy	integrated world economy in which there are few restrictions on the free movement of goods, services and labour across borders	standard of living	a measure of the economic wellbeing of people
hukou system	a Chinese household registration system that entitles the holder to a range of services such as healthcare and education; used to regulate the movement of people in China	tree change	a relocation from the city to a rural or regional area
informal economy	economic activities that are not taxed or regulated by any form of government	urban decay	the deterioration of the built environment; urban infrastructure falls into a state of disrepair and buildings are left empty for long periods of time
infrastructure	physical structures such as buildings, roads, water pipelines, sewers, electricity distribution systems, railways and airports	urbanised society	a society in which the majority of the population live in towns and cities
megacity	a city with more than 10 million people	urban sprawl	the outward spread of a city and its suburbs as they grow
population density	the number of people per square kilometre	urbanisation	the process by which an increasing proportion of a population lives in towns and cities
push and pull factors	the factors that cause people to leave the places where they live and the factors that draw people to places	world city	a city considered to be an important centre of global economic activity, such as New York, Tokyo, London and Paris

Urbanisation: Growth and impacts

Growth

Today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, when three out of five people will live in cities. Current urban population statistics are shown in Table 6.1.1. In the future, it is estimated that 93 per cent of urban growth will occur in developing nations, with 80 per cent occurring in Asia and Africa. The types of urban environments where people live are diverse. Nearly half the world's population live in settlements of less than 500 000 people, and one in eight live in one of the world's megacities. In 1950, there were 83 cities with populations exceeding one million; by 2008, this number had risen to 468. Figure 6.1.2 shows the increases in urban populations for different world regions, both historical and predicted. Three countries—India, China and Nigeria—are expected to account for 37 per cent of urban growth between 2014 and 2050.

Urbanisation

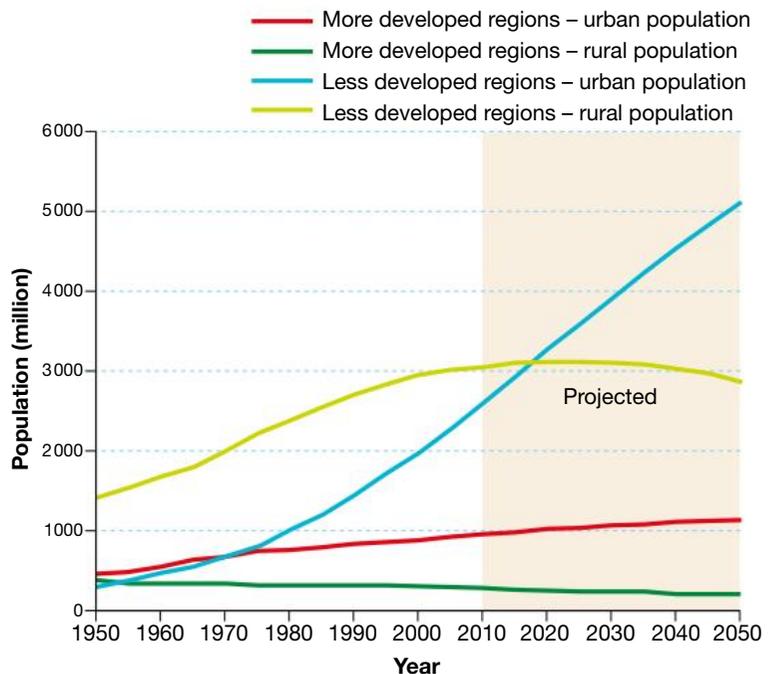
Urbanisation is the movement of people from rural areas to large cities, and occurs because of a number of **push and pull factors** (see Figure 6.1.3). The most rapid rates of urbanisation are found in developing countries. The world pattern of urbanisation is shown in Figure 6.1.4.

6.1.1 The proportion of people living in urban areas

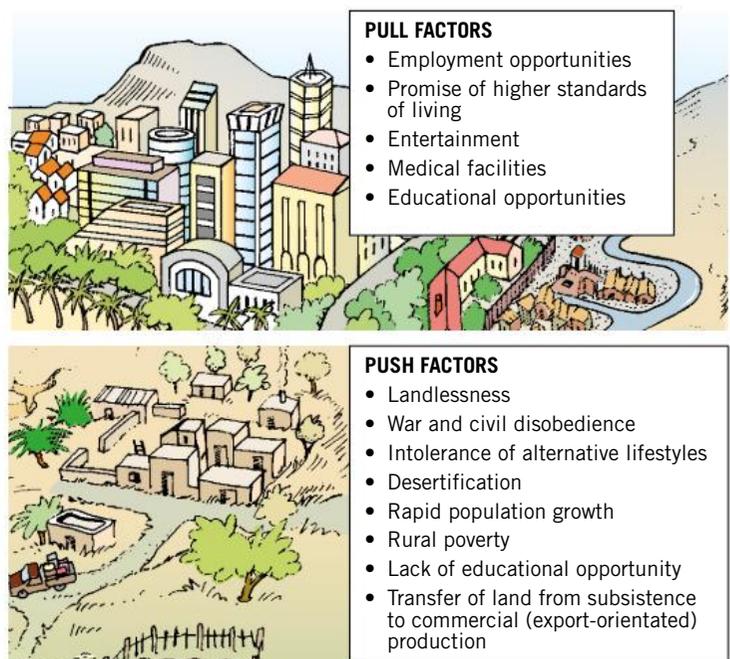
Area	Percentage of people living in urban areas	
	2011	2014
Africa	39	40
North America	80	82
Latin America and the Caribbean	80	80
Asia	44	48
Europe	71	73
Oceania	66	71
World	51	54
Developed countries	75	78
Less developed countries	46	48
Least developed countries	28	31

Source: Population Reference Bureau
World Population Data Sheet, 2015

6.1.2 Urban and rural populations, 1950–2050

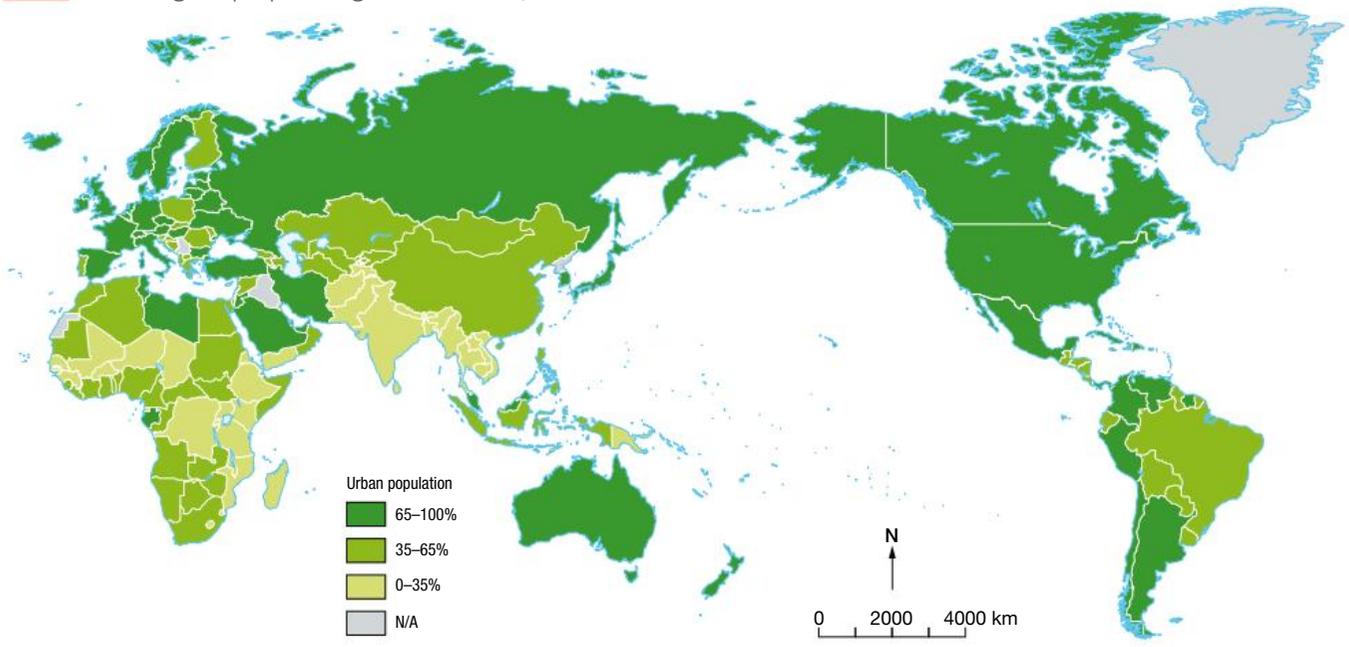


Source: World Urbanization Prospects, The 2011 Revision



6.1.3 The decision to move to large cities often involves both push and pull factors.

6.1.4 Percentage of people living in urban areas, 2014



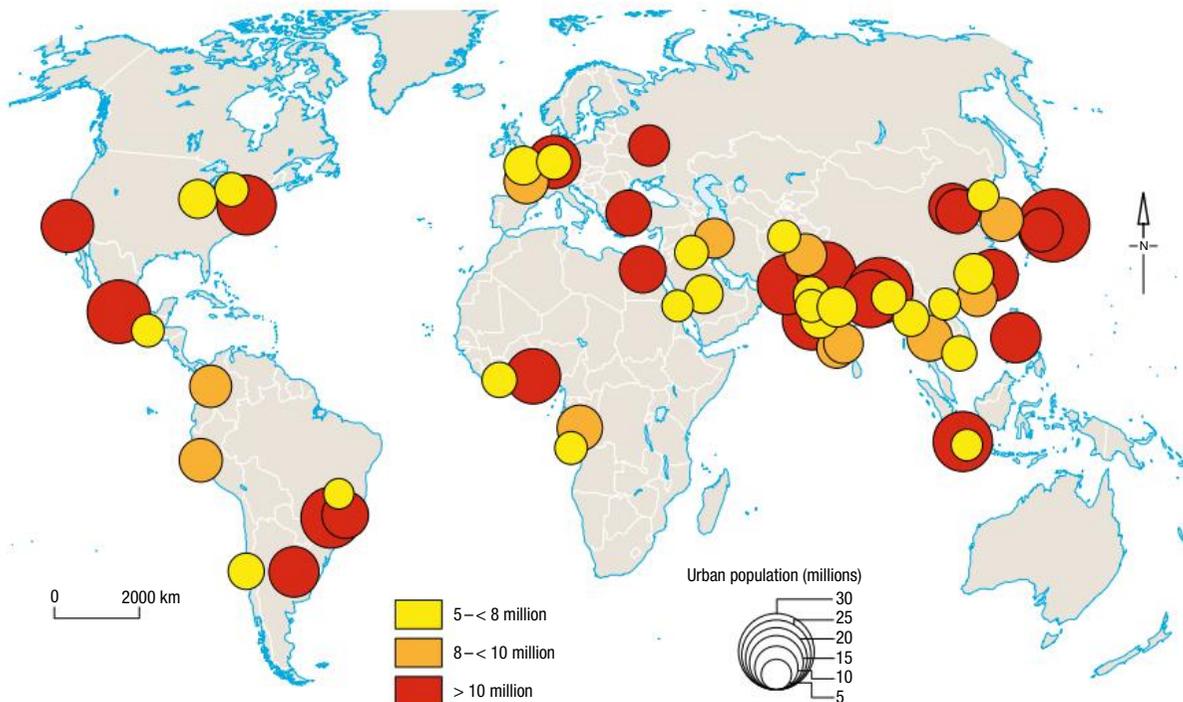
Source: World Urbanization Prospects, The 2014 Revision

Megacities

A **megacity** is a city with more than 10 million inhabitants. In 1950 there was just one megacity, New York; by 2011, there were twenty-three. Of the ten largest megacities, seven are in Asia (Tokyo, Delhi, Shanghai, Mumbai, Beijing, Dhaka and Kolkata), one is in South America (São Paulo) and one is in Central America (Mexico City). New York City is the only megacity in the developed world in the top ten. The distribution of the world's largest cities is shown in Figure 6.1.5.

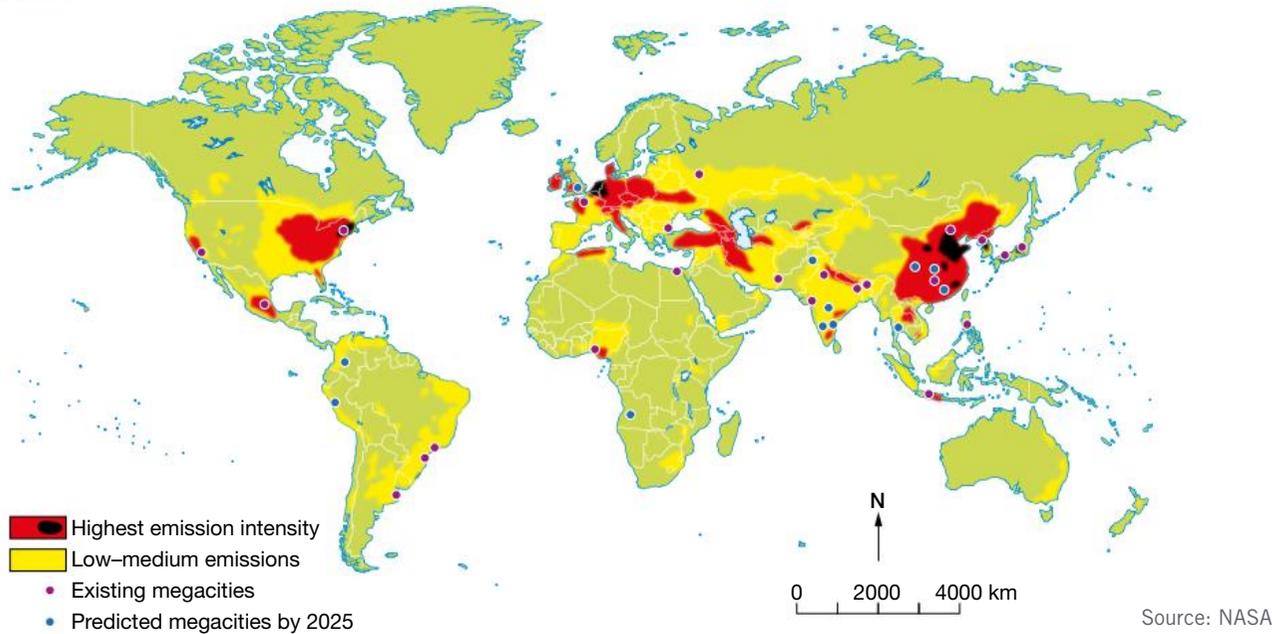
World cities

A city that has developed into a centre of global significance is called a **world city**. These cities have a level of economic and cultural control that extends well beyond their countries. Decisions made in these cities affect the wellbeing of people throughout the world. The most important of these cities are New York, London, Paris and Tokyo. Sydney is also classified as a world city.



6.1.5 The distribution of the world's largest cities. The biggest concentration of world cities is found in southern and eastern Asia.

6.1.6 Areas responsible for 70 per cent of fossil-fuel carbon dioxide emissions



Impacts on rural areas

When people move from rural areas to the city there are consequences in rural areas.

MORE DEVELOPED

In more developed countries, such as Australia, it is usually young people and people with young families who migrate to the cities. There can be severe effects on rural areas when families move to the cities. These effects include primary school closures due to lack of students, and shop and service closures because the remaining population is too small to support them.

LESS DEVELOPED

In less developed countries it is usually men between the ages of 15 and 45 who migrate to the cities. This means that families are split up. If the family goes too, the loss of a family can have an even more severe effect on the area they leave. Often the elderly are left in the countryside—those who are least able to look after themselves and tend the land.

Environmental impacts

CARBON EMISSIONS

Cities cover 3 per cent of the land's surface but are responsible for 70–75 per cent of carbon dioxide emissions from burning fossil fuels, as shown in Figure 6.1.6. Megacities are the biggest contributors to human-induced carbon emissions. Populations in cities are increasing and carbon emissions are increasing faster than population growth. The World Bank predicts that in the developing world megacities will grow by 4 per cent while their carbon emissions will grow by 10 per cent in the next 20 years. People living in cities on average use 5–10 times more energy than those living in rural areas.

URBAN HEAT ISLAND EFFECT

The heat island effect occurs when cities are warmer than the surrounding areas. The heat comes from built surfaces such as roads and buildings, which absorb heat during the day and slowly release it at night.

WATER CONSUMPTION

Cities use large amounts of water and produce large quantities of wastewater. As cities increase in size by population and area there is increased pressure on:

- access to safe water
- proper sanitation
- stormwater and wastewater disposal.

Impacts on cities in the developing world

The problems of large cities in the **developing world** are summarised in Table 6.1.7.

Quality of life and standard of living

The happiness, wellbeing and satisfaction of a person is referred to as their **quality of life**. Among the many factors that influence a person's quality of life are their family, health, income and access to services. A person's **standard of living** is usually measured in terms of their possessions, such as a house, a car or a computer. While these indicate a high standard of living, they cannot guarantee a high quality of life.

6.1.7 Problems of large cities in the developing world

High unemployment	The number of settlers from rural areas often exceeds the number of jobs available. Many people cope by working in the informal economy—for example as street vendors.	Too little water; water is often contaminated	The increased demand for water can exceed the capacity of existing sources. Groundwater sources and local waterways are often polluted by untreated sewage and toxic industrial wastes.
Poverty	Lack of access to employment results in poverty. Many people are forced to make a living by sorting waste for recyclables, begging in the streets or resorting to crime.	Overcrowded education and health facilities	Hospitals and schools find it difficult to cope with the increased demands placed on them by the new urban dwellers. Building new facilities is expensive.
Poor-quality, overcrowded housing	Lack of affordable housing forces people to crowd into slums or squatter settlements—illegal, self-built housing on unused land. These areas often lack even the most basic services (water, sewerage systems, electricity).	Environmental issues	Rubbish dumped in streets and waterways often remains uncollected. Open space in urban areas is lost to squatter settlements; trees are chopped down for firewood.
Inadequate infrastructure	The existing urban infrastructure is unable to cope with increased usage, resulting in failing transport, water supply and sewerage systems.	Governance	Corruption is common, resulting in the loss of funds for new infrastructure and housing. Laws protecting the environment and public health are not properly enforced.

ACTIVITIES

Knowledge and understanding

- 1 State where the rates of urbanisation are greatest. What problems does this create?
- 2 Outline the impact of urbanisation in rural areas in 'more developed' and 'less developed' countries.
- 3 Explain the difference between a megacity and a world city. Give examples of each.
- 4 Explain the difference between quality of life and standard of living.

Geographical skills

- 5 Study Table 6.1.1 and Figure 6.1.2. Identify those parts of the world with the highest and lowest levels of urbanisation.
- 6 Study Figure 6.1.4. With the aid of an atlas, do the following tasks.
 - a List the countries with more than 65 per cent of their population living in urban areas.
 - b Name ten countries in which 0 to 35 per cent of the population live in urban areas. Where are the majority of such countries located?
- 7 Study Figures 6.1.5 and 6.1.6 and explain the following statement. *There is a strong link between the location of megacities and increased carbon dioxide emissions.*

Applying and analysing

- 8 Study Table 6.1.7. Draw up a table with three columns and label the columns 'Economic', 'Social' and 'Environmental'. Place each problem in the correct column. Note: a problem may be listed in more than one column.

Investigating

- 9 Investigate the challenges faced by a large city in the developing world. Find out about the solutions to the problems experienced. Develop a multimedia presentation to communicate your research.
 - a Select a city and provide the following information about the people who live in the city:
 - population size, growth rate and age levels
 - literacy levels (male and female)
 - levels of education
 - unemployment
 - access to medical care and hospitals
 - access to clean water and sanitation.
 - b Copy and complete the following table.

City:		
Issue	Outline the issue	Solutions proposed
High unemployment		
Poverty		
Poor-quality, overcrowded housing		
Inadequate infrastructure		
Too little water; water is often contaminated		
Overcrowded education and health facilities		
Environmental issues		
Governance		

People and large cities

Living in a city

In a city, large numbers of people live in a relatively small area. Many people are happy living so close together and thrive on all that is on offer around them. However, the fast pace of city life does not appeal to everyone and some residents find it difficult to cope with the challenges of living in a city.

Social attractions

Those who find city living an enriching experience enjoy their contact with others and take advantage of the opportunities available. These include the following.

- **Social interaction** With so many living in cities there are more opportunities to socialise and make friends. People can also take advantage of the ethnic, community and lifestyle diversity that large cities have to offer. Some areas become popular within particular demographic groups, for example young professionals or tourist populations. Other neighbourhoods may become identified with particular ethnicities.

- **Cultural enrichment** The bright lights and excitement of cities attract people. There is a broader and more diverse range of activities for people to choose from. People are able to go shopping, visit galleries and museums, go to the theatre and attend sporting events.

Most large cities have experienced increases in their foreign-born populations in the last decade. For example, New York is home to over 200 ethnic communities. Locals can browse in specialty grocery shops or enjoy the varied cuisine. Manhattan's Chinatown is a vibrant district, famous for its wide selection of dim sum restaurants. Canal Street, shown in Figure 6.2.1, forms the main spine of Chinatown, and separates it from the neighbourhoods of Little Italy and SoHo.

6.2.1 Canal Street, Chinatown, in New York is popular with residents and tourists, who pack the footpaths looking for bargains from street vendors.



Social disadvantages

Some people find living in the midst of so many others confronting and difficult, for the following reasons.

- **Stress** The fast pace of city life is not for everyone. Many people become frustrated when they are held up by traffic or unable to find a parking spot. Much of the stress associated with city living is financial. With house prices and rents so high, people settle for tiny apartments close to where they work, which may not be what they would prefer. Others who choose to live further out face long journeys, with tolls to pay and higher transport costs.

- **Crime** Many people do not feel safe in large cities. The large number of people, properties and retail outlets mean more opportunities for crime, as shown in Table 6.2.2 which outlines the location and type of crime in New South Wales.
- **Isolation** People in large cities can be anonymous, and can suffer from isolation and loneliness. People are not always interested in helping those they do not know and contributing to communities they may belong to only briefly. In a very sad illustration of such isolation, in 2011 the remains of an elderly woman who had died eight years earlier were discovered in a terrace house in Sydney's Surry Hills.

6.2.2 Number of recorded criminal incidents for major offences, NSW, by Statistical Areas, 2014

	Murder	Assault	Sexual assault/ indecency	Robbery	Break and enter	Motor vehicle theft	Theft	Fraud	Malicious damage to property
Greater Sydney	43	33 405	5691	2577	24624	9084	54679	38259	36549
Capital Region	1	1 522	351	20	1 180	236	1 696	602	2017
Central West	3	2 427	500	55	2 319	455	3 378	793	2 992
Coffs Harbour – Grafton	2	1 424	357	34	1 021	286	1 705	444	1 590
Far West and Orana	5	2 505	401	53	2 271	391	2 735	510	2 730
Hunter Valley excluding Newcastle	2	2 194	526	85	1 955	745	3 687	1 067	2 934
Illawarra	6	2 293	446	137	1 734	658	3 796	1 343	2 696
Mid North Coast	4	2 095	438	66	1 847	450	2 482	609	2 337
Murray	2	1 170	207	34	1 056	244	1 499	296	1 378
New England and North West	3	2 572	483	57	2 204	395	2 942	619	2 946
Newcastle, and Lake Macquarie	3	3 300	685	157	2 295	926	5 772	2 164	3 893
Richmond–Tweed	6	2 256	428	58	1 467	448	2 772	1 015	2 348
Riverina	6	1 634	311	37	1 676	296	2 682	444	2 051
Southern Highlands and Shoalhaven	0	1 078	258	48	1 011	246	1 922	467	1 439

Source: NSW Bureau of Crime Statistics and Research, 2014

ACTIVITIES

Knowledge and understanding

- 1 Describe the positive social aspects of city living.
- 2 Explain how the city environment can make some people happy while others are lonely.

Applying and analysing

- 3 *The advantages of living in a big city outweigh the disadvantages.* Discuss.
- 4 Prepare a T-chart identifying the advantages and disadvantages of living in a small apartment near the centre of a city.
- 5 Discuss where you would prefer to live and explain why.

Geographical skills

- 6 Study Table 6.2.2 and do the following tasks.
 - a State the three most common criminal incidents.
 - b What percentage do they account for of the total?
 - c Select one type of criminal incident. Using a map of the NSW Statistical Areas, construct a scale for the selected type of incident, and shade and label where it has occurred.
 - d Describe any pattern emerging from your map. Give reasons to explain the pattern.

Australia's population distribution

Population density

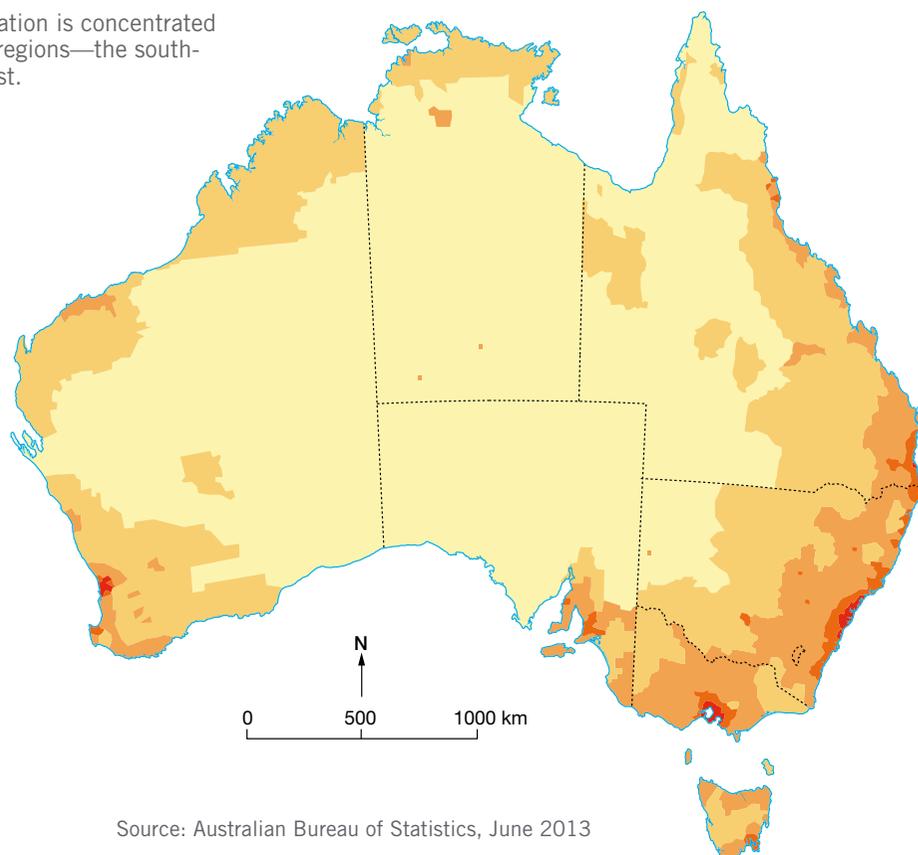
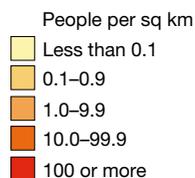
Population density in Australia is associated with different landuses.

- The closely settled coastal strip contains almost all the major urban centres and most of the large-scale industries and businesses.
- The moderately settled zone is dominated by agriculture and some small-scale industries.
- The sparsely settled zone is dominated by extensive grazing and scattered mining activities.

More than 86 per cent of the population, or 19.6 million people, live in urban centres. Fifty-four per cent of the population, or 12.3 million, live in Brisbane, Sydney, Melbourne and Adelaide. This is why Australia is often described as the most **urbanised society** on earth.

Australia's average population density is 2.9 people per square kilometre. This is the lowest of any of the continents, except for Antarctica. The highest population densities are found in the south-east corner of the continent. The uneven distribution of the Australian population is shown in Figure 6.3.1.

6.3.1 Most of Australia's population is concentrated in two widely separated coastal regions—the south-east and east, and the south-west.



Source: Australian Bureau of Statistics, June 2013

Changing distribution

The distribution of Australia's population is changing. The proportion of the population living in rural areas is declining. As a result, many small rural communities are struggling to survive.

The proportion of people living in the Northern Territory, Western Australia and Queensland has increased, while the proportion living in New South Wales, Victoria, South Australia and Tasmania has declined.

There are regional variations in population growth rates. During the 1950s and 1960s the fastest-growing areas were the state capitals—in particular Sydney and Melbourne—partly due to the expansion of industry, the arrival of immigrants and the decision of governments to expand cities.

The fastest-growing areas of Australia today are the areas surrounding the large cities and, most recently, the capitals of the resource-rich states of Queensland (Brisbane) and Western Australia (Perth). Most of the non-capital-city growth has occurred along the coast of New South Wales and south-east Queensland.

Factors affecting distribution

A variety of physical, historical and economic factors have worked together to influence population density in Australia.

Physical factors

Australia's harsh climate, scarce water resources, low rainfall (see Figure 6.3.2) and poor soils limit the area of the continent that is suitable for food production and settlement. Early European settlement was limited to the areas that could sustain the agricultural systems with which the settlers were most familiar.

Historical factors

In most cases, Australian's major urban centres developed on the sites first settled by European settlers. This gave them the advantage of early growth.

Australia was formed from six separate colonies in 1901. This is significant in explaining the present distribution of population. In each state and territory, the capital city is the largest city and is surrounded by rural settlements.

The tendency of state and territory governments to centralise administrative functions in the capitals has reinforced the dominance of the capital cities. For the most part, government departments and agencies are based in the capitals.

Economic factors

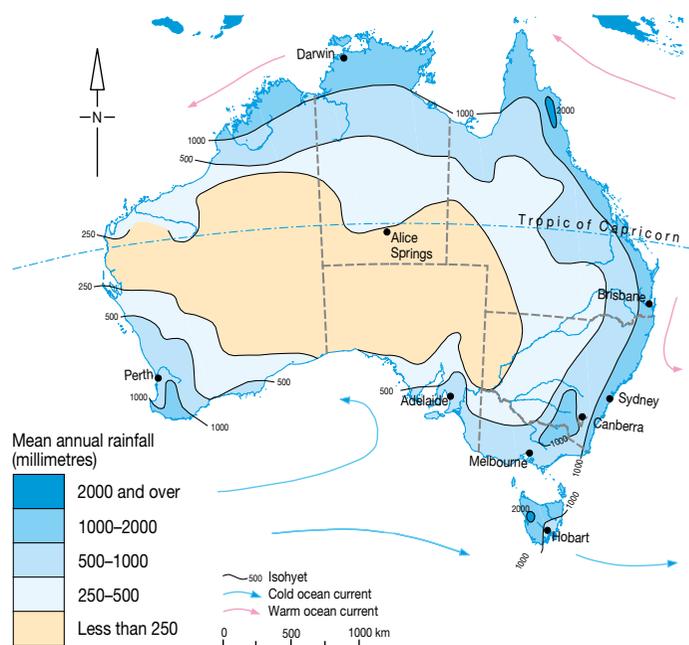
Due to their reliance on maritime trade, the first European settlements were located on the coast. In each case, the settlement's port facilities became central to the colony's economic wellbeing. For many years, life was sustained by goods imported from Europe. Gradually, the colonies developed their own economic activities, but their reliance on Europe continued; it was the major market for goods produced in the colonies.

For the first 100 years of European settlement, coastal shipping was the main means of communication because land routes were difficult to construct and slow to traverse. When rail and road networks were developed, they only served to reinforce the dominance of the large coastal cities. Usually they radiated out from the capital. Their function, in part, was to transport commodities to the ports, from where they could be exported to the world.

INDUSTRY, BUSINESS AND MANUFACTURING

Due to the colonies' reliance on trade, most of the large financial institutions, including the banks, established their headquarters in these large port cities. Industry too was attracted to these centres. They provided easy access to transport, resources and markets, both local and international. Traditionally, employers have always found it easier to attract labour to coastal locations.

6.3.2 Australian rainfall



Source: *Heinemann Atlas*, 5th edition

The location of manufacturing growth after 1945 served to reinforce the dominance of the large urban centres. There was a ready supply of labour and a market for the goods produced by manufacturers. Locations close to the major ports facilitated access to raw materials and export of the goods produced.

More recently, the ageing of the population has contributed to the development of coastal resort and retirement centres, such as the Gold Coast and Port Macquarie in New South Wales.

Urban concentrations

There is a range of advantages and disadvantages associated with large urban concentrations.

Advantages

Due to the number of people living in a specific area, it is less costly for governments to meet needs in cities. The advantages of urban areas are:

- better **infrastructure** (water, electricity, broadband, sewerage and public transport)
- better services (education, health care)
- a more diverse range of cultural and sporting activities
- a wide variety of restaurants, nightclubs and other forms of entertainment
- economic advantages (more businesses supplying all sorts of goods and services)
- more shops and competition
- more jobs and a variety of work.

Disadvantages

The disadvantages of urban areas are:

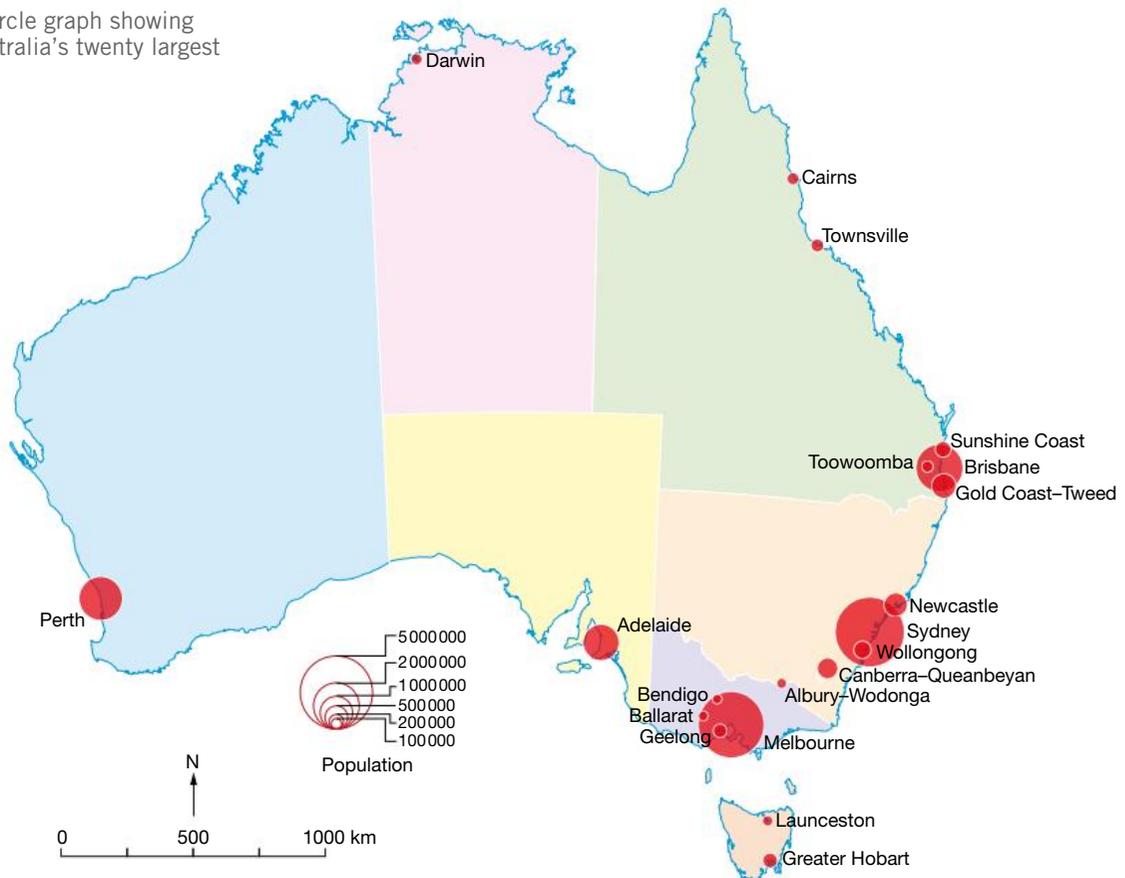
- traffic congestion
- air pollution
- polluted rivers and creeks
- expensive housing
- a lack of a sense of community
- higher levels of crime.

Urbanisation in Australia

The growth of the state capitals

In 1910, fewer than 40 per cent of Australians lived in the six state capitals. Today the state capitals account for 64 per cent of the population. A common characteristic of these cities is **urban sprawl**. The population density of the two fastest-growing cities, Brisbane and Perth, is only one-fifth of the average in European cities. Sydney and Melbourne, Australia's two largest cities, sprawl over an area four times larger than European cities with a similar population, consume more than double the amount of fuel for transport and generate three times the amount of greenhouse gases. The continued growth of these cities threatens the quality of the water from their surrounding catchments, the quality of air and the cleanliness of the oceans. Figure 6.3.3 shows Australia's major urban concentrations.

6.3.3 Proportional circle graph showing the distribution of Australia's twenty largest urban centres



Non-capital cities

Australia's non-capital cities tend to be much smaller than the capital cities. The largest of these are the industrial cities of Newcastle, Wollongong and Geelong, and tourist centres such as the Gold Coast.

There are also **regional centres**, or large cities and towns such as Tamworth, Dubbo, Ballarat, Townsville, Alice Springs and Launceston. Each of these centres exists to supply goods and services to its surrounding area, or hinterland, on the edges of the town or city. They have large shops, educational centres, professional services (such as lawyers and specialist doctors) and regional government and business offices.

Most of these regional centres continue to grow, but often at the expense of smaller rural communities. In smaller rural communities, populations are declining and levels of unemployment and welfare dependency are rising. Some shops, banks and businesses in these communities have been forced to close and some government services have been withdrawn or are now delivered by new technologies.

DID YOU KNOW?

Melbourne's population is expected to be larger than Sydney's by 2028.

Recent trends

The most rapid urban growth is now taking place in Perth and Melbourne (see Table 6.3.4). Sydney and Brisbane are also experiencing high rates of growth.

Regional centres throughout Australia are growing. Karratha in Western Australia, Singleton in the Hunter Valley, and Gladstone and Mackay in Queensland experienced rapid population growth during the mining boom. Queensland's coastal areas are popular locations for retirees and families, who are leaving the large cities for a **sea change**, or more relaxed lifestyle, in the smaller coastal communities.

Another trend is the **tree change**, or movement of people from suburban areas to communities just beyond the fringes of large cities. Many of these people **commute** to the city for work.

6.3.4 Australia's twenty largest significant urban areas, 2014

Rank	Name	Population	Average annual growth rate 2013–14 (%)
1	Sydney	4451841	1.8
2	Melbourne	4269138	2.2
3	Brisbane	2176799	1.7
4	Perth	1945140	2.3
5	Adelaide	1276701	1.0
6	Gold Coast–Tweed Heads	614379	1.6
7	Newcastle–Maitland	430755	1.2
8	Canberra–Queanbeyan	422510	0.9
9	Central Coast	323079	0.9
10	Sunshine Coast	297380	1.8
11	Wollongong	289236	0.9
12	Hobart	207663	0.6
13	Geelong	184182	1.4
14	Townsville	178649	1.6
15	Cairns	146778	1.3
16	Darwin	122571	1.7
17	Toowoomba	113625	1.0
18	Ballarat	98543	1.7
19	Bendigo	91692	1.6
20	Albury–Wodonga	87890	1.9

ACTIVITIES

Knowledge and understanding

- 1 Outline the relationship between landuse and population distribution.
- 2 List the changes taking place in the distribution of the Australian population.
- 3 Outline the factors affecting the distribution of the Australian population.
- 4 Explain why Australia is described as one of the world's most urbanised countries.
- 5 Identify the factors that distinguish Australian cities from those in Europe.
- 6 Describe the impact of the continued growth of the capital cities on the environment.

Applying and analysing

- 7 Brainstorm and list the advantages and disadvantages of urban concentrations. Construct a mind map summarising the key points.
- 8 As regional centres grow, smaller communities decline. What effect does this have on the smaller community?
- 9 Your advertising firm has been asked to prepare a campaign to attract people and investment to a major regional centre. In groups, develop your ideas for promoting the city. Use the following questions to guide your discussion.
 - a What does the city have to offer?
 - b Who should the campaign target?
 - c What would be the most effective way of promoting the city?
- 10 Working in groups, develop a concept map featuring the advantages and disadvantages of a sea change or tree change. Share your group's findings with the rest of the class.

Geographical skills

- 11 Study Figure 6.3.1. With the aid of an atlas, describe the distribution of Australia's population.
- 12 Study Figures 6.3.1 and 6.3.2. Describe the relationship between rainfall and population distribution in Australia.
- 13 Study Figure 6.3.3. Describe the distribution of Australia's major urban concentrations. What is the relationship between this pattern and Australia's political divisions and history?
- 14 Study Table 6.3.4 and do the following tasks.
 - a Identify the capital cities with the highest and lowest rates of growth. Suggest reasons for this variation.
 - b Identify the fastest growing non-capital urban centres. Speculate on the factors responsible for this growth.

Urbanisation in Asia

Growth in urban areas

Urban population growth in Asia is predicted to continue until 2025, as shown in Figure 6.4.1, and beyond. The demographic characteristics of a range of Asian countries and aspects of their quality of life are outlined in Table 6.4.2.

Scale of urbanisation

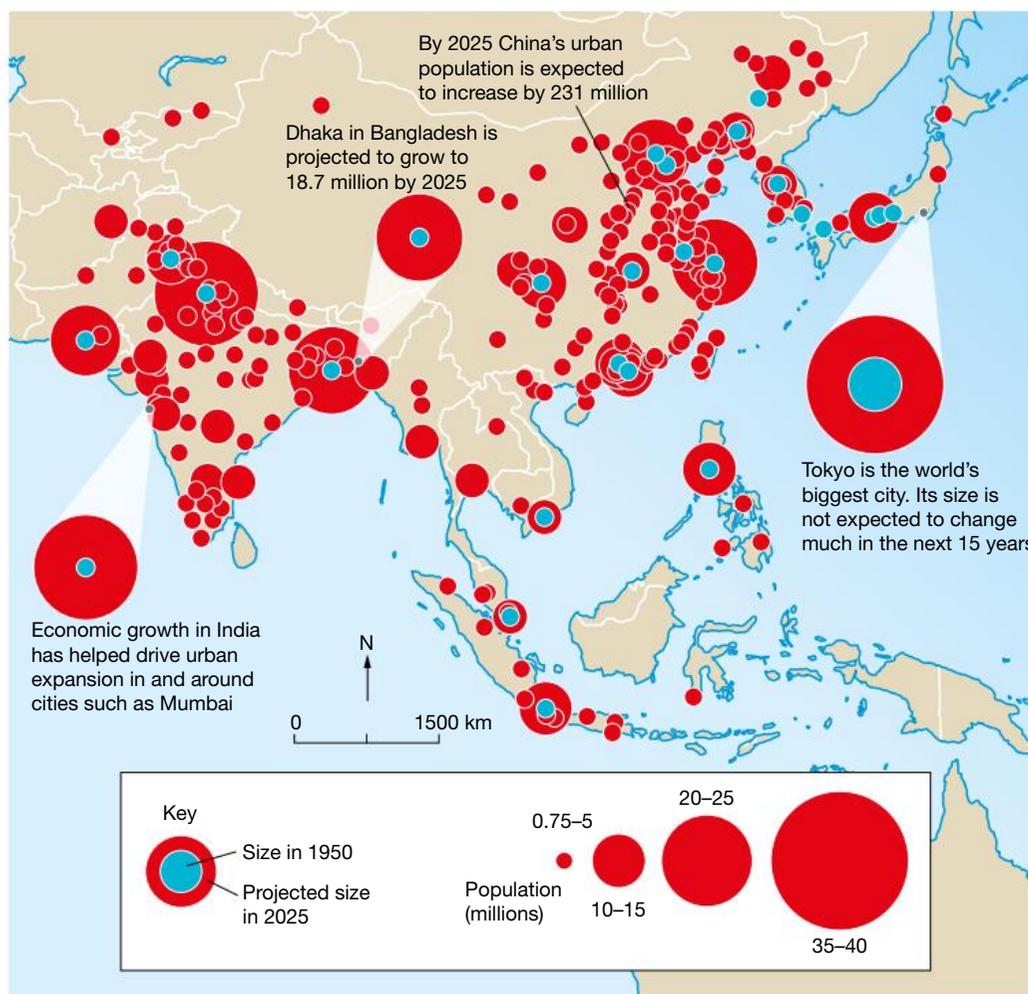
Urban populations in Asia are huge. Twelve of the world's twenty-three megacities are found in Asia. The two largest cities in the world are in Asia, and each has a population greater than 20 million. However, the level and rate of urbanisation vary across Asia. For example, Singapore, shown in Figure 6.4.3, is 100 per cent urban. In the Lao People's Democratic Republic (Laos), just 33 per cent of the population live in urban centres (see Figure 6.4.4).

The annual rate of increase in the urban population of Laos is relatively high at 4.9 per cent. Compare this to Japan, which has a level of urbanisation of 67 per cent and an annual rate of increase of just 0.2 per cent.

It is important to remember that, even though cities can have low rates of growth, the actual numbers involved can be very large. Seoul, South Korea, must make room for over 350 000 new residents each year, even though the actual growth rate is low.

China now leads the world in urbanisation. By 2050, 75 per cent of the Chinese population—1.1 billion people—will live in cities. In the Philippines and Indonesia, two-thirds of the population are expected to be living in urban areas by 2025.

6.4.1 The growth of urban areas in Asia, 1950–2025



6.4.2 Demographic characteristics of Asian countries

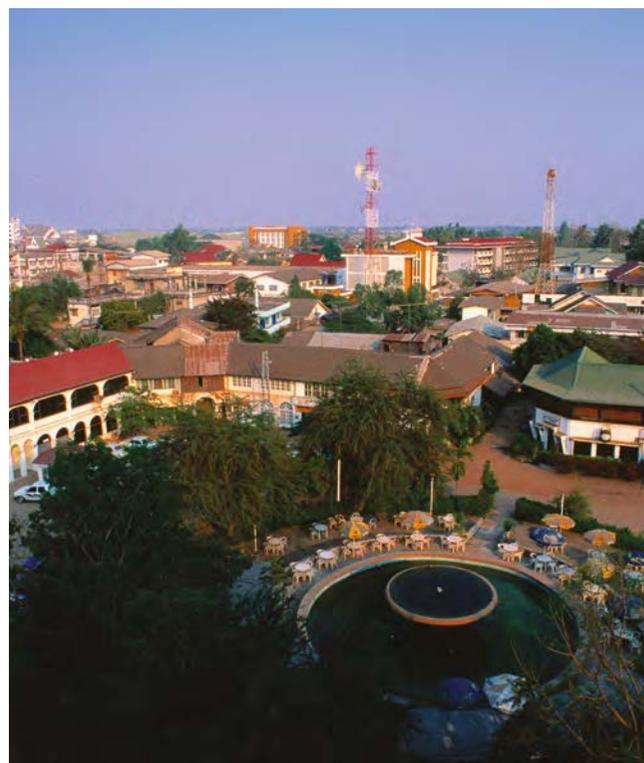
Country	Total population (millions) 2015	Average annual population growth rate 2010–15 (%)	Urban population (%)	Life expectancy at birth 2010–15 male (years)	Life expectancy at birth 2010–15 female (years)	Population using improved sanitation (%)	Population living below US\$1.25 per day (%)
China	1376.0	0.5	47	74	77	55	16
India	1311.0	1.3	30	66	69	31	42
Indonesia	257.6	1.3	44	67	71	52	29
Japan	126.6	-0.1	67	80	86	100	0
Kazakhstan	17.6	1.6	59	64	74	97	2
Lao PDR	6.8	1.7	33	64	67	53	44
Malaysia	30.3	1.5	72	72	77	96	2
Philippines	100.7	1.6	49	65	72	76	23
Qatar	2.2	4.7	96	77	80	100	0
Singapore	5.6	2.0	100	80	86	100	0
South Korea	50.3	0.5	83	78	85	100	0
Thailand	68.9	0.4	34	71	78	96	2
United Arab Emirates	9.2	1.9	84	76	78	97	0
Vietnam	93.4	1.1	30	71	80	75	22

Source: Adapted from data at UNFPA State of the World Population 2015

6.4.3 Massive public housing developments have been built to fix housing shortages in Singapore.



6.4.4 Vientiane is the capital and largest city in the Lao PDR.



SPOTLIGHT

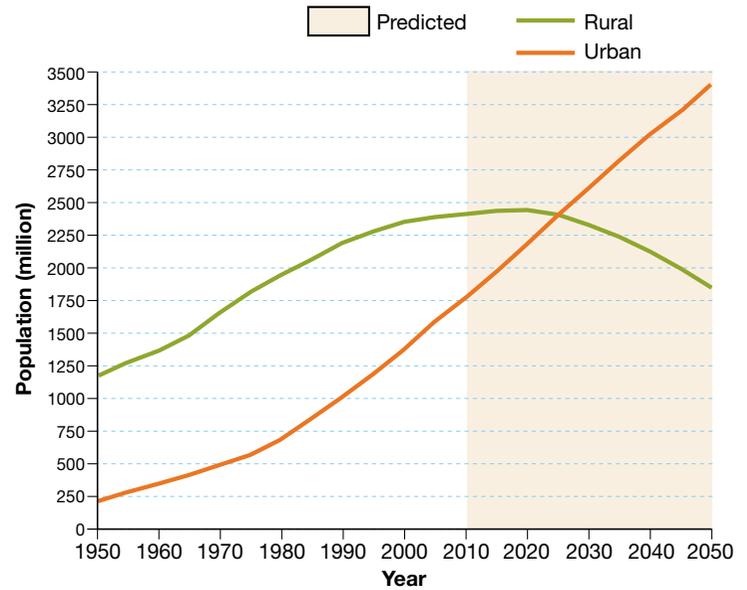
Urbanisation in Indonesia

Indonesia has experienced rapid urbanisation. Rural towns have been transformed into cities and expanding cities have absorbed neighbouring rural towns. These rural communities, while not originally urban, had very high population densities. Recently, the Indonesian government has tried to restrict migration to large cities by redirecting people to smaller communities or rural areas. Jakarta, with a population of 18.9 million, has a closed city policy. Residency permits are given only to those who can provide evidence of housing and employment. In addition, a new law was introduced in September 2009 that prohibits people from giving money to beggars and roadside workers. The new law also bans **squatter settlements** along riverbanks and highways. Jakarta is experiencing many negative effects of rapid urbanisation. Traffic jams in Jakarta, as shown in Figure 6.4.5, are a common event. Jakarta is built on a flood plain. Due to removal of groundwater for human use, Jakarta is experiencing land subsidence, or sinking. In response to the traffic congestion, a monorail is being planned for the city.



6.4.5 Average traffic speed in Jakarta is just 8.4 kilometres per hour. In 2011, a total of 474 new cars and 2946 motorbikes per day were added to the estimated 14.4 million vehicles in the city.

6.4.6 Population growth in rural and urban Asia, 1950–2050



Rates of urbanisation

The highest rates of urbanisation are often found in Asia's smaller cities. While the growth rates of cities with populations between 5 and 10 million have stabilised, and the growth rates of cities of over 10 million people slowed to 1.7 per cent a year between 2000 and 2010, cities with populations between 500 000 and 5 million have experienced the greatest growth, especially cities in China, India and the Philippines. Figure 6.4.6 shows the increase in population in rural areas declining, while urban populations continue to grow.

Reasons for rapid urbanisation

One of the main reasons for the rapid urbanisation occurring in Asia is the emergence of the **global economy**, which has resulted in the move of labour-intensive manufacturing to countries in South and East Asia, and Central and South America. The process has created a huge demand for labour. The opportunity for a relatively well-paid job in a factory is a powerful pull factor for people in rural areas. The growing urban centres also offer the possibility of better health care and education. Cities are also seen as more exciting and dynamic places, especially for the young.

For those unable to access the **formal economy** (economic activities subject to regulation and taxation), in cities there is the opportunity to supply goods and services to those who do. This has led to the growth of the urban-based **informal economy** (economic activities not regulated by government)—for example street vendors.

Declining death rates and, at least in some parts of Asia, high fertility rates have also fuelled urban population growth. Where villages have been absorbed into expanding urban areas there is often a lack of distinction between the urban environment and the previously rural community—people do not necessarily move to the city; they simply find themselves suddenly part of one.

Positive outcomes

Economic outcomes

Urbanisation has contributed to economic growth and increased living standards by raising incomes and reducing poverty. For example, factory workers are paid more than rural workers. Growing incomes contribute to local demand for goods and services, which further fuels economic growth.

Social outcomes

Urbanisation in Asia has influenced people's aspirations, lifestyles and social relationships. The more diverse mix of cultures, castes and religions found in cities is said to create greater harmony and break down social and cultural barriers.

Negative outcomes

Economic outcomes

The benefits of urbanisation are not evenly distributed. Up to 40 per cent of Asia's urban population live in slums and squatter settlements. The lack of access to clean water and sanitation means waterborne diseases spread rapidly. The infrastructure needs of cities (roads, schools, hospitals for urban residents) are often met at the expense of rural communities.

Social outcomes

In an attempt to keep pace with the demand for housing and the rate of economic growth, authorities have demolished whole urban districts—destroying the cultural, social and built heritage of the area, as is shown in Figure 6.4.7. Residents are often forced to relocate, and the sense of community that existed is destroyed.



6.4.7 Historic urban districts and their communities are often destroyed in order to make way for apartments and office towers.

ACTIVITIES

Knowledge and understanding

- 1 Describe the pattern of urbanisation throughout Asia.
- 2 Explain why urbanisation is occurring in Asia.
- 3 Outline the outcomes of urbanisation in Asia.

Applying and analysing

- 4 Discuss the likely reasons for Indonesia's introduction of a law to ban the giving of money to beggars.
- 5 You have been given the task of assessing the outcomes of urbanisation in Asia. You are to prepare a score sheet that can be used to rate the outcomes for each country. On your score sheet include the outcomes and a way to determine how each outcome will be measured.

Geographical skills

- 6 Study Table 6.4.2. Present the following information as a graph or series of bar graphs: urban population; population using improved sanitation; and population living below US\$1.25 per day.
- 7 Study Figure 6.4.6. Describe the actual and predicted trends in rural and urban populations in Asia.

Urbanisation in China

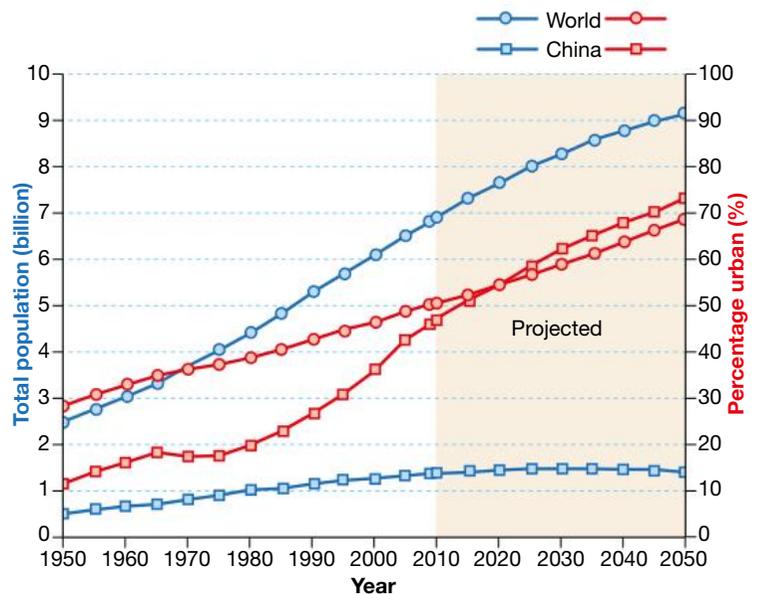
Growth of urbanisation

With a population of 1.4 billion, China is the world's most populous country. It also has a high rate of urbanisation—a process closely related to the country's emergence as a major economic power.

At the start of 2011, there were 665.57 million people living in urban areas and the level of urbanisation stood at 49.68 per cent. By 2030, over one billion people will live in China's cities. Meeting the needs of these new urban dwellers has been a major challenge for Chinese authorities.

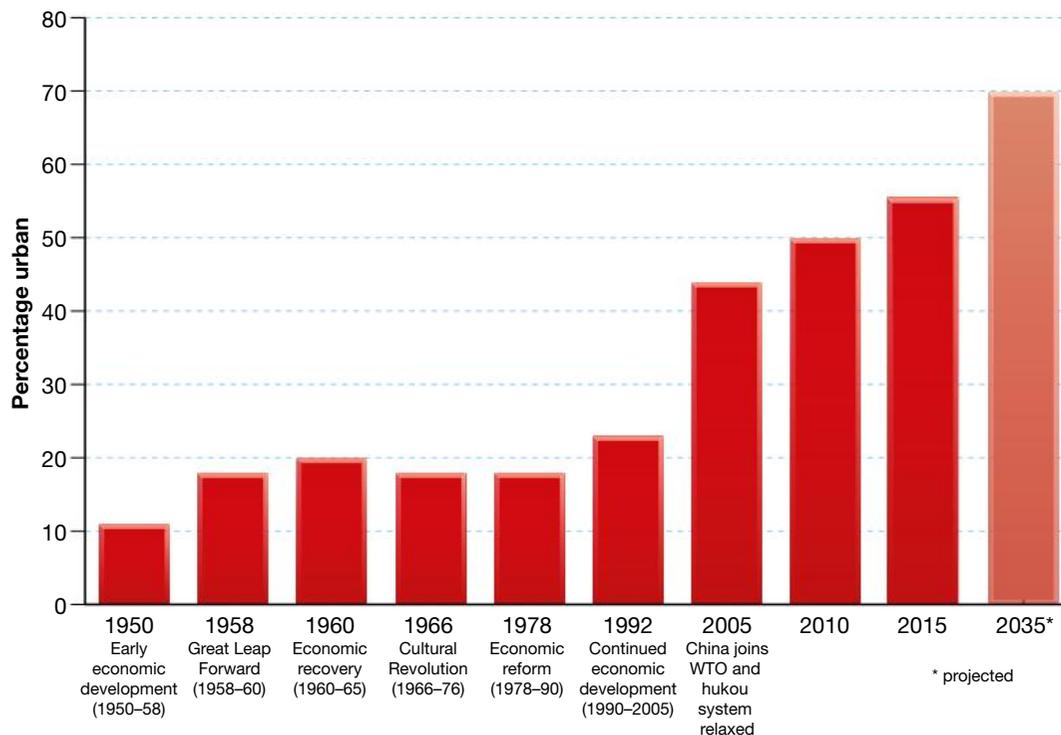
In 1949, there were just 132 cities with 57.67 million people, or 10.65 per cent of the population, living in urban areas in China. In 1987, the government adopted a strategy to control urban growth. This involved limiting the size of large cities, developing mid-sized cities (between 200 000 and 500 000 people), and encouraging the growth of small cities and small market centres. The outcomes of these policies are shown in Figures 6.5.1 and 6.5.2.

6.5.2 Levels of urbanisation, China and the world, 1950–2050



Source: United Nations, 2010

6.5.1 Economic policy and urbanisation in China, 1950–2035



Source: McKinsey Global Institute, *Preparing for China's Urban Billion*

The early years of the strategy were focused on limiting large cities. The government decentralised economic activity and power. State-owned enterprises were relocated to smaller cities, local authorities were given more power to achieve local economic growth targets, and some cities were designated to offer incentives to investors.

Urban spatial pattern

The Chinese government has favoured the development of small- and medium-sized cities over the development of very large cities. This has resulted in a unique spatial pattern of urban places. The urban system consists of large- and medium-sized cities linked to smaller urban centres, as illustrated in Figure 6.5.3.

In 2013, there were three main metropolitan areas consisting of a number of highly connected cities and towns. These were the Yangzi River delta, the Pearl River delta and the Beijing-Tianjin-Bohai region. Throughout the rest of the country there are a number of urban clusters that feature one or more cities at their centre. These are important zones of economic development, not just for the local region but for the country as a whole.

Outcomes of urbanisation

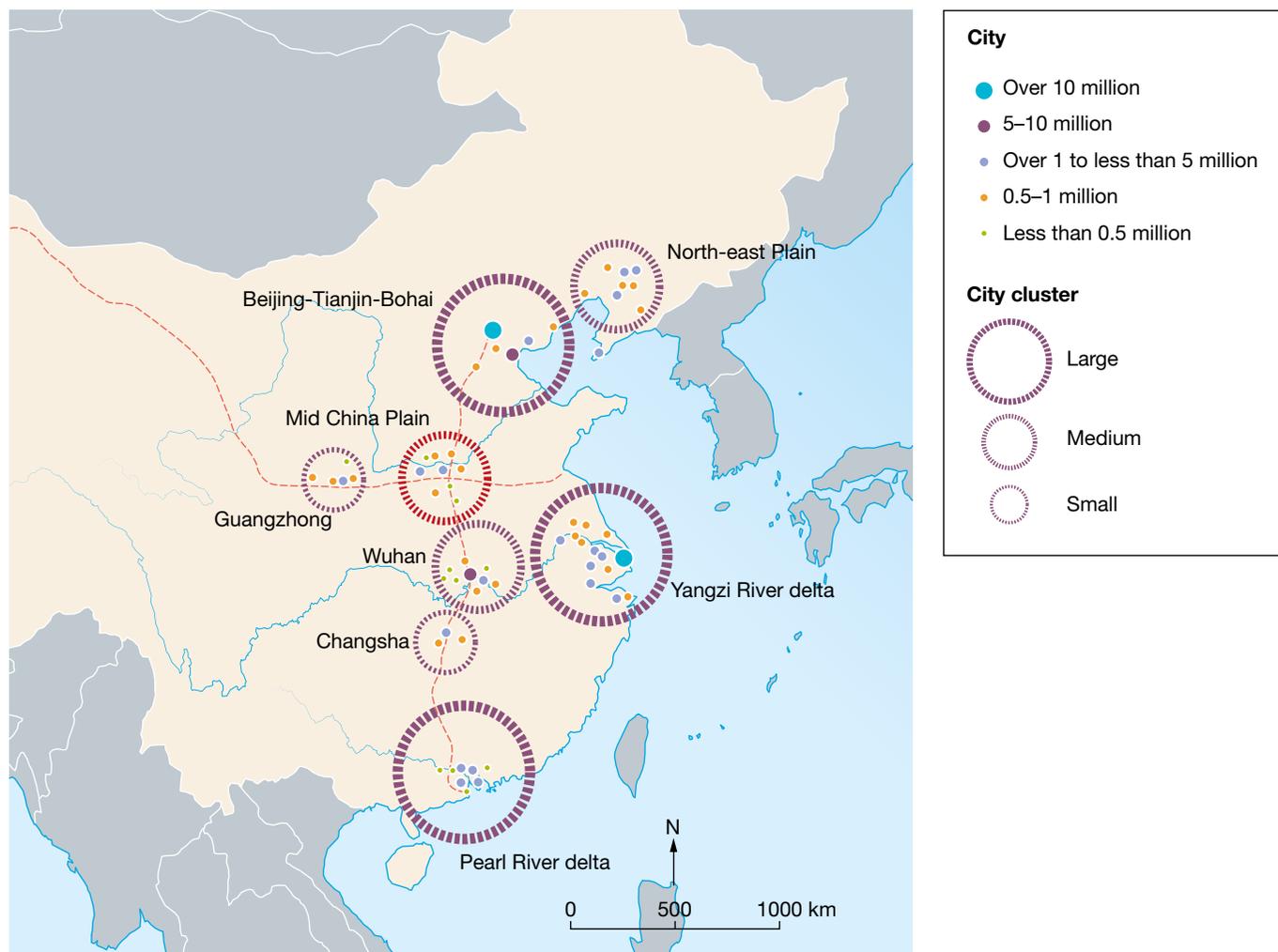
Economic benefits

Urbanisation has brought economic benefits for China. In 2011, China had the world's second largest economy and was the largest importer and exporter of goods in the world.

Meeting the needs of those moving to the cities also generates economic activity. For example, every additional 10 million urban residents results in an increase in the country's GDP of 4 per cent; 3.6 per cent of this is due to the demand for housing.

The growth in China's national economy has been accompanied by improvements in people's standard of living. A huge number of people have been lifted out of poverty. In 1981, 85 per cent of people were living in poverty (defined as living on less than US\$1.25 per day). By 2005, that figure had been reduced to just 16 per cent. The economic benefits have not benefited everybody, and the gap between the rich and poor has widened.

6.5.3 The distribution of cities (based on population) and city clusters (based on GDP) in eastern China



The plight of rural–urban workers

While urbanisation has been accompanied by greater employment and an improvement in living conditions, some groups still struggle economically. People who travel from rural areas to the cities looking for contract-based work are known as rural–urban workers, or *mingong* ('peasants who became workers'). In 2009, there were 230 million rural–urban workers.

Rural–urban workers face many difficulties.

- Many are employed in low-paid and dangerous jobs.
- They have long working hours—usually six and sometimes seven days a week.
- They live in poor or cramped housing, as shown in Figure 6.5.4.
- Approximately 40 per cent have no work contracts, meaning they are unable to complain about mistreatment, abuse or unsafe working practices.
- Approximately 21.3 per cent are entitled to a pension.
- Only 8.5 per cent are able to get unemployment benefits.

Housing shortages

In China, homes are expensive, and low-cost housing is in short supply. Rapidly increasing urban populations push up prices and rents. An apartment in an urban area in China can cost 8.3 times the average income of a household, or 29 times that of a low-income worker. In many cases, rooms in apartments are sublet to other families, resulting in overcrowding. One Shanghai complex was recently found to house 10 000 people in just 600 apartments.

6.5.4 Some rural–urban workers bring their whole families to the cities, where they often live in squalid conditions.



The government's response has been to allow developers to construct large-scale housing developments. Most of these, however, are still too expensive for low-income earners. The Chinese government announced that it would build 36 million low-cost homes by 2015, and has since reported that it has achieved this goal. This has been difficult to evaluate due to local governments using various types of housing development, such as resettlement housing and housing developed by work units, to meet the targets set by the government.

Health

Urban living gives people access to modern medical facilities and an income to pay for personal health care. However, the health of people in cities is threatened by air pollution, a more sedentary lifestyle, greater work-related stress, social detachment and high-fat diets, all of which contribute to poorer health outcomes.

Water

Half of China's largest cities are facing water shortages. Three hundred million people have no access to clean water and 700 million people drink water below WHO standards. Eighty per cent of China's rivers are too polluted to fish from. For example, less than 5 per cent of wastewater flowing into the largest river in Shanghai, the Huangpu, is treated, resulting in a river that is essentially dead. A total of 3.4 million cubic metres of industrial and domestic waste is dumped into it every day.

Pollution

According to the World Health Organization (WHO), seven of the world's ten most polluted cities are found in China. The scale and extent of urban pollution in China is immense. The air, water and soil are all affected and biodiversity has been reduced. In January 2013, north-eastern China recorded its highest ever levels of pollution. WHO considers concentrations of 25 PM_{2.5} particles (the most dangerous particles that people can inhale) per cubic metre to be unsafe; on 12 January, Beijing recorded a PM_{2.5} level of 993 per cubic metre. In some areas, visibility was reduced to 200 metres and flights were cancelled. Officials ordered schools to suspend outdoor activities and people were advised to stay indoors.

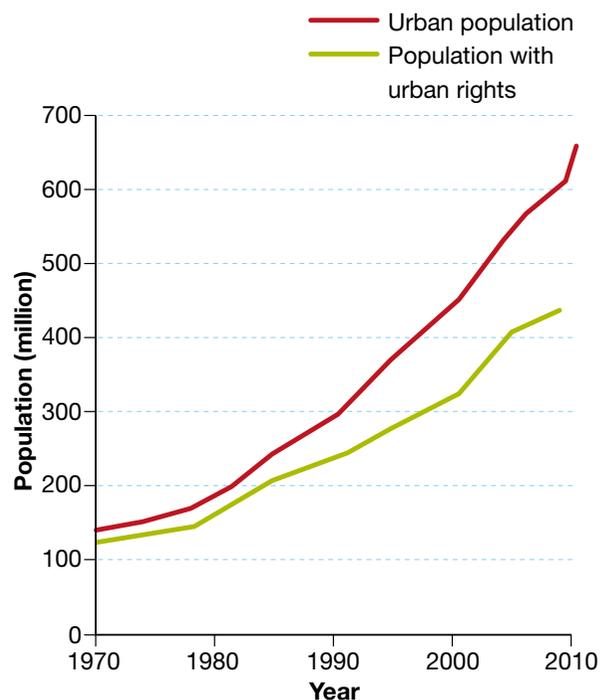
China's factories release huge amounts of pollutants, such as sulfur dioxide, into the atmosphere. The air quality of many of China's cities is described as moderately or severely polluted. WHO estimates that there are 300 000 premature deaths each year in Chinese cities because of outdoor air pollution. In addition, many of the pollutants react in the air to produce acid rain, which can affect soil acidity. Soil acidification (increase in the acidity of the soil) is an increasing problem for China's agricultural regions because it affects the fertility of the soil and therefore the ability to grow crops.

Hukou

Where a person may live in China has been controlled since ancient times by a system of residency permits known as the **hukou system**. Under the system, a person is officially identified as a resident of an area. In 1958, the Chinese government began to use the system to control the movement of people between urban and rural areas. Individuals were broadly classified as either 'rural' or 'urban' workers. A worker wanting to move from the country to an urban area to take up non-agricultural work had to apply for permission. The number of workers allowed to make such moves was tightly controlled. Authorities feared a massive movement of people into the cities, causing strain on city government services, damage to rural economies and increases in social unrest and crime. Until 1976, police regularly rounded up those without valid residence permits, detained them in detention centres and expelled them from cities. Today, the hukou system is only partially enforced, as the government is keen to increase the supply of skilled workers for industry.

Figure 6.5.5 shows the increase in the 'population with urban rights'. Residents who do not have hukou permits are often denied subsidised health care and their children are denied access to local schools.

6.5.5 The growth of China's total urban population and the number of people with permits to live in urban areas, 1970–2010



Source: National Bureau of Statistics and Ministry of Public Security, China

ACTIVITIES

Knowledge and understanding

- 1 Outline how the nature of China's urbanisation has differed from that of other countries since 1949.
- 2 Explain how the hukou system has been used to control China's rate of urbanisation.
- 3 Define the term '*mingong*'. Discuss the living and working conditions of these people.
- 4 Explain why housing is a hotly debated issue in China. What has been the government's response?

Applying and analysing

- 5 List the outcomes of urbanisation in China and place each outcome in a PMI chart.
- 6 Imagine you are a Chinese resident living in a rural village. Would you move to the city without a permit to live? Explain.

Geographical skills

- 7 Study Figure 6.5.1. Which policy/policies have had the greatest influence on urbanisation in China since 1950?
- 8 Study Figure 6.5.3. Describe the distribution of China's urban population.
- 9 Study Figure 6.5.5. Describe the trends in China's urban population and the number of Chinese with permission to live in urban areas.

Environment and large cities

Environmental impacts of large cities

The environmental impact of urbanisation raises many concerns. Large cities use land and resources, returning their wastes and pollutants to the very environment they depend upon. However, some experts believe that urbanisation is actually advantageous to the environment.

Cities impact upon the land they cover with buildings and roads. Cities also use resources beyond their boundaries. As large cities grow, their interference in the natural world increases, as Figure 6.6.1 shows.

Loss of habitat and agricultural land

With the pressure of population growth, cities push past their outer limits into the countryside beyond. When this occurs, market gardens just outside the city disappear and any remaining natural vegetation is cleared to make way for development. This outward growth of cities is known as urban sprawl. In Australia, the Australian Farm Institute claims that in the 12 years between 1997 and 2009, Australia's agricultural land area was reduced by 11 per cent, from 462 million

hectares to 409 million hectares, due in part to urban sprawl. Approximately two-thirds of Australia's perishable fruit and vegetables are grown on the outskirts of cities (see Figure 6.6.2) and these areas are under threat from urban sprawl.

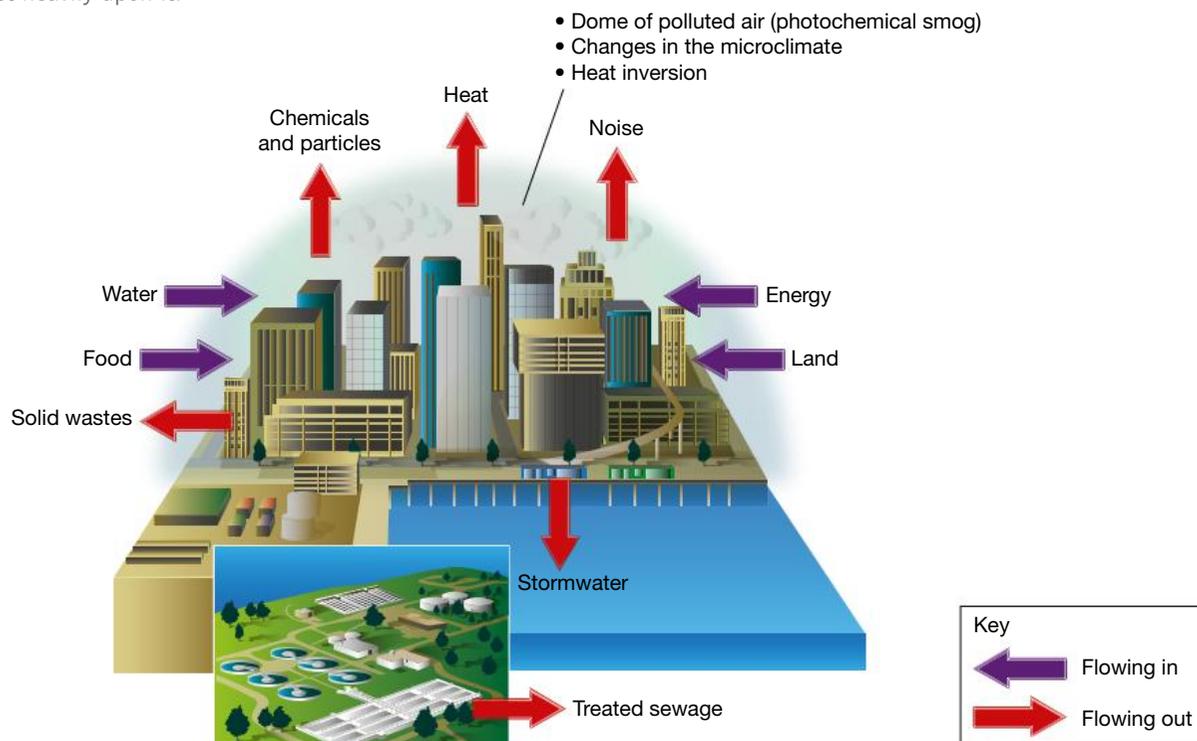
Air and pollution

Large cities have an impact on air and water quality. Pollutants from cars and factories produce photochemical smog, which can affect people's health. Waste materials are difficult and expensive to manage, especially those that are toxic, and landfill sites are needed to dispose of household and business waste.

Rethinking cities

In China, a 1.3 square kilometre 'Great City' has been proposed (see Figure 6.6.3). It will be a massive development that is completely sustainable and affordable. The city, planned for 80 000 people, will be centred on a mass transit hub, with all destinations within a few minutes walk, reducing the need for cars.

6.6.1 Cities depend on the environment and they also impact heavily upon it.





6.6.2 Kyeemagh Market Gardens, Sydney

The design will include a surrounding buffer landscape, which will include forests, valleys and lakes that are integrated into the city. Fifteen per cent of the land within the city will be devoted to parks and green spaces. Sixty per cent will be reserved for construction. The remaining 25 per cent will be used for roads and walkways.

Benefits of concentration

Some experts believe that concentrating growing populations in large cities can actually help to save the environment.

Energy efficiencies

If more high-rise buildings were built in urban environments, the resulting higher population densities would improve energy efficiency and lower emissions per capita. New York is one of the most energy-efficient cities in the United States of America, as more than half of its households use public transport rather than own a car.

Funding for environmental projects

Cities generate wealth that could be used to fund projects to protect the environment elsewhere. For example, money could be used to save endangered species and conserve habitats. Investment could be made in new technologies or infrastructure to reduce people's environmental impact. One example of this is the increasing number of bike paths being built in Australian cities, which help reduce traffic congestion and emissions from cars by encouraging people to ride their bikes.



6.6.3 China's pedestrian-focused city of the future

ACTIVITIES

Knowledge and understanding

- 1 Describe the impacts of urban sprawl.
- 2 Explain how the growth of cities causes pollution.
- 3 List the benefits of bigger cities.

Investigating

- 4 Choose one of the following topics:
 - photochemical smog
 - changes in the urban microclimate
 - heat inversion.

With the aid of a diagram, prepare a multimedia presentation, explaining how it occurs and the impact it has on the city environment and its residents.

USA's population distribution

Distribution of population

In 2016, the population of the United States of America was more than 320 million. The population of the United States is concentrated along the country's coasts (see Figure 6.7.1). Two-thirds of the people live in states along the three major coasts—38 per cent along the Atlantic Ocean, 16 per cent along the Pacific Ocean, and 12 per cent along the Gulf of Mexico. The smallest numbers live in the vast area between the Mississippi River and the Rocky Mountains, particularly in the central and northern Great Plains. While the Rocky Mountains and Plains states account for about half of the landmass of the country, they account for only 34 per cent of the population.

Overall, the population of the United States is more widely distributed over its landmass than is the case in Australia. The Great Plains, for example, is used quite extensively for agriculture. Much of inland Australia is desert. Figures 6.7.1 and 6.7.2 illustrate the relationship between precipitation and population density and distribution in the United States.

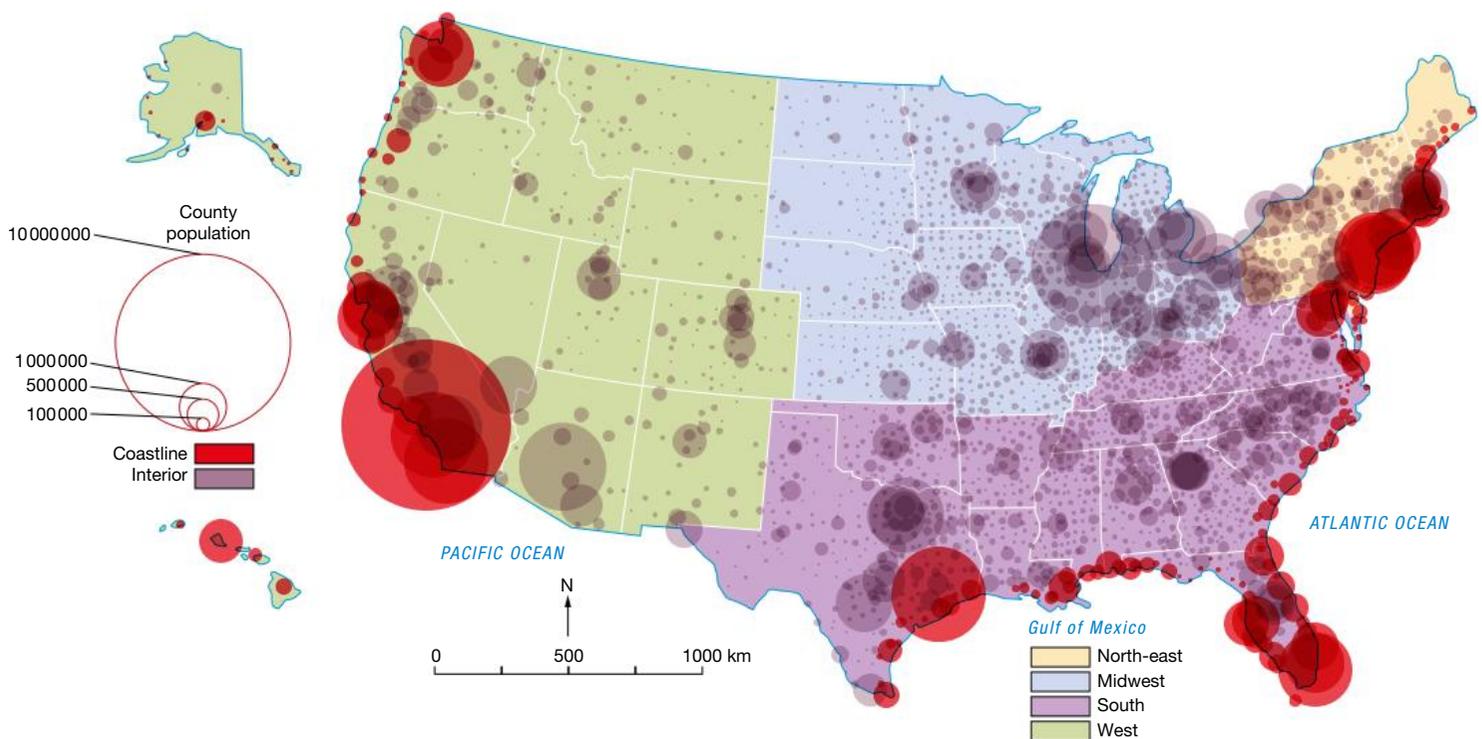
The United States has a much larger population than Australia. Australia's average population density is close to 2.9 inhabitants per square kilometre compared with 34 inhabitants per square kilometre for the United States. Significantly, however, a higher proportion of Australians (75 per cent) live on or near the coast.

Internal migrations

Since the 1960s, Americans have migrated to the south and west to a group of states known as the 'Sun Belt' (includes Florida, Nevada, Arizona, Utah, Colorado and New Mexico), seeking jobs, a warmer climate and sometimes a lower cost of living. Hundreds of thousands of retirees have also settled there.

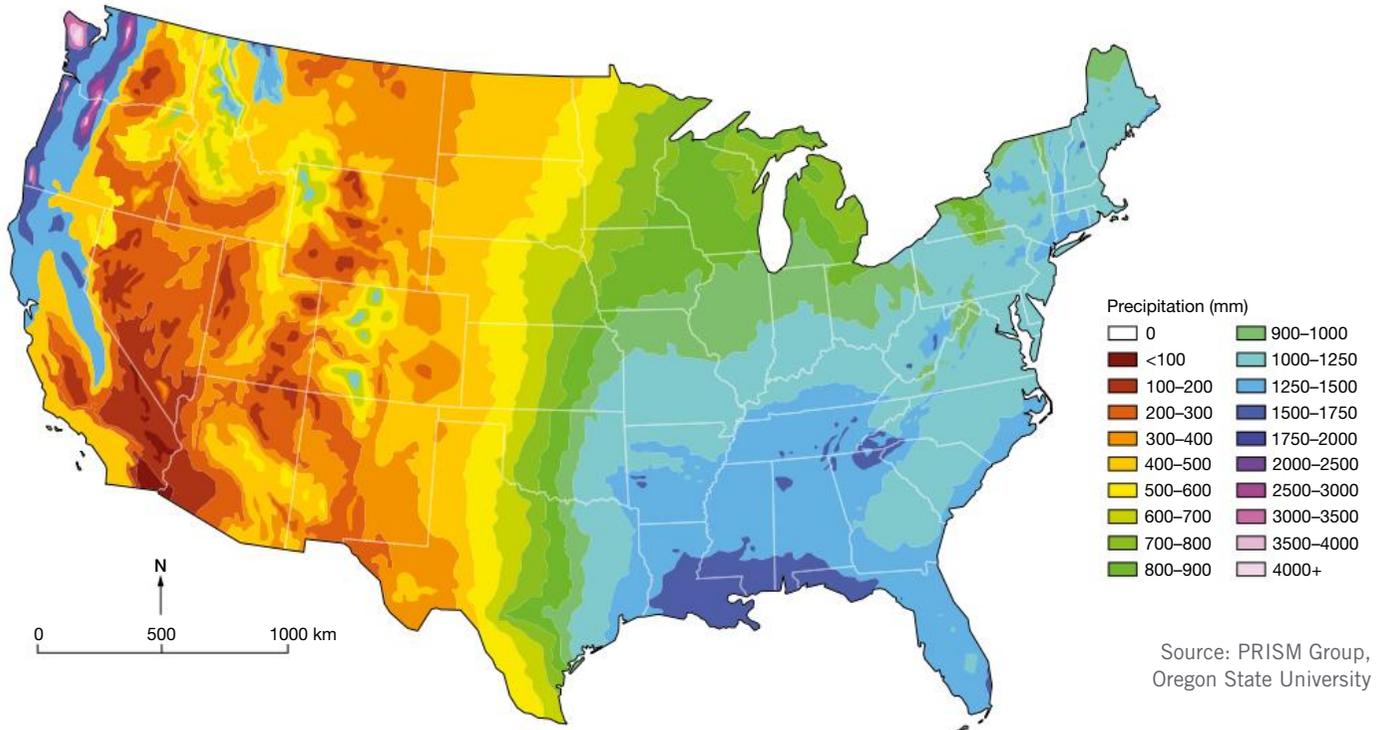
Internal migration is closely related to economic conditions. People will migrate to areas that have job opportunities. The 2010 census showed that North Dakota had the fastest-growing population, due to the growing oil shale industry.

6.7.1 Population distribution, United States of America, 2012



Source: United States Census Bureau, 2012

6.7.2 Annual precipitation, United States of America



The flight to the suburbs

Since the 1950s, there has been a shift in population away from America's inner cities to 'greenfield' suburban development well beyond the outskirts of the city. As a result, urban areas have deteriorated. Local governments in the United States are responsible for services such as schooling and policing. When an increasing number of middle-class taxpayers move to the greenfield suburbs, or **exurban regions**, local authorities in

urban areas are unable to raise sufficient taxes needed to fund such services. This has resulted in a downward spiral of **urban decay**. As services decline and decay, even more people flee.

This movement also has a racial dimension. The term 'white flight' has been used to describe the large-scale migration from racially mixed inner cities to more racially homogeneous suburban regions.

ACTIVITIES

Knowledge and understanding

- 1 Identify the parts of the United States that have experienced the fastest population growth. Which have shown the slowest growth?
- 2 Account for the uneven pattern of growth.
- 3 State what the distribution of the US population has in common with that of Australia. In what ways does it differ?
- 4 Account for the pattern of internal migration in the United States.
- 5 Describe the relationship between internal migration and economic conditions.
- 6 Explain how the movement of people in US cities could be described as having a racial dimension.

Geographical skills

- 7 Study Figures 6.7.1 and 6.7.2. Describe the relationship between precipitation and population distribution in the United States. Think of reasons why this relationship exists.

Location of cities

In addition to the age of rail, a range of factors account for the existing pattern of urban concentration in North America.

Climate and landuse

More of the United States is suitable for agriculture than is the case in Australia. While the Great Plains—which lie west of the Mississippi River and east of the Rocky Mountains—are classified as semi-arid prairie grasslands, they are capable of supporting ranching and irrigation-based agriculture. The climate is one of extremes. Very cold and harsh winters are followed by very hot and humid summers. East of the Mississippi River, population densities and rainfall increase. In the south, the climate is milder, but hot and humid in summer. In the north, winters are harsh. Precipitation is high enough to support more intensive forms of farming.

Geography

The existence of navigable waterways, most notably the St Lawrence River, which links the Great Lakes to the Atlantic Ocean, and the Mississippi River, allow ocean-going vessels to travel some distance inland. Cities such as Detroit and Cleveland thrived as a result of their access to the Atlantic Ocean via the St Lawrence River.

History

The largest concentration of large urban centres is in the north-east of the country—the original focus of European settlement. This region remains the most densely settled part of the United States.

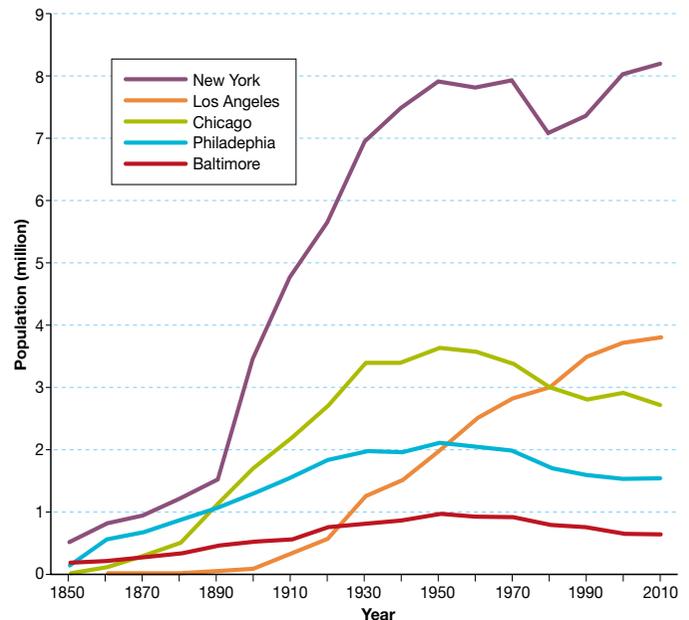
Governance

The United States comprises fifty states, each with its own capital city complete with all the administrative functions associated with government. This approach to government has contributed to the distribution of relatively large urban centres across the United States.

Changing urban populations

The urban population pattern of the United States is undergoing change. The country's industrial cities are losing population while the service-based cities are expanding. Figure 6.8.2 shows that while cities such as New York and Los Angeles are growing, others, including Chicago, Philadelphia and Baltimore, are declining.

6.8.2 While US coastal cities have continued to grow, inland cities, especially those traditionally associated with manufacturing, have experienced declining populations.



Source: United States Census Bureau, 2012

ACTIVITIES

Knowledge and understanding

- 1 State how the pattern of urban concentration in the USA differs from that of Australia.
- 2 Outline how the urbanisation process in the USA differed from the European experience.
- 3 Explain the role that railways played in developing the USA's pattern of urban concentration.
- 4 Outline how climate, landuse and geography have influenced the distribution of urban concentration in the USA.
- 5 Explain how the US system of governance has affected the urban pattern of the country.

Geographical skills

- 6 Study Figure 6.8.1 and do the following tasks.
 - a Identify the overall settlement pattern.
 - b List the possible reasons for this distribution.
- 7 Study Figure 6.8.2. Using data from the graph, outline the trends in urban populations for New York, Los Angeles, Chicago, Philadelphia and Baltimore.

CASE STUDY: Las Vegas

Geography and population

Las Vegas, shown in Figure 6.9.1, is located in an arid desert basin surrounded by mountains. Much of the landscape is rocky and dusty. The environment is dominated by desert-like vegetation, and the area is subject to torrential flash floods. The dry heat is an attraction, especially for tourists from the colder parts of North America.

With a population of just under two million, Las Vegas is one of the largest inland urban centres of the United States of America. The city is an internationally renowned tourist destination, famous for its vast casino-hotel-resort complexes and associated entertainment. The city's main entertainment precinct is concentrated along a 6.8 kilometre stretch of South Las Vegas Boulevard known as 'the Strip'. Las Vegas is also a major convention centre.

Origins and growth

Las Vegas was founded as a stopover for the pioneers travelling to the west, and became a railroad town in the early twentieth century. In 1931, the state of Nevada legalised gambling.

This led to the development of casinos. Major developments occurred in the 1940s, following the influx of scientists and staff working on the Manhattan Project—the World War II research project that led to the development of the atomic bomb.

Las Vegas's growth has always been closely linked to infrastructure. Completed in the 1930s, the giant Hoover Dam provided Las Vegas with the power and water needed to support the city's development. The construction of a highway to Los Angeles provided a link to one of the largest concentrations of people in the United States.

Las Vegas has experienced very rapid population growth since it was founded in 1905 (see Table 6.9.2). In the first decade of the twenty-first century, for example, Las Vegas's population grew by approximately 40 per cent. In the 1990s, it grew by more than 85 per cent. The satellite images in Figure 6.9.3 show the expansion of the metropolitan area over a period of just 25 years. Forty-six per cent of the city's population work in tourism-related jobs.

6.9.1 Las Vegas's famous Strip



6.9.2 Population growth of the Las Vegas metropolitan region, Clark County, Nevada

Year	Clark County population	Change (%)
1910	3321	
1920	4859	46.30
1930	8532	75.60
1940	16414	92.40
1950	48289	194.20
1960	127016	163.00
1970	273288	115.20
1980	463087	69.50
1990	741459	60.10
2000	1375765	85.50
2009	1902834	38.31
2013	2028000	6.20

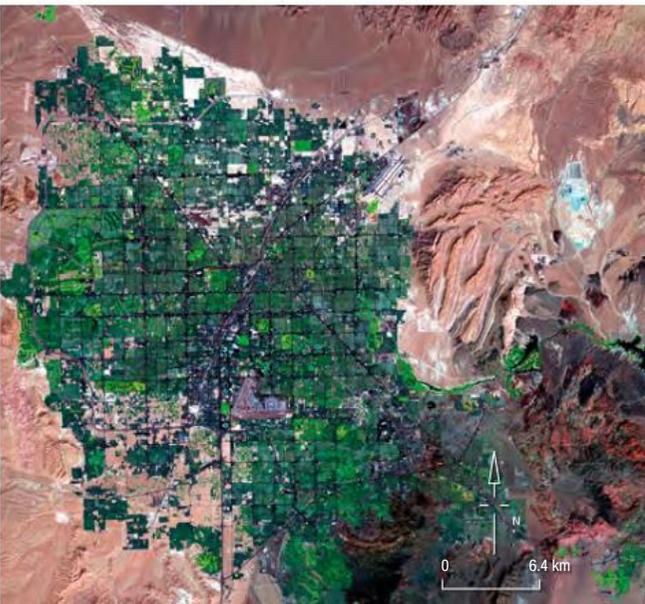
Source: United States Census Bureau

6.9.3 The growth of Las Vegas over the last quarter of a century is shown here in false-colour Landsat images. The dark purple grid of city streets and the green of irrigated vegetation extend in every direction to the surrounding desert.

1984



2015



DID YOU KNOW?

Seventeen of the twenty biggest hotels in the USA are in Las Vegas.

Tourism

Nearly 40 million people visit Las Vegas each year. Five million of these visitors travel there to attend the 19 000 conventions held in the city annually. Sixteen per cent of the city's visitors are international tourists.

The casino and entertainment complex constructed in Las Vegas by 1970 resulted in a rapid growth of airline connections and the development of the convention business. By 2010, McCarran Airport ranked 22nd in the world for passenger traffic, with 39 757 359 passengers passing through the terminal. The airport ranked ninth in the world for aircraft movement, with over half a million take-offs and landings.

The other advantage of Las Vegas is lots of hotel rooms. Nine of the top ten largest hotels in the world can be found in Las Vegas. The availability of so many hotel rooms has resulted in the emergence of the nation's largest convention business.

Gambling

Las Vegas is also a leading centre of gaming. Revenue from gambling now exceeds US\$9.2 billion per year. Las Vegas's initial advantage came from being home to the first large-scale gaming industry. Due to the increase in gambling around the world, especially in Macau, China, Las Vegas-based firms are now major suppliers of gambling expertise worldwide.

ACTIVITIES

Knowledge and understanding

- 1 State why Las Vegas is so well known internationally.
- 2 Outline the scale of the tourism and convention industry in Las Vegas.
- 3 Describe the geographical setting of Las Vegas.
- 4 Draw a timeline outlining the origins and stages of development of Las Vegas.

Geographical skills

- 5 Study Table 6.9.2. Construct a line graph illustrating the population growth of Las Vegas from 1910 to 2009. In which decade was growth most rapid?
- 6 Study Figure 6.9.3. Estimate the increase in the area of Las Vegas between 1984 and 2015.



Population movements

People move both within and between nations. Internal migrations occur when people move within their homeland for economic or lifestyle-related reasons. International migration involves the forced (as in the case of refugees) or voluntary movement of people.

Since early 1945, more than seven million people have come to Australia as new settlers. Today, nearly one in four Australians was born overseas. These new arrivals have reshaped the nation. Australia is now truly a multicultural society.

In China, economic factors are the principal reason why people move. The pace of economic change

in China has been extremely rapid and represents one of the most sustained and rapid economic transformations the world has ever seen.

In this chapter we will examine the reasons for, and the effects of, internal migration in Australia and China, and investigate the reasons for, and the effects of, international migration to Australia.

INQUIRY QUESTIONS

- What are the reasons for, and the effects of, internal migration in Australia and China?
- What are the reasons for, and the effects of, international migration to Australia?

GLOSSARY

counter-urbanisation	a process whereby people move from the city to rural areas	middle class	the social group between the upper and working classes, including professional and business people and their families
cosmopolitan lifestyle	a way of life drawn from aspects of the lifestyles of a range of cultures across the world	multiculturalism	a social policy that recognises the right of all citizens of a country to enjoy their cultural heritage and receive equal treatment and opportunities regardless of their background
exurbanisation	a process whereby people, usually affluent, move from the city to rural areas but continue to maintain an urban way of life, either through long-distance commuting or by using technology	nomadic	a way of life that involves moving across a territory seasonally in search of food and water
guest worker	a person who moves temporarily to another country for work	One Child policy	a policy introduced by the Chinese government to reduce its population growth—people were permitted to have only one child
gross domestic product	the total monetary value of goods and services produced in a country during one year	per capita	per person; often used with the term GDP
hukou system	a Chinese household registration system that entitles the holder to a range of services such as health care and education, used to regulate the movement of people in China	productivity (of land)	the amount of food or fibre produced from a unit of land
internal migration	the movement of people within a country	sea changer	a person who relocates from the city to the coast
international migration	the movement of people between countries on a permanent or semi-permanent basis	tree changer	a person who relocates from the city to a rural or regional area
involuntary migration	the forced movement of people between countries on a permanent or semi-permanent basis due to war, civil unrest, drought and famine	urban sprawl	the outward spread of a city and its suburbs as they grow
		White Australia policy	various historical federal government policies aimed at restricting non-white immigration to Australia from 1901 to 1973

7.0 The plight of Syrian refugees is an example of the movement of people between countries on a permanent or semi-permanent basis. In this instance the forced movement is a result of war and civil unrest. Australia has made a commitment to resettle 12 000 of those fleeing Syria.

Australia: internal migrations

Internal migration

Internal migration occurs when people move to other places within their own country. Four of the five fastest-growing regions in Australia are now found in Queensland. These are Brisbane, the Gold Coast, Moreton Bay and the Sunshine Coast. All are located in the south-east corner of Queensland. Figure 7.1.1 shows average net interstate migration, 2004–05 to 2013–14.

Economic migration

The reasons for internal migration are varied. Employment opportunities can attract people to certain areas. For example, there has been significant migration to North Queensland and parts of Western Australia due to those states' booming mining industries, as people can earn higher incomes.

Economic migration can bring about very significant change within communities. The increase in the population can be so sudden that local communities can be overwhelmed. Important infrastructure, such as roads, utilities (water and electricity supply), schools and hospitals, and a range of community services, are quickly overstretched. There can

be many economic benefits to local communities of internal migration, but in some cases, where the population grows very quickly, the impact on local economies can be negative. For example, housing shortages are very common and this has meant that house prices and rents have skyrocketed.

Lifestyle and retirement migration

Another group of internal migrants are the retirees and those who choose to move out of the cities for lifestyle reasons. Moving to be closer to family is another key factor in internal migrations.

There is also a significant movement of people within states. For decades, populations have been declining in many of Australia's smaller country towns. The people who once populated these towns have moved to the large cities on the coasts or to the larger rural centres.

Tree and sea changes

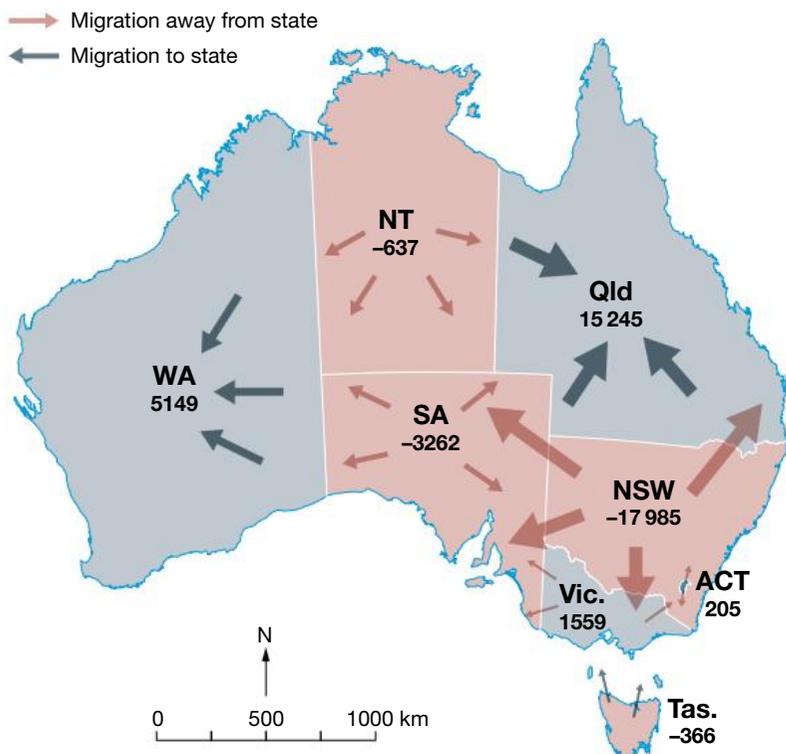
Over the last 15 to 20 years there has been an increase in the number of people moving away from cities to rural or coastal areas.

The terms '**counter-urbanisation**' and '**exurbanisation**' are used to describe the process of people moving away from cities but maintaining important links with the city, such as work. For example, in South Australia many people have moved from Adelaide to the Adelaide Hills. Here they have access to a rural lifestyle but, because the Adelaide Hills are relatively close to Adelaide, they are able to continue to work in the city.

Tree changers are people who move from the city to inland areas, such as from Sydney to Newcastle and Wollongong in New South Wales. Such regions offer larger blocks of land suitable for small farms and large gardens, smaller communities and a cleaner and greener environment.

Sea changers make their move from the city to the coast. The most popular coastal areas are those relatively close to the big cities.

7.1.1 Net interstate migration, annual average movement, 2004–05 to 2013–14



Source: Australian Bureau of Statistics

SPOTLIGHT

Mandurah, Western Australia

Located just 73 kilometres from Perth, Mandurah has become a popular sea change destination for Western Australians. It has a population of more than 80 000 people, and is expected to increase significantly in the next decade (see Figure 7.1.2). This makes Mandurah Western Australia's fastest-growing region. Mandurah is linked to Perth by a freeway and a railway, which opened in 2007. The opening of the railway made Mandurah a more popular destination. A significant proportion of the population, about 20–25 per cent, are expected to be aged over 65. This presents some challenges for the city, especially in terms of providing the health and other services needed by an older population.

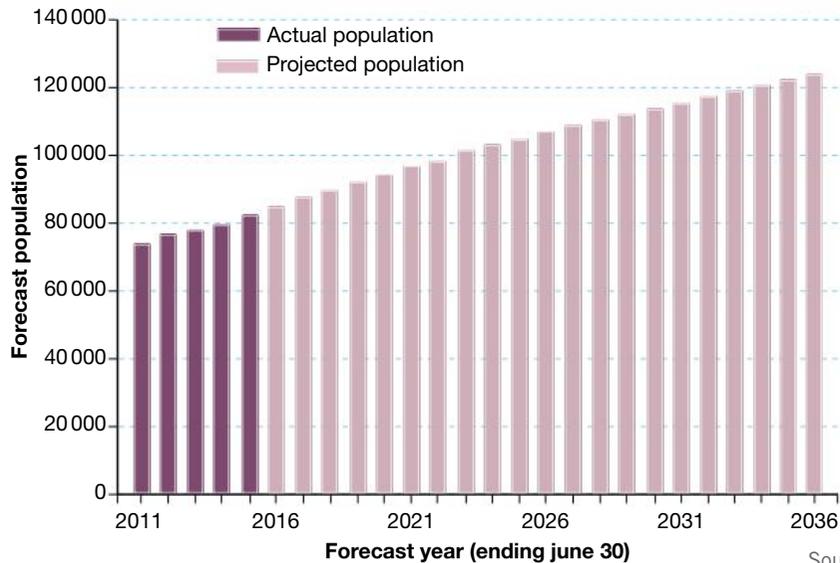
As Mandurah has grown, it has ceased to be the small, quiet fishing village it once was. Large shopping malls and housing estates now dominate much of the city. Some long-term residents fear that their town has lost some of its unique character. However, others welcome the increased population and the services and opportunities that this brings.

There are also concerns about the local environment. For example, there are currently 22 kilometres of canals in the city. These canals are carved out of the natural intertidal wetland and mud flats that form along the Mandurah Estuary, as shown in Figure 7.1.3.



7.1.3 Canal housing development in Mandurah

7.1.2 The projected population increase in Mandurah



Source: Forecast.id® website

ACTIVITIES

Knowledge and understanding

- 1 Write your own definition of the term 'internal migration'.
- 2 Outline some of the main reasons for internal migration.
- 3 Describe how internal migration can become a problem for local communities.

Applying and analysing

- 4 If you could migrate to anywhere in Australia, where would you go? Why?

- 5 Evaluate the short-, medium- and long-term impacts of the opening of the train line to Mandurah.

Geographical skills

- 6 Study Figure 7.1.1 and list the states (from highest to lowest) that have experienced population gains and losses from internal migration.

CASE STUDY: The mobility of Indigenous Australians

The traditional Indigenous way of life

Most of Australia appeared uninhabitable to the first Europeans but Aboriginal and Torres Strait Islander people successfully occupied the entire continent. While Europeans avoided the deserts and hot tropical north, these same areas provided good living for Aboriginal people.

Hunting and gathering

The Aboriginal people were **nomadic** hunters and gatherers who moved across their traditional lands. They had such an intimate knowledge of their environment that, in most areas, they could obtain sufficient food and raw materials for shelter, clothing and ceremonies in just a few hours. They were keen observers of the condition of their country and would move on when resources showed signs of declining, enabling the resources to replenish.

The extent to which Indigenous people moved across the land was determined by the **productivity** of the land. This was reflected in population densities over the continent. In the coastal areas, where there was plenty of food and water, they might spend months in one location and rarely move very

far. In the arid areas, they had to walk long distances between waterholes and food sources, which were spread over a much wider range.

Indigenous people also moved across the land to exploit seasonal foods and resources. They followed the breeding and movement of animals and fish, as well the cycles of flowering and fruiting plants. Their knowledge of such regular patterns was very deep and had been built up over thousands of years of careful observation.

Ceremonies, social exchange and trade

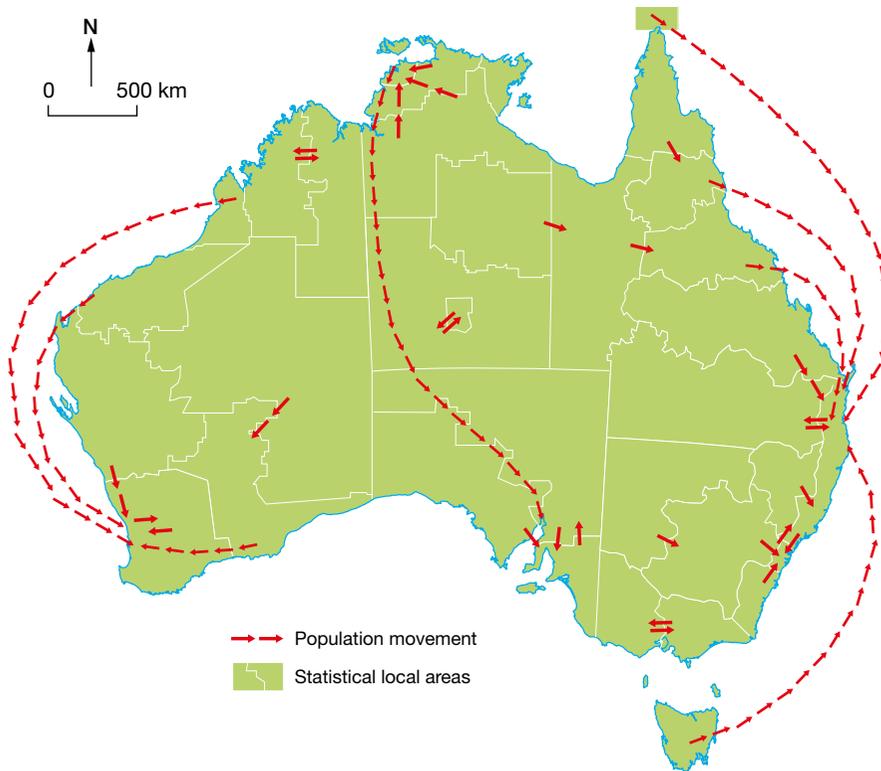
There were also annual migrations over great distances for spiritual purposes. The Snowy Mountains, for example, were of special significance. Aboriginal people were summer visitors to the highest peaks, coming from many directions and walking hundreds of kilometres to gather peacefully for trade, ceremonies and marriages. While in the mountains, they feasted on the Bogong moths that were readily available and considered a great delicacy.

The tracks used by Aboriginal people were well-known paths through their country. Songlines joined places of ceremonial significance (see Figure 7.2.1).

7.2.1 By singing songs in an appropriate sequence, Aboriginal people could navigate their way over hundreds of kilometres.



7.2.2 Most common destinations for Indigenous people in Australia



DID YOU KNOW?

Songlines, or Dreaming tracks, are paths that are recorded in traditional songs, stories and dance. By singing the songs, Aboriginal people were able to recognise landmarks and find their way over vast distances.

Mobility of Indigenous people today

Aboriginal and Torres Strait Islander people are highly mobile, as is shown in Figure 7.2.2. They travel for the usual reasons of education, employment, health services and sport. There has, however, been an overall pattern of migration from remote areas to cities. Despite this mobility there remains a strong attachment to place and kin.

The significance of place

Indigenous people are very attached to the place in which they or their ancestors were born. Many are very conscious of their own local territory, possessing a detailed knowledge of its geography and sacred histories. They retain family stories and memories of their country, which make it significant to them. If they move away, they feel that they must periodically return to their birthplace because of their attachment to place.

Maintaining kin relationships

The kinship system is central to Aboriginal social organisation. Family relationships by blood ties and marriage define the kinship system. 'Family visits' are not just about enjoying social occasions. They fulfil obligations that are essential in Aboriginal society. This pattern of movement is more common in rural and remote areas, particularly in northern Australia.

'Aboriginal people will, at no notice, join a vehicle travelling hundreds of kilometres away, taking with them no money and few provisions, and will have no idea of when or how they will return ...' Such travel is made possible by knowing that the vehicle is in the charge of a relative and

secondly that relatives can be found at the end-destination and intermediate stops along the way who would accept unannounced visits and provide support for visiting kin.

7.2.3 A reflection on Aboriginal people in Central Australia, from A Hamilton, 'Coming and Going: Aboriginal Mobility in North-west South Australia, 1970–71' in *Records of the South Australia Museum*, Vol 20, pp. 47–57

ACTIVITIES

Knowledge and understanding

- 1 Explain how Aboriginal people were able to live off the land over much of the Australian continent.
- 2 Describe how songlines assisted Aboriginal people to find their way.
- 3 Explain why Indigenous people are so mobile today.

Applying and analysing

- 4 Study Figure 7.2.2. Describe the pattern of movements between states.

Investigating

- 5 Investigate the Aboriginal trade in ochre that existed prior to European settlement.
 - a Using a map of Australia, label and annotate the sources of ochre and the trade routes.
 - b Explain how the ochre was gathered.
 - c What did the Aboriginal people use to trade for the ochre?
 - d Outline how the ochre was used.
 - e Were there any other main trade items? Explain.

China's internal migrations

Economic transformation

China's economic transformation has triggered one of the largest population movements in human history, as shown in Figure 7.3.1. The country's economic success has led to a rapidly rising standard of living. The main driver of urban growth has been, and will continue to be, **rural-urban migration**.

Between 2010 and 2025 the population of China's cities will grow by 350 million people, which is equal to today's population of the United States of America. One billion people will live in Chinese cities by 2030. The number of cities with more than one million people will reach 221 by 2030. Europe has only thirty-five today. In response to the population movements, the following infrastructure will be required.

- Five billion square metres of roads will need to be paved.
- Forty billion square metres of floor space will need to be built in five million buildings. Fifty thousand of these buildings will be skyscrapers.

- One hundred and seventy-five new mass-transit systems (public transport networks) will need to be built.

Population mobility

Until the end of the 1970s, 80 per cent of the Chinese population were rural dwellers and it was almost impossible for them to leave their villages. Under the **hukou system**, a person was registered in a household and identified as a resident of a particular area. People were required by law to stay in their district and they were not permitted to move elsewhere looking for work. People could qualify for coupons for food or receive medical treatment only in their own designated hukou, and so the government services that people needed to survive were tied to where they were registered. This kept the people in the countryside for decades.



7.3.1 Internal migration in China, 2000 to 2005

A shift in government policy

As the post-1978 economic reforms took hold, the rules of hukou system were progressively relaxed. Most significantly, people no longer required coupons to buy food, and a worker without an urban hukou could work in the city, as the government no longer assigned jobs to people. However, in doing so, workers were still ineligible for services such as health care, free education for their children and subsidised housing, all of which people who were registered in urban areas received. Despite these remaining limitations, the relaxing of the hukou system was enough for urbanisation to get underway. China's policy shift to accept and promote migration to urban areas was designed to create the pool of labour necessary for economic growth.

The hukou system today

The hukou remains one of the most valuable documents in China today. Migrant workers without an urban hukou still have trouble finding decent housing and education for their children. They are also denied a range of government benefits. It is especially hard to gain admission to university without being an urban hukou holder.

There has been a push to reform the hukou system. Shanghai, Guangzhou and Shenzhen have relaxed the rules. The local hukou can be obtained if the migrant invests in the city or

buys property. However, in crowded cities such as Beijing, where one-third of the residents are without the hukou, the government is hesitant to abolish the system, fearing that it would result in a surge of migrants to the city. They fear that such an influx would overwhelm the city's infrastructure and lead to even more overcrowding.

Internal migration

China's economic reforms involved its integration into the global economy. China quickly became the world's largest exporter of manufactured goods and a major importer of resources. Once-sleepy coastal fishing villages were suddenly transformed into major ports and manufacturing centres. The most rapid growth occurred in large cities in the coastal provinces, where the export industries boomed. Guangdong was known as the 'world's factory' due to the high number of factories and factory jobs there.

As the economy grew, it created new jobs and there was a flood of people leaving the countryside for the towns and cities in search of jobs and higher wages. Migrants on the move are shown in Figure 7.3.2. Migrants were employed in factories, on construction sites and in services (as security guards, cleaners, couriers and domestic workers). Most of the migrants were young people who did not want to stay in the rural villages, which offered little in the way of career options.



7.3.2 Migrants on the move, seeking jobs in the cities

Lives of internal migrants

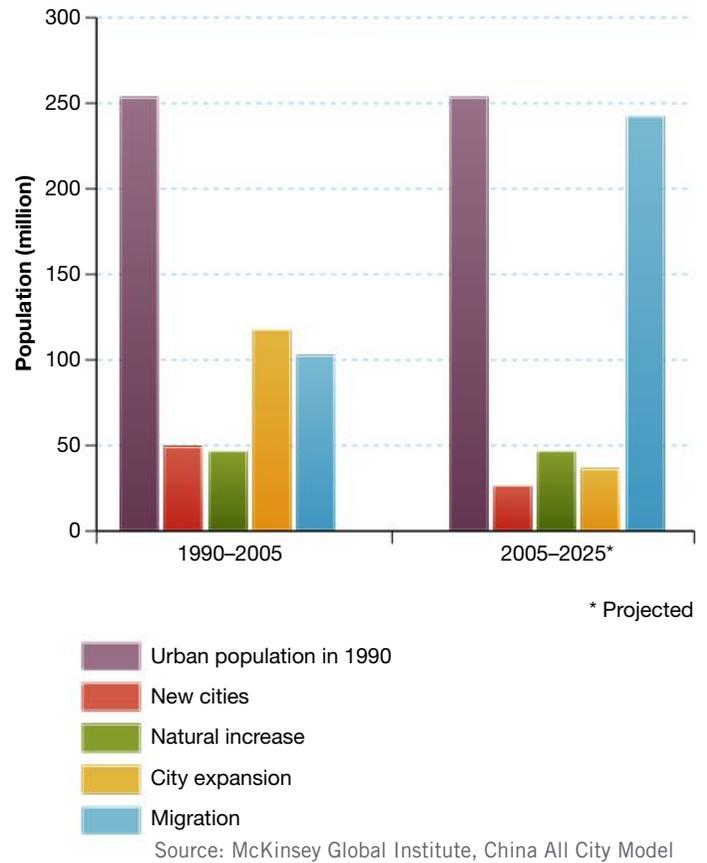
Migrant workers from rural areas make up to half of China's urban workforce and half of the country's **gross domestic product** (GDP), but suffer from discrimination. The migrants are denied access to public services in the cities, due to the hukou system, and often experience exclusion and abuse.

The future

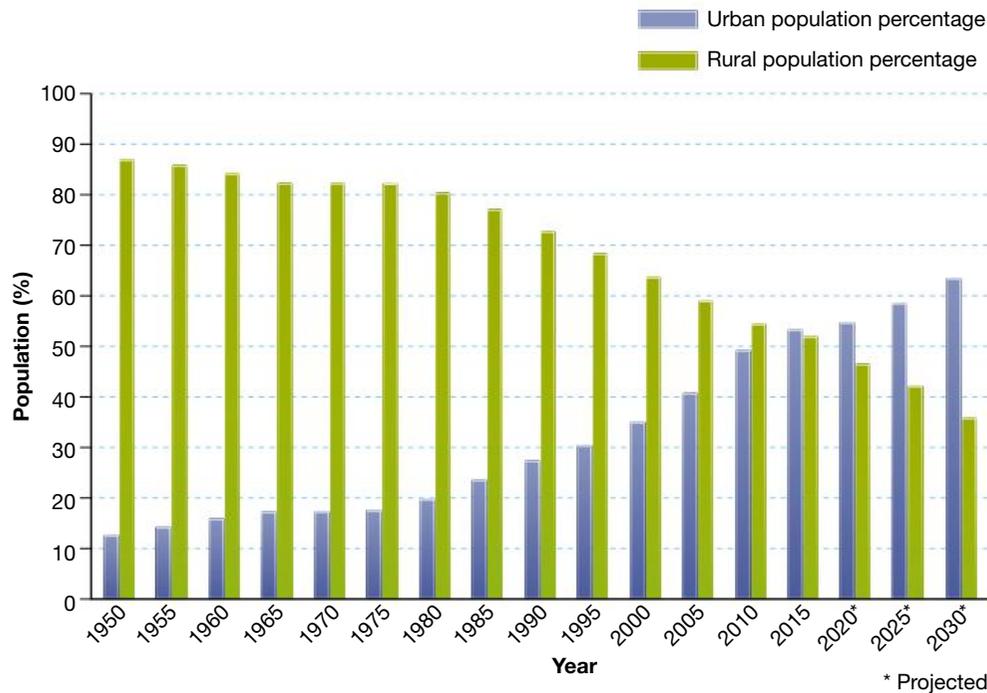
In 2012, the number of people living in urban areas exceeded the rural population for the first time, after 21 million people were added to the population of urban areas in just one year, as shown in Figure 7.3.3. The sheer numbers involved are staggering. Between 1990 and 2005, 103 million people migrated from rural areas to urban areas, and in the following 20 years another 243 million are expected to do the same (see Figure 7.3.4).

China's urban economy is expected to generate over 90 per cent of GDP. China's economic goals are closely tied to continued urbanisation. The government is committed to quadrupling **per capita** GDP by 2020 (from the 2000 level). This goal implies the continued growth of towns and cities, where the wealth is generated. This growth will create employment—a major pull factor—and internal migrations will continue to impact on China's cities and rural areas.

7.3.4 Sources of urban population increase in China between 1990 and 2025



7.3.3 China's rural and urban population growth, 1950-2030





7.3.5 A densely built residential apartment development near Ordos City in China. With an investment of over US\$161 billion by local government and revenue from the region's rich coal deposits, buildings to accommodate at least 300 000 residents, complete with modern facilities and grand plazas, were built on the site of an old desert village.

SPOTLIGHT

Cha Guoqun's story

Cha Guoqun left his village in search of work in the city of Hangzhou, in eastern China. When a cut on his leg became infected in November 2006 and prevented him from working, he visited a state hospital. As Cha had no health insurance, the doctor gave him two options: pay 1000 yuan (A\$120) a day for treatment, the equivalent of his entire monthly income; or have his leg amputated. Fortunately, Cha received help from a Christian charity hospital, which was able to save his leg.

This case highlights the plight of an estimated 150 to 200 million rural–urban migrants who have moved to China's cities in search of work and better lives.

While their labour has fuelled China's economic growth, the majority of internal migrants never gain permanent residency in urban areas. For the most part, the lives of migrant workers are miserable. They have to live in makeshift shelters and eat the cheapest bean curd and cabbage. They have no insurance and their wages are often delayed. They are also discriminated against by urban people.

ACTIVITIES

Knowledge and understanding

- 1 Explain what the hukou system is. How did it restrict population movements?
- 2 Describe and account for change in China's population movement policy. What was the impact of the change?
- 3 Outline the urban population projections for China into the future.
- 4 Compare the opportunities for those who have an urban hukou and those new migrants who do not.

Geographical skills

- 5 Study Figure 7.3.3 and answer the following questions.
 - a In which year did China have the highest percentage of rural dwellers?
 - b When did the rate of urbanisation start to accelerate?
 - c What percentage of the population is expected to be urban dwellers by 2030?
- 6 Study Figure 7.3.4 and answer the following questions.
 - a By 2025, how many people will migration have added to China's cities since 1990?
 - b Of the total increase in urban population between 1990 and 2025, what percentage will have been migrants?

Impact on Chinese cities

Rapid urban development

China is becoming an urban nation at a rate and on a scale never before seen. In just two decades, the lives of millions of Chinese people have been transformed. With increasing concentrations of people in industrial cities, the environment has become a casualty of the rural–urban migration. Huge areas of the countryside have become part of the rapidly advancing **urban sprawl**.

In China's eastern provinces are six of the world's top twelve economic 'hotspots': Shanghai, Beijing, Tianjin, Chongqing, Nanjing and Guangzhou. These cities are the favoured destinations of migrant workers. China's cities make up about 40 per cent of the global growth in the demand for residential and commercial floor space.

The government has built over a million new housing units in cities throughout China to deal with the rapid urbanisation. It has also provided assistance to workers to set up savings plans to purchase these units. The skylines of cities and the countryside are filled with construction cranes, as high-rise apartments are built. Urban sprawl is consuming the east coast of China.

Impact on urban dwellers

Economic growth has delivered greater prosperity to urban dwellers. People living in Guangzhou in 2010 were earning four times the income that people earned in 1993. Urban residents also receive more benefits and social services from the government, such as health insurance, pensions and

education. As city dwellers become more educated, they enter high-skilled jobs, where they earn even higher incomes. As a result, a **middle class** of wealthy consumers has emerged, and the numbers involved will lead to further economic growth. Figure 7.4.1 shows the rise in China's middle class.

Middle class

The increasingly wealthy middle class provides a huge market for consumer goods. Between 2000 and 2014, the number of automobiles per 100 urban households rose from less than one to about 26; the number of computers from 8 to 87; the number of mobile phones from 16 to over 200; and the number of microwave ovens from 16 to 73.

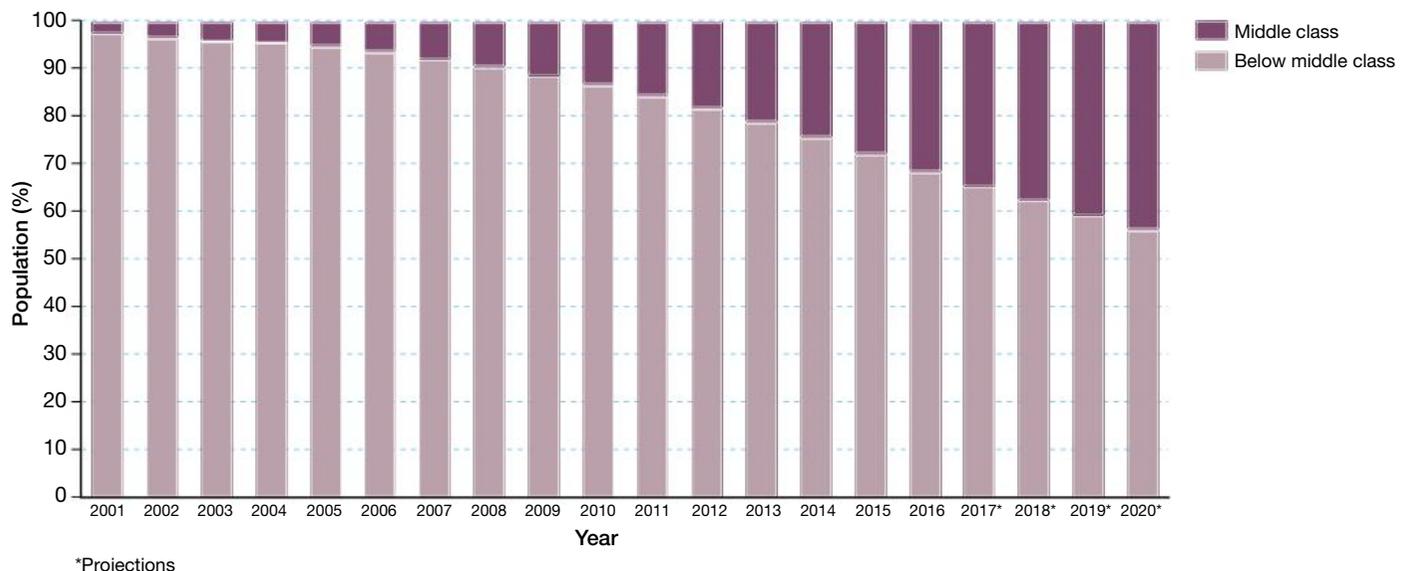
Inequalities within cities

Migration has led to greater inequalities within cities. The incoming rural migrants are generally uneducated and low skilled, and find it difficult to get well-paid jobs. This has led to tension between the rich and the poor. Over one-third of urban crimes have been linked to young migrants. There has also been a disturbing number of suicides among young migrant workers unhappy with their wages and working conditions.

DID YOU KNOW?

If current patterns continue, the number of middle-class Chinese will soar to 607 million by 2020, and spending by China's middle class will rival that of the United States of America.

7.4.1 The growth in China's middle class





7.4.2 Pollution over Shanghai, 2013

Environmental effects

As urban expansion continues to accelerate in China, the environmental consequences are alarming. A toxic, grey cloud often hangs over many of China's cities, as shown in Figure 7.4.2. Industrial wastewater and household sewage have contaminated rivers and coastlines. Water shortages and water pollution are becoming real threats. Air pollution has the

potential to become the main cause of death in China. Heavy smog from factory emissions and car pollution can cause lung cancer and cardiovascular illnesses.

Some government initiatives to develop clean energy sources are underway. However, imposing controls on pollution would slow the economic growth to which the government is heavily committed.

ACTIVITIES

Knowledge and understanding

- 1 Describe where the most rapid urban development in China has occurred and will continue to occur.
- 2 Outline how the government has assisted with housing.

Applying and analysing

- 3 Create a PMI chart of the outcomes of China's urban expansion.
- 4 Write a short response to the following topic.
The greatest achievement of China has become its biggest burden. In your response, consider the difficulty in balancing economic growth with environmental quality.

Investigating

- 5 Investigate the environmental issues of Chinese cities. Prepare an annotated visual display for a city of your choice, entitled 'Choking in growth'. You should include:
 - a map of the city
 - an overview of the city—population size, demographics, main industries, growth rates
 - an outline of the main causes of the pollution
 - current solutions to the pollution problem. For example, have policies been introduced? Are they working? Why or why not? Provide alternative solutions.

China's rural towns and villages

Promoting cities

For decades, the Chinese government has focused on promoting industrial development in the urban and eastern parts of China. This is where the government has invested in transport and communications infrastructure. The poorest people in China are now concentrated in remote townships and villages in the western provinces. The educational, health and nutritional status of people in these provinces is well below that of people living elsewhere in China.

The Chinese government seeks to avoid social unrest, which could quickly take hold and threaten the stability of the vast country, by concentrating government spending in urban centres. In rural areas, discontent is less likely to escalate, as the rural settlements and their populations are quite scattered.

An exodus of migrants

The big cities offer a wider range of employment opportunities, which is an attractive prospect for young people living in rural areas. The potential for a more enjoyable, modern and adventurous lifestyle is also a major attraction.

City-based workers retain strong ties to their families. They travel home for important events, but return to their relatively well-paid jobs in the cities.

The flow of people is not always one-way. During the 2008 global financial crisis, over 20 million workers returned to the countryside. Most returned to the cities as the world's economy recovered.

With so many young labourers leaving for the city, there are now many rural areas where it is mostly the elderly and women who are left to work on the farms. There are also many children left in the care of grandparents, while their parents work in the cities. An elderly man and his grandson are shown in Figure 7.5.1.

7.5.1 An elderly man and his grandson in Hebei Province, China



China's ageing population

In 1978, China introduced a new family planning policy, commonly known as the **One Child policy**. The policy permits families to have only one child. There have been changes to the policy since its introduction. The birth rate in China has fallen since the introduction of the policy.

Figure 7.5.2 illustrates China's falling birth rate in certain regions and an increasingly ageing population. Chinese officials are now discussing the emergence of a '4-2-1' family structure developing throughout China as families have only one child. The '4' refers to two sets of grandparents, the '2' to the parents and the '1' to the only child. Traditionally, children look after their parents and grandparents in their old age. This will now be the responsibility of just one child—and people are living longer. China's ageing society and this new family dynamic provide China with many challenges.

A widening gap between rural and urban

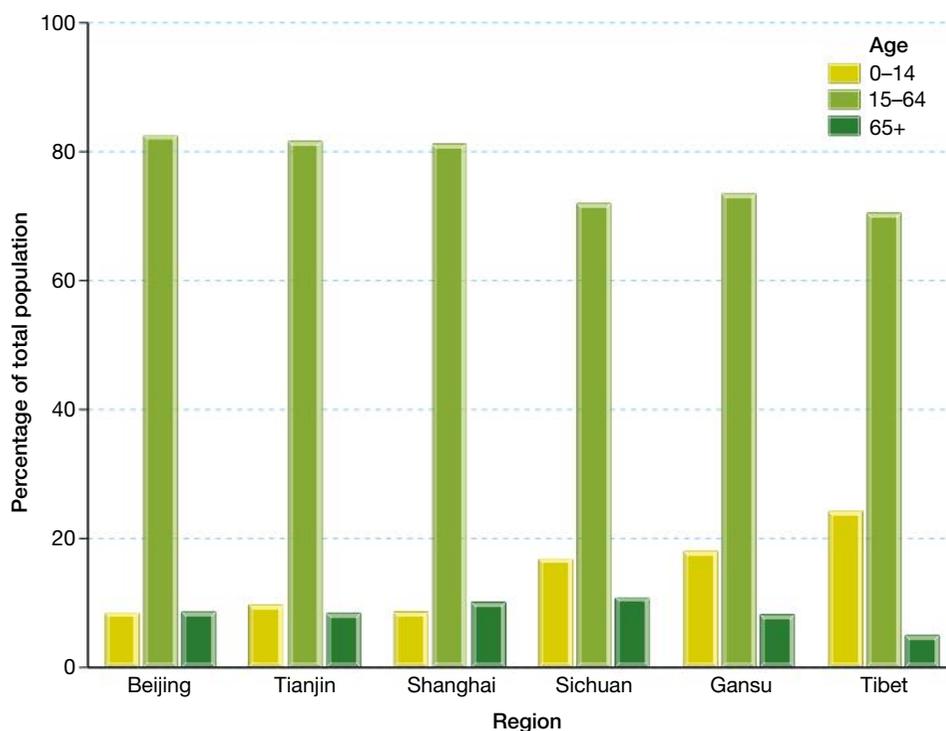
Half a billion people still live in rural areas, where almost 40 per cent of China's labour force work in agriculture. Some remote, inland regions remain much as they were 25 or even 100 years ago, with homes made of mud walls and earthen floors. Lack of adequate water supplies and sanitation services is common in many rural communities.

Despite China's economic transformation, the incomes of farmers are increasing more slowly than those of people working in the cities. The incomes of the rich have grown rapidly, which has widened the gap between rural and urban regions. The incomes of those living in the cities are, on average, two and a half times those of people living in rural areas.

Wide differences exist between the coastal provinces (where, increasingly, more people live in cities) and the inland provinces. This trend looks set to continue, as there are fewer opportunities in rural settlements. Rural schools have higher fees but fewer facilities than those in the city, so young people are disadvantaged. Many have to depend on farm labouring if they choose to stay in their village.

It is estimated that less than 30 per cent of the population in poor areas have safe drinking water and 22 per cent of rural residents cannot afford health care. The geographic distribution of health system coverage corresponds almost exactly with China's pattern of economic development, with the eastern provinces having the highest, followed by the central and then the western provinces.

7.5.2 Population of selected Chinese regions, mid-2010



ACTIVITIES

Knowledge and understanding

- 1 Explain why the Chinese government concentrates its spending in urban areas.
- 2 Analyse the movement of young people to and from the cities.
- 3 Describe and account for the widening gap between rural and urban areas.
- 4 Identify evidence for this widening gap.

Applying and analysing

- 5 Discuss the outcomes of the One Child policy and the creation of the '4-2-1' family structure.

Geographical skills

- 6 Study Figure 7.5.2 and do the following tasks.
 - a Identify the region with the highest percentage of people aged 0-14 years.
 - b List the regions with the lowest percentage of people aged 0-14 years.
 - c Tibet, a remote rural area, has the lowest percentage of people over 55 years of age. Suggest reasons for this.

International migration

Migration

Migration can be defined as simply the movement of people. Movement within a country, for example people moving from rural areas to the city, is called **internal migration**. Movement between countries is called **international migration**.

Who migrates

Each migrant undertakes the move for their own reasons. For some people the choice is voluntary and is made for lifestyle or economic reasons. For others there is no choice: natural disaster, war or a range of other concerns force them to move.

There are five broad categories of migrants: settlers, contract workers, professionals, undocumented workers, and refugees and asylum seekers.

SETTLERS

Settlers choose to move permanently to a new country. These people need to apply and then be accepted into their new country, usually by passing some type of test.

CONTRACT WORKERS

Contract workers are accepted for a short time into a country, usually for a set type of employment. For example, ski instructors may be permitted into Canada for the ski season.

PROFESSIONALS

As the world economy grows and companies become more global, the need for company employees to travel increases. Many of these transnational corporations move their staff around the world. These migrants are often referred to as expatriates and are usually short-term (2–3 years) migrants.

UNDOCUMENTED WORKERS

Undocumented workers are usually referred to as illegal immigrants. Many people in this category are smuggled into host nations. For example, there are an estimated six million illegal immigrants in the United States of America, mostly from Mexico. Other illegal immigrants may arrive in a country legally, usually as tourists, but then overstay.

REFUGEES AND ASYLUM SEEKERS

Refugees and asylum seekers flee their homes because of fear. If the authorities in the countries to which they flee confirm

that they are in danger, they are entitled to protection and perhaps even resettling in a new country. Asylum seekers are people who seek to have a government accept them. This type of migration is often referred to as **involuntary migration** because the migrants are forced to move.

Why migrate

The reasons for migration are complex and differ from person to person. However, there are three main reasons why a person would want to move to another location. They can be summarised as pull, push and network factors.

PULL FACTORS

These are often referred to as demand factors. They are those things that make a person want to go to a new location. Better employment opportunities and higher wages are typical pull factors. Social factors, such as the desire to be reunited with family members, are also pull factors.

PUSH FACTORS

These are often referred to as supply factors. They are those things that make a person want to leave a place. Unemployment, low wages, natural disasters—for example drought or famine—and war are common push factors. When people flee conflict they often have to leave most of their possessions behind them. Many spend years in camps, relying on aid from international organisations, like the people shown in Figure 7.6.1.

NETWORK FACTORS

These factors include the desire for a new experience or moving as a result of a company restructure.

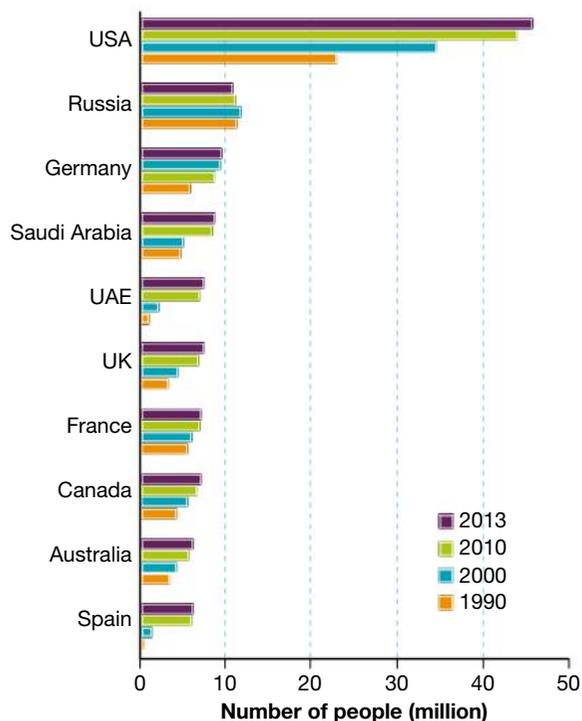
Migration has taken place for thousands of years. Globalisation, however, has made it easier for people to move. Work and education have become more international and many people spend some of their lives in countries other than their own.

Many migration patterns reflect traditional links. For example, many migrants to Great Britain come from Pakistan and India. Pakistan and India are former dominions (colonies) of Britain and so have historical links with Britain, and British influences in their cultures. Changes in government policies—such as the dismantling of Australia's **White Australia policy**—have enabled more global migration patterns.



7.6.1 Refugees at a camp near Damascus, Syria, queue to receive food supplies.

7.6.2 Top 10 countries with the largest migrant populations, 1990, 2000, 2010, 2013



Source: Migration Policy Institute

Migrant destinations

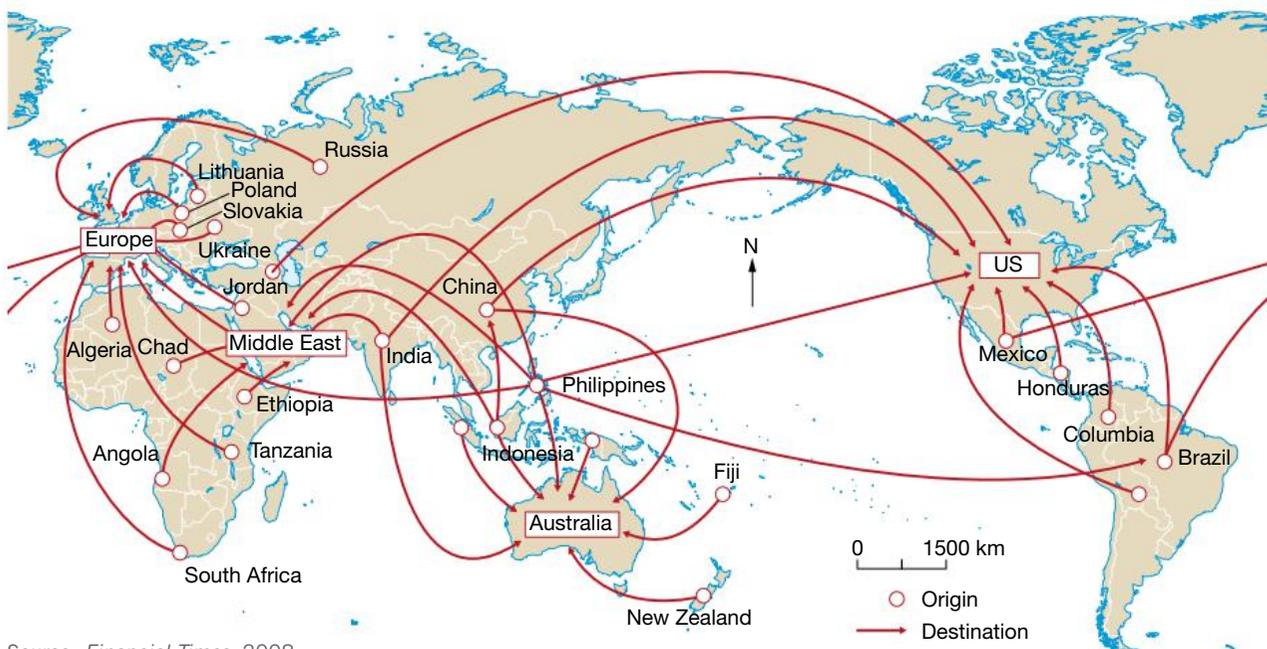
There are many countries around the world that have large overseas-born populations. These countries often offer opportunities for work, for example the United States of America, Canada and Germany, as shown in Figure 7.6.2.

Some countries have a large population of temporary migrants. For example, Saudi Arabia has a very large number of **guest workers**. These are people who temporarily move to a country for work. These guest workers do not have the full rights of other residents and usually do work that local people do not want to do. In Saudi Arabia, guest workers commonly do construction work, domestic work and other manual labour. In Hong Kong, an estimated 100 000 Filipino guest workers work as maids. These guest workers—all women—send the money they earn back to the Philippines, to help their families.

Figure 7.6.3 shows some of the main flows of people for work around the world. This map shows that the most common pattern of movement is from less developed countries to more developed economies. For example, there are significant flows of people from Mexico and South America to the United States. There are also large numbers of people moving from North Africa and Eastern Europe to the more prosperous and developed Western Europe.

Guest workers are not common in Australia, although in recent years there has been some movement of people to fill skilled vacancies in the mining industry. It is more common in Australia that people migrate permanently, or at least for long periods of time. Australia also has a large number of migrants from New Zealand. Australia and New Zealand have a special arrangement that allows the citizens of one country to work freely in the other for an unlimited period of time.

7.6.3 Major movements of people for work



Source: *Financial Times*, 2008

SPOTLIGHT

People trafficking

Unfortunately, not all migration is undertaken willingly. Human trafficking occurs when people are taken against their will from one country to another. In most cases this involves people being kidnapped or tricked into travelling to other countries for work, in many cases in the illegal sex industry. The United Nations estimates that up to 800 000 people are trafficked across borders illegally each year.

Research indicates that there are an estimated 700 000 victims of trafficking currently in the United States of America. This includes a large number of labourers who are forced into working in terrible conditions on farms and in small factories. Other countries in which there are large numbers of people-trafficking victims are Britain, Nigeria, Brazil, France, Saudi Arabia, the Netherlands and Japan.

In Australia there were 184 victims of trafficking identified by police and assisted between 2004 and 2008, mostly young women from South-East Asia who were trafficked into Australia to work in the sex industry. Thirteen people were convicted of related offences under Australian law in this period. There have also been allegations of labour trafficking in connection with Australia's 457 worker visa program. Under this program workers, mainly from the Pacific region, have been employed to work on Australian farms. There have been cases where the farm workers have been exploited under the program.

People-trafficking victims nearly always come from developing nations. Common source countries are in central Africa, South-East Asia and Eastern Europe.



7.6.4 This advertising campaign was run in the USA to highlight the problem of human trafficking.

ACTIVITIES

Knowledge and understanding

- 1 Distinguish between internal and international migration.
- 2 Explain what a refugee is. How does a refugee differ from other types of migrants?
- 3 Outline the pull factors for migration.
- 4 Outline the push factors for migration.
- 5 Explain what a guest worker is.
- 6 Describe the meaning of the term 'people trafficking'.
- 7 Explain the extent of the problem of people trafficking around the world.

Applying and analysing

- 8 Select one of the types of migration discussed in the text. Take the perspective of a migrant and write a letter to a family member about your migration experience and the reasons you migrated to your new country. Consider both push and pull factors.

- 9 In many countries, guest workers are open to exploitation. In a small group, discuss why you think this is the case. Share your ideas with the class.

Geographical skills

- 10 Study Figure 7.6.2 and answer the following questions.
 - a How many migrants were living in the United States of America in 2013?
 - b Calculate the approximate increase in the number of migrants living in Germany between 1990 and 2013.
- 11 Study Figure 7.6.3. Write a short report outlining some of the major flows of workers shown on the map. Explain why you think these flows exist.

Australian migration

Multicultural Australia

In the first half of the twentieth century the White Australia policy ensured that migrants to Australia were white Europeans. After World War II, this policy was gradually relaxed. More and more migrants, initially from southern Europe, particularly Greece and Italy, and then from Asia and finally the Middle East, came to Australia.

Australia is now one of the most multicultural countries in the world (see Figure 7.7.1). More than 200 different languages are spoken. Almost a quarter of all people living in Australia were born in another country. This is one of the highest percentages of any country. For example, only about 10 per cent of people in the United States of America were born outside the country.

Origin of settlers

Australia accepts migrants from around the world. The top 10 source countries for migrants to Australia in 2013–14 are shown in Table 7.7.2. As can be seen in the table, most migrants to Australia now come from less developed countries. This is a significant change. In the past, migrants mostly came from countries that were ethnically and culturally similar to Australia, such as the United Kingdom and Ireland.

Types of migrants

Under Australia's permanent migration program the largest category of new settlers is skilled migrants—approximately 68 per cent, with the remaining 32 per cent admitted through the Family Stream. For the 12 months between July 2013 and June 2014, 128 550 people migrated to Australia under the skilled migration program. This special program is designed to encourage migrants who have skills that Australia needs. For example, 6418 accountants, 5764 cooks, 2359 software engineers, 1972 registered nurses and 1235 developer programmers from around the world were allowed to migrate to Australia in 2013–14. These are all areas in which Australia has a skills shortage. Employers can sponsor skilled migrants



7.7.1 Australia is now one of the most culturally diverse countries in the world.

and individuals can apply to become skilled migrants. State governments can also nominate skilled migrants for visas in areas where they have a skills shortage.

Destination of settlers

Australia's large capital cities are the destination of most migrants when they arrive in Australia. More than 80 per cent of newly arrived migrants first settle in Sydney, Melbourne, Brisbane, Perth or Adelaide. More than 30 per cent of migrants settle in Sydney and about 25 per cent make their home in Melbourne. This reflects the fact that these large cities provide better employment prospects, especially for skilled migrants. The large cities also tend to have better access to support networks for migrants, such as intensive English language schools.

Citizenship	2011–12	2012–13	2013–14	% change 2012–13 to 2013–14
India	29018	40051	39026	-2.6
People's Republic of China	25509	27334	26776	-2.0
United Kingdom	25274	21711	23220	7.0
Philippines	12933	10639	10379	-2.4
Pakistan	4295	3552	6275	76.7
Ireland	4938	5209	6171	18.5
Vietnam	4773	5339	5199	-2.6
South Africa	7640	5476	4908	-10.4
Nepal	2472	4107	4364	6.3
Malaysia	5508	5151	4207	-18.3
Other	62638	61431	59475	-3.2
Total OECD countries	52517	50365	51114	1.5
Total	184998	190000	190000	0.0
New Zealand settlers	44311	41230	27274	-33.8

7.7.2 The number of people migrating to Australia from selected countries between 2011–12 and 2013–14. Migration currently accounts for much of Australia's population growth.

Source: Department of Immigration and Citizenship, *2013–14 Migration Program Report*

SPOTLIGHT

Humanitarian migration

An important part of Australian migration is the humanitarian program. This program supports refugees. Refugees are people who need the protection of another country as they can no longer live in safety in their own country. In 2014–15, people accepted into Australia under this program were typically fleeing war and persecution in their homelands, such as Burma, Afghanistan, Iraq and Syria.

7.7.3 Top 10 countries of birth of refugees accepted into Australia in 2014–15 under the offshore humanitarian program

Source country	Number
Iraq	2335
Syria	2232
Burma	2029
Afghanistan	1813
Democratic Republic of Congo	384
Eritrea	362
Bhutan	354
Iran	331
Somalia	287
Ethiopia	282
Other countries combined	600
TOTAL	11 009

Source: Australian Department of Immigration and Border Protection

ACTIVITIES

Knowledge and understanding

- 1 Describe how Australia's approach to migration changed throughout the twentieth century.
- 2 What is a skilled migrant?
- 3 Why do you think Australia has a focus on skilled migration?
- 4 Outline Australia's humanitarian migration program.
- 5 List the main destinations of migrants once they arrive in Australia.

Applying and analysing

- 6 Study Table 7.7.2. Write a short report outlining the major sources of migrants to Australia.
- 7 Study the data in Table 7.7.3 and do the following tasks.
 - a Describe the region/s from which the majority of refugees come.
 - b Construct a column graph to summarise this data.

Investigating

- 8 Select one of the countries shown in Figure 7.7.3 and use the internet and library resources to conduct research and prepare a short digital presentation on why refugees would be leaving this country. Present your presentation to the class. Include in your presentation:
 - a map of the country and an overview of the population (for example size and ethnic diversity)
 - the history behind the reason people are fleeing and the current situation.

Australia's cultural diversity

A nation of migrants

Immigration has played a key role in Australia's population growth and accounts for much of the cultural diversity of the country. The first arrivals were the ancestors of Indigenous Australians, who moved down from the islands of the Indonesian archipelago and New Guinea over 60 000 years ago.

European settlement

From the 1600s, during the great European voyages of discovery, there were a number of coastal landings, mainly on the arid western side of the Australian continent. The British first sailed along the well-watered east coast in 1770, and the first permanent European settlement, the British Crown Colony of New South Wales, was established in 1788. Initially a convict colony, free settlers started moving in from the early 1790s. The gold rush attracted many people, including the Chinese. Following Federation in 1901, the government implemented the White Australia policy, which excluded non-white immigrants. By 1945, the Australian population had reached seven million and was mainly Anglo-Celtic.

After World War II

After World War II (1939–45), Australia began a huge immigration program, based on the belief that it must 'populate or perish', following the near invasion by the Japanese during the war. As a result of the program, hundreds of thousands of people left war-torn Europe and migrated to Australia.

Between 1945 and 1972, over a million British people immigrated under the 'Ten Pound Poms' scheme, whereby British people—favoured by the Australian government—could migrate to Australia cheaply.

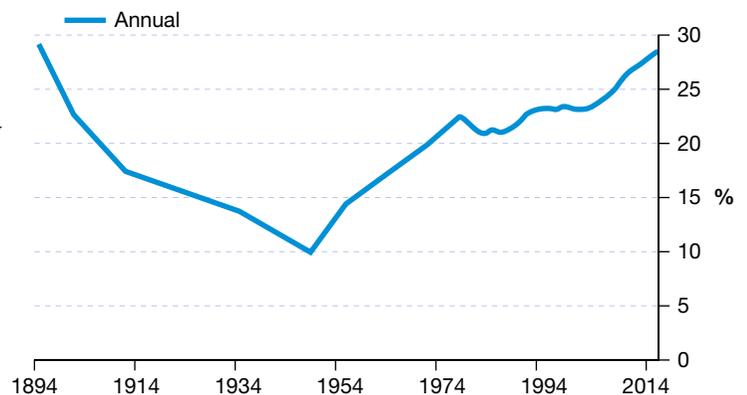
From the 1970s, millions of migrants and refugees arrived in Australia, looking for a life free from war, persecution and poverty. Waves of migrants came from the Asia-Pacific region, Africa and the Middle East.

In total, more than 6.5 million migrants and 675 000 refugees have settled in Australia since 1945.

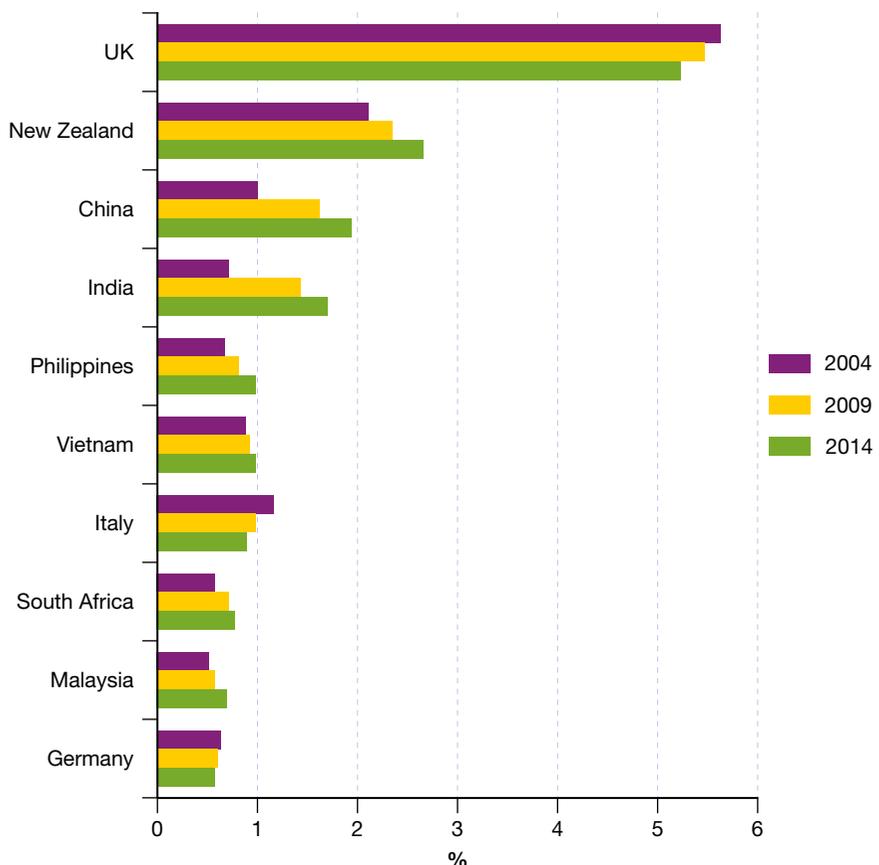
Multiculturalism

Multiculturalism is a social policy based on the ideas of inclusion, recognition and tolerance. It recognises the right of all Australians to enjoy their cultural heritage and to receive equal treatment and opportunities regardless of their background. It carries with it a responsibility to respect Australian values.

7.8.1 Australia's population born overseas, 1894–2014



7.8.2 Proportion of Australia's population born overseas 2004, 2009, 2014



Source: Australian Bureau of Statistics



7.8.3 Many different cultures are recognised and celebrated in Australia.

People and culture

Australia's linguistic and cultural diversity reflects the long history of migration to the continent. The cultural traditions of Indigenous Australians are among the oldest in the world, and Australia's migrants have brought their cultural traditions from over 200 countries.

Migrants have enriched the Australian way of life in many ways, as is illustrated in Figure 7.8.3. They have, for example:

- introduced new cultural celebrations such as Chinese New Year and St Patrick's Day
- contributed to the creative and performing arts, for example the Borovansky Ballet Company
- added colour and interest to Australian cities, for example in Lygon Street in Melbourne and Chinatown in Sydney
- introduced new sports and recreational pastimes, such as futsal and taekwondo
- introduced architectural styles, for example with joss houses, mosques and synagogues
- enriched school curricula through the addition of languages such as Mandarin and Arabic
- greatly expanded the range of foods eaten by Australians, for example pizza, sushi and burritos.

ACTIVITIES

Knowledge and understanding

- 1 Draw a timeline of Australian migration starting in 1788.
- 2 Define the term 'multiculturalism'.

Geographical skills

- 3 Study Figure 7.8.1 and list reasons for the trend that it shows.
- 4 Study Figure 7.8.2 and do the following tasks.
 - a In 2014, what percentage of Australia's population had been born in the United Kingdom?
 - b What is the next largest population born overseas after people from the United Kingdom?
 - c Name the fastest-growing group of overseas-born Australians since 2004.
 - d Prepare a mind map demonstrating the ways in which migrants have enriched the Australian way of life. Use examples different from those listed above to illustrate this.

International migration and urban lifestyles

Migration and urban concentration

Immigration has helped to shape the urban lifestyles of Australia since the first European settlement was established at Sydney Cove in 1788. Today, the lifestyles of those living in Australian cities reflect the growing ethnic and cultural diversity of the Australian population.

After the end of World War II, there was an increase in the number of Australians living in cities, and this trend has continued. This pattern can be clearly seen in migrant populations. Between 1947 and 2010 the following changes were observed between Australian-born and overseas-born Australians.

The number of Australian-born Australians living in:

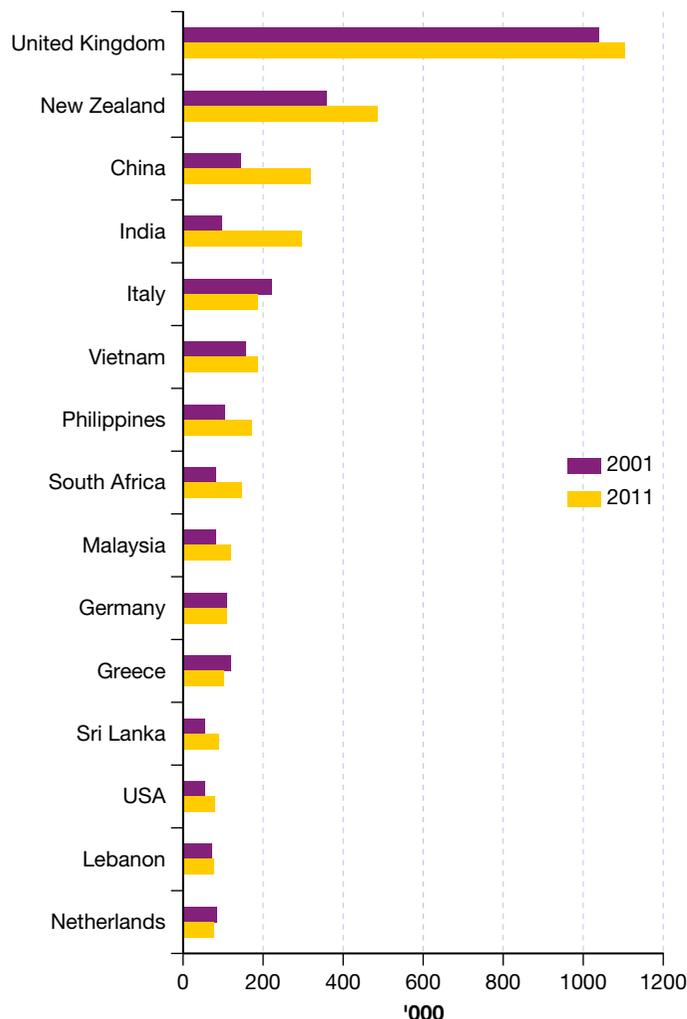
- large cities grew from 50 to 64 per cent
- rural areas decreased from 32 per cent to 14 per cent.

The number of overseas-born Australians living in:

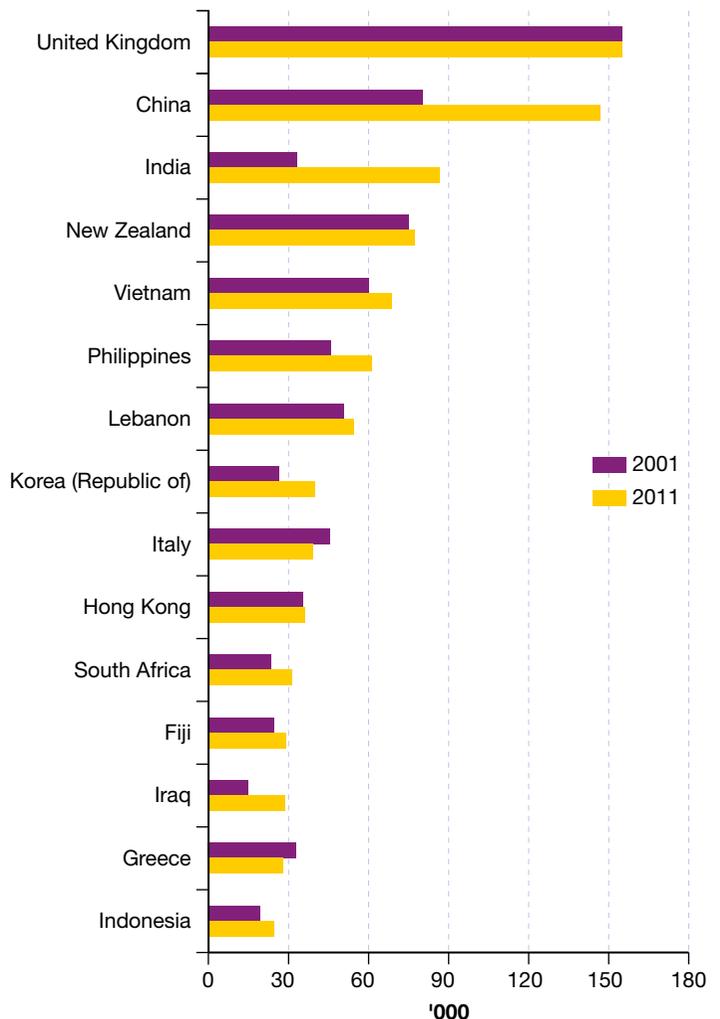
- large cities grew from 62 to 85 per cent
- rural areas decreased from 25 to just 6 per cent.

The majority of migrants to Australia have settled in the capital cities, particularly migrants from non-English speaking countries.

7.9.1 Migrants in Australia, by country of birth, 2001 and 2011



7.9.2 Migrants in Sydney, by country of birth, 2001 and 2011





7.9.3 Sydney's cafe culture is a lifestyle-related outcome of Australia's ethnic diversity.

Sydney and Melbourne

The majority of post-World War II migrants decided to settle in Sydney and Melbourne. As a result, these cities have the most international or **cosmopolitan lifestyles**.

In 2014, Sydney and Melbourne's share of the nation's overseas-born population was almost 55 per cent. While Sydney remains the most important centre of immigrant settlement (see Figure 7.9.2), there is some evidence of a shift, as people move from Sydney to the other capitals. There is also evidence of increased settlement beyond the capital cities.

Ethnic and cultural influences

The diversity of Australia's cities has been influenced by waves of migration, each characterised by a different mix of birthplace groups. These waves reflect changes in Australia's immigration policy and the changing national and global economic and political situation.

Migrant settlement patterns

Patterns of settlement vary among migrant groups. New South Wales, for example, has 75 per cent of Australia's Lebanese-born population, 63 per cent of the Iraqi-born, 63 per cent of the South-Korean-born, 60 per cent of the Fijian-born and 60 per cent of the Chinese-born. Victoria has 51 per cent of

Australia's Sri-Lankan-born population, 50 per cent of the Turkish-born, 49 per cent of the Greek-born and 42 per cent of the Italian-born. Western Australia, the state with the highest foreign-born proportion of population, attracts 30 per cent of all Singapore-born Australian residents, and is narrowly behind New South Wales in having the largest population of British-born. Queensland has attracted the greatest proportion of people born in Papua New Guinea (52 per cent) and New Zealand (38 per cent).

Impact on urban lifestyles

The cosmopolitan lifestyle enjoyed by residents of cities such as Sydney and Melbourne owes much to the cultural and ethnic diversity of their migrant populations. Some urban neighbourhoods have, over time, become associated with particular ethnic groups. These ethnic precincts are essentially clusters of immigrant entrepreneurs and service providers. These, in turn, attract the people who rely on these providers.

One of the most obvious outcomes of this process is the concentration of restaurants representative of different cultures. European, Middle Eastern and Asian cuisines are now an important part of our urban lifestyle. There are clearly defined restaurant and cafe areas in both Sydney and Melbourne. These are good examples of how different ethnic groups can enrich a culture. Residents of both cities have also embraced the European-inspired tradition of outdoor eating. Most cafes now have tables and chairs on the footpath, as shown in Figure 7.9.3, and some have outdoor areas to match those seen in Italy and France. The practice of eating out at restaurants and relaxing at pavement cafes is now common everywhere, and Australian's obsession with espresso coffee (introduced into Australia by southern Europeans) is central to the country's cafe culture.

ACTIVITIES

Knowledge and understanding

- 1 Explain why Sydney and Melbourne have the most international, or cosmopolitan, lifestyles.
- 2 Outline how the pattern of settlement arrivals has changed since World War II.
- 3 Identify some of the important differences in migrant settlement patterns.
- 4 Outline the impacts of migration on urban lifestyles.

Applying and analysing

- 5 List the ways in which your town or neighbourhood has been influenced by migration. Use the information collected to produce a whiteboard or pinboard-mounted mind map.
- 6 Draw on the ethnic diversity of your community to explore reasons why people chose to settle in Australia. Identify the ways in which different cultures have enriched your community.



Australia's urban future

The growth of cities needs to be carefully managed if we are to minimise their environmental impact while enhancing their liveability. A more balanced distribution of Australia's population would be one approach, but this would require substantial expansion of existing regional centres or the building of new cities at great cost to accommodate increasing numbers of people. The latter has been done before—Canberra, Australia's capital, was a planned city and built from the ground up. Careful planning can make our cities more sustainable, on a city-wide scale or at the level of individual households.

In this chapter we examine the ways in which urban centres can be managed to achieve sustainability and enhance liveability.

INQUIRY QUESTIONS

- How can the environmental sustainability and liveability of Australia's urban places be enhanced?
- How can individuals and communities contribute to a sustainable urban future?

GLOSSARY

commercial node a geographic point where economic or social resources/activities are (or will be) concentrated for the benefit of a community

densification increased numbers of people living in a prescribed area

greenfield site an area of land that has not been developed

life-stage cycle the various stages of life that people experience from their birth to their death

suburbanisation the process in which people and businesses move out from the central areas of cities and into the suburbs

urban consolidation increased population densities in existing urban areas

urban decay the deterioration of the built environment; urban infrastructure falls into a state of disrepair and buildings are left empty for long periods of time

urban renewal the process in which an unused area of urban land such as an industrial site is restored, redeveloped and improved

Managing growth of cities

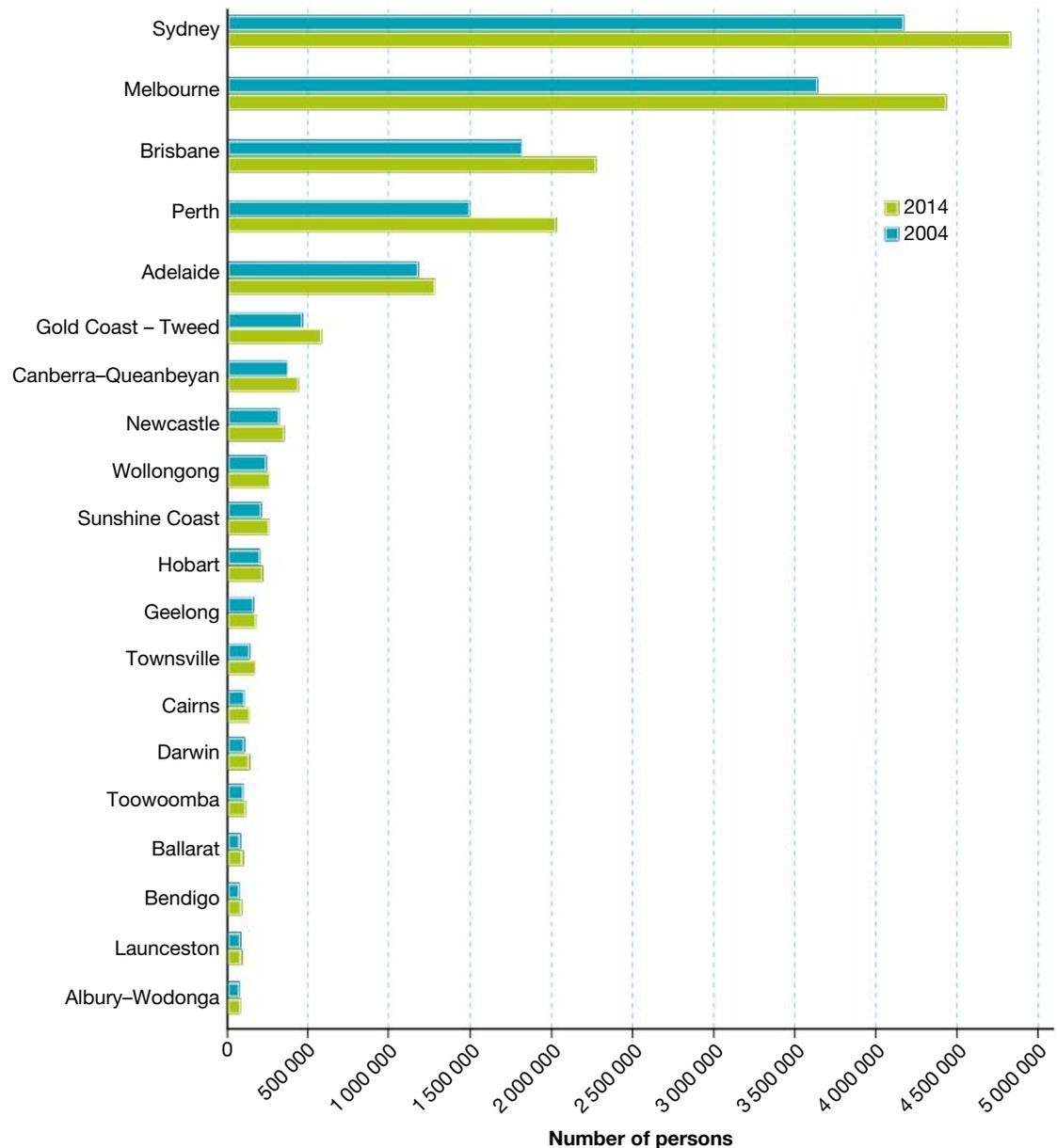
Australian cities

In Australia, 75 per cent of the population live in just eighteen cities, each of which has a population of at least 100 000 people. Sydney and Melbourne now have populations of more than four million. Brisbane has more than two million and Perth has 1.7 million.

The populations of Australia's eighteen biggest cities are shown in Figure 8.1.1. Almost 75 per cent of all jobs in the country and about 80 per cent of all economic activity are located in these eighteen cities. With so many people and jobs and so much wealth in our cities, governments around the nation recognise the importance of carefully managing their growth.

In 2010, the federal government released an important report about Australian cities called *Our Cities—Building a Productive, Sustainable and Liveable Future*. Key issues included in the report were:

- providing employment opportunities
- providing important infrastructure, such as public transport, sewerage systems and roads
- providing enough affordable housing
- making our cities more sustainable by reducing consumption and dealing better with waste.



8.1.1 Population of Australia's biggest cities, 2014

Source: Australian Bureau of Statistics, 2015



8.1.2 The Palmview greenfield site, at Caloundra South, Queensland, will be developed for housing.

Planning for housing

As Australia's cities grow, so too does the need for housing. The most common strategy used to increase the supply of new housing has been to develop housing estates on the edges of our cities. This is called **suburbanisation**. All Australia's cities and large towns now have complex suburban areas.

Economic costs

Suburbanisation continues to provide most new housing needed in Australia. Building new suburbs requires very detailed planning. Building the actual houses is the easy

part. Complex infrastructure, such as sewerage, electricity, gas, telephone and internet lines, roads and public transport systems also need to be developed. There must also be plans for schools, shopping centres and other important community services such as parks, libraries and childcare centres.

Environmental costs

The development of new suburbs typically involves clearing land that has been used for other purposes, such as agriculture or bushland. Geographers often call these areas **greenfield sites**, as they are undeveloped green zones (see Figure 8.1.2).

SPOTLIGHT

Sydney's NorthConnex

As Sydney's population continues to grow, so does the need for transport infrastructure. NorthConnex is a massive \$3 billion road tunnel project that will link the M2 and M7 Motorways with the M1 Pacific Motorway. The 9-kilometre tunnel will create a ring round around Sydney, allowing motorists to travel from south to north on freeways. It is estimated that more than 5000 trucks will use the tunnel daily, reducing impacts on local communities along Pennant Hills Road, the current route. However, there are many residents who are concerned about exhaust stacks from the tunnels that are being built in residential areas, highlighting the tensions between infrastructure development and local communities. The tunnel is expected to open in 2019.



8.1.3 The NorthConnex tunnel project and a similar project called WestConnex in Sydney's inner-west have created controversy, as residents have concerns about the location of the tunnel's exhaust stacks near their homes.



8.1.4 Darling Harbour and Pyrmont Bridge, 1937 (left) and Darling Harbour, 2007 (right)

SPOTLIGHT

Urban consolidation at Green Square

Green Square is a huge urban consolidation project in the inner Sydney suburb of Alexandria, not far from Sydney Airport. This \$13 billion project is transforming a former industrial area into a residential and commercial centre. The site is nearly 280 hectares in size and once fully finished, in 2031, will contain 30 500 apartments housing more than 61 000 people. By 2016, more than 10 000 apartments

were already built or under construction. In addition to the apartments, commercial and office space, it is anticipated that 21 000 people will also work in Green Square.

Enormous developments like Green Square reduce the pressure on cities to expand by adding new suburbs on the fringes. Some people have expressed concerns that the density of Green Square may cause overcrowding. Urban planners, however, point to the inclusion of recreational spaces, with open parks, shared cultural facilities and other initiatives as ways to ensure liveability at Green Square.



8.1.5 The City of Sydney is building a state-of-the-art library and outdoor plaza, an aquatic centre, a community creative hub, eleven parks, and open spaces and public artworks.

GREENFIELD SITES

In their natural, or near-natural state, greenfield areas provide important habitats for native animals. These animals are displaced by suburban development. Suburban development also increases rates of water pollution; for example, oil and rubbish left on roads can be washed into stormwater drains. Introduced species of plants can result in weed infestations. Feral animals either kill native animals or compete with them for food.

Social costs

As our cities continue to expand, more and more people are forced to travel greater distances to work. In many of our cities, hundreds of thousands of people commute very long distances from outer suburbs every day. In many cases these suburbs are not well supplied by public transport, so vast motorway systems are needed. Traffic congestion has become a major issue for Australia's large cities.

Commuting long distances has important social consequences: it affects people's health, as they spend so much time sitting in cars; it reduces the time they can spend with family and friends; and it costs families money to run a car. Traffic congestion also has environmental consequences. About 75 per cent of all Australians living in capital cities commute to work in cars, most commonly on their own. Cars are major contributors to air pollution in our cities. They also contribute significantly to greenhouse gas emissions, the cause of climate change.

Reducing urban sprawl

Urban consolidation involves the re-use of existing urban land for housing. Land that was once used for industrial purposes is redeveloped for housing. The Cockle Bay Marina redevelopment in Sydney is a large residential and commercial building project built on waterside land that is no longer needed for its original purpose. The changes can be seen in Figure 8.1.4. This type of development is often called 'infilling' because it fills in gaps in the city that have been created by land no longer being used.

Another type of urban consolidation is to increase the density of housing in a residential area. Building density means the number of houses that occupy an area. Increasing building density involves building a few townhouses (medium-density housing) or even a multistorey apartment block (high-density housing) on a large block of land.

Urban consolidation means that more people can live in cities, reducing the need to build new suburbs further away from the city centre. Urban consolidation does mean, however, that some suburbs will change, and this can create tensions. For example, residents can become distressed when large apartment blocks are built where single-storey houses once stood.

Reducing traffic congestion

Building better infrastructure

Public transport infrastructure is extremely expensive to build but reduces traffic congestion more than building new roads or tunnels. A freeway can carry 2500 cars per hour, while a train can carry 50 000 people in the same time.

Motorways can cost billions of dollars and are always politically sensitive when their construction requires the demolition of homes or the loss of bushland. Tolls are now widely used to fund road infrastructure.

Railways are even more expensive to build and often require subsidisation by taxpayers—to charge the commuter the actual cost of providing the service would make it too expensive to use.

Using public transport

One of the big issues is encouraging people to use public transport rather than their cars. Public transport needs to be accessible, convenient, relatively cheap, safe and clean. Providing car parks at railway stations is one way to encourage the use of public transport. Increasing the cost of parking is a way of discouraging the use of cars.

Public opinion is often divided on how best to meet the transport needs of city dwellers, especially when funds are limited. Some argue that public transport should be the priority. Others argue that more motorways are the answer.

ACTIVITIES

Knowledge and understanding

- 1 Outline the key points to consider when managing cities.
- 2 Define the term 'suburbanisation'.
- 3 State what a 'greenfield' site is.
- 4 Explain the process of urban consolidation.

Applying and analysing

- 5 Create a PMI chart about suburbanisation.
- 6 Discuss the advantages and disadvantages of urban consolidation.
- 7 Produce a campaign plan to encourage people to use public transport rather than drive.

Geographical skills

- 8 Study Figure 8.1.1 and answer the following questions.
 - a Which city experienced the greatest increase in population between 2004 and 2014?
 - b What was the approximate increase in population between 2004 and 2014 in Perth?
- 9 Study Figure 8.1.4 and list the major changes you observe.

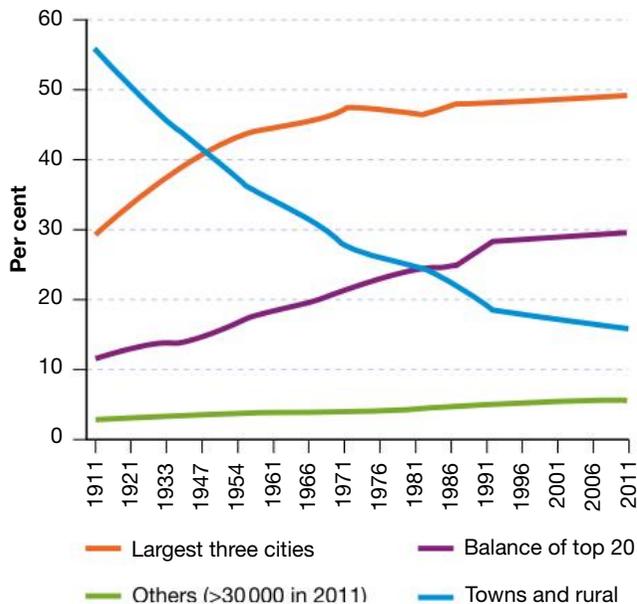
Impacts of large cities

Australia

As the population of a city grows, the city becomes like a giant magnet, drawing in more and more people and services from the places around it, as is shown in Figure 8.2.1.

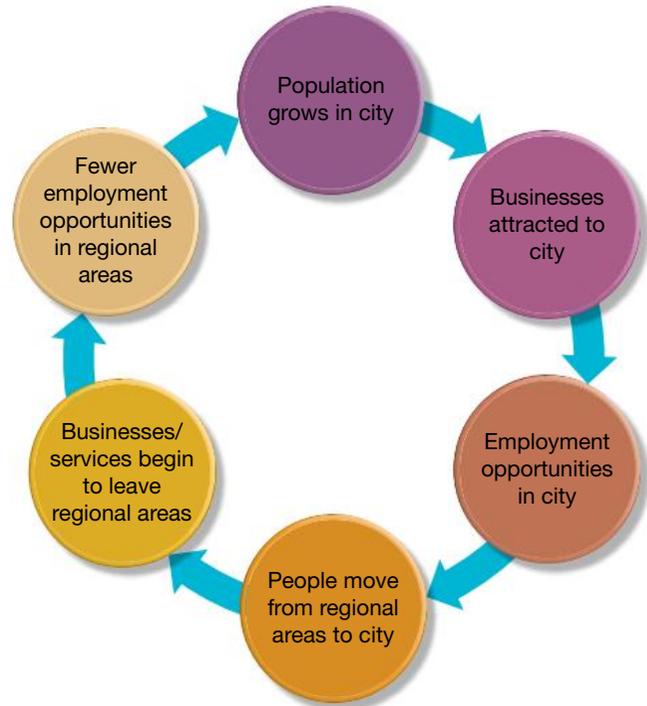
In Australia, the urban population is evenly spread, with five large cities—Sydney, Melbourne, Brisbane, Perth and Adelaide.

8.2.1 Population proportion by settlement type, 1911–2011. Note: the largest three cities are Sydney, Melbourne and Brisbane.



However, the growth of these large cities is having a significant impact on regional areas. As each city's population grows, it draws in businesses attracted by the growing population. This then begins a cycle that leads to regional areas losing population, jobs and services to cities, as outlined in Figure 8.2.2.

8.2.2 Growing cities attract population and employment from regional areas.



SPOTLIGHT

Doctors in regional Australia

In many parts of regional Australia, there are severe shortages of doctors. This is having an impact on the health of those living there. Table 8.2.3 shows the number of doctors per 100 000 people in different parts of Australia.

8.2.3 The number of doctors per 100 000 people

Remoteness area	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
Major city	343.8	366.1	394.6	422.8	382.6			472.7	372.1
Inner regional	202.6	196.4	188.7	147.5	163.3	457.9			212.1
Outer regional	118.8	106.9	236.6	127.8	193.4	178.3	433.8		188.0
Remote/Very remote	115.2	265.3	161.8	126.1	221.1	101.6	385.8		216.4
Total	308.6	332.7	334.6	353.9	336.7	366.4	442.9	474.2	331.4

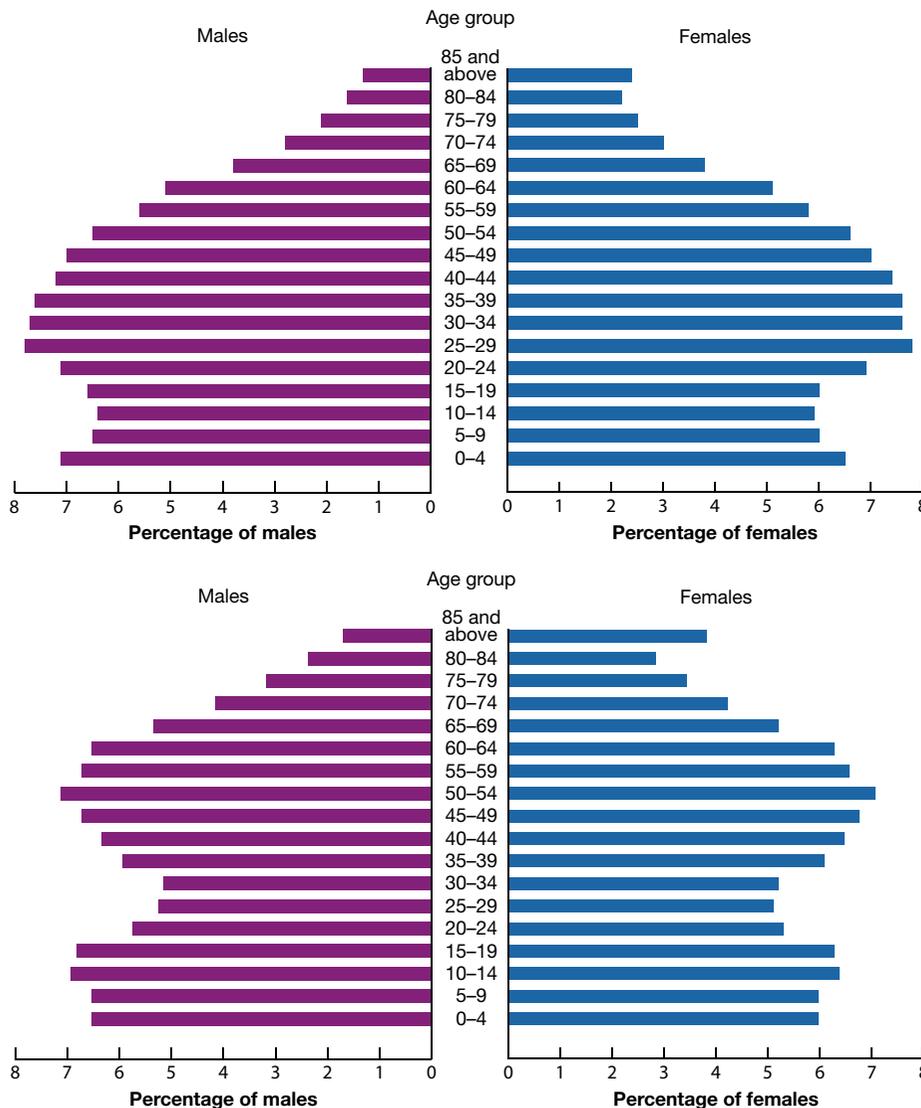
Source: Australian Medical Association, 2012

Rural Australia

The depopulation of regional areas is highlighted in Figure 8.2.4. The two population pyramids show the age distribution of people living in Sydney and regional New South

Wales. These pyramids show that while Sydney has a fairly even distribution of population, in regional New South Wales there is a dip in the percentages of people aged between 20 and 39 years. This is important because it shows that people

of this age group have left regional New South Wales. Most of those leaving do so to seek employment in Sydney. A similar pattern can be found throughout Australia, the one exception being those regional areas that have a major mining industry, such as northern Western Australia and central Queensland.



8.2.4 Population pyramids for Sydney (above) and regional New South Wales (below)

ACTIVITIES

Knowledge and understanding

- 1 Explain the difference in access to doctors for people living in cities compared with people living in other places in Australia.
- 2 List the reasons why people might be attracted to move to a city.
- 3 Explain what occurs when a region is depopulated.

Applying and analysing

- 4 Adopt the perspective of a young adult who lives in a regional part of Australia but is moving to a large city. Write a letter to a friend explaining your reasons for wanting to leave your town. Include in your response the economic and social reasons for your decision.

Geographical skills

- 5 Study Figure 8.2.1 and describe the changes in population by settlement type.
- 6 Study Figure 8.2.2 and write a short report explaining how cities can have an impact on the population of other places.
- 7 Study Figure 8.2.3 and do the following tasks.
 - a What is the total percentage of males and females aged 20–24 living in:
 - regional New South Wales?
 - Sydney?
 - b Using these graphs as stimulus, write a paragraph comparing the age structure of the populations of regional New South Wales and Sydney. Be sure to look for similarities and differences.

CASE STUDY: Canberra

A planned city

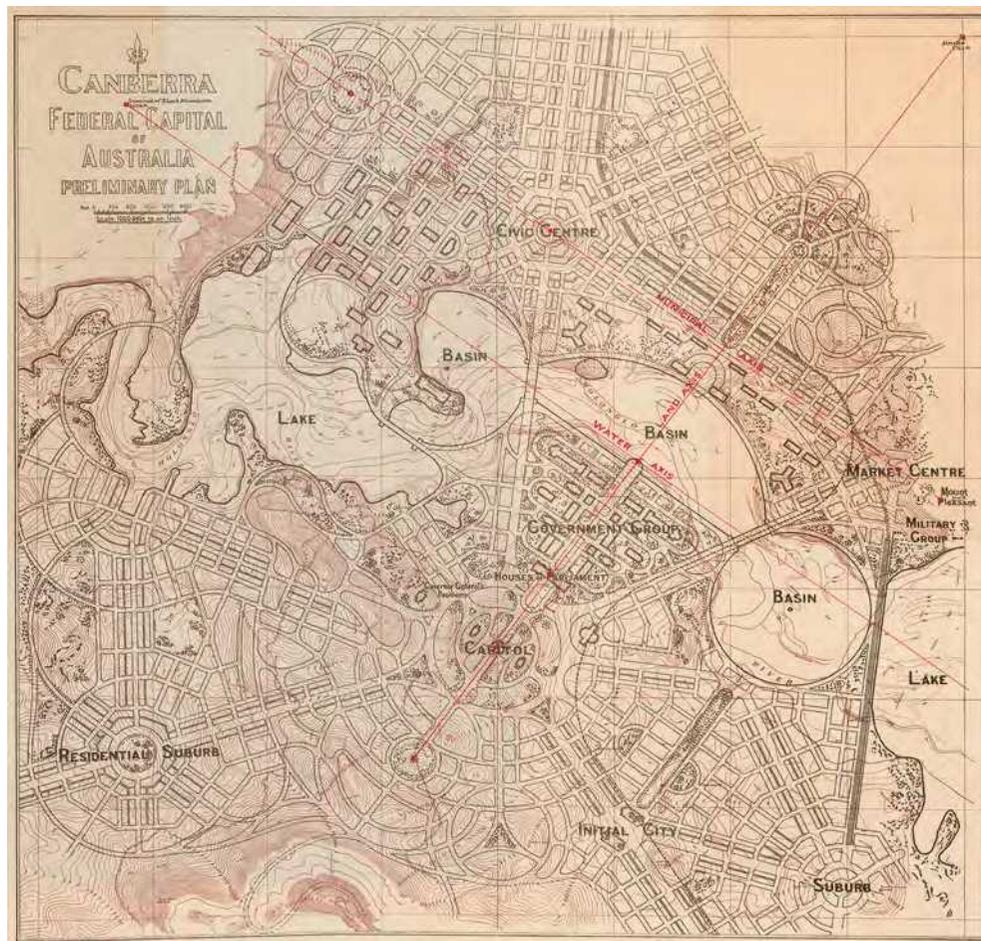
As a capital city, Canberra is a very different type of city. In many countries the largest city is also the country's capital. In the case of cities such as London, Paris, Tokyo and Jakarta, the capital city is also the country's main commercial centre. However, Canberra is a city that was planned and purpose-built as a capital city, much like Washington, DC in the United States of America.

Canberra is the most thoroughly planned Australian city. At Federation, in 1901, it was decided to build a capital city approximately midway between Sydney and Melbourne. Canberra is not a major commercial centre. It is dominated by government-related functions; its buildings include Parliament House and the headquarters of major government departments

and agencies. Canberra is also home to the country's major national institutions, such as the Australian War Memorial, High Court, National Library, National Gallery and National Museum of Australia.

The current site was named the Australian Capital Territory (ACT) on 1 January 1911. An international competition was then held to find a design for the new capital. More than 130 architects from around the world submitted plans. American architect Walter Burley Griffin's design was ultimately successful, with his original plan for a city based on a series of 'zones' in a concentric (circular) design. The winning design is shown in Figure 8.3.1. It can still be seen today in Canberra, which is shown in Figure 8.3.2.

8.3.1 Walter Burley Griffin's original design drawings for Canberra. The concentric design of unique zones is clearly evident.





8.3.2 There are many important national institutions in Canberra, including Parliament House.

Functions

Parts of the city still have very clear functions. For example, the area around the Capitol in Griffin's original plan is where Parliament House is located, the Civic Centre contains the main shopping and commercial districts, and the area Griffin called the Government Group (now the Parliamentary Triangle) contains the headquarters of major government departments.

Bush capital

Canberra is sometimes known as the 'bush capital' because of its location and because it is surrounded by grazing properties and tree-covered mountains. Canberra takes up just 20 per cent of the ACT, and more than 50 per cent is designated as nature conservation areas. These areas are an important asset for the people of Canberra, providing them recreational areas very close to the city. In 2003, these areas were also a cause of enormous tragedy when a massive firestorm that originated in bushland just outside Canberra engulfed several suburbs, killing four people and destroying more than 300 homes. A key part of the management of Canberra is now about planning for fires, as well as managing the growth of Canberra to minimise the impact of the growing city on the important nature conservation areas that surround it.

Population challenges

Dealing with a growing population is one of the key challenges facing Canberra. During the first decade of the twenty-first

century, the population grew by about 73 000, and by 2015 it had reached 390 800 people. Most of this growth has taken place in the northern part of the city, where new housing estates have been developed. For example, in the suburb of Gungahlin (Figure 8.3.3), about 10 kilometres north of the city centre, the population has more than doubled in the last 10 years. As the population of the region has soared, there have been concerns that these new areas lack adequate infrastructure. The Gungahlin Community Council, for example, has called on the ACT government to consider building a new hospital in the area.



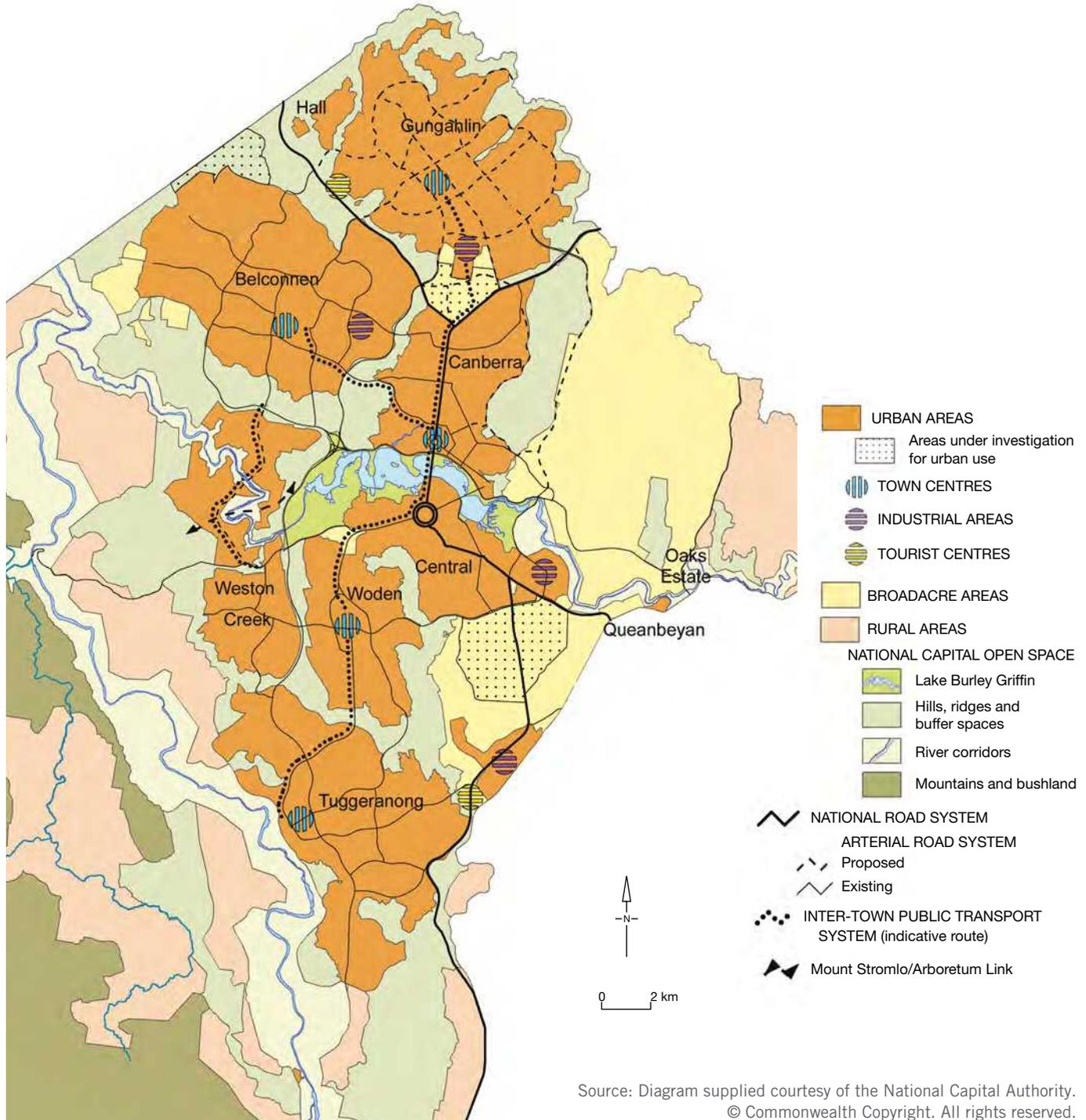
8.3.3 The population of Canberra suburb Gungahlin has more than doubled in the last 10 years.

Planning for the future

As the nation's capital, responsibility for urban planning and management is shared between the federal government and the ACT government. Over the years, there have been different plans developed for Canberra. The current plan is known as the National Capital Plan and sets out the future development of the city. Figure 8.3.4 shows how the land will be used in the future.

The National Capital Plan still includes the concentric design that Griffin developed. Another important feature is the natural bush spaces placed between the major urban areas. These areas, shown in pale green on the map, are areas that are not allowed to be developed for urban use. This land is sometimes set aside as nature conservation areas or may be used as parklands. These areas are an important way to manage the city's growth and to ensure that the character of Canberra as the 'bush capital' is retained.

8.3.4 Landuse for Canberra under the National Capital Plan



Source: Diagram supplied courtesy of the National Capital Authority.
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SPOTLIGHT

The Molonglo Valley development

The Molonglo Valley is located about 10 kilometres to the south-west of the Canberra city centre. It was one of the areas most badly affected by the 2003 bushfires. A new housing estate being developed (see Figure 8.3.5) includes the area where many houses were destroyed. The development is being designed to incorporate sustainability. The new suburbs of Wright and Coombs have both received eco-design certification from the Urban Development Institute of Australia.

One of the key aspects of the design of Wright is the use of a grid system. By placing the housing in grids, the suburb becomes far easier to walk around, minimising the need for cars. Nearly every house will be no further than 800 metres from a reliable and regular public transport service. There are areas for high-density housing, such as apartments, medium-density housing, such as townhouses, and low-density housing—freestanding houses.

This mix of housing caters for various types of families and means that the size of the suburb can be reduced. This helps to make the suburb more sustainable by reducing the impact on surrounding bush and farmland, and making the suburb more bike- and pedestrian-friendly.

8.3.5 The Molonglo Valley development



ACTIVITIES

Knowledge and understanding

- 1 Explain why Canberra is sometimes called the 'bush capital'.
- 2 Describe the population growth of Canberra in recent years.
- 3 Outline the main features of the National Capital Plan.
- 4 Explain how the urban design of the suburb of Wright helps to make it more sustainable.

Applying and analysing

- 5 Study Figure 8.3.1—the original plan for Canberra developed by Walter Burley Griffin—and do the following tasks in groups.
 - a Describe the main features of his design.
 - b What features of his design do you think work best? Explain why.
 - c What features would your group do differently? Explain why.
 - d Examine the National Capital Plan in Figure 8.3.4. What similarities are there between this plan and that developed by Walter Burley Griffin?
- 6 Refer to Figures 8.3.1 and 8.3.4. Take on the role of an architect designing a capital city for a newly formed country in the Asia–Pacific region. Prepare a basic design for the main parts of the city. Along with your design, prepare a briefing sheet explaining your design decisions. You should describe the location of your city—near a river, on the coast or inland—and the shape of the land.

Sustainable cities

Learning to live with nature

Bushland is a feature of all of Australia's large cities. Many suburbs are found close to the bush and have important bushland reserves, and even national parks, within them. As our cities grow, the surrounding bushland is placed under increasing stress. Expanding suburbs lead to the clearing of bushland. Domesticated animals, especially cats, are introduced to the bush from surrounding suburbs and hunt native animals. Garden plants escape into the bush, taking over from native flora. Therefore, it is important to protect remaining bushland reserves and to carefully manage the impact of our cities on them, including the flora and fauna that live there.

Designing better houses

The way Australians live has a considerable impact on the environment. The average Australian household produces around 14 tonnes of greenhouse gas emissions each year. Australia's ecological footprint (a way of measuring the overall impact on the environment) is more than 2.8 times the world average.

The average size of new homes in Australia has increased by 40 per cent since the 1980s, making our homes now the largest in the world. During the same time Australian families have become smaller. The average size of a new home in Australia is about 240 square metres; in Britain an average new home is less than 80 square metres. Such big homes use huge amounts of energy to heat in winter and cool in summer.

As energy prices rise, greater emphasis is being placed on more sustainable housing designs. This, coupled with a gradual shift towards smaller homes, will, over time, help to reduce the environmental impact of our housing.

SPOTLIGHT

Protecting Brisbane's squirrel gliders

The squirrel glider (Figure 8.4.1) is a native species whose natural habitat extends along the east coast of Australia from the Victoria–NSW border to far north Queensland. The glider is found in many locations throughout Brisbane, and the Brisbane City Council has developed an action plan to help protect it.

Loss of its natural habitat, as the suburbs of Brisbane continue to expand, is one of the main threats to the glider. There are also insufficient nesting sites. The glider nests in tree hollows but competition from introduced species,

such as the common myna bird, is reducing the number of hollows available. Domestic cats are another problem for the glider. Hunting by cats is common and is a major cause of death for gliders all along the eastern coast.

The Brisbane City Council is taking a number of steps to help protect the glider, including purchasing bushland where the glider is common and protecting it from development. The council has formed partnerships with other organisations to purchase more bushland. The council has also supported research to discover more about the glider, its habitat and its needs. This has helped in the creation of education programs for local residents, as well as the identification of bushland areas for protection.



8.4.1 Brisbane City Council is actively managing populations of squirrel gliders around the city.

Passive housing design

Passive design uses the natural climate to heat and cool homes. The orientation of the building is a key part of passive design. For example, if you live on the east coast, having large windows facing westwards means that the hot afternoon sun will heat up the house. This is ideal if you live in a cool climate.

Shade is an important consideration. If you have large evergreen trees, such as gum trees, close to the house, you may need to use more energy to warm and light your home in winter. Vines that are deciduous (lose their leaves in winter) provide shade in the hot summer months but allow warming sunshine in during winter.

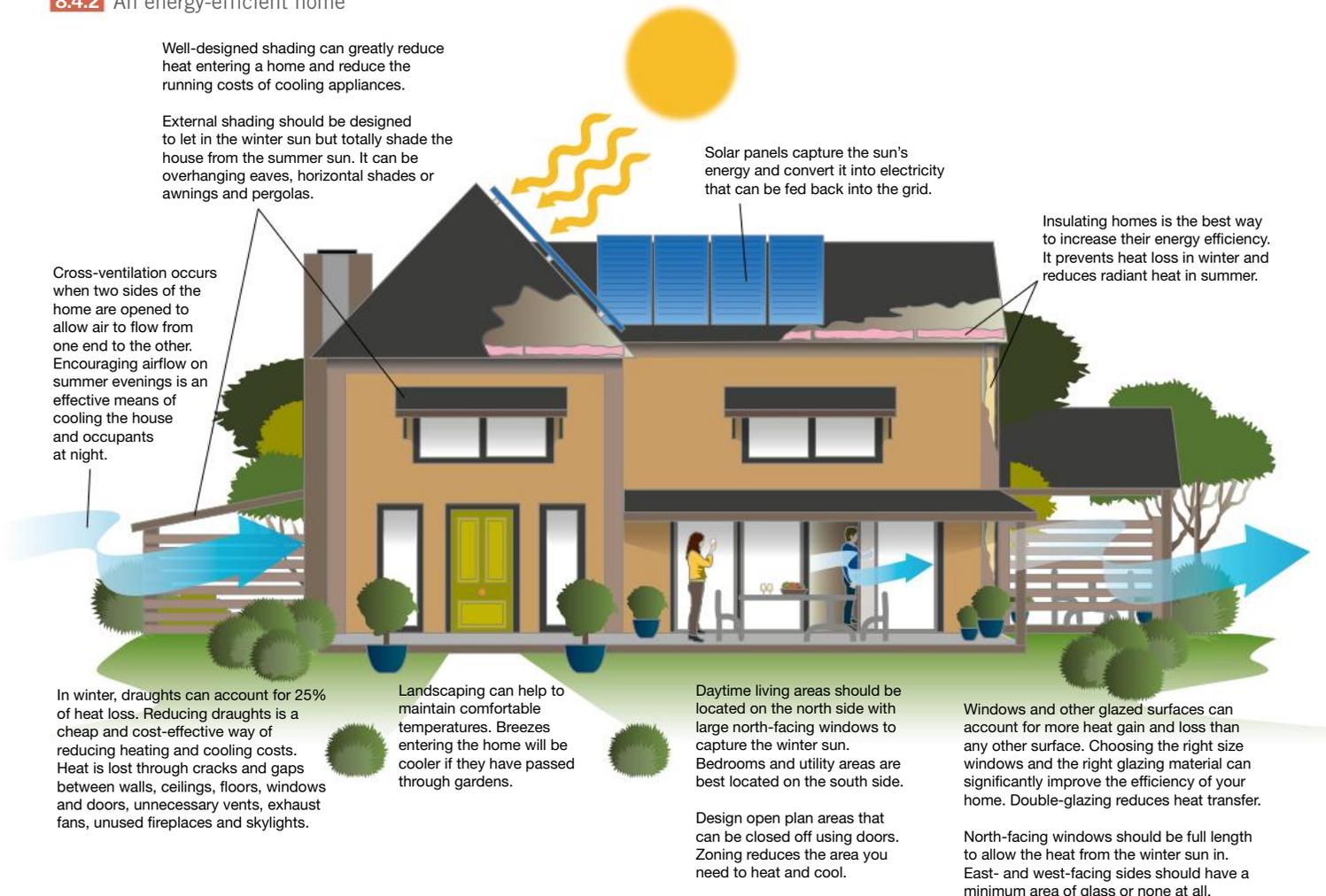
Dense materials such as concrete, bricks and stone are good insulators, which means that they are good for maintaining more even temperatures year round. Roof and wall insulation are also very important for maintaining comfortable temperatures. Installing skylights is a very effective strategy for reducing the amount of energy needed to light a home. Figure 8.4.2 shows the features of an energy-efficient home.

In parts of Europe and North America, grass has been grown on rooftops for many years. The grass rooftops provide excellent insulation as well as habitat for insects. Some architects are beginning to use rooftop gardens in their designs in Australia (see Figure 8.4.3).



8.4.3 A rooftop garden on a home in Melbourne

8.4.2 An energy-efficient home



Well-designed shading can greatly reduce heat entering a home and reduce the running costs of cooling appliances.

External shading should be designed to let in the winter sun but totally shade the house from the summer sun. It can be overhanging eaves, horizontal shades or awnings and pergolas.

Cross-ventilation occurs when two sides of the home are opened to allow air to flow from one end to the other. Encouraging airflow on summer evenings is an effective means of cooling the house and occupants at night.

In winter, draughts can account for 25% of heat loss. Reducing draughts is a cheap and cost-effective way of reducing heating and cooling costs. Heat is lost through cracks and gaps between walls, ceilings, floors, windows and doors, unnecessary vents, exhaust fans, unused fireplaces and skylights.

Landscaping can help to maintain comfortable temperatures. Breezes entering the home will be cooler if they have passed through gardens.

Daytime living areas should be located on the north side with large north-facing windows to capture the winter sun. Bedrooms and utility areas are best located on the south side.

Design open plan areas that can be closed off using doors. Zoning reduces the area you need to heat and cool.

Solar panels capture the sun's energy and convert it into electricity that can be fed back into the grid.

Insulating homes is the best way to increase their energy efficiency. It prevents heat loss in winter and reduces radiant heat in summer.

Windows and other glazed surfaces can account for more heat gain and loss than any other surface. Choosing the right size windows and the right glazing material can significantly improve the efficiency of your home. Double-glazing reduces heat transfer.

North-facing windows should be full length to allow the heat from the winter sun in. East- and west-facing sides should have a minimum area of glass or none at all.

Managing our water

Approximately 21 per cent of all water consumed in Australia is consumed in urban areas. The supply of water to our growing cities is one of the most significant urban management issues facing Australia. During the first decade of the twenty-first century, Australia experienced one of the longest and most devastating droughts on record. Major cities were placed on severe water restrictions and, in some inland towns, water supplies went very close to running out. Scientists predict that climate change will mean that many parts of Australia will have even less water in the future.

Many cities have built or are planning to build desalination plants, which turn salt water from the sea into fresh drinking water. However, these plants are expensive to build and run, and use huge quantities of energy to treat the water. Being more efficient in our water usage is a far more cost-effective way to manage our growing water needs.

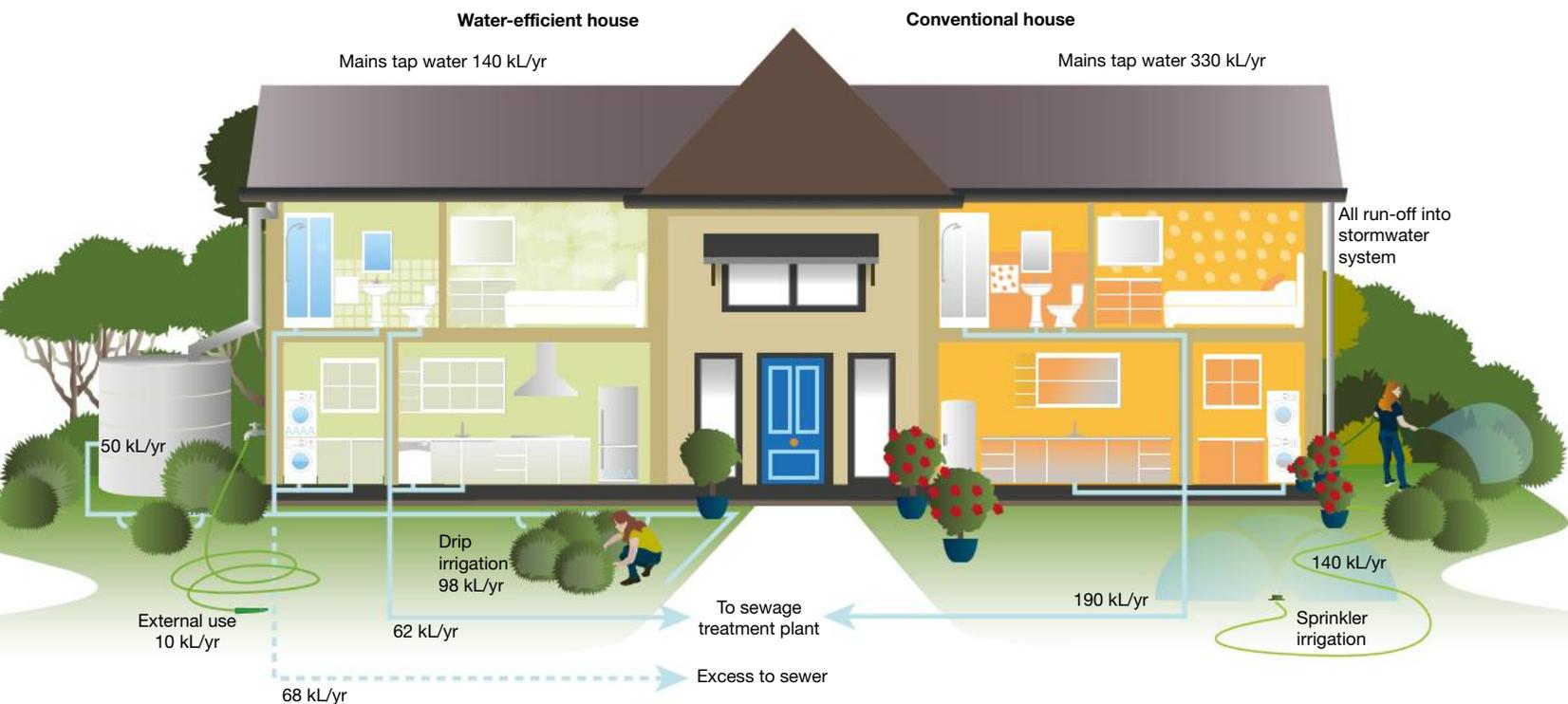
Appliances such as dishwashers and washing machines now come with water rating labels to help consumers select products that use water in the most efficient way (see Figure 8.4.4). Many local councils and state governments now also require new homes to have water tanks installed to capture rainwater, which can be used to water gardens, wash cars and even flush toilets.

8.4.4 Water rating labels help consumers select water-efficient products such as washing machines.



Figure 8.4.5 shows the difference a water-efficient home can make. A conventional home typically uses about 330 kilolitres (330 000 litres) per year. This can be more than halved in a water-efficient home. Installing AAAA-rated appliances in the kitchen and laundry, and using water tanks, water-efficient showerheads and dual-flush toilets can make a huge difference to the amount of water used in our cities.

8.4.5 Comparison between a water-efficient and a conventional home



Source: ACT Government
www.thinkwater.act.gov.au/water_savingtips/visit.shtml

SPOTLIGHT

Cleaning up Hobart's stormwater

Every city has complex drainage systems to carry away stormwater after heavy rains. Even a small city such as Hobart has nearly 340 kilometres of major stormwater pipes, and many more smaller pipes. As stormwater flows through the city, it picks up pollutants that then make their way into creeks, rivers and eventually the sea. In the past, after heavy rain, Hobart's Derwent River would be littered with the rubbish that had flowed from the stormwater system.

Hobart City Council has begun a program to install litter traps on major stormwater pipes (Figure 8.4.6). There are several different types of traps, from simple socks that go over the end of pipes as they reach creeks and trap the rubbish, to more complex floating traps that are used in major stormwater drains. Since these measures have been introduced, the level of litter reaching the river has been substantially reduced, improving the water quality and reducing the impact on the aquatic environment.

8.4.6 A floating litter trap used on the Hobart Rivulet to stop litter entering the Derwent River



ACTIVITIES

Knowledge and understanding

- 1 Outline the ways in which our cities affect the environment.
- 2 Explain how bushland is threatened by our cities.
- 3 Describe how Brisbane's squirrel gliders are being affected by the growth of the city.
- 4 Outline the strategies being used in Brisbane to reduce the impact on the gliders.
- 5 Explain the concept of passive house design.
- 6 State why it is so important that water is carefully managed in Australian cities.

7 Describe the purpose of water rating labels.

8 Outline how Hobart City Council is improving water quality from stormwater drains.

Analysing and applying

- 9 Consider your house. Prepare a list of the features of your house that make it more sustainable and the things that make it less sustainable. What changes could you make to improve the sustainability of your house?

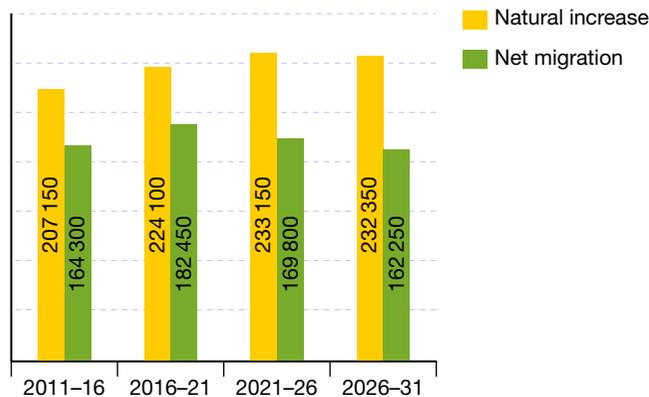
CASE STUDY: Sydney: Planning for a sustainable future

Growth projections

The population of Greater Sydney, which includes the Blue Mountains and the New South Wales Central Coast, exceeded 5 million in April 2016. More than 80 000 people were added to the city's population in both 2013–14 and 2014–15. Overall, the city absorbed 77 per cent of NSW's population increase. This rate of growth is likely to continue, as is shown in Figure 8.5.1.

An additional 1.5 million people will be added to the city's population in the years to 2030, when Sydney will have a population of 5.9 million. Effective planning will be essential and the role of geographers will be critical in determining answers to the following questions:

- Where will these people live and work?
- How will the city cope with the increase in population and traffic congestion?
- What will be the environmental impacts of this growth?

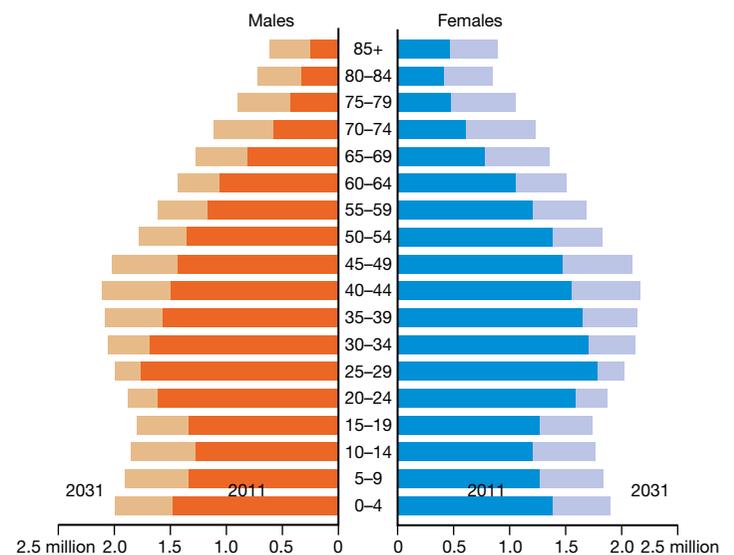


8.5.1 Composition of Sydney's projected population growth, 2011–16 to 2026–31

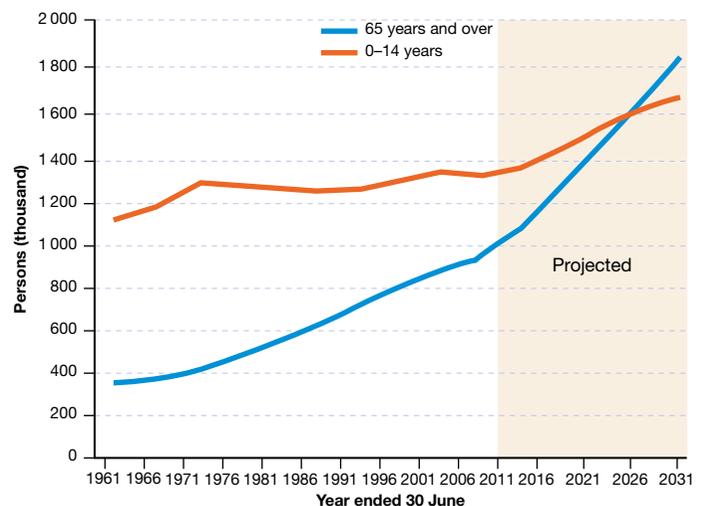
Components of growth

Over half of Sydney's growth over the next 20 years is likely to be driven by natural increase; that is, the difference between births and deaths. Overseas migration will also be an important driver of growth, with more international arrivals than departures. These will more than offset the net loss of people interstate and to other parts of New South Wales (internal migration).

Compared with Australia as a whole, Sydney has a relatively young population with large numbers of people of working age. The younger age profile in Sydney also means a large number of potential mothers contributing to a higher number of births in the city. The fastest growing age groups, however, are those over the age of 65, the Baby Boomer generation, and those who migrated to Australia during the postwar years (see Figures 8.5.2 and 8.5.3).



8.5.2 Age–sex structure of Sydney's population, 2011 (Census) and 2031 (projection)



8.5.3 NSW population, under 15 and 65 and older age groups, 1961–2031

The vision for Sydney's future

Sydney is, and will remain, a global city. It is Australia's largest city and its financial capital. Sydney is the sixteenth largest city economy in the world, ahead of major cities such as Singapore, Shanghai and Hong Kong. Sydney is also becoming a major global player in the delivery of financial and business services. The challenge for the city's planners is to ensure that the city remains competitive in the global economy with world-class services and transport. The city's planners also need to provide housing choices that meet the needs and lifestyle choices of an increasingly diverse population. The communities where people live need to be well connected, and the city as a whole needs to be sustainable and resilient. The city planners need to have a balanced approach to the use of land and resources that protects the natural environment.

Planning for the future

ENHANCE MOBILITY

Making it easier for people to move between their homes, jobs, shopping centres and recreational spaces is key to achieving a sustainable future. It involves increasing access to reliable and affordable public transport and addressing the city's traffic congestion through better roads. It also involves the development of employment and **commercial nodes** closer to where people live.

Parramatta is being developed as Sydney's second CBD. Other suburban nodes are being promoted as 'strategic centres'. These include Chatswood, St Leonard, Bondi Junction, Macquarie Park, Northwest, Blacktown, Rouse Hill, Bankstown and Hurstville. Additional suburban nodes, including Penrith, Campbelltown, Macarthur and Liverpool, are being promoted as 'regional city centres'.

Sydney's motorway network is being expanded. The WestConnex motorway will link Sydney's west and south-west with the CBD, Sydney Airport and Port Botany. In the city's north, the NorthConnex motorway will link the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills.

DID YOU KNOW?

Sydney's emergence as a world city can, to a very significant extent, be linked to the Keating government's decision to introduce the Superannuation Guarantee system in 1996. As of 30 June 2015, Australians had over \$2.02 trillion invested in superannuation. This vast pool of savings, the fourth largest of its kind in the world, needs to be managed. This encouraged some of the world's largest financial institutions to establish branches in Australia. Sydney is their preferred location.

The new Sydney Metro Northwest line will initially extend from Rouse Hill in Sydney's north-west to Chatswood. Eventually, the Metro will extend through the city centre (Metro City) before heading to Bankstown (Metro Southwest). The new stations being developed on the line will become a focus for medium- and high-density living. The city's light rail network is also being expanded. A new line, connecting Sydney's Circular Quay with Moore Park and the University of New South Wales, is under construction.

MAXIMISE HOUSING CHOICE

It will be important to provide a greater variety of housing types to cater for the changing composition of the population. This involves, for example, the development of high- and medium-density housing on major public transport nodes, especially those close to the city centre.

The demographic and social changes driving the need for more diverse types of housing include the changing lifestyle choices and changes to the **life-stage cycle** brought about by the later age of marriage and longer life expectancy.

The later age of marriage (and also child-rearing), combined with the increasing social acceptability of de facto and same-sex relationships, has increased the demand for medium- and high-density, often inner-city apartments, especially among young professionals, while at the same time reducing the demand for detached, suburban-based dwellings.

Those in the later stages of the life-stage cycle are also developing a preference for medium- and high-density living. With life expectancy now stretching to the mid-80s, Australians are enjoying 25–30 years in retirement. Many are electing to downsize from detached suburban dwellings to apartments, townhouses or villas. What they are seeking is a more flexible lifestyle unencumbered by the responsibilities of maintaining a detached dwelling with garden.

COMMUNITY-BASED INFRASTRUCTURE

Infrastructure such as schools, hospitals, utilities (electricity, water and sewerage), roads and public transport need to support communities as they grow. This will not only be important in the north-west and south-west growth centres, but also in urban consolidation developments closer to the city centre.

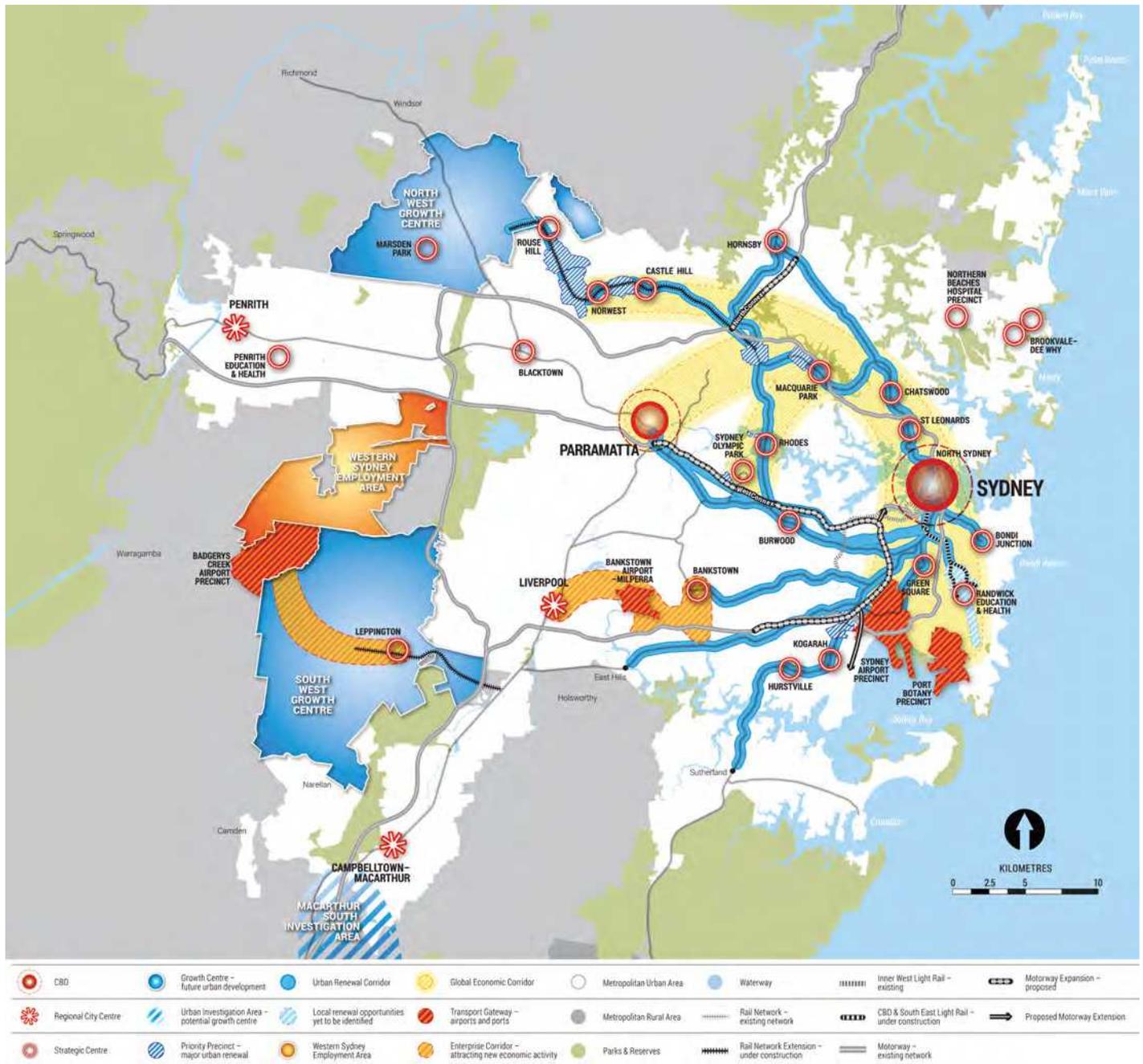
ENHANCED AMENITY

There is a need to protect the amenity of the city. This involves protecting the city's environment—harbour, coast, mountains, parks and open spaces.

A Plan for Growing Sydney

In response to Sydney's growing population, the New South Wales government released *A Plan for Growing Sydney* in December 2014. The report is a strategy for the future of the Sydney metropolitan area over the next 20 years. The Plan

provides key directions and actions to guide Sydney's economic growth, environmental management and liveability—including the delivery of housing, employment, infrastructure and open space, as outlined in Figure 8.5.4.



8.5.4 A Plan for Growing Sydney

Urban consolidation

Urban consolidation (or **densification**, as it is sometimes called) involves increasing population densities in an urban area in order to make more efficient use of existing infrastructure, and limiting the spread of urban landuses into surrounding rural areas (urban sprawl).

Inner city

The need for urban consolidation in Sydney is becoming increasingly clear. The housing target for the Sydney region is an additional 664 000 dwellings. It is not possible to meet this growth on the outer edge of the metropolitan region. The cost of providing the necessary infrastructure would be too great. Infilling is the only feasible option. Higher density living, especially in areas close to public transport nodes, is inevitable.

In Sydney, urban consolidation is closely associated with the process of **urban renewal** (the redevelopment of an urban area). Urban renewal is a response to **urban decay**—the process by which a previously functioning part of a city falls into disuse and disrepair. Large areas of inner Sydney, especially those associated with the city's old and abandoned port and industrial precincts, have become the focus of large-scale urban renewal projects. These include Barangaroo, Darling Square, Green Square and White Bay.

Middle suburbs

Outside the inner city, urban consolidation initiatives have focused on diversifying housing choice along Parramatta Road, the North West Rail Link, Anzac Parade and the Bankstown–

Sydenham corridor. In the future, the Sutherland–Sydenham, East Hills–Sydenham, Hornsby to Strathfield via Epping, Hornsby to North Sydney via Gordon, and Kings Cross to Bondi Junction rail corridors will become a focus of urban consolidation.

City's edge

Urban consolidation also includes the need for new, master-planned, suburban development on the city's periphery. Sydney's north-west and south-west growth centres will play an important role in providing housing and jobs for Sydney's growing population. The development of the North West and South West Rail Links, together with the city's motorway network, will link the new suburbs with the city's major employment and commercial nodes. Even in these greenfield developments, a variety of housing types are planned. Medium-density, and in some instances high-density, housing units are being constructed close to railway stations.

NEW ROUSE HILL

The New Rouse Hill development in Sydney's north-west is focused on lifestyle. It includes a mix of low- and medium-density housing and land for commercial landuses on a site adjacent to the Rouse Hill Town Centre and the new Northwest Metro. Residents of the development will enjoy exclusive access to recreational facilities, including a community pavilion with tennis and multi-use courts, swimming pool and gym. Parks and open spaces are conveniently located throughout the community within walking distance of each home.

ACTIVITIES

Knowledge and understanding

- 1 State by how much Sydney's population is expected to grow in the period to 2031. What are the main drivers of this growth? What challenges will this growth present?
- 2 Outline how the demographic character of Sydney differs from Australia as a whole.
- 3 Identify the principal factors contributing to the emergence of Sydney as a world city.
- 4 Outline the key elements of Sydney's plan to meet the needs of a rapidly growing population.
- 5 Define 'urban consolidation'. Why is it considered critical to meeting the housing needs of Sydney's growing population?
- 6 Explain the process of urban decay and renewal.

Geographical skills

- 7 Study Figures 8.5.1 to 8.5.3. Using data from the graphs, describe the changing demographic characteristics of Sydney in the period to 2031.
- 8 Study Figure 8.5.4. Identify the key elements of the *Plan for Growing Sydney* on the map.

Applying and analysing

- 9 Create a PMI chart on urban consolidation, comparing the inner city, middle suburbs and city fringe.



Environments

CHAPTER

9

At the beginning of the twentieth century there were 1.6 billion people on earth. Pollution and environmental degradation were problems, but were mainly local. The world still seemed vast, and large areas remained virtually untouched by the activities of people.

Just over 100 years later, the world's population was heading towards 7 billion and the environmental problems that have resulted from this rapid growth now affect the whole planet. How we manage these environmental challenges and how we address the social and economic inequalities that exist between and within places are critical to our future wellbeing.

This chapter introduces the concept of environmental functions, the major challenges to their sustainability and the environmental worldviews that influence how people perceive and respond to these challenges, as well as the differences in human wellbeing between places.

INQUIRY QUESTIONS

- What is the role of natural environments? Why are they important?
- What functions of natural environments support life?
- What are the main human-induced environmental changes?

GLOSSARY

bioaccumulation	the accumulation of substances such as pesticides in an organism	fossil fuels	a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms
biodiversity	the variety of all life forms: plants, animals and microorganisms; the genes they contain; the ecosystems of which they form a part; and the processes that link them	global warming	the gradual rise in average temperatures brought about by an increase in the heat-absorbing gases present in the atmosphere
carbon cycle	the naturally occurring processes in which carbon is exchanged between organisms and the environment	greenhouse effect	the atmospheric processes that maintain an average surface temperature of 15°C
desertification	the expansion of deserts due to overgrazing, soil erosion, climate change or prolonged drought	habitat	the physical environment in which a community of plants and animals lives
ecological	the relationship between living things (including people) and their physical environment	land degradation	the downgrading of the productive capacity of land due to the activities of people
environment	the totality of our surroundings	pollution	the release of any hazardous, or potentially hazardous, substance into the environment
extinct (species)	a species of animal or plant that no longer exists	poverty	the inability to meet the basic needs for food, clothing and shelter; the absence of money, goods or the means of subsistence

The environment: Life's support system

The environment

The **environment** is the totality of our surroundings and comprises the living and non-living features of the earth's surface. The term 'biophysical environment' refers to features that are altered or created by people, called the managed and constructed environments. People perceive, adapt to and use environments in different ways.

Geographers are interested in the relationship between people and the environment. People depend on the environment for their survival and wellbeing. The environment supports and enriches our lives by providing raw materials and food, absorbing and recycling wastes, and being a source of enjoyment, inspiration and spiritual wellbeing. It also influences our lifestyles, our recreational activities and the ways in which we use the land.

Environmental change

Environmental change is any alteration to an environment that disturbs natural **ecological** processes. Some environmental changes have beneficial outcomes for humans. The clearing of land for agriculture and the grazing of animals, especially when combined with irrigation, have increased food production; and mining and forestry have provided the resources necessary to construct water storage facilities, buildings, machines, vehicles and transport infrastructure. All these activities have promoted economic growth and employment. Some environmental changes can have negative effects, especially if they result in soil erosion, air and water pollution, or climate change.

Challenges to sustainability

Population growth

Many of the challenges facing humanity are directly related to the surge in the world's population. Increasing numbers of human beings, combined with improved material standards of living (for some), have greatly increased the demands people place on the planet, its resources, ecosystems and environmental processes.

Energy use

The burning of **fossil fuels**, which are used to meet people's energy needs, has had a major impact on the earth's atmosphere. The development of alternative sources of energy, such as solar energy, wind power, tidal flow and hydro-electricity, is one way of reducing people's reliance on fossil fuels.

Climate change

Over the last 200 years, the amount of carbon dioxide present in the atmosphere has increased by more than 25 per cent. The main cause of this increase is the burning of fossil fuels (oil, coal and natural gas) and the cutting down of trees, which convert carbon dioxide into oxygen. Increasing global temperatures, rising sea levels and the retreat of ice caps and glaciers have all been linked to this impact of people on the atmosphere.

Pollution

Pollution is the release into the environment of any matter that has a harmful effect. Pollutants, many of which are the product of our demand for consumer goods, can reduce the ability of the biophysical environment to provide ecosystem services (clothing, food and shelter).

Land degradation

The removal of natural vegetation (the result of deforestation, overgrazing and farming) is the main cause of **land degradation**. When trees are removed, the land is exposed to the agents of erosion: wind and running water.

Habitat loss

A **habitat** is the physical environment in which a community of plants and animals lives. There is a high level of destruction of habitats around the world. Animals and plants are dependent on their habitats, and once these are destroyed they are vulnerable to extinction. Some, such as the orang-utan in Indonesia (see Figure 9.1.1), are in fact facing extinction.



9.1.1 In the Tripa peat swamp forest of Indonesia, the Sumatran orang-utan population has declined by 80 per cent, as people have burnt forest to clear tracts of land for oil palm production.

Urbanisation

The migration of people from rural areas to large cities has created many problems. The rapid growth of cities, especially in developing countries, has overwhelmed the ability of authorities to meet the basic needs of the urban population. Overcrowding, pollution and the growth of squatter settlements are all results of rapid urbanisation.

Exploited oceans

The world's oceans are an important natural resource. Of particular importance are the world's fisheries. These supply vast amounts of food. Unfortunately, the rate at which this resource is being exploited is unsustainable. Pollution is another major problem affecting oceans. If oceans are to be used sustainably, their use must be carefully managed and there needs to be international cooperation.

SPOTLIGHT

Biosphere 2

In 1991, eight men and women moved into a US\$200 million purpose-built glass and steel replica of the earth's biomes in the Arizona desert. Known as Biosphere 2, the complex was designed to investigate whether the eight occupants could be self-sustaining in a sealed-off environment. It was hoped that a facility such as this could be used to colonise outer space.

The original idea was for the inhabitants to grow all their own food, and for the biomes, which included oceans with coral reefs, mangrove wetlands, tropical rainforest, savanna grasslands and a fog desert, to supply naturally recycled air and water. Despite the use of the latest technology, Biosphere 2 could not produce enough air, water or food to support the eight people. Significantly, the level of carbon dioxide could not be controlled. The experiment was abandoned after just three years. Today, the University of Arizona uses Biosphere 2 for scientific research.



9.1.2 Biosphere 2, a failed attempt to recreate the complex ecological processes of planet earth

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'environment' and outline its importance.
- 2 Outline what 'environmental change' is and explain how it can be both beneficial and detrimental.
- 3 Outline the impacts of world population growth on the environment and how this affects the wellbeing of people.

Applying and analysing

- 4 Study the Spotlight box 'Biosphere 2'. Describe what this example tells us about the complexity of the earth's environmental processes.
- 5 Construct an annotated mind map highlighting the key challenges to sustainability.

Towards a sustainable future

Environments and sustainability

Environments were once considered 'bottomless pits'—infinite stores of resources that could be exploited for the benefit of humans. Today, environments are seen as fragile, threatened systems in need of careful management. The concept of sustainability is at the centre of contemporary approaches to environmental management.

Sustainability in an ecological context refers to the ability of biological systems to remain diverse and productive. For humans, sustainability is about maintaining the capacity of the environment to support life, and the quality of life, well into the future.

Four functions of environments

The capacity of the earth to support life and human wellbeing depends on maintenance of the four functions of the environment, as outlined in Figure 9.2.1.

Source

The source function is the provision of the naturally occurring resources needed to sustain life and our material wellbeing. It includes the minerals and ores, timber and food—the plants we grow, the animals we graze and the seafood we harvest.

Sink

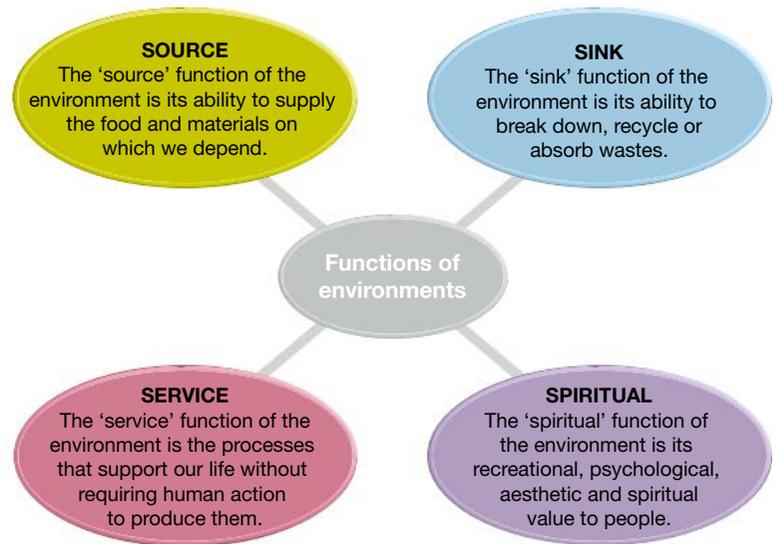
The sink function is the ability to break down, recycle or absorb and render harmless waste and pollution. The world's oceans, for example, are the largest active carbon sinks on earth. When waste output exceeds the limit of the sink function, long-term damage occurs.

Service

The earth's environmental service functions are all those things done for us by the biophysical environment; for example the absorption of carbon dioxide and production of oxygen by forests, and the filtering of water and recycling of nutrients via the process of decomposition by wetlands.

Spiritual

The spiritual functions of the environment include its cultural and recreational value to people and the ways in which it enriches aesthetic experience.



9.2.1 The four functions of environments

Sustainable development

Sustainable development is **development** that meets the needs of the present population without affecting the ability of future generations to meet their needs.

The aim of sustainable development is to achieve improvements in people's quality of life or wellbeing while protecting the environment. Sustainable development and good environmental management go hand in hand. If we are to put sustainable development into practice we must:

- use the earth's non-renewable resources in ways that do not reduce their usefulness for future generations
- involve people in making the decisions that affect their lives and their environment
- develop technologies that are cleaner, use less energy and require fewer natural resources
- reduce the waste we produce, and make products that last longer and are easy to recycle and repair
- reduce the amount of energy we use
- encourage the development and use of renewable energy from the sun, wind and flowing water.

SPOTLIGHT

The earth's carbon stores, sources and sinks

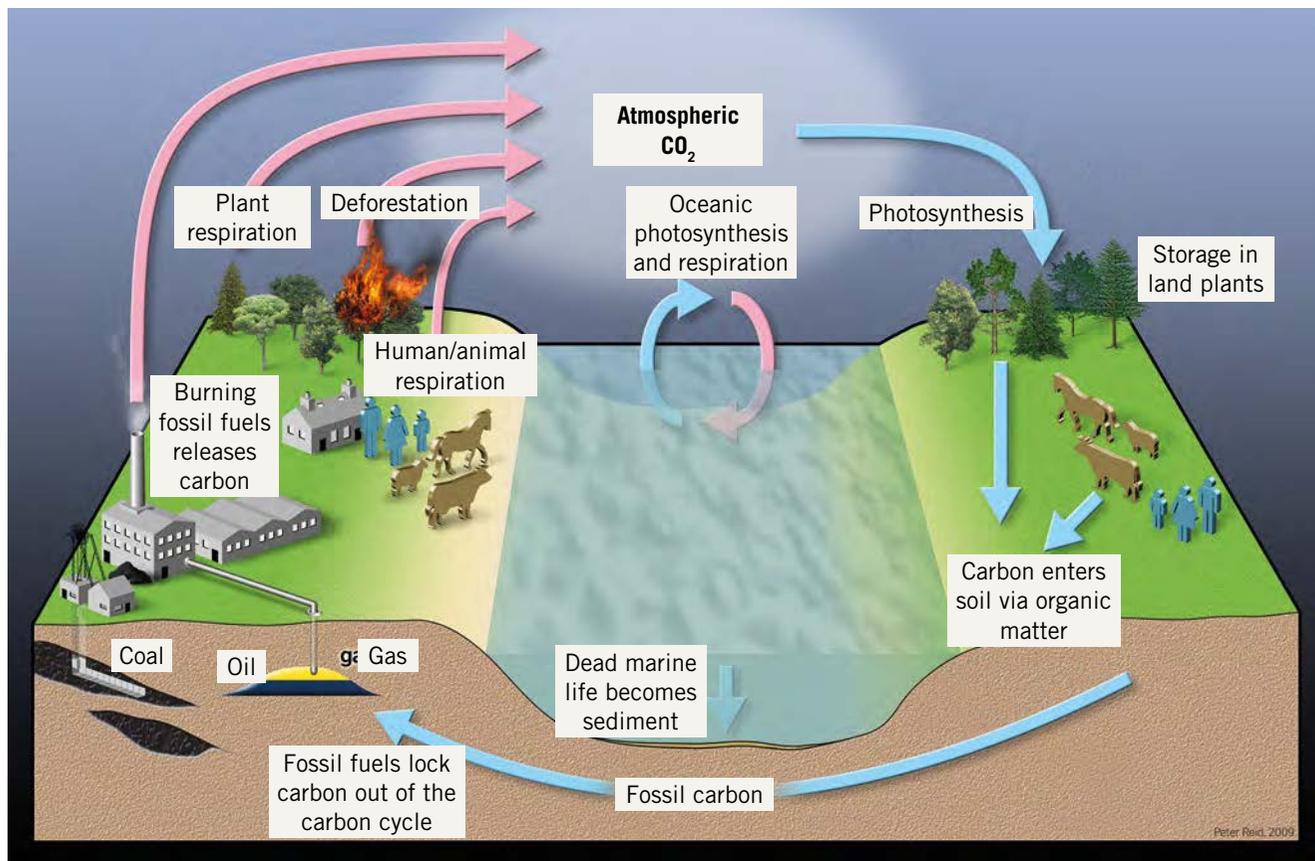
Carbon dioxide (CO₂) is continually recycled on earth. The environmental processes by which CO₂ is released to the atmosphere are called carbon sources, while processes that absorb it are called carbon sinks. The atmosphere, fossil fuels and the earth's forests, soils and oceans are important stores of carbon. Carbon is constantly moving between these different stores. A carbon sink absorbs more carbon than it gives off, while a carbon source emits more than it absorbs.

Volcanoes, forest fires, decomposition, respiration and, under certain conditions, the world's oceans are all natural 'sources' of atmospheric CO₂. When the oceans warm or are disturbed by storms they can release large amounts of dissolved CO₂.

Photosynthesis, forests, oceans and freshwater bodies and fossil fuels are all natural 'sinks' for atmospheric CO₂.

The amount of carbon in the atmosphere at any one time depends on the balance that exists between the various sources and sinks. This system of sinks and sources is referred to as the **carbon cycle** (see Figure 9.2.2).

9.2.2 The earth's carbon stores, sources and sinks



ACTIVITIES

Knowledge and understanding

- 1 State how our thinking about environments has changed over time.
- 2 Outline the four functions of the environment.
- 3 Explain what is meant by the term 'sustainable development'.

Applying and analysing

- 4 Identify the source, sink, service or spirituality functions of the environment shown in Figure 9.2.2. Which of these functions is of greatest value

to humans? Justify your choice. What would be the impact if this environment was degraded or destroyed?

- 5 As a class, brainstorm the concept of 'sustainability'. Develop a mind map highlighting the main points raised in the discussion. Use the mind map to write your own definition and explanation of 'sustainability'.
- 6 Email the Australian prime minister with suggestions about how the government could promote sustainable development.

Pollution

Air pollution

Air pollution is the contamination of the atmosphere by substances that can, either directly or indirectly, impact on human health and welfare. Sulfur dioxide, particulate matter, nitrogen oxides, carbon monoxide and lead are common atmospheric pollutants. Air pollution can irritate existing respiratory conditions, bring on an asthma attack, irritate people's eyes, produce unpleasant odours, damage property and reduce visibility. In the large cities of the developing world, air pollution is a major environmental problem.

Water pollution

Water pollution occurs when pollutants are directly or indirectly released into oceans, rivers, lakes and aquifers without adequate treatment to remove harmful substances.

Dirty water is the world's biggest health risk, and continues to threaten both quality of life and public health. Many of our water resources lack basic protection, making them vulnerable to pollution from farms, industrial plants, and activities such as fracking. This can lead to drinking water contamination, habitat degradation and beach closures. Urban run-off is a particular concern. When water from rain runs off roofs and roads into waterways, it picks up toxic chemicals, dirt, litter and disease-carrying organisms.

Solid wastes

Solid wastes include most of the rubbish we would normally throw into rubbish bins, plus many of the wastes produced by industrial plants and the building industry. As populations grow and standards of living increase, the amount of solid waste produced increases.

There are a number of environmental hazards associated with casual waste disposal. These include the contamination of groundwater by toxic substances; soil contamination; methane emissions; and dust, vermin and odour. These hazards can also occur in poorly managed landfill sites.

The alternatives to casual waste disposal are recycling, re-use and waste reduction.

- **Recycling** Materials such as glass, plastic, aluminium, steel and paper can be reprocessed and used again.
- **Re-use** Printer Ink cartridges, for example, can be refilled and re-used.

9.3.1 A well-managed landfill site



*HDPE (high-density polyethelene) is a strong plastic.

- **Waste reduction** You can choose to buy goods without a lot of packaging and use re-usable bags instead of the disposable plastic bags provided by supermarkets.

In Australia, 54 per cent of waste ends up in landfill sites (this is down from 93 per cent in 1996-97). Wetlands and old quarries have, for many years, been sites for the disposal of this type of waste, but wetlands are now considered too important to use for waste disposal, and old quarries are in short supply. Figure 9.3.1 shows a well-managed landfill site.

Types of waste

E-waste

Obsolete electronic goods (known as e-waste) are one of the fastest-growing waste types, and their safe disposal is a major problem. In 2013, nearly 50 million tonnes of e-waste was generated worldwide—or about 7 kilograms for every person on the planet. Mobile phones, laptops, tablets, iPods and iPads, plasma and LCD televisions and electronic gaming machines are all constantly being updated and replaced. These products are made up of hundreds of different materials and contain toxic substances such as lead, mercury, cadmium, arsenic and flame retardants.

Much of the e-waste generated in developed countries ends up in processing plants in India, China and other parts of Asia. There are concerns about the working conditions in these plants as exposure to toxic substances can be hazardous to health.

Plastic waste

Plastic shopping bags are very damaging to the environment. Consider the following facts.

- Australians consume about 6.9 billion plastic bags every year. If these were tied together they would stretch around the world thirty-seven times.
- Every year, up to 80 million of these bags find their way onto our streets as rubbish.
- The World Wide Fund for Nature estimates that more than 100 000 whales, seals, turtles and birds die every year as a result of plastic bags.

Environmental groups advocate the imposition of a plastic bag levy. By imposing this added cost on retailers (and/or consumers), environmental groups hope to encourage the use of re-usable alternatives.

MICROPLASTICS AND MICROBEADS

Microplastic pollution found in marine environments originates either from larger pieces of plastic broken into smaller pieces over time, or from cosmetic products (soaps, exfoliants and toothpastes) that contain microbeads made of polyethylene. These pieces of plastic, shown in Figure 9.3.2, are too small to be filtered during wastewater treatment and are discharged into the water cycle, making their way into freshwater and marine environments, then the food chain. There are efforts worldwide to lobby cosmetic companies to stop using microbeads in their products. The lobbying campaign has had some success, and many large international companies are phasing out their use of microplastics and microbeads.

Toxic wastes

Toxic wastes (sometimes referred to as hazardous wastes) are chemicals that can cause death or injury to living creatures. While toxic wastes are most often associated with industrial



9.3.2 Facial scrub particles shown in an electron micrograph. It is thought that small marine animals ingest the microplastics and pass the pollutant up the food chain.

processes, they can also be found in the home and are widely used in agriculture, medical procedures and light industries such as dry-cleaning establishments. Toxic wastes can pose a long-term risk to people's health. They can enter the food chain, where they accumulate in the fatty tissues of animals (a process known as **bioaccumulation**). Some of these animals form part of the human food chain. Once they accumulate, these toxic substances can cause birth defects, cancer and developmental disorders. Abandoned industrial sites can be a major problem, especially when the site and/or adjacent waterways contain e-waste concentrations.

DID YOU KNOW?

Scientists have found up to 60 fragments of microplastics per 100 milligrams of sediment at the bottom of Sydney's Middle Harbour.

ACTIVITIES

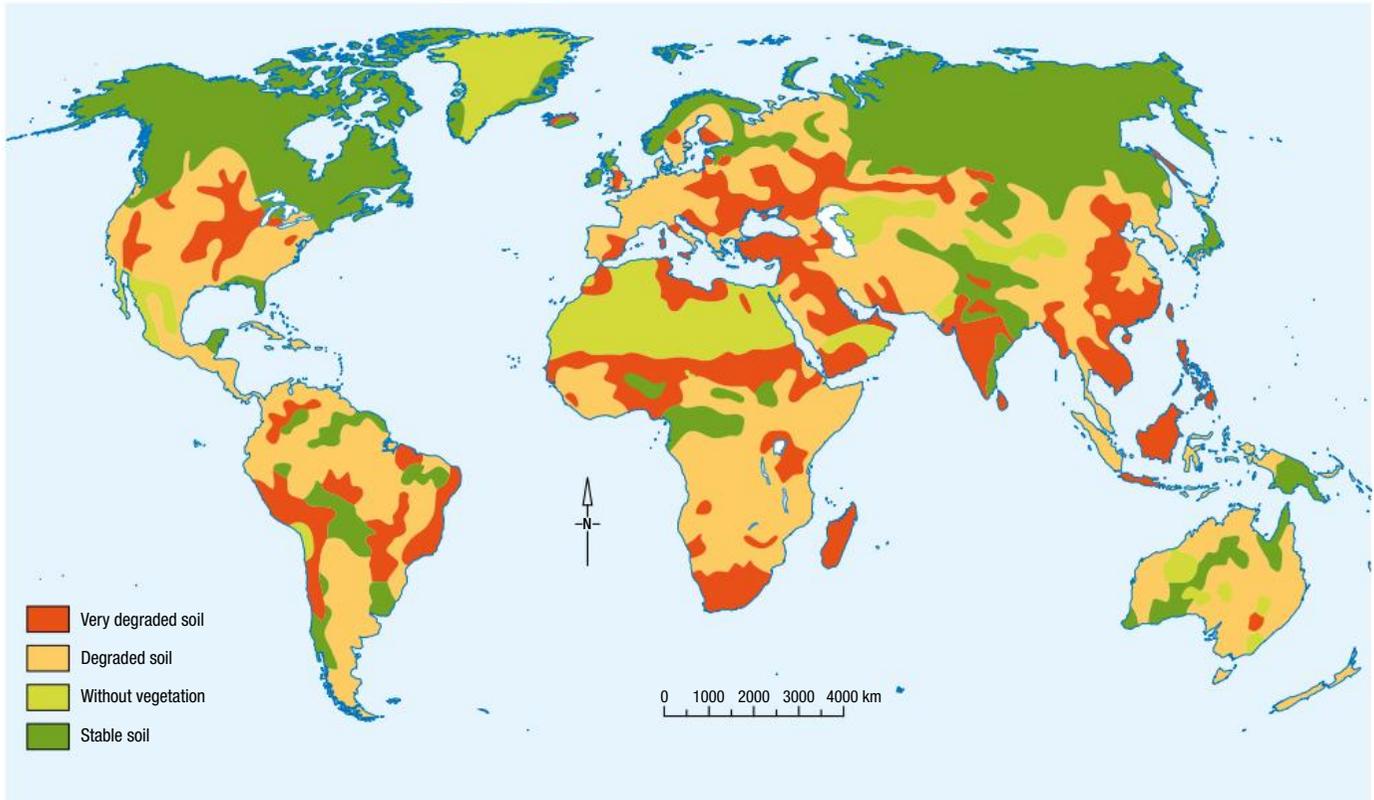
Knowledge and understanding

- 1 Define the term 'pollution'.
- 2 Outline the impacts of air pollution.
- 3 Explain why water pollution is considered a health risk.
- 4 State why the disposal of solid wastes is increasingly problematic.
- 5 Outline the alternatives to the dumping of wastes.

Applying and analysing

- 6 Study Figure 9.3.1. Write a report highlighting how a landfill site can be managed in a way that protects the environment.
- 7 Develop an information campaign educating the public about one of the types of waste: e-waste, plastic waste or toxic waste.

Land degradation



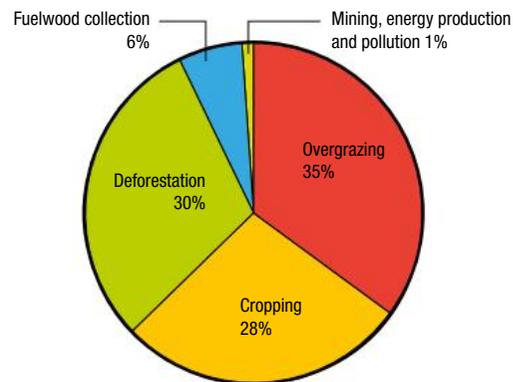
Source: UNEP

9.4.1 Land degradation is a worldwide problem.

Causes of land degradation

Land degradation is a worldwide problem, as is shown in Figure 9.4.1. The activities of people that contribute to land degradation include over-clearing of the natural vegetation (including deforestation)—a process that contributes to both soil salinity and erosion—and overgrazing by animals. When too many cattle or sheep are put onto an area of land, they eat all the grass and bushes, leaving nothing to hold the soil together. These heavy, hard-hoofed animals cause the soil to compact, and damage its surface. Elsewhere, overcropping of the land also exposes the land to erosion, as does the collection of fuelwood by people living in developing countries. These causes of land degradation are examples of poor land management. Usually this is unintentional, but it may be caused by greed. Figure 9.4.2 illustrates the main causes of land degradation.

If land is degraded, it loses its ability to produce the quality of vegetation or crops that it once did. Land degradation is one of the most significant environmental problems in the world because it is so widespread and so difficult to reverse.



9.4.2 Overgrazing is the largest single cause of land degradation.



9.4.3 Salinity

Soil degradation

Soils can be damaged, or degraded, in four main ways: through salinity, erosion, compaction and acidification.

Soil salinity

Increasing levels of salt in soils are common in some parts of the world, including Australia. They are caused by salty groundwater (water that is stored in rock and soil below the surface) reaching the surface of the soil. Normally, this water level is controlled by large trees, which pump water from the soil as they transpire. When trees are cut down, salty water may rise to the surface (see Figure 9.4.3). The water evaporates, leaving a salty crust.

Soil erosion

Soil erosion is the removal of topsoil by water or wind. Erosion occurs wherever the soil is unprotected by plant cover. Once the original plant cover is removed, soil can be carried away easily by strong winds or heavy rain. Winds can strip the land of its topsoil and carry it hundreds of kilometres, and heavy rain and run-off can cut deep gullies in the soil (see Figure 9.4.4).



9.4.4 Gully erosion

Soil compaction

Soil can be compacted by the weight of heavy machinery or the trampling of stock that are much heavier than native animals. The air spaces in the soil are compressed so that a hard layer develops on top. This reduces infiltration and makes it difficult to use the land for crops or pasture.

Soil acidification

Soil can be made acidic by the overuse of chemical fertilisers. Often, fertilisers are essential to ensure that the soil keeps producing crops. When used over a long period of time, however, fertilisers can also harm the soil.

Vegetation degradation

Natural vegetation can also be degraded. A natural ecosystem of plants can be changed in a number of ways. For example, vegetation can be affected by introduced plants. These can upset the natural balance of the ecosystem and spread uncontrollably.

Fires can also change the vegetation greatly. Although fire can be a natural part of the environment, it has a major effect on some species. It can remove some species, and encourage the growth of others.

Weed infestations often occur when vegetation is disturbed. Weeds are plants that have run wild (like animals gone feral) and have taken over from other species. Plants turn into weeds when they find conditions that are ideal and consequently come to dominate an ecosystem.

Desertification

One of the most serious forms of land degradation in the world is **desertification**, which means the creation of deserts. Desertification is a problem in parts of Africa, where the desert is steadily advancing over what used to be good farming land.

Desertification in northern Africa has occurred on the edges of the Sahara. These marginal lands have variable rainfall and can only be used with great care. A mixture of overuse and periodic change in the rainfall has destroyed the productive ability of the land. The results are creeping desert sands and salty water holes.

Role of poverty

Land degradation is both a cause and a result of **poverty**, with one contributing to the other. In subsistence economies, where people depend on the land for food, land degradation can result in greater poverty and human suffering. Developing countries often have high rates of population growth. This places increased demands on the land, as the land must be used more intensively to feed the growing numbers. This increased intensity of land use often exceeds the capacity of the land to cope.

As a result, it becomes degraded. This means less productive land per person, increased pressure on resources and even more land degradation.

Coastal degradation

The coastline is under constant attack from the natural forces of wind and waves. Because of this, the coastline is constantly changing: beaches and sand dunes erode and are rebuilt in response to wind attack, and sand dunes can migrate inland. Human activities along the coastline can increase the rate at which these changes occur. Coastal degradation is caused by inappropriate development and land use management practices along the coastline. Coastal developments for tourism, residential, commercial and recreational purposes place pressure on coastal areas, and may cause degradation.

The extent of this degradation is often related to population density. The distribution of the earth's population and the extent to which coastlines have been altered by the activities of humans are shown in Figure 9.4.6. The most extensively altered coastal environments tend to be found where population densities are greatest.

SPOTLIGHT

Fuelwood collection and the spread of deserts

The Food and Agriculture Organization (FAO) estimates that 40 per cent of the world's 2.7 billion people rely on fuelwood or charcoal (made from the partial burning of wood) as their primary source of energy for cooking and heating. This reliance is growing, as is the impact

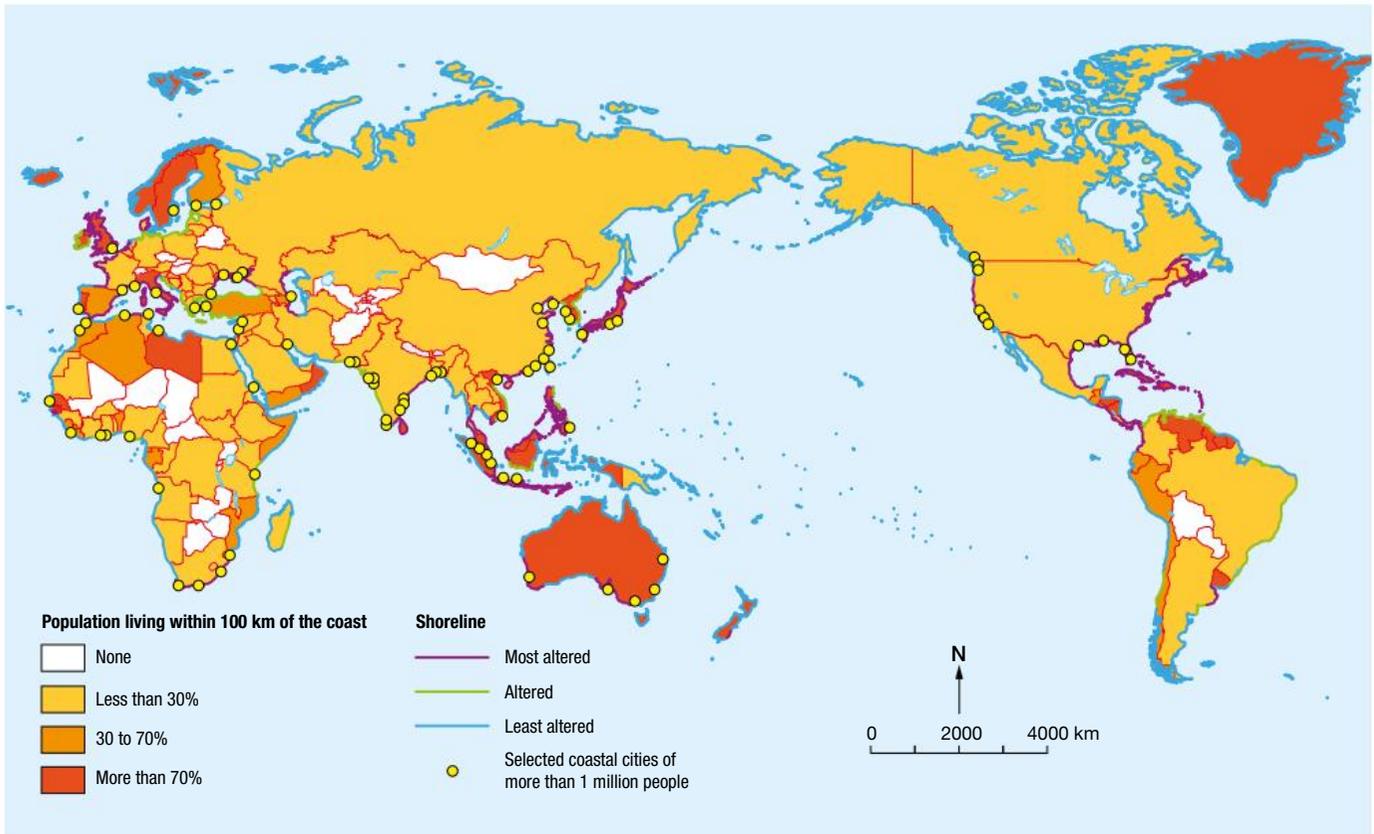
of charcoal use on the environment. The consumption of fuelwood has increased 250 per cent since 1960, while the world's population has increased by only 90 per cent.

Because the collection of wood is time-consuming and often exhausting, people in developing countries tend to remove all suitable vegetation in increasingly wide areas around their villages. As a result, the collection of fuelwood and building materials is an important cause of deforestation, land degradation and desertification.



9.4.5 More than 90 per cent of Haiti is deforested, in large part because most of the 8 million people use charcoal to cook.

9.4.6 There is a close relationship between population density and the extent of human impact on coastlines.



Source: World Resources Institute

ACTIVITIES

Knowledge and understanding

- 1 Define the process of land degradation.
- 2 Outline the causes of soil and vegetation degradation.
- 3 Outline the various types of soil degradation.
- 4 Define the term 'desertification'.
- 5 Explain how the collection of fuelwood contributes to the problem of desertification.

Geographical skills

- 6 Study Figure 9.4.1 and do the following tasks.
 - a With the aid of an atlas, identify, in general terms, those parts of the world with very degraded soils.
 - b Which continent has the largest area of degraded land?
 - c Which continent has the smallest area of degraded land?
- 7 Study Figure 9.4.2. Identify the main causes of land degradation.
- 8 Study Figure 9.4.6. Identify the regions of the world where the coasts have been most altered. Note the relationship between the level of alteration and population density.

Investigating

- 9 Investigate the strategies used to fight land degradation in a selected country and location. Present your findings as an annotated visual display. Include in your display a map of the location being investigated.
- 10 Conduct a survey of the school grounds or an area nearby to evaluate the amount of land degradation.
 - a Draw up a base map of the site.
 - b Look for evidence of damage to soil: erosion, compaction, waterlogging and salinity.
 - c Map the areas where nothing grows.
 - d Map the areas of plants. If possible, label them as native or introduced.
 - e Use this information to make a list of steps that could be taken to improve that particular area of land.

Exploited oceans

The world's oceans

The earth is sometimes referred to as the 'blue planet'. This is because two-thirds of its surface is covered by water: its four great oceans and the smaller seas. People have used these oceans and seas for centuries with little consideration of the long-term impact of their activities. Such indifference cannot continue. The wellbeing of the planet depends on the environmental functions performed by the oceans.

Human impacts on oceans

Some of the human impacts on oceans are:

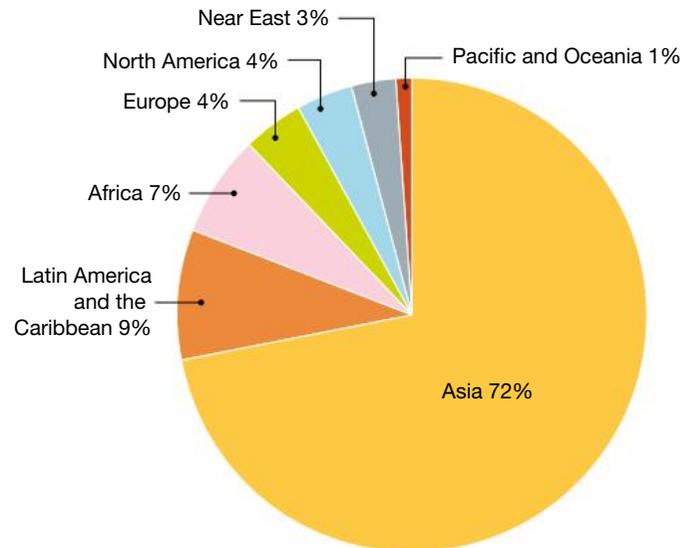
- over-exploitation of the world's fisheries (see Figure 9.5.1)
- dumping of toxic pollutants and oil spills
- increased flow of nutrients (such as agricultural fertilisers and sewage)
- dumping of plastics and other solid wastes.

Harvesting the world's oceans

More than 3 million fishing vessels now sift the world's oceans for seafood. This is twice as many vessels as in 1970. The regional distribution of these vessels is shown in Figure 9.5.2. In 2012, wild capture fisheries and aquaculture supplied the world with about 158 million tonnes of fish, and the fish export industry was worth more than US\$130 billion. Of this, 90 million tonnes were from aquaculture production, both inland and marine waters. This total catch equates to about

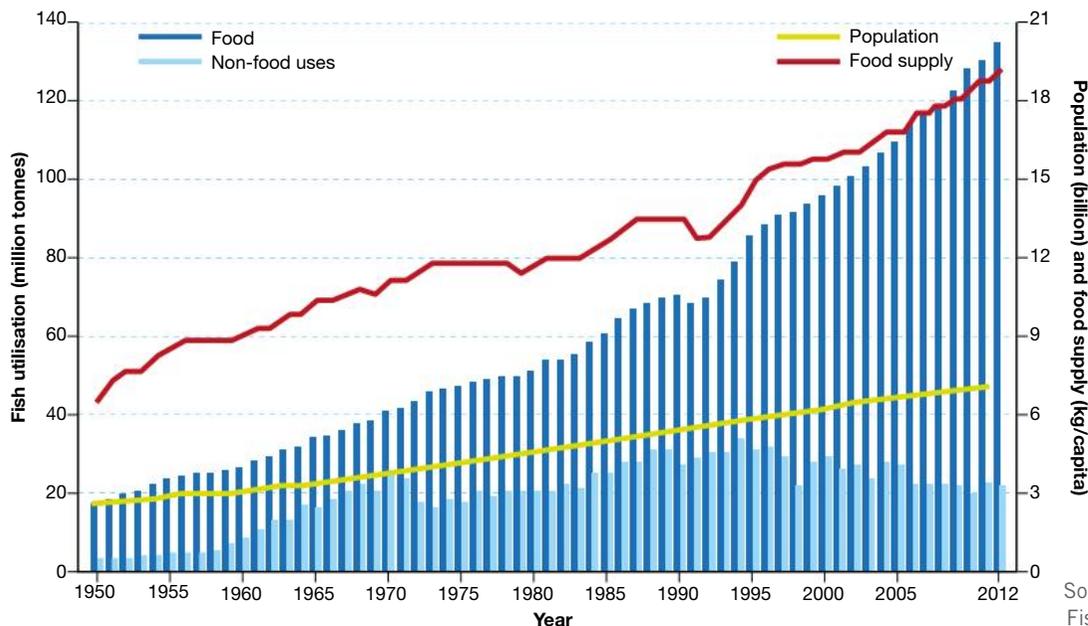
19.2 kilograms a year for the average person. Average fish consumption per country is shown in Figure 9.5.3.

9.5.2 Distribution of the world's motorised fishing fleet



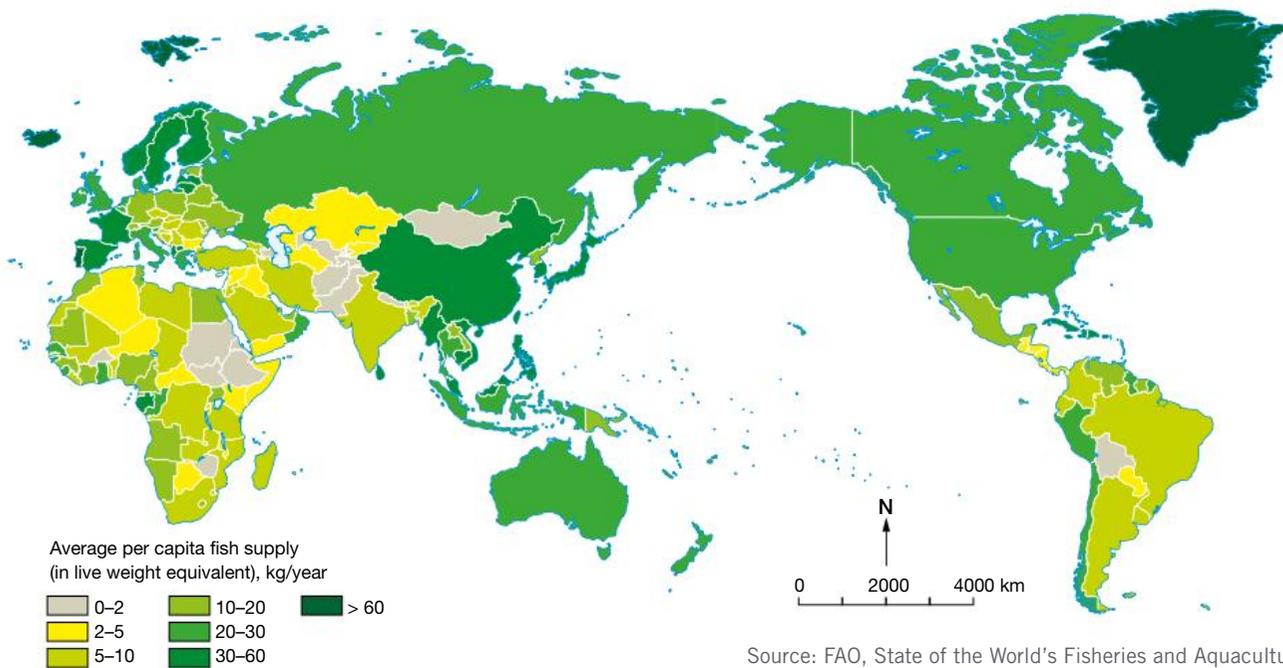
Source: FAO, State of the World's Fisheries and Aquaculture, 2014

9.5.1 World fish utilisation and supply



Source: FAO, State of the World's Fisheries and Aquaculture, 2014

9.5.3 Fish consumption per capita (average 2008–10)



Source: FAO, State of the World's Fisheries and Aquaculture, 2014

Protection efforts

In an effort to protect their fishing grounds, many countries have extended their territorial control from 12 to 200 nautical miles (300 kilometres) beyond their coastline. As a result, nearly 40 per cent of the world's oceans have now been claimed as exclusive fishing zones by countries, so restricting the access of foreign fleets to these waters.

In some regions, fish species have been exploited close to extinction. In other areas, fish yields are in serious decline. One such area is the Grand Banks of Newfoundland, Canada. In the mid-1990s, the Canadian government became so concerned with the rate of decline that it ordered a stop to fishing in the region. The impact on local communities was dramatic—40 000 people were put out of work. Despite this, distant-water trawlers operating out of Spain, Portugal and other countries continued to fish the edges of the Grand Banks just outside Canada's territorial waters.

Having reduced fish numbers in their own waters, many rich countries are now buying access to the waters of poorer countries. This disadvantages local fishers, who are unable to afford the technology used by the larger foreign-owned factory ships, which process the catch on board. In the waters off Senegal in western Africa, for example, locals must now travel further and further to get the same catch. Large long-range trawlers from China, South Korea, Spain, Japan and France are depleting Senegal's local fish stocks.

International efforts to regulate the industry have not yet met with much success. As the oceans are so vast, it is difficult to make sure that operators comply with international agreements.

Employment in fisheries

In 2012, there were 58.3 million people engaged in the primary sector of capture fisheries and aquaculture. More than 84 per cent of all people employed in the fisheries sector were in Asia, followed by Africa (more than 10 per cent) and Latin America and the Caribbean (3.9 per cent).

ACTIVITIES

Knowledge and understanding

- 1 Outline the actions countries have taken to protect their fishing zones.
- 2 Outline how people in developing countries have been affected by the growth of the fishing industry.
- 3 Explain why international efforts to regulate the industry have met with little success.

Applying and analysing

- 4 Create a mind map on the impacts people have had on the world's oceans.
- 5 Study Figure 9.5.1. Describe the trend in fish utilisation for food and non-food uses, 1950–2012. Compare this to the trends in world population and total food production.
- 6 Study Figures 9.5.2 and 9.5.3.
 - a Identify the parts of the world where fish consumption exceeds 20 kilograms per person per year. Which regions have the lowest level of fish consumption?
 - b Compare the distribution of the fishing fleet by region with average fish consumption.

Habitat loss

Habitat

A habitat is the biophysical environment in which a community of plants and animals lives. As habitats are destroyed, the communities of plants and animals that depend on them are displaced, with the result that some face extinction.

Pressures on biodiversity

As the world's population grows, so does the demand for food, clothing and shelter. As a result, whole habitats are lost and an area's **biodiversity** is destroyed. While some species are already **extinct**, a growing number of species are classified as endangered, vulnerable or threatened.

Levels of threat

The International Union for Conservation of Nature and Natural Resources (IUCN) classifies the threat to species on a scale, from threatened to extinct:

- **extinct**—not seen in the wild for the last 50 years
- **extinct in the wild**—found only in captivity (that is, in zoological gardens or seed banks)
- **critically endangered**—considered to be facing an extremely high risk of extinction in the wild
- **endangered**—considered to be facing a very high risk of extinction in the wild
- **vulnerable**—considered to be facing a high risk of extinction in the wild
- **threatened**—close to qualifying for the endangered or vulnerable categories in the near future.

The 2015 Red List, which sets out the status of 79 837 species, lists 23 250 species as threatened. At threat are 41 per cent of amphibian species, 40 per cent of gymnosperm plants, 26 per cent of mammals and 13 per cent of birds.

DID YOU KNOW?

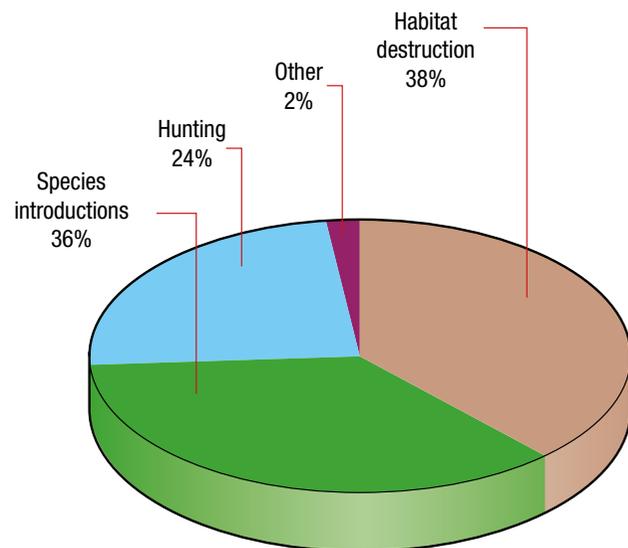
Only 1.9 million species have been identified out of an estimated 13 to 14 million species that are thought to exist.

Causes of biodiversity loss

Habitat loss and degradation

The main reason that so many species have become endangered or extinct in the past hundred years is loss of habitat. The clearing of land for housing, logging and farming is the main cause of this habitat destruction. The known causes of animal extinctions are shown in Figure 9.6.1.

9.6.1 Known causes of animal extinctions. Habitat destruction is the main cause of species loss.



Introduced species

Introduced species of plants and animals can be an important factor in the decline of established native species. Rabbits, foxes, camels, goats, cane toads, cats, blackberry and prickly pear are some of the introduced species that have gone feral in Australia. They compete with native species and often eliminate them from wide areas. Many small species, such as the short-tailed hopping mouse and the numbat, have become endangered because of hunting by introduced species.

Hunting (over-exploitation)

Over-exploitation is a significant cause of species loss and endangerment. Animals are hunted for food and skins. In the Caspian Sea, fishing for the highly valued beluga sturgeon's eggs, used to make caviar, has pushed the fish species close to extinction.

Disease

The emergence of infectious diseases in free-living wild animals is a growing threat to biodiversity. It is likely that other factors (for example pollution) have increased the exposure of some species to disease. In Tasmania, the state's population of Tasmanian devils has, since the late 1990s, been affected by a facial tumour disease. This disease has reduced the devil population significantly and now threatens the survival of the species. The cancer's origin is a mystery, but studies indicate that the animals pass it on from one to another (it is contagious).

Pollution

Many of the pollutants released into the environment by human activities have significant, large-scale impacts on the world's terrestrial and aquatic ecosystems. Acid precipitation, for example, has had a significant impact on the forests of Europe and North America, and industrial pollutants such as DDT are known to have caused significant declines in populations of many bird species, including the peregrine falcon and bald eagle. Toxic pollutants enter the food chain, causing birth defects and, in some cases, death.

Climate change

Global warming has the potential to transform ecosystems. These transformations will affect the community of plants and animals within ecosystems. Rises in sea temperature and the acidification of oceans, for example, may cause whole reefs to die.

Other causes

The impacts of natural disasters, urban development, tourism and the illegal trade in wildlife and animal-based products are also seen as threats to biodiversity.

WILDLIFE TRADE

The wildlife trade is the second largest illegal trade-based activity. Only the trade in drugs is bigger. It is also the most serious threat to a number of endangered and vulnerable species. The items traded can be alive or dead. International law enforcement agencies estimate that the illegal trade of wildlife is valued at US\$10–\$20 billion per year. While the trade is global, with routes extending to every continent, conservationists say the problem is most serious in South-East Asia. Despite international and local laws that aim to eliminate the trade, live animals (see Figure 9.6.2) and animal parts—often sourced from endangered or threatened species—are openly sold in markets throughout Asia.

9.6.2 Geckos hidden in a hollowed-out book seized at the Cairns mail centre by Australian Customs Service officers. The geckos were destined for a European collector of exotic animals.



SPOTLIGHT

China acts to curb illegal ivory trade

In early 2014, Chinese authorities destroyed more than six tonnes of illegal imported ivory. The move was welcomed as an important signal that the country backs action to stop elephant poaching. The ivory came from more than 600 African elephants, killed by those keen to make

money from the deadly trade. Conservationists say China is the world's largest consumer of trafficked ivory, most of which is used to make carved ornaments.

A global ban on the trade in ivory was imposed in 1989, in an effort to protect elephants from being hunted into extinction. Another strategy has been to sedate the elephants and to remove their tusks with saws, so denying the poachers the prize they seek.

9.6.3 Ivory being crushed by Chinese authorities



Why species loss matters

All species are part of different ecosystems and a full variety of life forms—that is, biological diversity—in ecosystems allows these ecosystems to function better. They can purify water, maintain the quality of the air we breathe, recycle nutrients and waste, provide food and shelter for other species and keep the population of some species from dominating an area or environment.

Plants and animals also supply many of the medicines that are used to cure human diseases. The medical potential of many species is yet to be fully realised.

Strategies for maintaining biodiversity

Attempts to protect habitats and biodiversity range from setting aside and protecting large areas of land to preserving species in zoos, botanical gardens and seed banks. None of the actions will, however, be sufficient to save many species from extinction.

DID YOU KNOW?

In the last 500 years, human activity is known to have forced 869 species to extinction.

Protected areas

Protected areas include national parks, wilderness areas, nature reserves and World Heritage sites. According to the World Conservation Union, there are now 6555 national parks worldwide, covering more than 13 000 000 square kilometres. This land has been set aside to provide protection for threatened habitats and to maintain biodiversity. This area is roughly the size of India and China combined, or 8.8 per cent of the earth's surface. A much smaller area (just 1 per cent) of the world's seas is protected.

To be successful, protected areas need to:

- be large enough to protect whole ecosystems and allow evolutionary processes to continue into the future
- have boundaries that are based on environmental rather than political considerations; for example, taking in a catchment area that might span more than one country
- take into account the interests of the local people, for example by not banning traditional hunting practices, which would only encourage poaching
- be surrounded by a buffer zone, which is an area surrounding the protected area where human activity is carefully managed
- be well managed and adequately funded.

Zoos, botanical gardens and seed banks

Zoos play an important role in captive breeding programs for endangered species, scientific research and public education. Animals bred in zoos are being used to repopulate their original homelands. Przewalski's horse, for example, has been reintroduced into northern China and Mongolia from animals reared at the San Diego Wild Animal Park in the United States of America. Seed banks have been established to store genetic material for future study and use.

International agreements

International agreements can make a great difference to the future of endangered species and threatened habitats.

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to protect species by limiting or banning international trade in particular items. It has sought to ban the trade in ivory to protect African elephants from poachers. Helped by breeding programs, the number of African elephants has increased significantly in Namibia, Botswana and Zimbabwe.

A side-effect of trade bans has been the growth of illegal trade. Private zoos, for example, are willing to pay thousands of dollars for pairs of Australian parrots and lizards. Birds are usually drugged, put into narrow tubes and packed into suitcases. Sometimes dozens of birds die on their way to their overseas destinations.

WORLD HERITAGE CONVENTION

The World Heritage Convention is an international agreement designed to protect important elements of our natural (and cultural) heritage. For a site to be included on the World Heritage List it must have important habitats for conservation of biodiversity and may contain threatened species with value to science or conservation.

CONVENTION ON BIOLOGICAL DIVERSITY

The Convention on Biological Diversity was adopted at the Earth Summit in Rio de Janeiro in 1992. The convention has three main goals: the conservation of biological diversity (or biodiversity); the sustainable use of its components; and a fair and equitable sharing of benefits arising from genetic resources.

ACTIVITIES

Knowledge and understanding

- 1 Define the terms 'habitat' and 'biodiversity'.
- 2 Outline the main causes of habitat destruction and species loss.
- 3 Outline the impact that introduced species can have on established native species.
- 4 Explain why we should be concerned about the loss of species.
- 5 Outline the conditions that need to be met if the protection of an area is to be successful.

Applying and analysing

- 6 Create a PMI about the role of zoos. Divide the PMI into the following sections: past, present and future.
- 7 As a class, discuss the following question.
Which is a more successful method of saving endangered species—habitat protection or a breeding program conducted in a zoo or animal park?
- 8 Create a mind map outlining the main threats to biodiversity.

Investigating

- 9 Investigate the ivory trade.
 - a Construct an annotated world map showing the origin of the ivory and the destinations to which it travels.
 - b Document on your map programs to stop the illegal killing of animals for ivory and to prevent people from purchasing ivory products.
Do not forget BOLTSS.

Our warming planet

Climate change

Life has existed on earth for nearly 4 billion years. During this time, the climate of the planet has undergone great change, from ice ages lasting tens of thousands of years to long periods of steamy heat. With each change, some species of plants and animals flourished, others adapted and some became extinct.

During the past century, increasing levels of greenhouse gases such as carbon dioxide (CO₂), shown in Table 9.7.1, have trapped enough heat in the atmosphere to raise the average temperatures by half a degree Celsius (see Figure 9.7.2).

If present trends continue, the earth's climate could be significantly altered, with melting glaciers, rising sea levels, increasing rates of desertification and shifting vegetation zones.

9.7.1 Concentration of CO₂ in the atmosphere, 1960–2016

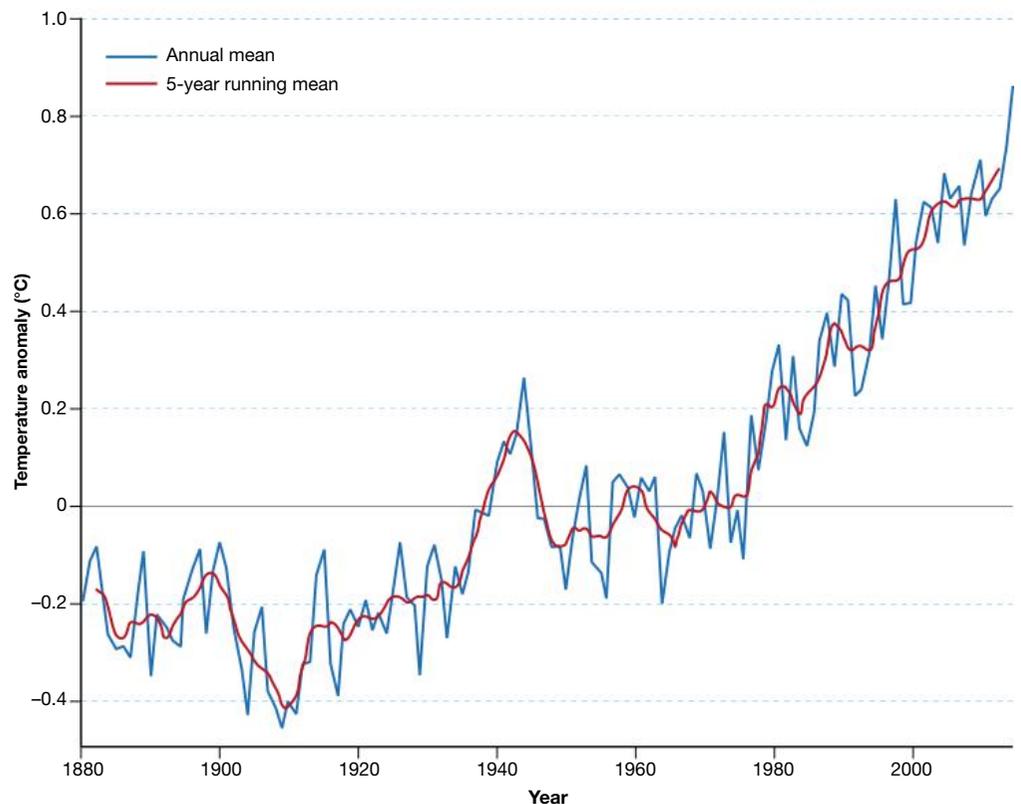
Year	Concentration (ppm*)
1960	316.91
1965	320.03
1970	325.68
1975	331.15
1980	338.67
1985	345.30
1990	353.83
1995	359.85
2000	368.77
2005	378.78
2006	380.91
2007	382.71
2008	382.71
2009	387.37
2010	389.85
2011	391.63
2012	393.82
2013	395.10
2014	397.81
2015	399.96
2016	402.52

* parts per million

Global warming

The main cause of climate change is **global warming**: the gradual rise in average temperature brought about by an increase in the heat-absorbing gases present in the atmosphere. The gases that make up the earth's atmosphere help trap and retain some of the heat radiated from the earth's surface. Without the atmosphere, the earth's surface temperature would average about -18°C instead of the present 15°C.

9.7.2 Global mean land–ocean temperature change from 1880 to 2015, compared to the 1951–80 mean. The blue line is the annual mean and the red line is a 5-year running mean.

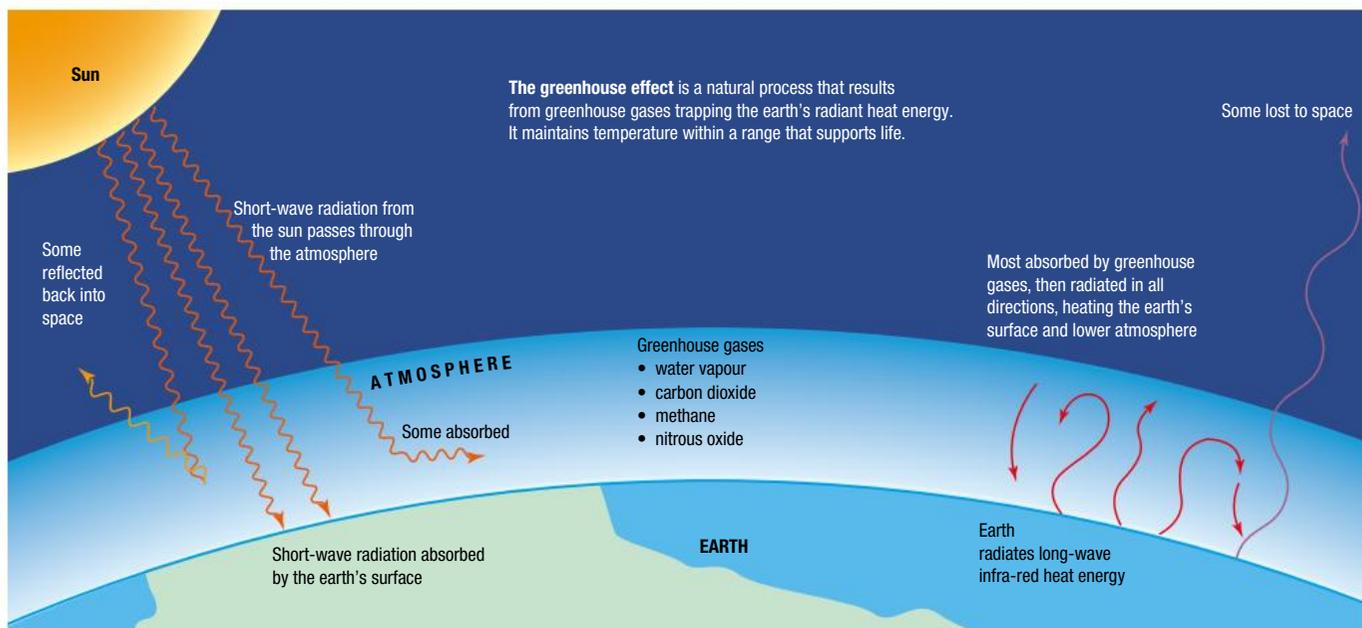


Source: NASA

The atmosphere lets only a fraction of the sun's energy (heat) make it directly back into space. The rest is trapped in the lower layers of the atmosphere, which contain various gases that absorb the heat and then radiate it back towards the earth's surface. This process is known as the natural **greenhouse effect** because it is similar to what happens in a greenhouse, or glasshouse, as shown in Figure 9.7.3. The natural greenhouse effect raises the average temperature of the earth by about 33°C (that is, from -18°C to +15°C).

The most important greenhouse gases are water vapour, CO₂, methane, nitrous oxide and fluorinated gases. Water vapour is the most important of these gases, because it is able to absorb large amounts of heat. Humans have very little direct control over the volume of water in the atmosphere but they do influence the levels of CO₂, methane and fluorinated gases in the atmosphere. These, in turn, intensify the effect of the water vapour. The hotter the atmosphere gets, the more water vapour it can hold, thereby increasing the amount of heat trapped. This is called the enhanced greenhouse effect and is thought to be the main cause of global warming (see Figure 9.7.4).

9.7.3 The natural greenhouse effect



9.7.4 The enhanced greenhouse effect

The diagram shows a globe with numbered callouts (1-9) pointing to various sources of greenhouse gases and heat-trapping processes:

- 1 Solar heat:** Incoming solar radiation passes through the atmosphere. It warms the land and sea.
- 2 Heat trap:** CO₂ in the atmosphere traps the heat reflected back from the earth's surface. If CO₂ levels increase, more outgoing heat is trapped.
- 3 Fluorinated gases:** Sometimes referred to as High Global Warming Potential gases, they include hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. They are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.
- 4 Deforestation:** Burning forests produce CO₂.
- 5 Fossil fuels:** The burning of coal, natural gas and oil releases large amounts of carbon into the atmosphere.
- 6 Vehicles:** Vehicle exhaust is a major source of heat-trapping gases.
- 7 Nitrous oxide:** Increased use of nitrogen-based fertilisers and fuel adds more nitrous oxide (a greenhouse gas) to the atmosphere.
- 8 Methane:** People and animals produce waste that produces methane, a greenhouse gas.
- 9 The oceans:** Oceans absorb CO₂ but it is being produced at a faster rate than it can be absorbed. A rise in sea temperatures will reduce the ocean's ability to absorb CO₂.

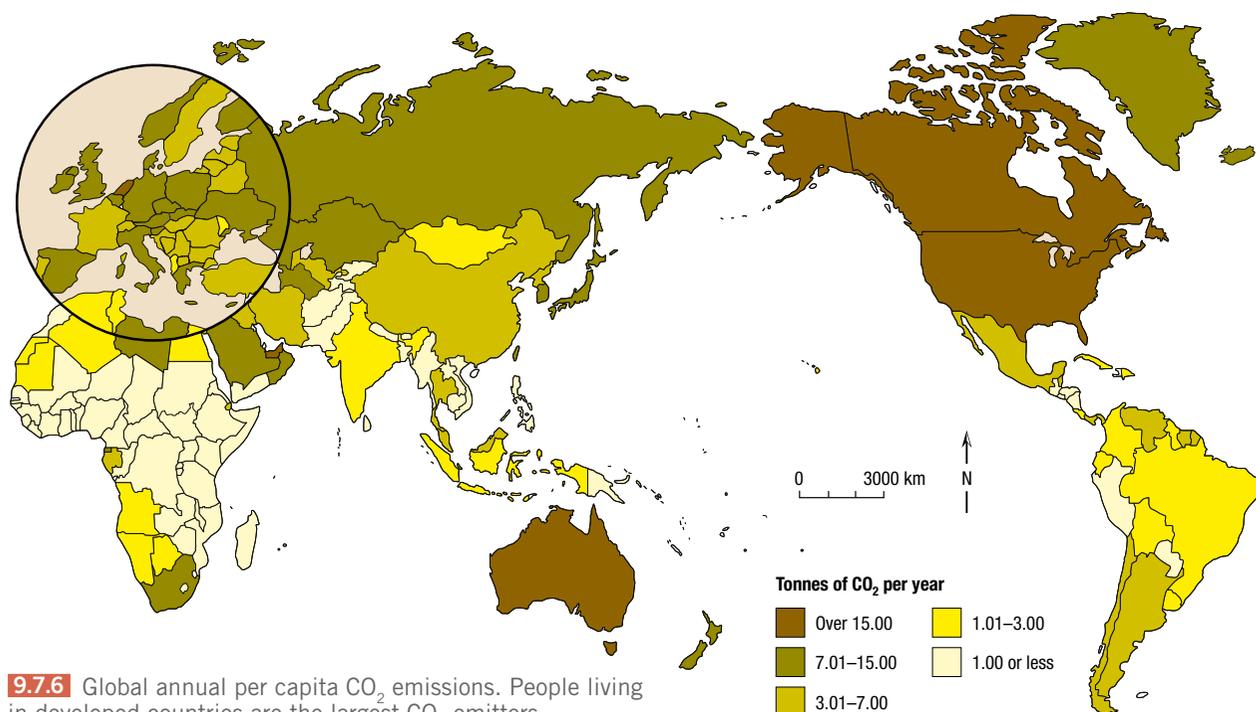
Table 9.7.5, which outlines the impacts of selected gases, shows that carbon dioxide is the largest contributor to the accelerated greenhouse effect. Figure 9.7.6 shows the amount of carbon dioxide emitted each year per capita. Estimating the actual rate of global warming is made difficult by the natural variability of the climate from place to place and from time to time. There are also other unknown factors that might significantly influence global temperatures, such as the role of the oceans. The ability of a large body of water to retain its present temperature for a long time might slow the atmospheric temperature rise for some time. Because so little is known of this effect, it is difficult to predict accurately the rate at which temperatures will increase.

Impacts of climate change

Now that scientists have accurately recorded the increasing concentrations of greenhouse gases in the atmosphere, they are turning their attention to the long-term impact of these gases on climate. Most scientists agree that the average temperature of the lower atmosphere will increase by between 1°C and 3.5°C over the next century. This increase is likely to affect environments and communities all over the world.

9.7.5 The contribution of selected gases to the greenhouse effect

Greenhouse gas	Natural origins	Human sources	Changes and impacts
Carbon dioxide 82%	<ul style="list-style-type: none"> • Volcanic eruptions • Naturally occurring fires • Respiration by plants and animals 	<ul style="list-style-type: none"> • Deforestation • Burning fossil fuels (coal, oil and natural gas) 	<ul style="list-style-type: none"> • Current concentrations are more than 30 per cent greater than before the Industrial Revolution. Thought to account for 60 per cent of the warming observed since 1850.
Methane 9%	<ul style="list-style-type: none"> • Decomposing plant and animal matter • Releases from geological deposits • Wetlands 	<ul style="list-style-type: none"> • Ruminant animals, including cattle and sheep • Rice paddies • Landfill sites • Burning of fossil fuels 	<ul style="list-style-type: none"> • There is now two and a half times more methane in the atmosphere than there was in the eighteenth century. Methane accounts for about 15 per cent of global warming.
Nitrous oxide 6%	<ul style="list-style-type: none"> • Natural atmospheric gas 	<ul style="list-style-type: none"> • Burning vegetation • Chemical fertilisers • Burning fossil fuels • Industrial emissions 	<ul style="list-style-type: none"> • The supply of nitrous oxides has increased by 15 per cent since 1800.
Fluorinated gases 3%	<ul style="list-style-type: none"> • No natural sources 	<ul style="list-style-type: none"> • Emissions from a range of industrial processes such as aluminium and semiconductor manufacturing 	<ul style="list-style-type: none"> • Small atmospheric concentrations can have large effects on global temperatures. They are the most potent and long-lasting of the gases emitted by human activity.



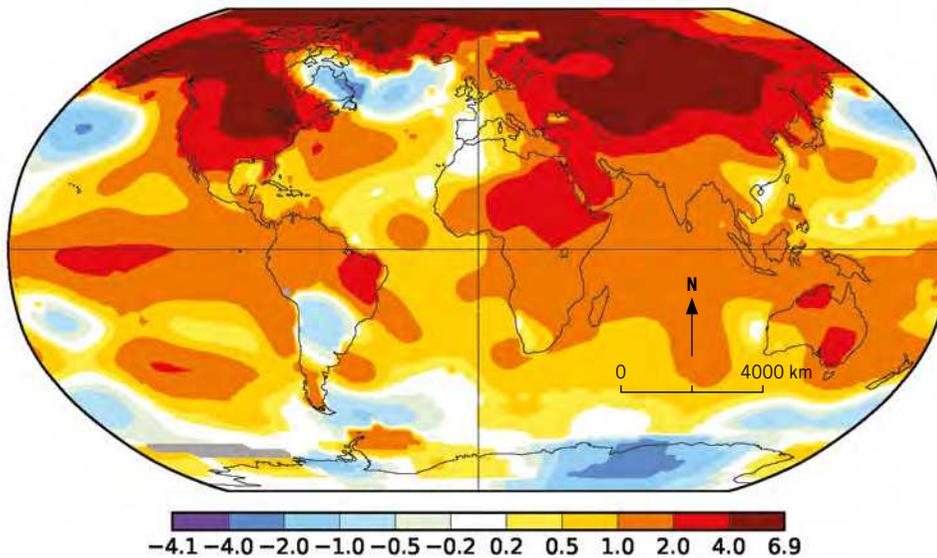
Source: World Bank, 2013

March 2016

L-OTI (°C) Anomaly vs 1951-1980

1.29

9.7.7 Mean global temperatures in March 2016, compared with the May average for 1951–80. Parts of the planet show clear signs of warming.



Source: NASA

Temperatures

The predicted increase will produce temperatures that were last experienced 100 000 years ago. Any increase will not be even across the globe (see Figure 9.7.7). Continental landmasses are likely to experience a greater temperature increase than ocean areas, because land absorbs heat faster than the sea. There is likely to be a greater temperature increase in regions in the high latitudes (that is, nearer to the poles) than near the Equator. Heatwaves are also likely to become more frequent and last longer.

Rainfall

Higher temperatures will result in much more water vapour in the air: about 6 per cent more for every 1°C increase in temperature. In some places, this will mean more intense rainfall and flooding. Increases in sea and land temperatures will produce complex changes in wind patterns and precipitation patterns.

Storm patterns

The combination of increased sea and air temperatures will affect the storm belts (areas of frequent storm activity) across the globe. At present, tropical cyclones are confined to latitudes 8–25° north and south of the Equator, where water temperatures are high enough to support the evaporation rate necessary for storms to form. With global warming, the storm belts will spread from the Equator. As a result, places on the same latitude as Brisbane (27°S) could regularly experience tropical cyclones, whereas they are presently out of range.

The warmer oceans will also create more intense storms.

Melting ice sheets and glaciers

Scientists have recorded the retreat of the world's glaciers over the last century. There is growing evidence that the ice shelves surrounding Antarctica are beginning to break up and melt.

SPOTLIGHT

Australian bushfires to become more deadly

The devastating Victorian bushfires of 2009 and the Blue Mountain blazes of 2010 focused people's attention on the relationship between climate change and the frequency and severity of bushfires. Scientists have found that the most intense fire weather seasons have occurred since the 1990s. Adelaide, for example, experienced the three worst seasons on record in 2001, 2003 and 2007. This period coincided with one of Australia's worst and longest droughts. More frequent and severe droughts are predicted as a consequence of climate change. Scientists predict that the number of very high and extreme fire weather days could increase by anywhere between 5 per cent and 65 per cent by 2020, depending on the rate of global warming, and by between 15 per cent and 300 per cent by 2050.



9.7.8 The tragic fires in Victoria in 2009 claimed 173 lives and destroyed more than 2000 homes.

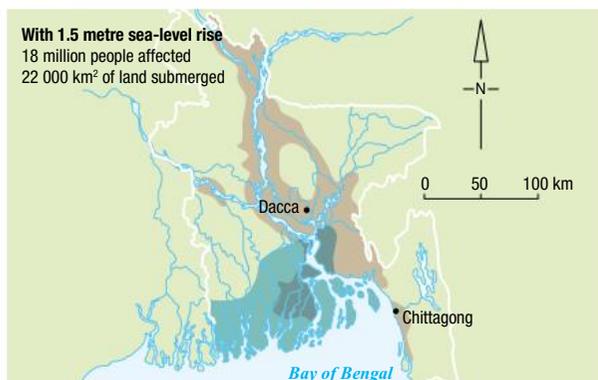
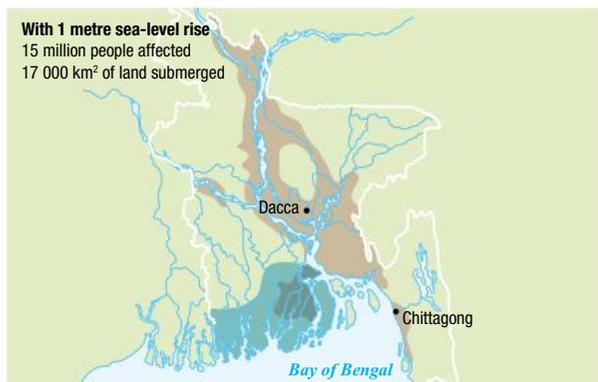
SPOTLIGHT

Bangladesh threatened by sea-level rise

Bangladesh is the seventh most populous country in the world, one of the most densely populated countries, and among the poorest.

The country is located in the low-lying Ganges–Brahmaputra river delta. This delta is formed from the sediments deposited by the Brahmaputra and Ganges rivers and their various tributaries as they flow into the Bay of Bengal. The alluvial soil deposited by these rivers has created some of the most fertile plains in the world.

Most parts of Bangladesh are less than 12 metres above sea level. It is believed that about 50 per cent of the land would be flooded if the sea level were to rise by a metre. If this happened, millions of people would become environmental refugees.



9.7.9 Large areas of Bangladesh will be flooded with even a modest rise in sea levels.

Changes in sea levels

Rising sea levels could have an impact on coastal communities.

It is predicted the polar regions will experience the greatest warming. If these predictions are correct, the melting of polar ice caps could be so great that it would add a significant amount of water to the oceans. In addition, since water expands as it warms, sea levels would be forced higher still. Average sea levels have risen by 10–25 centimetres during the twentieth century (see Figure 9.7.10).

Causes of sea-level rise

There are three processes that contribute to sea-level rise: thermal expansion, melting glaciers and mountain ice caps, and melting ice sheets.

THERMAL EXPANSION

All bodies expand when they are heated, and that is true for the water that covers 70 per cent of the planet. The oceans are expanding—upwards. It is estimated that this expansion will raise levels by 10 to 40 centimetres over the course of the century.

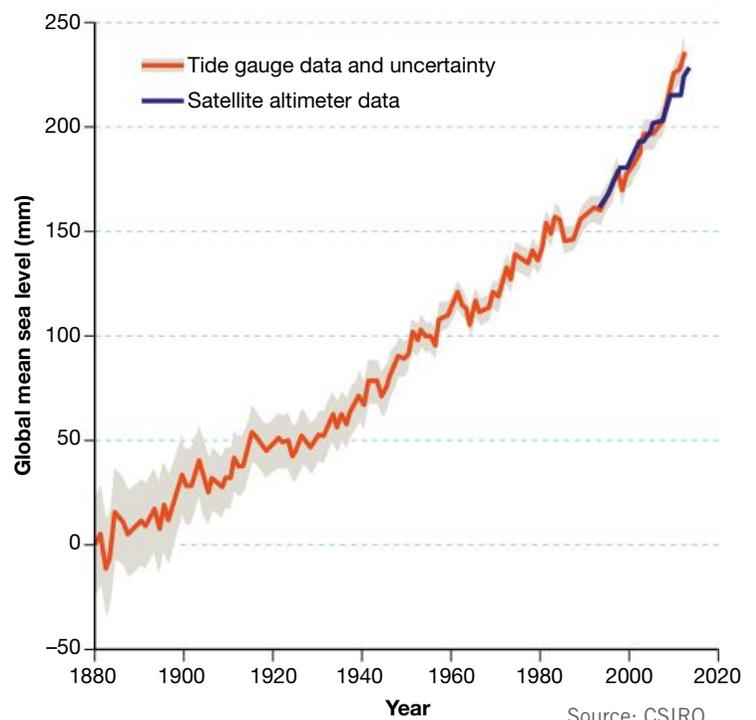
MELTING GLACIERS AND MOUNTAIN ICE CAPS

Melting glaciers and mountain ice caps (outside Greenland and Antarctica) are adding water to rivers that flow to the oceans. However, these remain a modest source of sea-level rise—possibly around 10 centimetres.

MELTING ICE SHEETS

The Greenland and Antarctic ice sheets represent vast reserves of frozen fresh water. The former would add 7 metres to sea levels if melted completely; the latter would bring a further 60-metre rise to the levels of the world's oceans.

9.7.10 Changes in sea level, 1880–2014. Sea levels have risen by about 20 centimetres over the last 100 years.



Combating global warming

At the 1997 Climate Change Conference in Kyoto, Japan, the countries of the industrialised world agreed, in principle, to cut their emissions of greenhouse gases. In the face of worldwide demands to reduce emissions, developing countries are torn between going along with the plan and trying to lift the standard of living of their people. In the long run, the wellbeing of all the world's people will require greater cooperation between countries and a commitment by individuals to a more sustainable lifestyle. We will, for example, need to:

- reduce the amount of fossil fuels used
- use alternative sources of energy, such as wind and solar power
- stop cutting down forests, especially rainforests
- conserve energy.

Efforts to develop a global strategy for reducing humanity's CO₂ emissions are ongoing.

Global warming deniers

Despite overwhelming scientific evidence that the planet is warming, there are still people who deny that this is occurring.

There is a range of views or perspectives, even among the sceptics. These range from outright denial that the earth is warming to a belief that climate change is real but the rate of warming and the predicted impacts of climate change have been greatly exaggerated. There is another view that global warming is due to natural processes, not human activity.

Groups opposed to any program aimed at reducing CO₂ emissions have focused on shaping the nature of the public debate about the issue.

In 2013, the *Guardian* newspaper reported that a small group of American billionaires, most of whom made their fortunes by exploiting fossil fuels, had donated more than US\$120 million to more than 100 anti-climate change groups and think tanks working to discredit the work of climate scientists.

Many large fossil fuel-based industries have also tried to discredit the work of scientists. Exxon Mobil, the giant American oil company, has, for example, spent millions supporting organisations that cast doubt on the science on which the warnings about a warming climate have been based.

ACTIVITIES

Knowledge and understanding

- 1 Explain what global warming is.
- 2 Explain how human activity has increased the effectiveness or intensity of the greenhouse effect.
- 3 Outline the factors that make it difficult to estimate the actual rate of future temperature increase.
- 4 Explain how global warming will affect the world's climate.
- 5 Explain why sea levels will rise.
- 6 Outline the actions taken by the international community to address the problem.

Applying and analysing

- 7 Study Figures 9.7.3 and 9.7.4 and compare the natural greenhouse effect and the enhanced greenhouse effect.
- 8 Explain what is meant by the term 'climate change denier' and discuss the impact of these people.
- 9 In 2012, President Barack Obama said: 'We must respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations. Some may still deny the overwhelming judgement of science, but none can avoid the devastating impact of raging fires and crippling drought and more powerful storms.' Write a short response to his statement.

Geographical skills

- 10 Using the data in Figure 9.7.1, construct a line graph showing the increase in atmospheric CO₂ concentrations since 1960.
- 11 Using data from Figure 9.7.2, describe the trends in global temperature over the course of the twentieth century.
- 12 Study Figure 9.7.6. With the aid of an atlas, do the following tasks.
 - a Identify the countries with CO₂ emissions greater than 15 tonnes per capita.
 - b Identify the regions of the world with annual CO₂ emissions of less than 1 tonne per capita.
 - c Using your knowledge of global inequalities, comment on the relationship between CO₂ emissions and level of economic development.
- 13 Study Figure 9.7.7. Identify the parts of the world that showed the greatest temperature anomaly (both positive and negative) in 2016 compared with the average for 1951–80.

Environmental management

Environmental change

While environmental change is inevitable, the extent of the change and the pace at which it is occurring have accelerated in the last 50 years, largely because of human activities. As the fate of the earth becomes increasingly linked with that of the human race, it has become even more essential that we have a deeper understanding of the connection between environmental change and human activity. 'Human-environment systems thinking' is a technique that we can use to analyse the complex interactions between people and the environment.

Scale of environmental change

Advances in technology have significantly increased the scale of the impact that humans have on the natural world. Human attempts to dominate nature have led to serious problems. There is now a growing appreciation of the challenges facing humanity. These include resource depletion, loss of biodiversity, pollution and climate change. Some scientists

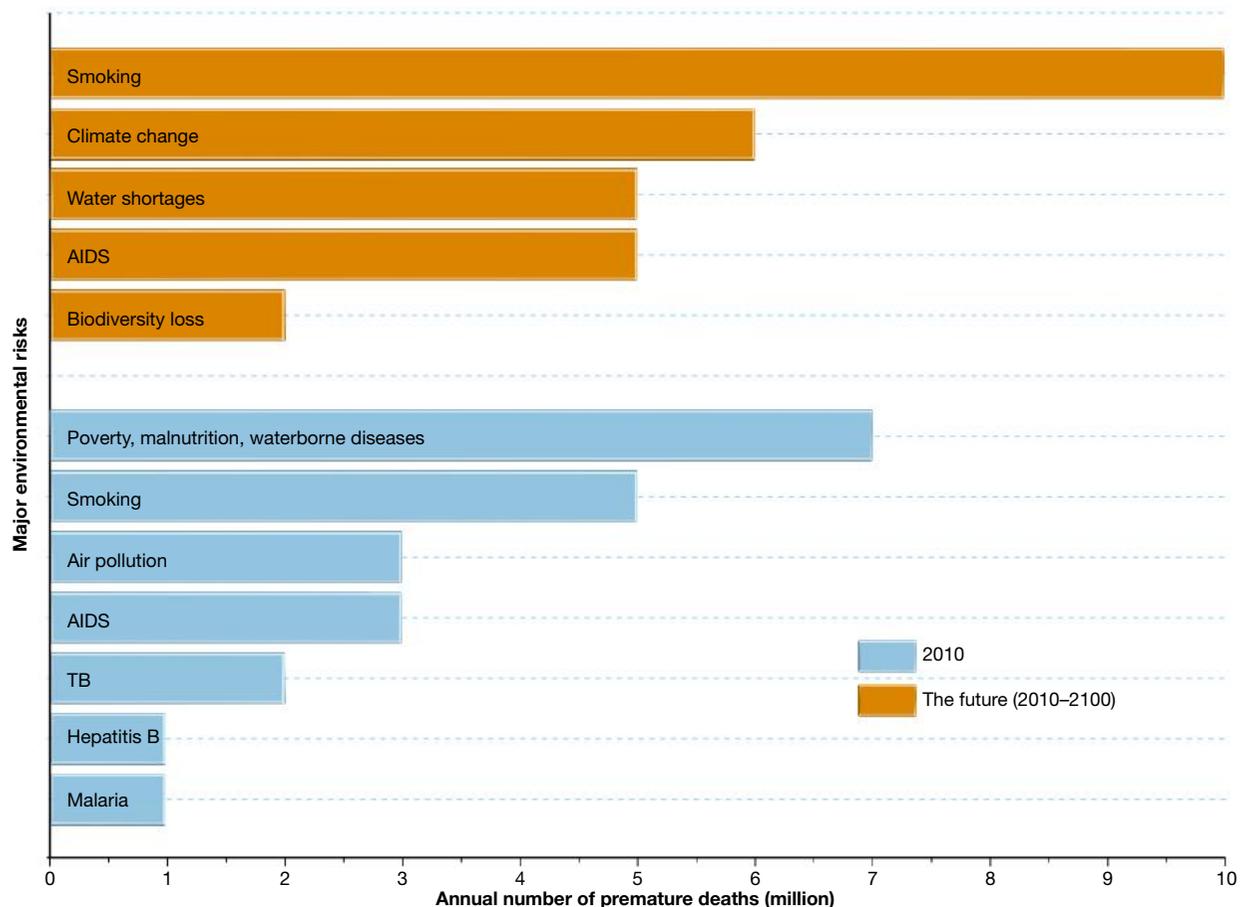
consider biodiversity loss and climate change the two most serious ecological risks to humans and other species. Estimates of human deaths from biodiversity loss and climate change 50 or more years into the future are difficult to make—they could be lower or higher than those shown in Figure 9.8.1.

A new way of thinking

Humans are not separate from nature. Continued human wellbeing relies on the life-support systems the earth provides. The changes needed to protect the natural world that sustains humans can only be achieved if there is a new awareness and understanding of the connections between humans and nature.

For too long, resources seemed limitless and nature was seen as being separate, somewhere out there in a wilderness area. Now, as environmental issues are seen to threaten people's wellbeing, there is a realisation that these issues must be resolved in ways that balance the needs of both humans and the environment.

9.8.1 Ranking of the major environmental risks in terms of the estimated number of people prematurely killed annually now and over the next 100 years.



Source: Data from UNFAO, UNEP, WB & US Centres for Disease Control and Prevention, and the World Bank

Systems thinking

'Systems thinking' involves looking at a system as a whole, rather than focusing on its individual parts. All system parts are interdependent and they affect the performance of the whole system. Systems thinking provides a framework for looking at the interrelationships of these individual parts and how one can influence another. These interrelationships are known as feedback loops and they are the cause of the complexity within systems. These loops can bring about unintended consequences. Systems thinking also enables patterns of change over time to be detected, rather than providing a snapshot at one particular point in time.

A system explained

In nature, a system is two or more parts interacting to operate as a whole within some boundary. The elements and processes of a system interact and affect one another, often in ways we cannot see. In a system, it is the nature of the relationships between the parts that is important—if elements or parts are added or taken away, the behaviour of the system changes.

Human-environment systems thinking

The biophysical environment has a number of components, and human behaviour and decision making are shaped by many elements, as listed in Table 9.8.2. Human-environment systems thinking is a useful approach to use when tackling the complexities of the relationships between humans and the environment, as it enables us to consider how one affects the other. It thus incorporates feedback loops. Ignoring feedback loops results in unintended consequences, as in the case of the introduction of the cane toad in Queensland.

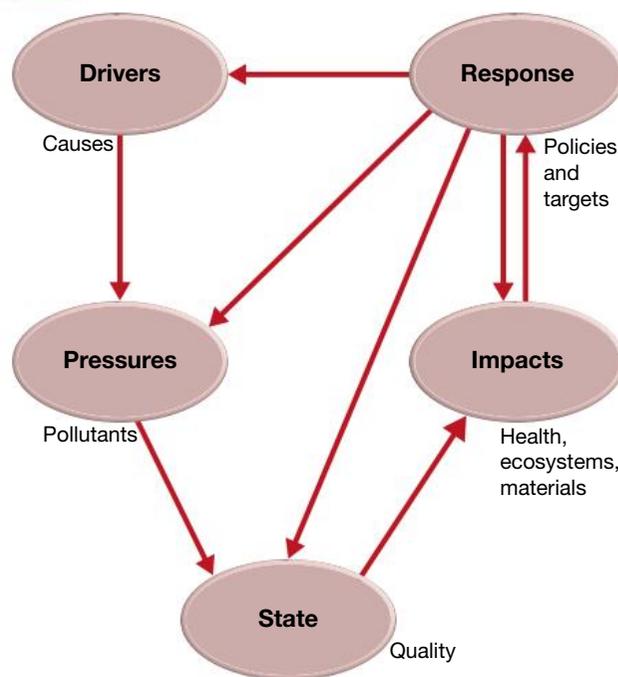
9.8.2 Human elements shaping the biophysical environment

Components of the biophysical environment	Elements shaping human behaviour and decision making
Atmosphere	Economics
Hydrosphere	Technology
Lithosphere	Politics
Biosphere	Demography
Cryosphere	Religion
	Society
	Culture

DPSIR framework

An example of human-environment systems thinking is the DPSIR (drivers–pressures–state–impact–response) framework, which is used to assess and manage environmental problems. According to the DPSIR model, there is a chain of links from the driving forces to impacts and responses. The framework assumes cause–effect relationships between the various

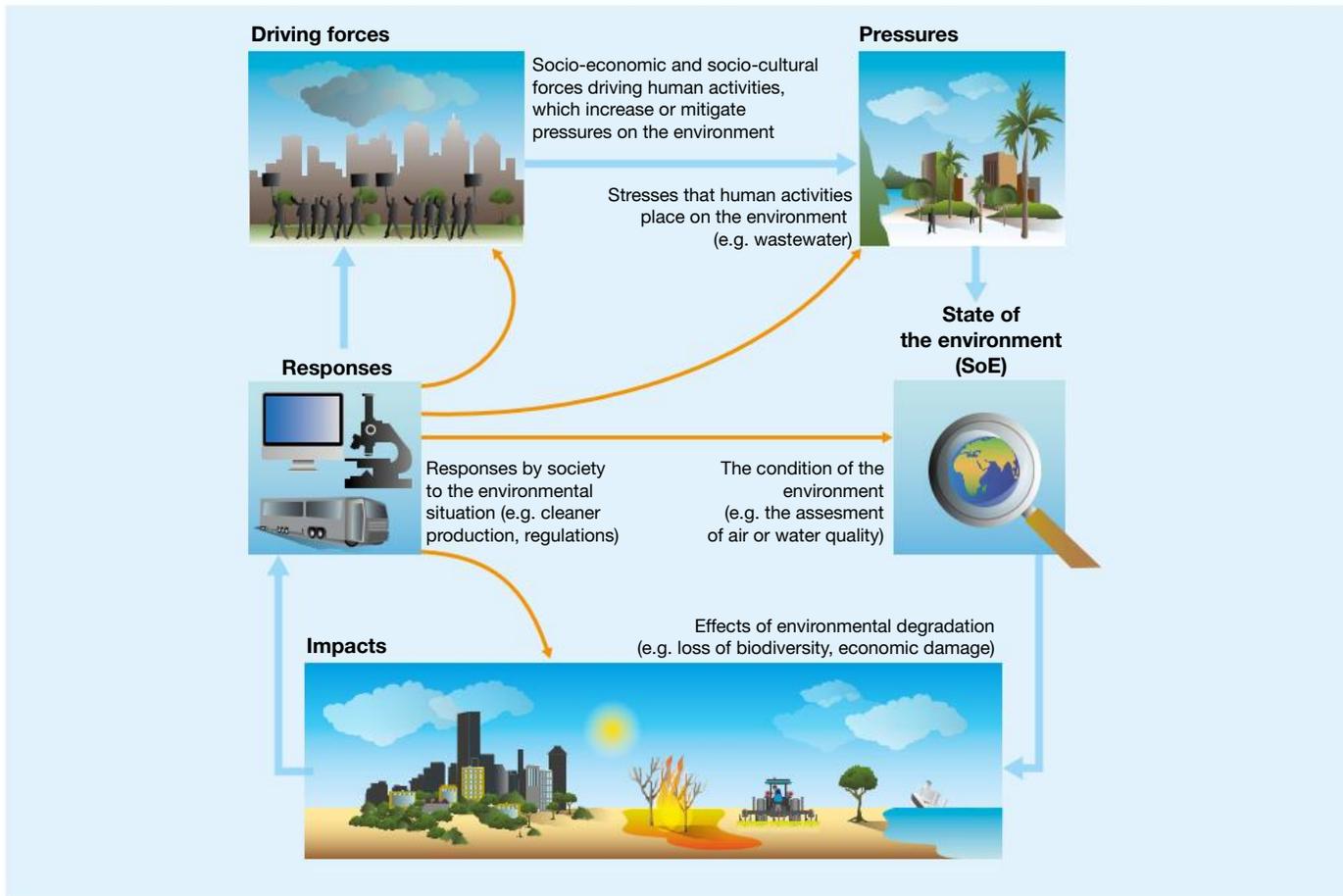
9.8.3 DPSIR assessment framework



components of the DPSIR model as shown in Figure 9.8.3. These components are:

- 1 Drivers:** the forces that drive human activities that cause environmental change. They are the ultimate factors that cause change.
Example: agricultural production to provide food.
- 2 Pressures:** human activities that place stress on the environment. They are the more immediate factors that affect environmental quality.
Example: clearing the land for cultivation and application of agrochemicals to boost yields.
- 3 State:** the state or condition of the environment.
Example: land degradation and declining water quality from sediment, nutrients and toxic chemicals that wash into rivers and lakes and sink into groundwater.
- 4 Impacts:** the effects of the environmental damage on the continued functioning of ecosystems and the earth's life support systems, which ultimately impact on human wellbeing.
Example: excessive and unsustainable agricultural practices that render the land unproductive and reduce food production; declining water quality from algal blooms and toxic contamination.
- 5 Response:** the responses by policy makers or society to the undesired impact on the environment. Responses can be directed at any part of the chain, from the drivers to the impact.
Example: conservation farming practices and organic methods of pest control. Total catchment management that involves all the stakeholders in a catchment working towards protecting environmental quality.

9.8.4 The DPSIR framework used by the European Environment Agency



DPSIR at work

Initially, all the data and information on all of the various components are collected and collated. They are then examined to establish possible connections, before the DPSIR model is used to determine just how effective any responses may be. A strength of this model is that it considers the possible implications of changes in order to minimise uncertainty and unexpected problems.

The model can be extended to include elements such as values and beliefs. The attitudes of humans, both as producers and consumers, can have a bearing on environmental quality and public acceptance of new ways to protect the environment that may be proposed by policy makers.

EUROPEAN ENVIRONMENT AGENCY

The DPSIR framework has gained international acceptance as a model for organising information about the state of the environment and addressing environmental issues. An early adopter of the framework was the European Environment Agency, which has used the DPSIR framework in its State of the Environment Reports, as shown in Figure 9.8.4.

Reporting on Australia's environment

The Australian government adopted the DPSIR model in the 2011 State of the Environment Report (SoE) (see Figure 9.8.5). This framework recognises the links from the drivers, such as economic development, through to the environmental impacts of human-induced pressures and management responses aimed at mitigating those pressures. The report identified climate change as the direct driver of change. Population growth (with associated growth in the constructed environment) and economic growth (with associated increases in consumption of resources and generation of waste) are indirect drivers.

The 2011 SoE report aimed to give Australians the best possible and clearest answers to three basic questions.

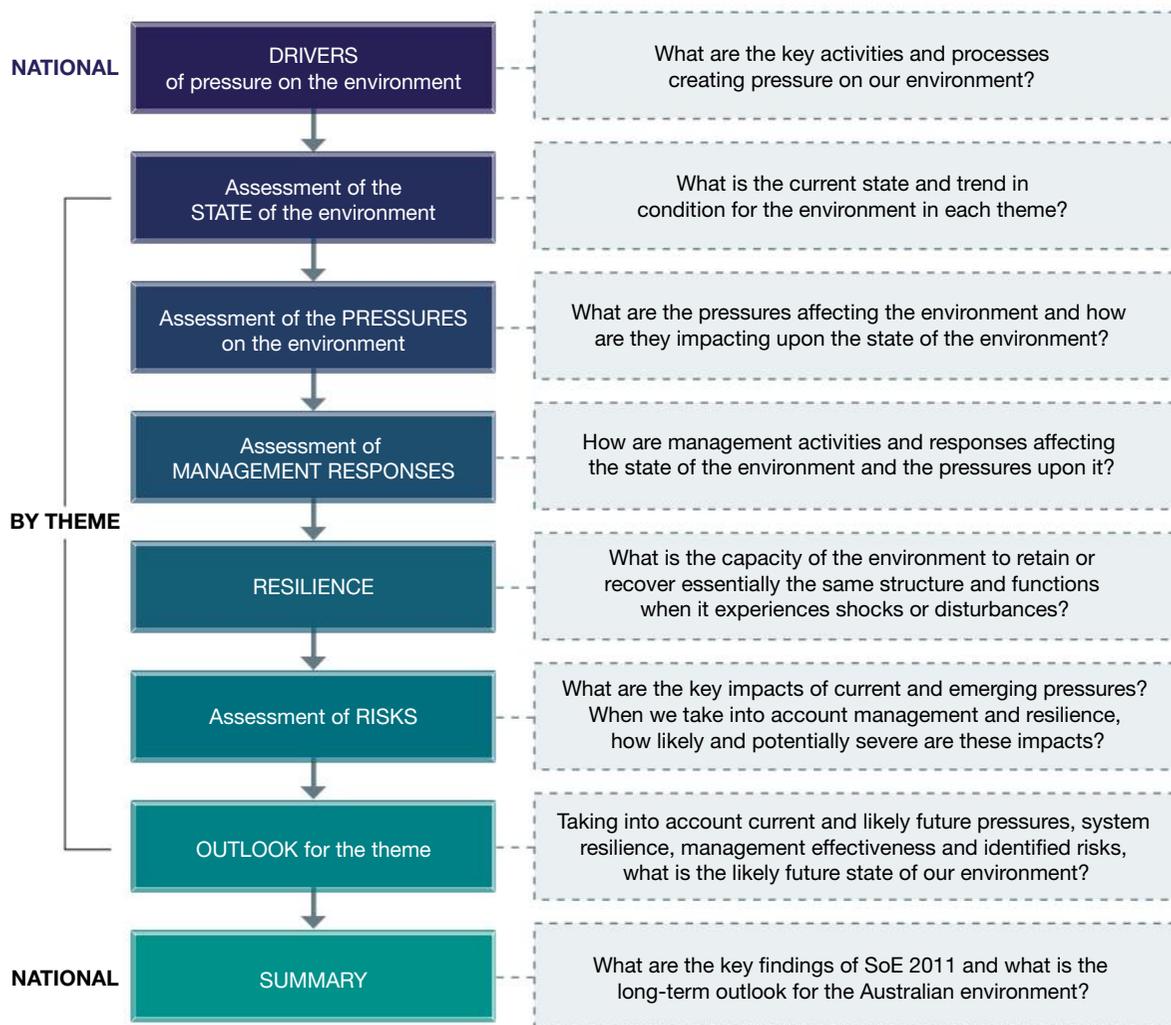
- 1 What is the current condition of the Australian environment (atmosphere, inland water, land, marine environment, Antarctic environment, biodiversity and coasts)?
- 2 What are the risks the Australian environment faces and are we doing enough to protect it?
- 3 Where is the Australian environment headed?

Environment and development

Development is the main priority of most nations. While environmental considerations may initially have been seen as limiting economic growth and development, there is now a realisation that development and the environment should be mutually supportive. The links or connections between

humans and their environment are complex, and in many instances the environment is quite fragile. There has been an increased emphasis on ecological sustainability, and effective policies must be underpinned by a good understanding of the systems being managed. The framework of human-environment systems thinking enables this.

9.8.5 Approach to reporting on Australia's environment



ACTIVITIES

Knowledge and understanding

- 1 Describe systems thinking.
- 2 Assess the value of systems thinking in effectively addressing an environmental problem.
- 3 Describe the components of the DPSIR framework.

Applying and analysing

- 4 Study Figure 9.8.1 and answer the following questions.
 - a What was the biggest cause of premature deaths in 2010?

- b How many people are expected to die prematurely from smoking per year in the future (2010–2100)?
 - c How many premature deaths each year are expected to be a result of environmental risks in the future (2010–2100)?
- 5 Study Figure 9.8.4 and answer the following questions.
 - a What are the two drivers of human activities?
 - b Analyse how the responses are connected to the other components of the DPSIR model.
 - c How might the use of this model in Europe improve the quality of the environment?

Environmental worldviews

Role of environmental worldviews

A worldview is essentially a perspective or point of view held by an individual based on a set of values and assumptions. When it is accepted and shared by many, it becomes a belief system. An environmental worldview is concerned with nature and how the earth and all its species and resources are managed. It has an ethical dimension, as it shapes what individuals believe is right or wrong about their behaviour in relation to the environment.

Taking the time to consider your environmental worldview enables you to have a deeper appreciation of your place in the environment and the implications of your decisions and actions. Your chosen environmental worldview shapes your behaviour and lifestyle choices. It also defines the boundaries of your actions and your readiness to take a stance on environmental issues.

A person's environmental worldview is shaped by their perceptions of:

- how the world works
- what an individual's role in the world should be
- what is correct environmental behaviour.

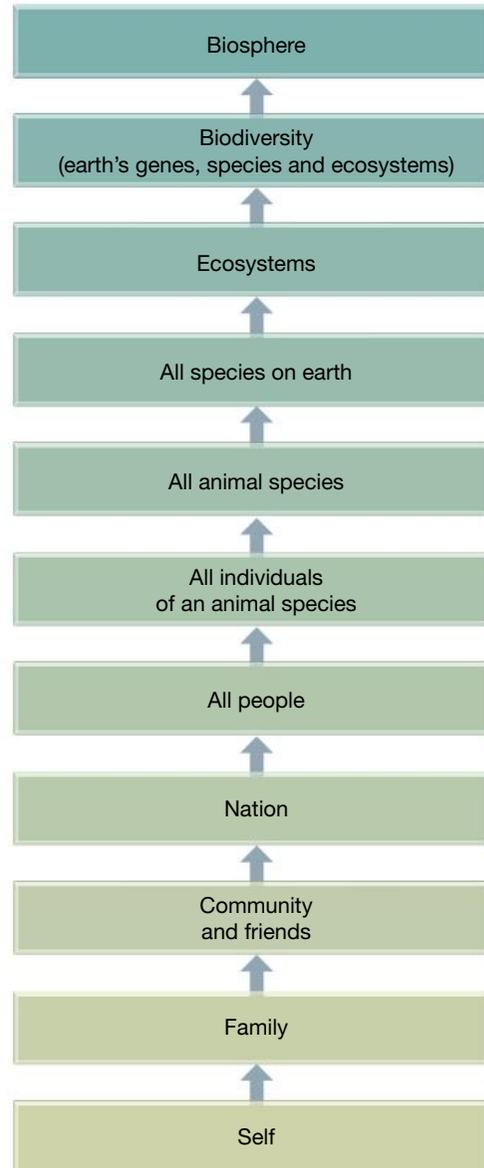
9.9.1 Some important ethical questions relating to the environment

- 1 Why should we care about the environment?
- 2 Are we the most important beings on the planet or are we just one of the earth's millions of different life forms?
- 3 Do we have an obligation to see that our activities do not cause the extinction of other species? Should we try to protect all species or only some? How do we decide which ones to protect?
- 4 Do we have an ethical obligation to pass the natural world onto future generations in at least as good a condition as we inherited?
- 5 Should every person be entitled to equal protection from environmental hazards regardless of race, gender, age, national origin, income, social class, or any other factor?
- 6 How do we promote sustainability?

Source: G Tyler Miller and S Spoolman, *Living in the Environment*, Brooks Cole, Belmont, 2012

Figures 9.9.1 and 9.9.2 list ethical questions and concerns in relation to the environment that will help develop a person's worldview.

9.9.2 Levels of ethical concern. People disagree about how far we should extend our level of ethical concern.



Source: G Tyler Miller and S Spoolman, *Living in the Environment*, Brooks Cole, Belmont, 2012

Conflicting environmental worldviews

People disagree about the severity of environmental problems. As a result, they hold diverse attitudes and approaches towards environmental management. These differences arise mostly from conflicting environmental worldviews, as there are many ways of looking at nature and the relationship of humans to it. These worldviews often differ on the issue of whether humans or nature are more important.

There are different ways of looking at nature and how humans relate to it. It is not surprising that most people hold worldviews that are human-centred, as the focus of their world is their own wellbeing. Major environmental worldviews differ in what is more significant—providing for the human population or guarding the natural world from exploitation and degradation to ensure the health of ecosystems and the biosphere. Each worldview implies very different approaches to what are considered appropriate responsibilities towards the environment (see Table 9.9.3).

Human-centred worldview

According to this worldview, humans are superior and the most important species on earth. Humans are considered to be apart from the rest of nature, and the value of other species and indeed the natural world is based on how useful they are to humans. As the dominant species, humans have unrestricted use of natural resources for their benefit alone. The belief underlying this worldview is that humans have an obligation only to themselves.

People with this worldview believe that what separates humans from other species is their intelligence. They have developed technologies to exploit resources and draw on the earth's life

support systems for their own purposes. The human-centred worldview measures success in terms of how well humans control nature to meet their ever-increasing needs and wants. Such beliefs have long been evident in human civilisations and have driven the pursuit of economic growth in the western industrialised nations of the modern world. Through research and development, new technologies have evolved to exert even greater control over natural processes and extract resources to support ever-growing economies.

In the human-centred worldview, all economic growth is good and there is almost unlimited potential for it to continue. This is based on the assumption that human ingenuity and technology will ensure that any shortages or problems are overcome. The emphasis in modern economies has usually been on short-term efficiency and profits, disregarding any long-term costs associated with environmental damage.

Stewardship worldview

This worldview has been held by indigenous peoples for thousands of years. Their strong spiritual connection with the natural world is ingrained in their daily lives. While they use resources to support themselves, they have an intimate knowledge and appreciation of their environment and act responsibly to ensure its continuing productivity. They are thoughtful managers or stewards of the natural world.

In modern times, individuals with a stewardship worldview accept the responsibility to be caring managers of the earth. They believe that they may use the available resources, but that this must be done in a sustainable way to ensure the availability of resources for future generations. Any form of economic growth and development that damages the environment is discouraged.

9.9.3 Comparison of three major environmental worldviews

Human-centred	Stewardship	Earth-centred
<ul style="list-style-type: none"> We are apart from the rest of nature and can manage nature to meet our increasing needs and wants. 	<ul style="list-style-type: none"> We have an ethical responsibility to be caring managers, or stewards, of the earth. 	<ul style="list-style-type: none"> We are a part of and totally dependent on nature, and nature exists for all species.
<ul style="list-style-type: none"> Because of our ingenuity and technology, we will not run out of resources. 	<ul style="list-style-type: none"> We will probably not run out of resources, but they should not be wasted. 	<ul style="list-style-type: none"> Resources are limited and should not be wasted.
<ul style="list-style-type: none"> The potential for economic growth is essentially unlimited. 	<ul style="list-style-type: none"> We should encourage environmentally beneficial forms of economic growth and discourage environmentally harmful forms. 	<ul style="list-style-type: none"> We should encourage earth-sustaining forms of economic growth and discourage earth-degrading forms.
<ul style="list-style-type: none"> Our success depends on how well we manage the earth's life-support systems mostly for our own benefit. 	<ul style="list-style-type: none"> Our success depends on how well we manage the earth's life-support systems for our benefit and for the rest of nature. 	<ul style="list-style-type: none"> Our success depends on learning how nature sustains itself and integrating such lessons from nature into the ways we think and act.

Source: G Tyler Miller and S Spoolman, *Living in the Environment*, Brooks Cole, Belmont, 2012

People with this worldview believe that they have an ethical responsibility to ensure that they leave the earth in a condition that is comparable to the one they inherited. This is because the earth and its resources are really being borrowed from future generations.

Earth-centred worldview

People with this worldview believe that nature exists for all species on earth, not just humans, and that humans are equal to other species, not superior. All forms of life have a value, regardless of their actual or potential use to humans.

The extent to which people are prepared to protect the natural world depends on the depth of their beliefs. Individuals with an earth-centred worldview believe that protection should go well beyond species protection and encompass the entire natural world. They believe that humans are part of, and entirely dependent on, nature, and that nature exists for all species. So they advocate sustainability, which includes protecting the earth's biodiversity and the maintenance of its life support systems for all forms of life. Preventing the depletion of the natural world by ensuring ecological sustainability not only keeps other species alive but also ensures the survival of humans as a species.

The Deep Ecology movement goes even further. Supporters of this movement believe that present human intrusion into the natural world is excessive. This follows from a conviction that each life form is significant, and the fundamental interdependence of diverse life forms underpins the richness of the natural world. Supporters of the Deep Ecology movement claim that all forms of life have the right to exist. As humans are no different from any other species, they have no right to interfere with nature.

Responding to environmental change

People have long held differing views on the environment. The stewardship worldview shaped the actions of indigenous people for thousands of years. With the emergence of civilisation and the voyages of exploration and subsequent colonisation, the human-centred worldview took over. As new frontiers were established, the wilderness was seen as something to be tamed and conquered so that it could be of use to humans and yield valuable resources. Even then, though, there were individuals who cherished the natural world and worked to protect it.

It is clear that there are extremes in the environmental worldviews held today. While many people may not fully embrace particular environmental worldviews, it is evident that there are differences in people's views about the causes of environmental issues in Australia and across the world. Individuals' differing perceptions of the seriousness of

environmental problems and what should be done about them present a challenge. With no consensus, it is difficult to develop and implement strategies to deal with the problems, which then become even worse and harder to solve.

Different views on climate change

The issue of climate change provokes more argument than any other environmental issue, yet it could well have the most profound impacts on the quality of our life in the future. Despite the overwhelming majority of scientists stating that climate change is real and becoming significantly worse because of greenhouse gas emissions, there are people who deny the severity of the problem.

- Freeman Dyson, Professor at the Institute for Advanced Studies, Princeton University, United States, believes that: Climate change is a real problem, partly caused by human activities, but its importance has been grossly exaggerated. We do not know whether the observed climate changes are on balance good or bad for the health of the biosphere. And the effects of atmospheric carbon dioxide as a fertiliser of plant growth are at least as important as its effects on climate.
- Jim Hansen, Director at NASA's Goddard Institute for Space Studies, United States, believes that: The argument about whether or not there is global warming is over. It is now clear that we have been in a strong global warming trend at a rate of 0.3°C per decade for the past 30 years, meaning there has been a 0.56°C global warming in that period. The earth is now at its warmest level in the period of instrumental data; that is, since the late 1800s.

Different views on solutions

Climate change is a global problem with global consequences and it needs a global solution and international cooperation. There are differences in the willingness of countries to reduce their emissions, as some consider that this might stifle their economic growth and development (see Figure 9.9.4). There are people who believe that carbon sequestration is the answer.

Carbon sequestration involves the capture and long-term storage of carbon dioxide. One way of doing this is geosequestration, whereby excessive carbon dioxide is buried deep beneath the earth in depleted gas or oil wells. There are concerns, though, that the carbon dioxide might leak out, especially if there is unexpected seismic activity.

Lowering greenhouse gas emissions is considered essential to mitigate human-induced climate change. Households and businesses should explore opportunities to increase their energy efficiency and reduce emissions. Governments and corporations need to invest in developing and commercialising clean energy technologies to reduce carbon pollution.

9.9.4 Cartoon by Justin Bilicki, illustrating that the findings of research are not always accepted and acted upon.



ACTIVITIES

Knowledge and understanding

- 1 Define the terms 'worldview' and 'environmental worldview'.
- 2 Explain why it is important for individuals to consider their own worldviews.
- 3 Describe what shapes an individual's worldview.
- 4 Identify three major environmental worldviews and consider how they differ in the relative importance placed on humans and the environment.
- 5 Define the term 'geosequestration'.
- 6 Explain why some nations are reluctant to reduce their emissions.

Applying and analysing

- 7 Study Figure 9.9.2. How far up the scale would you extend your own ethical concern? Justify your choice.
- 8 Build your ecological identity or worldview by answering the following questions.
 - a Where do all the things I use and depend on come from?

- b Where do all my waste products go?
- c What do I know about the environment I live in?
- d How am I connected to the natural world and other living organisms?
- e What is my purpose in life?
- f What is my responsibility as a human being living on this planet?
- 9 Study Table 9.9.3. Which of the worldviews illustrated fits most closely with your thoughts? Which of these is the best fit with your parents' worldview?
- 10 Many consider applying the precautionary principle is especially important when tackling climate change. Justify this position.
- 11 *It is widely accepted that humans do have an ethical responsibility to avoid being the cause of the premature extinction of species through their actions.*
To what extent do you agree with this statement? Discuss.

Aboriginal and Torres Strait Islander people: Environmental management

Australia's Indigenous population

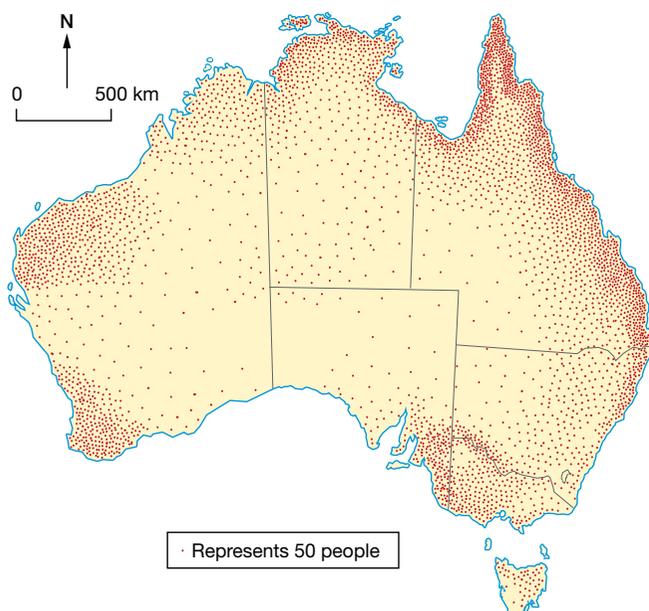
Australia's Indigenous population consists of Aboriginal people and Torres Strait Islander people. These two groups have their own characteristic identities, histories and cultural traditions, a product of adapting to quite different natural environments. They are still acknowledged as distinct populations within the Australian community today.

Aboriginal people

Aboriginal people occupied the whole of the continent of Australia at the time of the European settlement in 1788, as is shown in Figure 9.10.1. Aboriginal people exploited all its environmental and climatic variations, as they possessed a detailed knowledge of the natural world and its resources.

They were able to live off the land in the vast dune systems of the arid interior, even though the resources were relatively scarce, and they moved over a large area to hunt for food (see Figure 9.10.2). The population densities were much higher in the better watered parts of the continent along the east coast, in the tropical north and in the Murray–Darling Basin.

9.10.1 Estimated number and distribution of Aboriginal people in 1788



Torres Strait Islander people

Torres Strait Islander people come from the Torres Strait to the north of Cape York Peninsula in Queensland. There are 270 small islands between mainland Australia and Papua New Guinea. Of these, seventeen are inhabited. It is thought that they were occupied as people moved down from New Guinea (present-day Papua New Guinea and the Indonesian province of West Papua) at least 2500 years ago.

The Torres Strait Islander people have their own rich culture and traditions, which are quite distinct from those of the Aboriginal people. Being island communities, their lives are closely tied to the sea. This is reflected in the technology and material culture the Islanders developed, using materials such as fish bones, turtle shells and pearls. These were shaped and carved for tools such as fish hooks and spear tips, as well as highly prized decorative items used in ceremonies.

The Torres Strait Islander people relied heavily on trade with other islands in the region. For hundreds of years they had contact with visitors from Makassar (now part of Indonesia), who came to collect trepang or sea cucumbers. Trade continues with villages along the coast of New Guinea. Even though many of the Torres Strait islands are located just off the coast of New Guinea, they formally became part of Queensland in 1879. The majority of Torres Strait Islanders now live on the mainland in Queensland.

Models of sustainability

Underpinning all the interactions between Indigenous people and their environment were rules that imposed a strict discipline on the actions of each individual. This was reinforced by the Dreaming and the Dreaming Ancestors, who gave form to the landscape and bound people to their traditional Country. The strong attachment to this Country was not one of ownership, but rather a spiritual connection that carried with it many responsibilities.

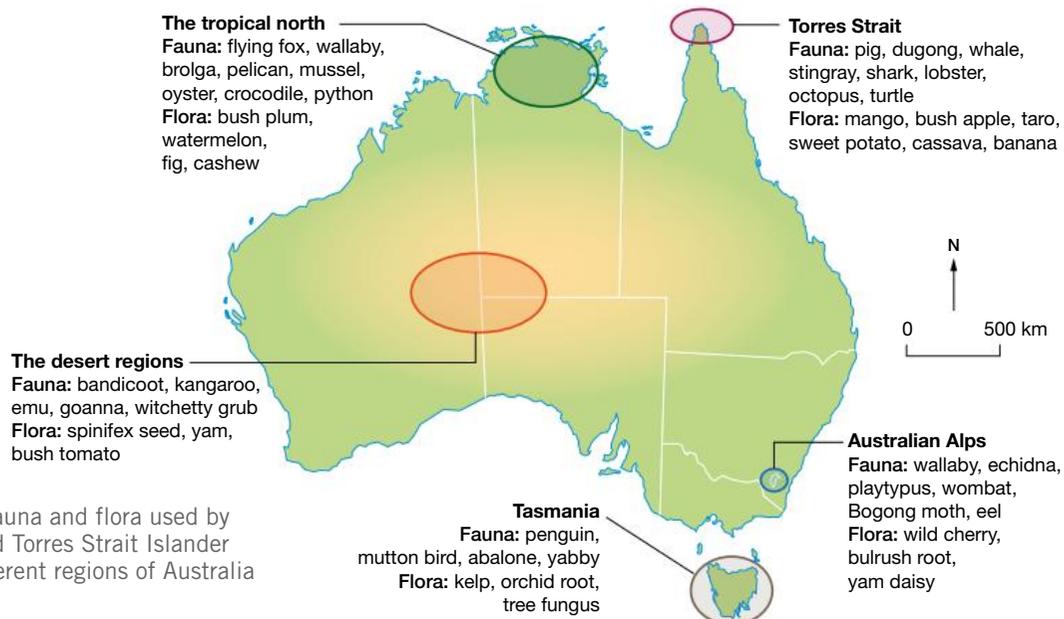
Aboriginal and Torres Strait Islander people successfully adapted to live in many different and some very difficult environments, using a wide range of food sources, as shown



9.10.2 Even in the seemingly inhospitable deserts of Australia, Aboriginal people were able to support themselves by hunting and gathering food.

in Figure 9.10.3. The items shown in each region are only a small selection of those used. The general pattern is similar everywhere, although there is regional variation according to the species available. For instance, seals were hunted in Tasmania and crocodiles and dugong in the north. People in

Tasmania did not eat fish, a fact that researchers have not been fully able to explain. Torres Strait Islander people had gardens in which they cultivated species that were the same as those in neighbouring Melanesia.



9.10.3 The fauna and flora used by Aboriginal and Torres Strait Islander people in different regions of Australia

Knowing the land and seas

Aboriginal and Torres Strait Islander people knew the location and timing of a large number of significant natural events, as they were carefully attuned to predictable changes in the weather and the tides, as well as the seeding and fruiting times of plants and the breeding cycles and migration habits of the animals they relied on for food. Such detailed knowledge was recorded in early encounters with the Aboriginal people of Arnhem Land.

... as accurately as any ecologist, and they are able to state without hesitation what food supply, animal and vegetable, each association will yield ... The accuracy with which an Arnhem Land hunter could name and give an association according to its botanical composition, and the food supply, woods for spears and other purposes, as well as resins and fibre plants that would yield at any season of the year was astonishing.

Source: DF Thomson, 'Arnhem Land: Exploration among an unknown people', in *Geographical Journal*, 113, 1949, quoted in B Gammage, *The Biggest Estate on Earth—How Aborigines Made Australia*, Allen & Unwin, Sydney, 2012

Most significantly, the natural world was much more important to the Indigenous people than just a means of survival; they saw themselves as its guardians or custodians. They felt a personal obligation to look after their Country and ensure the natural world was kept in balance.

Totems: Accepting individual responsibility

The foundation for sustainable management was the acceptance by each individual of their role in protecting the land and its totems. Indigenous people have a collection of totems that represent special plants, animals or places that they believe they are descended from. They cannot eat their particular totem and must ensure that its population is sustained. Each clan had a totem that linked it as a group. In addition, individuals had their own personal totem. This ensured the sustainability of food supplies that would otherwise not be available if the people ate everything they found.

The value of traditional ecological knowledge

Aboriginal and Torres Strait Islander people had an intricate knowledge of the ecology of their environment and they were careful to make sure that ecosystems remained in balance. They were successful in doing this on a continent-wide basis for tens of thousands of years, over which time there was a great deal of climatic variability.

Indigenous people's specific knowledge about their environment is now being acknowledged. Given their holistic view of their environment, this knowledge extends to an understanding of ecosystem functioning and the interactions that occur within them. They are especially familiar with subtle yet important shifts that can occur in ecosystem relationships, and know how to respond in order to restore the natural balance.

9.10.4 One of the Anindilyakwa Women Rangers, Groote Eylandt, Northern Territory. They work in the Anindilyakwa Indigenous Protected Area, which extends across the Groote Eylandt Archipelago. With relatively few introduced pests and no cane toads on the Eylandt, the Women Rangers are in a unique position to be strongly involved in biodiversity research and conservation activities.



Caring for Country

Given their vast knowledge and extensive experience, it is fitting that Indigenous Australians are having a growing, cooperative role in environmental management, as can be seen from the extract 'Indigenous land and sea management'.

Indigenous land and sea management

Indigenous land and sea management, also referred to as 'caring for Country', includes a wide range of environmental, natural resource and cultural heritage management activities undertaken by individuals, groups and organisations. In pre-colonial times, caring for Country was undertaken by individuals and clan groups with inherited rights and responsibility for particular land and sea estates, under the guidance of initiated elders and other knowledge holders. These cultural rights and practices still underpin all contemporary land and sea management activities, but they have adapted and evolved over time and are delivered by a diversity of local, regional, state, territory and national institutional arrangements.

Contemporary caring for Country embraces a combination of long-established cultural practices, such as species-specific ceremonies, seasonal use of traditional resources and use of fire to maintain desired environmental conditions, as well as contemporary practices such as feral animal and weed management, biodiversity surveys and satellite tracking of marine turtles.

There are now several hundred community-managed Indigenous land and sea management groups or organisations around Australia. Some of these comprise ranger groups employed by local community councils. Others are more fully developed Indigenous land and sea management agencies employing specialist planning and research staff as well as operational rangers, often with traditional owner governance arrangements that are separate from, or complementary to, local community councils. Although the majority of these groups and organisations are located in remote communities in northern and central Australia, Indigenous ranger groups and other Caring for Country initiatives occur throughout Australia, including the southern mainland states and Tasmania.

Indigenous ranger groups are generally engaged in patrolling, managing and monitoring areas of Aboriginal

land that have returned to Aboriginal or Torres Strait Islander ownership as a result of land claims or the recognition of continuing native title under the *Native Title Act 1993*. However, Indigenous ranger groups also increasingly engage in land and sea management activities in areas that may not be formally under Indigenous ownership, but lie within the traditional land and sea estates of the groups involved. This trend from tenure-based to Country-based Indigenous engagement in land and sea management reflects a growing appreciation by government agencies and the wider community that Indigenous Caring for Country rights, interests and obligations are based on cultural connections to traditional estates—irrespective of their current tenure. This trend can be observed, for example, in increased Indigenous engagement in national park and marine park management, whether or not these protected areas have been returned to Indigenous ownership.

The continued growth in the capacity of Indigenous groups to undertake their own land and sea management is likely to be accompanied by new and diverse partnerships with government, research and nongovernment conservation agencies. This will lead to mutual benefits for all parties. Land and sea management may be a long-term propitious niche for Indigenous people in remote communities and elsewhere in Australia, particularly since these initiatives are grounded in Indigenous culture and have been driven by Indigenous groups and organisations, rather than by government policies. The challenge for governments is to respond positively to this momentum without overburdening the recipients of funding and other support with excessive reporting and compliance processes.

Source: Adapted from D. Smyth, *Indigenous Land and Sea Management—a Case Study*. Report prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities on behalf of the State of the Environment 2011 Committee. Canberra: DSEWPoC, 2011

Working on Country

The Working on Country initiative was implemented by the Australian government in 2007. It recognises that protecting and conserving the environment is a shared responsibility. It is also designed to provide sustainable employment for Indigenous Australians.

Indigenous people have long-held cultural and traditional responsibilities to protect and manage their land and sea Country. They own an estimated 20 per cent of the Australian

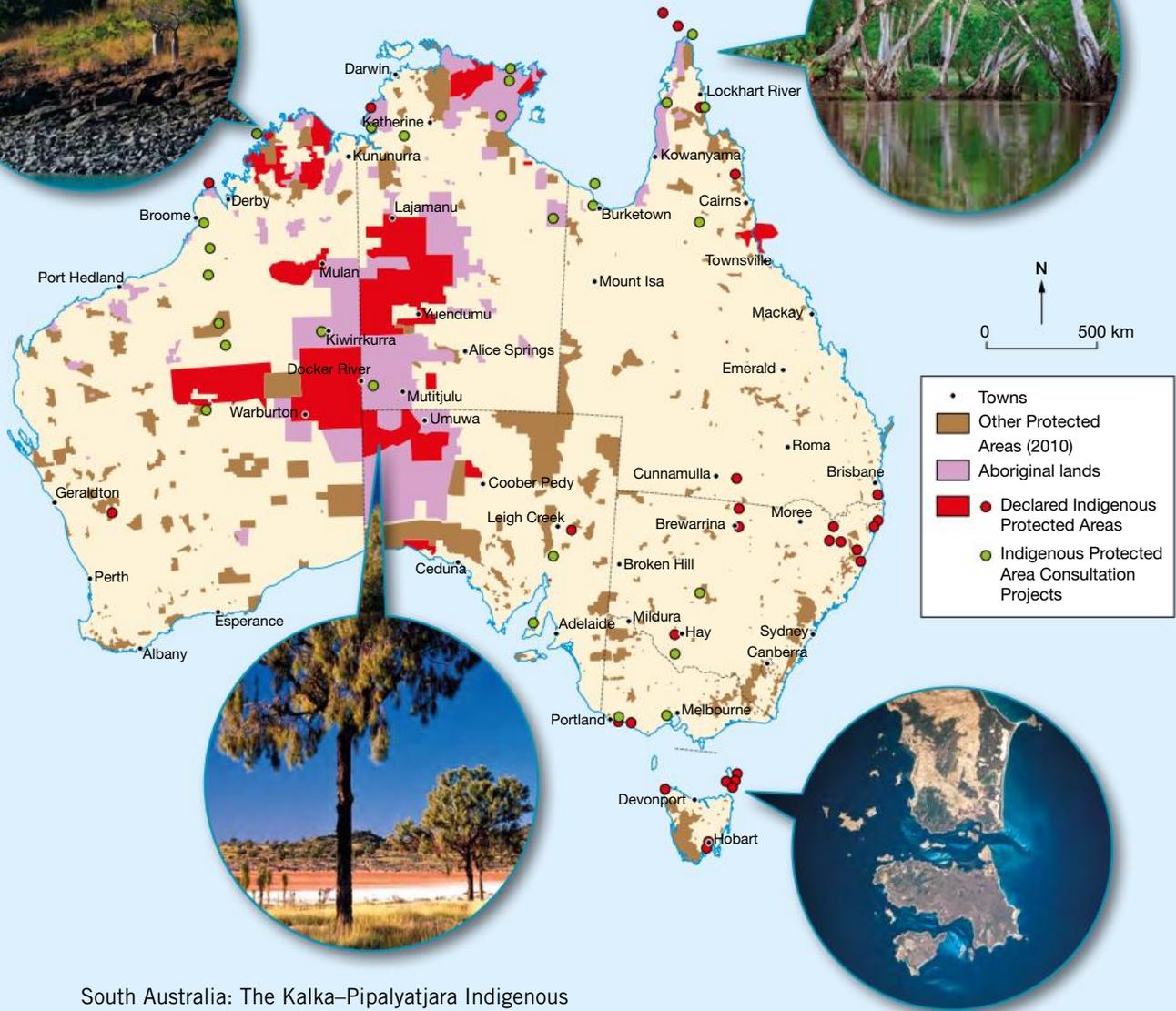
continent, upon which lie some of our most environmentally precious natural assets and which, for Indigenous people, is rich in cultural and spiritual meaning.

Working on Country builds on Indigenous traditional knowledge to protect and manage land and sea Country. Almost 700 Indigenous rangers across ninety-nine teams are employed across Australia on environmental projects, as shown in Figure 9.10.5. In 2015, over 730 rangers had been trained and employed through Working on Country.

9.10.5 Indigenous Protected Areas

Western Australia: The Dambimangari Indigenous Protected Area is located on the rugged, dramatic Kimberley coast between Broome and Darwin. Situated north of Derby, it stretches east to the Prince Regent area, covering more than 1.4 million hectares. Dambimangari provides a refuge for animals that have disappeared from other parts of Australia. Endangered animals include the quoll and the brightly coloured Gouldian finch.

Queensland: The Kaanju Ngaachi Wenlock and Pascoe rivers area stretches across nearly 2000 square kilometres of wet tropical forest and sand ridge country between Lockhart River, Coen and Weipa on Cape York. The Chuulangun Aboriginal Corporation manages the area, which is a place of significant social, cultural, spiritual, historical and economic value for its traditional owners.



South Australia: The Kalka–Pipalyatjara Indigenous Protected Area stretches for more than 580 000 hectares across the north-west corner of South Australia. The Tomkinson and Mann ranges dominate the north-west landscape of the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands, while in the south, sand-dune country with rocky outcrops provides habitat for a variety of plant and animal species.

Tasmania: Located in Bass Strait at the north-eastern tip of Tasmania, Mount Chappell Island and Badger Island form part of the Furneaux group of islands. These islands have long been regarded by Aboriginal people as an important part of the seasonal food-gathering cycle. The Tasmanian government handed them back to the Aboriginal community in 1995.

Indigenous Protected Areas

An Indigenous Protected Area is defined as an area of Indigenous-owned land or sea where traditional owners promote biodiversity and cultural resource conservation, according to an agreement with the Australian government. Indigenous Protected Areas make a significant contribution to Australian biodiversity conservation. They make up almost 25 per cent of Australia's National Reserve System.

The goals of the Indigenous Protected Areas element of the Caring for our Country initiative are to:

- 1 support Indigenous landowners to develop, declare and manage Indigenous Protected Areas on their lands as part of Australia's National Reserve System
- 2 support Indigenous interests to develop cooperative management arrangements with government agencies managing protected areas
- 3 support the integration of Indigenous ecological and cultural knowledge with contemporary protected area management practices. (Source: Department of the Environment)

Indigenous Protected Areas produce more than just environmental benefits. They help Indigenous communities to protect their significant cultural values for future generations. There have been beneficial spin-offs in terms of health and education, as well as economic and social benefits.

There are now fifty declared Indigenous Protected Areas and over forty consultation projects across Australia, as shown in Figure 9.10.5. There are plans to increase Indigenous Protected Areas by at least 40 per cent—an increase of at least 8 million hectares.

SPOTLIGHT

The biggest estate on earth

'Management was active, not passive, alert to season and circumstance, committed to a balance of life. The chief ally was fire. Today, almost everyone accepts that they burnt random patches to hunt or lure game. In fact, this was no haphazard mosaic making, but a planned, precise, fine-grained local caring.

'What plants and animals flourished were related to their management. Detailed local knowledge was crucial. Each family cared for its own ground, and knew not merely which species fire or no fire might affect, but which individual plant and animal, and their totems and Dreaming links. They knew every yard intimately, and knew the ground of neighbours and clansmen, sharing larger-scale management or assuming responsibility for nearby ground if circumstance required.

'They first managed country for plants. They knew which grew where, and which they must tend and transplant. They then managed for animals. Knowing which animals prefer ... the sweetest feed, the best shelter, the safest scrub. They established a circuit of such places, activating the next as the last was exhausted or its animals fled. In this way they could predict where animals would be. They travelled to known resources, and made them not merely sustainable, but abundant, convenient and predictable ...

'Three rules directed their management.

- Ensure that all life flourishes.
- Make plants and animals abundant, convenient and predictable.
- Think universal, act local.

'These rules imposed a strict ecological discipline on every person.'

Source: B Gammage, *The Biggest Estate on Earth—How Aborigines Made Australia*, Allen & Unwin, Sydney, 2012

ACTIVITIES

Knowledge and understanding

- 1 Identify the two components of Australia's Indigenous population.
- 2 Describe the attachment of Indigenous people to their environment.
- 3 Explain how Aboriginal and Torres Strait Islander people were able to live successfully across the Australian continent.
- 4 Explain why the totem system ensured a sustainable food supply for Aboriginal people.
- 5 Outline the benefits of the Australian government's Working on Country program and the establishment of Indigenous Protected Areas.

Applying and analysing

- 6 Study the extract 'The biggest estate on earth'. Compare the management practices of the Aboriginal and Torres Strait Islander people with those of contemporary management in Australia. Assess the sustainability of each.

Investigating

- 7 Investigate an Indigenous Protected Area in your state and prepare a report highlighting why the area is important and how it is being protected.



Forests

CHAPTER

10

Each year, approximately 16 million hectares of forests disappear. Only about 22 per cent of the world's original (old-growth) forest cover remains intact. Most of this is found in three large areas: the Canadian and Alaskan boreal forest, the boreal forest of Russia, and the tropical forest of the north-western Amazon Basin.

Today, forests cover more than one-quarter of the world's total non-polar landmasses. Slightly more than 50 per cent of the forests are found in the tropics and the rest are temperate and boreal forest zones.

In this chapter, we focus on environmental change and management using forest environments as an example. Of particular interest are the causes and consequences of the changes taking place and an evaluation of the strategies being used to manage these changes.

INQUIRY QUESTIONS

- What are the principal causes of environmental change in forest environments?
- What are the impacts of the environmental changes taking place in forest environments?
- What environmental management strategies are being used to protect forest environments? Are these strategies effective?

GLOSSARY

adaptive management mechanisms	a systematic process of continually improving management policies and practices by learning from the outcomes of previously employed policies and practices	emergent trees	trees that tower above the forest canopy
biodiversity corridors	plant corridors that connect healthy ecosystems as a way of maintaining biodiversity	endemic	native to a certain place
biomass	plant material derived from living, or recently living, organisms; as an energy source, biomass can be used either directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel	environmental strategy	a plan of action intended to accomplish a specific environmental objective
carbon sink	a forest, ocean or other natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere	hunter-gatherers	people who survived by catching game, fishing and gathering plant food
clear-cutting	the process by which all the trees in a forest area are cut down; this is the most efficient way for a logging operation to harvest timber	overstorey	the upper tree layer or canopy of a forest, where the crowns of the trees spread their branches and foliage to capture light to photosynthesise
connectivity conservation	a corridor of protected forest lands that extend over hundreds, and in some cases, thousands of kilometres to protect biodiversity and critical ecological processes	population viability	the ability of a population of a species to persist over time and avoid extinction
conservation reserves	areas of land set aside to maintain biodiversity and/or natural or cultural heritage values	shifting cultivators	people who clear a small patch of forest to grow food in gardens that they then abandon when yields decline
deforestation	the removal of large expanses of trees for their timber or to make way for other landuses	subsistence producers	farmers who grow just enough food to feed themselves and their families
		transboundary pollution	air and water pollution that travels from one jurisdiction to another, often crossing state or international boundaries
		understorey	the smaller plants adapted to the shady conditions of the forest floor

Forests: The biophysical environment

Forests

Forests are lands dominated by trees. Within them there are dynamic, relentlessly changing communities of living things interacting with the non-living components of the forest environment. Forests have long been considered special wild places representing nature untamed, but humans have exploited them and the damage is becoming increasingly evident.

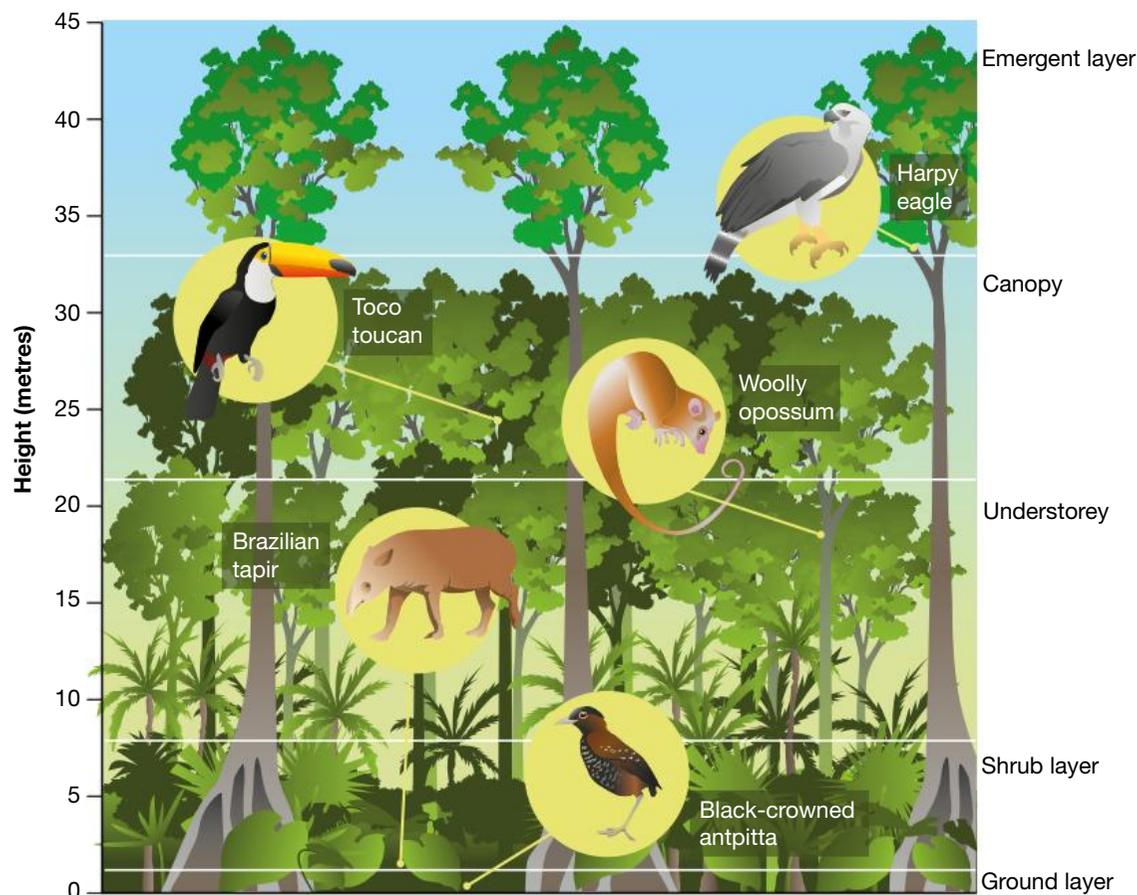
Elements and processes of the biophysical environment

To be classed as a forest, the trees that make up the forest must be more than 2 metres high and shade more than 20 per cent of the ground. To a person standing on the floor of the forest and looking upwards, more than 20 per cent of the sky would be covered by the foliage of the crowns of the trees.

A typical forest is composed of an **overstorey** and an **understorey**. The upper tree layer, or canopy, is made up of the crowns of the trees, where the branches and foliage spread to capture light to photosynthesise. Underneath is an understorey of smaller plants. In complex forests such as tropical rainforests, the stratification of the forest layers forms five distinct layers, as illustrated in Figure 10.1.1. **Emergent trees** tower above the general leaf cover of the canopy, and an understorey of smaller trees wait for their chance to fill a gap in the canopy when an old tree dies. Beneath them there are shrubs and ferns suited to the low light conditions, and a ground layer with little vegetation other than fallen leaves, seeds, fruit and decaying organic matter amid the massive roots and trunks of the trees.

Figure 10.1.1 also illustrates how rainforest species use the vertical dimension that a forest offers.

10.1.1 Each of the five layers of a tropical rainforest has specialised niches of plant and animal species.

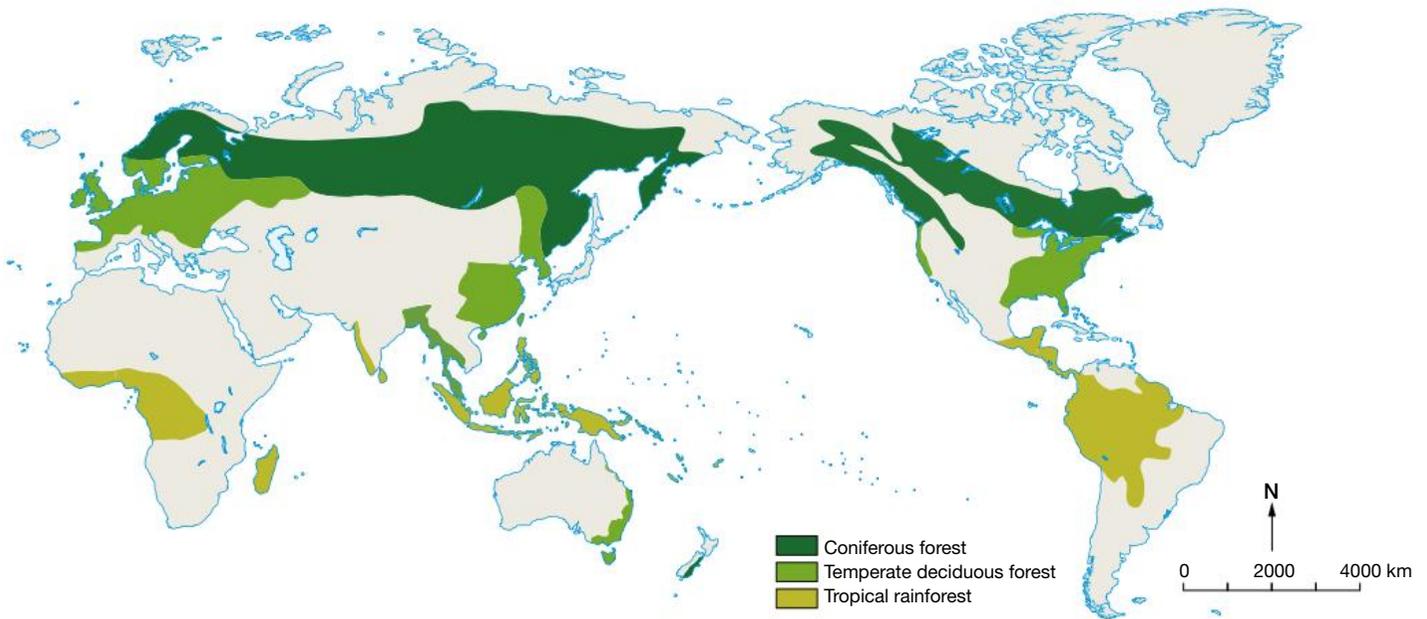


Types of forests

There are many types of forests, and they often merge almost invisibly with one another as the biophysical environment changes. There are three main types of forests: tropical, temperate and cold (northern coniferous, taiga or boreal).

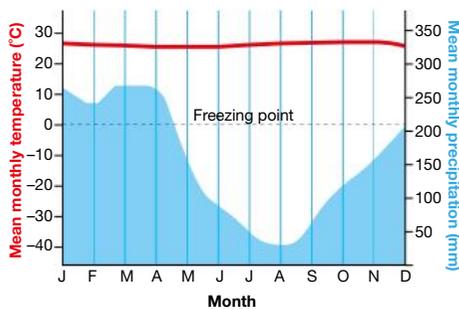
Figure 10.1.2 shows the location of these forests around the world. Forests are responses to particular combinations of varying temperature and precipitation levels that determine the processes operating within the biophysical environment (see Figure 10.1.3).

10.1.2 Global location of the main types of forests

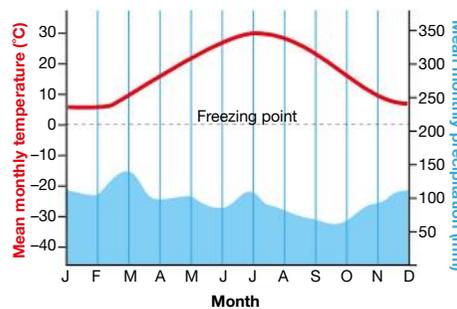


10.1.3 These climate graphs track the typical variations in annual temperature (red) and precipitation (blue) in (a) tropical, (b) temperate and (c) cold (northern coniferous, taiga or boreal) forests.

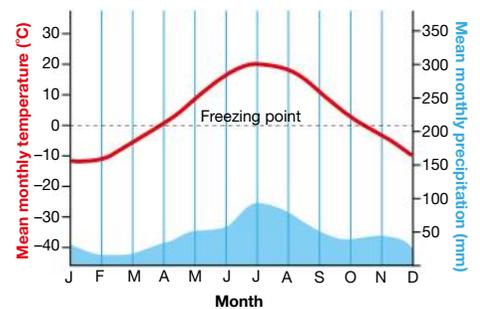
a Tropical forest



b Temperate (northern) forest



c Cold (northern) forest



10.1.4 The elements and processes of different types of forest environments

Type of forest	Location	Climate	Characteristics and processes
Tropical rainforests	<ul style="list-style-type: none"> From 0° to 10° north and south of the Equator in areas such as the Amazon Basin, Central Africa, Central America, Papua New Guinea and the islands of South-East Asia, and also extend down the east coasts of continents, e.g. Australia, where tropical rainforests are found in northern Queensland. 	<ul style="list-style-type: none"> Optimal conditions for plant growth as it is constantly hot (24°C to 28°C) and continuously wet (>1500 mm/year). Climate dominated by the unstable air of low pressure systems (a product of the intense heating). Large volume of water readily available to the plants but presents the greatest threat—leaches out soluble nutrients. 	<ul style="list-style-type: none"> The most luxuriant and dense of all forests. Dominated by broadleaf evergreen plants that keep their leaves all year, shedding only a few at a time as they become damaged, reducing their ability to capture light. Trees are draped with vines or lianas that spread their leaves out in the canopy to access sunlight. Very large biomass with immense biodiversity: many species; structurally dominated by trees; possesses many nutrient-conserving mechanisms (e.g. drip tips on leaves; mycorrhizal fungi wrapped around plant roots to quickly mop up nutrients in the soil before they are leached out by the excessive water). The humus soils quickly become impoverished if the living rainforest is removed (as the biomass is the source of nutrients).
Temperate deciduous forests	<ul style="list-style-type: none"> Located primarily in the eastern half of the United States, Canada, Europe and parts of Russia, China, and Japan. 	<ul style="list-style-type: none"> Moderate temperatures that change significantly with the seasons. Warm summers (20°C to 27°C) and cold winters (5°C to 10°C). Abundant precipitation evenly distributed throughout the year. Trees survive winter by going into dormancy, shedding leaves in autumn and replacing them in spring. 	<ul style="list-style-type: none"> The forest has a simple structure dominated by a few species, e.g. oak, maple, beech. Most trees have broad leaves that are shed in winter to avoid damage from freezing. Deep, rich soils enriched by the thick layer of fallen leaves that accumulate in the autumn.
Evergreen coniferous forests	<ul style="list-style-type: none"> These cold forests are found just south of the Arctic tundra in a broad belt across the northern regions of North America, Asia and Europe. They also sit above certain altitudes in the Rocky Mountains and Sierra Nevada of the United States. 	<ul style="list-style-type: none"> In the subarctic climate, winters are long (only 6 to 8 hours of daylight), dry (cold air holds limited moisture) and extremely cold (< -30°C). Summers are short and mild (short growing season). 	<ul style="list-style-type: none"> Dominated by a few species of evergreen conifer trees (cone-bearing) such as spruce, fir, cedar and pine. The small, needle-shaped, waxy-coated leaves of these trees conserve water at all times, which is vital when the ground is frozen. The trees are evergreen and, as they do not have to grow new needles, when the weather warms they can quickly take advantage of the brief summer. Plant diversity is low because few species can survive the winter when the soil moisture is frozen. Thin, nutrient-poor soils have a deep layer of partially decomposed pine needles (because of the low temperatures) which makes the soil acidic and prevents other plants growing on the forest floor. During the brief summer, the soil also becomes waterlogged in low-lying bogs.

Forest characteristics

Table 10.1.4 illustrates the main characteristics of, and processes in, forests.

Forest animals

Many of the larger animals of the world's forests are shy and unobtrusive. Quite often the only sign of those that live there may be a distant rustle of undergrowth or leaves as they make their escape. They are, however, fierce predators. The jaguars of the tropical rainforests of Central and South America have an exceptionally powerful bite that pierces the skull of their prey. The Bengal tigers of South-East Asia are well camouflaged in the rainforests by their stripes, which enable them to get very close to their prey. They have even been known to take down elephants.

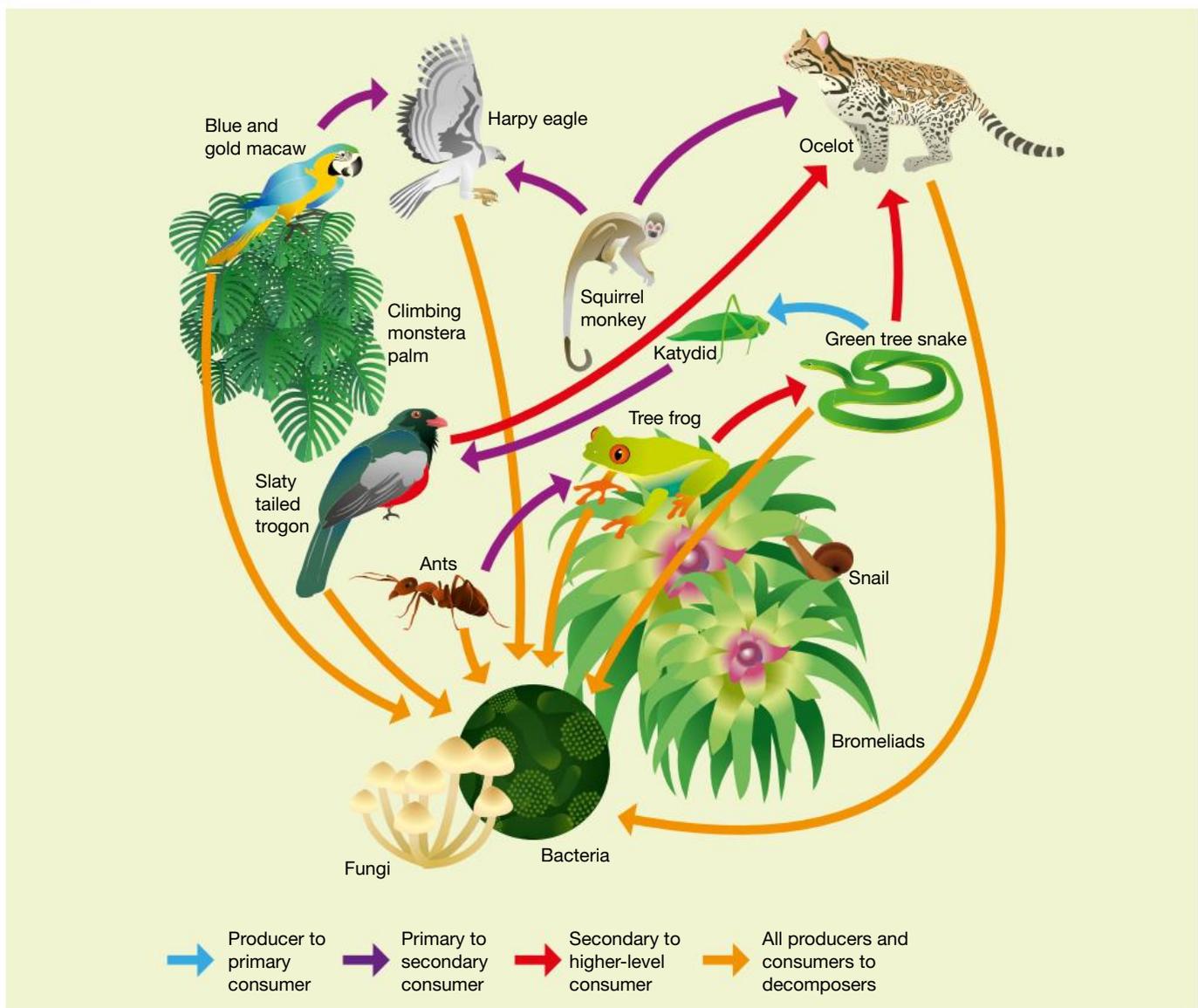
The most noticeable animals in the forests are those that live among the branches of the trees. Birds, insects, squirrels and monkeys dart and glide from one tree to another, filling the

rainforest with their calls and screeches. Yet it is the lives and habits of shyer and smaller creatures out of sight that are vital elements of the forest environment. None are more important than those found in the dark world below ground, where hordes of decomposers rapidly recycle the scarce soil nutrients that support the ongoing growth of the life forms above.

Interactions and natural balances

Forests offer many ways of living for a host of species of plants and animals. As a result, there is an immense **biomass** and biodiversity within forests. During the long course of evolution, animal and plant species have been shaped by the forest environments of which they are a part. Species, in turn, have had vital roles to play in maintaining natural balances that sustain life within those environments. Figure 10.1.5 shows some of the elements of, and interactions in, a tropical rainforest ecosystem.

10.1.5 The elements of, and interactions in, a tropical rainforest ecosystem (organisms are not drawn to scale)



Importance of the forest environment

Forests fulfil a major role in supporting the livelihoods and welfare of vast numbers of people in both developed and developing countries. Increasingly, the significance of forests in maintaining natural balances is being recognised. Scientists warn that clearing and degrading the world's remaining forests is a serious global environmental threat.

Economic services

Forests are valued for the economic worth of the raw materials they provide. More than 1.6 billion people around the world depend on forests for their livelihoods. Harvesting wood is one of the world's major industries; over half of the wood removed from the world's forests is used for fuelwood in cooking and heating, and the remainder is used in construction and papermaking. Global trade in non-wood forest products such as fruit, medicinal plants, fibre, gums and resins has recently been estimated at approximately US\$11 billion per year.

SPOTLIGHT

Forests are carbon sinks

Forests affect climate change because they influence the amount of carbon dioxide held in the atmosphere. Through photosynthesis, trees remove carbon dioxide from the atmosphere and store it for long periods of time until the trees fall over and rot, or are burnt, when the carbon dioxide goes back into the atmosphere. So living forests act as **carbon sinks** and they help to stabilise average atmospheric temperatures and slow climate change.

Ecological services

Forests are of immense importance in sustaining life on earth. They:

- support energy flow and nutrient cycling
- provide natural habitat
- promote biodiversity
- reduce soil erosion and protect water catchments by holding the soil in place
- absorb and release water, and aid in flood control
- purify water and air
- decompose wastes
- store atmospheric carbon
- produce oxygen
- influence local and regional climate.

Scientists have estimated the value of such ecological services and, as illustrated in Figure 10.1.6, it far outweighs the monetary value derived from the raw materials extracted from rainforests.

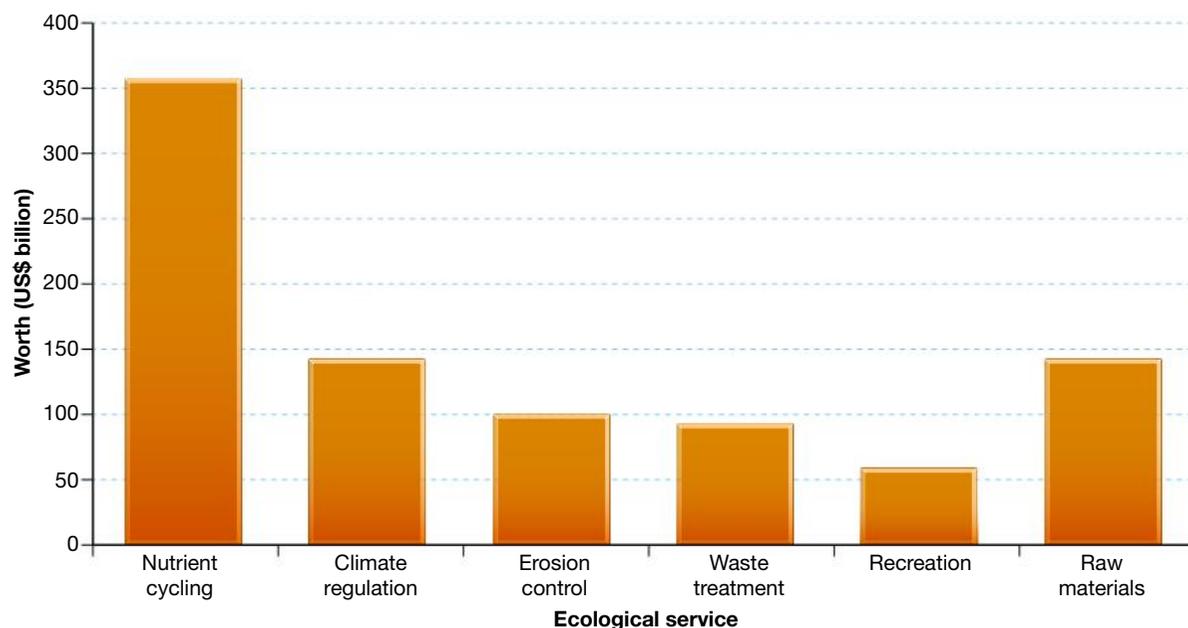
Spiritual functions

People value forests for many reasons. The social and cultural values of forests are intangible and so cannot be measured in monetary terms, but they can be profoundly important to people's sense of being and belonging. These values define worldviews and shape people's interactions with the natural

DID YOU KNOW?

The world's forests hold more carbon than the entire atmosphere.

10.1.6 Annual global economic values of some ecological services provided by forests, and the value of the raw materials they produce



world around them. Forests ‘often bear a deep significance, inspire affection and respect, reinforce cultural identity and are vital for spiritual wellbeing’, according to the International Institute for Environment and Development.

For indigenous people living in forests there is no separation between the spiritual and the physical worlds. They believe that spirits exist in the trees and the animals in the forest, and that they as humans are connected to them. The spiritual value of the forests is reflected in their traditions and folklore.

In European folklore and fairytales, forests—often referred to as the ‘woods’—are associated with mystery and lurking dangers. Powerful people have sought to have forests of their own. The Norman kings of England enclosed the forests around their

castles for their own sport and pleasure. In today’s world this same desire to hold onto forests can be seen in the creation of parks and reserves, which are now forests that ordinary people can enjoy. In an increasingly stressful world, making a connection with nature and experiencing the tranquillity of standing beneath towering trees has become especially appealing (see Figure 10.1.7).

DID YOU KNOW?

The total area of the world’s forest cover is 4 billion hectares, which represents nearly 30 per cent of the earth’s landmass. Approximately 56 per cent of these forests are located in tropical and subtropical areas.

10.1.7 South-west Tasmania’s Heritage-listed forest



ACTIVITIES

Knowledge and understanding

- 1 Identify the main features of a forest environment.
- 2 Differentiate between the two layers of a typical forest.
- 3 Describe and account for the variety of plants and animals that live in forests.
- 4 Outline the economic services provided by forests.
- 5 Explain how atmospheric carbon becomes stored carbon and why forests are such vital ‘carbon sinks’.

Applying and analysing

- 6 Explain the spiritual values that forests hold for people.

- 7 Prepare a poster that captures the service, sink and spiritual functions of forest environments.

Geographical skills

- 8 Study Figure 10.1.6 and answer the following questions.
 - a What is the value of raw materials gained from rainforests?
 - b What is the combined value of all the other ecological services?
 - c If extracting raw materials necessitates cutting down forests, what is the significance of this graph?

Forests: Causes of environmental change

Humans and forests

Meeting basic human needs and pursuing higher standards of living has largely been at the expense of the world's forests, past and present. For thousands of years, as settlement spread across Europe and North America, the temperate forests that once covered the land were cleared. The clearing of tropical rainforests escalated in the latter part of the twentieth century.

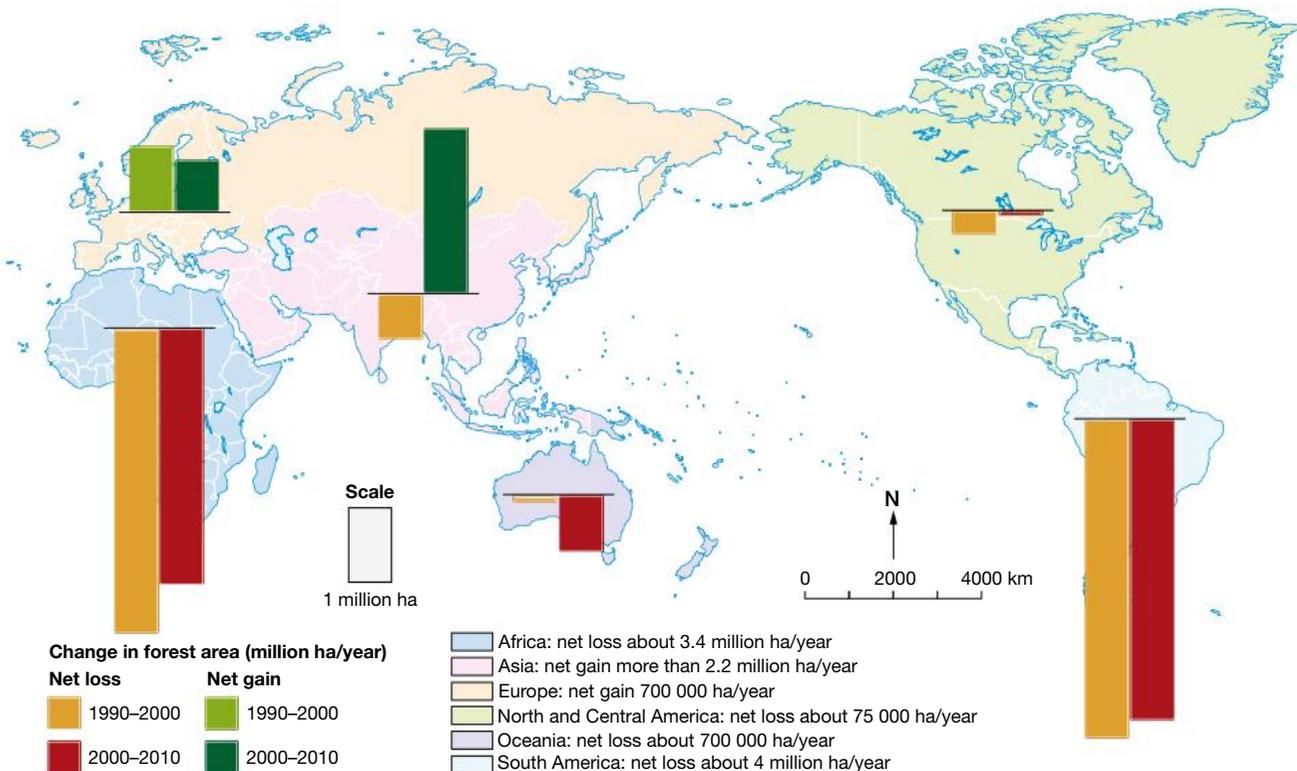
While humans have long considered forests to be special places, the products that they yield, or the ground on which they stand, is often valued above all else. Our ancestors felled trees for fuel and building materials, and cleared forests to grow crops and pastures for their stock. The trees were removed because they were obstacles to farming practices and they captured most of the available sunlight, leaving little for other types of vegetation underneath. Throughout Europe and North America, trees were associated with fertile land, which was highly favoured for agriculture.

The growth and spread of the world's population has been accompanied by increasing demands for land and forest resources.

With technological advancements, the scale of the extraction of resources and the accompanying environmental change have increased. Axes and crosscut saws have given way to chainsaws and modern electro-hydraulic harvesters, enabling whole slabs of forests to be clear-felled with greater speed. Areas of forest that were once spared because they were inaccessible or on slopes that were too steep are now being exploited.

Forest removal, or deforestation, is the most evident of the changes wrought by humans on forest environments. However, there are other significant threats to forest environments that directly or indirectly arise from human activities.

10.2.1 Annual change in forest area by region, 1990–2010. Losses are highest in South America and Africa. Australia had significant net losses in the period 2000–10 because of drought and fires.



Deforestation

Deforestation is the removal of large expanses of trees to provide agricultural land, timber and lumber products, and more recently, for energy and mineral extraction. According to the World Resources Institute (WRI), over the last 8000 years, human activities have reduced the earth's original forest cover by about 46 per cent, with most of the loss occurring in the last 60 years. The WRI estimates that about 40 per cent of the world's remaining intact forests will be logged or converted to other uses within two decades, if not sooner.

Current global concerns about deforestation are mainly about the conversion of tropical forests to agricultural land. Such losses are concentrated in areas of South America, Africa and Indonesia. Rates of deforestation were highest in the 1990s, when 16 million hectares of forest were converted to other uses or lost through natural causes each year. This eased to about 13 million hectares from 2000 to 2010. The rate of deforestation shows signs of decreasing, but it is still alarmingly high in several regions, as is shown in Figure 10.2.1.

Deforestation usually begins when a road is cut deep into a forest. This provides access to loggers and their equipment, and also settlers (see Figure 10.2.2). **Clear-cutting**, whereby all the trees are uniformly cut down, is the most efficient way for a logging operation to harvest timber. Foreign companies do

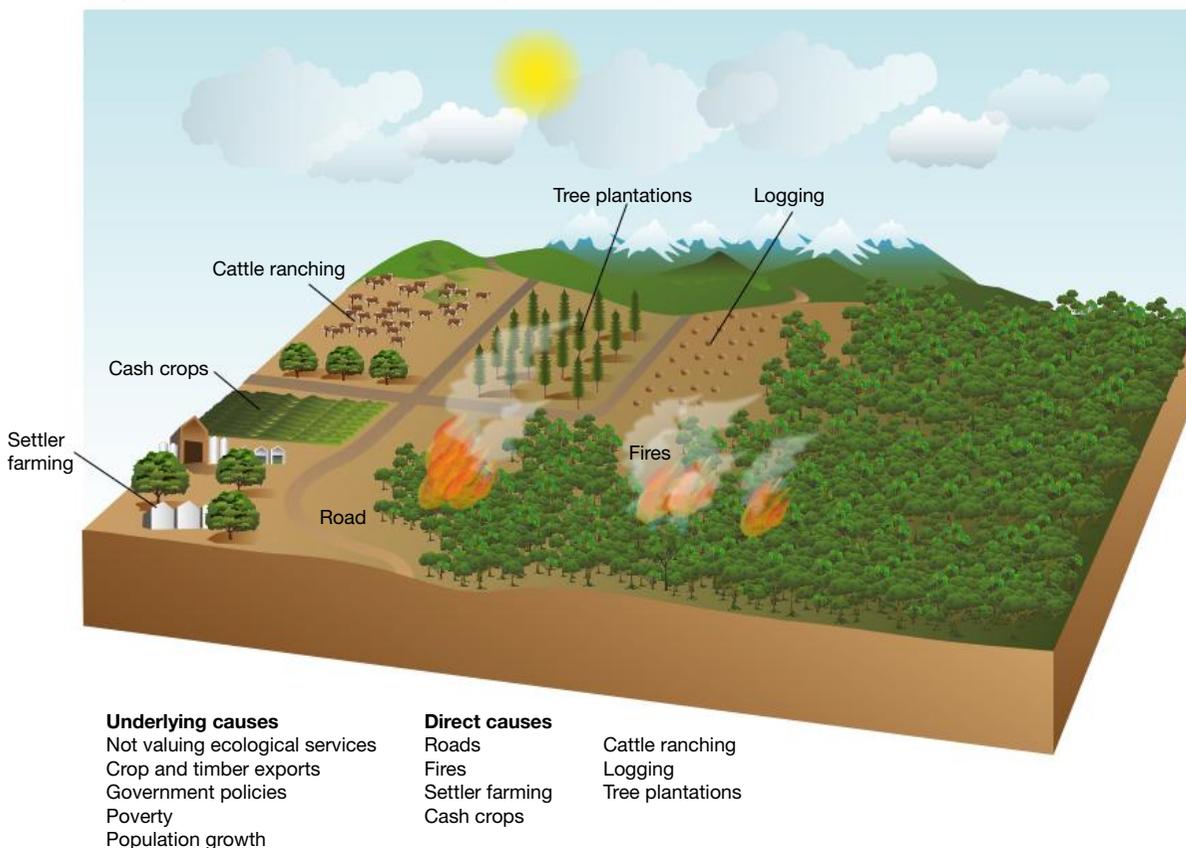
much of the logging in tropical rainforests. They are supported by concessions from governments. Once the timber has been removed, the land is sold to ranchers, settlers and plantation owners. Any remaining forests are usually burnt to clear the land. Such burning has been widely used to establish large plantations of soybeans in the Amazon Basin of Brazil and palm oil in Kalimantan and Sumatra in Indonesia.

Acid deposition

Industrial emissions have increased the concentrations of oxides of sulfur and nitrogen within the atmosphere. These combine with atmospheric moisture to yield sulfuric and nitric acids. The acids may then be carried long distances from their source, drifting for thousands of kilometres before they fall on the forest biomass as acid rain, snow or fog, and dry deposits such as soot and ash.

The widespread damage of acid deposition on forests has become evident in recent decades. Most of the forests in Eastern Europe, extending from Poland northward into Scandinavia, have had acid deposition. Many areas in south-eastern Canada and the eastern United States of America have been affected, particularly in the high elevation forests of the Appalachian Mountains from Maine to Georgia, where the forests sit in acidic clouds and fog.

10.2.2 Major causes of the destruction and degradation of tropical forests



Climate change, fire, disease and insects

Warmer and drier conditions are triggering rapid changes in the forests of North America. As trees are weakened by a lack of water they succumb to the ravages of diseases such as needle blight and intense insect attacks such as beetle infestations. Milder winters favour the survival of these invasive species, which multiply and kill more trees. The combination of drier forests and dead trees also increases the frequency and intensity of forest fires. As a result, millions of trees are being lost and the landscape is changing as tree species migrate (see Figure 10.2.3).

Biophysical processes changing forests

Forest environments support an immense biomass and rich biodiversity. Such great assemblages of flora and fauna are a product of 400 million years of evolution. Over this time, natural change has been evident but, as it was gradual, species had time to adjust and balances were restored. Current concerns about the impact of humans on forests, notably with climate change, are that it is happening too fast for nature to keep up with, and mass extinctions may result.

The productivity and complexity of the different forest environments reflect the biophysical processes supporting them. Human action, whether intentional or not, can disturb these and even sever important links.

Nutrient cycling in the Amazon Basin

The luxuriant growth of the rainforest is not a product of rich soils underneath. Rather, the rainforest supports itself by quickly and efficiently recycling the products of its own decay from debris that falls to the forest floor. This is especially important with the large, almost daily downpours of rain that would otherwise leach the nutrients out of the soil and carry them away. A whole range of **adaptive management mechanisms** help retain nutrients.

The impact of deforestation and subsequent farming in the Amazon Basin is evident when the soil becomes unproductive and impoverished within a matter of years. Once the biomass of the forest has gone, the source of nutrients for the soil disappears too. As the crops are harvested and consumed, little is returned to the soil. The problem is compounded when the heavy rain washes away the topsoil, leaving a clay-rich subsoil to bake in the hot tropical sun, forming a lateritic, or reddish clay, crust on the ground that is as hard as bricks.

Forest soils changing from acid deposition

Acid deposition does not usually kill trees directly, but it does weaken them by changing the biophysical processes at work in the soil in which the trees stand. The acidic water dissolves the useful minerals the tree depends on and washes them from

10.2.3 Dead, red lodgepole pines in Colorado are indicative of the landscape change underway.



the soil before the tree roots can use them. It can also activate aluminium in the soil, which inhibits tree growth.

Consequences of environmental change

Massive forest migrations

A team of scientists from Oregon, Montana and British Columbia have documented huge migrations of tree species across North America. They describe the change as one that is occurring on a broad landscape level. In some cases, the mechanism of change is fire, or insect attack; in others it is simply drought. Some forests may be replaced by grass savanna or sagebrush desert. In central California, researchers have found that more than half the species now in existence would not be expected to survive in the climate conditions of the future.

Peat fires in Indonesia

In Kalimantan, Indonesia, the peat that once lay protected in boggy soils below the forest dries out when the forests are cleared. Once this peat catches alight, the fires are very difficult to stop. Forest and land fires have caused **transboundary pollution** with smoke haze over South-East Asia for decades (see Figure 10.2.4). The indices of air pollution in Singapore, the southern Malaysia peninsula and elsewhere in Indonesia reached dangerous levels in 2013.

10.2.4 Forest and land fires caused choking smog and transboundary haze in South-East Asia in 2013.



ACTIVITIES

Knowledge and understanding

- 1 Define the term 'deforestation'.
- 2 Compare the rates of deforestation in the 1990s and early 2000s.
- 3 Explain why acid deposition has damaged forests.
- 4 Identify the major causes of landscape changes in the forests of North America.

Applying and analysing

- 5 Explain why humans must be included in any investigation of environmental change in global forest environments.

Geographical skills

- 6 Study Figure 10.2.1 then answer the following questions.
 - a What was the approximate net forest loss for South America in 2000–10?

- b What was the approximate net forest loss for Africa in the two decades shown?
- c What was the approximate difference in the net forest loss for Oceania in the two decades shown?

Investigating

- 7 Investigate nutrient cycling in a tropical rainforest. Present your findings on a poster annotated with text boxes outlining the nutrient-conserving processes that support the luxuriant forest growth.
- 8 Investigate deforestation and plantation agriculture in either the Amazon Basin or Kalimantan. Present your findings as a feature newspaper article.

Forests: Managing environments

Forest change

As environmental changes in the world's forests have become more evident and extensive, scientists have become concerned that the changes taking place are threatening the forests' survival. Human-environment systems thinking is being used to identify the causes of the changes taking place and to help develop effective strategies to manage them.

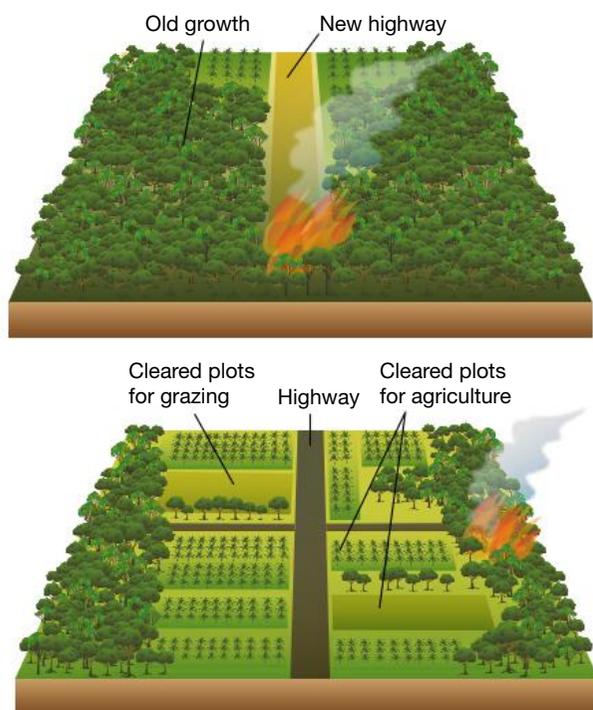
People's worldviews and forest management

Human-centred worldviews

Today, many of the world's tropical rainforests support a mixed population of farmers, ranchers, rubber tappers, construction workers, and forestry and plantation workers. These workers and their families often originate from outside the forest and have a human-centred worldview of the rainforest. They see it as a resource to be exploited.

Poverty is widespread in many tropical areas. Landless settlers gain access to the forest on the roads built by logging or mining companies (see Figure 10.3.1). For the most part,

10.3.1 Building roads into previously inaccessible forests is the first step to harvesting timber, but it also paves the way for fragmentation, destruction and degradation of forest ecosystems.



these migrants have a human-centred worldview, driven by a desperate need to feed their families. They clear the forest using the slash-and-burn method of production, but their practices are highly destructive. Not only are they armed with steel axes and chainsaws, but they also lack the skills of the original forest dwellers. The soil is quickly exhausted, the crops start to fail and the settlers simply clear more land.

As a result, larger and larger areas of forest are cleared, creating large open tracts of land. This makes it harder for the forest to regenerate, as seeding trees are too distant from the cleared plots. Slash-and-burn agriculture is now the main cause of deforestation in Latin America and Africa and the second most significant cause in Asia after plantation agriculture.

Stewardship worldviews

The first people to make a living within rainforests were probably **hunter-gatherers**, who ranged over huge territories in search of food. They had the ability to identify thousands of different types of plants and animals, and to recognise those that were edible or dangerous. The low population densities of tribes guarded against over-exploitation.

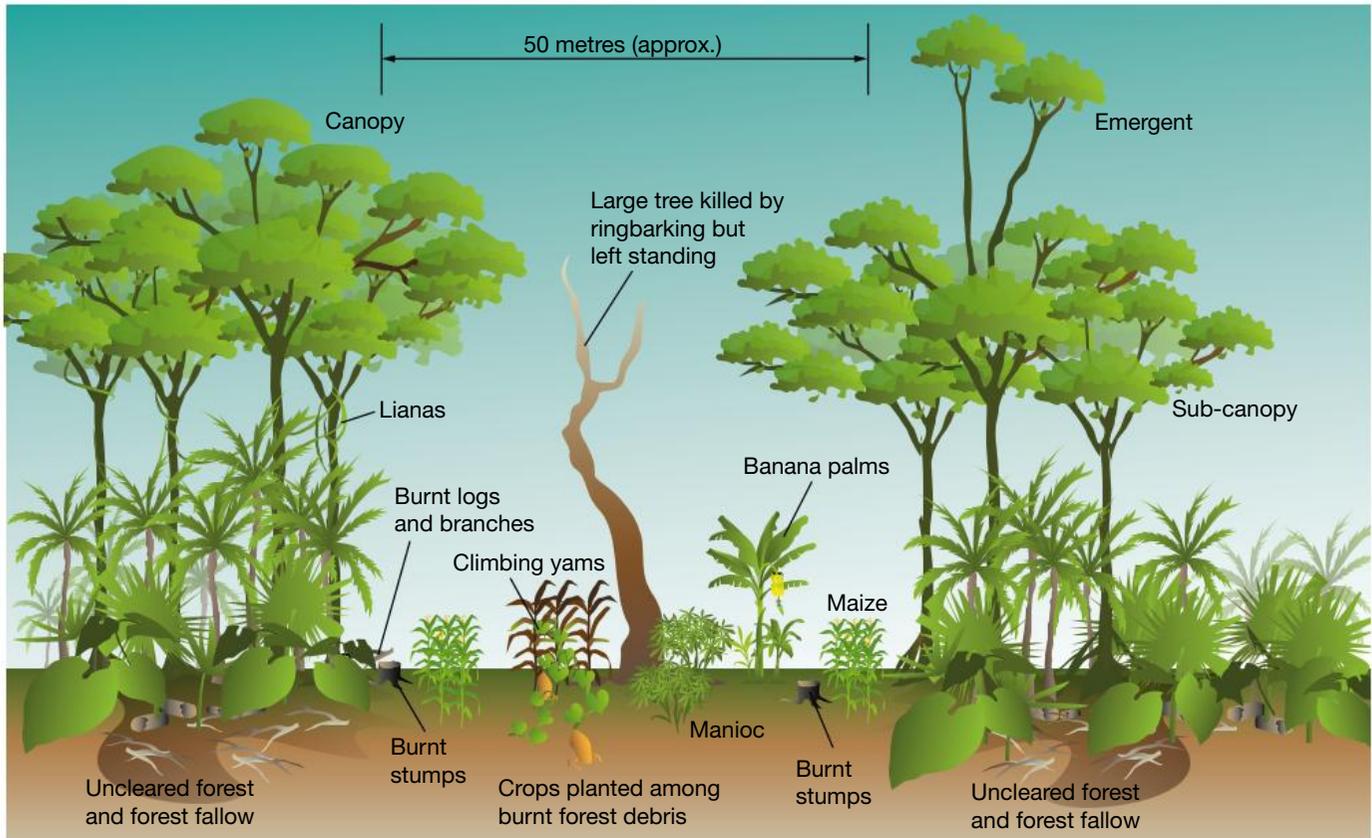
Early forest dwellers were also farmers. Traditional **shifting cultivators** cleared small patches of forest to grow food in gardens. Once a site was chosen, fruits and anything useful were harvested before the trees were ringbarked and the undergrowth hacked. When the undergrowth had dried out it was burnt to create a layer of ash that temporarily fertilised the soil (see Figure 10.3.2).

Initially, the yields from the garden plot were satisfactory, but they fell as the nutrients were used up and weeds invaded the garden. A plot would provide only a few good harvests before it was abandoned to be reclaimed by the forest. It could take up to 30 years for the site to regain its soil fertility and be ready for use again. Increasing population densities have inevitably resulted in increasing deforestation and made shifting cultivation unsustainable.

Earth-centred worldview

The first priority of the earth-centred worldview is the protection and restoration of forest ecosystems and their related species. Forest ecosystems are considered to be the most ancient ecosystems on earth and they hold immense biodiversity that must be valued and maintained. With the threats associated with climate change, the role of forests as global carbon sinks is considered especially important for the future. Recognising the natural values of forests is considered essential.

10.3.2 Cross-section through a typical garden of a shifting cultivator



Human-environment systems thinking

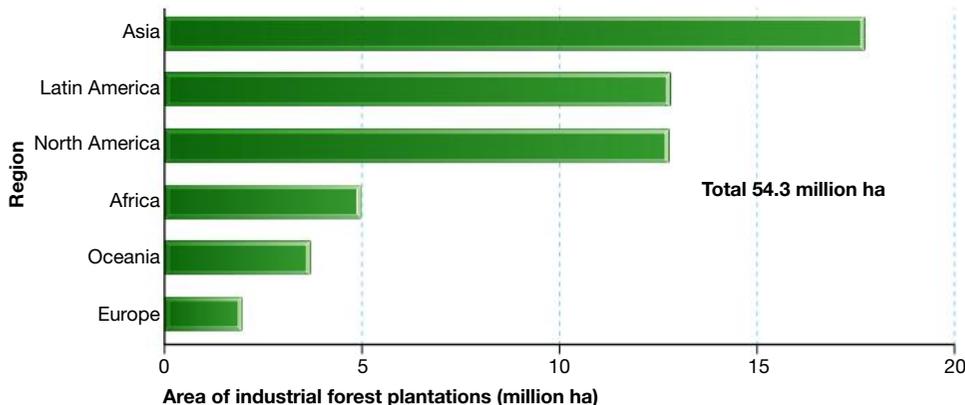
The human-environment systems thinking framework can help us to identify the drivers of deforestation.

Globalisation

Global markets consume rainforest products such as hardwood timber, latex, natural oils and resins, fruit, nuts and spices, and compounds used in pharmaceuticals. The most important forest resource in economic terms is timber, used in construction and furniture, and for fibre for the pulp and paper industry. Fifty years ago, almost all industrial wood was

harvested from natural forests, generally in the industrialised countries in the temperate regions of the Northern Hemisphere.

The globalisation of the timber industry is resulting in the establishment of fast-growing tree plantations in the tropical and subtropical zones in developing countries (see Figure 10.3.3). Corporations are investing in plantations in developing countries to take advantage of cheap land and labour. New technologies are being applied to generate rapidly growing trees that have all the desirable traits of industrial wood.



10.3.3 Industrial forest plantations by region, 2012. The global area of industrial, fast-growing plantations is 54.3 million hectares. These forests are intensively managed productive plantations, mainly of exotic introduced species.

Source: Indufor Plantation Databank, 2012

Poverty

Population pressure and poverty are major drivers of deforestation. Many people who live in the tropics are desperate to survive in the short term. They attempt to grow food in the forest because it is only there that they can find land. Massive numbers of landless migrants from the poor regions of Brazil's north-east and central-west were encouraged to settle in the new frontier of the Amazon under government land-settlement schemes (see Figure 10.3.4).

Conservation reserves and biodiversity corridors

Conservation reserves and **biodiversity corridors** are being established on a range of scales—from small areas set up by landholders to protect a patch of forest, through to large tracts of land. A major objective of establishing reserves and corridors is to protect the biodiversity of all the flora and fauna within a forest from threat or extinction.

Conservation reserves

Conservation reserves are areas of land set aside to maintain biodiversity and/or natural or cultural heritage values. They are protected by legislation passed by a government or because of an international agreement that a government is signatory to. Any human use of conservation reserves is usually restricted to activities that are deemed compatible with the reserve's natural values.

Biodiversity corridors

Land clearing has resulted in fragmented forests, with the result that plant and animal species cannot disperse or move freely across the landscape. Being confined to smaller areas puts species at risk, as they may be weakened by inbreeding and their numbers can be decimated by disease or catastrophic events such as fire. Connectivity corridors link isolated blocks of native forest with strips of vegetation that imitate the structure and diversity of the original forest cover.



10.3.4 Poor migrant families have moved into the Amazon and cleared the forest to grow food.

Biodiversity corridors are an effective method of raising both the number and diversity of species by allowing dispersal and movement from one area of key habitat to another. Corridors vary in their size. A farmer may plant a corridor of native vegetation about 40 metres long following a boundary fence. This allows trees to seed and animals to move easily. Large-scale corridors connect habitats regionally and even internationally.

Ecosystem-based management strategies

The ecosystems approach is an **environmental strategy** that integrates the management of land, water and living resources and emphasises that humans are an integral component of ecosystems. It recognises that management must be ecologically sustainable and for this to be assured, biodiversity must be protected, as biodiversity and healthy functioning ecosystems are vital for life on earth (see Figure 10.3.5).

Addressing drivers of environmental change

The drivers of environmental change have been identified as globalisation and poverty.

Lowering the demand for wood-based products reduces the pressure on forests. This may be achieved by:

- cutting the wastage of timber resources: in the 1990s, Japan was criticised for using tropical timber panels for moulding concrete in public works projects, only to discard the timber when the concrete had set
- recycling timber: many cabinetmakers and renovators are using recycled timber, as many of the specialty timbers are becoming harder to source—they have been over-exploited in the past
- using wood substitutes: considerable potential exists for non-wood fibre alternatives such as cereal straw, hemp and flax to be used as raw materials for board and paper manufacture.

Raising people's standard of living will also take the pressure off forests. This could be done by:

- helping farmers to obtain formal title to their land, so they are encouraged to use it more efficiently rather than just move on to a clear more forest once soils become depleted
- involving farmers in producing new products from the natural forest that have potential as exports
- improving farming methods and promoting alternative cultivation techniques such as permaculture, whereby the structure of the forest is mimicked. Availability of cheap credit will assist farmers to implement the changes needed.

10.3.5 The twelve principles of the ecosystem approach

- 1 The objectives of management of land, water and living resources are a matter of societal choices.
- 2 Management should be decentralised to the lowest appropriate level.
- 3 Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
- 4 Recognising potential gains from management, there's usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management program should:
 - a reduce those market distortions that adversely affect biological diversity
 - b align incentives to promote biodiversity conservation use
 - c internalise costs and benefits in the given ecosystem to the extent feasible.
- 5 Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
- 6 Ecosystems must be managed within the limits of their functioning.
- 7 The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
- 8 Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
- 9 Management must recognise that the change is inevitable.
- 10 The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biotechnology.
- 11 The ecosystem approach should consider all forms of relevant information, including scientific, indigenous and local knowledge, innovations and practices.
- 12 The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Source: FAO

ACTIVITIES

Knowledge and understanding

- 1 Describe how the hunter-gatherers and traditional shifting cultivators survived in the forest.
- 2 Outline how forests have been exploited by those with a human-centred worldview.
- 3 Identify the priorities of forest management of those with an earth-centred worldview, and justify such priorities.
- 4 Explain how both globalisation and poverty are driving deforestation.
- 5 Explain the benefits of ecosystem-based strategies.

Applying and analysing

- 6 Analyse how addressing the underlying and immediate cause of environmental change may protect forest landscapes.
- 7 Write an extended response on the following topic. *Explain how a system of agriculture that has worked well for thousands of years in tropical rainforests is breaking down under the pressure of human numbers.*

- 8 Study Figure 10.3.5 and select what you consider to be the three most important principles of the ecosystem approach. Justify your choice.

Geographical skills

- 9 Study Figure 10.3.2 and answer the following questions.
 - a What crops are grown in the garden?
 - b Why are large trees that have been killed by ringbarking left standing and debris left strewn across the garden?
- 10 Study Figure 10.3.3 and answer the following questions.
 - a What region had the most industrial forest plantations in 2012?
 - b How many hectares were occupied by industrial plantations in both Latin America and North America?
 - c What percentage of the world's industrial forest plantations were in Africa in 2012?

CASE STUDY: Canada's forests under threat

Canada's forests

Canada's forests and their associated wetlands, which have been described as one of the world's great ecological treasures, cover 60 per cent of the country's 9.9 million square kilometre landmass. Along with the Siberian boreal forest and the Amazon rainforest, they are the last significant stretches of forested land on earth that have never been touched by the large-scale footprint of human industrial activity.

Coniferous forests

Canada's vast coniferous forests are dominated by cone-bearing trees such as the spruce, fir and pine. The leaves of these trees are usually needle-like and most stay green all

year around (evergreen). The forests are able to survive cold temperatures and acidic soil. Coniferous forests are found mainly in the Northern Hemisphere. Figure 10.4.1 illustrates the distribution of Canada's forests.

Threats

Forestry, mining and energy projects across Canada are transforming huge swathes of the coniferous frontier, destroying wildlife habitat, disrupting animal migration patterns, threatening water quality and compromising ecosystem services.

10.4.1 Distribution of forest types, Canada

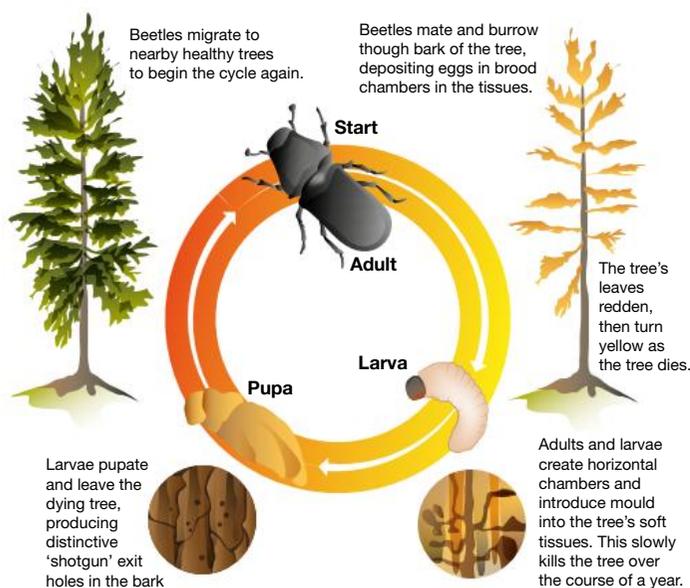


Today, about one-eighth of Canada's total forest area is affected by infrastructure, including roads and hydro-electric dams. Species such as the woodland caribou have disappeared from parts of the boreal forest and other wildlife, such as the wolverine, bear and wolf, are in trouble as the wave of development continues to push north.

There are now about 1400 human communities within Canada's boreal region. Many settlements were carved out of the forest to support a sawmill, pulp mill or mine, and in some cases, railway maintenance facilities. In total, boreal forestry activities support almost 400 000 direct and indirect jobs across Canada. Oil and gas exploration and development, forestry, pulp and papermaking and mining are the largest industries, along with tourism and other service-based activities.

Human activity is also contributing to infestation through the introduction of insect species. This infestation is a side-effect of international trade. Wood packaging from abroad is thought to be the source of the Asian longhorn beetle, which has no natural predators in Canada. The Asian longhorn has the potential to destroy a whole range of hardwoods by burrowing deep under the bark. An earlier alien invader was the gypsy moth, which attacks oaks and other broadleaf trees.

Canada's native species of insects can also cause enormous damage to the forests. One example is the mountain pine beetle, shown in Figure 10.4.2, which attacks many western Canadian pine species. A recent outbreak in numbers has devastated huge tracts of forest across British Columbia and parts of Alberta. Many experts believe this outbreak is linked to a series of warm, dry summers and milder winters—a result of global warming.



10.4.2 The life cycle of a pine beetle and its impact on the tree

Addressing forest degradation

To maintain ecological processes and the full complement of wildlife species, scientists argue that at least 50 per cent of Canada's forest ecosystem should be set aside as a permanent network of conservation areas free of disturbance. The rest should be carefully managed to preserve or restore its ecological wellbeing. Importantly, scientists also argue that these protected areas should accommodate the traditional uses of the land by First Nations people, and should be managed or co-managed by the First Nations in Canada.

Triad approach to forest management

A management option being trialled in Canada is the triad approach, which is being tested on 0.86 million hectares of deciduous forest in Quebec. Under the triad approach, the forest is divided into three distinct zones, with very different management objectives.

- 1 The conservation zone: The main goal is conservation of biodiversity and ecological processes. Human activities that interfere with these processes are restricted.
- 2 The natural disturbance-based management zone: Human activity such as partial logging is permitted, but it must mimic what happens with natural disturbances in the forest (such as storm damage). The goal is to build the resilience of the forest to such an event.
- 3 The intensive silviculture zone: This is the intensive logging zone, where timber is extracted.

The triad approach holds the promise of balancing the exploitation of a valuable natural resource while meeting the needs of the many different stakeholders and interest groups.

ACTIVITIES

Knowledge and understanding

- 1 State what is special about the Canadian forests.
- 2 Outline the features of the Canadian forests.
- 3 Outline the range of threats to the Canadian forests.
- 4 Explain what should be done to protect the Canadian forests.
- 5 Describe the triad approach to forest management that is being trialled in Canada.

Geographical skills

- 6 Study Figure 10.4.1. With the aid of an atlas, describe the distribution of Canada's various forest types.
- 7 Study Figure 10.4.2. Write a report describing the life cycle of a pine beetle and its impacts on the forests.

CASE STUDY: Australia's east coast forests

Connectivity conservation

Connectivity conservation is based on the idea that a corridor of protected lands extending over hundreds, and in some cases, thousands of kilometres can protect biodiversity and critical ecological processes. Connectivity conservation is based on a number of key ideas.

- Largely intact areas of forests need to be formally conserved in conservation reserves in order to maintain their ecological integrity.
- The land around the reserves can be managed so that it can act as a buffer zone against any outside threats to biodiversity.
- Cleared land provides opportunities for large-scale restoration of natural vegetation to connect the reserves so

that they are not left as isolated islands in which extinctions are likely.

- Conservation planning is done on a large scale to ensure that all the links and ecological processes essential for species to adapt to environmental change are in place.

A conservation corridor

A conservation corridor is a strategically located area of land that links key habitats for plants and animals. It may encompass a range of landuses, including agriculture, industry and human settlement, in addition to areas conserved as national parks or reserves.

10.5.1 The slopes of the Great Eastern Ranges include most of Australia's forests. Connectivity conservation is an approach now being used to manage environmental change within these forests.



To ensure the survival, health and resilience of all species—including humans—we need to look at how we can rehabilitate and 'reconnect' islands of vegetation on a large scale, so a mosaic of ecosystems can exist across the landscape and function more effectively.

Connectivity conservation is a holistic approach that uses science to identify where, why and how 'gaps' in the natural vegetation can be restored to provide more functional links in the ecosystem.

Great Eastern Ranges corridor

Seven large-scale connectivity conservation areas have been established to protect the integrity and resilience of Australian ecosystems. One of the largest is the Great Eastern Ranges corridor (GER corridor), shown in Figure 10.5.1. The GER corridor protects the forest landscape in the mountain ranges that run parallel to the east coast of Australia. The corridor extends from the Grampians in western Victoria to the Atherton Tablelands in far north Queensland and beyond, as shown in Figure 10.5.2.

Key facts

The Great Eastern Ranges corridor:

- is 3600 kilometres in length
- is 33 000 000 hectares in area
- goes across 14 bioregions
- contains three World Heritage Areas
- has the world's greatest concentration of primitive rainforest flowering plants
- has Australia's largest and tallest old-growth forests
- contains more than 8000 species of plants, of which 25 per cent are endemic
- contains the headwaters of 63 large rivers
- provides clean water to over 11 000 000 people.

GER corridor's biodiversity assets

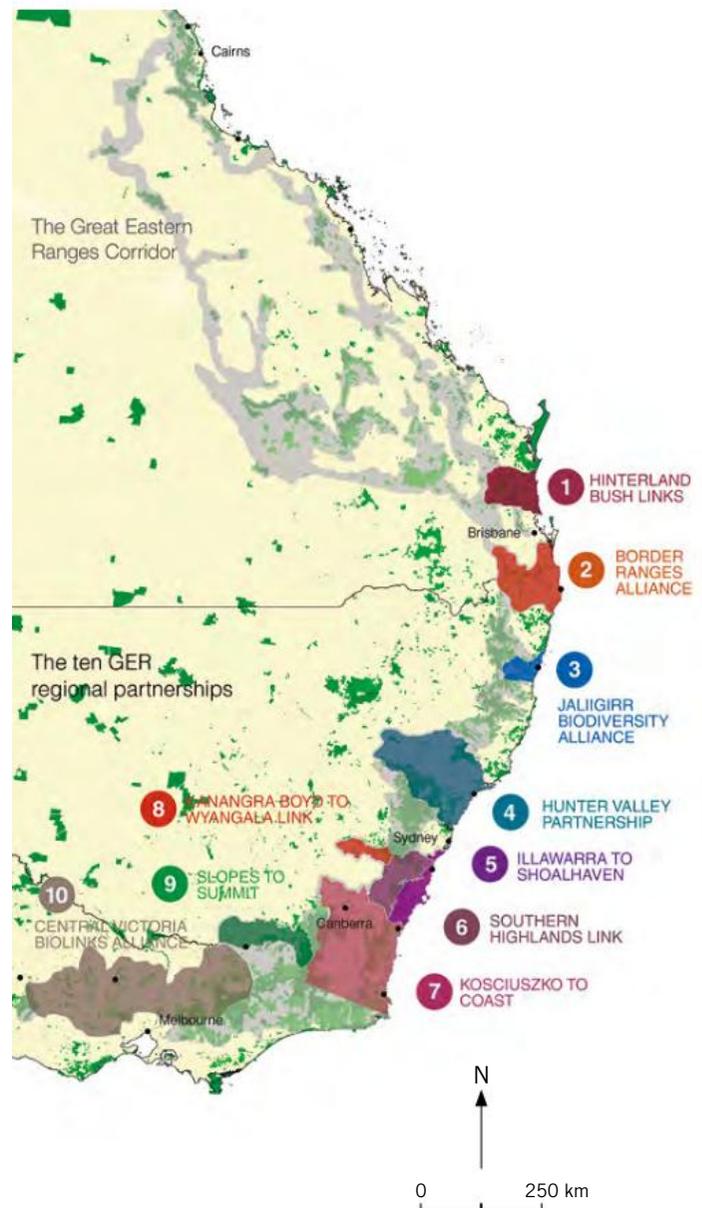
The biophysical environment in the GER corridor is one of the most biodiverse on the continent. Stretching over 28 degrees of latitude, the GER corridor includes significant areas of tropical, subtropical and temperate forests. It covers a number of climate zones, with major variations in temperature and rainfall. Along the ranges, tablelands and escarpments are Australia's least fragmented habitats, containing a rich diversity of flora and fauna, all of which have evolved over millions of years.

The three World Heritage areas (Wet Tropics, Central Eastern Rainforest Reserves and the Greater Blue Mountains) found in the GER corridor reflect the continent's evolutionary history. They provide evidence of the impacts of long-term global climate change, the long period of isolation since breaking clear of Antarctica (and Gondwanaland) some 60 million years ago, and adaptations to Australia's deeply weathered and infertile soils.

As a result, the region contains ancient and unique species of plants, the origins of which can be traced to Gondwanaland. The Wollemi pine is just one of these. There are many **endemic** plants and animals.

As the ranges receive high levels of precipitation, they support very productive ecosystems and thus have the largest amounts of biomass on the continent. The GER corridor contains most of Australia's rainforests and eucalypt forests and therefore the bulk of its forest-dependent flora and fauna.

10.5.2 The GER conservation corridor, which includes the Great Escarpment of eastern Australia and the Great Dividing Range and, in various places, large sections of intervening highlands



Threats to biodiversity in the GER corridor

There are a number of environmental changes that threaten the rich biodiversity of the GER corridor:

- **Land clearing** This has been the major contributor to the loss of biodiversity in Australia. The GER corridor is adjacent to the intensive agricultural zone along the east coast, where the major centres of population are also found. Habitat loss and fragmentation lead to the demise of species, as they are unable to maintain viable populations within increasingly smaller disconnected areas.
- **Invasive species** The introduction of feral animals and weeds has had devastating consequences for many native species. Of particular concern is lantana, a shrub that grows along the edges of the forests of the ranges and penetrates any disturbed areas. It forms a dense thicket that excludes any native species from growing beneath.
- **Fire** While Australia's vegetation evolved in the presence of fire, it is susceptible to considerable damage from very severe fires. For tens of thousands of years, there were frequent, low-intensity fires in the forests under traditional Aboriginal management. Since European settlement, fires have been deliberately prevented to protect people and property. As a result, the fuel load has built up in the forests and when fires do occur they can become large wildfires, the intense heat of which does severe ecological damage, even killing trees outright that would have normally regenerated.
- **Climate change** Accelerating climate change is placing even more stress on forests. According to the New South Wales Department of Primary Industries, climate change is likely to increase wildfire risk, largely through its impact on climate extremes. Projections suggest that the frequency of very high and extreme fire danger days in south-eastern Australia may increase by 4–25 per cent by 2020, and by 15–70 per cent by 2050.

Connecting nature

We need a better understanding of the complexity of the networks of interconnected systems within forest environments. The GER corridor initiative recognises that to fully understand a regional biodiversity asset (for example a particular forest), it is necessary to examine the continent-wide ecological processes that sustain it. The GER corridor uses science to identify the gaps in the forest cover and to determine how existing stands can be connected to restore the links and interactions that will protect biodiversity.

The challenge

Although parts of the GER corridor are well protected by national parks and reserves, much of the rich biodiversity is found on private and public lands outside these protected areas. The GER recognises that nature's interconnected systems need to be supported across the whole environment, not just in the protected areas of the landscape. So we seek to integrate conservation efforts in the land adjacent to and interconnecting with the existing reserve systems. This will allow habitats for plants and animals to be managed better or rehabilitated and strengthened where needed.

The approach

The GER is based on 'connectivity conservation', an approach that recognises the need for ecological processes to operate on a much larger scale than previously appreciated. By assessing these processes at local, regional and continental levels and harnessing the existing efforts of many landowners and organisations to respond strategically, we create the best conditions to preserve, restore and build resilience in our environment.

The key is simple—by creating stepping-stones between areas of native vegetation and managing and improving what is already in place, we reconnect to the landscape and improve the health of the environment on which we all depend. This approach will support our biodiversity by providing the best available opportunities for species to survive climate changes.

Source: Great Eastern Ranges Organisation

Connecting people

The GER initiative brings together all the people and organisations working on improving native habitats and protecting biodiversity along the eastern ranges—researchers, landholders, community and Indigenous groups, conservation organisations, local councils and other government bodies. This approach provides a broad range of expertise to draw on and is coordinated and supported by the GER. Such cooperation means that the resources can be put to use to yield the best results on a large, landscape scale.

The approach taken in the GER initiative involves raising awareness about biodiversity conservation over the full extent of the GER corridor. Local communities can be galvanised into action that fits in with the strategic approach to protecting biodiversity in all the forests along the ranges.

Management strategies

The GER initiative is an ambitious plan aimed at combating the threats to the biodiversity and ecosystem services of the forest landscapes of eastern Australia. For over a century, these landscapes have been under pressure from landuse intensification, invasion by introduced species and, more recently, rapid climate change. The GER corridor initiative is a large-scale, continent-wide approach to increasing the extent of forests and ecological connectivity within the landscape. Building such a continental lifeline will conserve biodiversity by supporting the survival of species.

Environmental

Connectivity conservation involves identifying the gaps in forest cover and restoring the natural vegetation, as can be seen in Figure 10.5.3. Connecting habitats and providing functional links between them is the key to achieving forest sustainability.

Conservation management in Australia has focused on species presence (snapshot data) rather than long-term viability and the need for connectivity conservation. This has been due to insufficient resources (time and talent) to fully implement **population viability** analyses for most corridor initiatives.

Economic

Funding has not matched the scale of the initiative's vision and objectives. Delivering the aims of connectivity conservation is difficult when funding is limited. Much greater financial resources and human energy are required than have been invested to date in reducing continental-scale pressures. One of the challenges for the Australian government is to create conditions needed to attract far greater investment in time, talent and financial capital to match the scale of need and ambition to expand conservation corridor initiatives.

Social

A real strength of the GER initiative is that it is socially inclusive. Local community networks have been involved in regional partnerships and people are working with an appreciation and understanding of how their efforts are contributing to the continental corridor initiative.

The future

Connectivity conservation on a continental scale is the key to providing more functional links within the forest ecosystems and thereby conserving biodiversity. The GER has the backing of the people who at a local level are committed to regional partnerships, which are part of the vision of the initiative. In time, as research advances and funds flow more freely, there will be more progress.



10.5.3 Volunteers in locally organised groups can work within regional partnerships that improve the connectedness and resilience of forest landscapes.

ACTIVITIES

Knowledge and understanding

- 1 Explain how connectivity conservation protects forests.
- 2 Explain the purpose of the GER initiative.
- 3 Account for the rich biodiversity within the forests of the GER.
- 4 Identify the threats to this biodiversity.
- 5 Explain what is meant by the term 'population viability'.

Applying and analysing

- 6 The GER provides clean water to over 11 million people. In a paragraph, explain why protecting the forests along the ranges of the GER is vitally important to this role.
- 7 As a class, debate the effectiveness of the GER initiative.
- 8 Study the photograph of the GER in Figure 10.5.3. What evidence is there of connecting nature in this landscape?
- 9 Evaluate the GER initiative against environmental, economic and social criteria.

Forests: Evaluating management responses

Monitoring forest management

As both communities and governments tackle the environmental issues confronting them, they have to recognise the importance of monitoring the state of the forests and evaluating the management responses. For such evaluation to be effective, environmental, economic and social criteria must all be applied.

Importance of evaluating management responses

Human wellbeing has long been connected with forests. Concern has been mounting over the threats to forests and the loss of important ecosystem services and renewable resources, species extinction and the reduction of carbon sinks. With only 10 per cent of the world's forests found in protected areas, it is evident the global forest cover is not being adequately conserved.

For too long, management responses addressing the threats to forests relied on trial and error. All too often there was inadequate attention given to carefully collecting evidence on what had or had not worked in the past. Such systematic evaluation of management was surprisingly scarce relative to the work undertaken to protect forests.

There is now an increasing awareness of the importance of establishing a measure of what management responses have accomplished, and in doing so learning from past successes and mistakes. This is particularly important given the scale of environmental changes now affecting forests, especially those driven by climate change. Increasingly, monitoring and evaluation are being recognised as essential tools of forest management.

Criteria for evaluation

There are many types of management responses and no single one is appropriate for all environmental changes. Having some vague notion that management will make a difference to environmental quality is not enough. When evaluating the effectiveness and appropriateness of management practices, it is important to have a clear set of evaluation criteria.

Environmental criteria

The foundation for forest management is the maintenance or improvement of the condition of the forest environment. This includes the conservation of biodiversity, the maintenance

of ecological processes and the protection of all the natural features in the landscape, such as soil, air and water.

Proper forest management will ensure that the countless interrelationships between species that have evolved over time are maintained, and that intricate food chains will continue to enable the energy flows and nutrient cycling that support forests. Environmental criteria are used to judge the extent to which a policy or response meets its intended objectives.

Economic criteria

Planning and implementing management responses requires funding. This may be provided by individual landholders, community groups, governments at all levels (local, state and federal), non-governmental organisations (NGOs) and intergovernmental organisations (IGOs).

Whatever the source, it is important that the management undertaken is both:

- **efficient:** it achieves its intended objectives or positive outcomes in protecting or improving forest cover
- **cost-effective:** it can be done at minimum cost to the landholder or society. Any waste or additional costs because of poor financial decisions can draw a lot of criticism and jeopardise the continuation of environmental programs.

One of the biggest challenges faced by developing countries is their inability to access the funds required to respond to environmental changes. Their governments often find it difficult to raise funds, as many of their people are **subsistence producers** who do not pay taxes.

In recent times, developed nations have faced their own economic dilemmas as national debts have increased as a result of the global financial crisis. Environmental programs are often cut to reduce government spending. Similarly, donations to NGOs may fall, as individuals become more cautious about parting with their money.

Social criteria

Fairness and equity are important, as success depends on community support. In reality, the costs and other impacts of management responses may not be spread evenly across a country. If they are thought to be inequitable, they will not be supported enthusiastically.

People can be made aware of how conservation and enhancement of forest ecosystems will improve their quality of life both now and in the future (see Figure 10.6.1). The extent to which local communities have been empowered to take ownership of the decision-making processes often determines the success or failure of management.

Trade-offs in decision making

Decision makers must attempt to balance environmental, economic and social criteria in environmental programs, and to determine the extent to which there can be trade-offs between them.

10.6.1 Services provided by healthy forest ecosystems



1 Storage of carbon in trees and soil



2 Pollination of plants/commercial crops



3 Decomposition of wastes



4 Provision of clean drinking water

A trade-off is a loss incurred in return for a gain, and is made with an awareness of the consequences. Management that protects the forest may result in financial costs such as lost production or restrictions on the use of the forest that may affect the quality of life of the people living there. Similarly, management that ensures a reasonable degree of equity for the people may have to sacrifice efficiency and cost-effectiveness.

For an individual landholder considering revegetating part of their property to create a belt of trees to encourage biodiversity, as shown in Figure 10.6.2, the trade-offs might result in the following gains and losses:

- gains: ecosystem services such as crop pollination, pest control, soil and catchment protection and carbon storage

- losses: land is taken out of production, thereby reducing the economic returns to the landholder. Costs are also incurred in purchasing tree seedlings and fencing off the area to keep stock out that may otherwise trample the seedlings.

The landholder has to weigh up short-term costs, which are mainly financial, against long-term environmental benefits that may guarantee the sustainability of production, both ecologically and economically.

Such choices about trade-offs must be made at every level of decision making. National governments and IGOs must debate the practical and ethical dilemmas of national and international conservation programs aimed at tackling environmental change. The challenge is to reduce poverty and provide a higher quality of life for those living in the forests of developing countries while safeguarding the environmental quality of those forests.

10.6.2 A landholder undertook revegetation of part of his property by creating a belt of trees. He was prepared to take land out of production for ecological benefits in the long term.



Improving the evaluation framework

Properly conducted evaluations enable more effective decision making in managing forest landscapes. Increasingly, scientific research and monitoring are being recognised as essential tools for effective evaluation (see Figure 10.6.3). Research into the functioning of forest ecosystems and the interconnections within them helps managers to gauge the impact, both immediate and future, of their actions. Research provides specific information about such processes, and monitoring shows if changes are occurring over time.

Conducting research and monitoring the condition of forest environments are crucial for determining the effectiveness of management responses and deciding if they need adjusting.

10.6.3 Scientific research and monitoring are essential evaluation tools.



SPOTLIGHT

The forests of Kosciuszko National Park

Kosciuszko National Park is renowned for its snow-covered alpine area where the climate is too cold for trees to grow. However, there are significant areas of forest at lower elevations within the park. In the steep country that falls away to the west, cool temperate rainforests are found in sheltered pockets, with drier sclerophyll forests on the lower slopes. Below the alpine area to the east, the snow gums of subalpine woodlands give way to expanses of tall forests of mountain gums and alpine ash.

In the 2006 Plan of Management for Kosciuszko National Park, the importance of monitoring, evaluation and reporting was emphasised:

Monitoring and evaluation are being recognised as essential components of park management. While research provides specific information on the park's values, monitoring is aimed at capturing baseline data, typically on the condition of these values,

and charting the nature and rate of change in condition over time. When collected and analysed in a systematic way, this information can provide the basis for evaluating the effectiveness of management policies and actions in achieving stated objectives. Adjusting and refining park policies and actions on the basis of monitoring results and the outcomes of performance evaluation produces an adaptive or responsive approach to management.

Existing monitoring programs in the park are primarily directed at detecting changes in alpine and subalpine vegetation communities, populations of certain threatened animals and threatened species, vegetation responses to fire, and water quality.

Source: Office of Environment and Heritage,
New South Wales

ACTIVITIES

Knowledge and understanding

- 1 Identify what are now increasingly regarded as essential tools of forest management.
- 2 List and explain the criteria for evaluating management strategies.
- 3 Define a 'trade-off' and outline some of the trade-offs that are made in the management of forests.
- 4 Explain why baseline data is important.
- 5 Explain how an adaptive or responsive approach to management can be achieved.

Applying and analysing

- 6 Write a short paragraph discussion of the following statement: *Managing environmental change in the world's forests can no longer be left to trial and error.*
- 7 Undertake a 'think, pair, share' activity to determine the most important evaluation criteria. What is the consensus of the class? Discuss the relative importance of each criterion and how decision makers must make trade-offs.



Inland water

CHAPTER

11

Life on earth depends on the waters of inland aquatic environments. These include flowing waters such as groundwater, creeks, streams and rivers; and standing waters such as lakes and wetlands. Some of these bodies of water are permanent, while others, such as intermittently flooded wetlands, are ephemeral.

Inland waters and wetlands not only meet the needs of humans, they also provide habitat for a variety of plant and animal species. Some animal species, such as fish and frogs, require water throughout their life cycle. Some may use aquatic areas for a specific stage of their life cycle, for example birds and amphibians. Still others may depend on aquatic ecosystems for resources such as food or as a corridor for movement. Under the right conditions, these environments can support large and spectacular breeding colonies.

INQUIRY QUESTIONS

- What are the main causes of environmental change in inland water environments?
- What are the impacts of the environmental changes taking place in inland water environments?
- What environmental management strategies are used to protect inland waters? Are these strategies effective?

While water is the driving force in nature, we often take it for granted. It is only when it is in short supply or rendered unusable that we really appreciate its worth.

In this chapter, we focus on environmental change and management using inland water environments as an example. Of particular interest are the causes and consequences of the changes taking place and an evaluation of the strategies being used to manage these changes.

GLOSSARY

aquiclude	an impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater	groundwater	water held underground in the soil or in pores and crevices in rock
aquifer	an underground layer of water-bearing permeable rock or unconsolidated materials from which groundwater can be extracted	hydrologic cycle	the circulation of water between the earth's oceans, atmosphere and land, involving precipitation as rain and snow, drainage in streams and rivers, and a return to the atmosphere through evaporation and transpiration
base flow	the portion of stream flow that comes from deep sub-surface flows, as distinct from groundwater flows; the flow that is largely independent of short-term variation in precipitation	overland flow	the water flow that occurs when the soil is infiltrated to full capacity and excess water flows over the land
ecosystem approach	a management approach that integrates the management of land, water and living resources in ways that promote conservation and sustainable use in an equitable way	sequestering	removing or withdrawing
fracking	the process of creating fractures in rock strata by injecting fluid into cracks to force them further open; the process allows more oil and gas to flow out of the rock strata and into a bore, from where they can be extracted	stream flow	the flow of water in streams, rivers and other channels; a major element of the water cycle
freshes	the sudden rise in the level of a river caused by heavy rain or melting snow	transboundary	crossing at least one political border, either a border within a country or an international boundary
		turbidity	a measure of water clarity that reflects the amount of material suspended in water
		water table	the level below which the ground is saturated with water

11.0 Dalyan Delta, near Mulga, Turkey, where silting has created a warren of reed-covered streams

The inland water environment

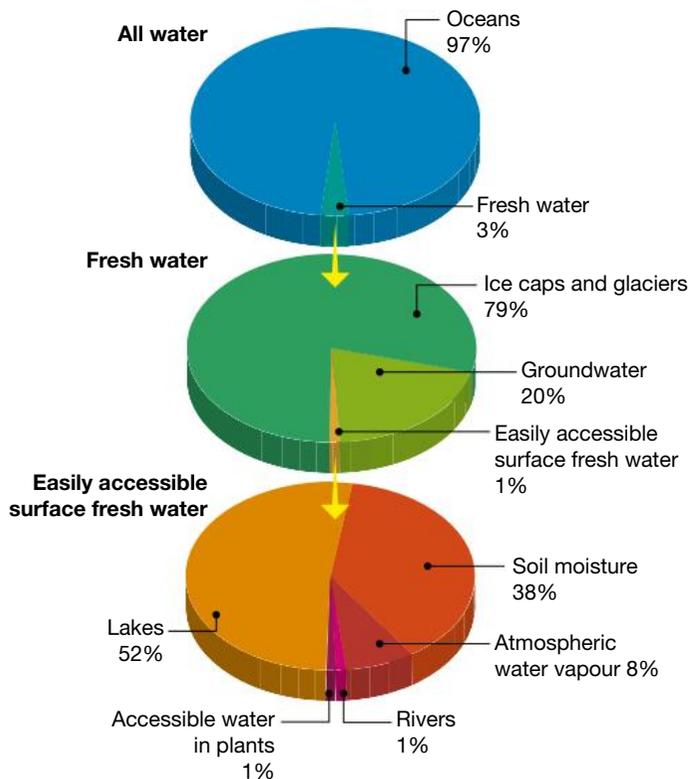
Inland waters

Inland waters are critical to life on land. They are part of wider landscapes that are rich in biodiversity and provide many services that sustain the earth's continuing productivity. Humans need water for their survival and use it extensively, withdrawing water from surface and ground-based sources, and as a means of disposing of pollutants. A decline in the health of inland waters is evident and must be addressed.

Elements and processes of the biophysical environment

Inland waters include springs, streams, rivers, ponds, lakes, flood plains, groundwater, cave waters and swamps and marshes. They are mostly fresh water, but in some areas are saline or a mixture of the two (brackish). All inland waters are part of the endless global circulation of water in the **hydrologic cycle**. Only 3 per cent of the world's water is found on land, and most of this is locked up in glaciers and ice caps, so the availability of fresh water is limited, as is shown in Figure 11.1.1.

11.1.1 Global water distribution



Types of inland waters

Inland waters are quite distinctive, especially in terms of where they are found in the landscape, and the manner and speed with which the water moves. Inland waters accumulate, either permanently or seasonally, in water storages above and below the land surface. Flowing water and still water are very different, as is the water that trickles through underground.

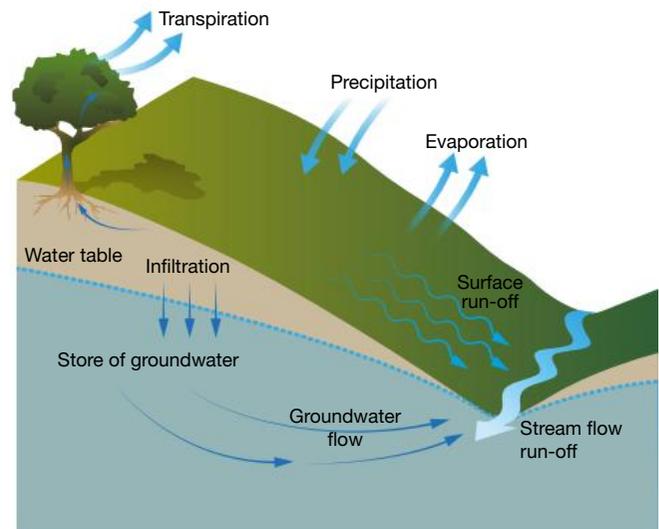
Much of the water that falls as precipitation returns quickly to the atmosphere through evaporation, or is transpired by plants. Some disappears under the land to become **groundwater**, while the remainder flows or accumulates as surface water, as shown in Figure 11.1.2. Both groundwater and surface water are closely interrelated. Water that runs across the land surface or collects upon it is the most visible and the most accessible to humans, and is considered the most important as a resource.

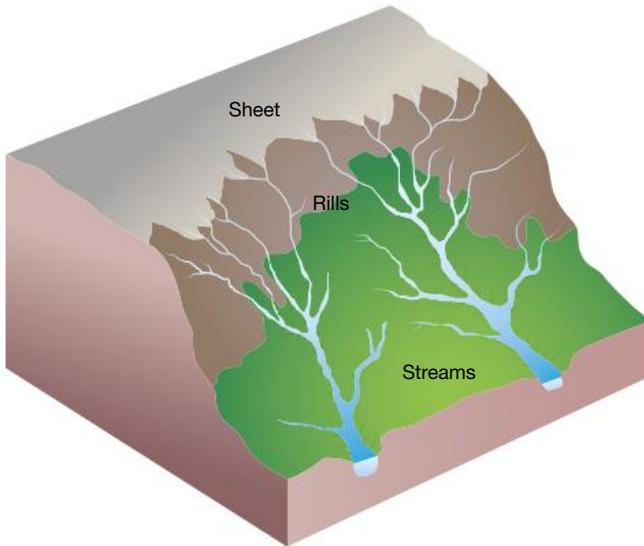
Surface water

RUNNING WATER

Surface water flow is called run-off. It may take one of two paths downslope—**overland flow** or **stream flow**. On a fairly smooth surface, overland flow can be seen as a sheet of water, but on steeper and rougher slopes the flow can be interrupted or broken, with the water concentrating in rills or rivulets, as shown in Figure 11.1.3.

11.1.2 Portion of the global water cycle showing water involved in the circulation over land areas





11.1.3 Movement of running water down a slope

Further downslope, the water concentrates in long, narrow channels or streams. The channel is the easiest path for the rapid flow of water and the load of sediment it carries. These channels or streams, which usually begin high up in hills or mountains, form the tributaries of rivers. Streams can vary enormously in width and length.

STANDING WATER

When surface water flows into natural dips on the land surface it can collect as still water in small shallow ponds or large bodies of deeper water known as lakes. Some lakes are the sources of rivers, and other rivers end in lakes. Australia is a continent with a sunken centre, and inland rivers such as the Barcoo and Diamantina drain towards Lake Eyre, which

is 15 metres below sea level. When rivers break their banks during a flood and spill out onto their adjacent flood plain, water can fill any depressions and sit there until it evaporates.

WETLANDS

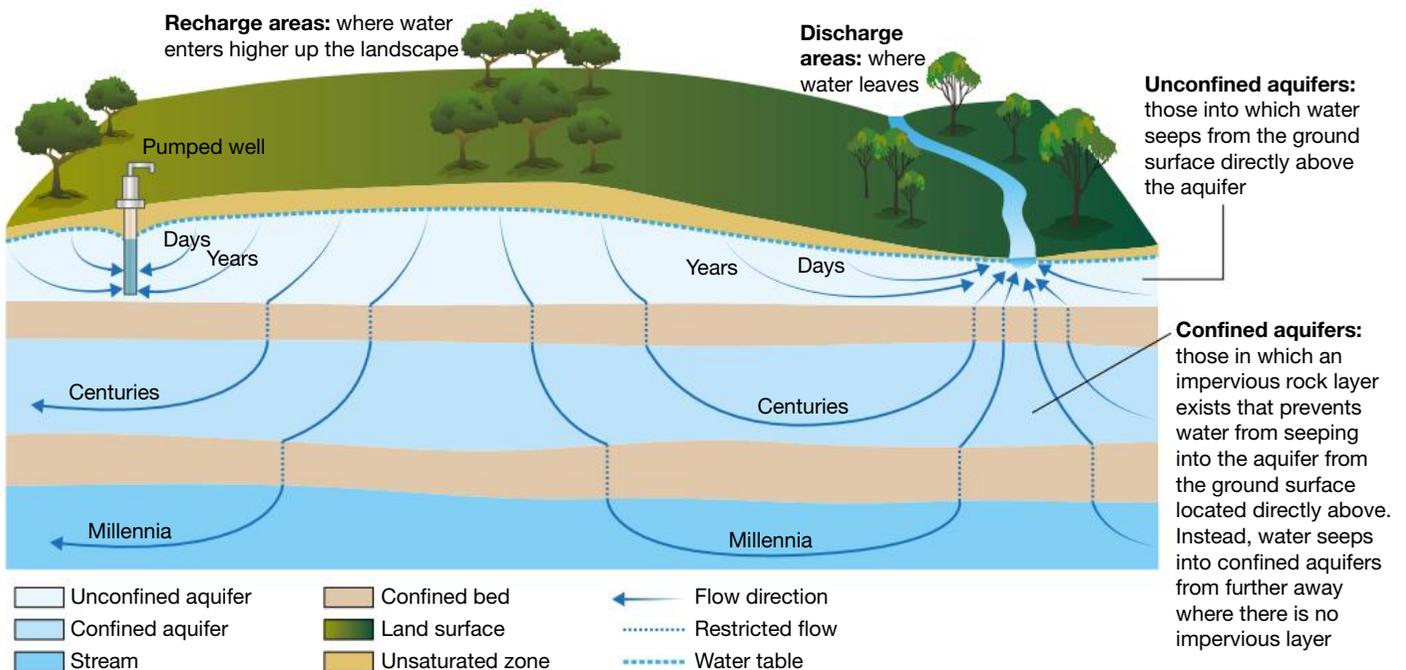
When shallow water permanently or temporarily covers any area of flat land, wetlands are created. The water in a wetland may be still or flowing, and fresh, saline or brackish. Wetlands such as swamps and marshes are found adjacent to rivers and lakes, and are characterised by water-saturated soils and aquatic plants.

Groundwater

When precipitation falls, it seeps into, or infiltrates, the soil and disappears below the ground. As gravity continues to pull the water downwards, it percolates or moves through the cracks and holes in porous rocks until it reaches impervious rock that stops any further downward percolation. Groundwater builds up in porous water-bearing rocks, forming an **aquifer**. Typically, water sits in tiny pores or spaces between the smallest rock particles in the aquifer. Its upper surface is called the **water table**.

Groundwater is recharged or replenished slowly when infiltrating rainfall or floodwaters seep down into the aquifers, in time scales ranging from years to millennia. Figure 11.1.4 illustrates groundwater flows. Eventually, all groundwater discharges back to the surface or the ocean.

11.1.4 Cross-section of two types of aquifers. An unconfined aquifer below the water table flows into a stream and is also drawn down in a well. Below that, two confined aquifers are renewed over much longer time scales.



Interactions and natural balances

Most of the water flowing down rivers comes from groundwater seeping into riverbeds. This is most visible in small streams higher up in the hills that are 'spring fed' as the water table reaches the surface. The most compelling evidence of this is that permanent rivers flow all the time, when months have gone by without a drop of rain or any overland flow into them. It is the constant, slow discharge of groundwater that sustains constant river flow. In many places where groundwater discharges naturally to the surface, bubbling into natural springs, it not only sustains these streams and rivers but also supports many other ecosystems, such as wetlands.

Rivers, lakes and wetlands are rich and diverse habitats. Even big rivers have quiet pools within them, and seemingly calm lakes have turbulent currents under the surface. Flowing water feeds into and moves out of bodies of still water. Inland waters are directly nourished from the land. As they move over the land they collect nutrients from fertile soil, as well as any leaf fall or organic debris that settles on the water surface. The nutrients are used by aquatic plants and continue to be recycled within the ecosystem. The shallow waters of wetlands are very conducive to life and are especially rich in biodiversity. They have complex, interrelated food webs, as can be seen in Figure 11.1.5.

Distribution and extent of inland waters

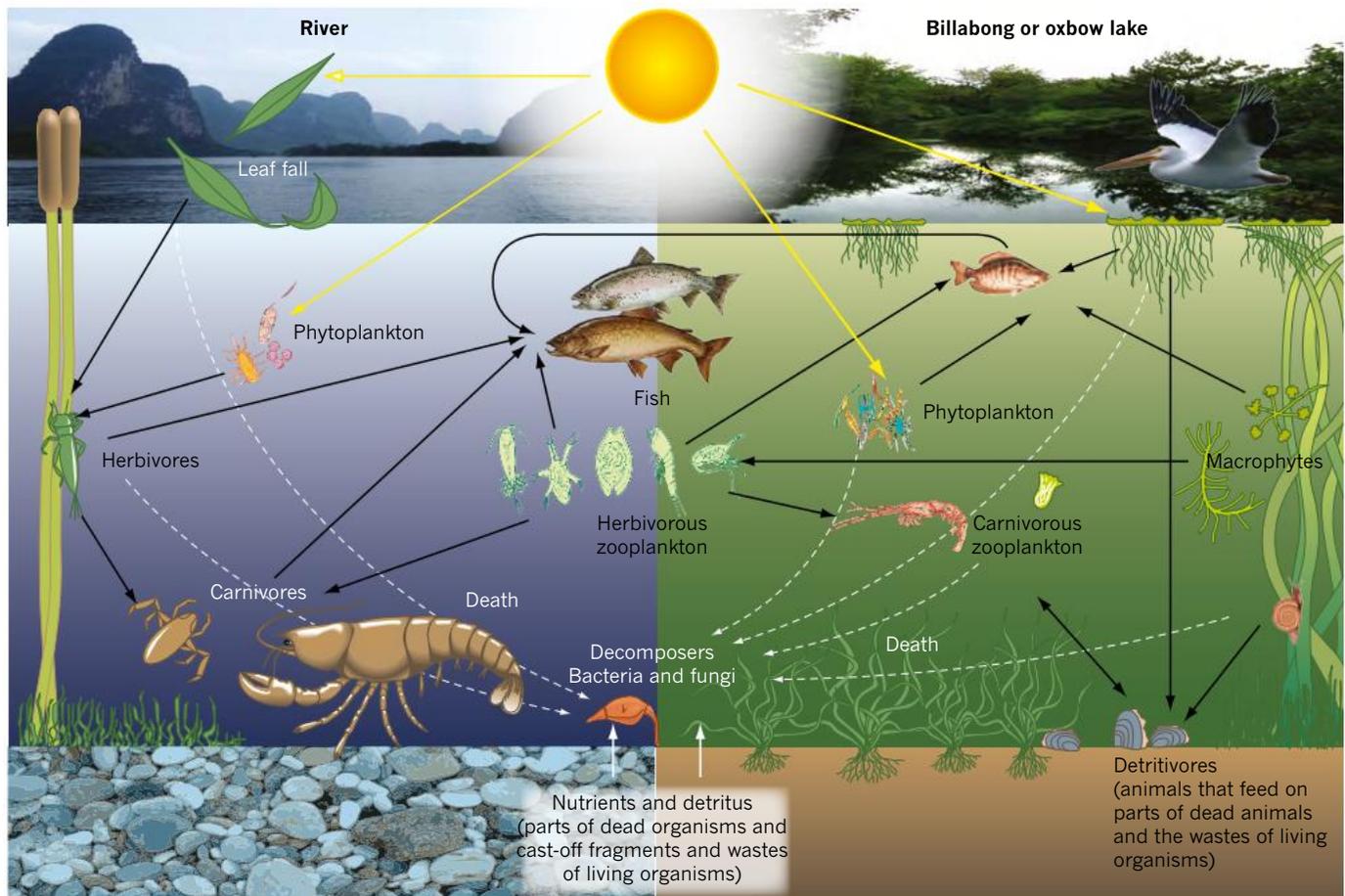
The planet's freshwater supply is virtually limitless in the sense that it is continuously recycled by the hydrologic cycle. However, it is unevenly distributed, with some regions being well watered and others having very little water. Australia is described as a continent with a wet rim and a dry interior.

Precipitation and run-off levels influence the distribution of river networks. Australasia contributes only 2 per cent of the world's fresh water discharged into the ocean, whereas over 30 per cent pours in from each of Asia and Latin America. There are estimated to be between 5 and 15 million lakes across the world, over 10 000 of them larger than a square kilometre. A disproportionate share of the larger lakes is found in North America, especially Canada, where glacial scouring created many depressions that have subsequently filled with water.

Inland water biodiversity

Water and biodiversity are interdependent. A disruption in either means a disruption to both. This is because all life depends on water. The hydrologic cycle not only drives the functioning of the biophysical environment, it also sustains life. Quite apart from the various processes of the cycle itself (such as precipitation, infiltration, surface run-off), water is

11.1.5 A billabong food web



fundamental to the physical and chemical processes upon which life depends. In turn, the storage, movement and transfer of the water are driven by physical attributes of the environment, which is a product of biodiversity.

Such interdependence can be seen in the following examples:

- Vegetation cover directly affects the rates of transpiration, evaporation, infiltration and run-off in a drainage basin. Slopes covered by forests readily absorb and capture water and maintain water quality by protecting soils from erosion.
- The flora, fauna and micro-organisms in inland waters play a significant role in purifying the water itself, by removing high levels of nutrients and contaminants.

Importance of inland waters

The major concentrations of the world's population demonstrate the importance of inland waters to humans. Fresh water is used in households, agriculture and industry. It is essential to our way of life and our economy. Water resources are an input in the production of almost all goods. Inland waters also support fisheries and tourism. Australia exports most of its agricultural produce and effectively supports a population of 67 million people globally.

Water environments have long held a deep spiritual value for Indigenous Australians. In a continent as dry as Australia, rivers, lakes and estuaries are also valued for their recreational opportunities and have become part of the national identity. Some people have a strong sense of place and quite an emotional attachment to iconic water environments, such as the Murray River.

Globally, inland waters are critically important for poverty reduction and the achievement of human development targets. Inland water biodiversity, especially inland fisheries, provides food security for millions of the world's poor. It is estimated that groundwater supplies drinking water for an estimated 1.5 to 3 billion people and, in most areas, groundwater is recharged through functioning wetlands. The rest of the world's population relies on the surface water provided by functioning freshwater ecosystems.

Ecological services

There are many important benefits derived from the ecological services provided by inland waters. These services include:

- habitats for terrestrial and aquatic species
- an extraordinarily high level of biodiversity, which includes not only life within the waters, but life that depends on inland water habitats.
- processing waste and absorbing nutrients, which keeps water clean
- flood management, as wetlands in particular absorb enormous amounts of water after extreme rain events
- climate regulation and carbon sinks.

SPOTLIGHT

Climate regulation and carbon sinks

One of the most important functions of wetlands is their role in the mitigation of global climate change through **sequestering** and releasing a major proportion of fixed carbon in the biosphere. Although peatlands cover only an estimated 3 to 4 per cent of the world's land area, they are estimated to hold 540 gigatonnes of carbon, representing 25 to 30 per cent of the carbon contained in terrestrial vegetation and soils.

Peatlands are made up of partially decayed, dead vegetation, which has accumulated over thousands of years. Peatlands are typically covered with water but are increasingly being cleared and drained to make way for plantations—palm oil, pulp and paper. When the peatlands dry out they are vulnerable to fires. In Indonesia, where peatlands have been cleared, forest fires have become a catastrophe. A study in 2012 attributed an average of 110 000 deaths a year to forest/peat fires in South-East Asia.

ACTIVITIES

Knowledge and understanding

- 1 Describe inland waters.
- 2 Identify the paths that water may take after it falls on land as precipitation.
- 3 Describe a wetland.
- 4 Explain why rivers continue to flow long after rain has fallen.

Applying and analysing

- 5 Study Figure 11.1.3 and describe how water flows down a slope to a river in a drainage basin.
- 6 Study Figure 11.1.4 and answer the following questions.
 - a Which type of aquifer is in more danger of contamination? Give reasons for your answer.
 - b Which aquifer is safer to drill into for a drinking water well?

Investigating

- 7 Research carbon sequestration in peatlands to determine why peatlands are so effective in storing carbon. Prepare a poster promoting the protection of peatlands.

Causes of environmental change

The condition of inland waters

Humans change almost all aspects of inland waters and the landscape they are part of—shifting water around for different uses, overusing and polluting it, and degrading the environment that supplies it. Globally, inland waters are being modified by human activities and they are in serious decline, due largely to the pressures placed on them by their various users.

Over half the world's largest river systems have been moderately or extensively modified by dam construction, flow regulation and water extraction. Over half the world's wetlands have been lost. Freshwater populations of vertebrate species were reduced by 50 per cent between 1970 and 2005. This is a sharper decline than has been observed in marine or terrestrial ecosystems.

Australia does not have a comprehensive account of the distribution or condition of its freshwater ecosystems. Major loss of habitat has been observed, but the exact loss of ecosystem values and species cannot be accurately reported. We do know that in the 40 per cent of the continent that has been most intensively used, over 85 per cent of the rivers have been degraded by human activity.

In the Murray–Darling Basin, twenty of the twenty-three rivers have been rated as being in poor or very poor ecological condition (see Figure 11.2.1). Populations of native fish have declined significantly over the past five decades, with fish communities currently reduced to about 10 per cent of their

pre-European levels. More than half of the thirty-five native fish species in the basin are considered threatened or rare. Exotic (introduced) species make up 56 per cent of the total fish biomass in the lower catchment.

According to the Commonwealth Scientific and Industrial Research Organisation, approximately 50 per cent of Australia's wetlands have been lost to other uses, including 90 per cent of the flood-plain wetlands of the Murray–Darling Basin, 50 per cent of coastal wetlands in New South Wales and 75 per cent of wetlands on the Swan Coastal Plain in the south-west of Western Australia.

Humans and inland waters

Disturbance and regulation of water flows

The demand for water has exploded over the last century, and the extraction, storage and diversion of water have significantly changed the distribution and movement of both surface water and groundwater. People have been altering rivers for thousands of years, but the scale of modifications has escalated. Most of the world's major river systems have been regulated; that is, they have dams, weirs, inter-basin diversions, canals and irrigation channels.

11.2.1 Monoman Creek, Chowilla flood plain, South Australia, during the millennium drought (circa 2000), with dying red gums and a blue-green algal bloom





11.2.2 Warragamba Dam, Sydney. The concrete barrier of the dam has been built across the river to impound its water.

Dams, such as the one in Figure 11.2.2, are the most significant form of river regulation. They capture and store river water and hold it until it is released to downstream users, giving water security to those in urban centres (for drinking water and industry) and on the land (for irrigation and stock water). Dams safeguard against extremes of both drought and flood in regions susceptible to unreliable rainfall. Dams also have the capacity to catch and hold back excessive run-off that would otherwise cause severe flooding problems downstream. Levees are constructed along the banks of rivers to contain floodwaters within river channels so they do not inundate flood plains. Embankments have also been built along rivers to improve navigation, as rivers are a major means of transportation.

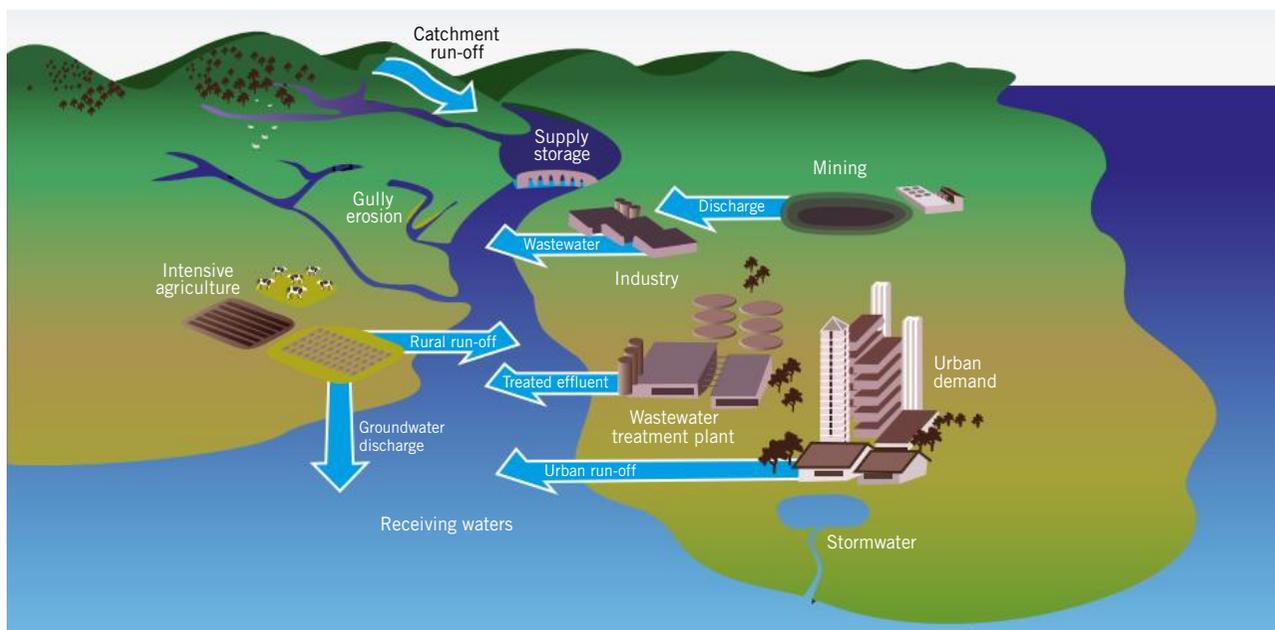
Deterioration of water quality

Over the past four decades, the contamination of water by toxic chemicals and the excessive loading of nutrients has contributed to the degradation of inland waters, as shown in Figure 11.2.3.

DID YOU KNOW?

A drop of oil can make 25 litres of water unfit for drinking.

11.2.3 There are many potential sources and pathways of pollutants in water bodies.



Source: *Water: Science and Solutions for Australia*, CSIRO, 2011



11.2.4 Water hyacinth is a weed that floats in a mass, covering waterways and causing the water underneath to putrefy.

TOXIC CHEMICALS

Over 200 000 human-made industrial and household chemicals are commonly used in Australia. They can enter waterways in run-off from cities and agricultural areas, wastewater discharge from industry and sewage works, and even settle on the water surface from the air above. Pesticides, herbicides, insecticides, polychlorinated biphenyls and petroleum hydrocarbons are all found in waterways. At worst, industrial accidents such as major chemical spills can have devastating consequences.

Another concern is the seepage of chemicals into aquifers. Contaminated rivers may be flushed clean after a big rain event, but aquifers are not, because groundwater movement is so slow and there is no dilution of the contaminants.

NUTRIENT LOADING

Sewage is the largest and most common cause of poor water quality in inland waters. Up to 90 per cent of sewage in the urban areas of poor developing countries flows untreated into waterways. Not only does sewage add excess nutrients to waterways, but it may also carry dangerous pathogens or disease-causing organisms such as bacteria and viruses. The rivers downstream of the largest cities are often little cleaner than an open sewer.

The excess application of fertilisers can load run-off with concentrations of phosphorus and nitrogen. Nutrient loading is projected to become an increasingly severe problem for inland waters.

SEDIMENT

Deforestation, overgrazing and ploughing have caused a massive acceleration of erosion in many catchments. Overland flow has carried the sediment into waterways. Nutrients are attached to the soil particles, compounding the problem of nutrient loading.

Pests and invasive species

The introduction of exotic species rates second to habitat degradation in causing freshwater species extinction, as the invasive species can become the dominant life form in an inland water environment. The water hyacinth was found in the upper reaches of the Amazon in the mid-nineteenth century and taken all over the world as an ornamental plant. It is now considered one of the worst aquatic weeds on the planet, infesting rivers, lakes, dams and channels on all continents apart from Antarctica. It quickly extends its range, choking waterways and reducing the availability of light and oxygen to other organisms (see Figure 11.2.4).

The global spread of exotic species has increased with the expansion of global commerce, shipping and aquaculture. Exotic fish introductions have eliminated or reduced the populations of native fish. Carp is a large freshwater fish native to central Asia. Introductions in many countries have helped to make carp the most widely distributed freshwater fish in the world. It is extensively farmed in Europe, Asia and the Middle East, and is a popular angling fish in Europe. However, in North America, Canada and Australia, carp is considered a significant pest.

Climate change

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

- reduced river flows and changes in seasonality of flows
- changes in species composition and community structure (such as loss of cool-adapted aquatic species)
- reduced availability of areas for waterbird breeding
- saltwater intrusion into freshwater bodies (through sea-level rise)
- changes in water quality, eutrophication levels and the incidence of blue-green algal outbreaks.

Changing inland water environments

Inland water environments have been sustained by the cycling of water in the hydrologic cycle. Altering the flow regimes of both surface water and groundwater, as well as changing the physical and chemical properties of the water, have affected the biophysical processes that sustain these environments.

Altered flow regimes in rivers

If the functions of inland water ecosystems rely on the availability of water, then moving water away from them will affect their biophysical processes. The construction of dams and weirs to control river flow interrupts the downstream movement of water and sediment.

- Dams change the pattern of the flow of a river, both lowering its overall volume and altering its seasonal variations. A more regular flow of water replaces the peak and low flows associated with normal variations in the climate. This can cause the ecological web in a river system to unravel, as species cannot adapt.
- All parts of inland water landscapes can be affected by changes to flow regimes. Flood-plain ecosystems such as wetlands are closely tied to a river's flooding cycle, as the river replenishes them with water and nutrients. Many aquatic species depend on the variations in flow for reproduction, hatching, migration and other important life-cycle stages.
- Above the dam wall, the free-flowing river ecosystem is transformed into an artificial slack-water reservoir habitat. This alters many of the physical and chemical properties of the water held there, such as temperature and dissolved oxygen levels. These new conditions may not suit the native species that evolved in the river and they suffer.
- The dam wall itself blocks fish migrations, so fish downstream can no longer reach their spawning areas.
- The dam wall holds back sediments that would naturally replenish ecosystems downstream.

Excessive extraction of groundwater

Some aquifers are replenished after rain when water seeps through soils or leaks out of gravelly riverbeds. However, most of the largest groundwater storages hold ancient water from wetter times, millions of years ago. They are hidden deep below the ground and have complex geological patterns that are not well understood. It is especially difficult to measure or even estimate the amount of recharge and yet knowledge of this is what should guide extraction rates.

Aquifers are being depleted, resulting in falling water tables and lower aquifer pressures. The problem is that there can be considerable time lags, even running into decades, before the

consequences of over-pumping are realised. Given that many inland water environments depend on groundwater, their needs play a key part in determining sustainable groundwater extraction rates.

Irrigated agriculture is now the largest consumer of groundwater, with 40 per cent of all cultivated land dependent on wells and bores. The countries with the biggest groundwater use are India (39 million hectares) and China (19 million hectares). Where aquifers lie under deserts, the groundwater has often been pumped to the surface and transformed the landscape, as in the case of Israel and California.

SPOTLIGHT

Do rivers all reach the sea now?

Some of the world's greatest rivers no longer reach the sea for much of the year. The Nile flows out of the Mountains of the Moon in East Africa, recharges in Lake Victoria, and crosses the Sahara through Sudan and Egypt via the High Aswan Dam before giving up the last of its water just short of the Mediterranean Sea. Even in the monsoon season, every last drop of water is usually extracted before the Nile has the opportunity to pass through its delta.

The Yellow River in China, having watered the cities and fields of half a billion people, is a trickle by the time it encounters sand bars at its mouth.

The Indus in Pakistan, the Euphrates in Iraq, the Rio Grande on the border of the United States and Mexico, and the ancient, once mighty Oxus of Central Asia all appear on maps as flowing into the sea. But the maps are one thing; the reality is often quite different.

ACTIVITIES

Knowledge and understanding

- 1 Assess the condition of Australia's inland waters.
- 2 Describe how surface water flows are disturbed and regulated.
- 3 Identify the sources of pollution in inland waters.
- 4 Explain how exotic species change aquatic ecosystems.
- 5 Describe the impact of dams on rivers.

Applying and analysing

- 6 Complete the following task. *I used to think that there would always be plenty of fresh water available. Now I think ...*
- 7 Conduct a class debate on the following topic. *Big dams are appropriate for Australia.*

Water flow and environmental health

Inland water and sustainability

The sustainability of inland waters depends on habitats supporting a stable and diverse mix of species. Altering the water flow changes the population of the producers (water plants and algae), which then affects the population of dependent species higher up the food chain. All these species need to maintain viable, suitably dispersed populations, or they are at risk of extinction.

Water needs of rivers

The distinctive flow patterns of rivers create a variety of habitats: **base flows** are slow and steady; **freshes** are rises of water level with faster currents, but with flows contained within the channel; flood peaks spread beyond the riverbanks to recharge flood plains and wetlands and reconnect them with the river. These are illustrated in Figure 11.3.1.

Water needs of flood plains and wetlands

Floods that spill out over flood plains bring with them a nourishing load of sediment. They also recharge shallow, unconfined aquifers, which can continue to feed into wetlands. This connection between the river and its flood plain is vital for life to continue in these watery habitats.

Different species are adapted to different flooding frequencies and depths. In the Murray–Darling Basin, for example, river red gum forests are found where floods occur typically every 1 to 5 years. If flooding does not occur at regular intervals, the red gum forests suffer extreme stress.

SPOTLIGHT

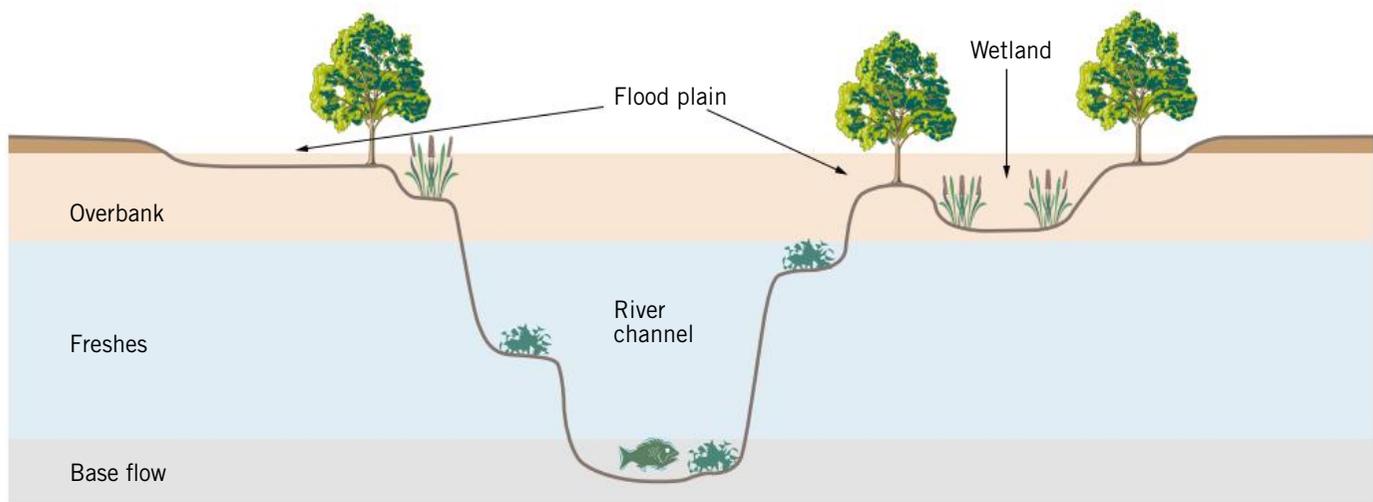
Ngurunderi's story

One of the main Dreaming stories telling of the creation of the River Murray is that of Ngurunderi, the all-powerful ancestor of the Ngarrindjeri people. Ngurunderi's long journey to the Coorong created the Murray and its landscape.

While there are several different recounts of Ngurunderi's story, the common theme is his long chase of the Murray cod (Ponde), towards the River Murray's mouth. As Ponde swam to escape Ngurunderi's spear, the wide sweeps of his tail widened the river and created its bends and turns. At last the giant fish arrived at Lake Alexandrina, where it foundered in the shallows.

With the help of Nepele (the brother of Ngurunderi's wives), Ponde was speared in the Lake. Ngurunderi divided the fish with his stone knife and created a new species of fish from each piece.

11.3.1 Different river features are inundated at different levels of flow. Overbank flows inundate flood plains and wetlands, and freshes fill much of the river channel with fast-flowing water.



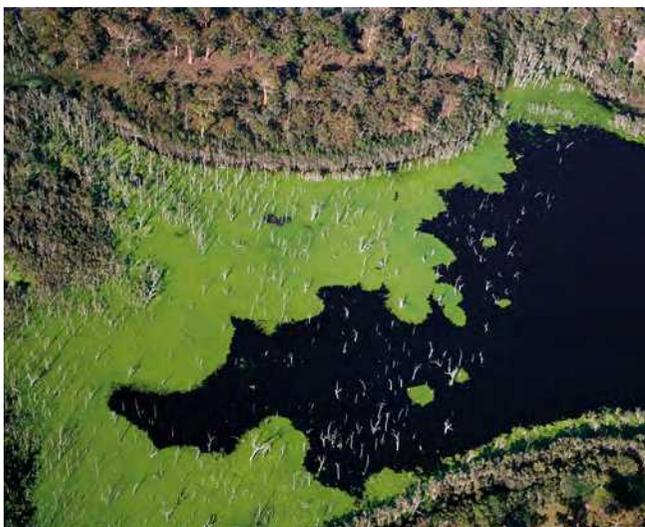
Source: *Water: Science and Solutions for Australia*, CSIRO, 2011

Water quality and ecosystem functioning

Changes in flow regimes are often accompanied by more pollution and sedimentation, which can lead to a significant loss in ecological functioning, such as the following.

- **Eutrophication** Algae occur naturally in inland waters and play an important role as producers. However, when the water becomes enriched with nutrients such as nitrogen and phosphorus, the algae grow rapidly in blooms and disrupt ecosystem functioning by covering water surfaces. They prevent light penetration by using up the oxygen in the water and they excrete toxins. Blue-green algae, or cyanobacteria, are especially poisonous when their cell walls rupture (see Figure 11.3.2).
- **Sedimentation** Sediments are transported by surface flow in rain events and are deposited when the flow wanes. They can cover and smother aquatic plants, preventing them from photosynthesising, which affects the food chain. Even while the sediments are in suspension in the water, they have an impact on ecosystem functioning, as they absorb heat. This increases the temperature of the water and, as it warms, the water loses its ability to hold dissolved oxygen. Deposited sediment can also become stirred up and re-suspend, releasing both nutrients and contaminants into the water.
- **Biomagnification** Biomagnification is a problem in aquatic ecosystems that are polluted by toxic substances such as heavy metals. At successively higher levels of the food chain, these substances become more concentrated. As a result, organisms at the top of the food chain generally suffer greater harm from a persistent toxin than the levels below.

11.3.2 Blue-green algae at Chaffey Reservoir near Tamworth, New South Wales



SPOTLIGHT

Tarmgaeddon

As conventional sources of oil are limited, the tar sands in the Canadian wilderness are being exploited. The tar sands, which now produce more than 1.3 million barrels of oil a day, are located in the largely untouched boreal forest of Alberta, and cover 140 000 square kilometres.

Tar sands are sludgy deposits of oily soil. To extract the oil requires enormous quantities of energy and several stages of industrial processing, which creates poisonous tailings ponds. In 2008, 1600 ducks accidentally landed on one of these and all died instantly. This mining activity occurs above Canada's biggest aquifer, and there is no guarantee that there will be no contamination of the aquifer.



11.3.3 Alberta tar sands

ACTIVITIES

Knowledge and understanding

- 1 Identify the various types of flows within rivers.
- 2 Explain why it is vital to maintain the link between a river and its flood plain.
- 3 Define the terms 'eutrophication' and 'biomagnification'.
- 4 Explain how high levels of sediment in surface flows have an impact on inland water environments.

Applying and analysing

- 5 Create a KWL chart about tar sand extraction in Canada.

Managing inland waters

Worldviews and environmental management

Humans must work towards a better understanding of how water can be managed, so that it will continue to meet both the needs of humans and the ecosystems on which they depend. Securing adequate fresh water has always been at the forefront of people's interactions with the environment, because without water they cannot exist. Yet there have been very different approaches to such interactions, reflecting the worldviews of those involved.

Human-centred worldview

For people with a human-centred worldview, water has become a commodity. It is to be extracted, exploited and traded. Gone is the spiritual connection with water and an appreciation that it is an ongoing giver of life. Water is an input into the vast range of economic activities to produce the food and all the commodities people want in order to secure what they believe to be higher standards of living.

The demands on inland waters include household drinking water and water for cooking; personal hygiene and sanitation; irrigation and other agricultural uses, such as watering

stock; industrial production for such purposes as fabricating, processing, washing, diluting, cooling and being incorporated into products; fisheries and aquaculture; waste disposal, whereby waterways carry away residuals from processes of human production and consumption; and recreational uses such as swimming, boating, waterskiing and angling.

As populations and economies grow, national governments invest heavily in water infrastructure to increase the availability of water. For more than 4000 years, dams and reservoirs have been constructed across rivers to collect and store vast amounts of water and then manage releases into rivers to meet the ongoing needs of people. Many of these dams are still in operation today. A human-centred worldview is exemplified in river basin diversion projects, when water is moved from one river basin to another for better utilisation by humans.

SAN JUAN-CHAMA PROJECT

The San Juan-Chama Project (Figure 11.4.1) consists of a series of tunnels and diversions that take water from the drainage basin of the San Juan River—a tributary of the Colorado River—to supplement water resources in the Rio Grande watershed. The project delivers water for irrigation and municipal water

11.4.1 San Juan-Chama Project, New Mexico and Colorado, USA



supply to cities along the Rio Grande, including Albuquerque and Santa Fe. Such schemes divert vast amounts of water, taking much of the natural flow away from one basin purely to meet the demand for water of people living in another.

Where countries share river basins, **transboundary** issues of water quantity and quality may arise and conflicts can occur. Future wars could well be fought over control of this critical resource, just as they were over Gulf oil in the twentieth century.

SPOTLIGHT

The Bontoc people of the Philippines

The Mountain Province is a landlocked region on the island of Luzon in the north of the Philippines. It is characterised by a belt of volcanoes from which arose a large mountain range known as the Central Cordillera. The region is dissected by a number of swift-flowing streams that carry the heavy rains of the summer monsoon. The Bontoc are a highland tribal group who have lived on the banks of the Chico River for centuries.

The Bontoc are agriculturalists and support themselves by growing rice, corn, coconut, sugar cane, bananas, pineapple, coffee, mangoes, tobacco and abaca (a banana-like plant). Securing their food supplies is only possible with careful management of water resources. They are fortunate to live in a tropical climate with constant high temperatures that are favourable to plant growth. The soils are also particularly fertile, as they are derived from volcanic rock and have a rich mix of nutrients. There is little flat land available, as 83 per cent of the region is mountainous, but the Bontoc overcome this by cutting terraces into the hillsides, creating level fields to cultivate. While plenty of rain is brought by the summer monsoon, the Bontoc have had to cope with a dry season from December to February.

The Bontoc's stewardship worldview guides their water management practices; they believe that humans are at one with nature and can never be above it. Nature is viewed as the source of all life and as such it is respected and nurtured.

The Bontoc live by the principle of communal ownership, whereby equity and cooperation are a priority. A foremost consideration in their water management is ensuring that water is equally distributed to all rice-field owners in the dry season. Through a cultural irrigation practice known as *oblis*, they take turns in watering their rice fields in the dry season.

Water sites (springs, rivers and lakes) are considered sacred places, and rituals and ceremonies are performed to express respect for and devotion to the spirits that guard their water. In return, the spirits bestow abundant and clean water on the people. There are also myths that warn of conflict over water.

The Bontoc's approach to water management is holistic, linking the forests and the mountains with their water. The very old practice of terracing prevents soil erosion and maintains the forest watersheds. The Bontoc mastered the

ancient stone walling techniques, using stones they hauled up from Chico River. The stone walls hold back water, and so the terraced fields act as reservoirs, which are used to water crops in the dry season. The standing water has altered the microclimate in the area, as more evaporation results in more local rainfall. The Bontoc also have taboos forbidding disturbance of any springs or forests in catchment areas.

Today, the Bontoc have by choice retained most of their traditional culture. The Bontoc society possesses a wealth of traditional knowledge that sustained their water resources through centuries. The Bontoc municipal government has a more human-centred worldview and has adopted a modern bureaucratic approach to managing the water resources of the Central Cordillera. Officials are concerned that the once clean and reliable supply of water is becoming murky and depleted and there is a potential water crisis.

There are other pressures on the mountains, as the Central Cordillera not only has mineral resources, but the region also holds enormous potential for hydro-electric production. At least 5 million kilowatts of power could be generated if its rivers were dammed, which would provide over half of all of the electricity needs of the Philippines. If the rivers were dammed, the Bontoc lands would be flooded and the people displaced.



11.4.2 The Bontoc are particularly adept at rice terrace farming.

Stewardship worldview

Water is central to the cultural and spiritual values of many indigenous communities. In many instances, indigenous people regard water not merely as being essential for human survival, but as an important part of their spiritual wellbeing. Water is an important part of the Australian Indigenous Dreamtime narratives used to explain the creation of the world and natural features of the environment. Significantly, indigenous knowledge systems are based on the principles and practices that balance their immediate needs and the needs of the environment, people and other living things, as well as the needs of future generations.

In Australia, inland waters not only provided Indigenous people with drinking water, they were also a particularly bountiful source of food—not just fish, but also the animals that were drawn to waterholes and streams to drink. Water was also taken from wells and rivers to irrigate crops.

Indigenous people developed successful systems of water management. Underlying this was the acceptance of a communal need to be at one with nature, and a recognition that water resource management was the responsibility of every person. As a consequence, they employed the principles of sustainable management, ensuring the ongoing supply and quality of water.

ABORIGINAL PEOPLE OF THE MURRAY-DARLING BASIN

The traditional owners of the lands in the Murray-Darling Basin have deep cultural, social, environmental, economic and spiritual connection to their lands and waters.

Aboriginal people have lived in the basin for thousands of years and there are at least 10 000 known water-related Aboriginal sites in the basin. The rivers and flood plains are of particular importance. Today there are over forty Aboriginal Nations in the Murray-Darling Basin.

The lands of the Murray-Darling Basin provided the region's Aboriginal people with a diverse and abundant source of food, water and shelter (see Figure 11.4.3). Shell middens of freshwater mussel shells, together with bone remnants of wallabies, yabbies, lizards, fish and birds, give us an insight into the diet of Aboriginal people.

The Aboriginal people still talk about how the waters of the basin sustain their life and identity. They view themselves as an integral part of the river system, and as a result they feel a responsibility to ensure the health of rivers.

Earth-centred worldview

Inland waters and the sediments they carry are integral to the processes that support ongoing life on land. Exploitative extraction or pollution of these waters compromises these processes and the resulting environmental changes can be disastrous. People with an earth-centred worldview have been more active in protecting inland waters than other environments. The importance of maintaining the supply of fresh water is evident, but it may well be that lakes and rivers evoke strong feelings in those who believe that the integrity of such natural places must be protected.

One of most direct interventions by an individual with an earth-centred worldview was the purchase by former

11.4.3 Low stone-walled fish traps once used by Aboriginal people for catching fish in the bed of the Barwon-Darling River





11.4.4 Lake Barombi Mbo, south-west Cameroon

businessman Douglas Tomkins of 32 000 square kilometres of land in Chile to protect the lakes, forests and mountains from exploitation for power generation, industry and agriculture. He established Pumalin Park, which is now recognised by the Chilean government as a nature sanctuary, despite the government's early efforts to promote the development of the region.

Most people with an earth-centred worldview do not have the financial resources to accomplish what Douglas Tomkins did, but they can bring about change that provides protection for inland waters at risk. They can pressure governments to be more mindful of the natural values of inland waters and the importance of these values in sustaining those waters. Protection can be sought under the intergovernmental Ramsar Convention.

Ramsar Convention

The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem. The convention uses a broad definition of wetlands, including lakes and rivers, swamps and marshes, wet grasslands and peatlands.

The convention's mission is 'the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world'. Lake Barombi Mbo (see Figure 11.4.4) is a small crater lake in Cameroon, Africa. It is especially important because it is an area where speciation (the process of evolutionary adaptation) has been proven to take place. It is at risk from pollution, overfishing and sedimentation, and it has been nominated as a Ramsar site so that it can be protected.

ACTIVITIES

Knowledge and understanding

- 1 Describe the way in which many indigenous people view inland waters.
- 2 Explain how the Bontoc people managed their water resources in a sustainable manner.
- 3 Outline the demands on inland water by people with a human-centred worldview.
- 4 State the mission of the Ramsar Convention.

Geographical skills

- 5 Refer to Figure 11.4.2. Construct a photo sketch and label the main features. Explain how terracing is carried out and how it benefits the mountainous environment.

Applying human-environment systems thinking

Aim of water management

The aim of managing water resources is to safeguard human access to quality fresh water while maintaining sustainable aquatic and associated terrestrial ecosystems. Human-environment systems thinking provides a useful framework for developing effective and sustainable water management practices.

Assessing the state of an environment

To manage inland waters it is important to assess the current state of the environment and how it has changed over time. In assessing the state of an environment, it is useful to use the following questions to frame the inquiry.

- 1 State of water
 - What is the water quality? (An assessment based on the ecological quality of the water and levels of nutrients, pesticides and heavy metals)
 - How much water is there? (An assessment based on data on run-off, availability, demands and any evidence of water stress)
- 2 Time-based trends
 - Is water quality getting better or worse?
 - Is the amount of water increasing or decreasing over time?
- 3 Is there a problem, and if there is, what is causing the problem?
 - Humans and their domestic-based uses?
 - Industry?
 - Agricultural uses?
- 4 Are there policies in place to work on solutions?
 - Have aims and targets been decided upon?
 - Who has been employed to work on solutions?
 - Has a time frame been implemented?

The state (type, quality and quantity) of water is determined by natural factors such as geology and climate and also by the pressures exerted by human activities. For example, geology will influence the amount of mineral material in water, while agriculture is a significant driver in terms of ecological quality, nutrient and organic pollution, hazardous substances and water quantity.

The European Environment Agency (EEA) applies human-environment systems thinking, acknowledging that humans have an impact on the biophysical environment, and applies the DPSIR (drivers–pressures–state–impact–response) framework to water issues. The analytical DPSIR framework allows a comprehensive assessment of the issues through examination of the relevant driving forces and pressures on the environment. The use of this framework to assess water quantity and quality is illustrated in Figures 11.5.1 and 11.5.2.

Management strategies

Much of the pressure on inland water environments is a legacy of the past and a human-centred worldview: the impounding of rivers, the drainage of wetlands, the clearing of native vegetation in catchments and the introduction of pests and invasive species. Given the magnitude of such changes, and the recognition that they cannot be reversed, these pressures remain. This makes the choices made now even more important if inland water landscapes are to be managed more sustainably and restored.

The challenge ahead is to rehabilitate and protect inland water environments while enabling sustainable use of water resources. Humans cannot do without water, and with their increasing numbers they are going to want more of it. This comes at a time when it is clear that more water needs to be given back to the environment to restore natural balances—otherwise the quantity and quality of water in the future will be compromised, not just for humans, but for all life. The biodiversity of inland waters is the evolutionary capital for continued productivity. This is especially important given the threats associated with climate change.

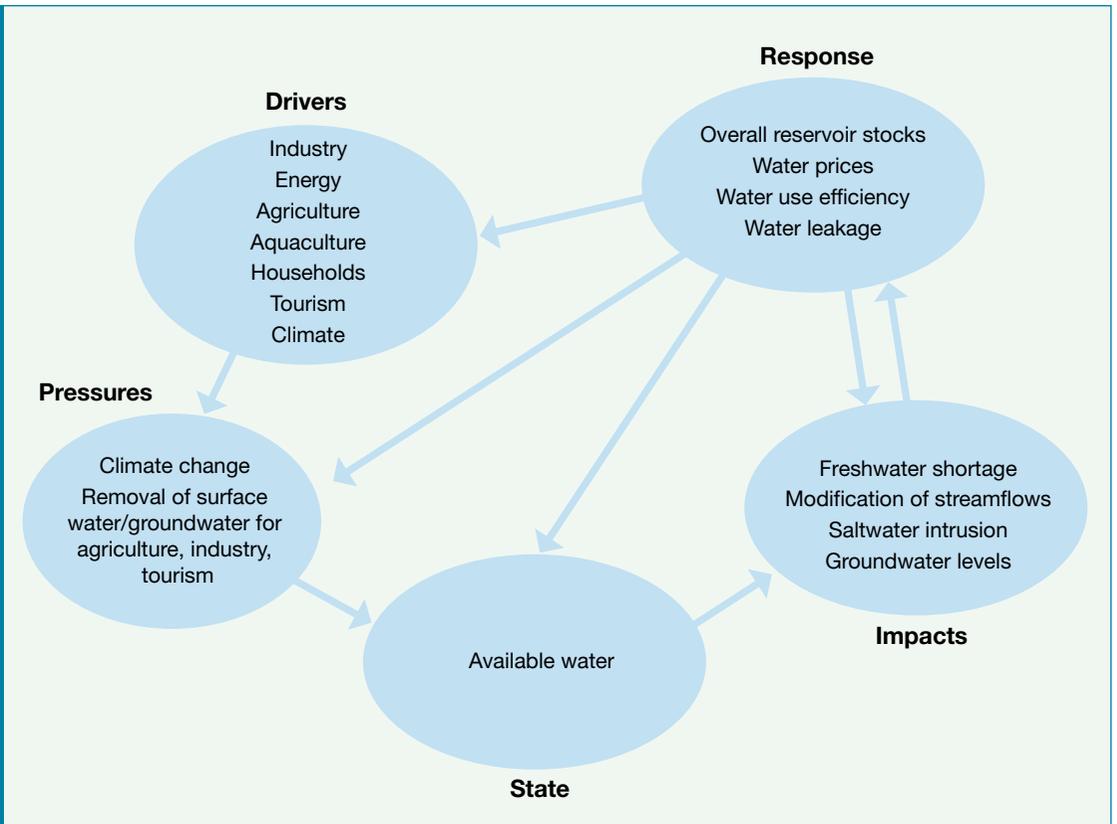
Ecosystem approach

The **ecosystem approach** to inland water management integrates the management of land, water and living resources in ways that promote conservation and equitable sustainable use. The ecosystem approach calls for the focus to be on the ecosystem: its components, structure, processes and functions and all the interactions that occur among its organisms and their environment.

11.5.1 A DPSIR framework for managing water quantity

Water quantity

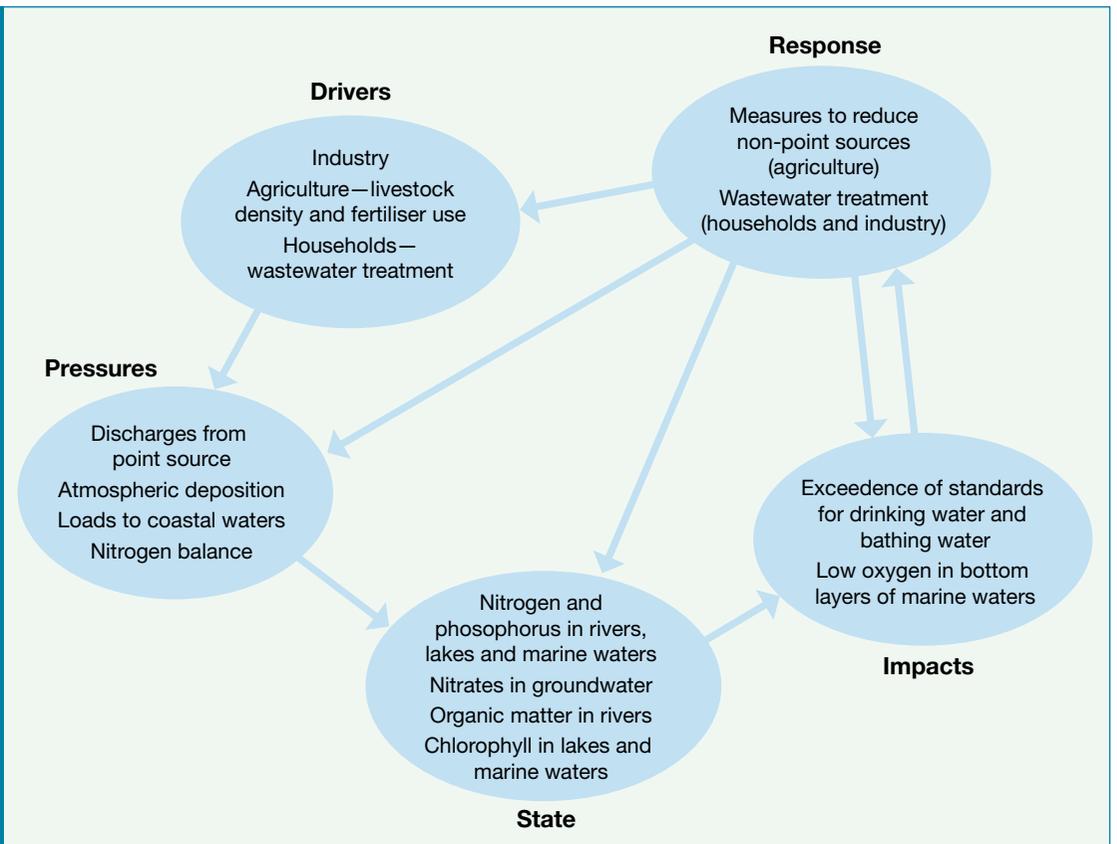
Water availability problems occur when the demand for water exceeds the amount available during a certain period. Fresh water shortages occur frequently in areas with low rainfall and high population density and in areas with intensive agricultural or industrial activity.



11.5.2 A DPSIR framework for assessing water quality—organic pollution and eutrophication

Water quality—organic pollution and eutrophication

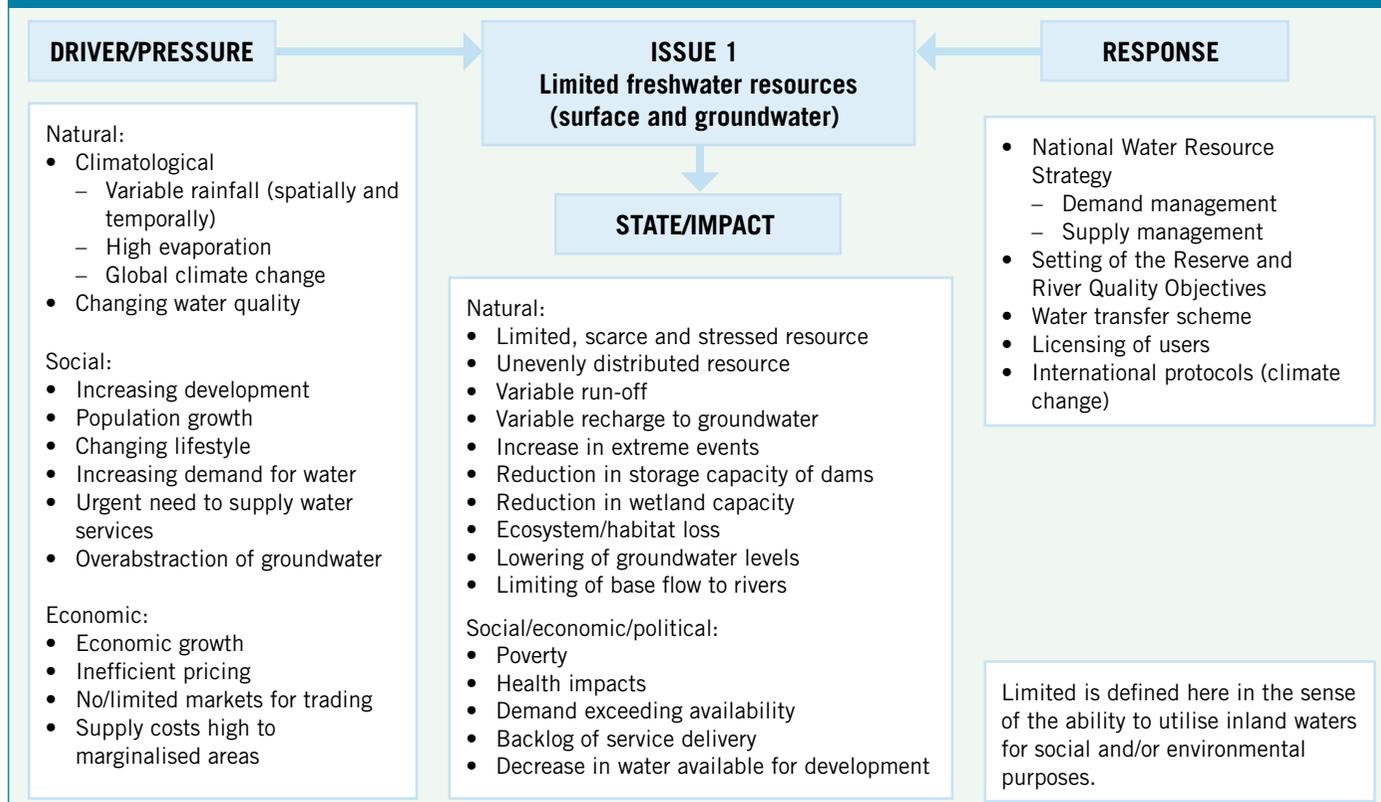
The effects on the aquatic environment of organic pollution, caused by discharges from wastewater treatment, plants, industrial effluents and agricultural run-off, include reduced river-water chemical and biological quality, as well as impaired biodiversity of aquatic communities.



Drivers affecting South Africa's inland water resources

Inland water systems are affected by two main drivers, natural (e.g. climate) and human-related (e.g. development). These drivers cause certain pressures on inland waters, which result in impacts on freshwater resources, by changing the quantity of ground/surface water and/or by changing the quality of ground and/or surface water.

The DPSIR framework for managing limited freshwater resources in South Africa is shown below.



11.5.3 A DPSIR framework for managing limited freshwater resources in Africa

ADAPTING THE DPSIR MODEL

The approach includes humans in the mix. Given the complexity and the dynamic nature of ecosystems, there is recognition that management must be adaptive, as shown in the DPSIR model for South Africa in Figure 11.5.3.

UN Watercourses Convention

The UN Watercourses Convention (UNWC) was established to govern the management and protection of international watercourses. It deals specifically with international water law and policy. The Convention applies to surface and underground water systems that cross international borders, and includes all major rivers, their tributaries, and connected lakes and aquifers. The UNWC takes into account and promotes the ecosystem approach in the use of such watercourses by considering transboundary environmental effects. This enables cooperation between nation states in:

- arriving at a reasonable and equitable use of shared water resources
- undertaking measures to rehabilitate and restore degraded ecosystems.

Following the ecosystem approach, the UNWC makes it clear that environmental concerns and ecosystem protection are just as much within their area of responsibility as the amount of water used. Thus both water quantity and quality are scrutinised. A priority is also the rehabilitation and restoration of degraded inland water ecosystems.

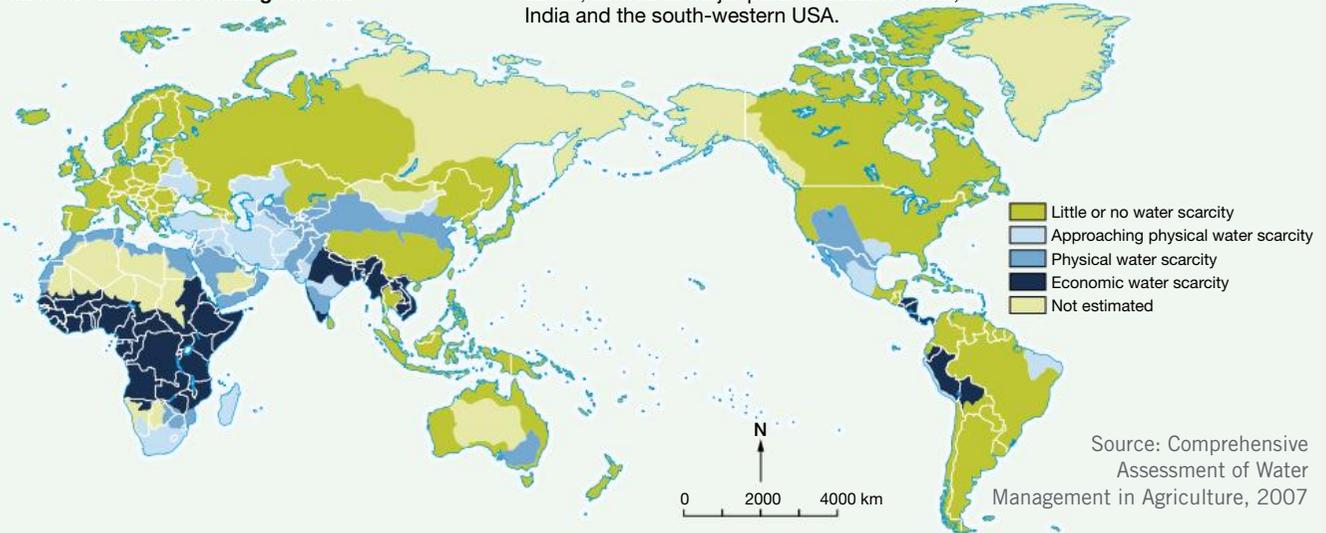
Integrated Water Resource Management

The increasing need for a more holistic approach to environmental management has led to the development of Integrated Water Resource Management (IWRM), now considered to be the most effective means of managing inland waters. In the IWRM approach, water is viewed as less of a commodity and more of a resource that needs to be equitably shared by all users, including nature. The IWRM approach involves all stakeholders working together to identify the costs and benefits of various water uses and finding an appropriate balance between development and sustaining ecosystems.

An estimated 1.4 billion people live in river basin areas where water use exceeds minimum recharge levels.

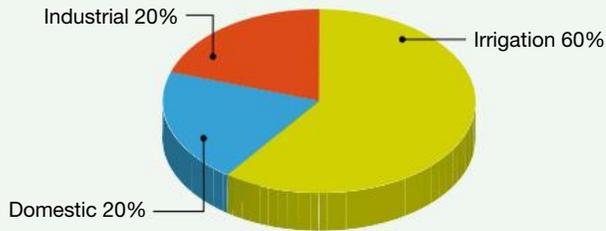
GLOBAL WATER STRESS

Arab region countries have high levels of water stress, as well as major parts of eastern China, India and the south-western USA.



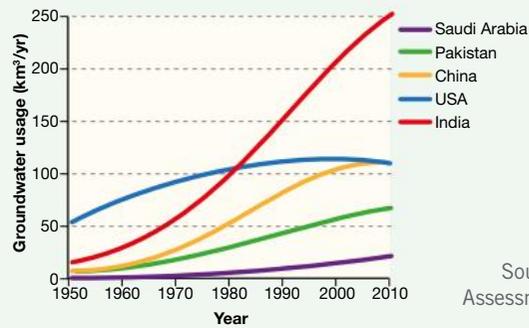
DEMAND FOR GROUNDWATER

As of 2010, the world's aggregated groundwater abstraction is estimated at up to 1000 km³ per year



Source: National Groundwater Association, 2013

Trends in selected countries



Source: World Water Assessment Programme, UNESCO, 2012

11.5.4 All the world's inhabited continents are experiencing water stress as consumption levels rise.

Addressing the causes of environmental change

The current state of inland waters—that is, declining water quantity and quality—is a result of too much water being extracted, too many pollutants being added, and little concern about inland water environments (see Figure 11.5.4). In order to address the causes of environmental change, all users must be more aware and responsible in their water usage. People must realise that they are all downstream or across the shore from someone else.

There needs to be a universal appreciation that:

Water is unique amongst our natural resources because whilst it is renewable, it is not replaceable. We have various substitutes for energy resources and most commodities, but there is no substitute for water. Once it is gone or degraded through overuse or pollution, it cannot be substituted.

Convention on Biological Diversity, Drinking Water, Biodiversity and Development, 2010, UN Water

ACTIVITIES

Knowledge and understanding

- 1 Describe Integrated Water Resource Management.

Geographical skills

- 2 Refer to Figure 11.5.4 and do the following tasks.
 - a Identify the parts of the world that experience the greatest water stress.
 - b Suggest reasons why water stress is an issue in these regions.
 - c What was the approximate consumption of water by Saudi Arabia in 1990?
 - d What was the approximate increase in consumption by the USA from 1950 to 2010?
 - e Which country had the biggest increase in consumption from 1950 to 2010? What do you think this is a result of?

CASE STUDY: The Great Artesian Basin

Australia's fabled inland sea

From the early 1800s, European explorers went in search of the fabled inland sea of Australia, thought to be west of the Blue Mountains. As no major rivers were seen to be entering the sea along the coast, it was believed that the rivers must flow to an inland sea. The first expedition to look for the inland sea was led by John Oxley, NSW surveyor-general, in 1817. Later expeditions were undertaken by Charles Sturt in 1828, who mapped the Macquarie River and reached the Darling River. There was no inland sea to be found above ground, but underground was the Great Artesian Basin (GAB).

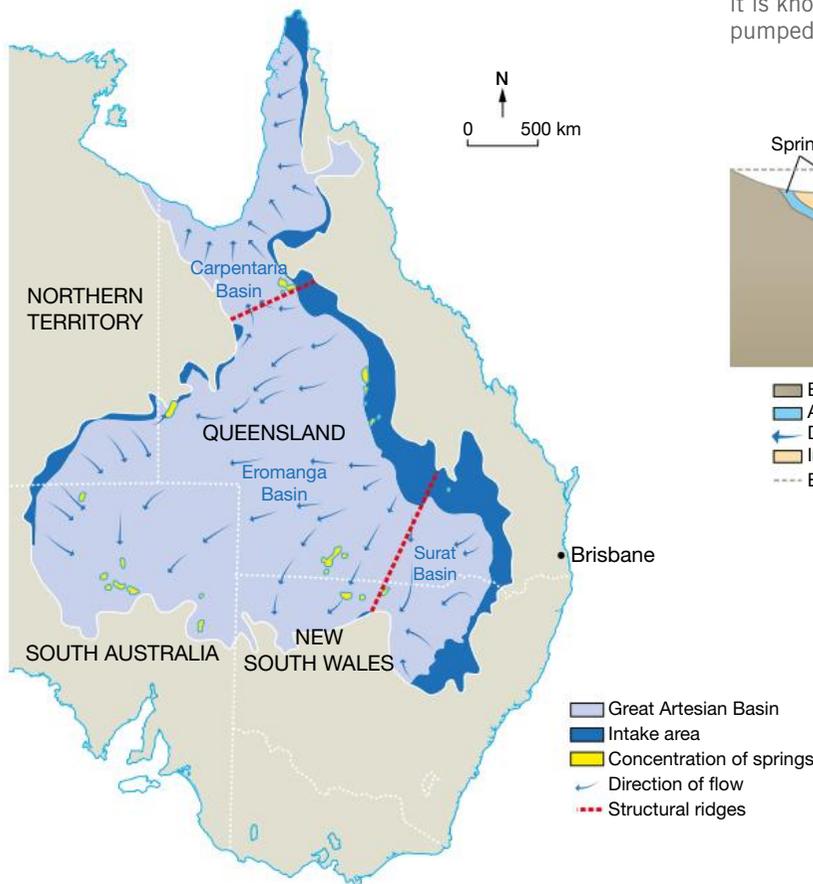
The GAB is Australia's largest freshwater resource. It underlies one-fifth of the continent, including parts of Queensland, New South Wales, South Australia and the Northern Territory—an area of more than 1.7 million square kilometres. The GAB is composed of many different layers of rock. Some layers, such as sandstone, are aquifers, while others are impermeable, as rocks

such as mudstone and siltstone will not allow water through them. These impermeable layers are called **aquicludes**.

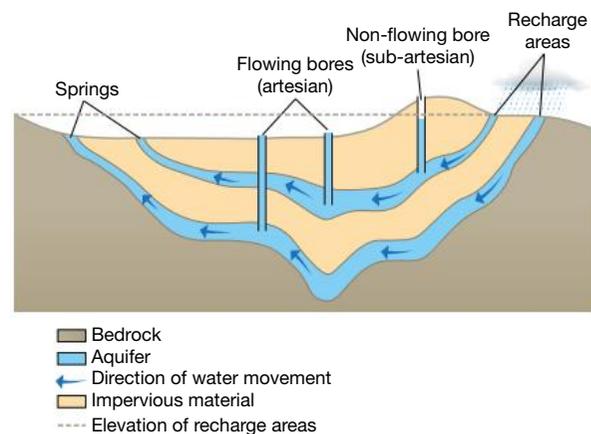
Figures 11.6.1 and 11.6.2 show that the GAB aquifers fill, or recharge, on the edges of the basin, where the sandstones are exposed. Water moves through the aquifer very slowly, at a rate of only 1 to 5 metres a year. The GAB is bowl-shaped and the aquifer is sealed by aquicludes. The water at the lowest part of the basin is stored under pressure. When a bore is sunk, it rises to the surface.

Water can naturally discharge at the surface in springs where the water table is intersected because the aquifer slopes upwards towards the surface, or where there is a fault line. There are numerous springs on the basin's fringes. As they are permanent sources of water in an otherwise dry environment, they support rare flora and endemic invertebrates and fish. They support luxuriant growth of sedges, bulrushes and reeds as high as 3 metres (see Figure 11.6.3). They are also referred to as 'mound springs,' as they look like miniature volcanoes.

11.6.1 Location of the Great Artesian Basin



11.6.2 If the water in a bore reaches the surface unassisted, it is known as a flowing or artesian bore. If it has to be pumped up, it is called a sub-artesian bore.





11.6.3 A mound spring in the desert

SPOTLIGHT

Indigenous people's connection with *kwatye* (water)

Dean An Chee of the Southern Arrente people is Senior Ranger, Witjira National Parks and Wildlife Service, South Australia.

Witjira National Park is located on the western edge of the Simpson Desert in the far north of South Australia. The responsibility to care for this country belongs to my people, the Indigenous Southern Arrente people, and the Irrwanyere Aboriginal Corporation. We have cared for this country for a long, long time.

Located in this area are many mound springs, which are central to our Tjukurpa. Tjukurpa contains our spiritual connection, our law, our culture, our heritage and the stories associated with the land. *Kwatye* is an Arrente word for water within the Great Artesian Basin. Well before my elders' time it provided more than just a source of water for Indigenous people. For it was and remains a travel path, which connects many Indigenous groups.

This water is a source of healing when we are sick, and it provides us with many spiritual and cultural interests. For it is our lifeblood, which we need to survive. It allows us to continue our ceremonies, which incorporate our rich and unique culture that is still strong today. For it is these sources of water that provide an adequate and valuable food source rich in fish and other foods for my people. As one of the traditional elders of this country, Mr Bigey Lowe, says: 'We are in the middle of *kwatye* (water), it is all around us, we have to look after this place.'

Source: Adapted from Dean An Chee, 'Indigenous People's connection with *Kwatye* (Water) in the Great Artesian Basin', Great Artesian Basin Coordinating Committee, 2002

Precious water in a parched land

The fresh water of the GAB is the only reliable source of water in many arid and semi-arid regions of Australia. It supports pastoralism, industry, mining and tourism in the region.

For tens of thousands of years, the mound springs and their pools provided Australia's Aboriginal people with permanent water supplies and food. Knowing where to find the springs was a matter of survival as they moved through the desert. Their use of this inland water was sustainable, as they only collected what they needed and what was naturally replenished.

When Europeans arrived and discovered these large pools of water, they set up pastoral properties. In 1878, a shallow bore was sunk near Bourke, New South Wales. It produced flowing water. Within a decade, more than 500 bores had been sunk around the margins of the basin. Because the water was held under pressure, most of it flowed freely into open drains to water stock. Initially, some of the bores would shoot water 100 metres into the air and supply up to 455 megalitres in a day.

Within just a decade, there were concerns about the decline in flow from bores. Despite this, more were drilled and thousands of kilometres of open drains were dug for over a century. In that time, an amount of water equal to 100 times the volume of Sydney Harbour was extracted—and more than 90 per cent of it was wasted. It was wrongly assumed that rainwater would seep through quickly into the sandstone in the east and recharge the basin. Scientists now know that this will take millions of years.



11.6.4 A coal seam gas well

Coal seam gas

Coal seam gas (CSG) is a type of natural gas extracted from underground coal seams at depths of 300 to 1000 metres. CSG can be captured and used for generating energy, or processed into liquefied natural gas and exported. The extraction of CSG has raised many issues, including fears about damage to the aquifers and the contamination of the water in them.

Water must be removed from the coal seam to enable the CSG to move up to the surface. There is a fear that this will alter groundwater levels, thereby damaging the aquifer. In some coal seams, it is necessary to create fractures to provide pathways through which the gas can flow. This is done using a technique known as hydraulic fracturing, or **fracking**. This technique involves injecting a fluid made of water, sand and chemicals into the well under high pressure (see Figure 11.6.4). The fluid is then pumped back to the surface, where it has to be disposed of. There are concerns that some gas could escape and that the chemicals used could contaminate both groundwater and surface water.

Strategic Management Plan

The Strategic Management Plan (SMP) was launched in 2000 to provide a framework for responsible groundwater and related natural resource management in the GAB. It guides governments, water users and other stakeholders on policies, programs and actions required to achieve optimum economic, environmental and social benefits from GAB groundwater resources. The aspirations of basin-wide management for the future are listed in Figure 11.6.5.

The Great Artesian Basin Sustainability Initiative has assisted with the implementation of the SMP by providing finance to landholders to rehabilitate bores and replace bore drains with piped systems, as shown in Figure 11.6.6.

Evaluation of the Strategic Management Plan

The plan has been assisting land managers to achieve more sustainable property and stock management. The success of such efforts can be judged by considering the criteria used in evaluation.

Environmental criteria

The water savings are substantial and in many places the water pressure is on the rise. Some springs have started flowing again, restoring the aquatic habitat and ecosystem functioning. However, the rate of recovery in the western side of the basin is slow.

Economic criteria

The financial assistance provided by the government has helped landholders to attend to their bores and reduce waste. This is an expensive process and the landholders would have been unlikely to undertake it otherwise. Funding from the government is dependent on the state of the economy and political priorities.

Social criteria

The plan is supportive of landholders and they are receptive to the framework being a basin-wide management plan. The greatest conflict relates to the relatively new practice of coal seam gas extraction.

Aspirations for basin-wide management

Key elements of the vision for the state of the Great Artesian Basin in 50 years:

- The GAB is widely recognised and cooperatively managed as a resource of national importance.
- Water managers have a sound understanding of the dynamic hydrological functioning of the GAB resource.
- Recognising the benefits for all Australians, judicious management of GAB water:
 - maximises productivity within limits of sustainability, based on scientific evidence
 - retains options to allocate water for uses which may not yet have been conceived, for the benefit of future generations
 - enhances biodiversity and cultural values associated with GAB water
 - is integrated effectively with management of land and management of other water resources.

Improvements in the state of the Great Artesian Basin from judicious management of water are evident in the following Key Outcomes (20 years):

- Basin pressure continues to be restored to the levels required to meet balanced biophysical, cultural and socio-economic objectives in state/territory plans, and this pressure can be sustained.
- Wastage of water is reduced to negligible levels.
- Improved productivity is enabled and sustained.
- Land degradation from water-use practices is reduced to negligible levels.
- The 'natural' condition of biodiversity is enhanced by improved water distribution.
- The health of GAB springs and groundwater-dependent ecosystems is enhanced and sustained.
- Cultural heritage assets associated with the GAB are recognised and protected.

These aspirations form the basis for Resource Condition Targets in the GAB Strategic Management Plan Assessment and Reporting Framework.

Source: GAB Consultative Council

11.6.5 Aspirations for basin-wide management

11.6.6 Before: a free-flowing bore drain; after: a capped bore



ACTIVITIES

Knowledge and understanding

- 1 List the states in which the GAB is located.
- 2 Explain how groundwater moves through the GAB.
- 3 Describe the process of fracking.
- 4 Assess the significance of the GAB to Aboriginal people.
- 5 What has been the impact of Europeans on the GAB?

Applying and analysing

- 6 Why will it take millions of years for the GAB to be replenished?
- 7
 - a Complete a KWL chart about coal seam gas extraction.
 - b Conduct a class debate on the following topic.
Coal seam gas extraction should be banned from northern Australia.

Investigating

- 8 Refer to Figure 11.6.2. Using the internet, research groundwater movement in the GAB. Redraw the diagram and replace the labels with text boxes providing more detailed explanations.

CASE STUDY: The Pangani River Basin

The Pangani River Basin

The Pangani River Basin drains a large area in north-eastern Tanzania along the border with Kenya (see Figure 11.7.1). The source of water is rainfall on the mountains and snowmelt from Africa's highest mountain, Mt Kilimanjaro. The major threats to water security are environmental degradation, climate change and increased usage.

Water usage in the Pangani River Basin

The Pangani River Basin is one of the most productive areas of Tanzania. As it is fed by snowmelt from Mt Kilimanjaro, it is, like the mountain, feeling the adverse impacts of climate change. There is currently not enough water to meet demands in the basin and conflicts are emerging between various water users.

The Pangani River Basin has a population of 3.7 million people. Eighty per cent rely on agriculture for their livelihood. Most live in the highlands and foothills, where rainfall is higher. There is large-scale production of sugar, coffee and flowers, as well as small-scale growing of corn and rice. All these crops are, for the most part, irrigated. A large proportion of the farmers believe that they do not have enough access to water.

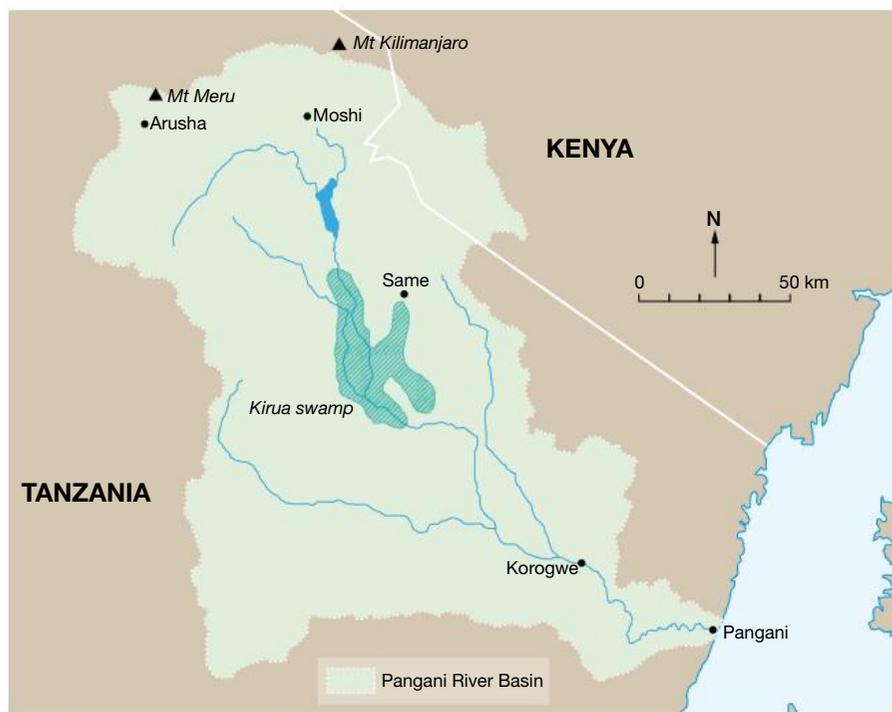
There are also many nomadic pastoralists who depend on livestock and are forced to move from place to place in search of water (see Figure 11.7.2). The river provides a livelihood for some of the poorest people, who turn to fishing when crops fail (see Figure 11.7.3). In addition, the basin also has four hydro-electric power facilities that supply 17 per cent of Tanzania's power needs.

Considerable conflict has arisen over water resources in Tanzania, the extent of which is evident in Table 11.7.4. Some conflicts have been quite violent, with farmers accusing pastoralists of destroying their livelihood, as herds of cattle eat and trample crops when heading to the river to drink.

Inland waters are already clearly over-allocated, and this is without allowing for the vital needs of the basin's aquatic ecosystems and inland water environments.

DID YOU KNOW?

Almost 90 per cent of the surface flow from the Pangani River is used for irrigation and hydro-electric power generation.



11.7.1 Location of the Pangani River Basin



11.7.2 Pastoralists and their cattle on the move, seeking water



11.7.3 Fishing is very important for the survival of the poorest people in Tanzania.



11.7.4 Conflicts in the Pangani River Basin

1 Communities and conservationists: In the highlands, conservationists conflict with the community. The establishment of national parks to conserve catchment areas and increase tourism has generated revenue. The farmers would like to use the conservation areas for farming and gathering fuelwood. The pastoralists would like to graze or move their livestock there.

2 Upstream and downstream users: Conflict is caused by higher allocation of water for highlands users, hence inadequate water for small farmers in the lowlands. There are complaints that the share for downstream users is not adequate.

3 Hydro-electricity producers and other users: Since the establishment of three hydro-electric power stations along the Pangani River, small-scale irrigators have complained that water rights were introduced to protect the power-generating plants.

4 Communities and donor agencies: The competition between donor agencies in the basin generates confusion in the community. They exacerbate water problems in the basin because they compete for the same resources.

5 Farmers and pastoralists: Conflict between these two groups is a result of an increase in the number of livestock in the basin. Cattle destroy natural vegetation and crops.

6 Rural–urban competition: Water pollution increases as the urban areas grow and as farmers use more chemical inputs to grow enough food to feed the fast-growing population.

7 Communities and river basin authorities: Communities are not satisfied, as they are not involved in making decisions when it comes to policy formulation.

Key challenges

Several studies have shown that the Pangani River Basin is already water-stressed. The river's flow has decreased dramatically in recent years and water demand is expected to double within a decade. The Pangani River Basin Management Project (PRBMP) identifies a number of challenges that need to be addressed. These include:

- frequent cycles of droughts and floods
- population and economic growth
- conflicts over access to water resources
- environmental degradation.

Deterioration of inland water environments

The rivers in the highlands of the basin are no longer perennial (that is, flowing all year). The Kirua swamp has, as a result, been reduced to a fraction of its original size due the over-extraction of water, which has prevented its flooding.

Impact of climate change

The overstretched water resources of the Pangani River Basin are also being adversely affected by climate change. The most visible effect is the diminishing snow on Mt Kilimanjaro. An increase in temperature of 1.8 to 3.6°C, increasing evaporation and decreasing rainfall would also result in a 6–10 per cent reduction in annual flow in the drainage basin. Meteorologists have already noted that the climate patterns are changing and the trend towards shorter rainy seasons is set to continue. The more frequent and severe droughts associated with climate change are affecting Tanzania.

Development and implementation of the project

In 2002, the PRBMP was established to manage the basin's water resources. As Tanzania is a developing country, it could only undertake such a project with financial support and technical expertise from a number of sources. These include the United Nations Development Programme (UNDP), the

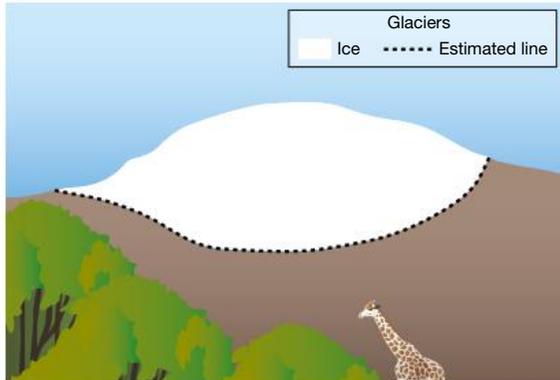
SPOTLIGHT

Melting ice on Kilimanjaro

Mt Kilimanjaro is an important water source for the Pangani River Basin. With its famous glacial ice cap rapidly melting, Kilimanjaro has become an international symbol for climate change. It is predicted that its ice cap will be completely gone by 2025.

11.7.5 Melting ice on Kilimanjaro

1912



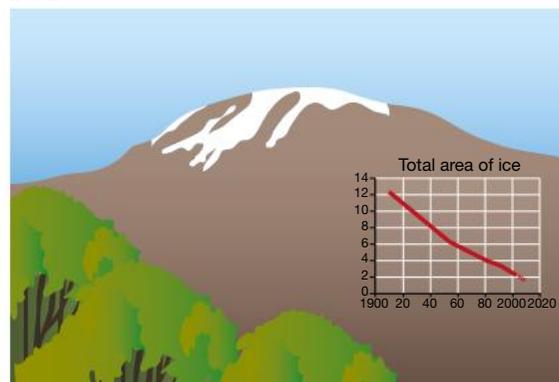
1993



2000



2002



European Union, the Netherlands Development Organisation, and the International Union for Conservation of Nature (IUCN).

The project promotes Integrated Water Resource Management (IWRM), which involves the coordinated development and management of water, land and related resources, in order to support the equitable provision and wise governance of fresh water for livelihoods and to protect the environment for current and future generations. The maintenance of aquatic ecosystems is accorded the second highest priority in water allocation over allocation of water for basic human needs.

The emphasis is on the sustainable use of water and achievement of this requires people to consider the needs of other potential water users and take into account the overall distribution and scarcity of water across the entire river basin.

The PRBMP has undertaken to:

- generate technical information: an Integrated Flow Assessment has been implemented to build an understanding of the hydrology of the river basin and the flow-related nature and functioning of the river ecosystem
- develop participatory forums: the establishment of catchment associations and community-led projects will enhance conflict resolution in the basin, as people are being consulted and participating in decision making.

The full development and implementation of the plans for the project go beyond simply allocating to one or more water-use sectors (see Figure 11.7.6). To truly move towards sustainability is far more complex and will occur over a considerable time span. The timeline of implementation may be one to two decades, even though the political will, funds and technical skills exist.

Evaluation of the project

The success can be judged by considering the criteria used in evaluations.

Environmental criteria

Tanzania is the first nation in East Africa to raise awareness about climate change impacts. It has also given priority to the maintenance of aquatic ecosystems and has undertaken extensive field assessment of the quality of these systems. However, there is currently not enough water in the basin to meet demands of the people, let alone allow for environmental flows.

Economic criteria

The PRBMP is fortunate to receive substantial international funding to undertake field investigations and generate important technical information about the basin. However, the high level of poverty in the region puts a lot of pressure on people desperate to support themselves. Their actions can have a negative impact on inland waters.

Social criteria

The PRBMP is certainly socially inclusive; it has, for example, developed participatory community forums. However, conflict is still rife in some areas, which again is driven by poverty. There have been a number of deaths in the struggle between the small farmers and the pastoralists.

11.7.6 Changes in the Pangani River Basin

BEFORE

Over-exploitation of water resources
Ineffective management
Limited knowledge about the basin's ecosystem
Conflict

AFTER

Participatory governance—IWRM Plan drafted
Increased institutional capacity at basin level
Increased knowledge about water resources
Empowered water users
Conflict resolution
Platforms for stakeholder dialogue

ACTIVITIES

Knowledge and understanding

- 1 Describe the drainage of the Pangani River Basin.
- 2 Explain why the highlands are favoured for agriculture.
- 3 Identify the challenges being faced.
- 4 Explain the impact of climate change on river flows.

Applying and analysing

- 5 Study Table 11.7.4. List the conflicts in the Pangani River Basin and decide whether or not each conflict has a social, economic or environmental impact. Note that some conflicts will have more than one impact.

Investigating

- 6 Study Figure 11.7.1. Describe the location of the Pangani River Basin. Find out what Mount Kilimanjaro's elevation and altitude are, and explain why it has snow on its summit.
- 7 Study Table 11.7.4. Research the various conflicts identified. Show where these conflicts are occurring on an annotated visual display based on a map of Tanzania.

IN THE FIELD: Rivers and water quality

Aim

The aim of this fieldwork activity is to investigate a river and its water quality. A fieldwork investigation of a length of river provides an opportunity to learn more about these important features of the physical environment. It also allows you to practise a range of geographical skills.

How to investigate a river

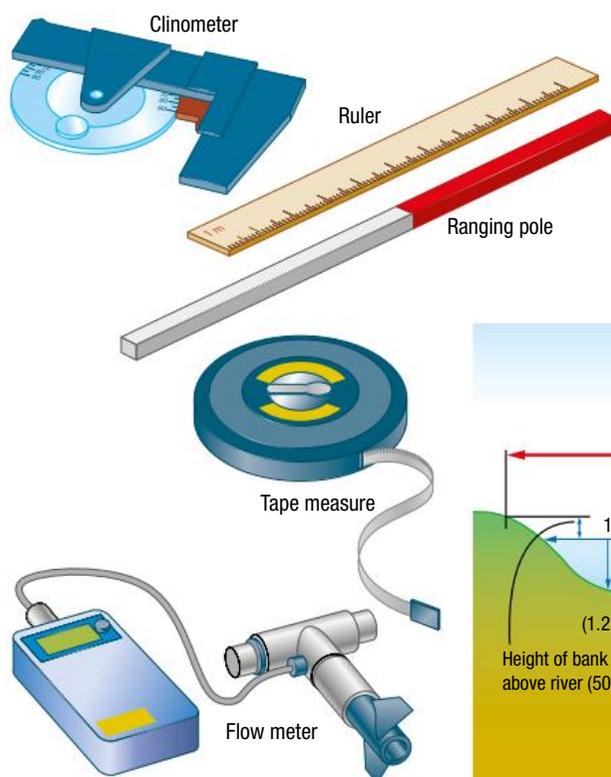
A variety of instruments will be required to investigate a river (see Figure 11.8.1):

- clinometer
- ruler
- ranging pole
- tape measure
- stopwatch
- flow meter.

You will need to select a river or stream location that has the following features:

- a bridge to cross
- easy access to riverbanks at a variety of locations.

11.8.1 Tools used to collect data in the field



Drawing a cross-section

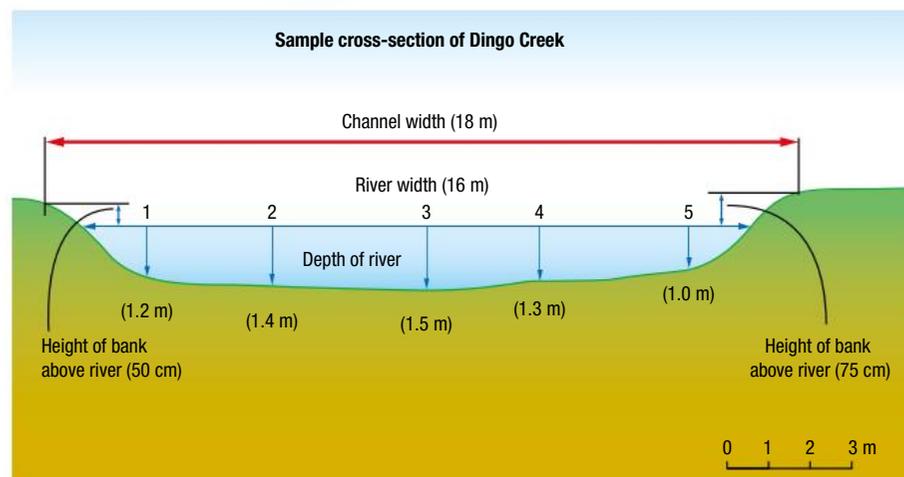
To draw a cross-section of a river, you need measurements of the:

- depth of the river
- width of the channel
- width of the river from bank to bank
- height of the bank above the river.

Using these measurements, construct your cross-section by carrying out the following steps.

- 1 Study the measurements you have collected and select a scale that will fit on your paper. Start your cross-section by drawing a line representing the width of the river. Make sure you leave enough space to draw in the river channel below it.
- 2 Look at the measurements for the height of the bank above the river level on both sides and mark the position of both banks. Measure the width of the channel from bank to bank. Now draw in the banks.
- 3 Mark in the riverbed by using your measurements of the depth of the river from the surface. Join the points together to show the shape of the riverbed. Add a scale and a heading, as shown in Figure 11.8.2.

11.8.2 Sample cross-section



Calculating the cross-section

To calculate the cross-section of an area of river, carry out the following steps.

- 1 Use a long tape measure to determine the average width of the river.
- 2 Measure the depth of the water at regular intervals across the width of the river (for example every 100 centimetres). A 2-metre pole marked with 10-centimetre intervals will assist you in this task. If there is a low bridge over the river, stand on it to measure the depth of the river. Record your measurements on your data record sheet.
- 3 Calculate the average depth by adding all the depth readings and dividing by the number of readings. Using the data shown in Figure 11.8.3, the average would be $(1.2\text{ m} + 1.4\text{ m} + 1.5\text{ m} + 1.3\text{ m} + 1.0\text{ m}) \div 5 = 1.28\text{ m}$.
- 4 Multiply the average depth by the average width of the river to give the area. Using the data shown in Figure 11.8.2, the area would be $1.28\text{ m} \times 16 = 20.48\text{ m}^2$.

11.8.3 Data sample for a cross-section

Width of channel (bank to bank): 18 metres						
Average width of river: 16 metres						
Height of bank above the river:		<ul style="list-style-type: none"> • Left side: 50 centimetres • Right side: 75 centimetres 				
Depth of river:		Left bank		Right bank		
	Reading	1	2	3	4	5
	Depth	1.2 m	1.4 m	1.5 m	1.3 m	1.0 m

Calculating water velocity

The most accurate way to measure water velocity is to use a flow meter. If you don't have a flow meter you can use the following procedure.

- 1 Select a straight section of the river that is free of pools and/or shallow, fast-flowing sections. Measure out a distance of 50 metres.
- 2 Find an object that will float on the surface of the river. The object should be brightly coloured and it is best if it is heavy enough to be partly submerged in the water. With the aid of a stopwatch, measure how long it takes for the floating object to cover the 50 metres. Ensure that you select an area of riverbank you can easily and safely access.
- 3 Take at least three readings. For greater accuracy, take readings on both sides of the river and in the middle. Record your readings on your data record sheet. Average the readings to determine the water velocity.

Calculating river discharge

Discharge is the amount of water that flows from a river catchment and into another river system, the sea or a lake. The discharge can be calculated by using the following formula:

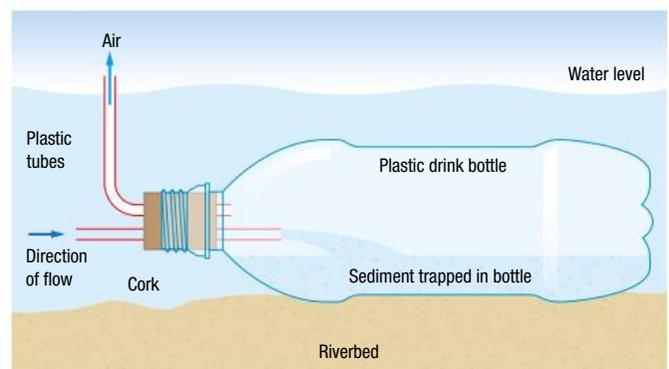
$$\text{Discharge} = \text{velocity} \times \text{cross-sectional area}$$

Measuring suspended load

The suspended load of a river comprises fine sand particles, silt and clay. The amount of suspended material in water is closely linked to the level of discharge. To measure the amount of suspended load in a river, carry out the following steps.

- 1 Use four 1-litre plastic bottles to collect water samples at four sampling sites along the course of a river. When preparing each plastic bottle, block the opening with a cork and then drill two holes through the cork. Push two flexible plastic tubes through the holes, as in Figure 11.8.4.
- 2 Anchor the bottle to the riverbed with two or three stones. When doing so, make sure that you stand downstream, so that you do not stir up too much sand and sediment.
- 3 When the bottle is full, remove it from the river and remove the cork and plastic tubes. Seal the bottle with its original screw cap. Repeat the exercise at your other sampling sites. Allow the bottles to stand overnight.
- 4 Observe the layer of sediment that has collected at the base of the bottle. Make note of the sediment's colour, the water's clarity (turbidity) and, if possible, the amount of time it takes for the sediment to settle.
- 5 Shake the bottle so that the sediment is again redistributed through the water sample and then very slowly pour the contents of the bottle through a previously weighed piece of dry filter paper. You could use a filter suction pump to assist in this process.
- 6 Allow the sediment-encrusted filter paper to dry for at least 48 hours, or dry it in an oven for 1–2 hours at 100°C. Subtract the weight of the dry filter paper to find the weight of the suspended sediment. Express your answer in grams per litre of water.

11.8.4 Sediment sampler



Measuring turbidity

Turbidity refers to the cloudiness of water, which is caused by suspended sediment. To measure the turbidity of a river, carry out the following steps.

- 1 Collect a 1-litre sample of water at a number of sites along the course of a river.
- 2 Transfer the samples into separate glass containers. Allow the water to stand for at least 24 hours so the sediment will settle.
- 3 Using a ruler, measure the depth of sediment at the bottom of each container. Record your data in a spreadsheet file and present your data as a graph.

Measuring water quality

You can measure how clean river water is without having to use expensive equipment. One simple method involves looking at the kinds of animals that are found in creeks and rivers. The health of a river ecosystem can be measured by the variety of animal species present. If the water is polluted, many species find it almost impossible to survive. To assess water quality, carry out the following steps.

1 Select a suitable site

You can approach the task in one of two ways. You can:

- compare pollution levels in two or more rivers or creeks
- measure how pollution levels change down the course of one river or creek.

2 Equipment

You will need the following equipment:

- a white dish or tray
- a magnifying glass
- bottles and jars for water samples
- a pond dipping net
- turmeric paper (which turns brown in ammonia)
- pH paper (which measures acidity)
- a clipboard, pencil and recording sheet for drawing up a results sheet, as shown in Figure 11.8.5.

3 Take measurements and make observations

At each of the selected sites, complete the following experiments. Repeat each experiment three times at each site to make sure the results are reliable.

TURBIDITY

Fill your jar with water. Is the water clear or is it muddy? Allow the water to stand for 10 minutes. How clear is the water now? How much sediment has settled on the bottom of the jar?

Filter another sample of the same water through some filter paper or blotting paper. Observe what remains on the paper.

SMELL

Using the same jar of water, smell the contents. Does the water smell? Record your observations on the results sheet.

pH TEST

Fill your dish with water taken from the river or creek. Place a piece of indicator paper in the water. Estimate the pH by comparing the test strip with the indicator chart (see Figure 11.8.6). Significant variation in recordings taken at different sites may indicate pollution.

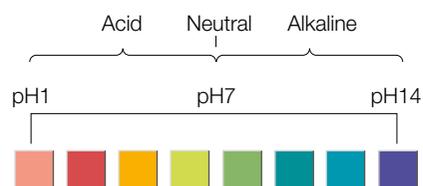
AMMONIA TEST

Use the turmeric paper to test a sample of water taken from the creek or river. If the paper turns brown, ammonia is present in the water. Ammonia is a poisonous chemical that builds up in water when it is polluted by sewage, rotting vegetation and carbon-based chemicals.

11.8.5 Water quality results sheet

Water quality results					
Name of waterway:	_____			Date:	_____
Location:	_____				
Site number:	<input type="text"/>				
Test	1	2	3	Comments	
Turbidity					
Smell					
pH					
Ammonia					
Organisms					
Site observations					

11.8.6 A pH chart



Organism survey

Scientists have found that the number and variety of water bugs found in a stream can indicate the amount of pollution present. By sampling the water bugs in a local stream, you will get an idea of the quality of the water.

Water bugs live in many different parts of the stream. Some live on the water's surface, others at the bottom of the river or creek, in the surrounding vegetation or among the rocks.

Scoop your net through the weeds growing on the riverbed, through the plants growing on the water's edge, and through the water at various depths. Wash off the excess mud by dunking the base of the net into the water. Empty the contents

of the net into your white tray and, with the aid of a magnifying glass, look for bugs similar to those shown in Figure 11.8.7. List the organisms present in your sample.

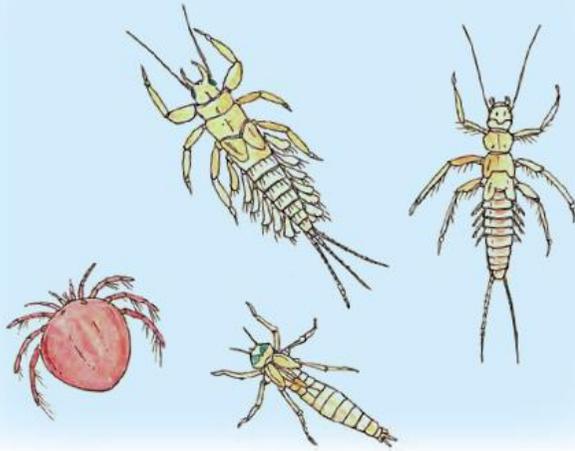
If you can identify sensitive and very sensitive bugs, the quality of the water is quite good. If only tolerant and very tolerant bugs are present, the creek or river probably has quite high levels of pollution.

SITE OBSERVATIONS

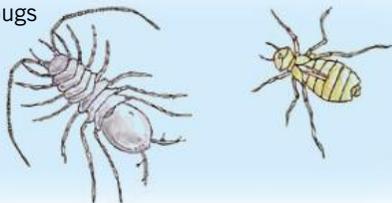
Record any additional observations about the sites selected. Identify any possible sources of pollution. Use photography to illustrate your notes.

11.8.7 Some of the small aquatic animals found in rivers and creeks

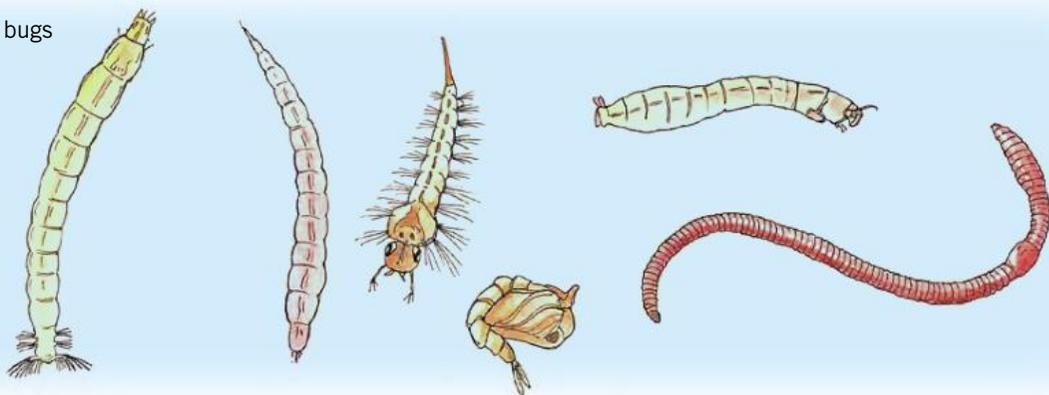
Very sensitive water bugs



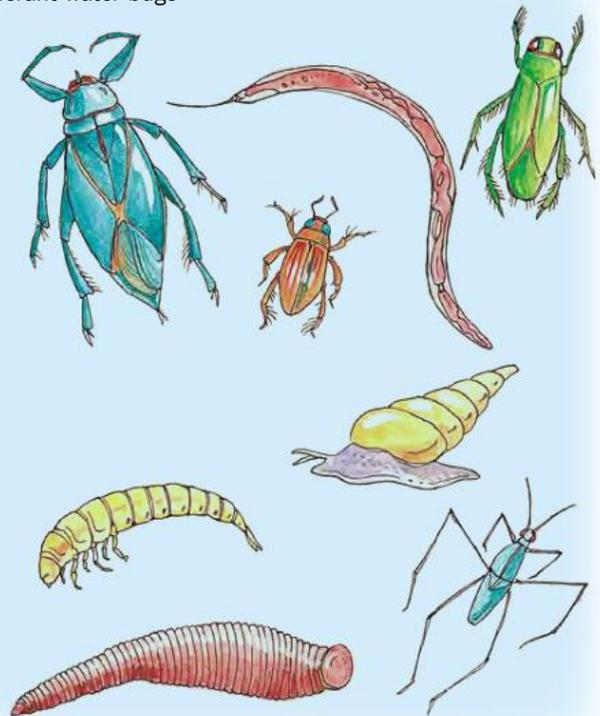
Sensitive water bugs



Very tolerant water bugs



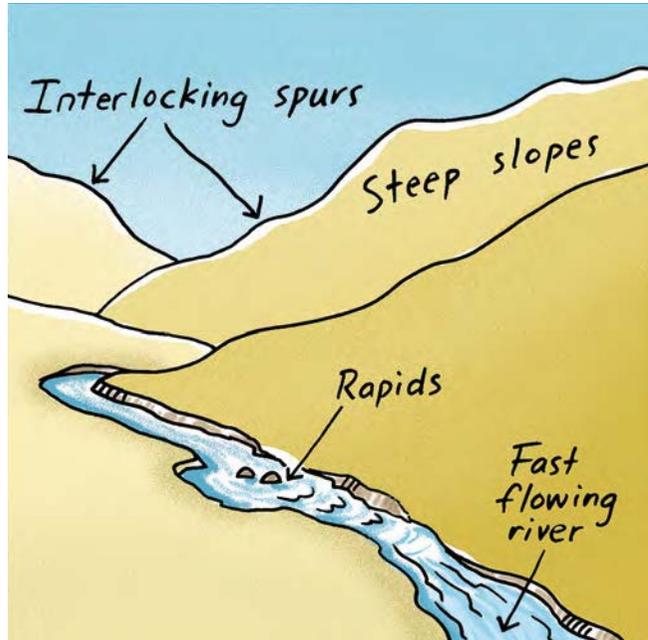
Tolerant water bugs



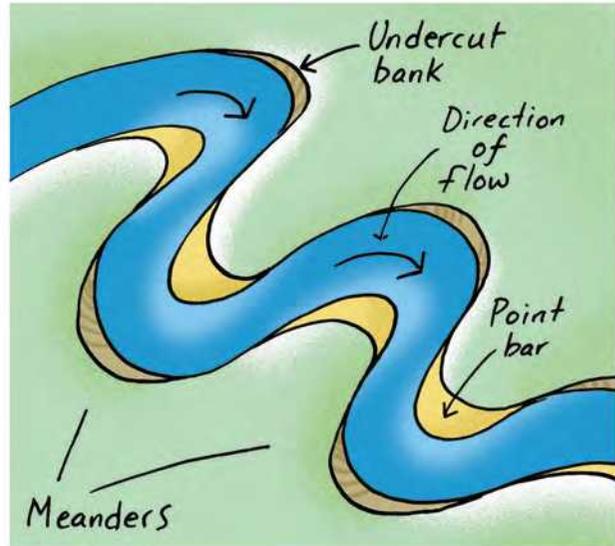
Drawing a field sketch

To draw a field sketch of the river being studied, use Figures 11.8.8 and 11.8.9 as a guide.

11.8.8 Annotated field sketch of the upper reach of the river being studied



11.8.9 Sketch plan of the mid-reach of the river being studied



ACTIVITIES

Aim

To investigate the physical features of a river and water quality

Instructions

- 1 Select a suitable river to investigate and include a map of the area investigated.
- 2 Draw a cross-section.
- 3 Calculate the cross-section of the river. Collect data and record it in a data record sheet similar to the sample below.

River: Sandy Creek	Location: Site 1	Date: 23 May 2014
A. Cross-sectional area		
Average width of the river	15 metres	
Channel depth at various points (in centimetres)		
Point 1:	20	
Point 2:	25	
Point 3:	35	
Point 4:	45	
Point 5:	30	
Point 6:	20	
Average depth:	$175/6 = 29$ centimetres	
Cross-sectional area: average river width \times average depth $15 \times 0.29 = 4.35$ square metres (ii)		

- 4 Calculate water velocity.

- a Collect data and record it on a data record sheet similar to the sample below.
- b Select data from two different locations and follow the steps above.

River: Sandy Creek	Location: Site 1	Date: 23 May 2014
B. Water velocity		
Length of river section:	50 metres	
Measurement 1:	75 seconds	
Measurement 2:	90 seconds	
Measurement 3:	85 seconds	
Average:	83.3 seconds	
Average velocity:	$50/83.3 = 0.6$ metres per second (i)	

- 5 Calculate river discharge.

River: Sandy Creek	Location: Site 1	Date: 23 May 2014
C. Discharge		
Velocity (i) \times cross-sectional area (ii) 0.6 metres per second \times 4.35 square metres $= 2.61$ cubic metres per second		

- 6 Measure turbidity. Collect data and record it in a data record sheet similar to the sample in Figure 11.8.5.
- 7 Measure suspended load.

- 8 Measure water quality. Collect data and record it in a data record sheet similar to the sample provided.
- 9 Draw a field sketch of the river area being studied.

Option 1

Create an annotated visual display of the area investigated.

- a Take images of the river channel, upstream and downstream, and land on either side of the river channel.
- b Explain how each has influenced, or might influence, the river channel.
- c Annotate the photos and explanations around the map of the area of river investigated.

Option 2

Investigate the river from its source to the mouth of the river. Include the following information:

- topography, vegetation and landuse
- how the river water is being used (agriculture, irrigation, recreation, household use, etc.)
- problems associated with the river (pollution, reduced water flow, etc.).

Present your findings in a multimedia presentation and/or oral presentation.

Evaluation

- 9 Once you have collected enough data, display the results and comment on your findings. Include the following in your commentary:
 - a a description of the features of the section of river that you investigated

- b information about changes in speed flow along the river
- c information about levels of turbidity and suspended load—was there a correlation between the two?
- d information about water quality—was there a correlation between the two?

Option 3: Taking action

If you find that your local creek or river is polluted, you might like to do something about it. In small groups, discuss the actions you could take. You might consider:

- writing to the Environment Protection Authority and your local council
- mounting a public information campaign using posters and leaflets warning of the dangers of water pollution.

Conclusion

10 Describe what you have learnt about river profiles.

Fieldwork reflection

- 11 Write a short report outlining:
 - a the way you gathered your data
 - b what worked well and what did not
 - c how you would improve the effectiveness of the fieldwork if you were to repeat it.
- 12 As a group, list the skills you have developed when undertaking the fieldwork activity. Share your findings with other groups. What were the most commonly cited skills? Which skills did other groups identify that differed from your group's list?



11.8.10 High school students checking nets for aquatic indicators of water quality on a river field trip



Spatial variations in human wellbeing

CHAPTER 12

Enhancing the wellbeing of people living in the world's poorest countries is one of the great challenges facing humanity. In Geography, you study 'development' to identify the ways in which developing countries can improve wellbeing and eliminate absolute poverty.

In the period since World War II, and the subsequent decolonisation process in Africa, Asia and other parts of the world, the peoples and governments of the most developed countries have acknowledged that they have a responsibility to assist the world's poorest countries to improve the lives of their people.

In this chapter we examine the global pattern of human wellbeing and how it is measured. We also investigate causes of the global differences in these measures among countries.

INQUIRY QUESTIONS

- To what extent does human wellbeing vary between and within countries?
- How is human wellbeing measured and mapped?
- Why are there spatial variations in human wellbeing and what are their consequences?
- What are the principal issues in human wellbeing?

GLOSSARY

absolute poverty	a lack of access to the minimum or essentials for living
cash crops	crops grown for sale rather than consumption
colonialism	the practice of acquiring full or partial political control over another country, occupying it and exploiting it economically
debt bondage	an arrangement whereby a person is forced to pay off a loan with direct labour in place of currency, over an agreed or indeterminate period of time
developed world	rich countries of the world; most rich countries are industrialised and incomes are high. After fulfilling their everyday needs of water, food and shelter, most people have money left over for buying consumer goods and luxury items
developing country	a poor or middle-income country; in many of these countries, most people depend on subsistence farming. For all but the few people who are very rich, life is a constant struggle to satisfy the basic needs
development	a process of change that results in an improvement in the quality of life of a community. It usually involves reducing poverty
economic growth	the growth in the productive capacity of the economy (and in national income)
fertility rate	the average number of children born to each woman

indentured servitude	a labour system whereby a person is bound to work for another for a specified period of time
Industrial Revolution	a period of major industrialisation that took place in Britain and the rest of Europe during the late 1700s and early 1800s
life expectancy	the average period that a person may expect to live
maternal mortality	the death of a mother during childbirth
middle class	the social group positioned between the upper and working classes. It includes professional and business people and their families
relative poverty	a condition in which people are unable to maintain the average standard of living in the society in which they live
sanitation	the infrastructure related to the collection and disposal of human waste
slavery	a person being owned as property by another person
slum	a run-down established neighbourhood in which most people live in poverty
social infrastructure	the basic facilities necessary for human development; includes health (hospitals), education (schools) and housing
subsistence production	production at a level sufficient for a person's own use or consumption, without any surplus for trade

12.0 An Indian girl searches through garbage for scrap at a landfill site in New Delhi, India.

Development and human wellbeing

Wellbeing

The term 'human wellbeing' refers to the quality of life experienced by people individually and collectively. It can be measured using statistics such as **life expectancy**, educational attainment and income, and by the subjective judgements people make about their quality of their life.

Global variations in wellbeing

The quality of life experienced by people largely depends on whether they live in a developed or a **developing country**. In Australia, a child born today can expect to live to about 81.85 years of age, but a child born in Ethiopia can expect to live to just 59 years.

Variations in human wellbeing can also be found within countries. A homeless person living on the streets of an Australian city or a disadvantaged Indigenous Australian living in a remote outback community may have much in common with people living in the squatter settlements of a developing world city. Similarly, a wealthy business owner living in Ethiopia may enjoy a quality of life as good as that experienced by people living in a developed country. Geographers call these differences 'inequalities'.

Defining development

Development is a contested term. It can be viewed as simply the outcome of **economic growth** or it can be understood in terms of an ongoing, dynamic, socio-economic process, the aim of which is a sustained improvement in people's quality of life or wellbeing.

The process of development involves improving the quality of people's life through increasing per capita incomes, reducing poverty and enhancing individuals' economic opportunities and life choices. It is sometimes defined to include better education, improved health and nutrition, conservation of natural resources, a cleaner environment and a richer cultural life. It can also include relief from the factors that limit the life choices people are able to make. Development involves taking action—addressing issues such as poverty, child labour, malnutrition and starvation, tyranny and repression, human rights, the rights of women and minorities, the denial of economic opportunities, child labour and social deprivation.

Defining wealth

A country's wealth is often measured using gross domestic product (GDP): the total value of the goods and services produced each year. GDP per person, or per capita, is calculated by dividing the country's GDP by the number of people

living in that country (see Figure 12.1.1). Another commonly used measure is the Human Development Index (HDI) (see Figure 12.1.2), which takes into account income, life expectancy and education. The Inequality-adjusted Human Development Index (IHDI) measures the level of human development, taking inequality into account. In a country with no inequality, the IHDI is equal to the HDI, but falls below the HDI if inequality rises.

GDP per capita, or the HDI, tells us only part of the story. Other factors contribute to our sense of wellbeing. We often refer to these as qualitative factors. In other words, they cannot be easily measured. Examples are happiness, environmental quality, personal freedoms and lifestyle.

Defining poverty

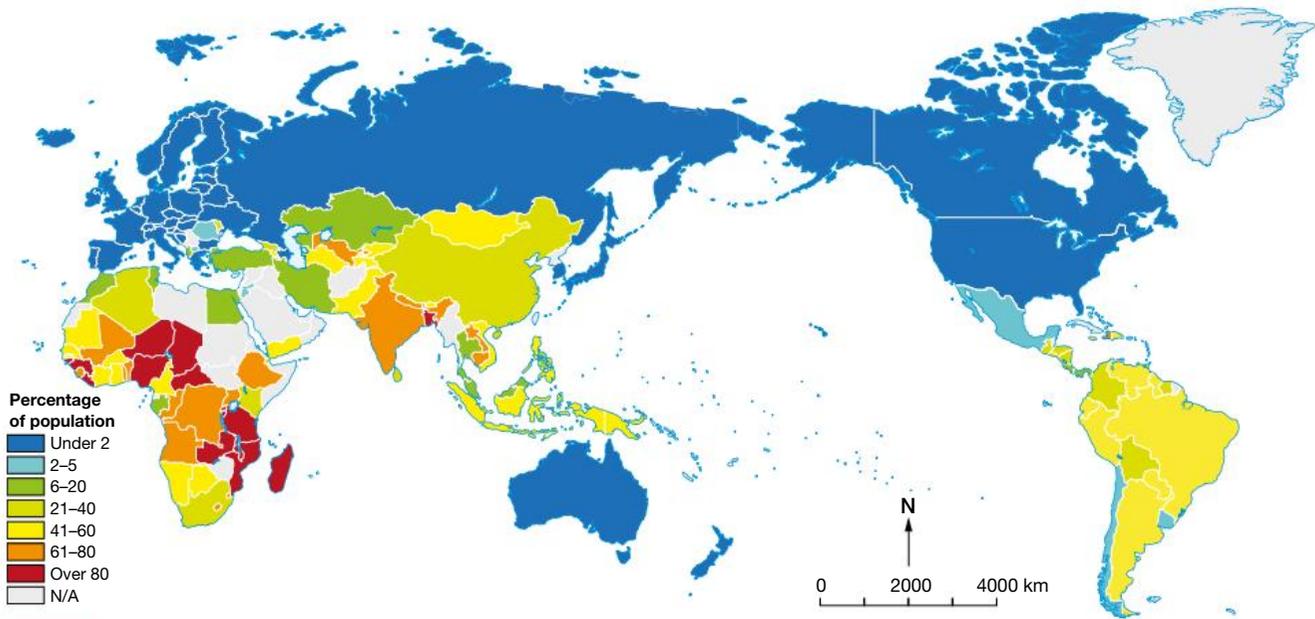
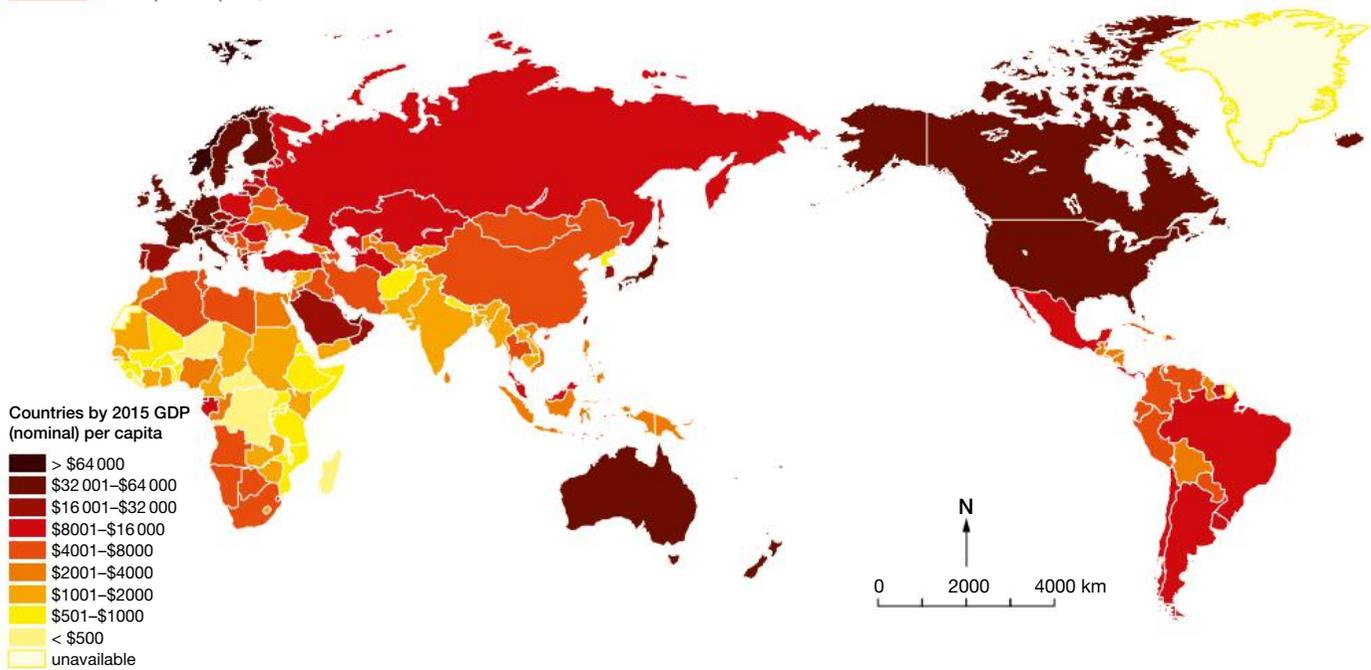
GDP can also be used to rank the world's poorest countries but, as with wealth, this gives you only part of the picture. Before you can make a judgement about the overall level of a country's development, you need more information about the way that people in that country live.

Poverty is often defined as either relative or absolute poverty. **Absolute poverty** is coping without the resources (food, clothing and shelter) necessary for life. People living in absolute poverty are barely surviving. **Relative poverty**, on the other hand, is the situation in which some people are poorer than others in the community but still have access to adequate food, clothing and shelter.

Global inequalities

In early 2014, Oxfam, the international non-government aid agency, reported that the world's eighty-five richest people controlled wealth of \$1.7 trillion, an amount equal to that held by the world's poorest 3.5 billion people. In other words, a small group of people, just enough to fill a double-decker bus, had accumulated as much wealth as that shared by half the world's people. This staggering figure highlights the inequalities evident in the world today. The wealth of the richest 1 per cent of the world's population was about \$110 trillion, 65 times the total wealth of the bottom 50 per cent of the world's population. Although poverty has been reduced, inequality has not. In the 20 years between 1990 and 2010, the number of very poor fell by half (as a percentage of the total population) in developing countries, from 43 per cent to 21 per cent—a reduction of almost 1 billion people. Despite such gains, 1.1 billion of the world's 7 billion people still live below the internationally accepted extreme-poverty line of just \$1.25 a day.

12.1.1 GDP per capita, 2014



12.1.2 Human Development Index, 2014

Source: World Bank

ACTIVITIES

Knowledge and understanding

- 1 Define 'human wellbeing'. How can it be measured?
- 2 Identify the scales at which variations in human wellbeing occur.
- 3 Explain how the HDI differs from GDP.
- 4 Explain how the IHDI differs from the HDI.
- 5 Explain the difference between absolute and relative poverty.

Applying and analysing

- 6 List the inequalities that exist in your own community.
- 7 In groups, discuss what you consider to be the basic minimum requirements for a person living

in your community. Consider food, education and health facilities. Draw up a list as a result of the discussion. See how much agreement there is between individuals and groups.

Geographical skills

- 8 Study Figure 12.1.1. With the aid of an atlas, identify the parts of the world with the highest and lowest GDP per capita.
- 9 Study Figure 12.1.2. With the aid of an atlas, identify those parts of the world that have the lowest ranking on the HDI. Which countries have the highest HDI?

Measuring and mapping human wellbeing

Assessing human wellbeing

Human wellbeing can be measured using qualitative (subjective) measures of how people perceive the quality of life they experience, or quantitative (objective) measures, for example life expectancy, education levels and income.

Qualitative indicators

The qualitative or subjective indicators of human wellbeing are those aspects of our standard of living that are difficult to measure, such as political freedoms, social opportunities and guarantees of personal security. They include human rights, the nature of governing institutions, the quality of the environment, the level of

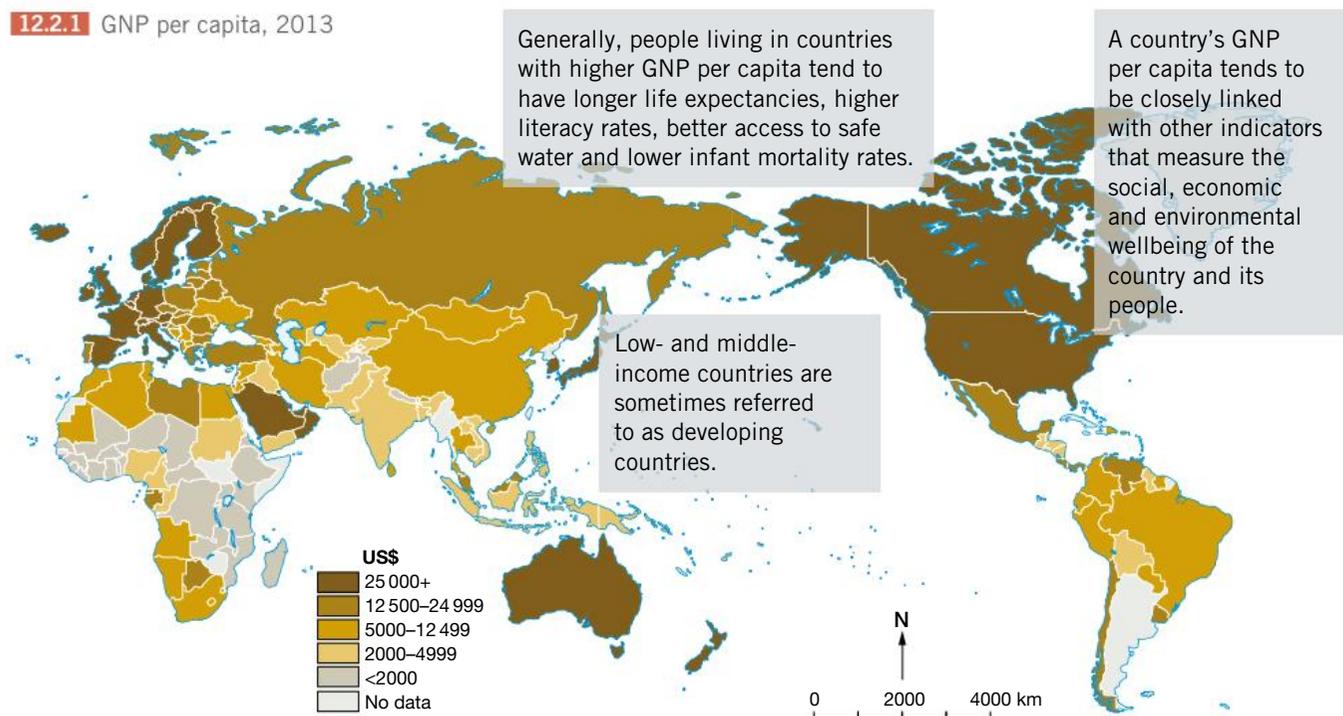
social participation and access to leisure. These aspects are about the capacity of the individual to exercise their rights, especially economic, cultural and social rights. They involve the elimination of poverty, inequalities, suffering and injustice.

Quantitative indicators

Gross national product per capita

When many people think about human wellbeing, they often focus on economic growth. It is not surprising, therefore, that gross national product (GNP) per capita is one of the most commonly used measures of human wellbeing, as is shown in Figure 12.2.1.

12.2.1 GNP per capita, 2013



World's 10 richest countries (GNP per capita, US\$, 2014)		
Rank	Country	GNP per capita (US\$)
1	Luxembourg	110 665
2	Norway	97 363
3	Qatar	93 397
4	Switzerland	84 733
5	Australia	61 887
6	Denmark	60 634
7	Sweden	58 887
8	Singapore	56 286
9	USA	54 629
10	Ireland	53 313

World's 10 poorest countries (GNP per capita, 2014)		
Rank	Country	GNP per capita (US\$)
10	Malawi	253
9	Burundi	295
8	Central African Republic	378
7	Gambia	422
6	Niger	440
5	Madagascar	449
4	Liberia	461
3	Dem. Rep. of the Congo	475
2	Guinea	550
1	Ethiopia	567

Source: World Bank

GNP per capita is the total value of goods and services produced within a country in a particular year, together with income received from other countries (for example interest and dividends), less similar payments made to other countries, divided by the country's population.

The use of GNP has been criticised for failing to accurately measure economic activity, especially in developing countries, where activity often takes place outside the formal economy or where data collection processes are often under-resourced. Other indicators used to measure economic growth are energy consumption per capita and employment. Such production-based indicators can be used to rank countries on the basis of their relative economic development. However, they tell us very little about the spatial and social inequalities in the distribution of benefits derived from economic growth, and nothing about the qualitative dimension of human wellbeing.

Composite quantitative measures

Several new indices have been introduced over the years to provide a more accurate insight into human wellbeing. These include a range of multiple component (or composite) measures such as the Human Development Index (HDI), the Inequality-adjusted Human Development Index (IHDI), the Multidimensional Poverty Index (MPI) and the Gender-related Development Index (GDI).

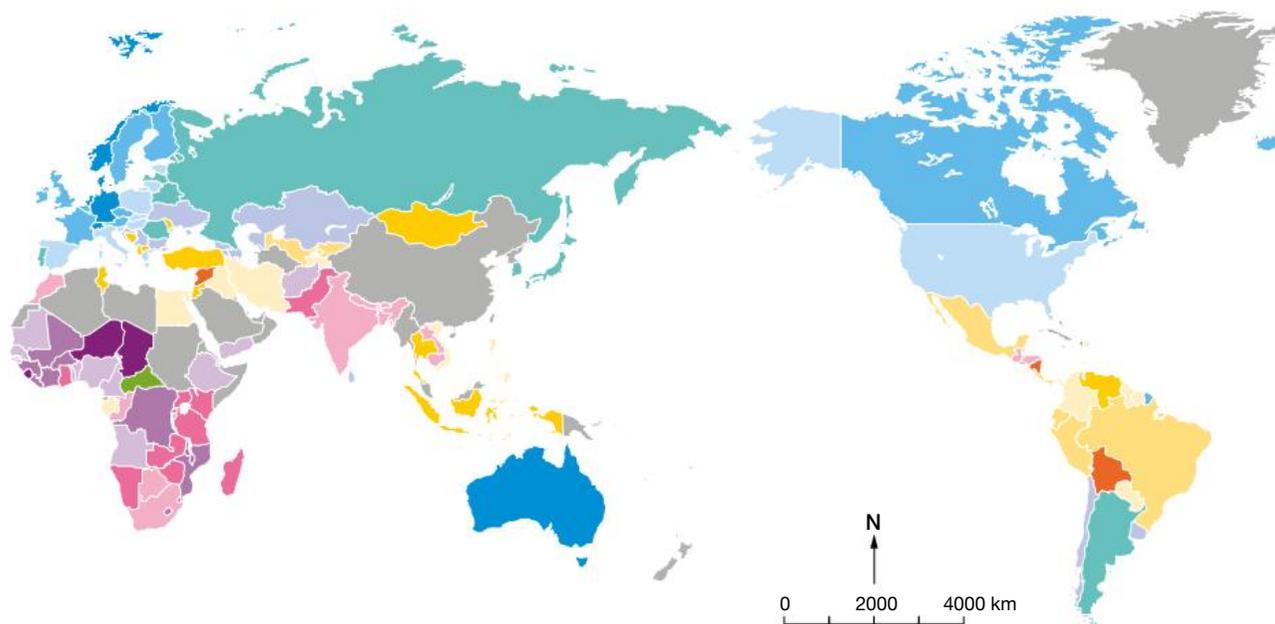
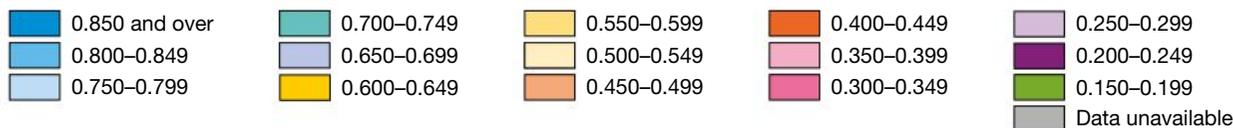
HUMAN DEVELOPMENT INDEX

The HDI allows for a range of developmental factors to be taken into account when measuring human wellbeing or progress. These factors are income, life expectancy and education. The index is not without its limitations. While it allows for easy comparisons between countries on an aggregate of the indicators, it does not provide an indication of the relative performance of each of the components. It also tells us little about inequalities in wellbeing within countries.

INEQUALITY-ADJUSTED HUMAN DEVELOPMENT INDEX

The IHDI seeks to measure the level of human wellbeing and the level of inequality. Under conditions of perfect equality, the IHDI is equal to the HDI, but falls below the HDI if inequality rises. IHDI is a measure of the actual level of human development (taking into account inequality), while the HDI can be viewed as an index of the potential human development that could be achieved if there were no inequality (see Figure 12.2.2).

12.2.2 Inequality-adjusted HDI, 2014



Source: Human Development Report, 2015

12.2.3 HDI and IHDI by rank, 2015

HDI rank		IHDI rank	
1	Norway	1	Norway
2	Australia	2	Switzerland
3	Switzerland	3	Netherlands
4	Denmark	4	Australia
5	Netherlands	5	Denmark
6	Germany	6	Germany
6	Ireland	7	Sweden
8	USA	7	Iceland
9	Canada	9	Ireland
9	New Zealand	10	Finland
11	Singapore	11	Canada
12	Hong Kong	12	UK
13	Liechtenstein	12	Slovenia
14	Sweden	14	Czech Republic
14	UK	15	Luxembourg
16	Iceland	16	Belgium
17	South Korea	17	Austria
18	Israel	18	France
19	Luxembourg	19	Slovakia
20	Japan	20	Estonia
21	Belgium	21	Japan
22	France	22	Israel

Source: United Nations Development Programme

Table 12.2.3 shows the HDI ranking for the top twenty-two rated countries compared to their inequality-adjusted ranking. While the United States of America has the eighth-highest HDI, its ranking dropped to 27 when it was adjusted for income, health and educational inequality.

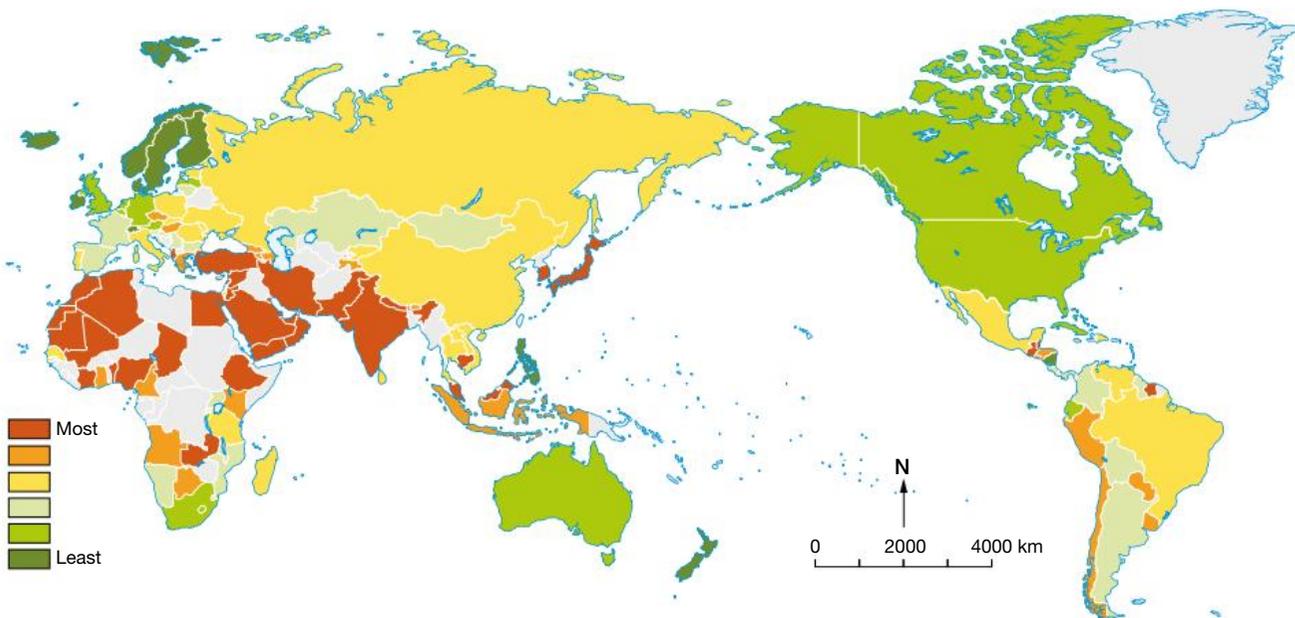
MULTIDIMENSIONAL POVERTY INDEX

The MPI was developed in 2010 by the United Nations Development Programme and the Oxford Poverty and Human Development Initiative. It uses a range of factors, beyond just income-based criteria, including nutrition and child mortality; years at school and percentage of children completing five years at school; percentage of households with electricity, proper **sanitation**, access to safe drinking water; and factors such as the type of household flooring and the type of cooking fuel used.

GENDER-RELATED DEVELOPMENT INDEX

The GDI 'discounts' the HDI for gender inequalities in its component indicators and the Gender Empowerment Measure (GEM), which measures gender inequality in terms of political and economic participation by women, for example the number of female politicians and participation in the labour force and types of work. The GDI is shown in Figure 12.2.4.

12.2.4 The Gender-related Development Index measures the gap between the sexes in four key areas—health (life expectancy, etc.), access to education, economic participation (salaries, job type and seniority) and political engagement.



Source: World Economic Forum, 2013

SPOTLIGHT

Sustainable Development Goals

The Sustainable Development Goals (SDGs), officially known by the title 'Transforming Our World: The 2030 Agenda for Sustainable Development', are a set of 17 aspiration goals with 169 targets.

- Goals 1–6: No poverty; zero hunger; good health and well-being; quality education; gender equality; and clean water and sanitation (see Figure 12.2.5)
- Goals 7–12: Affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; reduced inequalities; sustainable cities and communities; and responsible consumption and production
- Goals 13–17: Climate action; life below water; life on land; peace, justice and strong institutions; and partnerships for the goals



12.2.5 Walking to the water pump to collect water, Malawi

ACTIVITIES

Knowledge and understanding

- 1 Distinguish between quantitative and qualitative data.
- 2 Explain why geographers are interested in mapping such data.
- 3 List the various quantitative measures of human wellbeing. Explain what each seeks to measure.
- 4 Explain what is meant by the term 'composite measure'.
- 5 Outline the disadvantages of relying on a narrow measure such as GNP per capita.
- 6 Explain what the IHDI seeks to measure.
- 7 Outline the qualitative measure typically used to measure human wellbeing.

Geographical skills

- 8 Study Figure 12.2.1. With the aid of an atlas, describe the distribution of countries classified as:
 - a 'high income'
 - b 'low income'.

- 9 Study Figures 12.2.1 and 12.2.2. Write a sentence or two outlining any significant differences in the pattern of human wellbeing illustrated by GNP per capita and the inequality-adjusted HDI.
- 10 Study Table 12.2.3. Identify those countries whose:
 - a IHDI is considerably below its HDI rank
 - b IHDI is considerably above its HDI rank.

Investigating

- 11 Undertake research to complete the following table.

Country	GNP per capita	Life expectancy	HDI	IHDI	MPI
Australia					
Mexico					
Turkey					
Uganda					
Niger					

Progress in human wellbeing

Poverty reduction

In 2013, the United Nations (UN) reported that poverty reduction in the developing world was exceeding all expectations. It concluded that there was a 'global rebalancing' taking place, with higher growth in at least forty poor countries, helping to lift hundreds of millions of people out of poverty and into a new global **middle class**. It also concluded that the wellbeing and prospects of so many people had never changed so dramatically in such a short period of time. Showing the way are nations such as Rwanda, Nepal and Bangladesh, where

extreme (or absolute) poverty could disappear in the lifetime of present generations. Close behind are Ghana, Tanzania, Cambodia and Bolivia. Figures 12.3.1 and 12.3.2 illustrate the progress in human wellbeing around the world.

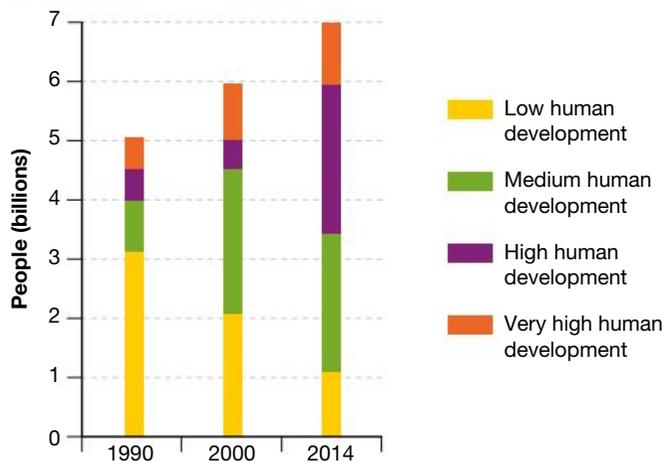
This improved global picture is the result of international aid and development projects investing in schools, health clinics, housing, infrastructure and access to water. The UN noted that trade is a key factor in improving conditions in countries such as Afghanistan, Ethiopia, Rwanda and Sierra Leone. These improvements were observed in the past, when poverty was measured strictly in income terms, without taking into account factors such as health, education and living standards.

This improvement can, at least in part, be attributed to the success of the UN's Millennium Development Goals.

India's and China's changing fortunes

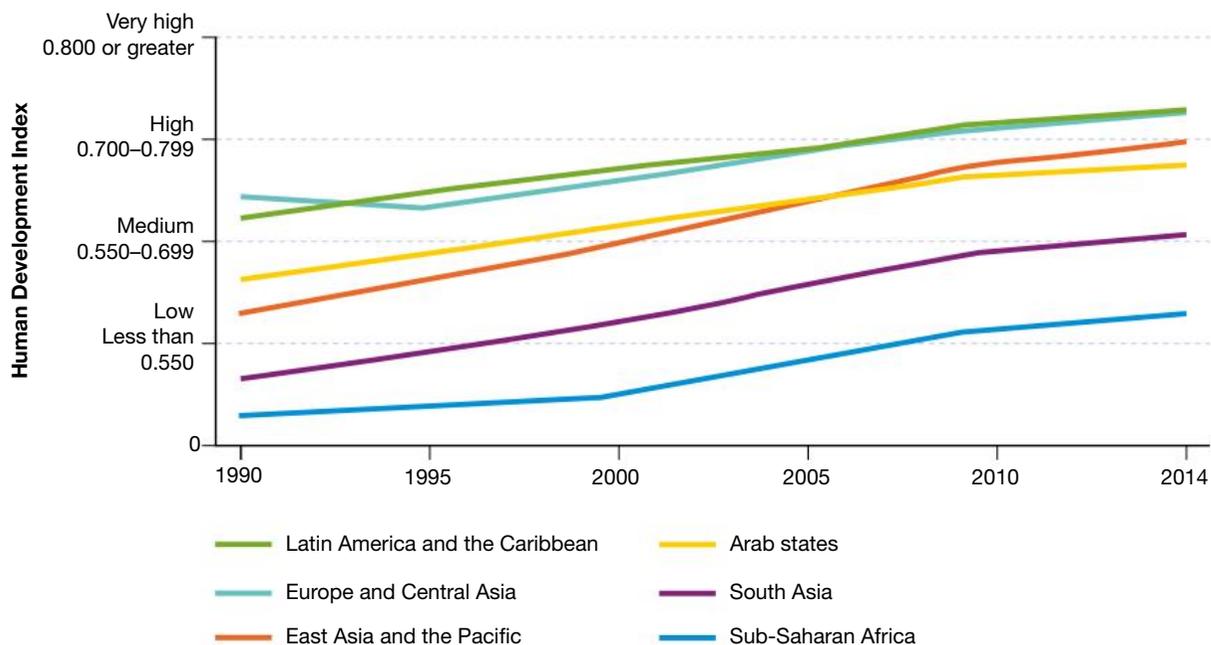
Experts conclude that at the dawn of the **Industrial Revolution** (about 1750), India's per capita income was some 10 per cent above that of England. They also argue that India's and China's technological sophistication once exceeded Europe's. For example, when Marco Polo visited China in the 1290s, he found that the Chinese were far ahead of the Europeans—he brought back to Europe porcelain, paper, paper currency and the compass. By 1800, levels of human wellbeing in China, India and Japan were lower than those in Europe. The balance had changed. The people of Europe (and North America) were then to enjoy generally higher levels of human wellbeing for the next two and a half centuries.

12.3.1 Human development, 1990, 2000 and 2004



Source: Human Development Report

12.3.2 Progress in human development since 1990



Looking to the future

By 2020, there will be a major shift in the global balance of economic power compared with today. Emerging economies will grow in importance and China will overtake the United States of America in terms of GDP. Consumer markets in emerging economies will present great opportunities, but their rapid growth will pose a challenge to the global environment. Translating this economic success into improvements in human wellbeing will be a major challenge. China has had great success in alleviating poverty, but qualitative indicators of human wellbeing, such as human rights and the state of the environment, lag well behind those in most of the **developed world**.

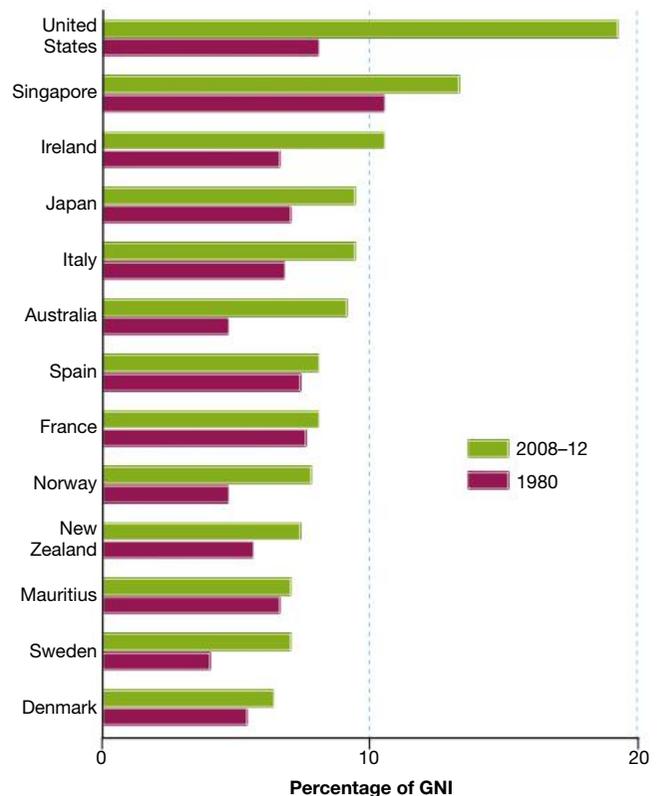
Australian wellbeing

Levels of human wellbeing have been high in Australia for much of its post-1788 history, and are now among the highest levels of human wellbeing in the world. Australia's Aboriginal and Torres Strait Islander people, however, experience levels of wellbeing well below those of non-Indigenous Australians.

Challenges to poverty reduction

Despite reductions in poverty levels worldwide, inequalities within countries continue to grow. The share of national income of the richest 1 per cent has grown significantly since 1980, as is shown in Figure 12.3.3. According to a report by Oxfam, the total wealth of the richest sixty-two people in the world is the same as the total wealth of the poorer half of the world's population, or 3.6 billion people. Since 2010, the wealth of the world's poorest people has declined 1 per cent, or a trillion US dollars. The Oxfam report estimates that, globally, super-rich individuals have amassed a total of US\$7.6 trillion in offshore accounts. Tax on this amount of income would generate an extra US\$190 billion in tax revenues, which would be available to governments worldwide every year.

12.3.3 Share of national income going to the richest 1 per cent of the population, selected countries, 1980 and 2008–12



In order to reverse inequality and increase the wellbeing of all, Oxfam's report called for governments to:

- crack down on tax evasion and end the use of tax havens by businesses and wealthy individuals
- invest in public services
- increase the income of the poorest paid people.

ACTIVITIES

Knowledge and understanding

- 1 Outline the key pieces of information relating to the changes in spatial wellbeing over time highlighted in this unit.
- 2 List some key technologies Marco Polo brought to Europe from China.
- 3 Explain how the spatial pattern of wellbeing is likely to change in the future.

Applying and analysing

- 4 What implications will the shift in the global balance of power have for human wellbeing?

Geographical skills

- 5 Study Figures 12.3.1 and 12.3.2. Using data from the graphs, write a paragraph outlining the advances made in raising human wellbeing.
- 6 Study Figure 12.3.3. Estimate the difference in percentage between 1980 and 2008–12 for each country. Rearrange the graph from the greatest to the least difference. Describe any changes between Figure 12.3.3 and the new list. Can you account for these differences?

Causes of spatial inequality

External factors

Legacy of history

Many of the world's poorest countries were once colonies, part of vast European empires. In the years immediately after World War II, most colonial powers gave up, or were forced to give up, their colonial territories. The legacy of **colonialism** remained and it influenced the development paths of many of the former colonies.

Many of the colonies were used as markets for finished products and other surpluses produced in the industrialised countries. At the same time, the colonies supplied raw materials and foodstuffs needed by the colonial power. Restrictions were often placed on colonies so that they could not produce goods that were already produced by the colonial power, or trade freely with countries other than the colonial power. Such arrangements were obviously designed to benefit the colonial power rather than the colony (see Figure 12.4.1), and placed severe limits on the colony's economic activities. Many of these established trade relationships have continued, with the wealthy countries, long after the demise of

colonialism, continuing to dominate international trading relationships. The uneven distribution of wealth between countries is thus shaped by relationships established in the colonial era. Many of the former colonies still suffer from continued economic dependence on the more developed regions of the world. In addition, the large-scale acquisition of land throughout the developing world by developed nations, shown in Figure 12.4.2, threatens traditional forms of agriculture in places such as Africa.

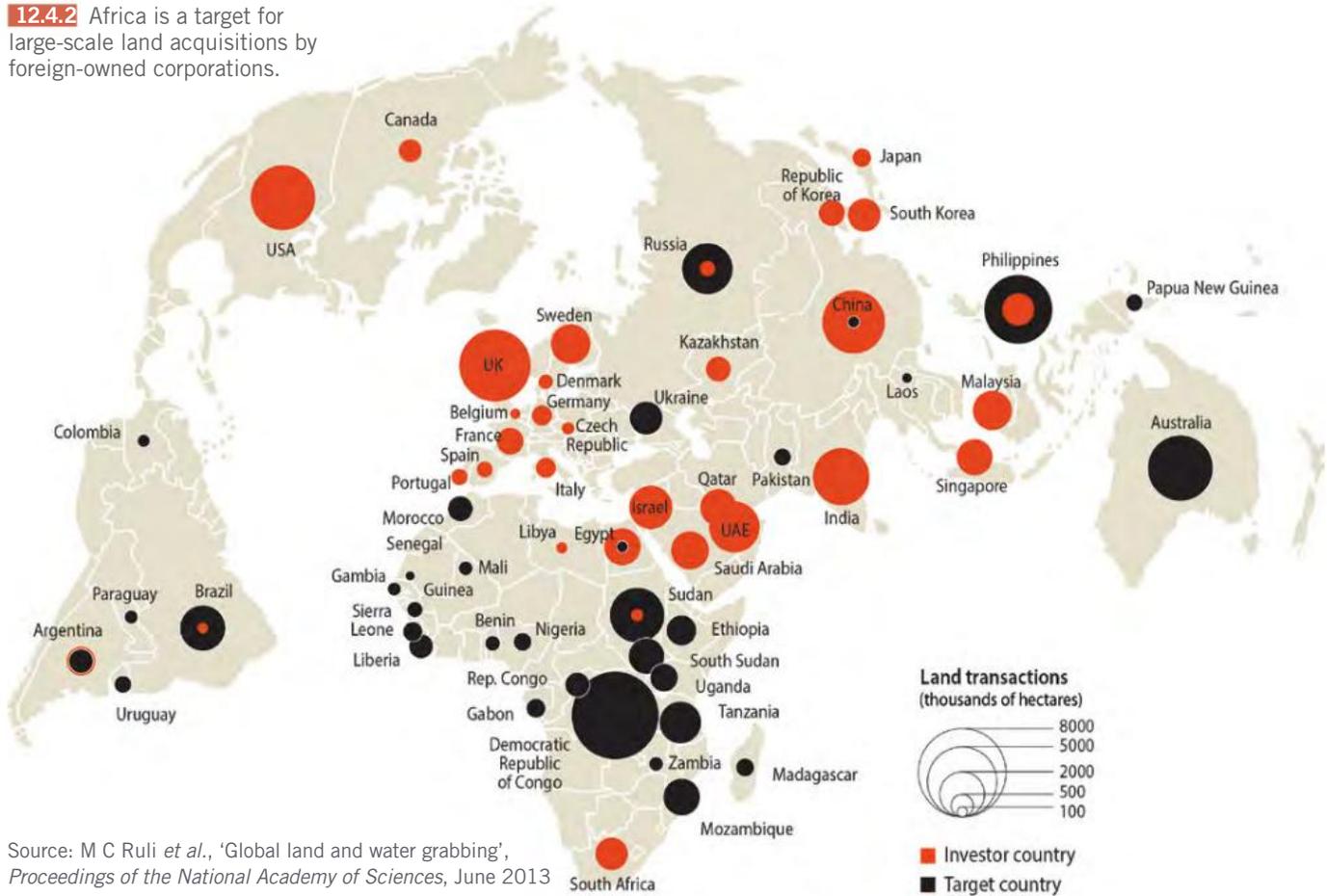
Trade imbalances

Most developing countries are still net importers of manufactured goods. Manufactured goods are generally more costly than the raw material exports that most developing countries are able to sell. Many poor countries are still dependent on the industrialised, wealthy countries for numerous high-cost imported goods. Meanwhile, these poor countries rely heavily on the exploitation of their natural resources (see Figure 12.4.3) and the production of agricultural products for their export earnings.



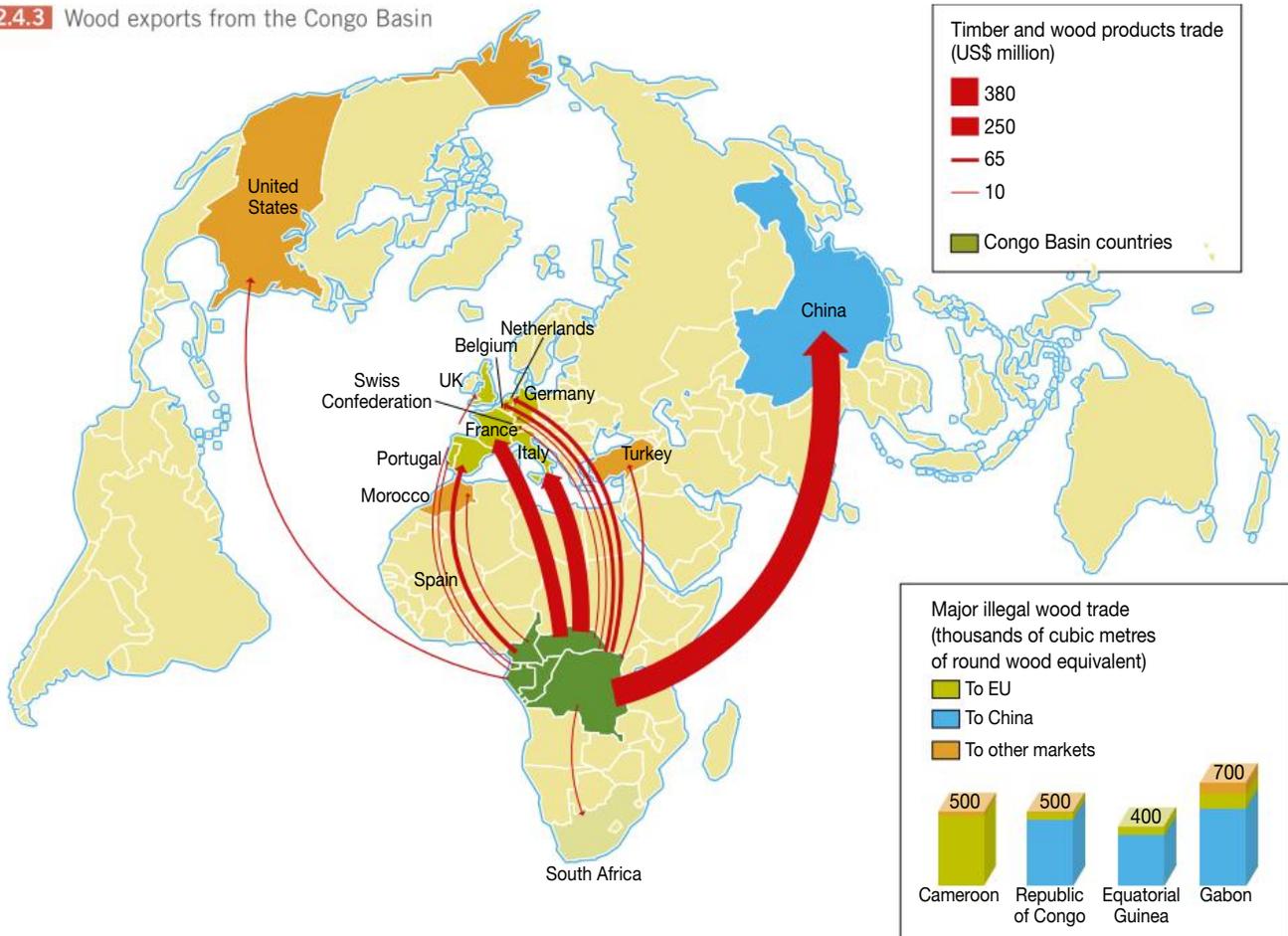
12.4.1 'The White Man's Burden (Apologies to Kipling)', *Judge Magazine*, 1899. 'The White Man's Burden' was originally a poem by Rudyard Kipling. It offered a critique of European imperialism and the notion that Western domination was for the benefit of the developing world.

12.4.2 Africa is a target for large-scale land acquisitions by foreign-owned corporations.



Source: M C Ruli *et al.*, 'Global land and water grabbing', *Proceedings of the National Academy of Sciences*, June 2013

12.4.3 Wood exports from the Congo Basin





12.4.4 Child workers on a cocoa farm, Sinikosso, Cote D'Ivoire

Developing countries have increased their share of global output, but they are usually at a disadvantage in world trade: the value of their imports often exceeds the income earned from their exports. As a result, they are likely to incur a debt rather than earn surplus income through trade.

In many poor countries, people have been encouraged to convert farmland from **subsistence production** to production of **cash crops** (such as tea, coffee and flowers), in order to earn export income. This can have devastating effects on poor local farmers, who forego more dependable subsistence farming systems in favour of cash cropping. In doing so, they become dependent on export income, which in turn depends on continued and consistent demand for cash crops. Their country also becomes highly dependent on unreliable sources of export earnings.

Transnational corporations

Transnational corporations (TNCs) are large organisations that have operations in several countries. The parent company is usually based in a developed country. TNCs frequently operate subsidiary companies in developing countries. Developing countries are attractive to TNCs because of their abundant supply of cheap labour, often accompanied by less stringent industrial relations laws regarding wages, hours of employment and working conditions. They also appeal because of the lower cost of inputs (such as land and services) and the availability of cheap raw materials.

Figure 12.4.4 shows child workers on a cocoa farm. There have been widespread reports of child slavery in the least developed countries that rely on exports.

The goods manufactured cheaply in poor countries are sold to consumers in wealthy countries (or the rich elite in poor countries). These items are frequently beyond the financial reach of those employed to manufacture them.

Dependency on development assistance

Many poor countries are heavily dependent on development assistance (or overseas aid) supplied by wealthy countries.

There are three major types of aid.

- **Bilateral aid** This is development assistance provided by governments of wealthy countries to governments of developing countries.
- **Multilateral aid** Multilateral aid is given by international institutions, such as the World Bank, the International Monetary Fund (IMF) and the Asian Development Bank. This aid is frequently provided in the form of loans.
- **Non-governmental aid** This is distributed by non-governmental, non-profit organisations (NGOs), which receive most of their income from donations by the general public.

There is considerable debate about how aid should be distributed. Some donors are concerned about corruption. Others fear that aid is being diverted to projects that do little, if anything, to enhance human wellbeing. There is, however, a shift towards poverty-focused projects that directly involve poor people in the design of projects intended to assist them to improve their own lives.

Internal factors

Population growth

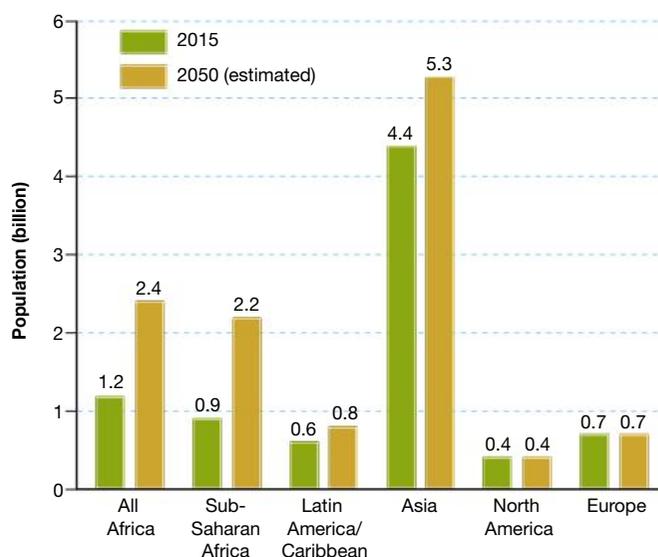
A country's ability to provide for the needs of its people is affected by the growth rate of its population. If the rate of population growth exceeds the rate of economic growth, for example, the share of the 'economic pie' each person gets becomes smaller. Similarly, a country's ability to provide medical and educational facilities, infrastructure and adequate food supplies is immediately affected by any rise in **fertility rates**.

PREDICTING POPULATION GROWTH

With a projected growth of 1.3 billion between now and 2050, Africa will add more population than any world region. Virtually all of that growth will be in the fifty-one countries of Sub-Saharan Africa, the region's poorest countries. Even this projection assumes that birth rates will decline steadily in all countries of Sub-Saharan Africa because of an increase in the use of family planning. If birth rates do not decline steadily, future projections of population growth will have to be increased.

The world's population is projected to reach 9.6 billion by 2050. Most of this growth will take place in those countries least able to cope. While the total population of the developed world will remain at about 1.3 billion, the population of the world's least developed forty-nine countries is projected to double from about 950 million in 2015 to 1.8 billion by 2050, as is shown in Figure 12.4.5.

12.4.5 Population growth by region, 2015 and 2050



Much of this population growth will occur in Africa, which is expected to be home to 2.5 billion people—a quarter of the total world population—by 2050, up from its current population of about 1.1 billion. This growth is a consequence of the high fertility rate in Africa, which, at 4.8 children per woman now, is almost twice the global average of 2.5 children per woman. Nigeria, the most populous nation in Africa, is expected to have a population of 444 million by 2050.

Resource base

The differing levels of wellbeing that people experience can be partially attributed to the resource base available to communities or countries. Some countries have been able to generate considerable wealth from the exploitation of natural resources. The United Arab Emirates, for example, has been able to generate vast wealth by exploiting oil reserves. Other countries, however, have only limited opportunities to generate income from the exploitation of natural resources.

When a country's biophysical environment (that is, its climate, soils and landforms) is capable of supporting a range of agricultural activities, the country has the potential to become self-sufficient in food production. Surpluses can be traded internationally to generate capital for investment in other areas. If the environment is incapable of supporting large-scale food production, a country may be forced to rely on costly imports to meet the needs of its people.

A lack of natural resources need not be an impediment to the enhancement of human wellbeing. Japan, for example, has few natural resources but has been able to achieve a high level of wellbeing by importing raw materials and exporting manufactured goods.

Political instability

Attempts to alleviate poverty and improve human wellbeing can be hampered by political instability, which can cause war and civil unrest, weak political institutions and corruption. Instead of funds being devoted to development-related activities and projects, or the enhancement of **social infrastructure**, which may improve levels of human wellbeing, they are often diverted to finance the activities of the military and police forces. Conflict can result in damaged infrastructure, destruction of crops, displacement of people and disruption of the economy.

While much of the present-day political instability in Africa is internal, its origins often lie in the artificial national boundaries. These are a product of European colonial expansion, which divided Africa into colonies without taking local interests into consideration.

Debt burdens

Under pressure to meet debt accumulated in the early post-colonial era, many developing countries sought to increase export earnings by allowing the exploitation of natural

resources such as native forests and mineral deposits. For the same reason, they encouraged the production of cash crops for sale to the consumers in developed countries. Many poor countries struggle to cope with the burden of debt repayments.

The debt burden of developed countries has been at the centre of a campaign by a range of NGOs. The global Make Poverty History campaign, for example, has campaigned for global debt relief.

Militarisation

Once colonies achieved independence, they were faced with concerns about their security. These concerns were reinforced by ruling elites, who often saw a strong military as a means of protecting their position of privilege. Expenditure on armaments contributed to the newly autonomous country's debt burden and used resources that could have been devoted to meeting the basic needs of its people.

Environmental degradation

Environmental degradation in developing countries is both a symptom of poverty and a contributor to ongoing disadvantage. At the local level, people are often engaged in practices that can cause environmental degradation. This is frequently the result of the struggle for survival. Population growth and increased use of land for commercial agriculture can force the expansion of subsistence agricultural activities into more marginal areas. This results in land being cleared for agricultural purposes or to access timber for fuelwood. Furthermore, the overuse of the land results in the loss of soil fertility. At the national level, the need to repay foreign debt means that governments have encouraged the extension of cash cropping, mining and forestry, frequently at the expense of the environment.

In some areas, such as the Sahel region of Africa, overuse of land and destruction of ground cover have led to rapid desertification. Because the boundaries of the desert are gradually being extended, arable land is subject to increasing pressure through overuse. Subsistence farmers simply do not have the resources to reverse these processes or to be able to reduce their use of the land. Thus, the land is further degraded and becomes less fertile, and the poor become still poorer. Today there is growing concern about the impacts of climate change on the world's most vulnerable people.

Compounding issues

There are a number of issues that compound the difficulties faced by developing countries.

- Low levels of human wellbeing hinder development. It can be argued, for example, that poor health can reduce the productivity of people. Similarly, low levels of national income mean that some governments do not have the capacity to invest in healthcare services and education facilities.

- The priorities of governments may affect human wellbeing within countries. For example, one government may choose to spend the limited available capital on meeting the basic needs of the poor majority. Another government may direct it towards priorities such as the protection of the interests of wealthy elites or military expenditure.
- The persistence of rigid social systems and cultural traditions can hinder improvements in wellbeing for some social groups or communities.

ACTIVITIES

Knowledge and understanding

- 1 Describe the nature of the relationship between the colonial power and the colony prior to independence.
- 2 Outline how developing countries are often disadvantaged through their engagement in world trade. What impacts can the imbalance in trade have on developing countries?
- 3 Explain why developing countries offer an attractive base for TNC activities.
- 4 Outline the effects of the burden of debt on developing countries.
- 5 Distinguish between bilateral, multilateral and nongovernmental aid.
- 6 Explain the relationship between population growth rates and the prospects for increasing levels of human wellbeing.
- 7 Explain the link between a country's resource base and levels of human wellbeing. Are there any exceptions?
- 8 State how political instability affects efforts to enhance human wellbeing.
- 9 Explain how environmental degradation is both a symptom of poverty and a contributor to ongoing disadvantage.

Applying and analysing

- 10 Construct a mind map to illustrate the external and internal factors that have an impact on human wellbeing in a developing country.
- 11 Study Figure 12.4.1 and do the following tasks.
 - a Identify the characters shown carrying the peoples of the colonies in baskets. Who do they represent?
 - b Identify the goal being pursued and name the barriers encountered.

- c Identify the perspective from which the cartoon is drawn.
- d Would it be appropriate to draw such a cartoon today? If not, why not?

Geographical skills

- 12 Study Figure 12.4.2. Identify the main markets for timber and wood products harvested from the tropical forests of the Congo Basin. Why has this fragile and ecologically significant natural resource been exploited?
- 13 Study Figure 12.4.3 and do the following tasks.
 - a Identify the five largest investor countries.
 - b Identify the regions of the world targeted by those seeking to acquire land.
 - c Describe the overall pattern that emerges.
- 14 Study Figure 12.4.5 and do the following tasks.
 - a Calculate the percentage increase in the projected population of Africa, Sub-Saharan Africa and Asia. Which region will show the greatest rate of increase?
 - b Compare the rate of increase in Sub-Saharan Africa with 'All Africa'.
 - c Which regions will have no net increase in population between 2013 and 2050?

Investigating

- 15 Investigate the use of fuelwood in developing countries. Include in your report the following information:
 - a what the fuel is used for
 - b how collection results in land degradation
 - c alternatives to fuelwood.

Human wellbeing: The issues

Barriers to improving human wellbeing

Poverty

Extreme poverty is most common in areas where poor health and lack of education deprive people of productive employment; environmental resources have been depleted or spoiled; and corruption, conflict and poor governance result in the waste of public resources.

According to the World Bank, 12.7 per cent of the world's population lived at or below US\$1.90 a day in 2013. That's down from 37 per cent in 1990 and 44 per cent in 1981. This means that, in 2013, 896 million people lived on less than \$1.90 a day, compared with 1.95 billion in 1990, and 1.99 billion in 1981. Progress has been slower, however, at higher poverty lines. Over 2.1 billion people in the developing world lived on less than US\$3.10 a day in 2013, compared with 2.9 billion in 1990. So even while the share of the world's population living under that threshold nearly halved, from 66 per cent in 1990 to 35 per cent in 2012, far too many people are still living in poverty. Sub-Saharan Africa and southern Asia account for about 40 per cent of the world's population living in extreme poverty.

Low per capita income

In general, developing countries tend to have low levels of per capita income compared to wealthier countries. By the end of the first decade of the twenty-first century, the richest 20 per cent of the population had three-quarters of the world's income, while the poorest 40 per cent between them consumed only 5 per cent of the world's income. The very poorest 20 per cent of the global population had only 1.5 per cent of the world's income.

Lack of adequate shelter

Approximately 33 per cent of the urban population in the developing world, or about 880 million people, lived in **slums** in 2015. The proportion of the urban population living in slums was highest in Sub-Saharan Africa (61.7 per cent) followed by South Asia (35 per cent). While these percentages are declining, absolute numbers are not, due primarily to the fast pace of urbanisation.

Lack of access to clean water and sanitation

Some 663 million people still rely on water from unsafe sources. Eighty-three per cent of these people live in rural areas. Of those who have access to a source of safe drinking

water, 38 per cent do not enjoy the convenience and associated health and economic benefits of piped drinking water at home. Instead, they spend considerable time and energy queuing up at public water points and carrying heavy loads of water over long distances.

The United Nations estimates that 2.4 billion people do not use an improved sanitation facility. In Sub-Saharan Africa, 44 per cent of the population uses either shared or unimproved facilities, while in southern Asia, the proportion of the population using shared or unimproved facilities has declined to 18 per cent, but open defecation remains the highest of any region (39 per cent). Between 1990 and 2015, 2.1 billion people gained access to a flush toilet or other improved sanitation facility.

Low life expectancy

Diseases originating from contaminated water supplies, inadequate sanitation, poor nutrition, inadequate or inappropriate health care and poor hygiene disproportionately affect the poor. Many diseases deepen poverty and make living conditions worse.

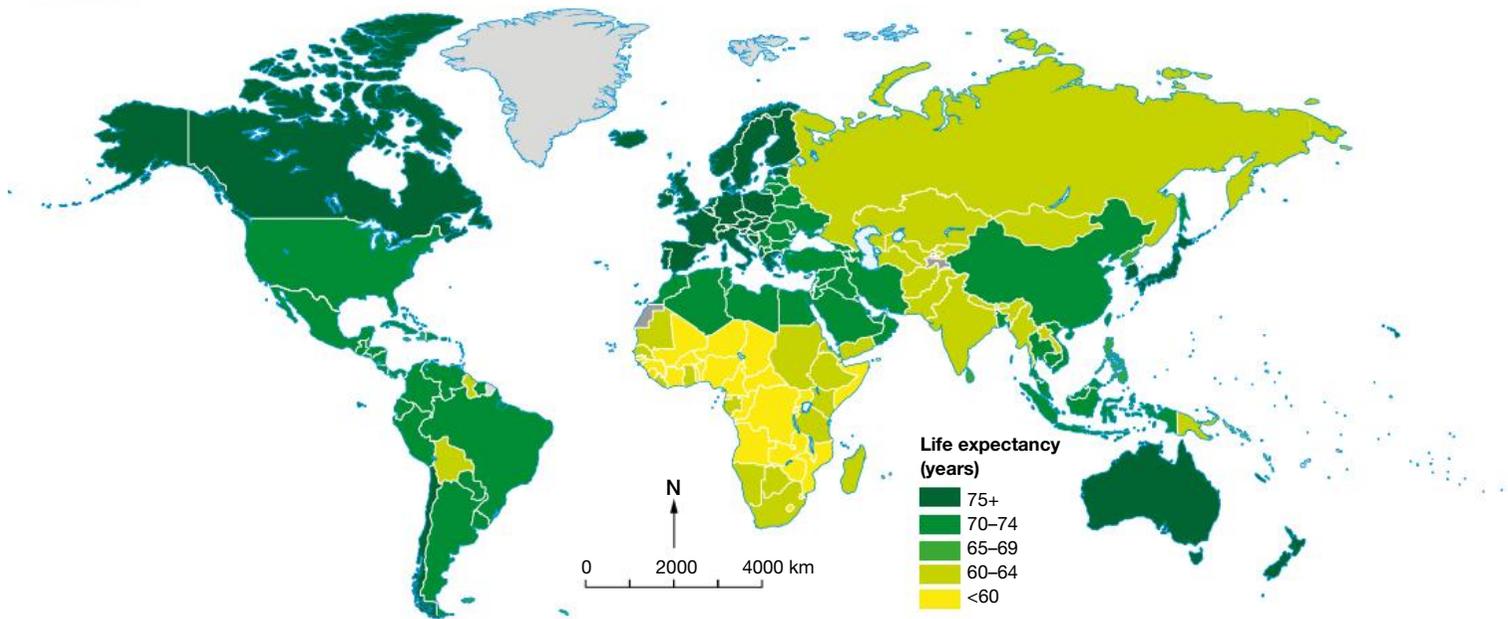
Many diseases in poor countries are preventable and treatable. Poverty often prevents people from accessing these treatments and medications. Gastroenteritis, which can readily be treated, results in about 1.8 million child deaths annually. A greater proportion of women and infants in less developed countries are likely to become very ill or die as a result of lack of medical care at childbirth.

The average life expectancy in the least developed countries was only 62 years in 2015, compared with 79 years in the more developed countries. Figure 12.5.1 illustrates the differences in life expectancy for people in wealthy and poor countries.

Dietary deficiencies

Dietary deficiencies result from inadequate food intake. The amount of food available may be inadequate or it may be of poor quality. In 2015, 25 per cent of the world's population (795 million) was classified as undernourished. Most undernourished people lived in developing countries. Women and children are the most vulnerable. India alone has 65 million undernourished children. Worldwide, 495 million women and children under 5 years of age are undernourished—150 million, or one in four, in Africa; 315 million, or one in seven, in Asia; and 30 million, or one in eleven, in Latin America and the Caribbean.

12.5.1 Life expectancy, 2015



Source: Population Reference Bureau



12.5.2 Pneumonia, diarrhoea, malaria, measles, HIV/AIDS and malnutrition are the primary killers of children in developing countries. Many of these diseases are preventable through inoculations.

Low access to health services

The availability of health services is generally low in developing countries. In Africa, countries such as Niger, Malawi and Tanzania have just two physicians per 100 000 people, while Uganda and Angola have eight. In Australia, there are 374 physicians for every 100 000 people, while the equivalent measure in Belgium is 449 for every 100 000 people.

High maternal mortality rates

Maternal mortality is defined as the death of a woman while pregnant or in the days after giving birth or having a pregnancy terminated. High rates of maternal mortality occur in the same

countries that have high rates of infant mortality. This reflects a lack of access to skilled medical care during childbirth and poor nutrition. Over 90 per cent of maternal deaths occur in developing countries.

Significantly, however, the global maternal mortality ratio has declined by 47 per cent over the last two decades, from 400 maternal deaths per 100 000 live births to 210 between 1990 and 2010. All regions have made progress, with the highest reductions in eastern Asia (69 per cent), northern Africa (66 per cent) and southern Asia (64 per cent).

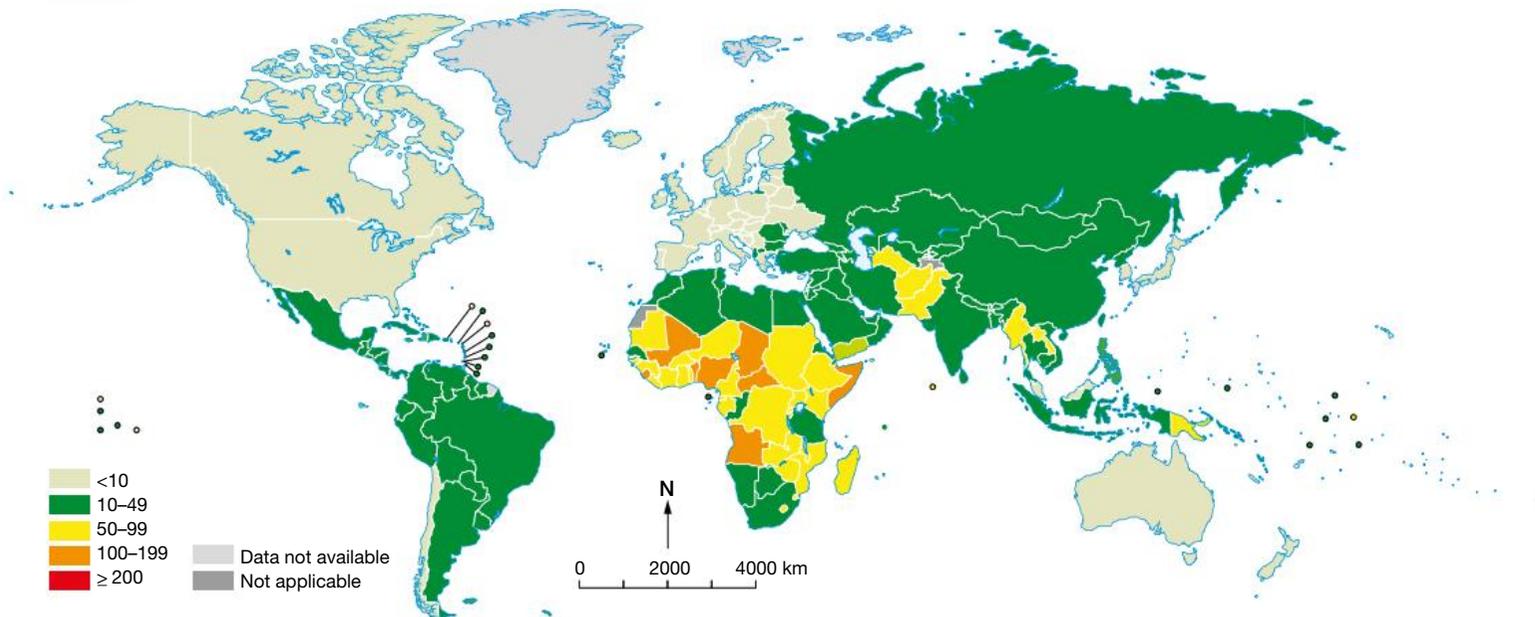
Relatively high levels of illiteracy

The adult literacy rate is generally 99 per cent in developed countries, compared with 76 per cent in developing countries. In the least developed countries, the adult literacy rate is just 54 per cent.

Worldwide, 57 million children were not attending school in 2013. Thirty million of these were in Sub-Saharan Africa. While progress has been made in the number of children receiving a primary education, the rate of improvement is slowing. Between 2000 and 2011, the number of children not attending school declined by almost half, from 102 million to 57 million, but between 2008 and 2011, the number of children of primary school age not attending school fell by only 3 million.

Children and adolescents from the poorest households are at least three times more likely to be not attending school than those from the richest households. Girls are more likely to be not attending school than boys in both primary and lower secondary age groups—even girls living in the richest households.

12.5.3 Under-5 mortality rates (probability of dying by age 5 per 1000 live births), 2015



Source: WHO

High infant mortality rates

In the less developed countries, infant mortality rates were 44 per 1000 live births in 2015, and 62 per 1000 in the least developed countries. This compares with just five deaths per 1000 in the more developed countries. The under-5 mortality rate is particularly high in some of the poorest countries—more than 120 per 1000 live births in some countries. In Afghanistan, the rate was 129 per 1000 live births. Australia's rate was just 3.9 per 1000 live births. Six million children under the age of 5 died in 2015. Figure 12.5.3 shows the distribution of these deaths.

High rates of population growth

Worldwide, annual population growth is 2.5 per cent; in developed countries it is 1.5 per cent, in developing countries it is 2.6 per cent, and in the least developed countries it is 4.4 per cent. Growing populations in the world's poorer countries place added strain on already limited national resources. This creates additional demand for employment, schooling, infrastructure, health and other services.

Child exploitation

Hundreds of millions of children are exploited. Much of this occurs in developing countries. The worst types of exploitation are child labour and trafficking, child marriage and sexual exploitation.

Indebtedness

Developing countries tend to be heavily indebted. Initiatives to 'forgive' debt since the early 1990s have reduced the debt burden of many countries. Despite this, on average, the total debt service burden of developing countries still represents 13 per cent of total exports of goods and services. The external

debt of many developing countries drains public budgets, using the resources needed to support essential service provision and improve levels of human wellbeing. For debt reduction initiatives to be effective, the money saved needs to be used to boost social programs and reduce poverty.

Emphasis on primary production

Worldwide, one-third of the global workforce is engaged in agriculture, often subsistence production. Although the process of urbanisation has been accelerating in developing countries, the greater percentage of their labour force is still engaged in agricultural activities, as is outlined in Figure 12.5.4. The percentage of the population engaged in agriculture was less than 2 per cent in the United States of America in 2010. Worldwide, about 60 per cent of all child labourers—129 million girls and boys—work in agriculture. More than two-thirds of them are unpaid family members.

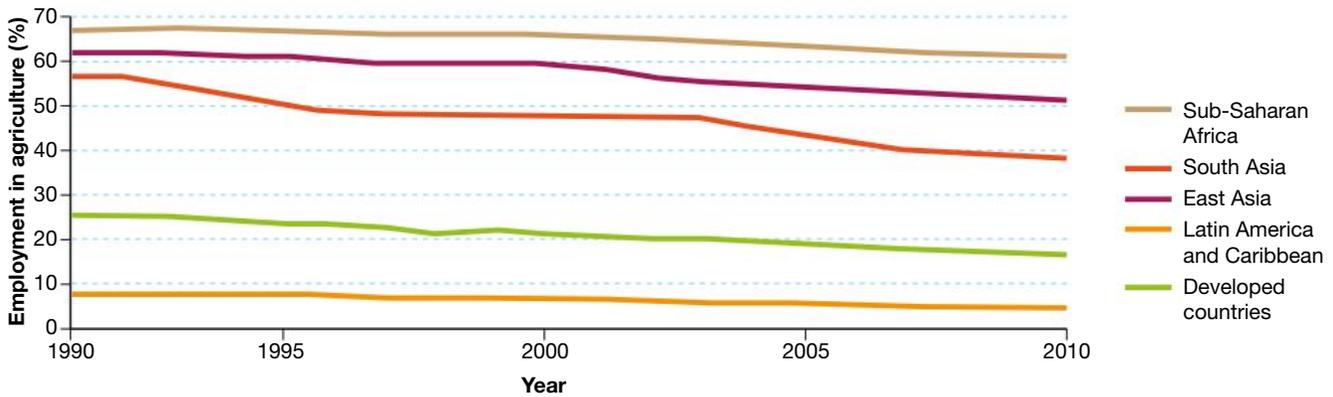
Rural–urban inequality

There continues to be a significant gap between the wellbeing of those living in rural areas and that of people living in urban centres. In 2011, only 53 per cent of births in rural areas were attended by skilled health personnel compared with 84 per cent in urban areas. Eighty-three per cent of people without access to a source of improved drinking water live in villages.

Low levels of technology

In developing countries there are comparatively low levels of technology and science-based applications in agriculture and industry. Labour-intensive methods of production still dominate in both agriculture and industry in the world's poorest countries.

12.5.4 Employment in agriculture is falling worldwide, but the sector still accounts for more than half of total employment in Sub-Saharan Africa and South Asia.



Source: FAO

Low levels of energy consumption

Low national incomes are often reflected in low levels of public infrastructure provision. In 2015, 1.2 billion of the world's people were living without electricity. Most of these people (493 million) lived in South Asia, followed by Africa (587 million) and East Asia (182 million).

In Afghanistan, for example, only 30 per cent of the population has access to electricity. Worldwide, 80.5 per cent of people have access to electricity. In developing countries, the figure is 74.7 per cent. In the United States of America, consumption of electricity was 87 217 kilowatt-hours of electricity per person in 2012, compared with India's 6280 kilowatt-hours. The worldwide average was 21 283 kilowatt-hours of electricity per person.

Lack of commitment to environmental sustainability

The growth in global carbon dioxide emissions is accelerating; emissions are now more than 46 per cent higher than they were in 1990. Forests continue to be lost at an alarming rate. Overexploitation of marine fish stocks is resulting in diminished yields. Birds, mammals and other species are heading for extinction at an ever faster rate, with declines in both populations and distribution.

ACTIVITIES

Knowledge and understanding

- 1 Outline the extent of extreme poverty in the world.
- 2 State the extent to which lack of access to water and sanitation impacts negatively on human wellbeing.
- 3 How many people are estimated to be involved in primary production around the world?

Applying and analysing

- 4 Outline the extent to which hunger and diet deficiencies exist in the world today. What are the consequences of poor nutrition?
- 5 Outline the relationship between the provision of electricity infrastructure and electricity consumption per capita. What other factors may influence energy consumption?

- 6 Construct an annotated mind map to illustrate the characteristics of developing countries.
- 7 Draw up a list of improvements that have taken place in human wellbeing since 1990.

Geographical skills

- 8 Study Figures 12.5.1 and 12.5.3.
 - a Describe the distribution of:
 - i the lowest and highest life expectancy rates
 - ii the lowest and highest under-5 mortality rates.
 - b Is there a link between the two maps? Explain.
- 9 Study Figure 12.5.4. Using data from the graph, describe the trends in agricultural employment.

Access to water

Millennium Development Goals

One of the targets of the Millennium Development Goals was to halve the percentage of people without sustainable access to safe drinking water and basic sanitation between 1990 and 2015. Although this target was met in 2010, nearly 800 million people still rely on unimproved water sources (surface water from lakes, rivers, dams, or unprotected dug wells or springs) for their drinking, cooking and personal hygiene.

Sustainable Development Goals

Goal 6 of the Sustainable Development Goals is 'Clean water and sanitation'. Along with the ongoing aim of supporting and strengthening the participation of local communities in improving water and sanitation management, the targets of this goal are as follows.

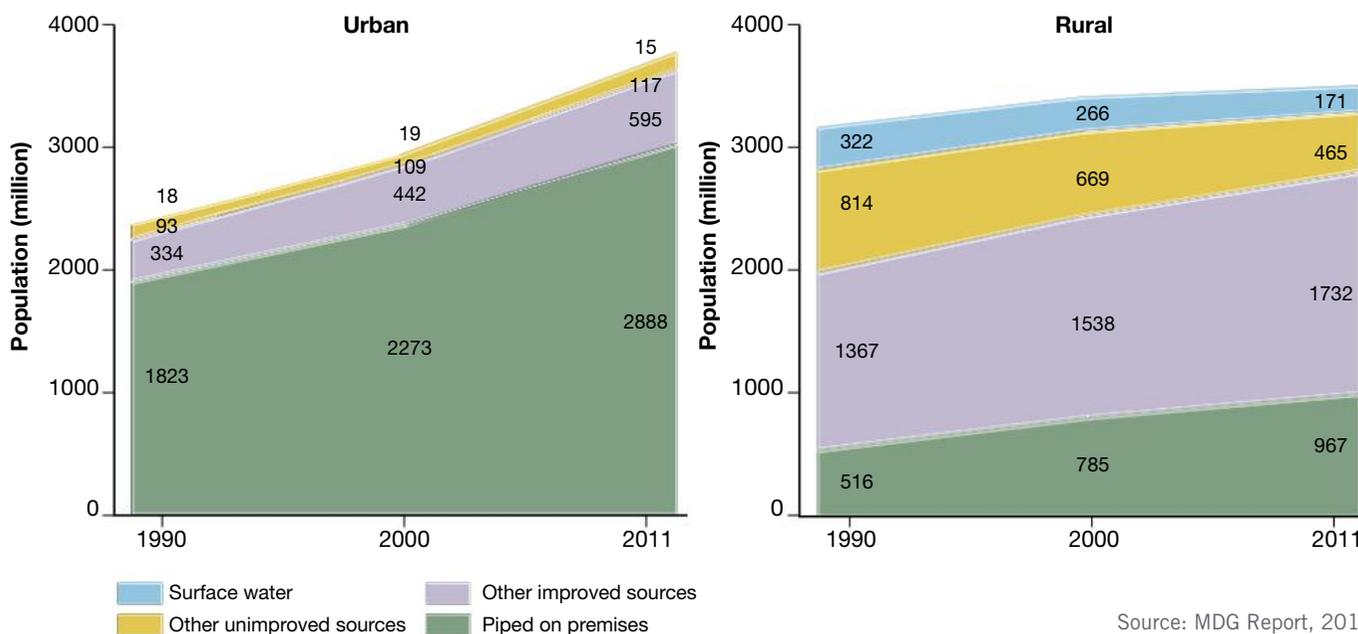
By 2020:

- protect and restore water-related ecosystems (mountains, forests, wetlands, rivers, aquifers and lakes)

By 2030:

- achieve universal and equitable access to safe and affordable drinking water
- achieve access to adequate and equitable sanitation and hygiene and end open defecation, and pay special attention to the needs of women and girls and those in vulnerable situations
- improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe re-use globally

12.6.1 Population with access to drinking water, urban and rural areas, 1990, 2000 and 2011 (million)



- substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater scarcity and substantially reduce the number of people suffering from water scarcity
- implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
- expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes. (Source: UN)

Improved sources of water

Access to an 'improved water source' refers to the availability of a clean, safe and reliable source of drinking water. Improved sources include piped water on premises (a piped household water connection located inside the user's dwelling, plot or yard) and other improved sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater collection).

Access

The proportion of the world's population with access to improved drinking water sources increased from 76 per cent to 91 per cent globally between 1990 and 2015. While the proportion of the population with access to water is above 90 per cent in Latin America and the Caribbean, northern Africa and large parts of Asia, it is only 63 per cent in Sub-Saharan Africa. There are also big gaps between urban and rural water access. While an estimated 96 per cent of the world's urban population had access to an improved water supply source, only 81 per cent of rural dwellers did (see Figure 12.6.1).

Source: MDG Report, 2013

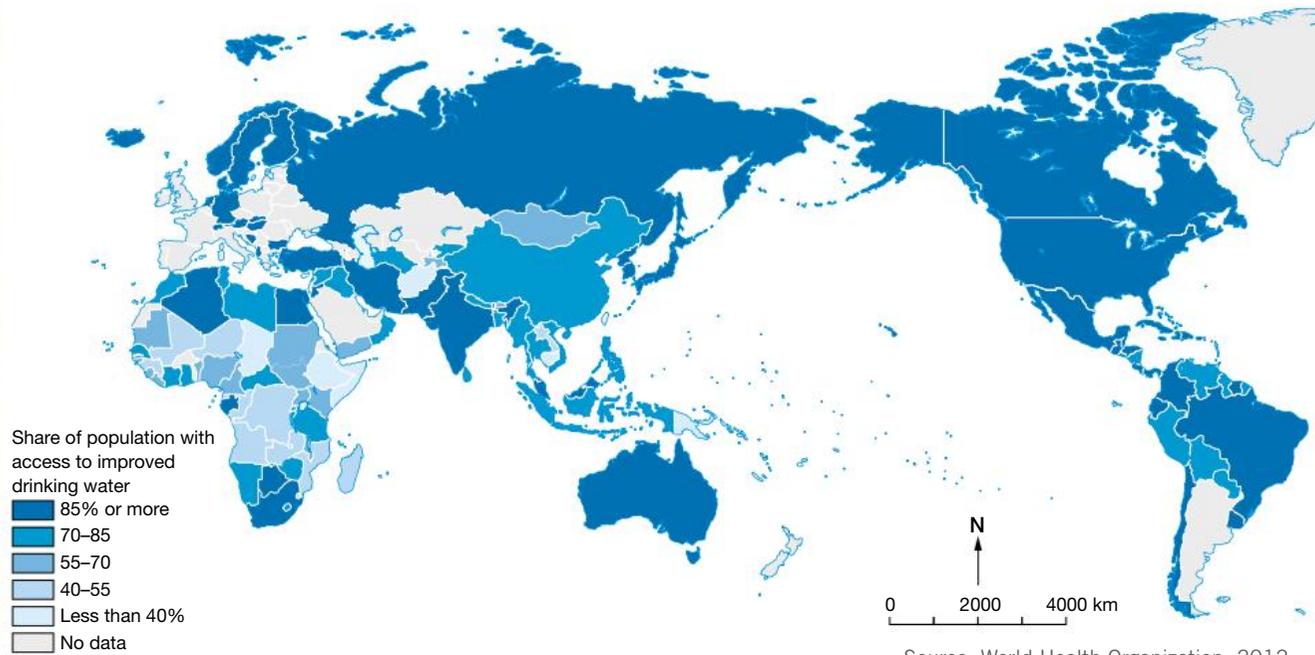
SkillsBuilder

Choropleth maps

Choropleth maps are a special type of thematic map. Areas on the map are shaded in proportion to the measurement of the data being displayed. A system of colour progression is used to depict the data. This typically takes the form of different shades of the one colour, with the darkest shade showing the distribution of the highest data category.

Figure 12.6.2 is an example of a choropleth map. The areas coloured the deepest shade of blue are those with the highest percentage of the population who have access to an improved water source.

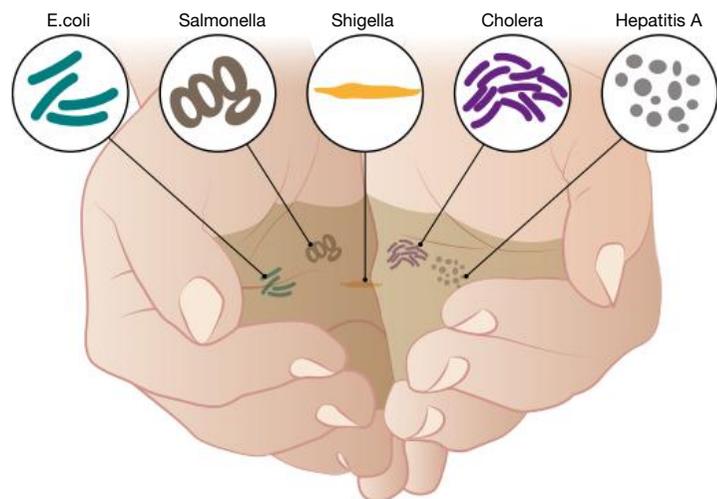
12.6.2 Access to an improved water source



SPOTLIGHT Waterborne disease

Waterborne diseases occur when people drink contaminated drinking water. When the same contaminated water is used in the preparation of food, people can contract a range of food-borne diseases. Examples of diseases transmitted through contaminated water are diarrhoea, cholera, dysentery, typhoid and hepatitis A.

Diarrhoea is responsible for the deaths of 1.8 million people every year, most of whom are children living in developing countries. The main source of this disease is water contaminated by untreated human waste. Lack of proper sanitation is a serious health risk. It affects billions of people around the world, especially the poor and disadvantaged.



12.6.3 Contaminants found in water that cause waterborne diseases



12.6.4 Indian women living in the state of Telangana, 200 kilometres from Hyderabad, carrying water to their village

Water: A woman's burden

In many countries, women are responsible for fetching the water for their family, as shown in Figures 12.6.4 and 12.6.5. Water is required for drinking, cooking, washing clothes and personal hygiene. Women often walk many kilometres, carry heavy burdens, wait for hours and have to pay exorbitant prices. Often the water is contaminated, even deadly. In these instances, they face a terrible choice—certain death without water or possible death from waterborne disease. It has been estimated that women in developing countries spend a combined 200 million hours a day collecting water.

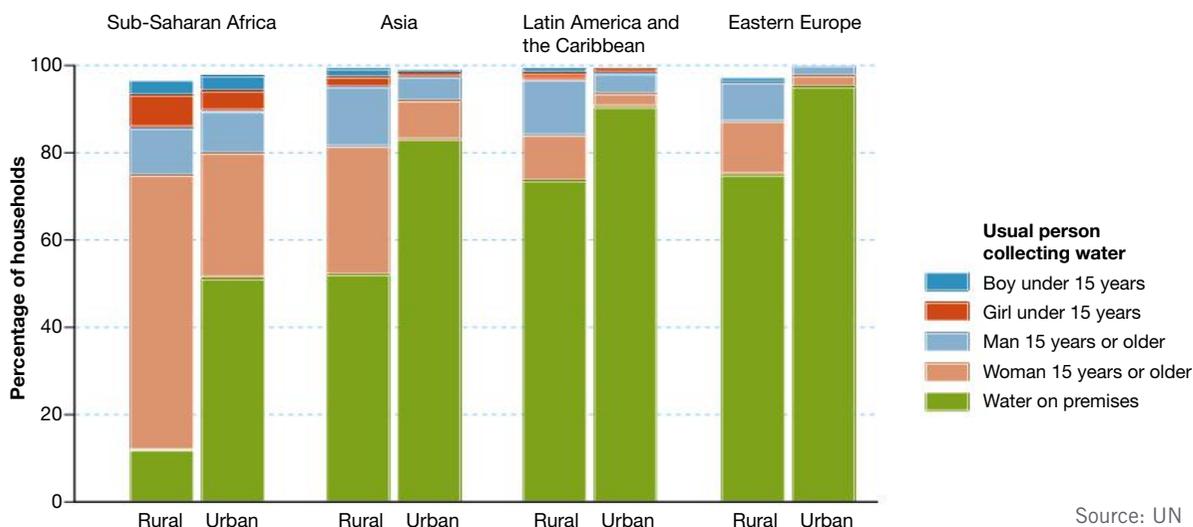
Once they are old enough, young girls join the effort. They too spend countless hours fetching this basic necessity of life. The work they do is often dangerous. The sides of a well can collapse, burying the women and girls. There is also the physical burden of the loads carried. Water-filled containers are often carried on the head. This creates physical demands on the body, especially the spine and neck.

The impacts, however, go beyond physical injury. The dual aspects of the water crisis—lack of water and of sanitation—lock women in a cycle of poverty. They cannot attend school; they cannot earn an income.

Many NGOs focus their efforts on providing a convenient, safe source of water for communities throughout the developing world. The benefits of installing a simple pump are many, but include:

- increased school attendance, level of education and literacy rates, as girls no longer need to miss school to secure water for their families
- improved health for women and girls
- reduced child and maternal mortality as a result of access to safe water and improved hygiene during childbirth
- reduced physical injury from lifting and carrying heavy loads of water
- reduced risk of rape and sexual assault, and increased safety in general, as women and girls do not have to walk long distances to fetch water
- new opportunities for women's employment as well as greater autonomy and independence.

12.6.5 Distribution of households by person responsible for water collection, by region and urban/rural areas



Source: UN

ACTIVITIES

Knowledge and understanding

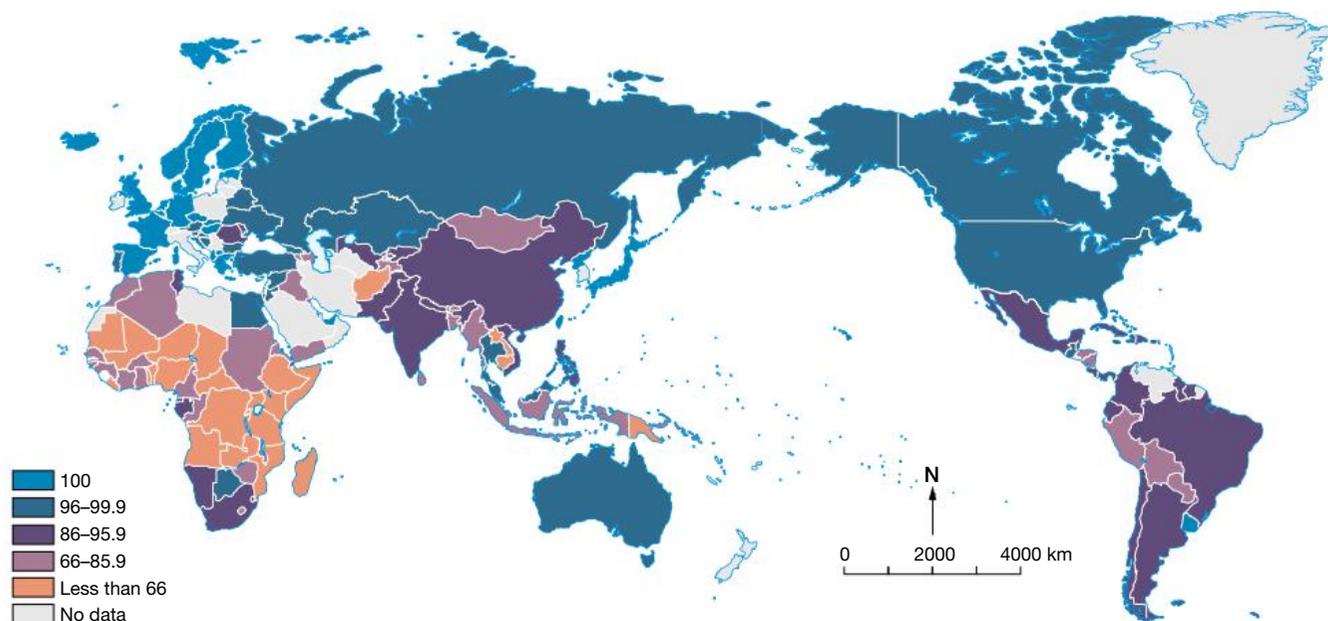
- 1 Outline the extent to which access to improved water sources has increased since 1990.
- 2 Explain what constitutes an 'improved water source'.
- 3 Explain what a choropleth map is and state the technique that is used to show variations in data categories.
- 4 Outline the health implications of carrying large amounts of water over long distances.
- 5 Describe the benefits of providing villages with safe, convenient sources of clean water.

Geographical skills

- 6 Study Figure 12.6.1. Using data from the graphs, write a series of paragraphs outlining the variations in access to drinking water experienced by those living in rural and urban areas.
- 7 Study Figure 12.6.2. With the aid of an atlas, describe the spatial distribution of countries in which less than 40 per cent of the population has access to an improved source of water.

Access to sanitation

12.7.1 Percentage of population with access to adequate sanitation facilities



Source: World Bank, 2010

Sanitation

Sanitation is a basic need and provides a means of safeguarding people's physical wellbeing. The provision of adequate sanitation in communities prevents the spread of disease. Currently, around 1 billion of the world's population lack access to adequate sanitation.

Access to improved sanitation

Figure 12.7.1 illustrates worldwide access to adequate sanitation facilities. In 1990, just under half (49 per cent) of the global population had access to improved sanitation. By 2013, this had increased to 64 per cent. The MDG target for 2015 was 75 per cent. This target was not met. In 2015, 68 per cent of people had access to improved sanitation. From 1990 to 2015, 2.1 billion people gained access to a latrine, flush toilet or other improved sanitation facility (see Figure 12.7.2).

Sanitation infrastructure

Lack of sanitation infrastructure forces people to defecate in the open, in rivers or near areas where children play or food is prepared. This increases the risk of disease transmission. The Ganges River in India has 1.1 million litres of raw sewage dumped into it every minute. This is frightening when you

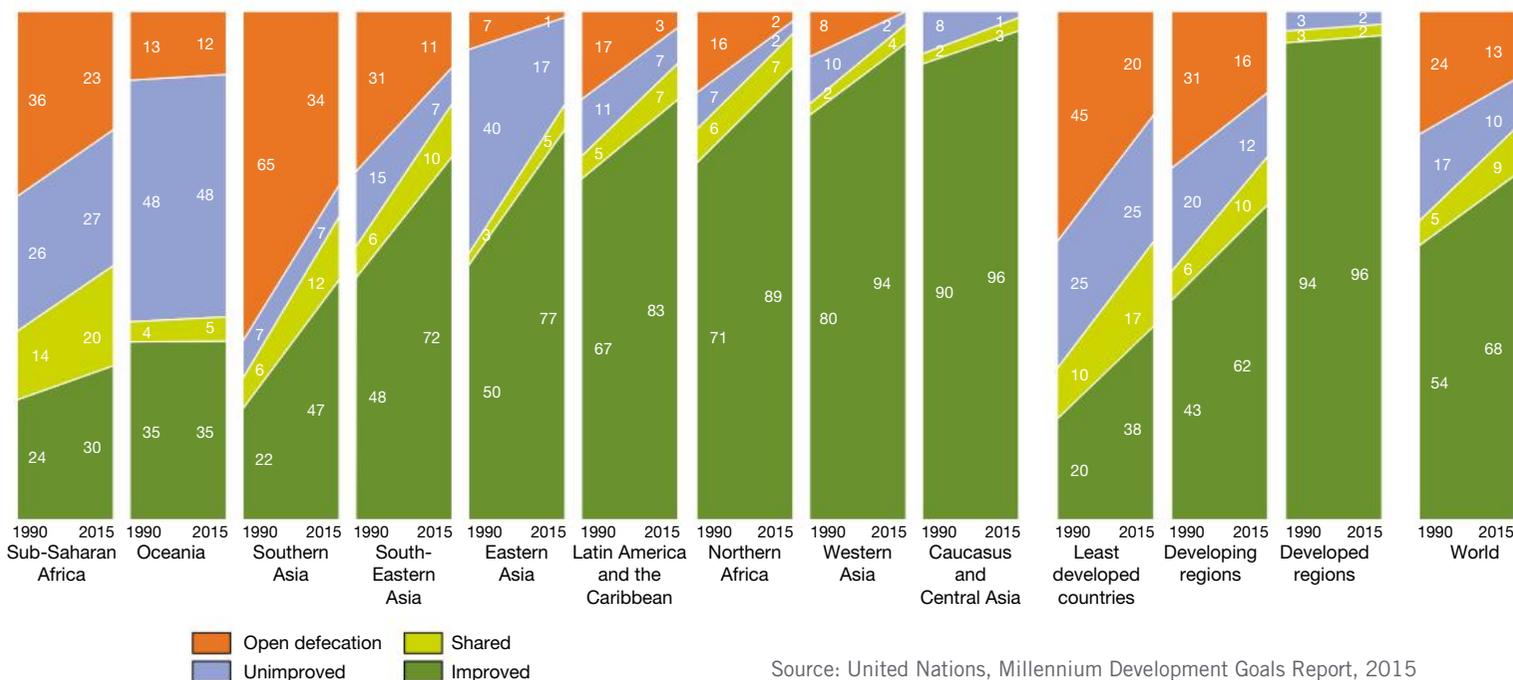
consider that just one gram of faeces in untreated water may contain 10 million viruses, one million bacteria, 1000 parasite cysts and 100 worm eggs. Improving sanitation infrastructure can have an immediate impact on public health. It can, for example, reduce diarrhoea death rates by up to a third. In Africa, 115 people die every hour from diseases linked to poor sanitation, poor hygiene and contaminated water.

In addition to improvements to people's health, the provision of sanitation has a number of important social benefits. The provision of sanitation in schools, for instance, encourages children, and girls in particular, to attend school. The liveability of neighbourhoods improves as the incidence of open defecation declines.

Addressing the issue

While the proportion of the global population that resort to open defecation declined from 24 per cent in 1990 to 13 per cent in 2015, it remains a problem. In response, authorities now focus on stopping the practice of open defecation through community-level action and influencing social norms to the point where open defecation is no longer considered acceptable. In almost 100 countries around the world, new approaches to sanitation have taken root and the number of declared 'open-defecation-free villages' is rising.

12.7.2 Proportion of population by sanitation practices, 1990 and 2015 (per cent)



Source: United Nations, Millennium Development Goals Report, 2015

This is only part of the challenge. Providing the necessary infrastructure (toilets, storage facilities, pumping stations, sewerage and water pipelines and treatment works) is a major undertaking. It is expensive and, with rapid rates of urbanisation, it is often difficult for urban authorities to keep pace with population growth. However, not all solutions need be expensive or high-tech. The construction of communal toilet facilities is a low-cost response to the lack of sewerage infrastructure.

The pour-flush toilet

The pour-flush toilet has a water seal that avoids the problems associated with odour and insects. Excreta deposited in the latrine is flushed by pouring 2–3 litres of water into the pan. The mixture is directed into a pit, where the biodegradation of organic wastes occurs. The water used in the flushing process percolates through the soil surrounding the pit. The potential for groundwater pollution is, therefore, very high. Pour-flush toilets are not a suitable solution to the sanitation needs of the urban poor when the groundwater table is close to the surface.

Sludge has to be regularly emptied from the pit. The use of two adjoining pits alternately enables the sludge in a full pit to undergo further decomposition while the other pit is being used. It also facilitates the manual emptying of sludge after further decomposition.

As with pit latrines and composting toilets, grey water (waste water from the kitchen, laundry and bathroom but not the toilet) has to be treated separately. This is often done by the construction of a seepage pit or trench.

ACTIVITIES

Knowledge and understanding

- 1 Outline the consequences of people not having access to adequate sanitation facilities.
- 2 Describe the impacts of untreated sewage on waterways such as the Ganges River.
- 3 Explain why the provision of sanitation is considered to be so important to people's wellbeing.
- 4 Outline the strategies being used to meet the sanitation needs of people. What are the benefits of these strategies?

Geographical skills

- 5 Study Figure 12.7.1. With the aid of an atlas, identify the regions of the world that experience the lowest levels of access to sanitation.
- 6 Study Figure 12.7.2. Using data from the graph, write a paragraph outlining the advances made in the provision of sanitation between 1990 and 2015.

Child exploitation

12.8.1 Children at work in a charcoal factory in the Philippines



Child labour

UNICEF estimates that 150 million children aged 5–14 years are engaged in child labour; that is, one in six children in the world. Many are working in hazardous situations or conditions (see Figure 12.8.1). Some children work deep underground mines, while others work in factories, handling toxic chemicals and pesticides or using dangerous machinery. They also work as domestic servants and plantation labour. Some are forced into child prostitution.

The problem is worst in Sub-Saharan Africa, where it is estimated that about one in three (or 70 million) children are engaged in child labour. In South Asia, another 44 million children are working. India has the highest number of child workers of any single country—an estimated 29 million children between the ages of 5 and 14.

Those living in the poorest households and in rural areas are most likely to be engaged as child labourers. Those burdened with household chores are overwhelmingly girls. Millions of girls who work as domestic servants are especially vulnerable to exploitation and abuse. Labour often interferes with children's education.

Child trafficking

The trafficking of children—often by illegal means—involves the recruitment, abduction, transportation or receipt of children for the purpose of exploitation. Exploitation includes forcing children into prostitution, forced labour and begging, and using them for the harvesting of internal organs. It may also include illegal international adoption, trafficking for early marriage and the recruitment of child soldiers. Child trafficking is a crime under international law and under the national legislation of many countries.

Child marriage

Despite many countries restricting marriage to those above a minimum age of 16 to 18, traditional (under-age) marriages are still widespread. Poverty, tradition and conflict make child marriage relatively common in Sub-Saharan Africa, South Asia and the Middle East. In many tribal systems, a man must pay the girl's family in order to marry her. In many parts of Africa, this payment, which is made in cash, cattle, or other valuables, is less for older girls. Even before puberty it is common for a married girl to leave her parents to be with her husband.

Many early marriages are linked to poverty, as the girl's parents often need the money raised to feed, clothe, educate and provide shelter for the rest of the family. In parts of Ethiopia and Nigeria, over 50 per cent of girls are married before the age of 15 and some are married as young as the age of 7. In parts of Mali, 39 per cent of girls are married before the age of 15. In Niger, over 70 per cent of girls are married before the age of 18 (see Table 12.8.2).

12.8.2 Child marriage (under 18 years): the 20 countries in the world where it is most prevalent (percentage of all marriages)

Country	Percentage of all marriages
Niger	75
Central African Republic	68
Chad	68
Bangladesh	65
Guinea	63
Mali	55
South Sudan	52
Burkina Faso	52
Malawi	50
Madagascar	48
Mozambique	48
India	47
Eritrea	47
Somalia	45
Sierra Leone	44
Zambia	42
Nepal	41
Dominican Republic	41
Ethiopia	41
Nicaragua	41

Source: Girls Not Brides, 2013

Sexual exploitation

Prostitution of children under the age of 18 years, child pornography and the (often related) sale and trafficking of children are widely seen as crimes of violence against children. They are a form of economic exploitation, just like forced labour or slavery. The children exploited in this way often suffer damage to their physical and mental health. They are especially vulnerable to sexually transmitted diseases, including HIV/AIDS. Under Australian law, any Australian found guilty of involvement in child sex tourism faces up to 17 years in jail.

Child soldiers

Thousands of children serve as soldiers in armed conflicts around the world. Boys and girls, some as young as 8 years old, serve in government forces and armed opposition groups. They carry out a variety of roles. They may fight on the front lines, participate in suicide missions, and act as spies, messengers or lookouts. Once recruited, children undergo varying degrees of indoctrination. Often this process is very brutal. Girls may be forced into sexual slavery. Many are abducted or recruited by force, while others join out of desperation, believing that armed groups offer their best chance for survival.

Children are still involved in armed conflict in a number of countries. These include the Central African Republic, the Democratic Republic of the Congo, Mali, Pakistan, Somalia, Sudan, Syria and Yemen, among others (see Figure 12.8.3).

12.8.3 A child soldier at the Cambodian refugee camp of Nong Samet on the Thai–Cambodian border



Slavery

Worldwide, nearly 30 million people, many of them children, are enslaved. They are trafficked to work in the sex industry or as forced labour, and they are sometimes victims of **debt bondage** or even born into servitude. There is still evidence of hereditary slavery, particularly in parts of West Africa and South Asia. According to the Global Slavery Survey of 2013,

slavery still exists in 162 countries and almost 21 million people are victims of forced labour (see Figure 12.8.5).

Slavery is the possession or control of people to deny freedom and exploit them for profit or sex, usually through violence, coercion or deception. The definition includes **indentured servitude**, forced marriage and the abduction of children to serve in wars (as child soldiers).

SPOTLIGHT

Ending child marriage

Every year it is estimated that 14 million girls are married before they turn 18. Globally, about 400 million women aged between the ages of 20 and 49 were married before the age of 18.

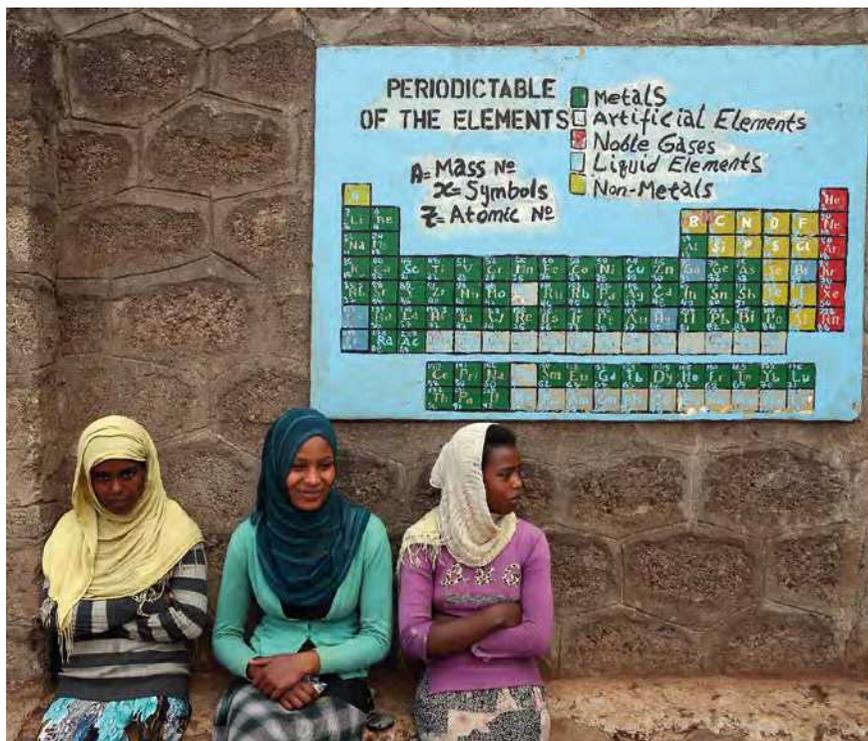
UNICEF and NGOs such as Girls Not Brides are working together to eliminate child marriage by:

- providing information, skills and support networks for married girls or girls at risk for early marriage
- educating parents, religious and traditional leaders and community members
- improving the accessibility and quality of schooling for girls
- providing economic support and incentives for girls and their families
- fostering and enabling legal and policy frameworks.

Ban Ki-Moon, Secretary General of the United Nations, said that 'education for girls is one of the best strategies for protecting girls against child marriage'. Expanding access to primary and secondary education can delay, and even prevent, early marriage. According to a study conducted by the International Center for Research on Women, girls with 0–3 years of education were six times more likely to marry before adulthood than girls who had received a secondary education. Many child brides are forced to leave school early.

In Addis Ababa, Ethiopia, it is estimated that three-quarters of streetwalkers (prostitutes who walk the streets) are escapees from the countryside, fleeing early marriage. One local NGO, Godanaw Rehabilitation Integrated Project, is providing skills training and health care to thousands of female streetwalkers. At AGOHELMA, one of the oldest orphanages in Ethiopia, one of their main aims is to educate women and enhance their economic power.

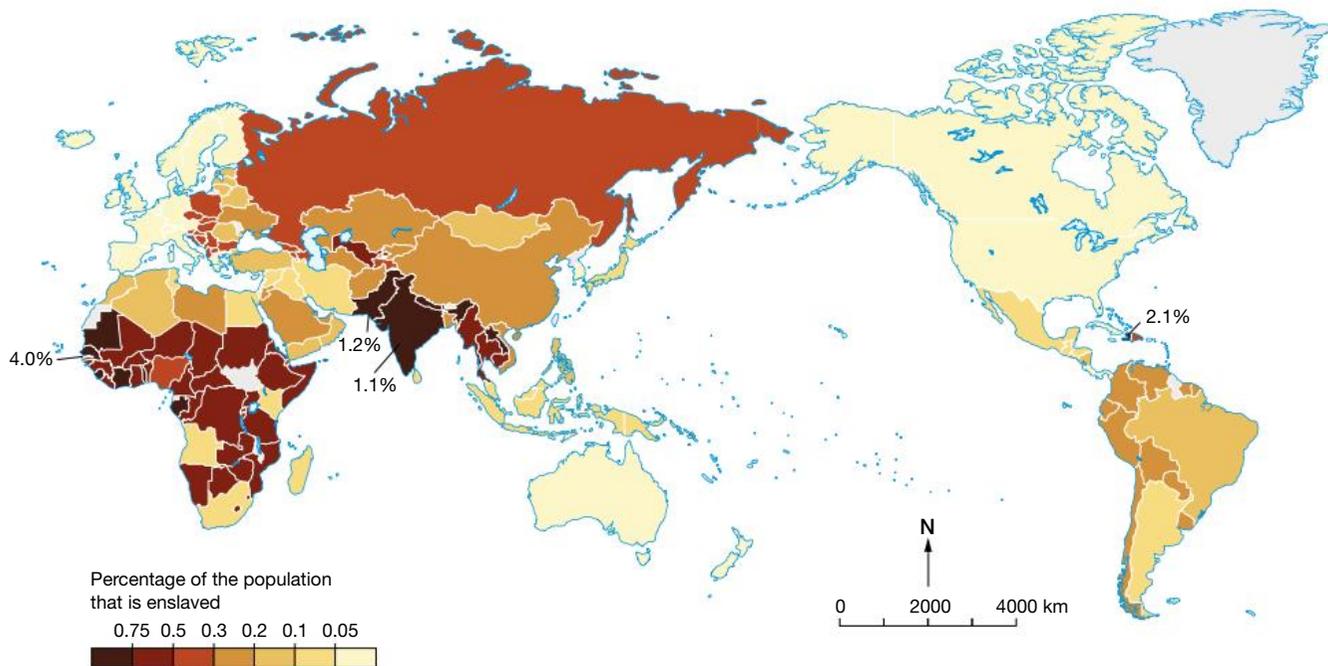
12.8.4 Female secondary school students sit under a poster showing the periodic table of the elements in the courtyard at an AGO school (founded by Abebech Gobena in 2013) in Addis Ababa, Ethiopia.



Ten countries account for three-quarters of the world's slaves. In India, where slavery ranges from bonded labour in quarries and kilns to commercial sex exploitation, 13.9 million people are enslaved. After India is China, with 2.9 million, followed by Pakistan (2.1 million), Nigeria (701 000), Ethiopia (651 000), Russia (516 000), Thailand (473 000), Democratic Republic of Congo (462 000), Myanmar (384 000) and Bangladesh (343 000).

Often the victims of enforced labour are captured or kidnapped before being sold or kept for exploitation, whether through 'marriage', as unpaid labour on fishing boats, or as domestic workers. Others are tricked and lured into situations from which they cannot escape, with false promises of a good job or an education.

12.8.5 Percentage of the world's population that is enslaved



Source: Global Slavery Index, 2014

ACTIVITIES

Knowledge and understanding

- 1 Outline the consequences of child exploitation in developing countries.
- 2 State how extensive child labour is in developing countries. Where is it most commonly practised?
- 3 Explain what child trafficking is. List the reasons why children are traded.
- 4 Explain the link between poverty and child marriage.
- 5 Define 'slavery'.

Applying and analysing

- 6 As a class, discuss the issue of child exploitation. Summarise the key points raised in the discussion in the form of a mind map.

- 7 Debate the following topic. *For many people living in developing countries, putting their children to work is a necessity and should not be viewed as exploitation.*

Geographical skills

- 8 Study Figure 12.8.5. With the aid of an atlas, identify the parts of the world with the highest percentage of the population enslaved.

Investigating

- 9 Use the internet to investigate the issue of child labour or child trafficking. Develop a short multimedia presentation to educate the public about the extent of the problem. Give at least one example of child labour and the steps that non-governmental organisations such as UNICEF are taking to address the problem.

Access to shelter

Shelter

Shelter is one of humanity's most basic needs, but due to poverty many people are forced to live in unacceptable conditions. The problem is worst in the world's developing countries where large cities, often referred to as megacities, are growing at a rapid rate, largely as a result of urbanisation.

Urbanisation

For the millions of poor in developing countries, the move to urban areas has long been seen as a means of improving their standard of living; that is, getting better jobs and earning higher incomes. This motivation, when combined with their experience of deteriorating conditions in rural areas, has generated a flow of migrants to cities, particularly in the last three decades.

Big shift

Throughout the developing world, the numbers of people moving from rural areas into large cities have overwhelmed authorities. They have found it impossible to meet the demand for housing and even the most basic urban infrastructure, such as water and power supplies, sanitation and public transport, not to mention medical services and schools. Many people moving to these urban areas are poor and unable to find accommodation. They are forced to find shelter in squatter settlements or slums. Squatter settlements are informal, often illegal, settlements, built by poor people using material scavenged from the streets. A slum is a run-down established neighbourhood in which most people live in a state of poverty.

Worldwide, approximately one-third of the developing world's urban population, or about 940 million people, live in squatter settlements and slums. As is shown in Figure 12.9.2, the proportion of the urban population living in slums is greatest in Sub-Saharan Africa. Western Asia is the only region in which the proportion of the population living in slums has increased since 2000.

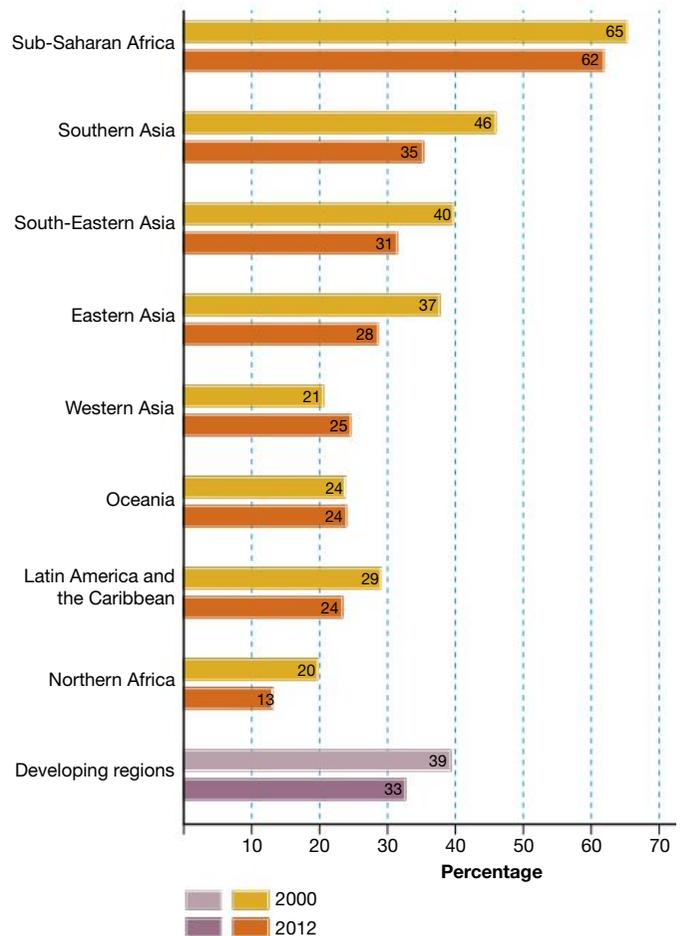
Squatter settlements

With few resources or skills, many of the new arrivals are unable to find space in the slums of the megacities. Their only option is to build their own simple housing on vacant land,

using materials scavenged from the streets. Because of their 'non-legal' status, squatter settlements have few services and little infrastructure.

The plight of these people is often ignored by government agencies, many of which view the 'invasion' of urban areas by 'the masses' and the development of squatter settlements as a social evil to be eliminated. Bulldozing of these settlements is common.

12.9.1 Proportion of urban population living in slums, 2000 and 2012



Source: United Nations, Millennium Development Goals, 2012

Slums

Slums are areas of congested, substandard housing characterised by poverty, squalor, and urban and social decay. They differ from squatter settlements only in terms of land tenure. Typically, slum owners have title to the land on which the slums are located.

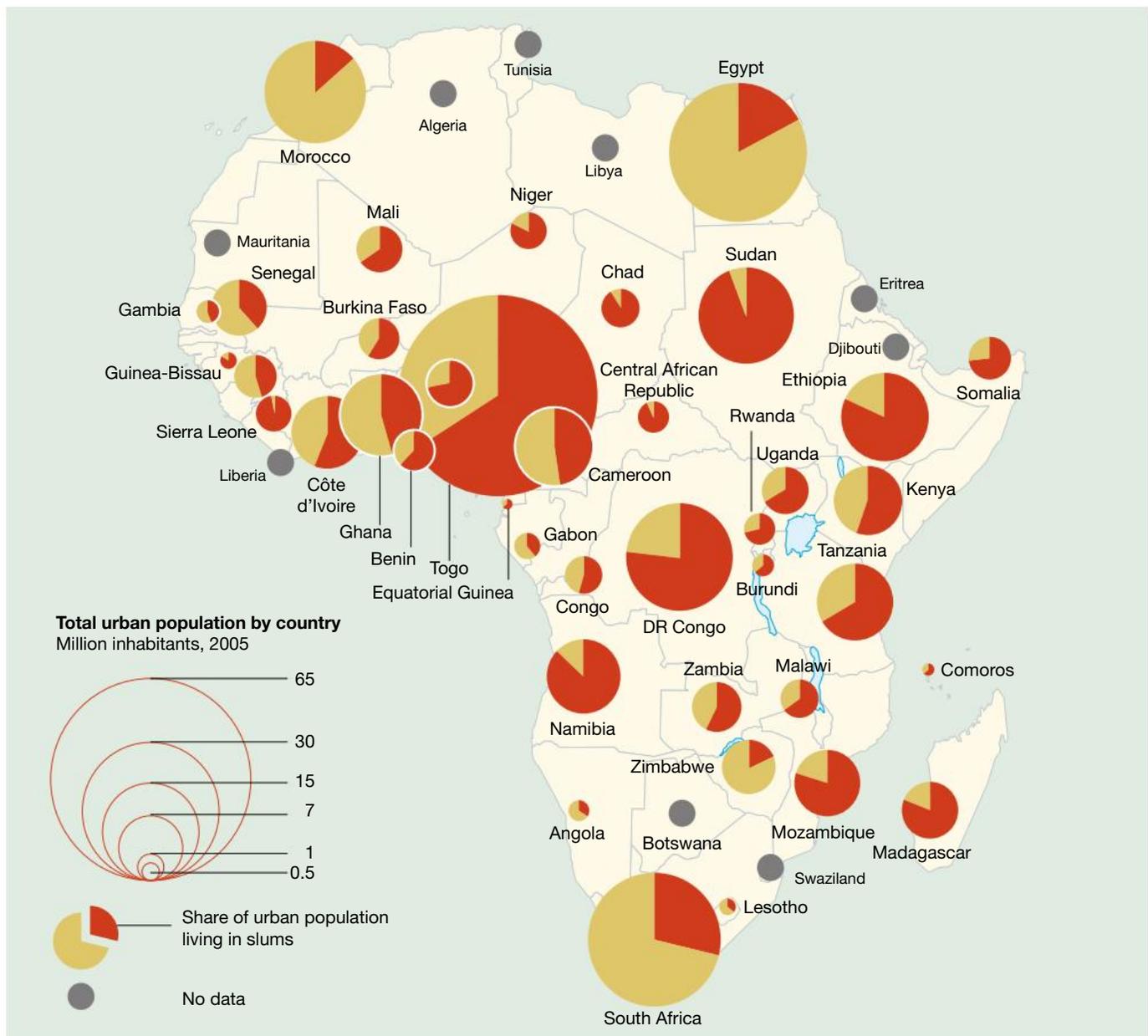
Slums develop for a variety of reasons. These include rapid rural–urban migration, economic stagnation and depression, high unemployment, poverty, poor planning, politics, natural disasters and social conflict. Generally, however, the poor concentrate in those areas of the city where rents are lowest, resulting in spatial concentrations of the poor and marginalised.

12.9.2 Africa's slum populations. Note that this map does not include separate data for Sudan and South Sudan, as the data was generated before partition.

Africa's rapidly growing cities

Africa has joined India and China as the third region of the world to reach a population of 1 billion people—a number that is expected to double by 2050. By then, there will be three times as many people living in Africa's cities. The continent that had fewer than 500 000 urban dwellers in 1950 may have 1.3 billion, or 60 per cent of its population, one hundred years later.

Cairo is now Africa's largest urban area, with 11 million people, but by 2015 it will have been overtaken by Lagos, with around 12.4 million inhabitants. By 2020, Kinshasa is expected to be the continent's second-largest city. Many of the new dwellers will crowd into slums. Others will simply build their own rough shelters on any unoccupied land (see Figure 12.9.2).



Source: UNDESA, *The World Urbanisation Prospects, The 2009 Revision*, 2010.

SPOTLIGHT

Mapping slums

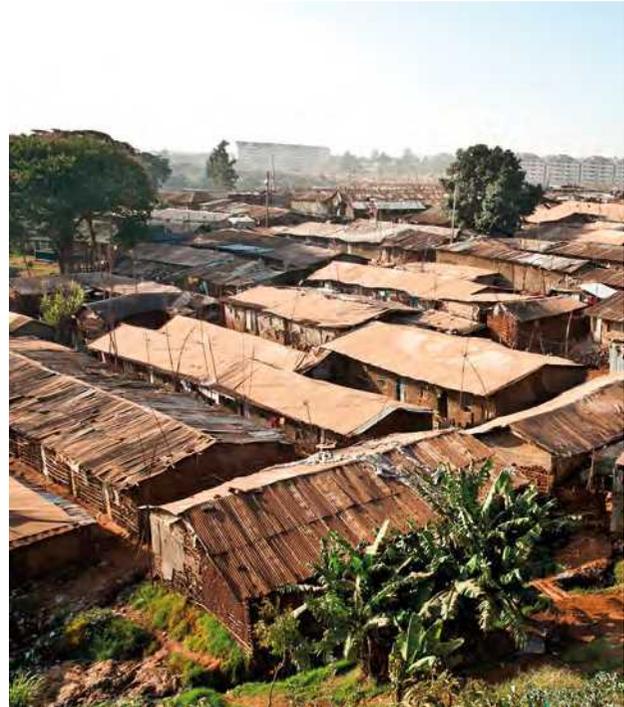
Kibera and Mathare are the oldest and largest slums in Nairobi, Kenya. They comprise thirteen villages and are home to nearly 200 000 people. In 2012, a group of activist cartographers and local community members got together to map the area, using handheld Global Positioning System (GPS) devices. The slum has no addresses or street names, no open or communal spaces, and the sewers are open. The group mapped the location of buildings and narrow lanes, but they also mapped informal schools, storefront churches, daycare centres, dark corners with no streetlights, illegal dumping grounds and broken manholes. With the aid of the map, the community was able to lobby local authorities to install street lights in the more dangerous areas.

The slum mapping movement began in India and has spread around the world. Maps enable slum communities to:

- bring the most urgent problems to the attention of the authorities
- present evidence when dealing with authorities
- record their habitation of an area
- show that a slum is not an empty space and is inhabited.

NGOs can also use the maps to raise awareness of the needs of communities.

12.9.3 Kibera slums



12.9.4 The Mathare Valley, shown here in an aerial map. Residents are using handheld GPS devices to map the area.



Addressing the problem

A range of strategies is used to address the issue of squatter settlements and the development of slums. These include a combination of slum removal, slum improvement initiatives, urban infrastructure upgrades and public housing construction.

In the case of squatter settlements, the most effective approaches involve giving people legal title to the land on which they have built their simple shelters. With the security this provides, people are more willing to invest whatever money they might have in improving their housing. Authorities can also improve the health and wellbeing of the squatters by providing basic infrastructure: clean water, communal sanitation facilities, electricity, schools and health clinics. NGOs play an important role in addressing the needs of these communities.

Homelessness

Homelessness, which exists in more, less and least developed countries, is an example of the inequalities in human wellbeing that exist within and between countries. Without access to

shelter, the homeless are forced to 'sleep rough' on pavements, in parks and under bridges and freeway overpasses. There are many causes of homelessness. Some of the most common are poverty, lack of affordable housing, mental illness, substance abuse, domestic violence, natural disasters, evictions and foreclosures. Worldwide, there are an estimated 100 million homeless people.

In Australia, one in every 200 people is homeless; that is, without safe, secure or affordable housing. In 2015, 105 237 Australians experienced homelessness. Fifty-six per cent were males, 44 per cent females. Twenty-five per cent were Aboriginal and Torres Strait Islander people. Twenty-three per cent of Australian's homeless were children and one in four homeless people was under 18 years of age. Fourteen per cent were over the age of 55 years.

Of those who are homeless, 44 per cent are staying temporarily with relatives and friends, 20 per cent are living in boarding houses, 18 per cent are sleeping rough on the streets and 18 per cent are staying in accommodation provided by the homeless support system.

ACTIVITIES

Knowledge and understanding

- 1 Outline the impacts of lack of shelter on the wellbeing of people.
- 2 Explain the process of urbanisation. Why does it lead to the growth of slum and squatter settlements?
- 3 Explain the difference between a slum and a squatter settlement.
- 4 Outline the response of authorities to the growth of squatter settlements.

Applying and analysing

- 5 Study Figure 12.9.3. As a class, brainstorm the conditions and problems facing people living in such conditions.
- 6 As a class, discuss why giving people legal title to the land on which they have built their homes often results in an improvement of their quality of life.
- 7 Drawing on your discussion in Activity 6, write an account of what it would be like to spend a week in a squatter settlement.

Geographical skills

- 8 Study Figure 12.9.1. Identify the region that experienced the greatest reduction in the proportion of its urban population living in slums between 2000 and 2012. In which region did the proportion of the population living in slums increase?

- 9 Study Figure 12.9.2. Which country has the largest urban population? Which country has the highest proportion of its urban population living in slums? Estimate the size of South Africa's urban population.

Investigating

- 10 Access the Habitat for Humanity website. Outline the role of the NGO and give at least one example of how it seeks to improve the conditions in which people are forced to live in developing countries.
- 11 Use the internet to investigate the issue of access to shelter in a megacity. Present your findings to the class in a multimedia presentation. Include in your presentation the following:
 - a map of the slum area
 - population statistics—past, current and future—of the city and slum
 - information about where slum-dwellers come from
 - reasons for people's move to the city—identify the reason as a SHEEP (social, historical, economic, environmental or political) factor
 - discussion of the major issues in the slum.

Select one of the major issues facing the slum-dwellers and investigate efforts to improve this issue.

NGOs: Making a difference

Non-governmental organisations

A non-governmental organisation (NGO) is any non-profit, voluntary citizens' group organised on a local, national or international scale. It is typically task-oriented and driven by people with a common interest. NGOs perform a variety of service and humanitarian functions. These include bringing citizens' concerns to governments, advocating and monitoring policies and encouraging political participation through provision of information. Some NGOs are organised to deal with specific issues, while others promote a range of causes. They provide analysis and expertise, serve as early warning mechanisms, and help monitor and implement international agreements. People join NGOs because they believe they can achieve more by working with others to influence the decision-making processes of governments and large corporations.

NGOs and development assistance

NGOs are active in addressing a range of challenges facing developing countries, such as:

- water and sanitation: Lifewater International, WaterAid, Safe Water Network, Water for People and Wash, Charity: Water

- health care: Médecins Sans Frontières (see Figure 12.10.1), CARE International and the Red Cross
- worker exploitation: Global Exchange, Clean Clothes Campaign and Rugmark
- wellbeing of children: Save the Children, The Smith Family
- human rights: Amnesty International and Human Rights Watch
- development (range of issues): Oxfam, World Vision.

NGOs in the field

Many NGOs are able to reach the most marginalised and vulnerable people in developing countries. Because they do not take sides, they are able to work in areas that are difficult to access due to armed conflict or civil unrest. Many also have expertise in working in emergency situations where fast and flexible responses are essential. NGOs focused on development-related projects are also skilled in empowering local communities. Their initiatives are likely to have long-term benefits only when recipients of the assistance are involved in the planning, design, construction, operation and maintenance of projects. This creates a sense of ownership and responsibility for a project. NGOs are also skilled in getting the most out of even small investments of capital.



12.10.1 Médecins Sans Frontières mobile clinic in Central African Republic treating people with malaria

SPOTLIGHT

Amnesty International

Amnesty International is an independent NGO with over 3 million supporters in more than 150 countries and territories. The vision of Amnesty International is to enhance human wellbeing through the creation of a world in which every person enjoys all the human rights enshrined in the Universal Declaration of Human Rights and other international human rights instruments. One way in which this NGO works to achieve its mission is to act on behalf of some of the most vulnerable members of society.

Amnesty International plays a very specific role in the international protection of human rights by focusing its activities on prisoners.

- It works to secure the release of prisoners of conscience. These are people detained for their beliefs, colour, gender, ethnic origin, language or religion, who have not used or encouraged violence.

- It works for the fair and prompt trials of all political prisoners. It also works on behalf of people who have been detained without charge or trial.
- It opposes the death penalty, torture and other cruel, inhumane or degrading treatment or punishment.

Amnesty International seeks to raise public awareness about human rights abuses (see Figure 12.10.2) and mobilise public opinion by having its supporters participate in letter-writing campaigns. Written appeals calling for the release of specific prisoners of conscience are sent to government leaders accused of suppressing prisoners' human rights.

Amnesty International protests are examples of active citizenship. This involves people taking seriously their responsibilities as citizens and becoming active participants in the political process.



12.10.2 Amnesty International protest in London, 2007, against inhumane treatment of prisoners at the US military prison at Guantanamo Bay, Cuba

ACTIVITIES

Knowledge and understanding

- 1 Explain what an NGO is. Why has the number of these organisations grown in recent years?
- 2 Outline the ways in which NGOs achieve their aims in the field.
- 3 Explain what Amnesty International is. What are the aims of this organisation?
- 4 Describe how Amnesty International acts to protect people's human rights.

Applying and analysing

- 5 As a class, discuss the ways in which NGOs act to increase public awareness of particular issues and influence decision makers.

- 6 Conduct a class brainstorm on the following question. *Why would I want to join an NGO?*
- 7 Design a sticker that highlights the issues addressed in this unit. Use design or desktop publishing software for a professional finish.

Investigating

- 8 Select one of the NGOs listed in this unit. Access the NGO's website. Prepare a short oral report outlining the origins of the organisation, its mission and the main issues it deals with.



Human wellbeing: Australia

Australians enjoy one of the highest levels of human wellbeing in the world. As a nation they also enjoy one of the highest life expectancies of any country, although this is not true for Aboriginal and Torres Strait Islander people. Indigenous Australians can expect to live 10 to 17 years less than other Australians. Babies born to Indigenous mothers die at more than twice the rate of other Australian babies, and Aboriginal and Torres Strait Islander people experience higher rates of preventable illness such as heart disease, kidney disease and diabetes.

Addressing this disadvantage is a national priority, but progress has been slow. Experience has shown that the most effective interventions are those that include local Indigenous communities in decision-making processes.

INQUIRY QUESTIONS

- What are the reasons for, and consequences of, spatial variations in human wellbeing in Australia?
- To what extent does the wellbeing of Indigenous Australians vary from that enjoyed by non-Indigenous Australians?
- To what extent have initiatives to improve human wellbeing in Australia been successful?

In this chapter we investigate the reasons for, and consequences of, spatial variations in human wellbeing in Australia, with specific reference to the experience of Aboriginal and Torres Strait Islander people. We also examine initiatives designed to improve human wellbeing in Australia.

GLOSSARY

absolute poverty	lack of access to minimum or essentials for living	quintile	a statistical value representing 20 per cent of a given population
Country	the land to which an Indigenous Australian belongs and their place of Dreaming	relative poverty	condition in which people are unable to maintain the average standard of living in the society in which they live
dispossession	the act of taking away or forcing people from their land, economic base, way of life and culture	self-help initiative	a project to assist people to improve their situation or their community without assistance from others
equality of opportunity	equal treatment of all people in a society, regardless of race, age, gender, religion, or mental or physical disability	socio-economic status	a level of economic and social wellbeing based on factors such as employment, income, education and social position relative to those of others
locational disadvantage	geographic isolation from a range of goods and services	social mobility	the movement of individuals, families or households between the various levels of class in Australia, for example from middle-class to upper middle-class
non-governmental organisations (NGOs)	non-profit, often volunteer-based, groups of people seeking to achieve a collective goal locally, nationally or internationally	spatial inequality	distinct geographical divisions between poor and affluent populations
poverty line	the estimated level of income needed to secure the necessities of life; this amount differs between countries	terra nullius	(Latin) a territory belonging to no one, or a territory over which no one claims ownership; the concept has been used to justify the invasion and colonisation of Australia
quartile	a statistical value representing 25 per cent of a given population		

Poverty in Australia

Poverty

In theory, no one in Australia should live in a state of **absolute poverty**. Australia's social welfare safety net means that everyone should have access to adequate food, clothing and shelter. But we have all seen homeless people living on the streets of our large cities and we know that some people go without meals. Australia enjoys one of the highest standards of living in the world. What is evident is that the wealth that underpins this high standard of living is not evenly distributed. Some people have a larger share than others.

Relative poverty occurs when people do not enjoy a minimum standard of living as determined by a government. In Australia, the minimum standard of living is defined by what is referred to as the **poverty line**. The poverty line is set at 50 per cent of median income. In Australia, for a single adult, the poverty line was \$522.21 per week in late 2015; for a couple with two children it was \$882.09.

Poverty in Australia: Key facts

- **Poverty rate:** An estimated 2.5 million people, or 13.9 per cent of the Australian population, live below the internationally accepted poverty line.
- **Income support:** 40.1 per cent of people on social security payments live below the poverty line.
- **Unemployed:** 61.2 per cent of people who are unemployed live below the poverty line.
- **Working poor:** 33.2 per cent of people living below the poverty line come from a household with wages as their main income.
- **Location:** 13.8 per cent of people live in poverty in capital cities compared with 14 per cent outside capital cities. Tasmania has the highest proportion of its population living below the poverty line (15.1 per cent). The ACT has the lowest (9.1 per cent).

Source: *Poverty in Australia 2015*,
a report by the Australian Council of Social Services (ACOSS)

Poverty in Australia: People at most risk

- Women are more likely to experience poverty than men (14.7 per cent compared to 13 per cent).
- Sole parents (most commonly women) are at a higher risk, with 33 per cent living in poverty in 2012. Nearly 37 per cent of all children in poverty were in sole-parent households.
- Children and older people face higher risks of poverty compared with other age groups (17.7 and 14.8 per cent respectively).

SPOTLIGHT

Homelessness

More than 100 000 Australians are homeless. This means that on any one night, one in 200 Australians is sleeping rough. Of these, 56 per cent are male and 44 per cent female. Twenty-five per cent of the homeless are Aboriginal and Torres Strait Islander Australians and 30 per cent were born overseas. The homeless take shelter in boarding houses (18 per cent) or supported accommodation (20 per cent), live temporarily with others (17 per cent), share overcrowded dwellings (39 per cent), or sleep in improvised dwellings, cars or tents, or on the streets (6 per cent).

Seventeen per cent of the homeless are under the age of 12. Ten per cent are 12–18 years of age. Fifteen per cent are 19–24 years of age and 18 per cent are 25–24 years of age.



13.1.1 Homeless in the land of the 'fair go'. Homelessness is one of the most visible forms of poverty in Australia.

- Overseas-born residents are at greatest risk of poverty, especially when their main language is not English (18.8 per cent). Those born in English-speaking countries are also at risk.
- An estimated 19.3 per cent of Aboriginal and Torres Strait Islander people live in poverty.
- An estimated 27.4 per cent of people with a disability live in poverty.
- More than 60 per cent of people who are unemployed live below the poverty line, as do many who rely on part-time and casual employment.

Inequality in Australia

In a country that has long prided itself on being the land of the 'fair go', the gap between people who have much and people who have little continues to grow. The nature and extent of inequality is the responsibility of policy makers. Governments have the capacity to either reduce inequality or increase it. Tackling inequality is a political choice, not an economic problem.

Inequality is bad for Australia. It undermines the fairness of our economic system and results in division within society. Countries with lower levels of inequality tend to have faster and more lasting economic growth. Countries with high levels of inequality often experience high levels of violence, suicide, mental illness and imprisonment, and lower life expectancy.

Inequality means that people in the lower income groups do not have the same access to opportunities as those in the higher groups. For example, those in the lowest groups find it more difficult to access higher education than someone in the highest group. Wealthier people can afford not to rely on services such as public schools and public hospitals. They use private schools and hospitals. When this happens, they have less interest in supporting public schools and hospitals, leading to a more divided society.

In the past, government policies have protected Australia from the worst forms of inequality. But Australia must be careful to avoid policies that increase inequality. When the government cuts income support to the needy, people who rely on such payments slide further down the inequality scale.

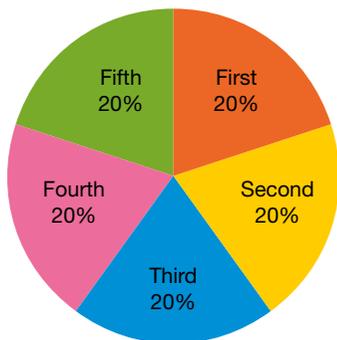
Measuring inequality

Inequality can be measured in two ways:

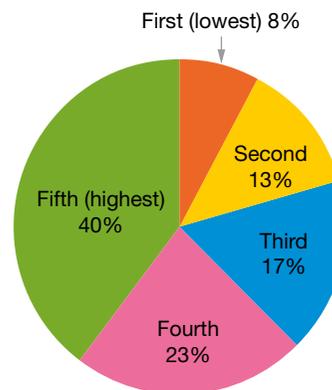
- 1 by determining how much income a person or household receives; that is, income inequality
- 2 by determining how much wealth is held by a person or household; that is, wealth inequality.

Wealth inequality is higher in Australia than income inequality. If the distribution of income and wealth by **quintile** were equal it would look like the distribution in Figure 13.1.2. In Australia, though, the share of income is not equal. Figure 13.1.3 shows

13.1.2 If the distribution of income and wealth by quintile were equal in Australia



13.1.3 The distribution of income in Australia is unequal.



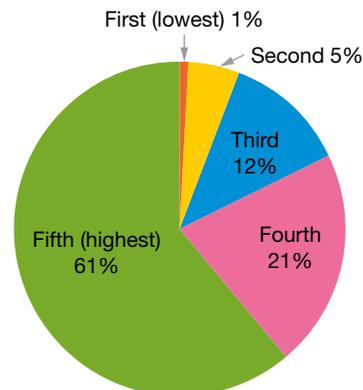
that, when looking at average income in Australia, a person in the highest income group has about five times the income of a person in the lowest income group. People most likely to be found in the lowest income group include:

- older people
- sole parents
- unemployed people
- people from culturally and linguistically diverse backgrounds.

Note: A quintile is a statistical value representing 20 per cent of the total population. The first quintile represents the lowest (poorest) fifth of the population (1–20 per cent); the second quintile represents the second fifth (21–40 per cent) and so on. The fifth quintile is the wealthiest 20 per cent of the population.

The share of wealth in Australia is not equal, as is shown in Figure 13.1.4. When looking at average wealth, a person in the highest wealth group has about seventy times as much wealth as someone in the lowest wealth group. People in the highest wealth group are more likely to have their wealth in the form of property, shares and superannuation. Those in the lowest quintile are more likely to hold their wealth in the form of low-value items such as cars and home contents.

13.1.4 The distribution of wealth in Australia is unequal.



Tables 13.1.5a and 13.1.5b show the income and wealth quintiles in Australia.

13.1.5a Income and households

	First (lowest)	Second	Third	Fourth	Fifth (highest)
Average annual income before tax	\$33 911	\$67 113	\$99 570	\$134 127	\$232 175

Source: *Poverty in Australia 2015*, a report by ACOSS

13.1.5b Wealth and households

	First (lowest)	Second	Third	Fourth	Fifth (highest)
Average total wealth	\$31 100	\$190 900	\$437 700	\$766 400	\$2 212 200

Source: *Poverty in Australia 2015*, a report by ACOSS

Inequality is increasing

The gap between the poorest and wealthiest groups is increasing. The share of income and wealth going to the wealthiest 20 per cent of households has increased, while the share going to the poorest (and, in the case of wealth, also the middle) groups has decreased over the past two decades. Over the 25 years to 2010, real wages increased by 50 per cent on average, but by just 14 per cent for those on lower incomes compared with 72 per cent for those on higher incomes. In terms of wealth, the wealth of the top 20 per cent of households increased by 28 per cent in the period 2004–2012; by comparison the wealth of the poorest households increased by just 3 per cent.

Barriers to equality of opportunity

Equality of opportunity is the concept that everyone can realise their full potential via education and employment, irrespective of factors such as their socio-economic status, gender, ethnicity or age.

There are a number of barriers to **social mobility** in Australia:

- discrimination barriers (for example gender, ethnicity, age)
- welfare trap barriers (for example intergenerational welfare dependency)
- employment barriers (for example shortage of low-skilled jobs)
- education barriers (for example access to resources such as computers, text books)
- health barriers (for example chronic health conditions, disabilities)

- housing barriers (for example overcrowding, poorly maintained housing)
- spatial and transport barriers (for example distance from services and employment opportunities).

These issues can be very difficult to solve. There are, however, some steps that can be taken to help ensure that all Australians enjoy an acceptable standard of living:

- providing incentives for the new knowledge-based industries to locate in the areas most seriously affected by economic and technological change
- retraining those who have been marginalised and demoralised by the decline in manufacturing employment
- ensuring that young people are better educated and therefore better able to fill the jobs being created in the new information-based economy
- redistributing income (via the tax system) from high-paid to low-paid Australians
- increasing government spending on health care, education, housing and public transport.

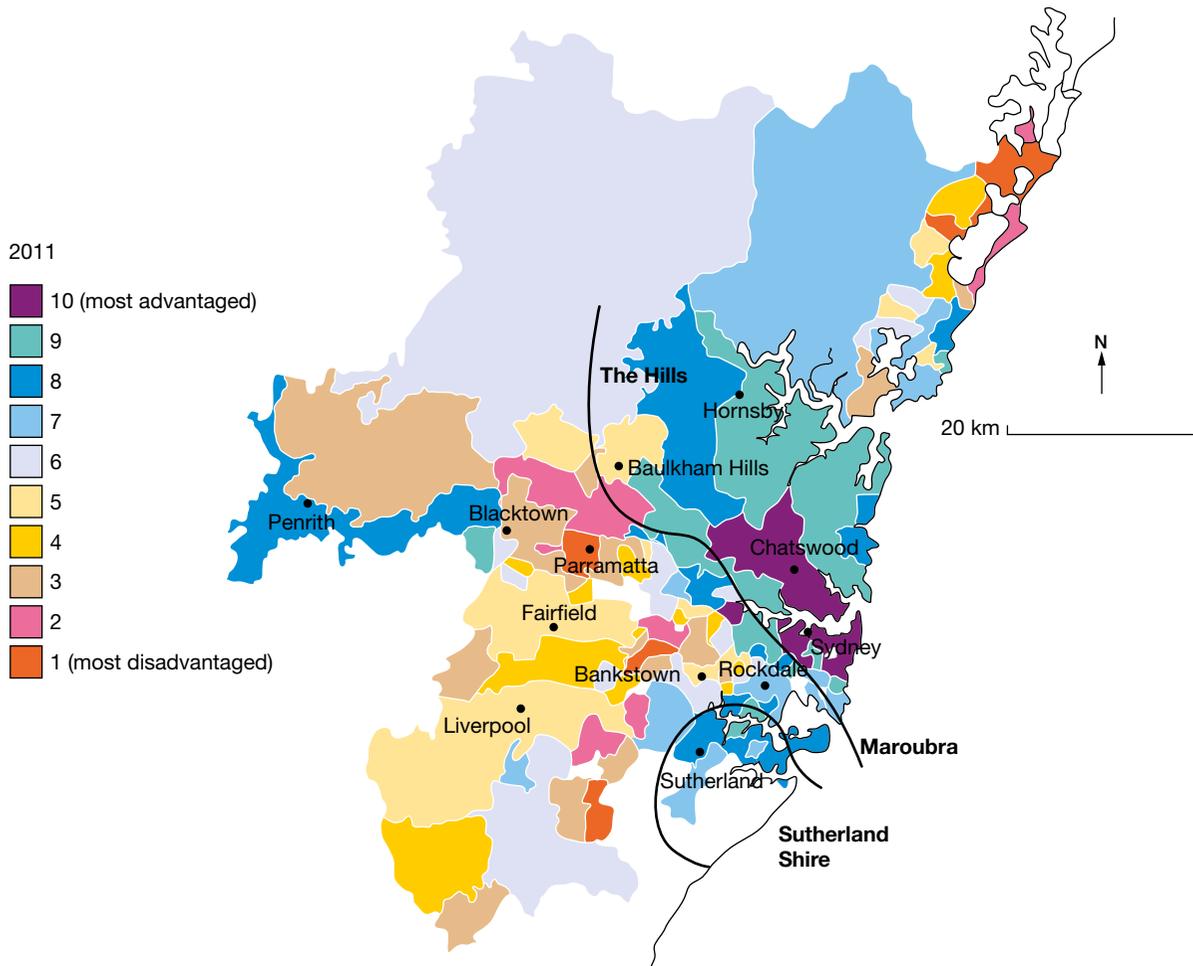
Spatial pattern of wellbeing in Sydney

Sydney has more **spatial inequality** than any other Australian city, and the difference in living standards between the most advantaged and the most disadvantaged parts of the city is becoming greater. Areas of poverty, unemployment, violence and social distress are now a feature of Sydney. There are also areas characterised by great wealth and privilege. However, care must be taken when making generalisations such as these. Within all suburban areas there are people with different levels of income and wealth.

Figure 13.1.6 highlights the spatial pattern of wellbeing in Sydney. Sydney could be described as a ‘divided’ city with an affluent north and east and a less affluent south, west and south-west. Some of these suburbs have pockets of extreme poverty, while others house families who are slightly below the average means.

The processes responsible for the development of this pattern of advantage and disadvantage are closely related to a person’s income and/or wealth. The greater the person’s wealth and/or income, the greater the choice they can exercise in where to live. Those with the greatest financial resources can afford to buy or rent in the most desirable parts of the city. Those with few financial resources can only afford to buy or rent in the less desirable parts of the city (where the demand for housing is lowest). This means that the most disadvantaged concentrate in the least popular part of the city, often far from the services they need and what employment opportunities there are. This results in **locational disadvantage**.

13.1.6 A line drawn from the Hills District to Maroubra in the eastern suburbs effectively divides the city in two. The main exception to this is the relatively affluent area to the south of the Georges River (Sutherland Shire).



ACTIVITIES

Knowledge and understanding

- 1 State why no one in Australia should live in 'absolute poverty'.
- 2 Define 'relative poverty'.
- 3 Outline how the 'poverty line' is determined in Australia.
- 4 Outline the extent of poverty in Australia. Who is most at risk?
- 5 State the extent and nature of homelessness in Australia.
- 6 Explain why inequality is bad for Australia. What are its impacts? How can it be addressed?
- 7 State how inequality in Australia is measured. What trends are apparent?
- 8 Outline the barriers to 'equality of opportunity'. How might these barriers be addressed?

Geographical skills

- 9 Study Figures 13.1.3 and 13.1.4. Using data from the graphs, describe the distribution of income and wealth in Australia.
- 10 Study Figure 13.1.6. Describe the pattern of advantage and disadvantage in Sydney. Account for this pattern.

Applying and analysing

- 11 Create a mind map about the impacts of poverty in Australia.
- 12 You are preparing a debate about poverty in Australia and you are on the affirmative side. Outline your arguments supporting the following topic.
All Australians have a right to an acceptable standard of living.

Spatial patterns of Indigenous advantage and disadvantage

Socio-economic status

A widely accepted indicator of disadvantage is a person's **socio-economic status**. It takes into account factors such as educational attainment, occupation, income and housing. The Australian Bureau of Statistics (ABS) defines relative socio-economic advantage and disadvantage in terms of people's access to material and social resources, and their ability to participate in society.

In every part of Australia, Indigenous Australians are worse off, and do not enjoy the same level of wellbeing, as most other Australians. They consistently experience disproportionately higher levels of social disadvantage.

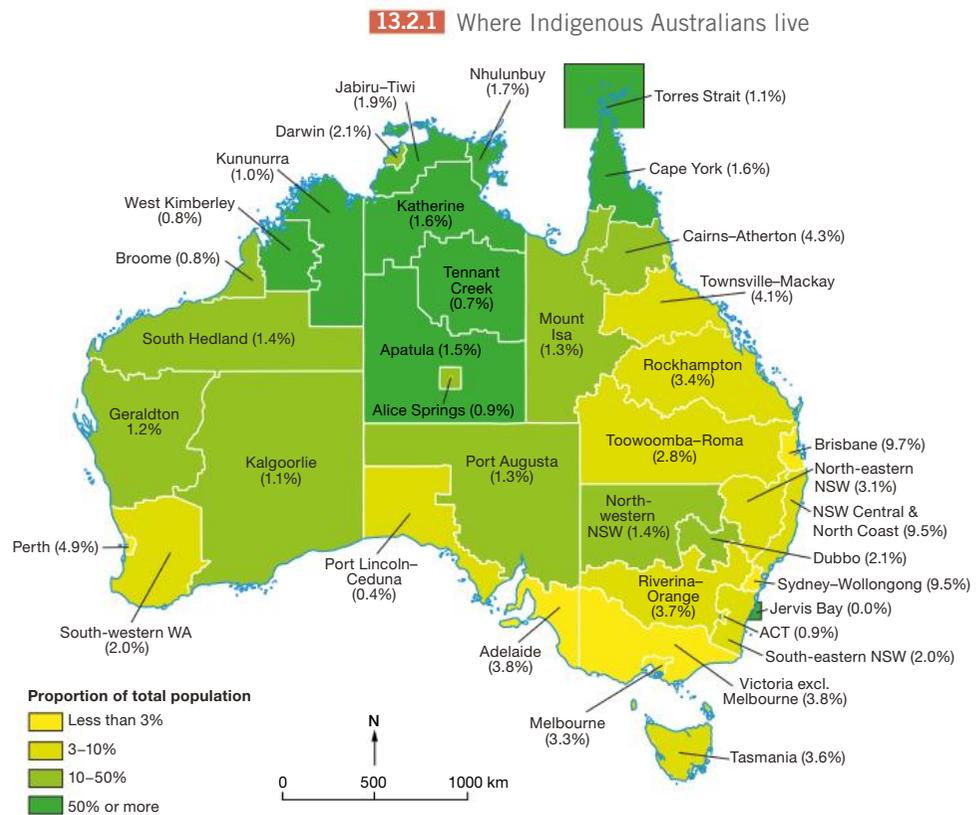
Housing

Indigenous Australians are more likely to live in areas where their friends and neighbours are relatively disadvantaged. More than a third of Indigenous Australians (36.6 per cent) live among the most disadvantaged 10 per cent of the Australian population and only 1.7 per cent live among the most advantaged top 10 per cent.

SPOTLIGHT

Where Indigenous Australians live

Figure 13.2.1 illustrates the percentage of the total population in regions across Australia who identified as being Indigenous in the 2011 Census. The percentage is highest in the relatively remote regions of north, central and western Australia. Yet the regions with the greatest absolute numbers of Indigenous Australians are in the south and east of the country—Brisbane, the central and northern coasts of New South Wales, and the Sydney–Wollongong region all have an Indigenous populations of 60 000 or more. The most remote regions have populations of about 10 000 or less.



Source: Customised calculations using the 2011 Census

Variations in the spatial patterns of disadvantage

The Australian Bureau of Statistics uses a variety of economic and social information about people and households within an area to create the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD). The ABS measures education levels, occupation and types of jobs, home ownership and size, car ownership, internet connection and the health and disability within an area.

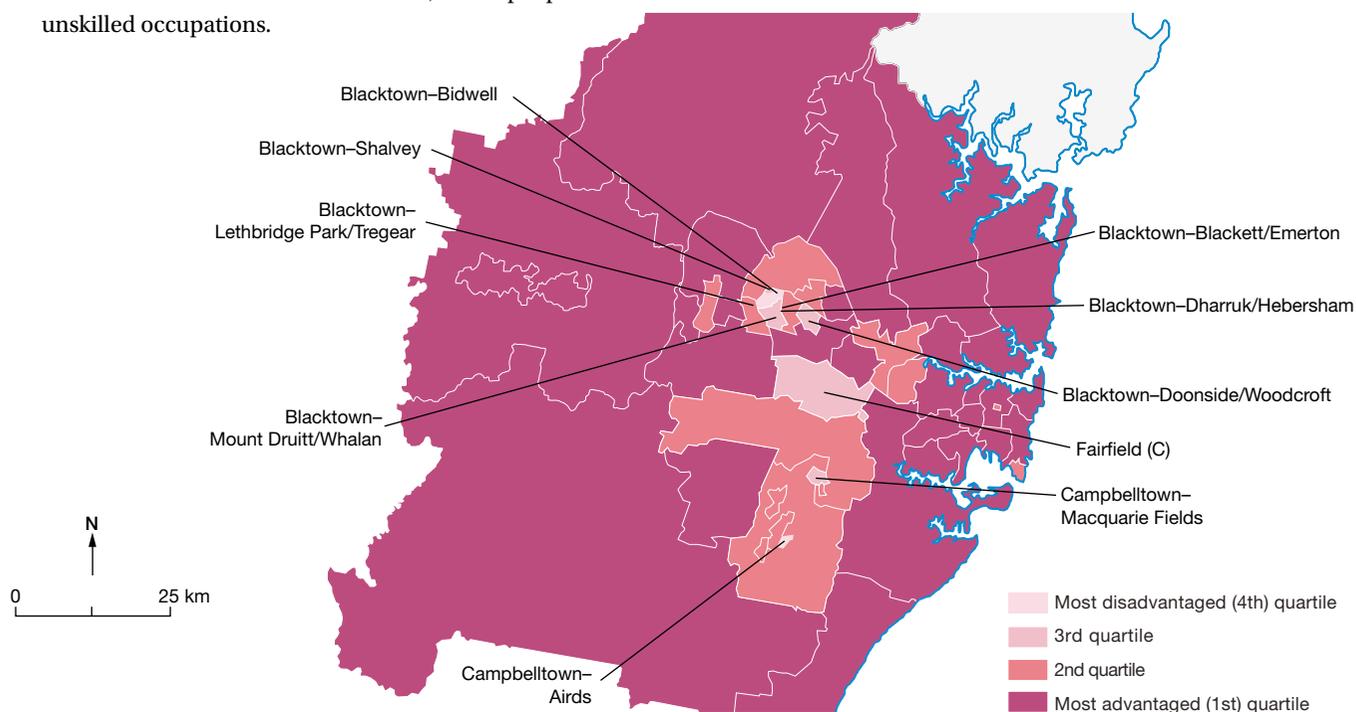
- A low score indicates greater disadvantage and a lack of advantage. For example, there are many households with low incomes, or many people in unskilled occupations, and few households with high incomes, or few people in skilled occupations.
- A high score indicates a relative lack of disadvantage and greater advantage. For example, there are many households with high incomes, or many people in skilled occupations, and few households with low incomes, or few people in unskilled occupations.

Spatial patterns in Sydney

While the advantage and disadvantage differences between Indigenous and non-Indigenous populations are greatest in remote areas, even in remote areas some communities fare better than others. There are also wide variations in both regional and urban communities.

The Sydney metropolitan area has the greatest diversity in the socio-economic status of Indigenous Australians. In 2011, according to the IRSAD, six of the seven most advantaged Indigenous areas in Australia were found in Sydney. The smallest disadvantage gap between the two populations was in Sydney's lower north. Yet ten areas that were found to be especially disadvantaged were also in Sydney (see Figure 13.2.2).

13.2.2 Patterns of Indigenous advantage and disadvantage in Sydney



ACTIVITIES

Knowledge and understanding

- 1 Identify those parts of Australia that have the highest percentage of Indigenous Australians and those that have the greatest numbers.
- 2 Describe the ABS definition of socio-economic status.
- 3 Outline the measures used to determine socio-economic status.
- 4 Describe how advantage and disadvantage are measured.

Geographical skills

- 5 Study Figure 13.2.1 and answer the following questions.
 - a In which state/territory do Indigenous Australians make up the largest percentage of the population?
 - b In which state/territory do Indigenous Australians make up the smallest percentage of the population?
 - c What percentage of Australia's Indigenous population is found in New South Wales?
 - d What percentage of Australia's Indigenous population is found in the Northern Territory?

Origins of disadvantage

Dispossession

Despite having lived sustainably in Australia for up to 60 000 years, Aboriginal and Torres Strait Islander people were quickly plunged into turmoil with the arrival of Europeans in 1788. Many of the issues that trouble Indigenous Australians and disadvantage them today can be traced back what has happened in the past and the attitudes of non-Indigenous people at the time.

Aboriginal and Torres Strait Islander people believed in respect and responsibility for **Country**, their ancestors and each other. They believed in the collective responsibility for land. They did not see it as a privately owned commodity to be bought and sold.

The colonial mindset

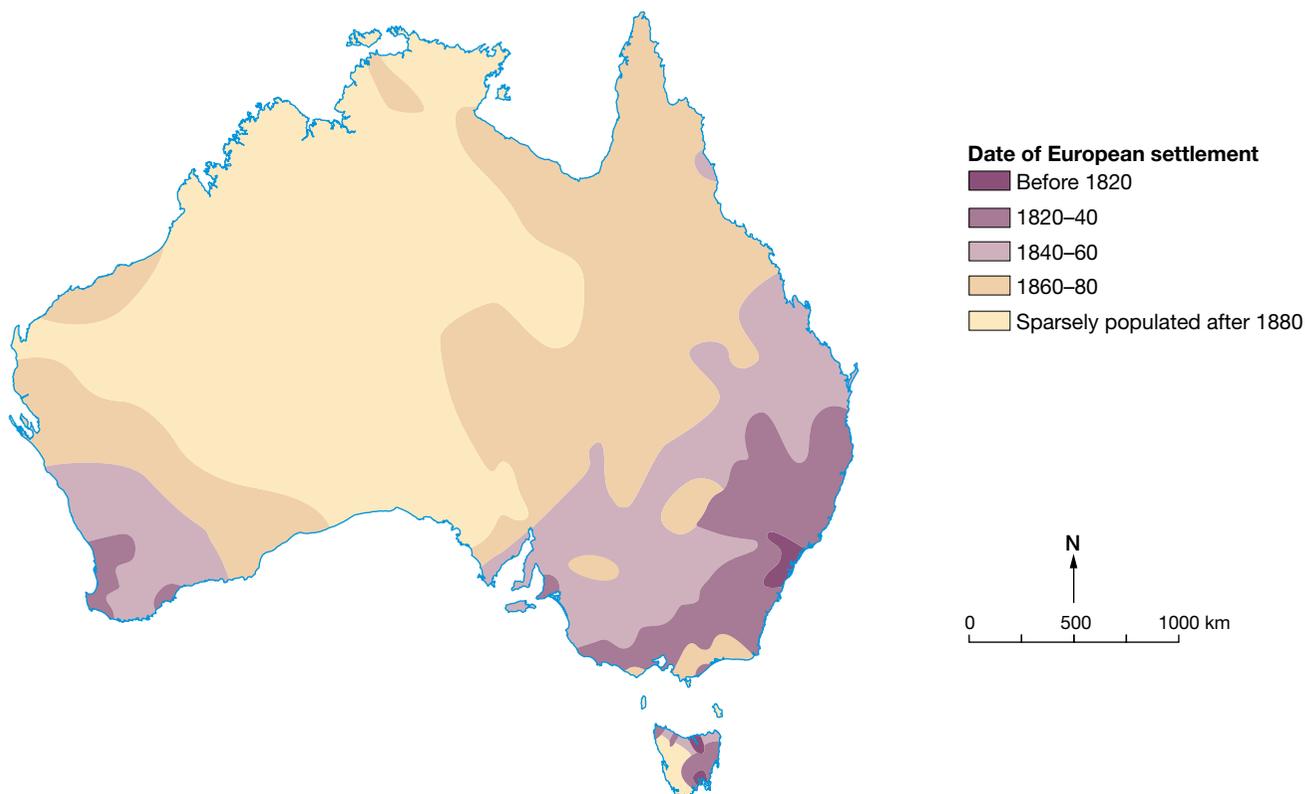
When the British arrived, they laid claim to the country, applying the notion of *terra nullius*—a land belonging to no one. They justified this position by arguing that there were no permanent structures to indicate ownership. Thus, the occupancy rights of the original inhabitants were ignored and, from an Aboriginal perspective, the invasion of their lands by Europeans began.

Missions and reserves

The colonial frontier spread out from the British colony in New South Wales across the continent during the nineteenth century (see Figure 13.3.1). There were inevitable conflicts as Aboriginal people resisted having their food and water supplies taken away from them. They were excluded from their traditional lands. Some were offered refuge on mission settlements, but they were expected to adopt European ways (see Figure 13.3.2). The government also established reserves where they could protect and control Aboriginal communities, but the conditions were often very poor. Many drifted to the edges of towns, and lived in the worst of circumstances.

Indigenous Australians were severely affected by the spread of European settlement. They had no immunity to introduced diseases such as influenza, tuberculosis and smallpox. Disease swept through communities even before they came in direct contact with any settlers. The Indigenous population dipped below 100 000 in the first half of the twentieth century.

13.3.1 Settlement of Australia



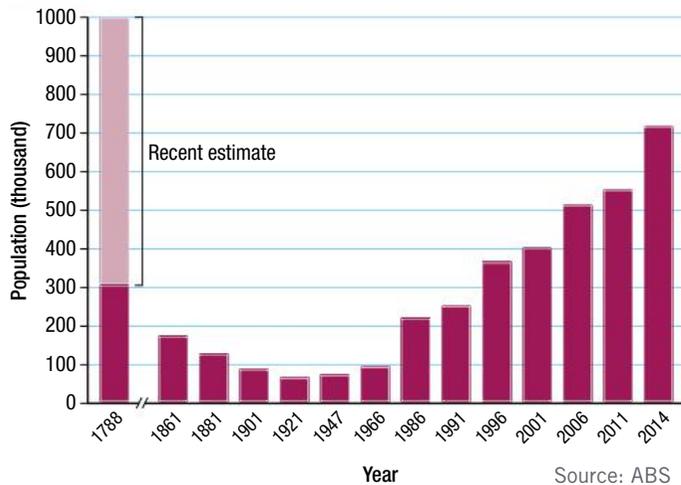


13.3.2 An Aboriginal community outside the church of a mission at Lake Tyers in Victoria's Gippsland region in 1910

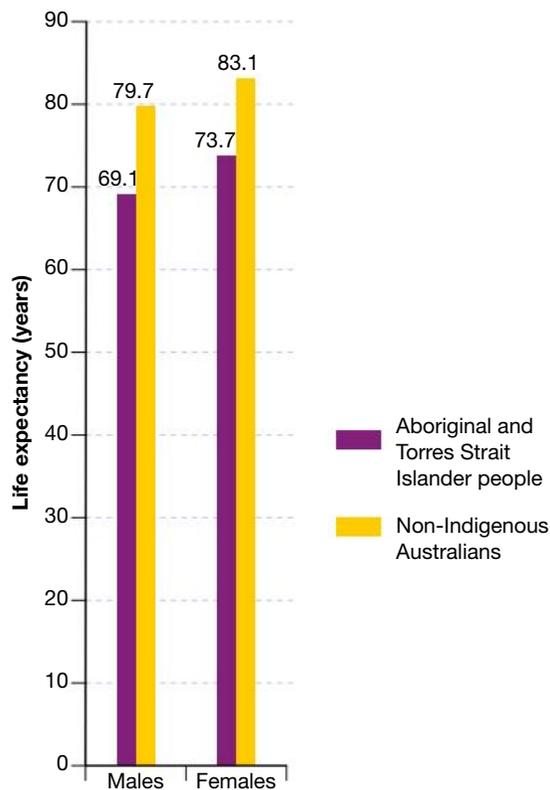
Consequences of dispossession

The forced relocation of Indigenous Australians from their traditional lands to missions and settlements had a dramatic impact on Indigenous population levels, as shown in Figure 13.3.3, and on their health and wellbeing. The social consequences of **dispossession** and marginalisation compounded the problems. They could no longer support themselves as they had done successfully for tens of thousands of years. This resulted in a dependence on government welfare payments. They were pushed into remote areas, far removed from many of the services most Australians take for granted.

13.3.3 Changes in the Indigenous population



13.3.4 Life expectancy at birth, Indigenous and non-Indigenous Australians by sex, 2010–12



HEALTH

Indigenous Australians generally have poor health compared with other Australians, as indicated by a lower life expectancy (see Figure 13.3.4). Heart disease is a major cause of premature death, and diseases such as diabetes, liver and kidney disease, and cancers linked to smoking, are more prevalent in Indigenous Australians. The health of Indigenous people prior to their contact with Europeans was much better, as they had a more nutritious diet and an active lifestyle.

Discrimination, depression, poverty and idleness feed behaviours that affect quality of life. Drug and alcohol addiction and abuse have become embedded in many Indigenous communities, with serious consequences. Heavy drinking brings on health problems and leads to violence, which often triggers assaults, self-harm and family breakdowns.

DID YOU KNOW?

Indigenous people are twice as likely to be smokers as non-Indigenous people. Petrol sniffing has also become common in young males, who risk brain damage and premature death.

13.3.5 Cartoon by Nicholson, *The Australian*, 2005

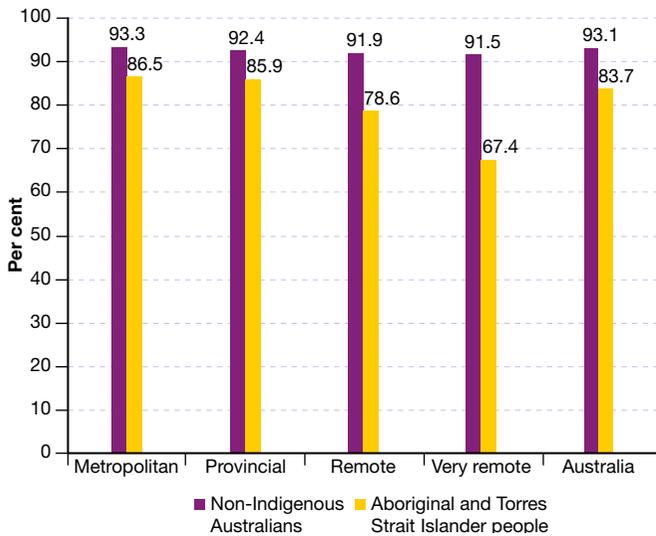


EDUCATION

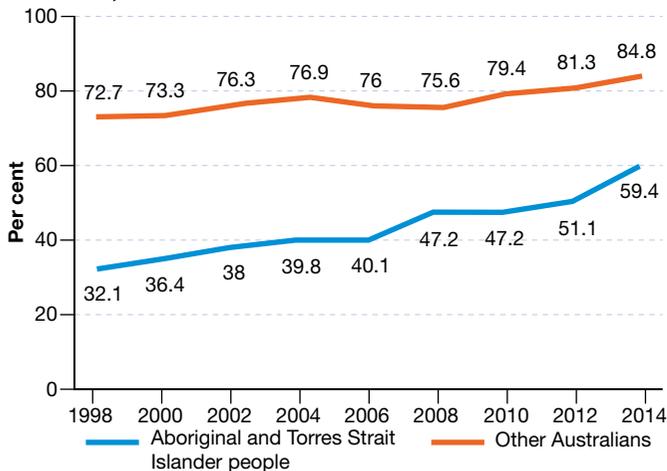
Educational outcomes for Aboriginal and Torres Strait Islander people remain well below those achieved by the non-Indigenous population, as is shown in Figure 13.3.6. Participation and retention rates are low. Literacy rates also remain low compared with the non-indigenous population. Students in remote areas experience the greatest disadvantage.

13.3.6 Indigenous and non-Indigenous populations on selected measures of wellbeing

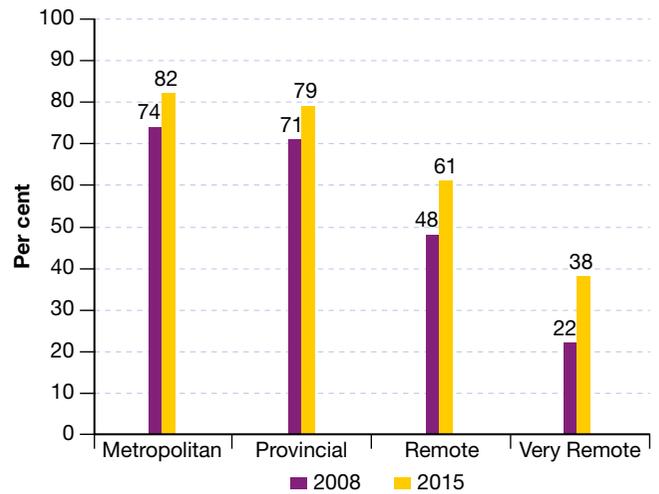
a Student attendance rates (per cent), Years 1 to 10 combined, by Indigenous status and remoteness, Semester 1, 2015



b School retention rates for Year 7/8 to Year 12 by Indigenous status, 1998–2014



c Indigenous students reaching National Minimum Standards for Year 5 reading by remoteness, 2008 and 2015



Source: Closing the Gap Report

ACTIVITIES

Knowledge and understanding

- 1 Explain how the British justified their claim on Australia.
- 2 Outline how the Aboriginal way of life was affected by the spread of settlement.
- 3 Describe how Aboriginal health and wellbeing suffered.

Applying and analysing

- 4 Study Figure 13.3.5. As a class, discuss the point Nicholson is seeking to make in his cartoon. What is the link between work and social and economic disadvantage?

Geographical skills

- 5 Study Figure 13.3.3 and answer the following questions.
 - a What was the estimated percentage change in population from 1788 to 1921?
 - b For how many decades was the population estimated to be below 100 000?
- 6 Study Figures 13.3.4 and 13.3.6a–c. Using data from the graphs, write a paragraph comparing Indigenous and non-Indigenous populations on the measures of wellbeing illustrated.

Investigating

- 7 Research the living conditions of Aboriginal and Torres Strait Islander people after they were displaced by European settlement. Prepare an annotated visual display contrasting this existence with their traditional way of life and demonstrate how it affected their health and wellbeing.

Measuring wellbeing

Measures of wellbeing

The difference in the levels of disadvantage of Australia's Indigenous and non-Indigenous populations is widely acknowledged and considered unacceptable. Aboriginal and Torres Strait Islander people are disadvantaged in many ways. Obtaining accurate measurements of such disadvantage is vital if we are to eliminate the gap.

Life expectancy

The differences are most apparent in the population pyramid in Figure 13.4.1. The shape for the Indigenous population resembles that of a developing country, with lower life expectancies and a younger population. Over one-third of the population is aged 15 years or less, compared to one-fifth of the non-Indigenous population.

Life expectancy is a broad indicator of a population's long-term health and wellbeing. In 2010–11, the life expectancy for Indigenous males was estimated to be 69.1 years, which is 10.6 years less than for non-Indigenous males. For Indigenous women it was 73.7 years, some 9.7 years below non-Indigenous women. In 2011, fewer than 4 per cent of Indigenous people were 65 years or over, compared to 14 per cent of non-Indigenous people. There has been a slight improvement in recent years, but the life expectancy of Indigenous Australians is still unacceptably low compared with that of other Australians.

Health

A health survey of Aboriginal and Torres Strait Islander people in 2012–13 revealed that:

- one in six Aboriginal and Torres Strait Islander people had asthma (twice as high in remote areas)
- one in eight reported diseases of the ear and/or hearing problems
- one in eight had heart disease
- they were three times more likely than non-Indigenous Australians to have diabetes.

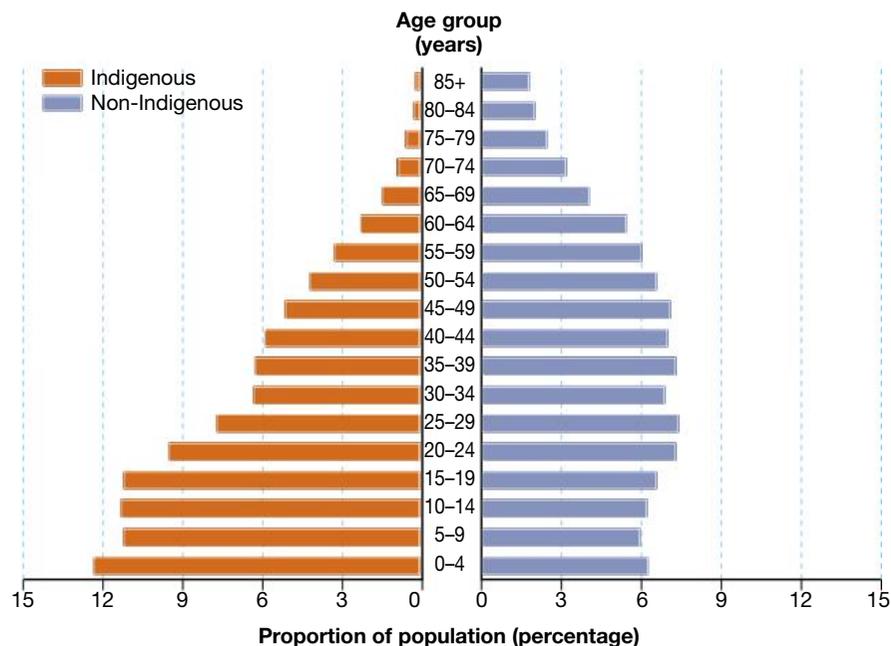
Education

There is a significant number of Indigenous students who are failing basic literacy and numeracy tests, and a large gap is evident between Indigenous and non-Indigenous educational outcomes, particularly at higher levels of attainment. Gaining an educational qualification provides broader life prospects for young people. In 2011, only 44 per cent of the Aboriginal and Torres Strait Islander population aged 15–64 had attained Year 12 or Certificate Level II or above, nearly 30 per cent less than the non-Indigenous rate of 73 per cent.

Impact of remoteness

As Table 13.4.2 illustrates, disadvantages tend to increase with the degree of remoteness. Indigenous people in all remote and very remote areas are comparatively disadvantaged across each of the measures of education, employment and income. A rate ratio compares the rates of disadvantage in two groups that differ by demographic characteristics or exposure history. Figure 13.4.3 shows the variations in the levels of wellbeing by state/territory.

13.4.1 Population pyramid of Indigenous and non-Indigenous populations



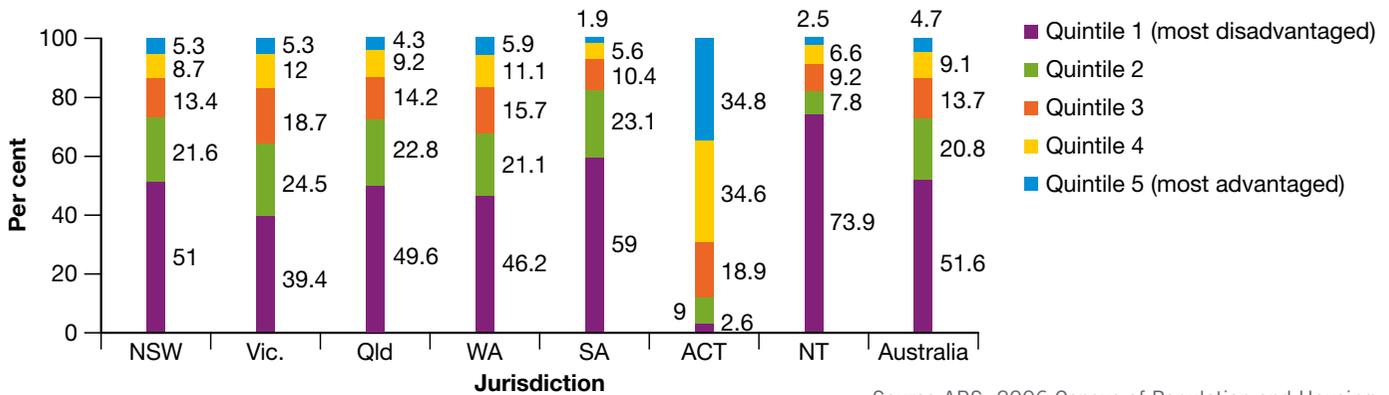
13.4.2 Life expectancies at birth of Indigenous and non-Indigenous populations, by Remoteness Areas, 2010–12

	Aboriginal and Torres Strait Islander (years)	Non-Indigenous (years)	Total	Difference between non-Indigenous and Aboriginal and Torres Strait Islander life expectancy at birth (years) ^(a)
Males				
Major cities and inner regional	68.0	79.9	79.7	11.9
Outer regional, remote and very remote	67.3	78.5	77.4	11.2
Females				
Major cities and inner regional	73.1	83.0	82.8	9.9
Outer regional, remote and very remote	72.3	82.5	81.5	10.2
Difference between males and females				
Major cities and inner regional	-5.1	-3.1	-3.1	--
Outer regional, remote and very remote	-5.0	-3.9	-4.1	--

(a) Differences are based on unrounded estimates
 -- Not applicable

Source ABS, Life tables for Aboriginal and Torres Strait Islander Australians, 2013

13.4.3 Population distribution by advantage/disadvantage, Indigenous population by state/territory and total population



Source ABS, 2006 Census of Population and Housing

ACTIVITIES

Knowledge and understanding

- 1 Why is it important to measure disadvantage?
- 2 Compare the life expectancy of Indigenous and non-Indigenous populations.
- 3 Describe the health of Indigenous Australians.
- 4 Describe the effect of remoteness on the levels of disadvantage experienced by Indigenous Australians.

Geographical skills

- 5 Study Figure 13.4.1 and do the following tasks.
 - a Compare the percentages of the Indigenous population in the 0–9 years cohort with the percentage of non-Indigenous Australians.

- b Compare the percentage of the Indigenous population above 65 years with the percentage of non-Indigenous Australians.
- 6 Study Figure 13.4.3 and answer the following questions.
 - a Which state/territory has the lowest percentage of Indigenous Australians classified as ‘most disadvantaged’? Suggest possible reasons for this.
 - b Which state/territory has the highest proportion of the Indigenous population classified as ‘most disadvantaged’?

Disadvantage in remote communities

Recognising the disadvantage

The level of disadvantage experienced by Indigenous Australians increases with the degree of geographic remoteness. Overcoming such disadvantage is regarded as a national priority by the Australian government. The issues are often complex, however, and will require governments to work with Indigenous communities rather than simply impose what outsiders consider to be the most appropriate response.

Isolation compounds the multiple disadvantages suffered by remote communities (see Figure 13.5.1), already shattered by family dysfunction. The people are often welfare-dependent and there are serious social issues associated with drug and alcohol abuse and gambling.

Education

Indigenous schools—those with more than 75 per cent Indigenous enrolments—have the highest educational failure rates in Australia. Some 20 000 students are enrolled in such schools, which are located mainly in bush communities on Indigenous land where there is no private-sector economic activity and no real jobs. As a result, the inhabitants are totally dependent on welfare. These schools typically have failure rates of more than 90 per cent. In the few schools where specific programs have been put in place to get students to school, and students make progress from day to day and from week to week, attendance booms.

Education in remote communities

Improving educational outcomes is the key to overcoming disadvantage. Acquiring literacy and numeracy skills improves employment prospects. Breaking away from welfare dependency and gaining meaningful work transforms lives and flows on to better health and living conditions. This can only be achieved if children are able to attend a school. Some live so far away from existing schools that it would not even be possible to get there in a day. Those living in the remotest areas suffer the greatest disadvantage and ways must be found to address the situation.

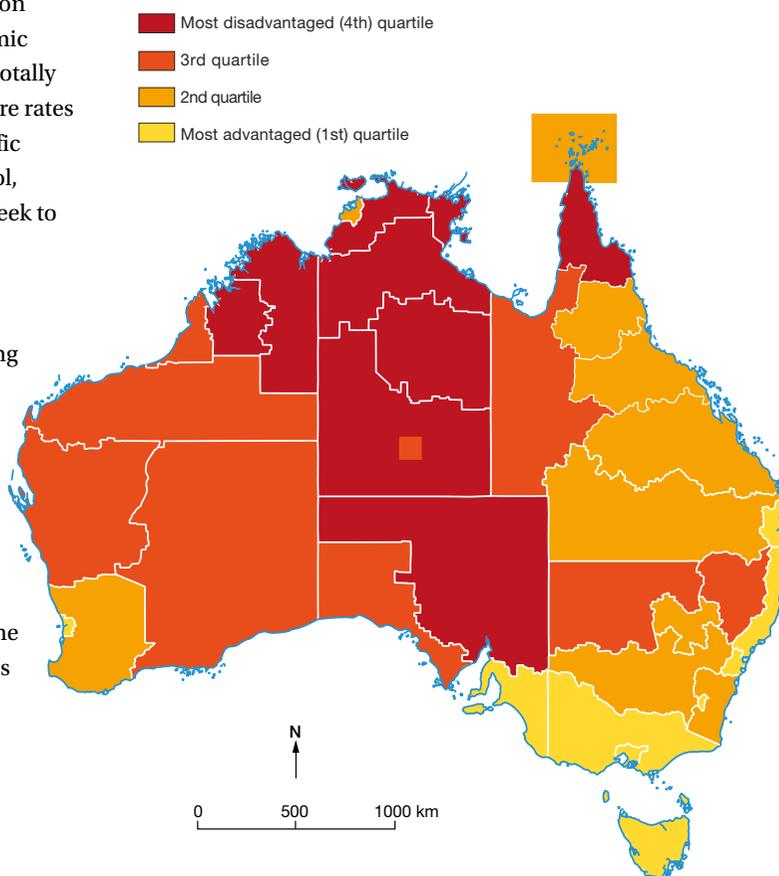
Getting students to attend schools regularly is difficult in communities where parents do not value education. It is of the utmost importance that school attendance is effectively promoted.

The success of a school is closely tied to the quality of the teachers. Good teachers must be provided with incentives such as public housing to remain in remote communities, where they are desperately needed.

Reconnecting with Country

Traditional lands are deeply significant to Indigenous Australians, and those who have lost their connection to it have suffered the most. The barriers that prevent Aboriginal and Torres Strait Islander people from living on their Country according to their culture need be removed.

13.5.1 Disadvantage/advantage across Australia. The most disadvantaged parts of Australia are in remote areas.



SPOTLIGHT

Remote community of Yuendumu

With a population of 800 people, Yuendumu is one of the largest Aboriginal communities in central Australia. As it sits on the edge of the Tanami Desert and is some 300 kilometres north-west of Alice Springs, the community has faced all the problems associated with remoteness. Isolation, idleness and boredom have led to violence and alcohol and substance abuse, especially among young people.

The community faced a crisis in 1993 when half of the teenage population had taken to petrol sniffing and roaming the street in gangs at night. As a response to the crisis, these young people were taken from Yuendumu to

a safe environment at Mount Theo, a remote outstation 160 kilometres away and over 50 kilometres from the closest road, so they could not run away. Here they were looked after by the Warlpiri tribal elders, while their bodies detoxified and recovered from petrol sniffing.

While at Mount Theo, the young people reconnected to their traditional Country and its culture with trips to significant sites. There was a mix of recreational and cultural activities, and they were taught how to hunt and track animals, cook traditional food, paint and make their own fires. It was a safe and supportive environment for them to discuss and deal with their problems. The program successfully stopped petrol sniffing in the community.



13.5.2 Founders of the Mount Theo program, Johnny Miller OAM (right) and Peggy Brown OAM (left), who set up the outstation as a place of respite for petrol sniffers in 1993

ACTIVITIES

Knowledge and understanding

- 1 Describe the problems faced by remote communities.
- 2 Explain why education is important.
- 3 With reference to the Mount Theo program, assess the importance of connection to Country in overcoming disadvantage.

Applying and analysing

- 4 Consider the distribution of the Indigenous population throughout Australia. Do you think that efforts to improve the quality of life of Indigenous Australians should be directed to remote areas? Justify your decision.

Geographical skills

- 5 Study Figure 13.5.1 and do the following tasks.
 - a List all state and territories from the most advantaged to the most disadvantaged.
 - b What are the most advantaged areas in New South Wales, Queensland and Western Australia? Can you provide reasons for this distribution?

Investigating

- 6 Research how the young people of Yuendumu are currently being supported. Present your findings in an annotated visual display. Include a location map of Yuendumu.

Closing the gap

SPOTLIGHT

Closing the Gap, Prime Minister's Report, 2016

As in previous years, there have been mixed levels of success in meeting the targets. The report shows that, while progress against a number of the targets has been limited, the actions taken over recent years are making a difference. There have been some tangible successes and continuing improvement in many of the areas critical to addressing inequality. While long-term improvements are evident, it is important to note that overall progress has been varied and that meeting many of the Closing the Gap targets remains a significant challenge.

- The target to halve the gap in child mortality by 2018 is on track. Over the longer term, Indigenous child death rates declined by 33 per cent and the gap narrowed (by 34 per cent) between 1998 and 2014.
- While total Indigenous mortality rates have declined over the longer term, particularly from circulatory diseases (such as heart disease and stroke) the target to close the gap in life expectancy is not on track, based on data since the 2006 baseline.
- The latest data shows mixed progress on the target to halve the gap in reading and numeracy for Indigenous students by 2018. The proportion of Aboriginal and Torres Strait Islander students achieving national minimum standards across the eight areas (reading and numeracy for Years 3, 5, 7 and 9) is on track in four of these areas.
- An increasing proportion of Aboriginal and Torres Strait Islander young people are completing Year 12, up from 45.4 per cent in 2008 to 58.5 per cent in 2012–13. This means the target to halve the gap in Year 12 attainment by 2020 is on track.
- The target to halve the gap in employment by 2018 is not on track. Factors such as economic growth, strong Indigenous businesses and gains in Indigenous education will have an impact on the results.

Meeting all the Closing the Gap targets will be challenging, and will take a national commitment and resolve across Indigenous-specific and mainstream programs. Responsive and innovative solutions are essential to address the current disparity and build a promising future. This will be achieved through true partnership between governments, businesses and Aboriginal and Torres Strait Islander people.

Source: Adapted from the Executive Summary of *Closing the Gap, Prime Minister's Report, 2016*, Australian Government

Challenges and targets

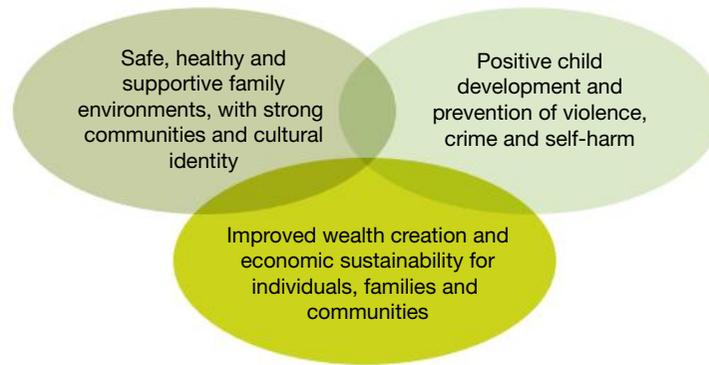
A commitment to 'closing the gap' has been initiated to overcome the disparity in human wellbeing that exists between the Aboriginal and Torres Strait Islander people and non-Indigenous Australians.

All governments are committed to six targets set by the Council of Australian Governments (COAG). These are listed in Figure 13.6.1. Over time, a strategic framework has been developed to tackle the underlying causes of Indigenous disadvantage (see Figure 13.6.2). Comprehensive strategies and policies will need to be sustained for a long time given the enormity of the challenge. Each of the targets is measurable and closely monitored to determine if progress is being made. Results are published annually by the Australian government in the Closing the Gap reports.

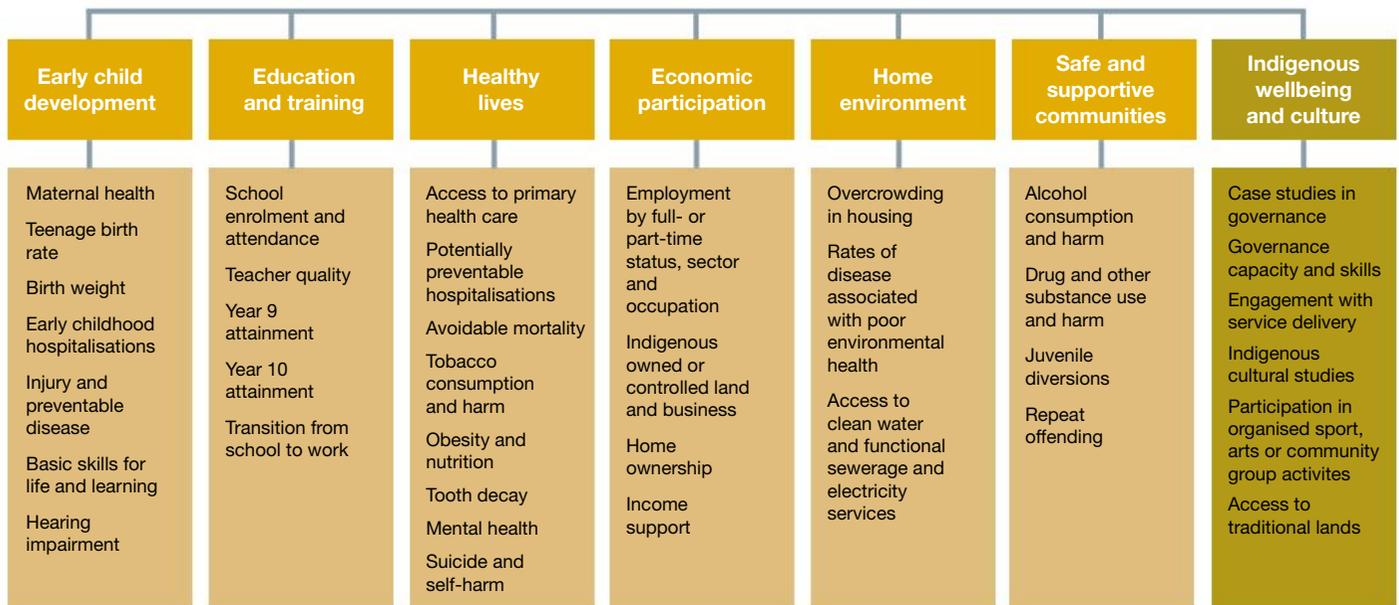
13.6.1 Closing the Gap targets

Closing the Gap targets	
	Close the life expectancy gap within a generation (by 2031)
	Halve the gap in mortality rates for Indigenous children under five within a decade (by 2018)
	Ensure that all Indigenous 4-year-olds in remote communities have access to early childhood education within 5 years (by 2013)
	Halve the gap for Indigenous children in reading, writing and numeracy within a decade (by 2018)
	Halve the gap for Indigenous people aged 20–24 in Year 12 or equivalent attainment rates (by 2020)
	Halve the gap in employment outcomes between Indigenous and non-Indigenous Australians within a decade (by 2018)

13.6.2 The framework for Closing the Gap



COAG targets	Headline indicators
Life expectancy	Post-secondary education—participation and attainment
Young child mortality	Disability and chronic disease
Early childhood education	Household and individual income
Reading, writing and numeracy	Substantiated child abuse and neglect
Year 12 attainment	Family and community violence
Employment	Imprisonment and juvenile detention



ACTIVITIES

Knowledge and understanding

- 1 Explain why the Closing the Gap program was initiated.
- 2 Summarise the findings of the *Closing the Gap Prime Minister's Report 2016*.
- 3 Account for the government choosing 'getting children to school' as its first priority.

Applying and analysing

- 4 Refer to Figure 13.6.2. Select one of the COAG targets and show how some of the strategic areas

for action shown would work towards achieving that target.

- 5 Create a symbol to represent the Closing the Gap commitment.

Investigating

- 6 Research the strategies used by the Australian government to improve the school attendance of Indigenous students. Present your findings in a newspaper report.

Self-help initiatives

Local and regional action

While national leadership and funding are important, local and regional actions are crucial in addressing the multiple disadvantages faced by Aboriginal and Torres Strait Islander people. **Self-help initiatives** empower Indigenous people, and build upon and reinforce a network of resources and relationships within the local community.

Indigenous stockmen back in the saddle where the wild cattle roam

When wild cattle mustered off the coastal wetlands of Cape York got top price at the Mareeba sales in September 2012, the Wik people took a step out of the tortured past of welfare dependence towards securing their economic future.

Just weeks before the Federal Court travelled to the missionary town of Aurukun, 650 km northwest of Cairns, to deliver the final determination of the 20-year Wik native title case, the \$1.32-a-kilogram paid for the herd of Brahman and red horn cross marked an equally important milestone for a community besieged by addiction, violence and unemployment.

Frustrated with decades of government programs, offering only menial jobs and little training, four of the Wik clans in 2011 incorporated a company, APN Cape York, that is drawing on traditional and historical knowledge and the latest in cutting-edge innovation to turn a profit and return people to their traditional 'country'.

With the help of contracted cattlemen, young men who were jobless and on 'the grog' before being recruited by



APN are resurrecting the legend of the Indigenous stockman, mustering the progeny of the herd left behind after the 1990s demise of the white-run pastoral company. [See Figure 13.7.1.] Stephen Marpoondin told *The Weekend Australian*: 'This is part of our history, this is what our fathers and grandfathers did. There was pride and it hasn't been there for a long time.'

'But now we are back on our land, working, learning, the fellas in town look up at us, they want to get away from the grog and fighting and come work with us.'

13.7.1 With the help of contracted cattlemen, young Aboriginal men are being recruited to muster the wild cattle.

The company's head, Canberra Grammar-educated traditional owner Bruce Martin, said APN arose out of anger about the 2009 imposition of the Bligh Government's Wild Rivers preservation laws throughout Cape York and a growing desire for the community to determine its own destiny.

The son of traditional woman Dorothy Pootchemunka and anthropologist David Martin said APN was driven by

the families living in Aurukun who met monthly to direct its operation.

‘The company came out of the families talking about what they wanted for the future and to take control,’ he said.

‘We want sustainable businesses, ones that employ our people, properly train our young people as stockmen, builders, plumbers.’

Modestly resistant to be labelled a ‘leader’, Mr Martin said it was also about returning the community ‘to country’, the expansive plains and wetlands teeming with wildlife, through improvements in infrastructure and the economic need to work the land.

Camps of workers and their families are springing up along the lakes and waterways as the business of mustering and yarding the wild cattle runs from dawn to dusk. Indigenous stockmen work alongside the few non-indigenous contractors, veteran cattlemen who are passing on their expertise. The main camp, where plans are made and orders given, is a cheerful place, with a permanent fire, an endless supply of food and a shared atmosphere that important work is being done.

‘What the governments never understood, and where the regional



organisations have fallen short, is that they prescribed to us what they thought needed to be done,’ Mr Martin said.

‘But to get any plan to work, you need to take ownership and that is what we have done.’

APN is also moving into the construction business and has set up a ranger division, winning competitive tenders for environmental management programs across the 750 000 hectares of ‘country’ that stretches along the western side of the Cape York Peninsula.

Using traditional burn-off methods, they have reduced the number of late

13.7.2 The young stockmen are back on their land, learning and working and taking pride in what they are doing.

dry-season fires sparked by lightning strikes in an abatement program being banked as carbon credits, with the oversight of the CSIRO, to be eventually traded on the market.

The burgeoning success of APN, governed by a board made up of people from the four clans, is more evidence of a seismic shift among the leadership of the 1200 people living in Aurukun to tackle dysfunction and to move from a reliance on ‘sit-down money’.

Source: Michael McKenna, *Weekend Australian*, 27 October 2012

ACTIVITIES

Knowledge and understanding

- 1 Outline the problems faced by the Wik people in Cape York.
- 2 Describe how they are undertaking to change their lives and why they take such pride in their efforts.
- 3 Explain the impact this initiative has on the community.

Applying and analysing

- 4 As a class, discuss the following questions.
 - a Why has this initiative been successful where other regional organisations have fallen short?

- b What is meant by the final comment: ‘to tackle dysfunction and to move from a reliance on “sit-down money”’?

Investigating

- 5 Research the history of Indigenous stockmen in Australia and create a collage of photographs.
- 6 Research the Wik native title case. Prepare a summary report on this case and assess how it is significant to the current self-help initiative being undertaken by the Wik people.

Role of NGOs

Non-government organisations

While governments have an important leadership role in addressing Indigenous disadvantage, **non-governmental organisations (NGOs)** are also very active in helping to build better lives for the Aboriginal and Torres Strait Islander people. In many instances, they work closely with people to build on and strengthen the network of relationships and the resources of local communities.

Given all that needs to be done to ensure that the life opportunities of Indigenous Australians are comparable to those of non-Indigenous Australians, NGOs have a significant role to play. By their very nature, those who work or volunteer in such organisations display a genuine desire to make a difference in the lives of others. NGOs are able to raise funds from donations or subscriptions, and this money is put to use in supporting initiatives to enhance the wellbeing of Indigenous people.

Global NGOs often become involved in widely publicised issues. The situation of the Aboriginal and Torres Strait Islander people has drawn international attention. Amnesty International has been vocal in campaigning to protect the human rights of Indigenous Australians, especially the maintenance of their connection with their traditional, ancestral lands.

Many Australian NGOs are very committed to working with Indigenous Australians.

Anglicare NT

Anglicare NT is one of the main providers of government-funded welfare, social justice and community development programs in the Northern Territory. Over eighty-five different programs now run in urban, regional, rural and remote communities, with 300 staff and 250 volunteers working for the organisation.

- **Child and Youth Residential Support Service** This provides a stabilisation, assessment and transition unit for children and young people aged between 8 and 17 years who cannot immediately be placed with kin or in foster care. They are assisted in reconnecting with family and schooling, and their health problems are attended to.

- **East Arnhem Youth Services** This is a free and confidential service that provides support, information, referral and practical assistance to young people, families and communities. It delivers the following programs:
 - ReConnect—early intervention youth homelessness program, linking young people, family and community
 - Youth Drop In Activity Zone—after school and holiday and activity events
 - Your Choice Nhungu Malatjarryunarawu—information, education and activities for young people and families, reducing alcohol and drug-related harm.
- **Paperbark project—Bellies, Birth and Bubs** This program provides pregnancy awareness sessions, runs youth-friendly childbirth education classes, supports remote-based infant/maternal health/midwifery practitioners, hosts community awareness events and provides targeted perinatal support for Indigenous young women from remote communities.

13.8.1 Paperbark project—Bellies, Births and Bubs: an Anglicare NT program



The Fred Hollows Foundation

The Fred Hollows Foundation is inspired by the work of the late Professor Fred Hollows (1929–93). When he became aware of the high incidence of eye disease among Aboriginal and Torres Strait Islander children and adults, Professor Hollows organised the provision of medical services to treat people in remote areas.

Fred Hollows inspired many doctors and other health professionals to volunteer their time for the National Trachoma and Eye Health Program. From 1976 to 1978, his teams visited 465 communities and screened 100 000 people, of whom 62 000 were Indigenous Australians. They found that nearly half Australia's Indigenous population had trachoma, and in some regions in the Northern Territory and Western Australia, the rate was 80 per cent. Approximately 27 000 people were treated for trachoma, more than 1000 operations were performed and more than 7000 pairs of glasses were dispensed.

13.8.2 An ophthalmologist screens a man for diabetic retinopathy.

The Foundation was established in 1992. It continues to work to achieve Professor Hollows's vision of a world in which no one is needlessly blind and Indigenous Australians exercise their right to good health.

Aboriginal and Torres Strait Islander adults are six times more likely to go blind, but 94 per cent of vision loss is preventable or treatable. The Foundation's program in Australia focuses on education, screening and treatment to put an end to these alarming figures.

The Foundation supports increased investment in, and access to, culturally appropriate eye care services for remote and under-served Aboriginal and Torres Strait Islander communities.

Since 2013, the Foundation has been working with governments and partners to screen more than 26 000 Indigenous Australians and support 3175 eye operations and treatments, including sight-restoring cataract surgery and treatment for diabetic retinopathy (see Figure 13.8.2). The Foundation has also supported the training of 452 doctors, nurses, and community health workers and leaders.



ACTIVITIES

Knowledge and understanding

- 1 Describe how NGOs are active in addressing Indigenous disadvantage.
- 2 Outline the services provided by Anglicare NT.
- 3 Assess the work of the Fred Hollows Foundation.

Investigating

- 4 Select an NGO that works with Indigenous people. Research this NGO and create a pamphlet to promote the NGO and encourage people to donate to it.



Coastal environments

CHAPTER 14

The coastline is the area where the land meets the sea. The exact point at which this occurs is difficult to determine because of the dynamic nature of tides. As a result, the term coastal zone is often used instead. This is the zone in which the interaction between the sea and land processes occurs. The coastal zone includes many types of environments: coral reefs, the continental shelf, coastal barrier islands, estuaries, salt marshes and mangroves. Many of the planet's coastal environments are under threat. Fifty per cent of world's population live within 10 kilometres of the sea and fourteen of the fifteen largest megacities are located on the coast. Given the scale of this human impact, and the ecological importance of these environments, it is critically important that they are effectively managed.

In this chapter, we focus on environmental change and management, using coastal environments as an example. Of particular interest are the causes and consequences of the changes taking place and an evaluation of the strategies being used to manage these changes.

INQUIRY QUESTIONS

- What are the principal causes of environmental change in marine environments?
- What are the effects of the environmental changes taking place in marine environments?
- Which environmental management strategies are being used in marine environments? Are they effective?

GLOSSARY

continuous resource a renewable resource, the availability of which is not affected by human activity; for example the energy of the sun

ecotourism responsible travel to natural areas that conserves the environment and improves the wellbeing of the local people

hard engineering the controlled disruption of natural processes through the use of human-made structures

landuse zoning plans outlining how land can be used in an area

longshore drift the process by which sand moves along a beach shoreline as a result of waves approaching the shore at an angle

resonance the process whereby an outgoing low tide collides with the incoming high tide, causing a wave of water to be pushed into a bay

sand dunes long hills of sand formed by the wind

soft engineering the use of vegetation and other materials to soften land–sea interactions

turbidity the amount of suspended sediment in water

upwelling upward movement of water from deep in the ocean

The importance of coastal environments

Biophysical interactions and natural balances

All ecosystems are the result of biophysical interactions. The biophysical environment is made up of four parts, known as the four spheres. These spheres are:

- **the hydrosphere**—water and its movement
- **the atmosphere**—the gaseous layer that surrounds the earth
- **the lithosphere**—the earth's solid outer shells, including soils and rocks
- **the biosphere**—flora and fauna.

The interaction of these spheres helps to determine the nature of the ecosystem that is found at any particular location.

Every time a wave crashes into a headland, energy is transferred from the wave to the rock, and slowly breaks the rock down. Coasts are often referred to as 'boundary environments'. This is because they are found at the edge of marine (water-based) and terrestrial (land-based) environments. This interaction between the sea and land is at the centre of the coastal ecosystem.

Importance of the coastal environment

Buffer zone

A coastal environment is a little like a bumper bar on a car. In a collision, the bumper bar bears the shock of the impact and absorbs much of the energy of the collision, helping to reduce damage to other parts of the car. Similarly, the coastal environment takes the full force of the waves and tides from the sea. This helps to minimise the impact to areas further inland. When humans begin to change the coastal environment by removing **sand dunes**, clearing coastal wetlands and dredging, this protective buffer is lost.

Breeding grounds

Coastal environments play a very important role in the broader marine environment. Many of the world's marine species, even those that spend most of their time in the deep oceans, use coastal areas as breeding grounds as well as food sources. From a human perspective, most of the fish species that are harvested for human consumption come from coastal waters (see Figure 14.1.1).



14.1.1 Most of the world's fish are caught in coastal waters.

These coastal waters are the most productive. This is because they are rich in nutrients, which are brought to the coastal waters by river systems and by **upwelling**. Upwelling is a process whereby nutrient-rich waters from the deep ocean are pushed upwards towards the surface. Shallower coastal waters also have greater penetration of sunlight, which provides energy for aquatic plants (through photosynthesis). These plants are an important source of food for many species.

Cultural importance

For many indigenous cultures, coastal areas have great spiritual and cultural significance. For example, in Australia, Aboriginal and Torres Strait Islander people have important creation stories that link directly to coastal waters. Coastal waters have always been an important source of food for traditional owners. Traditional hunting in indigenous communities around the world is practised as part of the management of coastal environments.

Coral reefs

Coral reef systems, such as Australia's Great Barrier Reef, are among the most complex and diverse ecosystems in the world. These very important environments are found in the warm, shallow coastal waters of the tropics. They require very specific conditions to grow, and coastal areas where reefs exist require special management to ensure that they are not destroyed.

Waves

Waves are one of the most important features of any coastal system. A wave is created when energy is transferred from the atmosphere to the surface of the water in the form of wind. This energy can be carried vast distances until it is released at the shoreline as the wave breaks. At this point, the energy is transferred to the land.

In the open ocean, waves move as swell, with the energy moving in an orbital motion. When in deep water, the waves do not change their shape. These types of waves are known as waves of oscillation. Once the waves enter the shallow waters of the **coastline**, they are transformed into waves of translation. This takes place because the waves begins to interact with the seabed, which gradually slows the base of the waves, but not the crest. Consequently, the waves increase in height until they break. Figure 14.1.2 illustrates this.

Waves demonstrate interactions between the spheres at the coast. The wind that provides the waves with energy comes from the atmosphere. The energy is then transferred into the water of the hydrosphere. The wave then breaks because its orbital motion is interrupted by the sea floor, which is part of the lithosphere.

Waves may be constructive or destructive.

Constructive waves

Constructive waves tend to be less powerful and are usually created by lighter winds. They bring sediment such as sand onto the beach and so gradually construct the beach and other coastal features.

Destructive waves

Destructive waves are more powerful waves and are usually associated with large storm events. These waves strike the beach with so much power that they pull sand back with them as the swash retreats back into the sea. During very big storms it is possible for waves to take huge quantities of sand from beaches.

SPOTLIGHT

Beaches washed away

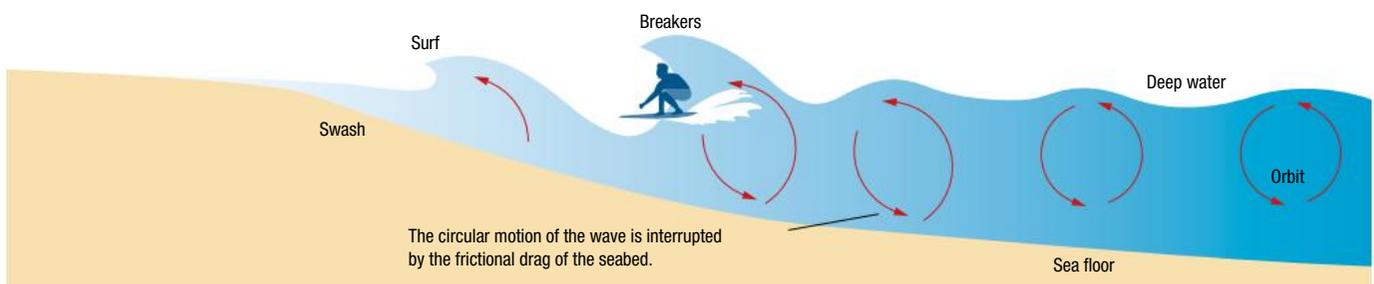
In June 2013, beaches along the coasts of southern Queensland and northern New South Wales were extensively eroded by huge waves, as shown in Figure 14.1.3. The waves were created by a weather pattern called an east coast low. This is a very unstable weather cell that creates strong winds, which cause the very destructive waves. In 2013, a series of these low-pressure systems over a number of weeks brought flooding rains and high winds.

An easy way to tell constructive and destructive waves apart is to look at the colour of the water as the wave breaks. With a constructive wave you will see the sediment caught up in the water as the wave breaks. Destructive waves, on the other hand, will look clear and glassy.

14.1.3 During the winter of 2013, powerful destructive waves eroded vast quantities of sand from beaches, including here at Surfers Paradise on Queensland's Gold Coast.



14.1.2 How a wave breaks



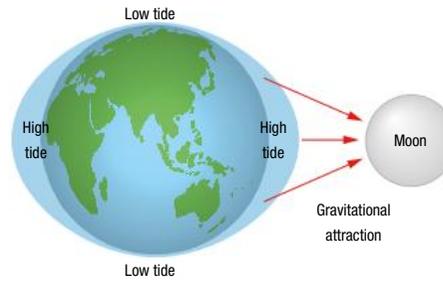
Tides

Tides rise and fall twice a day, due to gravitational forces. The most significant of these is the gravitational pull created by the moon. The pull of the sun and the rotation of the earth itself also contribute to the tides.

Figure 14.1.4 shows that the moon pulls water to the side of the earth closest to it. This creates a bulge or high tide. A similar bulge is then created on the opposite side to compensate. Between the bulges, water is repelled to create a low tide. Every fourteen days, the moon and sun are in alignment. This creates an extra-strong gravitational pull that results in a particularly high tide, known as a king tide.

When a king tide and a storm occur at the same time, the effects of the high tide and destructive waves often lead to a storm surge. Storm surges are caused by very low-pressure cells, such as tropical cyclones. These severe storms form over the ocean and the low pressure causes the air to rise, pulling the sea surface up with it. Storm surges can do tremendous damage.

14.1.4 The gravitational pull of the moon is the main cause of tides.



Functions of coasts

Table 14.1.5 outlines the different functions of coastal environments.

14.1.5 Functions of coasts

Function	Coastal environments
Source function	<ul style="list-style-type: none"> About 15 per cent of all protein consumed by humans is in the form of seafood. Most of this is taken from coastal waters, making this a crucial environment for feeding the world's growing human population. Coastal areas are crucial habitats for many animal species that rely on the coast for both food and shelter. For example, the iconic dugongs of Hervey Bay rely entirely on the coastal seagrass beds for their food.
Sink function	<ul style="list-style-type: none"> The value of coastal areas as important carbon sinks is becoming more widely recognised. Sometimes referred to as 'blue sinks', coastal ecosystems such as intertidal wetlands and seagrass beds are important in absorbing carbon dioxide, as well as adding vital oxygen to the water. Recent research has found that blue sinks are far more effective at capturing and storing carbon dioxide from the environment than so-called green sinks, such as rainforests. Coastal environments have been used for centuries as places to 'dump' waste. In more recent times this has become more regulated, but most coastal communities still use coastal waters to disperse treated sewage and other waste.
Service function	<ul style="list-style-type: none"> Coasts are important 'zones of transition' from the marine to the terrestrial (land-based) environment. One of the most important service functions of the coast is to act as a barrier to the sea. For example, dune systems absorb the energy of storm waves, reducing impacts such as potential flooding from storm surges. Coastal environments play a crucial role in the movement of sediment. Wave action not only erodes the coast, creating sediment, but it also moves sediment onto and off the shoreline. Currents then move this sediment, often very long distances. These processes allow for the creation of new landforms elsewhere, for example barrier systems and sand islands. Coastal ecosystems, such as intertidal wetlands, mud flats and estuaries (coastal rivers), are very important breeding and nursery grounds for a vast number of marine species. Many species, such as prawns, that are very important to commercial fishing begin life in the coastal ecosystems.
Spiritual function	<ul style="list-style-type: none"> For many indigenous cultures, coastal environments have an important spiritual value. Aboriginal and Torres Strait Islander people, whose traditional lands include coastal areas, have strong links through their Dreaming stories to the coastal environment. For non-indigenous people, coasts have important aesthetic and psychological value. Coastal-based tourism is worth billions of dollars annually, as people enjoy spending time in coastal settings.

SPOTLIGHT

Superstorm Sandy

In October 2012, a powerful hurricane called Sandy developed in the Caribbean Sea. The storm caused considerable damage throughout the Caribbean, killing fifty-four people on the island nation of Haiti and leaving a trail of destruction across Jamaica and the Bahamas. The storm then headed northwards up the east coast of the United States of America.

On the evening of 29 October, the storm struck the coast near Atlantic City in New Jersey. A king tide had increased the high tide by a further 20 per cent, making the storm surge created by the hurricane even more intense. As the storm continued, sea water surged over the sea walls in Lower Manhattan in New York City. The water flowed into tunnels and even the city's famous subway was flooded. The strong winds caused a massive construction crane, seventy-four stories up on a skyscraper, to collapse, and a large tanker ran aground on Staten Island. Waves were measured at more than 10 metres in New York Harbour.

By the time the storm blew itself out, 149 people had been killed, more than 8.5 million people were left with no electricity, at least US\$20 billion in damage had been caused to private property and about US\$19 billion worth of damage had been caused to public infrastructure, including the subways, bridges and other important assets. Even the Statue of Liberty was badly damaged by huge waves and was not re-opened until July 2013, more than eight months after the storm.



14.1.6 The impact of Superstorm Sandy can be seen in these photos. The same location is shown before and after the storm.

ACTIVITIES

Knowledge and understanding

- 1 Explain why coasts are considered boundary environments.
- 2 Outline the four spheres of the biophysical environment.
- 3 Explain the importance of coastal areas as buffer zones.
- 4 Outline the role of coastal environments in the broader marine ecosystem.
- 5 Describe why coastal waters are more productive than the open ocean.
- 6 Outline the spiritual importance of coastal environments to traditional cultures.
- 7 Describe the process of wave formation.
- 8 What are waves of translation?
- 9 Compare destructive and constructive waves.
- 10 Define a tide.
- 11 Outline the factors that lead to a storm surge.

Applying and analysing

- 12 Using a flow chart, describe the processes of a wave breaking onto the beach. In your flow chart show how the different spheres are involved.
- 13 Examine Figure 14.1.3. Describe the impact that the destructive waves have had on this part of the Queensland coast.
- 14 Read the Spotlight box 'Superstorm Sandy' and do the following tasks.
 - a Outline the nature of the storm.
 - b Explain why Sandy was such a damaging storm.
 - c With the aid of Figure 14.1.6, describe the damage done by the storm.
- 15 Take on the role of an environmental leader. Prepare a letter to the Australian government, encouraging it to place greater protections on an area of coast. In your letter, outline the importance of the coast.

Causes of environmental change

People's impact on coasts

About half the world's population live within 10 kilometres of the coast, and fourteen of the fifteen largest cities on earth are located on the coast. This places considerable pressure on our coastlines. As the human population along the coastline continues to grow, so do the environmental changes that humans cause. For centuries, humans have viewed the oceans as a **continuous resource**, a place that could be exploited and used without concern. This view has led to coastal areas being extensively developed and changed. They are often seen as convenient places to dispose of rubbish, sewage and other contaminants, leading to widespread pollution and environmental damage.

Pollution

It is estimated that about 80 million tonnes of plastic are produced each year. Much of this plastic is disposed of, with a significant amount making its way into the world's oceans and coastal areas, as shown in Figure 14.2.1. Plastics have a long life span, taking about 500 years to fully decompose in the oceans. Their buoyancy means that plastic rubbish can travel vast distances.

Once in the oceans, plastics enter the food chain when marine animals mistakenly eat them. More than 200 species of animals, including whales, seals, crabs, sharks and dugongs, are known to be affected by plastics. A build-up of plastics releases toxins into the blood stream, organs and tissues of these animals. Many are also killed by being entangled in the rubbish.

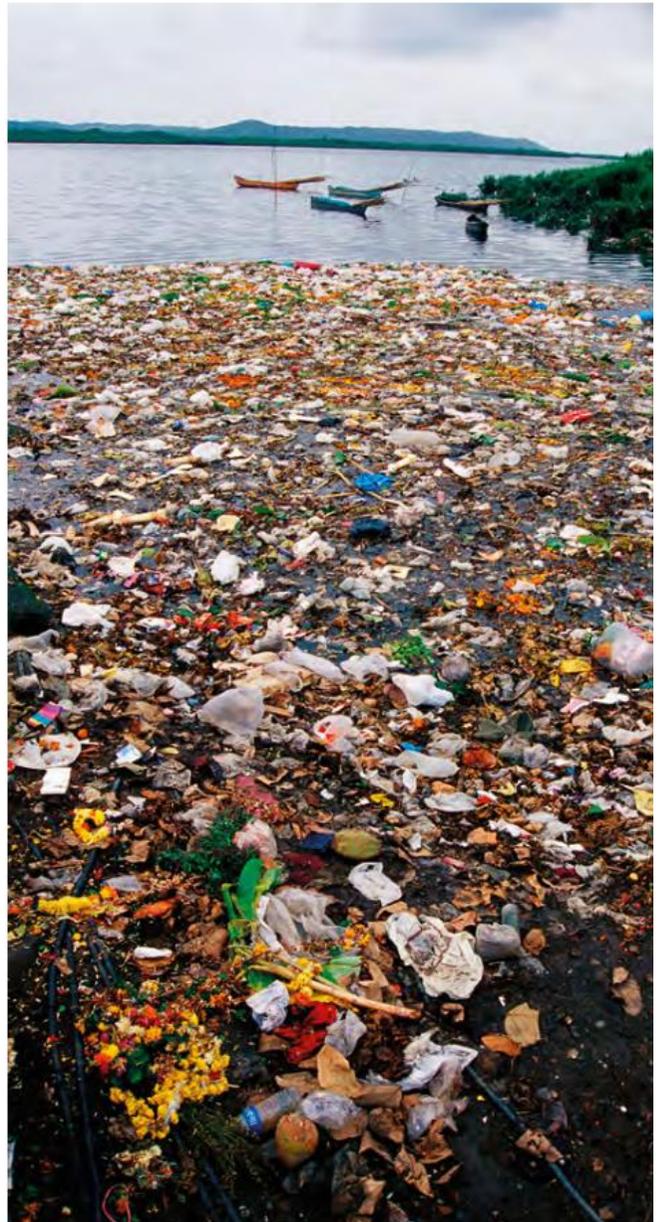
GHOST NETS

About 640 000 tonnes of fishing equipment is lost at sea every year. Much of this is lost in coastal waters. Lost fishing nets, known as ghost nets, kill marine life long after they have been lost, as shown in Figure 14.2.2.

The coast of the Gulf of Carpentaria, in the far north of Australia, is one of the most isolated and least populated places on earth. Yet there is a major problem with ghost nets there, even though there is very little fishing in the area. The nets are believed to come from fishing grounds in Asia, washed into the Gulf of Carpentaria by ocean currents.

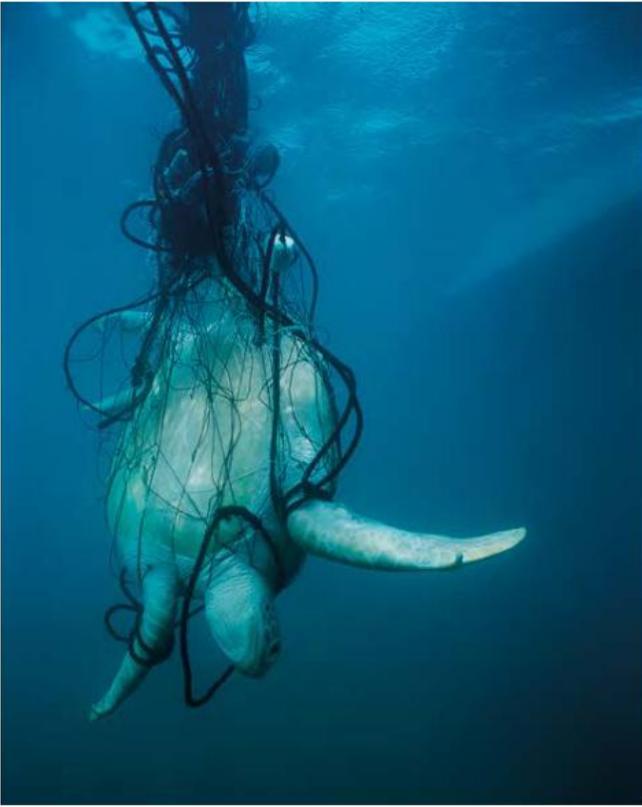
Ghost Nets Australia is an environmental group established in 2004 by twenty-two Indigenous communities. Its task is to remove ghost nets from beaches in northern Australia. Since it started work, more than 7500 nets, each capable of killing thousands of marine animals, have been removed

14.2.1 The Indian city of Mumbai has a population of more than 18 million. There is considerable pollution of the environment of the extensive coastal mangrove forests that grow around the city.



from beaches. Turtles are the most common species found in the nets. Turtles need to rise to the surface to breathe, but the nets trap them, causing them to drown. When Indigenous rangers and environmental volunteers remove the nets from the beaches, they stop them from being washed back out to sea to start a cycle of death again, saving countless animals in the process.

14.2.2 Ghost nets continue to kill marine life long after they have been lost.



Destroying buffer zones

Coasts are home to very important infrastructure and commercial structures. Almost all the world's trade is done using ships, which require the construction of huge port facilities. These facilities are often built on reclaimed land, which is land that is created by filling in coastal areas, or by destroying important coastal environments, such as wetlands, mud flats and sand barriers.

Ships are also increasing in size and this has meant that deeper and wider harbours are needed. Dredging the sea floor is now very common in many large ports. This involves removing mud and other sediment from the sea floor, changing the environment dramatically.

Development

Most of the world's human population lives on or near the coast, and the demand for more and more development has seen coastal environments placed under great stress. Coastal landforms, such as intertidal wetlands and coastal dunes, are often destroyed to make way for canal housing estates, tourist facilities and other developments, as in Mandurah, shown in Figure 14.2.3.

14.2.3 Large-scale urban development has dramatically changed the coastal environment in Mandurah, south of Perth.





14.2.4 Taken in 2009, this image from an orbiting spacecraft shows some of the artificial islands off the coast of Dubai. Since then, more islands have been added.

DUBAI'S ISLAND BUILDING

Dubai is one of the seven emirates that make up the United Arab Emirates. It is a large city, and hugs the coastline of the Persian Gulf. Made wealthy from its rich oil reserves, Dubai has a reputation for huge construction projects. One of these projects was the construction of huge islands off the coastline for housing and resort developments, as shown in Figure 14.2.4. At present there are four main developments, three in the shape of enormous palm trees and the fourth in the shape of the world's landmasses.

The islands are made from sand dredged from the bottom of the Persian Gulf and then moulded using special sand-spraying ships. Research by environmental scientists has found that construction of the islands has had considerable environmental impact. During construction, the sand buried wildlife and increased **turbidity** (cloudiness of the water), which, in turn, reduced the amount of sunlight in the water, killing aquatic plants. Another major impact is the disruption that the new islands cause to the flow of currents in this part of the Persian Gulf. This also affects the movement of sand and other sediments.

SPOTLIGHT

Community protests over Gladstone Harbour redevelopment

Gladstone is located about 550 kilometres north of Brisbane, close to the southern end of the Great Barrier Reef. With its large harbour, Gladstone is the perfect location for port facilities for the export of billions of tonnes of coal and gas mined to the west in central Queensland.

Gladstone Harbour has been dredged to make it deeper for the massive bulk carriers that will use the port. Many

environmentalists are concerned that the dredging will affect the environment of the harbour and that there will be a big increase in shipping through the Great Barrier Reef to access the port. This increased shipping could lead to devastating oil spills. Community groups such as Save the Reef have implemented a major campaign to highlight the risks. The emergence of such groups over the last few decades highlights the changing attitudes towards the coastal environment and the need to protect it.

14.2.5 Greenpeace and other environmental groups have joined community groups to protect Queensland's coastal environment.



ACTIVITIES

Knowledge and understanding

- 1 Explain how past attitudes towards the coastal environment have led to its degradation.
- 2 Outline the problem of plastics in the world's coastal and marine environments.
- 3 Explain what a 'ghost net' is. Describe the environmental impacts of the nets.
- 4 Describe the construction methods used to create islands in Dubai and the impacts they have on the coastal environment.
- 5 Outline the concerns of environmentalists about the Gladstone Harbour development.

Applying and analysing

- 6 Working in small groups, take the perspective of environmental leaders. Research and prepare a presentation to be delivered to an upcoming United Nations conference on environmental pollution caused by plastics.

Investigating

- 7 Study Figures 14.2.3 and 14.2.4. Using the aerial photograph as a source, brainstorm a list of the ways this type of development affects the coastal environment.
- 8 Visit the Ghost Nets Australia website and summarise the work being done by the organisation to reduce the hazards of ghost nets.

Managing coastal environments

Coastal protection

Although much of the world's population lives near the coast, there has been little attention paid to the protection of coastal environments. This lack of concern has seen coastal environments destroyed to make way for urban development, infrastructure such as ports, and unsustainable tourism.

Whenever humans want to live near the sea, there will be a tension between the need to protect the coastal environment and the interests of humans. An increasing number of people see the value of the coastal environment and its need for protection, and there are many community-based organisations actively engaged in the protection of the coastal environment. Over recent years, much tougher environmental restrictions have been placed on new coastal developments in many countries, including Australia. These restrictions are often the result of community pressure and protests.

Coastcare, which was formed in the 1990s, is one such organisation. Across Australia there are about 2000 separate Coastcare groups working to protect stretches of the Australian coastline. Coastcare groups are made up of individuals who volunteer some of their time to undertake environmental works. For example, Coastcare groups are often involved in coastal sand dune revegetation. This is a labour-intensive task. The free labour of volunteers enables local councils to undertake this important work, which might otherwise be too expensive for them to do.

Strategies for managing the coast

Environmental management strategies can be divided into two types:

- 1 **protective**—used to protect coastal environments from damage in locations where human impact has been minimal, or where the environment has already been repaired
- 2 **restorative**—used to repair damage already done by human activities.

In order to be successful in the long term, restorative strategies need to be followed up by protective strategies.

Protective strategies

While a large proportion of the world's coastal environment has been altered by human activity, there remain large areas that are relatively intact. Protective strategies are crucial for ensuring that these areas remain safe from human impacts.

Restricting development along coastlines is one of the most effective strategies for protecting them. Determining the type of activities allowed in an area is known as **landuse zoning**. Through careful zoning, coastal environments can be protected from large-scale urban developments that can destroy the entire ecosystem.

Sometimes zoning can also be used to enable more appropriate developments. For example, zoning can be used to ensure that development does not take place on the most active parts of beaches, such as in the dunes. Keeping buildings away from this area reduces the need to construct sea walls and other sea defences. In many coastal communities, there is pressure on local authorities to build environmentally damaging sea defences to protect homes and developments against erosion from the sea.

SEA WALLS

Sea walls are commonly built along stretches of coastline where there is erosion that threatens property. They are usually built from concrete or large stones, to absorb the power of the waves. In nature, dune systems, which are large accumulations of sand, usually absorb the power of the waves. However, in many places the dunes have been flattened to make way for development, and the sea walls are needed.

When a wave smashes into a sand dune, much of the energy is able to pass out of the wave and into the sand. However, when a wave hits a sea wall, the energy is unable to pass through the solid surface, and is reflected back. This reflected energy is often powerful enough to erode sand from in front of the sea wall, a process known as scour. Scour in turn causes the beach in front of the wall to be eroded, as shown in Figure 14.3.1.

FENCING

A simple but highly effective protective strategy is fencing. Dunes play a crucial role in the functioning of many coastal areas. Dunes are created by winds causing sand to pile up into huge mounds, over which vegetation eventually begins to grow. The vegetation is critical to stabilising dunes and preventing them from blowing away.

As people cross sand dunes to access beaches, they walk on the vegetation and gradually kill it. This is known as trampling. Trampling exposes the sand and the dune begins to be eroded by the wind. By installing fencing around the dunes and some educative signage, trampling can be substantially reduced.



14.3.1 This sea wall at Teignmouth in the south of England has caused so much erosion that its foundations are now visible at the base of the wall.

Fencing works best when pathways through the dunes, known as access ways, are provided (see Figure 14.3.2). For example, providing access ways linking car parks to popular beaches helps to ensure that people stay off the dune vegetation. A board and chain walk—narrow strips of wood connected by

a flexible chain—can be used to cover the sand and reduce erosion in the access way. Dune vegetation is very susceptible to fire, so installing bins at either end of the access ways helps to reduce the risk of fire from cigarettes and glass.

Restorative strategies

When the coastal environment has been degraded by human activity, restorative strategies are needed to repair the damage. These strategies are often time-consuming and can be expensive, but they can be highly effective at undoing the damage. Restorative strategies are effective only if the restored environment is then protected from any future harm.

One of the most widely used restorative strategies in coastal ecosystems is revegetation. Coastal sand dunes are an important part of many coastal environments, and vegetation is essential for their stabilisation. Replanting of dune systems is often undertaken by volunteers, such as Coastcare.



14.3.2 Fencing dunes and funnelling people into access ways helps to reduce the impact of beach goers on the dunes.

HARD ENGINEERING

For centuries, humans have been trying to tame the coastal environment. By their nature, coasts are highly dynamic places, meaning that they are constantly changing. This does not suit human developments that require stability. To overcome the dynamism of the coast, humans have used complex engineering to try to control the power of the sea. This is often referred to as **hard engineering**.

One of the best examples of hard engineering is the Italian city of Venice, which has literally been built out of the sea. Venice lies at the north-eastern end of the Adriatic Sea within a very large lagoon. The coastal environment once consisted of 118 small islands surrounded by marshes and shallow lagoon waters. From the thirteenth century onwards, the lagoon was slowly transformed by creating 160 canals between islands, criss-crossed by about 400 bridges. Wooden pilings were driven into the soft mud of the marshes and the city was

built on top. Today, Venice is one of the most visited cities on earth. However, it requires constant maintenance and is slowly sinking into the mud.

The people of the Netherlands have been using hard engineering to protect themselves from the sea for more than a thousand years. About 20 per cent of the country's landmass, on which about 20 per cent of its population live, is below sea level. As levels rise as a result of climate change, hard engineering projects in the Netherlands are becoming bigger, more complex and much more expensive. One of the most impressive is the huge Maeslant storm surge barrier, shown in Figure 14.3.3, which protects the port of Rotterdam from flooding. The barrier has two massive doors, each 240 metres long, that can be closed within 90 minutes to stop the sea from flooding into the Nieuwe Waterweg (New Waterway) Canal, which connects Rotterdam to the North Sea. During big storms, the gates close to protect the port and surrounding land.



14.3.3 Maeslant storm surge barrier

SOFT ENGINEERING

Soft engineering is a very different technique for managing the coastal environment, and is becoming more popular. Instead of being used to change and control the coast, soft engineering is meant to work with nature and change how people interact with coasts. One example of soft engineering is the restoration of old dune systems so that the dunes can absorb the power of storm waves. This in turn means that expensive and damaging sea walls can be removed.

Soft engineering is usually cheaper in the long run because there is no ongoing maintenance. However, soft engineering projects are often undertaken at the expense of development projects. For example, land has to be put aside for dune

restoration that might otherwise be developed, and sometimes this can be seen as 'wasting' the resource. People with this view generally see the ecosystem in terms of its value for human use rather than its ecological value.

Figure 14.3.4 shows a soft engineering project off the coast of Louisiana, in the United States. The US National Oceanic and Atmospheric Administration (NOAA), with other partners, has constructed earthen terraces and barrier islands to create wetlands, which will trap sediment and create new land over time. It has been estimated that Louisiana lost approximately 0.5 million hectares of land during the twentieth century and continues to lose 65 square kilometres of coastal wetlands every year.



14.3.4 NOAA restoration project, Louisiana. This photograph, taken three months after the hurricanes Katrina and Rita, shows new land being built between earthen terraces.

ACTIVITIES

Knowledge and understanding

- 1 Outline the changing attitude towards coastal environments.
- 2 State the tension between the interests of humans and the protection of the coastal environment.
- 3 Describe the role of the community in protecting the coastal environment.
- 4 Explain the difference between protective and restorative strategies for environmental management.
- 5 Outline the concept of zoning and explain how it can be used to protect the coastal environment.
- 6 Describe the role of fencing dunes in protecting coasts.
- 7 Explain the value of access ways through fenced dunes.
- 8 Outline the importance of replanting dunes as a restorative strategy.

- 9 Explain the difference between hard and soft engineering.
- 10 Outline the advantages of soft engineering over hard.

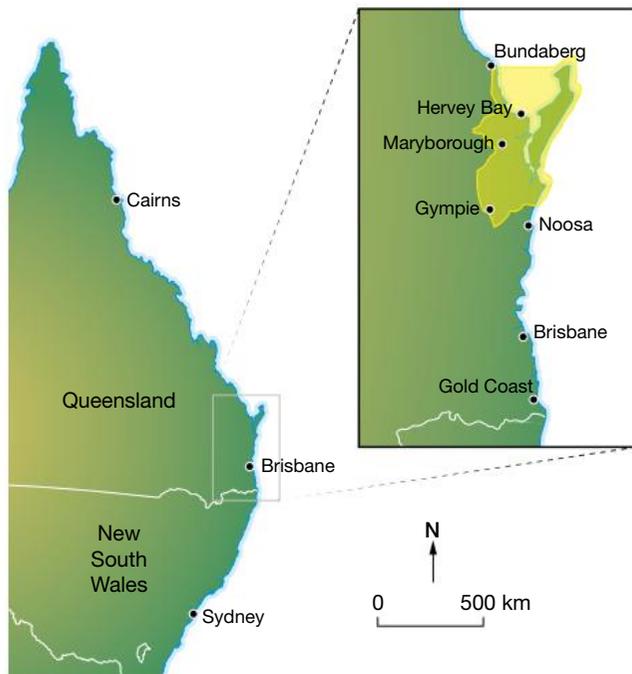
Applying and analysing

- 11 Examine the information in the text on sea walls and do the following activities.
 - a Explain why sea walls are built.
 - b Outline the environmental consequences of sea walls.
 - c Taking the perspective of an environmental manager for a local council on the coast, prepare a presentation to give to residents about why the council should look for alternatives to building a sea wall that residents want.

CASE STUDY: The Great Sandy Region

Location

The Great Sandy Region is located to the north of Queensland's Sunshine Coast, stretching northwards from Noosa to the Burnett River north of Bundaberg (see Figure 14.4.1).



14.4.1 Location of the Great Sandy Region

Biodiversity of the Great Sandy Region

The Great Sandy Region is one of the most biologically diverse places in Australia. Its waters contain more fish species than the Great Barrier Reef and it provides a habitat for half of Australia's bird species. The sand there is the key geological feature of the region, which contains some of the most ancient sand dune systems found anywhere on earth. Fraser Island, shown in Figure 14.4.2, is the largest sand island in the world.

The sand that makes up the landform features of the Great Sandy Region has been accumulating for millions of years. The vast sandstone mountain ranges of eastern Australia have been gradually worn down by running water and the sand has been swept out to sea by coastal river systems. Powerful currents, moving parallel to the shoreline, have carried the sand northwards in a process known as **longshore drift**. At Hervey Bay, in the heart of the Great Sandy Region, rocky headlands have trapped the sediment in a basin.



14.4.2 Fraser Island

Over thousands of years, sea levels have risen and fallen. At times of low sea level, the sand has been exposed, enabling the wind to shape the sand into the huge sand dunes that are found throughout the region today.

Human impacts

In the decade 2001–11, the population of the Fraser Coast Regional Council—the Local Government Area, or LGA, which is located over much of the Great Sandy Region—grew by 31 per cent, adding more than 23 000 permanent residents to the area. Much of this growth took place in Hervey Bay, where the population increased by 43 per cent.

Three major rivers flow into Hervey Bay—the Mary, Burnett and Burrum. The Paradise Dam on the Burnett River was opened in 2005 and there have been plans to build a new dam on the Mary River at Traveston Crossing.

As the region's population grows, the amount of water used by humans increases. The amount of fresh water being taken out of these important river systems is beginning to change the chemical make-up of the waters of the Great Sandy Region. During dry years, the flow of water down the rivers and into Hervey Bay declines considerably. Marine scientists have found evidence of hyper-salinity in parts of Hervey Bay.



14.4.3 Mangrove forest in the Great Sandy Region

Many marine species within the Great Sandy Region are very sensitive to changes to salinity. Mangrove forests (see Figure 14.4.3), found throughout the region, are also very sensitive to increases in salinity. These forests are critical to the health of the whole ecosystem of the Great Sandy Region, as many of the marine species breed and hatch their young in mangrove forests.

Tourism

Each year, close to 750 000 people, including 120 000 international tourists, visit the Fraser Coast region. Fraser Island and Hervey Bay (see Figure 14.4.4) are the most popular destinations. About 3 million people holiday on the Sunshine Coast, which is located on the southernmost part of the Great Sandy Region.

The tourism industry is vital for the economies of the towns in the region. Significant parts of the coast have been extensively developed to provide resorts and hotels. This has resulted in land clearing and the loss of important habitats, including mangrove forests. The development of a large marina and hotel complex on the shore of Hervey Bay opposite Fraser Island has altered the structure of the coastline. Tourism developments affect water quality because of increased urban run-off, sewage, rubbish and other pollutants.



14.4.4 Large-scale tourist developments have taken place in Hervey Bay.

SPOTLIGHT

Managing Fraser Island's dingo population

One of the most iconic species of Fraser Island is the dingo. The dingo is the apex species on the island, meaning that it is at the top of the food chain and it helps to keep the island ecosystem in balance. As the number of people visiting the island has grown, the number of interactions between dingoes and people has also grown. In some cases, this has resulted in death and injury to people. In 2011, a 3-year-old girl was mauled by dingoes.

After each attack on a person, there have been calls to reduce the number of dingoes by culling them. After the 2011 attack, rangers shot and killed the two dingoes thought to be responsible. Part of the problem is that some campers and visitors have been feeding the dingoes and they are beginning to lose their fear of humans.

A dingo management plan was released in July 2013 by the Queensland government. The plan aims to reduce the risk of dingo attack by reducing human interactions with the dingoes. This is to be achieved by:

- temporarily closing camping grounds where the behaviour of dingoes has been modified due to human interactions
- tagging more of the animals to track their movements
- installing more signage and improving public education programs about the dingoes and the importance of not feeding them.



14.4.5 The management of Fraser Island's dingo population is challenging.

False water rat

The false water rat, or water mouse as it is commonly known, lives in the intertidal zone along the eastern coast of Queensland. This tiny creature, shown in Figure 14.4.6, weighs less than 70 grams. It lives in the mangrove forests and salt marshes that fringe the coast. It is currently listed as vulnerable and suffers from unsustainable human activities. Feral pigs and red foxes, which are introduced species, hunt the water rat.

Fens

Fens are saturated environments in which ridges of peat, which is undecomposed vegetation, lie between pools of water, creating a patterned formation (see Figure 14.4.7). They are common in wet and cold environments. The fens of Fraser Island, which began to form about 6000 years ago, are the only fens found in subtropical areas. The soils within fens are devoid of oxygen, which is why vegetation does not decompose.

The fens on Fraser Island are important to the island's overall environment because they are one of the few areas on the island that is open; the rest is covered by thick rainforest. The fens are an important habitat for several species of birds, such as the threatened ground parrot; mammals, such as the false water rat; and amphibians, including several species of endangered frog.



14.4.6 False water rat



14.4.7 The unique patterned fens environment of Fraser Island

Managing threatened ecosystems

The Great Sandy Region contains a wide variety of ecosystems. Each of these requires specific management strategies.

National Park

The Great Sandy Region National Park was established in 1971. Covering a total area of almost 75 000 hectares, the park covers a large part of the Great Sandy Region. In 1992, Fraser Island, which is within the Great Sandy Region National Park, was also made a UNESCO World Heritage site. This inclusion was made in recognition of the island's unique natural features, including complex dune systems, dune lakes and rainforests. The inclusion of Fraser Island on the World Heritage list means that there is an extra level of protection of this important environment.

Ramsar Convention

The Ramsar Convention is an important international law that helps to protect habitats used by migratory birds. As several species of migratory birds, some of which fly from as far away as China and Siberia, spend time in the fens on Fraser Island, the fens are considered to be an important site for global bird migration.

Another important ecosystem in the Great Sandy Region that is part of the Ramsar site is the region's intertidal wetlands. This unique ecosystem includes extensive mangrove forests, which line much of the region's coastline and estuaries. Salt water moves up the tidal rivers at high tide and fresh water flows down from inland at low tide. In total, the Ramsar site covers more than 93 000 hectares, including open water, channels and creeks.

Impacts and strategies

The main environmental impacts that require management within the wetlands are:

- feral introduced animals, including pigs, which dig up the ground; and foxes, which prey on wading birds and water rats
- weeds, which take over the native vegetation—very often these weeds come from domestic sources; for example, people living in urban areas close to the wetlands have garden plants, including grass, such as kikuyu, which then invade the wetlands
- human interactions, especially the swash from boats, which causes erosion; off-road vehicles, which cause damage; overfishing; and abandoned fishing equipment such as lines and nets, which entangle turtles and birds
- pollution, including rubbish and water pollution from stormwater drains, which eventually release water and the pollution into the wetlands.

Strategies to manage these impacts include the following.

- Feral animals are tracked, in order to collect data about them. Traps and culling are used to reduce their numbers.
- Weeds are carefully monitored in order to contain weed outbreaks before they can get out of control.
- Human interactions are managed through education of visitors about their impacts. Signage throughout the region helps to remind people to act responsibly, for example signs at popular fishing spots about not leaving equipment. Controls are also important, for example speed zones for boats to minimise swash from motors, and restrictions on 4WD access to confine vehicles to areas where their impacts are reduced. These controls are reinforced by education programs as well as rangers.
- The flow of rubbish into the waters of the region is reduced by simple strategies such as installing bins at popular tourist spots and using rubbish traps across stormwater pipes.

As the area is so popular with visitors, careful management of visitor numbers is crucial to protecting the region.

Introduced species

Bitou

Bitou, shown in Figure 14.4.8, is a highly aggressive weed that grows rapidly across sand dunes, eliminating native flora. It produces huge quantities of seed, giving it advantages over other species. The bush is native to South Africa and was introduced to Australia to help stabilise dunes after sand mining.

Bitou is a major problem in New South Wales, where it is present in 60 per cent of dune systems and 80 per cent of headlands. Within the Great Sandy Region, including Fraser Island, it is a small but growing problem. Without careful management, the species could easily get out of control. Monitoring across the region is important to keep track of

outbreaks of the weed. Hand pulling—literally pulling out the plants by hand—is very effective but quite expensive, as it uses so much labour. Coastcare volunteers do much of this work across the region.



14.4.8 Bitou bush

Gambusia

Gambusia, shown in Figure 14.4.9, is a small fish introduced from California to help control mosquitoes. Gambusia competes with native species and since its introduction it has had a huge impact on native species numbers. Dealing with the gambusia is proving challenging but the use of biological controls has had some success in other parts of Australia.



14.4.9 The tiny introduced gambusia, sometimes called the mosquito fish, has devastated native small fish populations.

SPOTLIGHT

Fire management

Managing for fire is also an important strategy for protecting the Great Sandy Region's ecosystems. Some of the region's environments are very vulnerable to fire, for example the patterned fens and dune systems of Fraser Island. The peat ridges of the fens are composed of undecomposed vegetation, which is very flammable—so flammable that in many parts of the world it is used as the main fuel source. In the dune system, vegetation is critical for holding the dune together. Without vegetation cover, the exposed sand is easily eroded by wind. Fires in the dunes can have a devastating impact on the whole ecosystem.

The main source of fire in both the dunes and the fens is human activity. For example, campfires lit in the dunes can easily get out of control and burn the woody plants that make up the dune vegetation. Discarded rubbish, especially glass and cigarettes, can be a source of ignition. Throughout the region, signage alerts visitors to the risk



14.4.10 Signs such as this are used across Fraser Island to help manage the risk of fire.

of fire. Rubbish bins have been installed and camping is confined to designated areas where the fires can be built in pre-dug pits to minimise risk. Rangers patrol regularly to enforce these rules.

ACTIVITIES

Knowledge and understanding

- 1 Describe the location of the Great Sandy Region.
- 2 Describe the processes that have led to the creation of the Great Sandy Region.
- 3 Explain how vast dune systems such as those on Fraser Island have been formed.
- 4 Outline the population growth in the Great Sandy Region.
- 5 Describe the impact of tourism on the environment of the region.
- 6 Describe the environment of the patterned fens.
- 7 Why are the patterned fens such an important habitat on Fraser Island?
- 8 Explain the purpose of the Ramsar Convention.

Applying and analysing

- 9 Copy and complete the following table to summarise the environmental issues facing the Great Sandy Region and the environmental management strategies used to deal with them.

Environmental issue	Management strategy

- 10 Examine Figure 14.4.4. Describe the impacts on the environment that are evident from this development.
- 11 In a small group, design a poster or a digital presentation for visitors to Fraser Island about management of dingoes. You may wish to visit the Fraser Island National Park website.
- 12 As a class, discuss the dangers of fire to the environments of the Great Sandy Region. Brainstorm strategies for managing this risk and record your ideas in a mind map.

Investigating

- 13 Write a short report explaining the consequences of dam building along the rivers that feed fresh water into the Great Sandy Region.
- 14 Prepare an extended response on the following topic. *The wetlands of the Great Sandy Region are an important ecosystem that needs careful management.*

CASE STUDY: The Bay of Fundy, Canada

Location

The Bay of Fundy is a large bay off the Atlantic Ocean on Canada's east coast (see Figure 14.5.1). The bay covers a total area of more than 9000 square kilometres, stretches more than 150 kilometres and at its entrance is 52 kilometres wide. It is renowned for its enormous tidal range, which is the difference in height between low and high tides. Every 12 hours and 25 minutes the tide rises as high as 21 metres (16 metres is the norm across the whole bay), the highest tide in the world.

The huge tides of the Bay of Fundy, shown in Figure 14.5.2, are the result of the unique shape of the bay. High cliffs surround it, reaching upwards of 60 metres in some parts. The shape of these cliffs creates narrow inlets within the bay, which act as funnels for the incoming and outgoing tides. When the tides

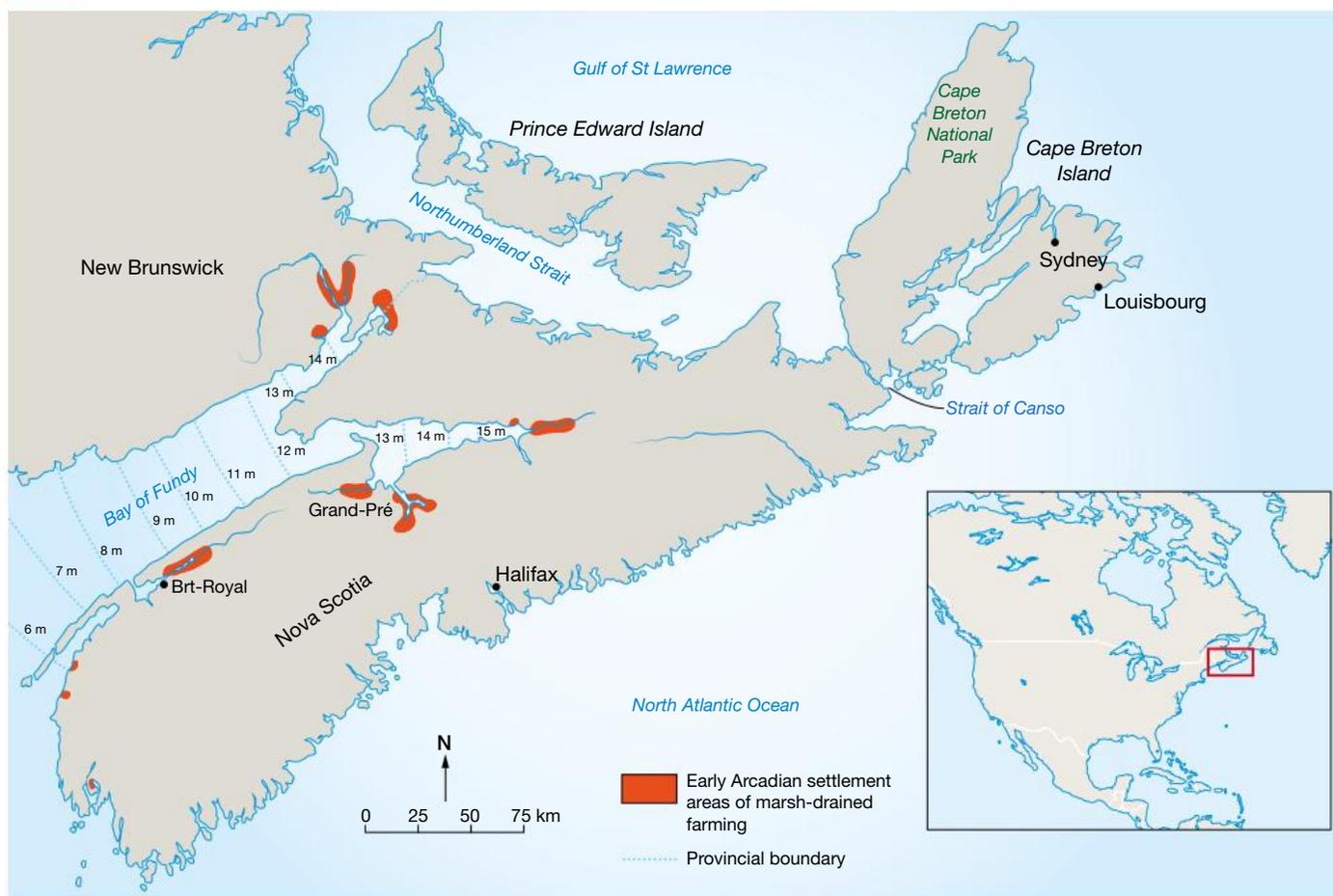
enter the bay at its mouth they are normal, but as they push up the ever-narrowing bay they are 'squeezed' by the surrounding cliffs and the increasingly shallow base, causing the water to rise. The outgoing low tide collides with the incoming high tide, causing a wave of water to be pushed into the bay, a process called **resonance**.

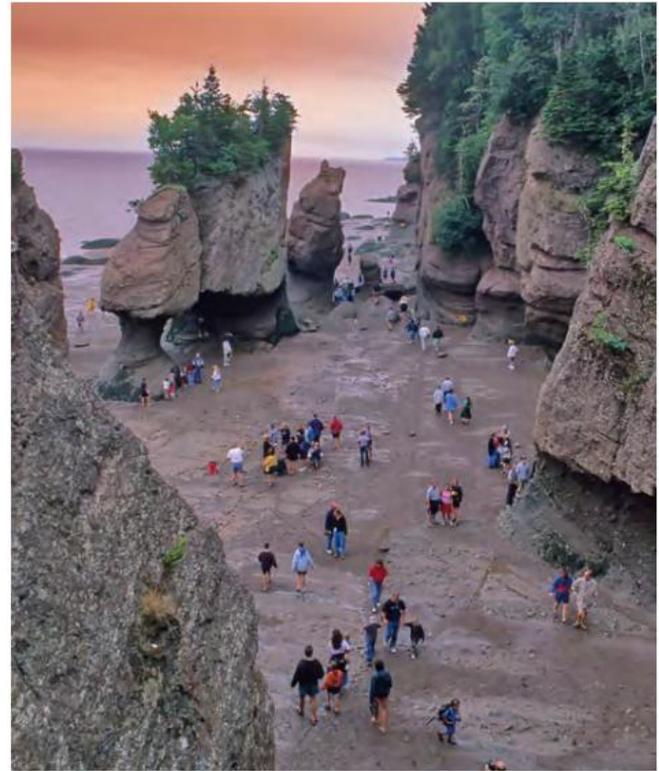
Human impacts

Draining the marshes

The salt marshes lining Nova Scotia's Bay of Fundy have been drained for agriculture since the early 1600s. The Arcadian people—French settlers who first claimed Nova Scotia as their home—employed their dyke-building skills to drain

14.5.1 Location of the Bay of Fundy, showing average tidal ranges





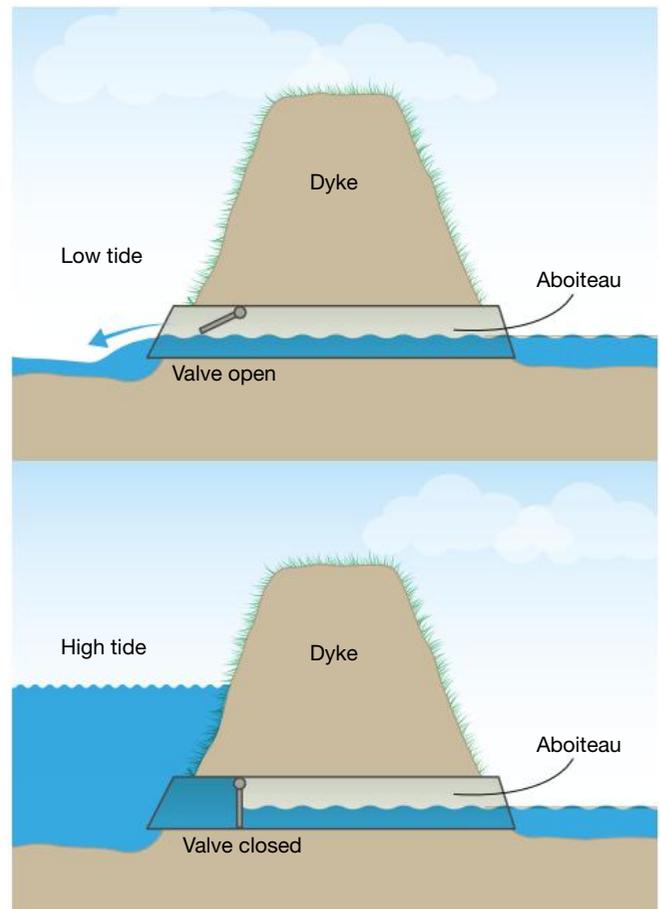
14.5.2 The Hopewell Rocks in the Bay of Fundy at high and low tides

salt marshes, reclaiming thousands of hectares of productive farmland.

The Arcadians built the dykes along the outer marsh areas. Their construction required an enormous amount of work due to the great tidal range experienced in the bay. Sometimes these structures were constructed by driving five or six rows of logs into the ground, laying other logs, one on top of the other, between these rows, filling all the spaces between the logs with well-packed clay and then covering everything over with sods cut from the marsh itself. Sometimes dykes were built by simply laying marsh sods over mounds of earth.

The Arcadians also devised a system of drainage ditches with an ingenious one-way water gate called an aboiteau. The aboiteau (see Figure 14.5.3) was a hinged valve in the dyke that allowed fresh water to run off the marshes at low tide but prevented salt water from flowing onto the farmland as the tide rose. After letting rain (and snow) wash away the salt from the marshes over a period of 2–4 years, the Arcadians were left with fertile soil that yielded abundant crops.

Building and maintaining the complex system of dykes and valves required a high level of cooperation. Everyone had to be vigilant and ready at all times to repair breaches that could be caused by storm waves or simply by soil erosion.



14.5.3 The ingenious one-way water gate, called an aboiteau, used to drain Nova Scotia's marshlands

Impacts of tourism

As far back as the nineteenth century, the Bay of Fundy was a popular tourist destination. With the growth in **ecotourism** and nature-based tourism in the last 20 years, tourism in the region has boomed, and now more than 1.2 million people visit the region annually.

Tourism needs to be well managed to bring substantial economic benefits to the local community without causing significant harm to the environment. Tourism has a number of impacts on the bay's environment.

- Many migratory bird species stop in the Bay of Fundy on their annual migrations. Sandpipers feeding on the exposed mud flats at low tide are disturbed by large numbers of tourists and the time they have to feed is reduced.
- There are more than twenty whale-watching businesses in the bay, and careful management is needed to ensure that the whales are not stressed by too much human interaction.
- About 200 000 people now visit the Bay of Fundy each year on cruise ships. The ships coming into the bay are getting larger and there are concerns that the wake of the large ships will increase erosion of both the bay floor and the surrounding cliffs.

Tidal power

The huge tides in the Bay of Fundy make it an ideal location for the development of a tidal power industry, but there are some serious environment concerns about tidal power. The large turbines (see Figure 14.5.4) and associated equipment can alter the flow of currents and sediments in the bay. The blades of the turbines can hit animals and the noise they create interferes with animal movements in the bay. One of the least understood but most significant concerns relates to the electromagnetic fields created by the turbines. Many species, such as rays, sharks and many shorebirds, use the earth's natural electromagnetic fields to navigate. The huge turbines create their own fields and this can confuse the animals and lead to navigational errors as well as cause distress.

Climate change

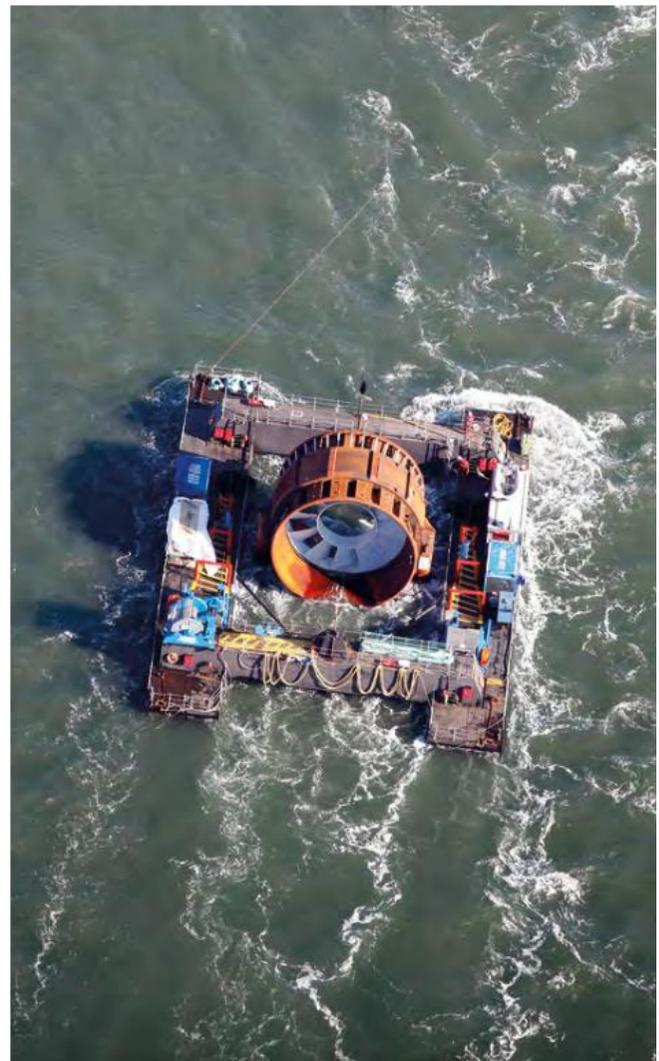
The high tidal range in the Bay of Fundy means that the area is subject to very high levels of erosion. Studies conducted by scientists working for the Province of Nova Scotia have found that tides may rise by as much as 10 per cent in the Bay of Fundy as a result of climate change. Of particular concern is the impact of this on salt marshes (see Figure 14.5.5) and mud flats.

The flora and fauna located in the mud flats and salt marshes have adapted to the inundation from the incoming tides twice a day. As sea levels rise, less and less of the salt marshes and mud flats are exposed at low tide, destroying the ecosystem that the plants, animals and micro-organisms have adapted to. Climate change will also cause an increase in storm activity, which will lead to more erosion.

Local authorities are planning to put in place management strategies for reducing the impact of climate change on the delicate ecosystem of the Bay of Fundy. One of the most important strategies is to closely monitor the effects of rising sea levels on the shoreline environment. This includes gathering data on wave energy and its impacts on erosion, and undertaking detailed studies of threatened species. With a bank of data, better management strategies can then be devised to help protect the bay from climate change.

Some of the strategies being planned for the bay include:

- construction of sea walls and other sea defences
- soft engineering
- revegetating salt marshes further inland
- beach nourishment, which involves dumping additional sand onto beaches after erosion by storms and high tides
- construction of vegetation strips using plants such as seagrasses to reduce the speed of waves as they approach the shoreline.



14.5.4 Part of a huge wave energy turbine being transported to a site in the Bay of Fundy



14.5.5 Salt marshes, like these at Fox River, in the Bay of Fundy, are at risk from climate change.

Introduced species

Foreign species are most commonly introduced into the bay by ships. As ships move around the world, species attach themselves to the hull and ‘hitch’ a ride to new areas. Ballast water can also contain unwanted species. Ships take on ballast to weigh them down when they have light loads and release the water once they take on heavier loads. When pumping in the ballast, foreign species can be taken on board and then discharged elsewhere.

COMMON PERIWINKLE

The common periwinkle is believed to have been introduced into the bay in the early 1800s, possibly intentionally to provide a source of food. This snail-like mollusc lives in large numbers on the rocks and mud flats of the intertidal zone. The periwinkle’s success has come at the expense of native molluscs, several of which have disappeared from the bay.

EUROPEAN GREEN CRAB

The European green crab competes with native oysters, molluscs, crabs, scallops and a range of other species in the bay. It has a wide diet and its numbers have increased significantly.

AQUATIC PLANTS

Codium, shown in Figure 14.5.6, is not yet well established in the Bay of Fundy but scientists are very concerned about it. Sometimes called green sea fingers, it grows very densely and chokes out native species. It also reduces sunlight penetration, so that the sea floor often becomes barren. This disrupts the food chain, affecting many species.



14.5.6 Codium is an introduced seaweed that has the potential to cause great damage in the Bay of Fundy.

Local and international protection

The importance of the Bay of Fundy is recognised at a global level through the Ramsar Convention. Four specific areas within the bay are protected under the Ramsar Convention, which requires the Canadian government to ensure their protection and management. There are also many other areas of the Bay of Fundy that are protected by federal, provincial and local governments. These range from large areas such as national parks through to small conservation areas that are managed by local authorities.

Managing introduced species

Management of introduced species is complex, but the most effective strategy is to intercept them before they arrive. Strict regulation of commercial shipping is important for the Bay of Fundy; for example, the hulls of ships must be painted with anti-fouling paint. This special paint is applied to the bottom of a ship to stop molluscs and aquatic plants from attaching themselves. Without anti-fouling paint, species can 'catch a free ride' on the hulls of ships and travel into new waters, where they compete with local species.

Controls over the discharge of ballast water have also been introduced. Ballast water is used by ships to weigh them down when they have little cargo on board. The water is taken in by

the ship at one port and then discharged as it takes on cargo at a different port. As the ship takes in the water, small aquatic animals and plants can also be sucked into the ballast tanks and these can then be released when the ballast is discharged elsewhere. Ships entering the Bay of Fundy must now discharge their ballast well out to sea, and nets must be installed over ballast intakes.

Restoration management strategies

The environmental importance of the marshes is now recognised, and a number of projects to restore this environment are now underway. In the Upper Bay of Fundy, a number of dykes have been removed, along with some dams that blocked waterways. As a result of these actions, fresh water is beginning to move back across the low-lying areas and the tidal flow is being restored.

Studies have shown that salt marshes and other wetlands can quite quickly reinhabit the restored areas. At a 13-hectare test site on St Croix River, when a dyke was removed, former farmland began to return to a wetland habitat within a year. Plants began colonising the area once the tidal flows returned, and birds and other species began to return soon after (see Figure 14.5.7).

14.5.7 The dyke lands are an important part of the Bay of Fundy. Restoration work is beginning to return parts of them to their natural state.



Managing aquaculture

There is a growing aquaculture industry in the Bay of Fundy. Most of the farms produce salmon in large cages in parts of the bay (see Figure 14.5.8). One of the consequences of the salmon farming is that large amounts of nitrogen and phosphorus are produced by uneaten fish food and the digestive systems of the fish. These chemicals can interrupt the normal food chain and cause the growth of algae, which can produce an imbalance in the environment. Scientists from the University of New Brunswick and elsewhere have been working on solutions for reducing the environmental impacts of aquaculture on the bay.



14.5.8 Aquaculture in the Bay of Fundy requires careful management.

One strategy is to use the by-products of the fish and the uneaten food as a source of food for other commercial species. For example, kelp and mussels are grown on ropes around the cages. They use the nutrients added by the fish farms to grow, consuming them before they enter the broader environment. Ultimately, it is expected that the kelp and mussels can then be harvested and sold for food and other commercial purposes.

SPOTLIGHT

Learning from the First Nations

Canada has a significant indigenous population. In the north are the traditional lands of the Inuit people. In the rest of Canada, the indigenous people are known as the First Nations. In the Bay of Fundy region, the Mi'kmaq people are the traditional owners. They have a strong cultural and religious connection to the land and waters of the region, and have developed an intimate knowledge of the environment over the centuries.

The knowledge of the Mi'kmaq people is now being recognised and utilised to assist in the management of the Bay of Fundy. Before major projects take place in the region, the Mi'kmaq people are consulted and a special study known as a Mi'kmaq Ecological Study (MEKS) is undertaken. These special studies incorporate the unique knowledge and perspective of the indigenous traditional owners into broader environmental assessments.

ACTIVITIES

Knowledge and understanding

- 1 Explain the reason for the massive tides in the Bay of Fundy.
- 2 Describe the impact of tourism on sandpipers.
- 3 Describe the impact of climate change on the Bay of Fundy.
- 4 Outline the strategies being developed to manage climate change in the Bay of Fundy.
- 5 Describe the role of shipping in introducing foreign species into the Bay of Fundy.
- 6 Explain the impact of codium on the environment of the Bay of Fundy.
- 7 Explain how the peoples of the First Nations of the Bay of Fundy are helping to manage its environment.
- 8 Outline the impacts of aquaculture and the strategies used for managing these impacts.

Applying and analysing

- 9 Take on the role of environmental scientist for the province of Nova Scotia. You have been appointed to conduct community briefings on the impacts of climate change and how communities can better

manage these impacts. Using the information in the text and research from the internet, prepare a digital presentation and present it to the class.

- 10 In a small group, design an educational campaign about the risk of codium to the Bay of Fundy. Your campaign should be targeted at local people and outline the problem as well as how locals can help deal with the threat. You may wish to design a digital campaign, posters or radio or television advertisements.
- 11 Prepare a short report on how the dyke lands of the Bay of Fundy are being rehabilitated.
- 12 As a class, discuss whether the benefits of tidal power outweigh the impact on the environment. Justify your response.

Investigating

- 13 Using the internet, conduct research into tourism in the Bay of Fundy. Make a list of the type of activities that can be done in the bay. Share your list with a partner and together brainstorm the potential impacts of the activities on the environment. Record this in a mind map or list.



Marine environments

Marine environments cover a vast area of the earth's surface and extend from the shallows surrounding the continental landmasses to the depths of the ocean—the deepest point of which is just over 10.9 kilometres below the surface of the western Pacific in the Marianas Trench.

The diverse ecosystems that make up the marine environment are facing unprecedented pressure from an increasing number of potentially competing uses. These include oil and gas extraction, fisheries, aquaculture, shipping, port expansion, coastal development, waste disposal, recreation, tourism and conservation. Extensive science-based knowledge of our marine environments is critical if we are to protect these critically important ecosystems.

In this chapter, we focus on environmental change and management, using marine environments as an example. Of particular interest are the causes and consequences of the changes taking place and an evaluation of the strategies used to manage these changes.

INQUIRY QUESTIONS

- What are the principal causes of environmental change in marine environments?
- What are the effects of the environmental changes taking place in marine environments?
- What environmental management strategies are being used in marine environments? Are they effective?

GLOSSARY

acidification an increase in the acidity of ocean water as a result of the uptake of carbon dioxide from the atmosphere. An estimated 30–40 per cent of carbon dioxide released by humans into the atmosphere dissolves into oceans, rivers and lakes

atmosphere the blanket of air surrounding earth

by-catch fish caught unintentionally while catching targeted fish species

carbon cycle a series of naturally occurring processes in which carbon is exchanged between organisms and the environment

heat budget the balance between the incoming and outgoing heat

hypoxic water a water body in which oxygen levels are extremely low

marine debris human-created waste that has deliberately or accidentally been released in a lake, sea, ocean or waterway

thermal expansion the tendency of water (and other matter) to change in volume in response to a change in temperature

watershed high ground that marks the boundary between two drainage basins; in the United States of America, refers to the drainage basin itself

Marine environments



15.1.1 Salt fields in La Palma in the Canary Islands off the north-west coast of Africa. Sea water is collected in ponds and evaporated, leaving pure salt.

The oceans

Earth is often referred to as the 'blue planet'. More than 70 per cent of the earth's surface is covered by oceans, and they account for 96.5 per cent of all the water found on the planet. The marine ecosystem is, therefore, the largest of all the environments, but it is also one of the least explored and known.

Salt water

Salt water is the defining feature of all marine environments. It is composed of about 96.5 per cent liquid water, in which chloride and sodium are dissolved. The salt in sea water arrives in the sea via rivers that carry huge quantities of dissolved chemicals because of the weathering of rocks inland. Chemical reactions cause salt that has been held in a solid state in rocks on land to become dissolved and then transported by rivers to the sea, where it remains dissolved in the water and mud of the oceans.

Chemical analysis shows that the salinity of the world's oceans has been fairly constant for the last 1.5 billion years. This indicates that equal amounts of salt are removed from, and deposited in, the oceans.

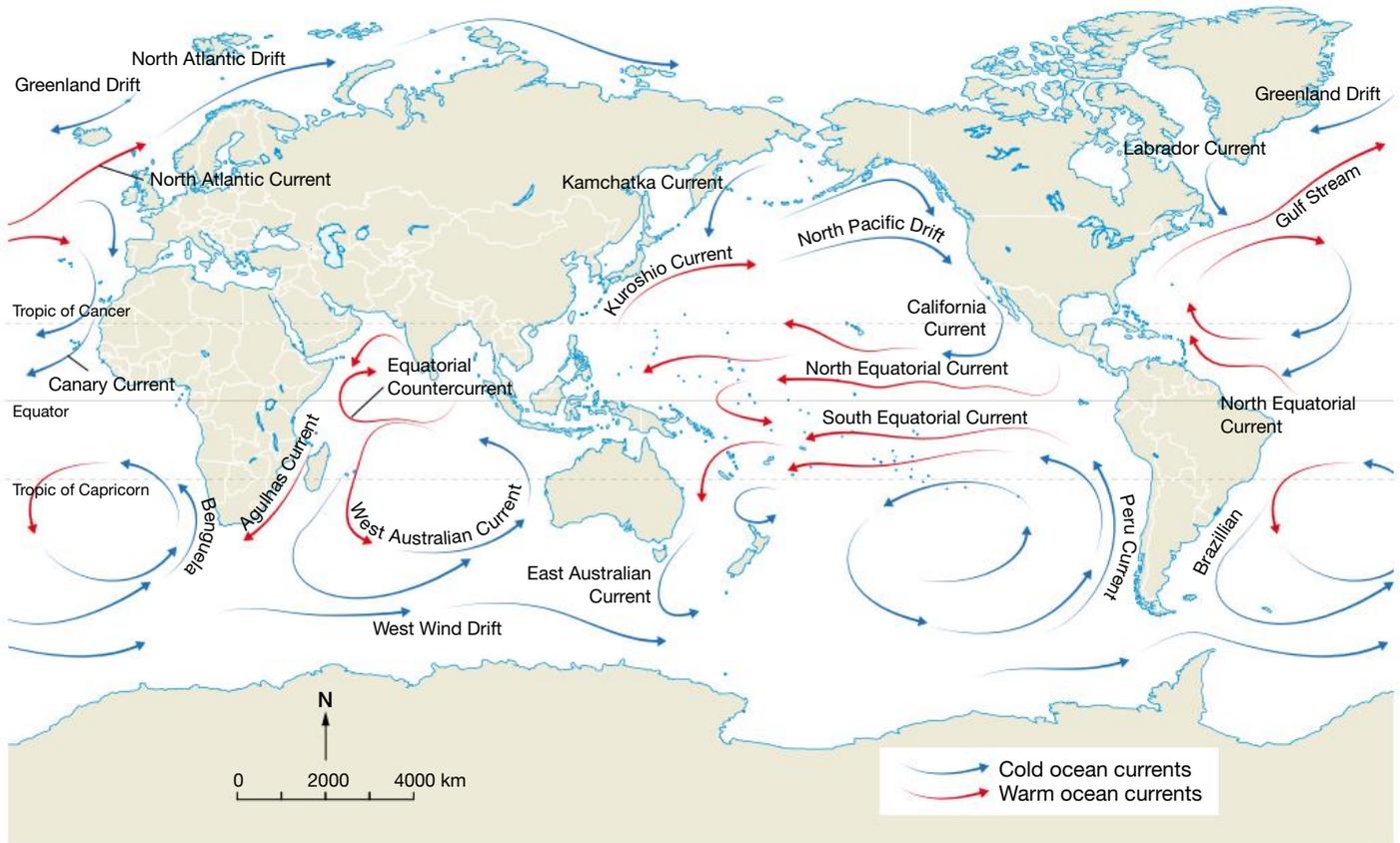
A considerable amount of salt is lost due to evaporation. The wind also blows a large amount of salt onshore each year. Some salt is also lost as it reacts with hot basalt lava spewed onto the ocean floor by underwater volcanoes. Salt is consumed by sea creatures, especially tiny diatoms that have a silica-based shell. Humans have collected salt throughout history using the method shown in Figure 15.1.1.

Currents

Currents are critical to all life on earth. Currents are very complex and many factors affect the direction in which they flow. Generally, currents move huge volumes of water around the globe, helping to regulate temperatures (see Figure 15.1.2). Warm water and air that form around the Equator, where the sun is at its strongest, move towards the poles, making the areas north and south of the Equator warmer. Conversely, the cooler air and water of the poles move towards the Equator, reducing temperatures. Currents are therefore crucial in creating what scientists call the global **heat budget**.

Ocean currents are divided into two types.

- **Surface currents** These are usually driven by the wind. They affect only about 10 per cent of the oceans' volume. However, these currents are better understood because



15.1.2 Main surface currents in the world's oceans

they affect the top layers of the oceans. For example, it is these surface currents that sailors have used for centuries to help propel their ships around the globe.

- **Sub-surface currents** These are density-driven currents. They form because dense water sinks due to gravity, displacing less dense water; in other words, dense water pushes less dense water out of the way. The density of the water is determined by its temperature and salinity (the amount of salt it contains).

As water temperature rises, the water's density decreases. Consequently, waters close to the Equator tend to have lower densities. As salinity levels rise, water density decreases. Salinity levels are affected by how much fresh water is deposited into the ocean area. For example, rainfall, run-off from rivers, and melting ice all add fresh water and this in turn reduces the salinity.

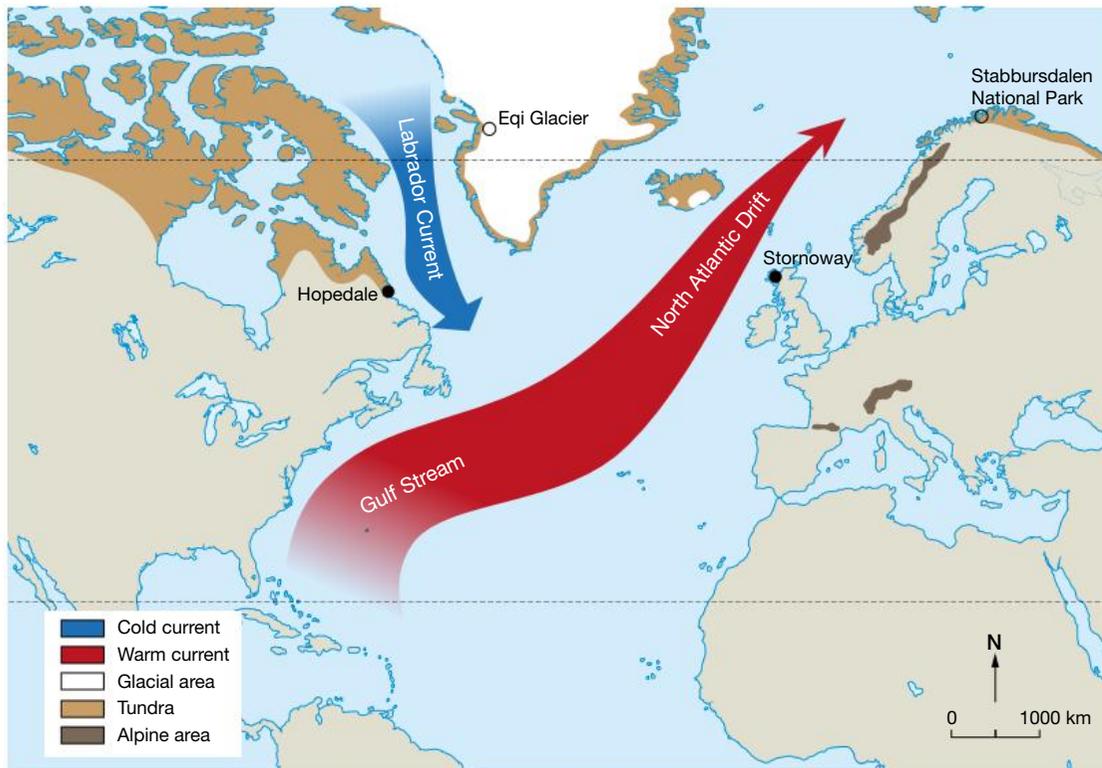
The Humboldt Current

Sometimes called the Peru Current, the Humboldt Current is a very slow-moving current that brings cold water northwards from Antarctica up the western coastline of South America. Its cold, slow-moving waters allow for very little evaporation, creating the arid and extremely dry landscape of the west coast of the continent (see Figure 15.1.3).

While the Humboldt produces an arid and desolate environment on land, in the ocean it has the opposite effect. As it runs into the continental shelf along the coast, it brings to the surface water full of nutrients from the ocean floor. These nutrients form the base of a complex food chain that supports the great diversity of sea life found in the eastern Pacific.

15.1.3 The Humboldt Current has a considerable cooling influence on the climate of Paracas in Peru, one of the driest places on earth.





15.1.4 The Gulf Stream is one of the most important sea surface currents in the world.

The Gulf Stream

The Gulf Stream is one of the best known ocean currents. It is a surface current that forms in the Gulf of Mexico. Warm water flows into the Gulf from the Caribbean Sea, where the hot tropical sun creates an average sea surface temperature of 27°C. Southerly winds blowing northwards from the Equator towards the North Pole then push the warm current up the east coast of the United States of America and Canada. Ultimately, the Gulf Stream continues to flow into the North Atlantic Ocean as the North Atlantic Current.

The warm waters of the Gulf Stream moderate temperatures, keeping them much warmer than they otherwise would be. The Gulf Stream therefore plays a critical role in enabling human life in North America and northern Europe.

Figure 15.1.4 shows that North America's tundra and glacial areas are located next to the cold Labrador Current that flows south from the polar region. These environments support low levels of life and are constantly frozen. In areas nearer the warm waters of the Gulf Stream, these harsh environments give way to more hospitable places, such as the forests of Scandinavia. Therefore, even though Norway and Greenland are the same distance from the Equator, they have very different environments because of the influence of the Gulf Stream (see Figure 15.1.5).



15.1.5 Grasses and shrubs grow in Stabbursdalen National Park, in Finnmark, Norway (top) under the warming influence of the North Atlantic Drift, a warm ocean current. At a similar latitude is the Eqi Glacier of Greenland, where the currents are cold.

Functions of marine environments

Table 15.1.6 outlines the source, sink, service and spiritual functions of marine environments.

15.1.6 Functions of marine environments

Function	Marine environments
Source function	<ul style="list-style-type: none"> Ninety per cent of the world is ocean. With so much of the marine world unexplored, it is difficult to determine the number of marine species, but it is estimated that between 50 and 80 per cent of all life on earth is found in the marine environment. About 80 million tonnes of seafood are taken out of the world's oceans each year. This accounts for about 15 per cent of all the protein eaten by humans. Marine environments are sources of many important minerals and fuels. About 26 per cent of the world's current oil supplies comes from deep ocean wells. It is expected that much of the world's future oil and gas will come from the deep ocean.
Sink function	<ul style="list-style-type: none"> The marine environment is the world's biggest carbon sink. It absorbs about 90 thousand million tonnes of carbon annually and releases about 88 thousand million tonnes, meaning it is an important store of carbon dioxide, which is critical for dealing with global warming. For decades, humans have used the marine environment to dump wastes. This has included deep-sea disposal of nuclear waste and other highly toxic chemicals. Today there are international laws regulating this but it is still a problem.
Service function	<ul style="list-style-type: none"> Fifty per cent of all the oxygen on earth comes from the ocean's phytoplankton. The marine environment is critical for supporting life on earth. Ocean currents, along with air currents, control the global heat budget. They transport warmth away from the Equator towards the poles, warming these regions, while transporting cooler water towards the Equator, moderating temperatures there.
Spiritual function	<ul style="list-style-type: none"> For many cultures, the sea is a crucial element of their spiritual life. For example, for traditional cultures throughout the Pacific, the ocean and its animals are worshipped as gods bringing life to the island peoples.

ACTIVITIES

Knowledge and understanding

- Describe the composition of salt water.
- Outline the role of currents in the global heat budget.
- Explain why waters close to the Equator have lower densities.

Applying and analysing

- Construct a flow diagram showing how surface and sub-surface currents form.
- Copy and complete the following table comparing the Gulf Stream and the Humboldt Current.

	Gulf Stream	Humboldt Current
Location		
Impact on climate		
Impact on environment		
Other		

Geographical skills

- Study Figure 15.1.2.
 - Compare the currents that circulate around Australia and Antarctica.
 - Using your knowledge of climate in Australia and Antarctica, explain how these currents influence the climate of each region.

The importance of marine environments

The oceans

The marine environment is the largest of all of earth's ecosystems. It includes the oceans, salt marshes, intertidal wetlands, mangrove forests, estuaries, lagoons, coral reefs, ocean depths and sea floor.

The earth's oceans cover 71 per cent of the planet's surface area. Deep oceans, where ocean depths are greater than 200 metres, make up 87 per cent of this. The deep ocean is an environment we know very little about, yet it is critical to all life on earth. Figure 15.2.1 shows the angler fish, a species that lives in the deep oceans.

The marine environment accounts for about two-thirds of the world's ecosystem services. These are the services that environments provide in order to keep the world functioning: providing the oxygen we breathe and moderating temperature extremes. Phytoplankton, tiny photosynthesising plants found in the world's oceans, provide 50 per cent of all the oxygen on earth.

15.2.1 The angler fish lives 1000 metres below the surface of the water.

Oceans: The benefits Carbon cycle

One of the most important service functions of the marine environment is the role it plays in the **carbon cycle**: moving and storing carbon. In recent decades, with growing knowledge of the impact of human activities on the carbon cycle through the burning of fossil fuels, the importance of the oceans in the cycle has become more apparent. Rising levels of carbon dioxide in the **atmosphere** are the main cause of climate change, leading to global warming. Marine organisms, ranging from microscopic phytoplankton through to large marine mammals such as whales, take carbon from the atmosphere and deposit it in the deep oceans. Without the oceans taking carbon out of the atmosphere, there would be no life on earth. Increasing levels of atmospheric carbon, due to human activities, are causing an increase in the acidity of the water. This process, known as **acidification**, is affecting the ocean biosphere (fauna and flora). Figure 15.2.2 shows the effect on sea urchins of the increasing acidity of the oceans.



15.2.2 Acidification as a result of high levels of CO₂ causes a sea urchin's spines to dissolve (left). Compare this with a sea urchin under normal CO₂ conditions (right).



DID YOU KNOW?

A 2010 study published in *Nature* reported that the number of marine phytoplankton has declined by 40 per cent since 1950, at a rate of about 1 per cent per year, possibly in response to ocean warming.

Economic benefits

In a typical year, more than 80 million tonnes of wild fish are caught in the world's oceans. The global fishing industry employs about 35 million people directly and a further 300 million people indirectly, and is worth at least US\$80 billion a year. Seafood is the major source of protein for millions of people. Additionally, the world's oceans are major trade highways. Ships transport virtually all the world's raw materials,

from coal and oil to wheat and rice. More than 100 million containers of goods containing everything from T-shirts to mobile phones are moved across the oceans every year.

Social benefits

The marine environment has an important spiritual and cultural value. Many people feel joy when they see whales in the wild or hear waves crashing onto the beach. The indigenous people of Hawaii, like many other Pacific peoples, have a strong spiritual bond to the marine environment. The ocean is referred to as *ke kai popolohua mea a Kane* (the deep dark ocean of Kane) and has great religious importance. For the Hawaiians, the ocean provided everything that they needed and therefore was worshipped and honoured.

ACTIVITIES

Knowledge and understanding

- 1 Outline the role of the marine environment in terms of ecosystem services.
- 2 Explain the role played by the oceans in the carbon cycle.
- 3 Describe the benefits humans receive from the oceans.

Applying and analysing

- 4 Assume the perspective of an environmentalist. You have been asked to prepare a presentation to the United Nations on why the world needs to take better care of the oceans. Prepare a short digital presentation and oral report, and present in the class. You may wish to do this activity in a small group.

Human impacts on marine environments

Marine pollution

Vast areas of the marine environment have been subject to great change as a result of human activity. Unlike land environments, much of the world's oceans is beyond the control of individual nations. The oceans are largely left unmanaged and their use is unregulated. This has resulted in unsustainable fishing and dumping of wastes and toxins.

Marine debris, or marine litter, is defined as any persistent, manufactured or processed solid material discarded or abandoned in the marine or coastal environment. Marine debris is harmful to marine life, especially to protected species of birds, sharks, turtles and marine mammals.

Marine debris may cause injuries or death through drowning, injury through entanglement and internal injuries or starvation following ingestion. Discarded fishing nets and hooked lines are among the most dangerous of all marine debris. They kill marine life long after they have ceased to be used by humans.

Other marine pollutants include chemical discharges from factories and farms, such as fertilisers and pesticides, sewage, urban run-off and discharges from ocean-going vessels.

SPOTLIGHT

The Great Pacific Garbage Patch

The Great Pacific Garbage Patch is an enormous collection of rubbish that has accumulated in the eastern Pacific Ocean between Japan and North America, in the North Pacific Gyre. A gyre is a circular ocean surface current created by wind movements and the rotation of the planet. The centre of a gyre tends to have very stable and calm waters. Rubbish from across the Pacific has accumulated and become trapped in the North Pacific Gyre. A similar, smaller rubbish accumulation is found in the North Atlantic Gyre. The North Pacific Gyre contains a huge array of materials. Much of it is tiny particles of plastics that enter the food chain, slowly poisoning marine life. Sea turtles, mistaking plastic bags for jelly fish, ingest them and die.

Scientists visiting the remote part of the Pacific have collected up to 750 000 pieces of plastic in a single square kilometre. The rubbish is so dense in some parts that the whole food chain is disrupted. Sunlight cannot penetrate through the surface, which leads to the collapse of the phytoplankton that form the basis of the food web and rely on sunlight.

Dealing with this vast rubbish patch has been very challenging. As no country has control over the waters in which it is found, action has been slow. At present, much of the work is limited to research and alerting the public to the nature of the issue. In 2010, a group of activists sailed *Plastiki*, a raft made entirely from plastic rubbish, across the Pacific from San Francisco to Sydney to highlight the damage that plastic is doing to the marine environment.



15.3.1 Found in one of the most isolated places on earth, the Great Pacific Garbage Patch is a vast accumulation of plastics and other rubbish.



15.3.2 In 1979, the *Atlantic Empress* collided with another ship off the South American coast, releasing 287 000 tonnes of oil.

Oil and gas exploration

Oil and gas are the world's most widely used energy sources. Known as fossil fuels, oil and gas deposits (coal is also a fossil fuel) were formed millions of years ago when dead plants and animals sank to the seabed and were covered by layers of mud and sand, which were eventually compressed into rock.

Land-based reserves of oil and gas have been exploited for decades and offshore deposits are now being identified and exploited. Huge rigs are constructed to drill through the sea floor and pump out the oil and gas under pressure. These are then transferred to processing plants, often offshore floating factories, and then sent ashore. Technological advances have made oil and gas exploration possible in areas previously too hard to exploit, for example deep-ocean drilling and drilling in the inhospitable Arctic Ocean. As near-shore reserves continue to dwindle, more and more drilling is likely to take place in deep oceans.

The world's oil and gas are not evenly distributed. Huge reserves are found in the Middle East, Central and South America and in the North and Arctic seas. To move the fuels to where they are consumed, massive oil tankers and pipelines have been constructed. The tankers are the largest machines ever built by humans and have the capacity to move more than a billion tonnes of fuel around the world each year. While accidents are quite rare, due to improvements in safety standards, the environmental impacts of oil spills can be devastating. In July 1979, the *Atlantic Empress* collided with another tanker, the *Aegean Captain*, off Tobago in the Caribbean Sea (see Figure 15.3.2). The accident led to the spill of 287 000 tonnes of oil into the Caribbean Sea and the Atlantic Ocean, and was the biggest tanker spill in history. Oil is highly toxic to marine species and its effects linger for decades.

Climate change

The impact of climate change on the marine environment is extreme. One of the most obvious consequences is sea-level rise. As the world's climate warms, a process of **thermal expansion** takes place. When water warms, the particles in water expand; therefore the level of the water rises as it warms. Scientists believe that sea levels may rise by as much as 1 metre. Rising sea levels are already leading to flooding of low-lying islands and coastal areas. The world's oceans absorb huge quantities of carbon, and as atmospheric carbon increases, so does the carbon stored in the oceans. This increase in carbon is slowly turning the oceans more acidic. This acidification is having an impact on the biosphere. For example, some animals can no longer make strong shells.

As temperatures rise, ecosystems around the world are being affected. Fragile coral reefs that require very specific temperature ranges are disappearing. There are also grave concerns for the future of the huge ice sheets that lock away most of the world's fresh water. The Greenland ice cap beyond the Arctic Circle is already beginning to shrink, as is shown in Figure 15.3.3. The fresh water that is added to the oceans as a result of the melting changes the chemical composition of the sea water. This in turn affects the movement of ocean currents, which are driven by changes in water density, associated with how saline (salty) the water is.

Scientists fear that changes to the density of waters around Greenland could affect the Gulf Stream, which regulates temperatures across the eastern part of North America and the north-west of Europe. Ironically, the world becoming warmer may cause the Gulf Stream to stop flowing, bringing freezing temperatures to a large part of the world.

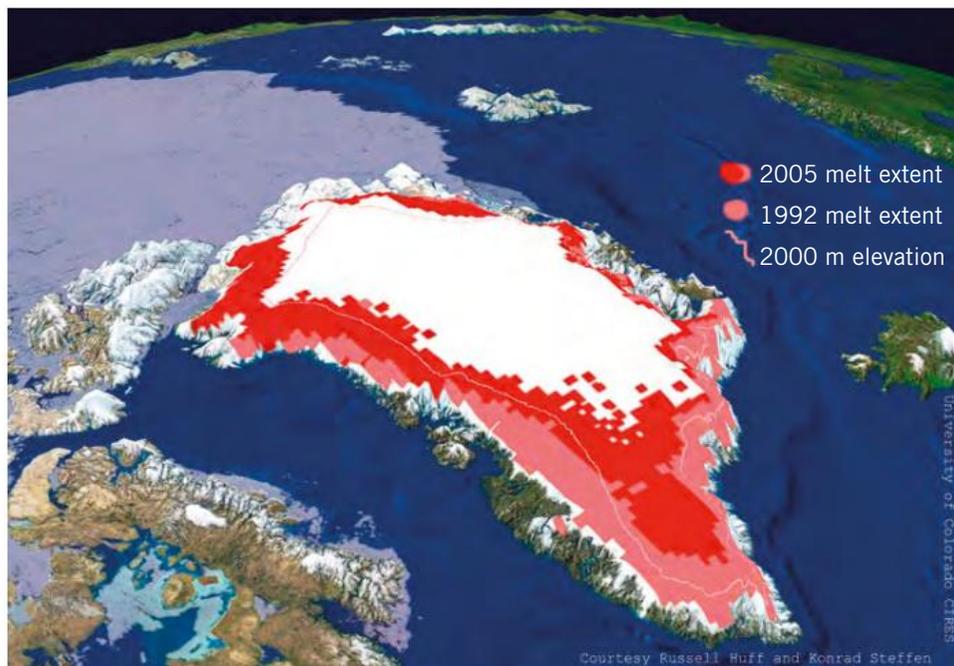
SPOTLIGHT

Polar bears

Polar bears are found north of the Arctic Circle. They rely on the sea ice to hunt seals, their main source of food. Global warming is reducing the Arctic sea ice level, affecting the ability of polar bears to hunt for food. As a result, female polar bears do not obtain enough food to store sufficient energy for pregnancy, and so are having fewer or no cubs.



15.3.4 A polar bear nurses her two cubs.



15.3.3 The extent of the Greenland ice cap, 1992 and 2005

Source: Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, 2005



15.3.5 Cod fishing, 1979

Fishing

More than 15 per cent of the world's population rely on seafood for their main source of protein. As the world's human population has increased, the strain on the world's fish stocks has grown markedly. Since the 1970s, about twenty of the world's most important fishing grounds have disappeared as a result of unsustainable fishing practices. The collapse of the Grand Banks cod fishery (see Figure 15.3.5) in the North Atlantic Ocean is one of the best known examples. This once vast and seemingly endless fishing ground had disappeared by the 1990s, due to overfishing.

In addition to declining fish stocks, large-scale commercial fishing has other consequences for the marine environment. The heavy gear that trawlers drag across the sea floor kills species that cannot move. Large nets catch many non-commercial species that are simply thrown away—this is known as **by-catch**. Driftnets can be up to 65 kilometres long and are dragged through the water for a number of days, trapping fish indiscriminately. Some nets now have special escape routes for dolphins and turtles, but they are not used in most parts of the world.

ACTIVITIES

Knowledge and understanding

- 1 What is the Great Pacific Garbage Patch?
- 2 Explain why there has been so little attention paid to the garbage gyre.
- 3 Outline the main causes of climate change.
- 4 Explain the impact of climate change on the marine environment.
- 5 Outline the impacts of commercial fishing on the marine environment.

Applying and analysing

- 6 Write a short report on the risks to the marine environment posed by oil and gas exploration.
- 7 Work in small groups. Using the text, the internet and other sources, produce a digital presentation on the impact of human activities on marine environments. Share your presentation with the class.

Managing marine environments

Agreements and cooperation

Environmental management is usually the responsibility of governments, but much of the world's marine environment lies beyond the territorial limits of individual nations, in an area known as the high seas. Individual governments do not have the power to manage this environment. Consequently, international cooperation is critical for its effective management.

Until the late twentieth century, there was very little cooperation or agreement between nations regarding environmental management. Today, a growing number of international agreements deal with the protection of the marine environment.

International agreements can only be successful in protecting the environment when a significant number of nations are prepared to follow the rules set out in the agreements. Sometimes nations act in their own interests rather than in the broader global interest, and this limits the success of international cooperation.

Convention for the Prevention of Pollution from Ships

One of the first attempts to create an international agreement regarding the marine environment was the International Convention for the Prevention of Pollution from Ships in 1973. Most countries were not interested in the agreement until a series of tanker accidents in 1976 and 1977. These accidents highlighted the danger to the environment posed by oil tankers. In 1978, Regulations for the Prevention of Pollution by Oil were added to the Convention now known as MARPOL.

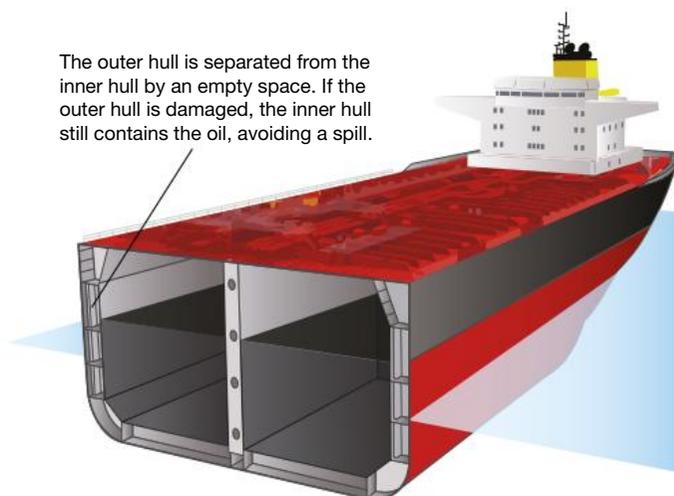
The Convention requires all new tankers to have double hulls: an outer and an inner hull with a gap between them, as shown in Figure 15.4.1. If the outer hull is damaged by a collision, the inner hull should remain intact and stop oil from flowing out.

Other parts of the Convention control the movement of dangerous substances, such as radioactive materials. There are also restrictions on the dumping of toxic chemicals, rubbish and sewage from ships.

Wellington Convention

The Wellington Convention is an international agreement to protect the marine environment in the South Pacific region. Its full title is the Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific. It was agreed to in 1989. This convention protects fishery resources throughout the South Pacific Ocean by banning fishing with driftnets over 2.5 metres long.

15.4.1 Cross-section of a double-hulled oil tanker



The outer hull is separated from the inner hull by an empty space. If the outer hull is damaged, the inner hull still contains the oil, avoiding a spill.

Driftnets are sometimes called 'walls of death'. The nets are strung out to drift near the surface and capture fish by entangling them around their gills. Traditionally, driftnets were small, but modern commercial driftnet boats use very large nets. These nets are equipped with floats to keep them on the surface and weights that attach to the sea floor, creating a curtain to trap anything that swims into the net.

As the nets do not discriminate, they create very large by-catches. These are species that are not meant to be caught and they are often thrown back, already dead. Turtles are particularly vulnerable, as are dolphins and many shark species. Driftnets become even more dangerous if they are lost at sea. The nets are made of nylon, and can float around for decades, entangling animals. The success of the Wellington Convention has led to the protection of other marine environments outside the South Pacific. Authorities in the United States have banned driftnetting along parts of the western US coast.

Whaling in the Southern Ocean

In 1982, the International Whaling Commission (IWC) placed an indefinite moratorium on the commercial hunting of most whale species. A huge whale sanctuary was declared in the Southern Ocean in 1994. Known as the Southern Ocean Whale Sanctuary, the sanctuary protects the important feeding grounds for many whale species around Antarctica. Since the introduction of the moratorium, whale numbers have increased.

Although it is a member of the IWC, Japan has continued its whaling program, arguing that its program is for scientific research. Environmental groups and whale experts argue that this is a lie. They say that the program is purely for commercial whaling, and the whale meat is sold in fish markets in Japan. They also point out that almost no scientific papers about the program have been written by Japanese researchers, while scientists studying whales in other countries produce excellent research without harming any whales at all.

Japan had been exploiting a loophole in the international agreements that regulate whaling for scientific hunting. Other countries have argued that Japan is not acting in the best interest of the environment and is not fulfilling its obligations under the agreement. Environmental groups have taken more dramatic action. Sea Shepherd is one of the most vocal critics of the Japanese program. It sends ships to harass the Japanese whaling fleet. Groups such as Sea Shepherd rely on individuals to support them and apply pressure to the Japanese Government to abandon its whaling program.

In 2014, the International Court of Justice in The Hague ordered Japan to cease whaling in the Antarctic. The ICJ ruling stated that Japanese whaling was commercial and not for scientific purposes. This was in violation of the IWC moratorium.

Marine management in Australia

Australia has become a world leader in managing its marine environment. The fishing industry is heavily regulated, with strict quotas used to maintain sustainable fisheries. Extensive marine parks have also been established along large areas of the Australian coast, as shown in Figure 15.4.2. Some people have been critical of these parks as they limit commercial fishing.

With the Australian demand for seafood growing every year, it has been argued that Australia is protecting its marine environment at the expense of environments elsewhere. Well over \$1 billion worth of seafood is imported into Australia annually, much of it from South-East Asia. There are concerns that Australian consumers are fuelling the destruction of the marine environment throughout the region.

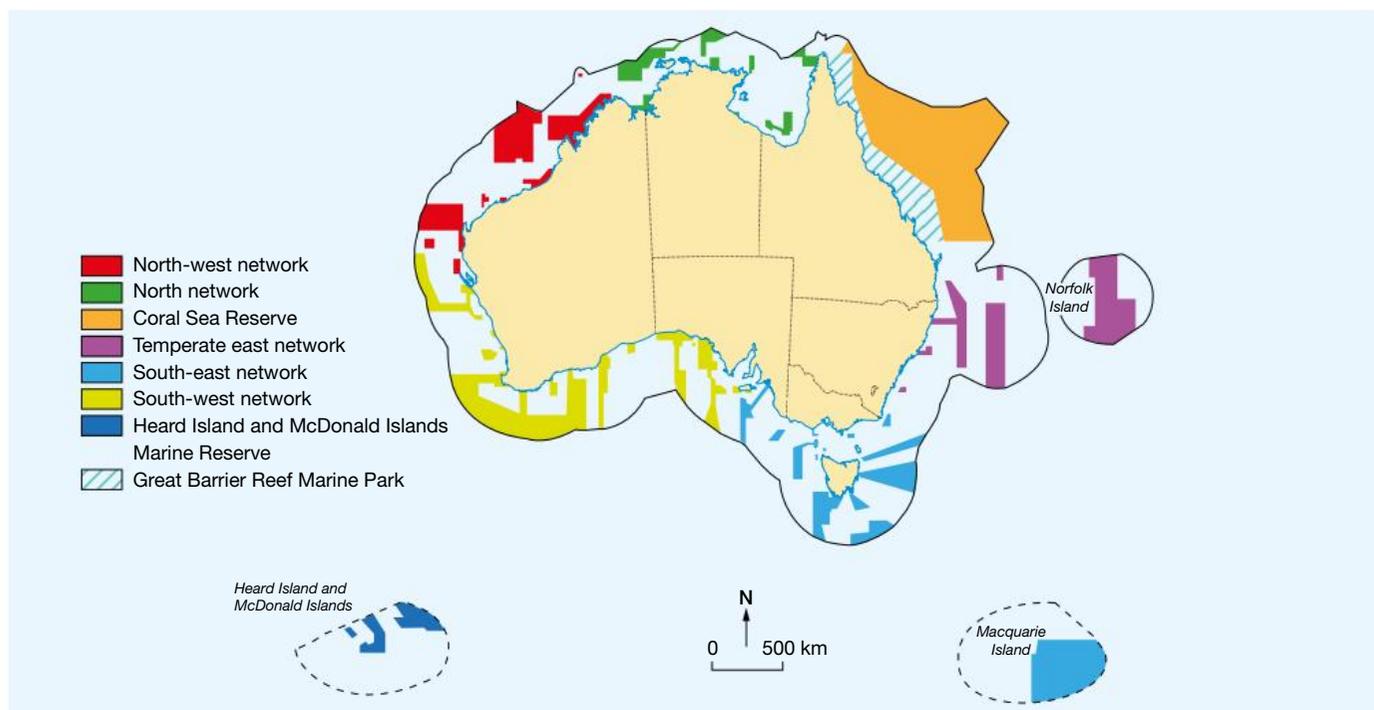
The role of the individual

The everyday actions of individuals can have a very significant impact on the marine environment.

Everyday actions

When individuals drop rubbish on the ground, it makes its way into stormwater systems and eventually floats out to sea. This is how the rubbish collected in North Pacific Gyre. Individuals taking greater responsibility for their rubbish is more effective than the installation of rubbish traps over stormwater outlets.

15.4.2 Australia's extensive network of protected marine environments. Note that Macquarie Island, Heard Island and McDonald Islands are not shown on the map in their correct location according to the scale.



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Direct action

Environmental organisations such as Greenpeace and Sea Shepherd rely on individuals for support.

In 2013, oil companies began drilling deep-sea wells well to the north of the Arctic Circle. Environmentalists fear that the pristine environment here will be destroyed by a

spill. In 2013, thirty Greenpeace activists boarded an oil rig (see Figure 15.4.4) and attempted to unfurl a banner highlighting the dangers of drilling. They were arrested by Russian police.

SPOTLIGHT

Managing the Great Barrier Reef

Covering an area of 348 000 square kilometres, the Great Barrier Reef (GBR) is the largest coral reef system in the world.

In 1981, the importance of the GBR to the entire world was recognised by the United Nations Education, Scientific and Cultural Organization (UNESCO) when it listed the reef as a World Heritage site. This recognition was based on the enormous biodiversity found on the reef. Fifteen hundred of the world's 13 000 fish species are found there, along with six of the seven turtle species, more than 200 species of birds, 500 species of seaweed, 600 species of echinoderm, 125 species of shark and rays and about 360 species of hard coral.

Managing a large-scale environment with such an amazing diversity of species is challenging. The fact that it is a marine environment adds further complications.

Hundreds of large ships navigate through the reef every year, travelling to and from the huge coal ports on the Queensland coast, and up to 2 million tourists visit the region every year. An increasing number of visitors arrive on cruise ships.

The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for balancing the interests of humans and the need to protect the environment. It has established different management zones in which activities are controlled. About 85 per cent of tourism activity is confined to just 7 per cent of the reef system, minimising the impact, and commercial fishing is limited to certain areas. The GBRMPA also conducts reef and marine research to learn more about how to manage the reef. Warmer water can cause corals to expel the algae (zooxanthellae) which gives them their colour, causing them to become completely white. This is called coral bleaching, shown in Figure 15.4.3. Most corals struggle to feed themselves without their zooxanthellae.



15.4.3 Coral bleaching in the Great Barrier Reef



15.4.4 Greenpeace activists attempting to board a Russian oil rig

Consumer choice

Consumers are increasingly aware that the decisions that they make about products can have a significant impact on the environment. Much of the canned tuna sold in Australian supermarkets now is labelled as 'dolphin friendly'. This means that the tuna has been caught by methods that protect dolphins from being accidentally caught. This growth in dolphin-friendly tuna production developed at the end of the twentieth century as a result of consumer demand.

An awareness of the damage that large-scale commercial fishing causes to the environment has led to a rise in demand for sustainable seafood. The Marine Stewardship Council now provides certification that companies can use to indicate to consumers that they have met rigorous standards for harvesting seafood in a sustainable fashion.

Consumer boycott

The Brent Spar, a 4000-tonne facility located in the North Sea, was constructed in 1976 to temporarily store oil from oil rigs until it was taken ashore by tankers.

In 1997, energy company Royal Dutch Shell, which owned Brent Spar, announced it was planning to sink the storage facility, as it was no longer in use. Environmentalists feared that sinking the facility would cause huge environmental damage, as it was contaminated with toxins. Greenpeace called on consumers to boycott Shell petrol stations throughout Europe. This boycott proved so successful that Shell backed down and agreed to tow Brent Spar to Norway to be thoroughly cleaned, dismantled and recycled.

ACTIVITIES

Knowledge and understanding

- 1 Explain why managing the marine environment in the area known as the high seas is challenging.
- 2 Outline the importance of international agreements for managing the marine environment.
- 3 Describe how the MARPOL Convention protects the marine environment.
- 4 Outline the purpose of the Wellington Convention.
- 5 Assess the justifications given by Japan for whaling in the Southern Ocean.
- 6 Outline why the Great Barrier Reef was given World Heritage status.
- 7 Describe the role of environmental organisations in protecting the marine environment.

Applying and analysing

- 8 Create a PMI chart on marine parks in Australia.
- 9 Design an advertising campaign to encourage individuals to take action to protect the marine environment.

Investigating

- 10 Assume the role of a fisheries manager. You have been asked to give a presentation to the Environment Minister of a developing nation that allows large driftnets to be used in its waters. Prepare a digital presentation to convince the Minister to agree to the Wellington Convention.

CASE STUDY: Bass Strait

Location

Bass Strait is a wide channel separating mainland Australia from Tasmania. At its widest point, it is 240 kilometres across. Close inshore, its depth is often less than 20 metres, but at its deepest it exceeds 120 metres. The shallowness of Bass Strait creates a perfect environment for large swells and waves, and consequently it is famous for its rough seas.

The vast Southern Ocean lies to the west of Bass Strait and the Tasman Sea to the east (see Figure 15.5.1). Low-pressure weather cells, which form in the Southern Ocean, sweep up from Antarctica towards Australia. These cells bring with them large storms and seas, creating strong south-westerly winds in the Indian Ocean, which are funnelled into the eastern part of Bass Strait. These winds create the legendary storms characteristic of Bass Strait. During these storms, the waves regularly reach 4 metres and can exceed 7 metres.

Biodiversity of Bass Strait

The cool waters of Bass Strait are highly productive and support a wide diversity of marine life. In the coastal waters, mammals such as seals are found, and extensive kelp forests provide an important habitat for many creatures.

The giant cuttlefish is found in these forests. These beautiful creatures, which grow to more than 1 metre in length, have a life span of only two years. The short life span means that disturbances to the breeding cycle can have a dramatic impact on the species. Giant cuttlefish are commonly caught as by-catch by commercial fishing operations.

Human impacts

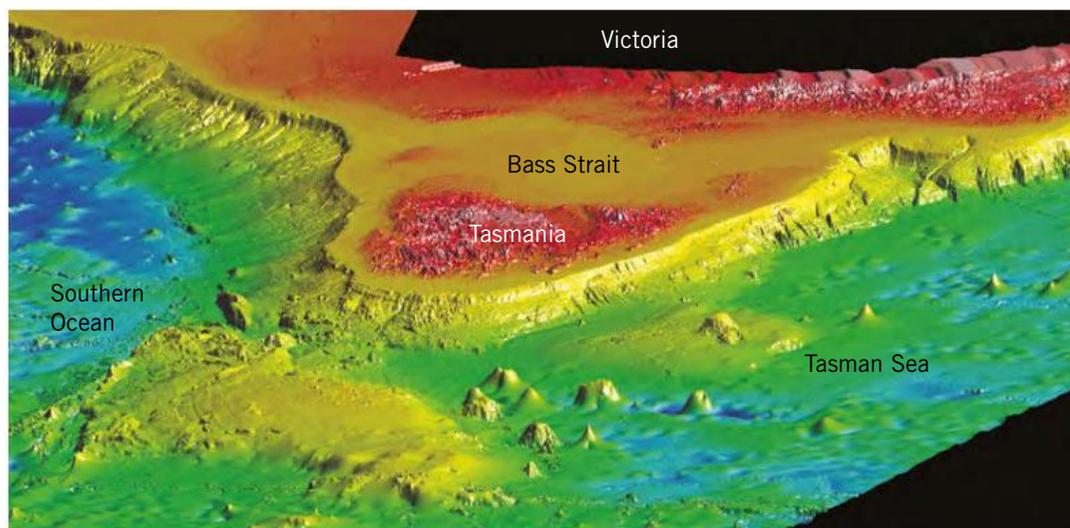
Bass Strait is a busy and important shipping route. Threats of oil spills from shipping accidents are ever-present but, fortunately, large oil spill accidents have been rare. Since the 1960s, oil and gas exploration and drilling have been undertaken in Bass Strait.

Bass Strait's oil reserves are declining and some experts predict that the fields will cease production within the next decade or two. Energy companies are now turning their attention to gas, which is considered to be a cleaner energy source than oil. The demand for gas is growing in Australia and around the world. Several large companies are now actively drilling for gas reserves in Bass Strait.

The huge oil rigs that dot the north-eastern part of Bass Strait (see Figure 15.5.2), off the Victorian coast, pose one of the greatest risks to the environment. In October 2013, 750 litres leaked from the Cobia pipeline into Bass Strait. Although it was only a small leak, environmentalists have pointed to the spill as evidence that the oil infrastructure in Bass Strait is ageing. Some of it is more than 30 years old and it is feared that more serious spills may occur in the future.

Managing Bass Strait

Although now in decline, the oil industry is important in meeting Australia's energy needs. Bass Strait is also important to the shipping and the fishing industries. This human activity takes a toll on the environment of Bass Strait. It is now extensively managed.



15.5.1 The continental shelf, showing Bass Strait, located between mainland Australia and Tasmania



15.5.2 Oil rigs dot the Victorian side of Bass Strait.

Dealing with pollution

The coastline of Bass Strait is quite heavily populated, especially the Victorian coastline, which takes in Port Phillip Bay. The urban areas abutting Bass Strait have long been a source of pollution. Toxins from industry, sewage, plastics and other rubbish all take a toll on the marine environment.

Algal blooms have become a feature of Bass Strait coastal waters in recent years. The blooms can grow very large and have a great impact on the environment. The algae are toxic and take oxygen out of the water, which leads to the deaths of fish and other marine life. In 2013, the emergence of toxic blooms in the north of Tasmania, shown in Figure 15.5.3, resulted in a ban on shellfish harvesting in much of Bass Strait. The blooms are caused by run-off from inland areas that is rich in nutrients, such as fertiliser, and also by the release of untreated sewage. Management and treatment of stormwater is essential for reducing the impact of the algal blooms.

Research conducted by La Trobe University into seabirds in Bass Strait has revealed the impact of plastics. One study into fledgling (very young) mutton-birds on Phillip Island found that they have on average seven pieces of plastic in their stomachs. These plastics are toxic and can gradually kill the birds. Researchers found that the nest-bound chicks had been fed regurgitated fish containing plastics by their parents.

Authorities are beginning to deal with this issue through education programs to alert the public that the rubbish they

drop into drains and gutters makes its way into the marine environment. Traps installed over stormwater pipes and booms that are strung across waterways also capture rubbish. These are effective but require regular emptying and maintenance.



15.5.3 This 2004 algal bloom in Bass Strait was so large that satellites were used to track it.

SPOTLIGHT

Tamar Valley pulp mill

Forestry is one of the most significant and controversial industries in Tasmania. A large pulp mill to make paper has been planned for Bell Bay in northern Tasmania since 2004. The mill has been approved and in 2013 the original owners of the site, Gunns, went bankrupt, and the approval for the mill was offered for sale.

Some local residents and environmentalists have always opposed the mill, claiming that it will have a huge impact on the environment, including Bass Strait. They have been led by the Friends of the Tamar Valley group. The group uses community action and protests to highlight the dangers of the mill.

If built, the mill is expected to dump about 640 000 tonnes of waste water into Bass Strait daily. This waste will contain a mixture of chemicals, including highly toxic dioxins and furans (a type of dioxin). Both these toxins remain in the environment for decades and gradually affect the entire food chain.



15.5.4 Community and environmental groups protesting against the construction of a pulp mill in Bell Bay on the coast of northern Tasmania

Managing the oil and gas industry

Oil and gas drilling poses one of the greatest risks to the marine environment of Bass Strait. Fortunately, there has not been a major spill of oil in Bass Strait but the environmental impact of a major rig incident could be catastrophic.

The National Offshore Petroleum Safety and Environmental Management Agency (NOPSEMA) is an Australian government agency that has responsibility for regulating oil and gas exploration offshore. NOPSEMA conducts environmental assessments into drilling applications and is responsible for monitoring the environmental impacts of offshore gas and oil operations. The agency also coordinates responses to oil spills, and works with the industry to develop contingency plans to ensure that spills are dealt with quickly and correctly.

Managing the fishing industry

Bass Strait has an important commercial fishing industry. Throughout much of the twentieth century, this industry was unrestricted, and unsustainable catches led to a decline in important commercial species. Today, as in other fishing zones in Australia, Bass Strait fishing is subject to quotas and strict licences to ensure that fishing is sustainable.

One of the most significant seafood industries in Bass Strait is the scallop industry. In the 1980s, more than 300 boats harvested about 40 000 tonnes of scallops annually from Bass Strait. In December 2005, the Australian Fisheries Management Authority (AFMA), which manages commercial fishing

throughout Australia, closed the Bass Strait scallop fishery. This was to allow the vast scallop beds to replenish after many years of unsustainable harvesting. In May 2009, scallop harvesting in Bass Strait was allowed again (see Figure 15.5.5), but AFMA imposed extensive restrictions. This included reducing the number of boats to just seventeen. Strict quotas for each boat are developed each year, based on detailed surveys.



15.5.5 Harvesting scallops in Bass Strait

Evaluating management

Table 15.5.6 provides an outline and an evaluation of the management strategies of selected industries in Bass Strait.

15.5.6 Evaluation of the management of Bass Strait

Management strategy	Environmental criteria	Economic criteria	Social criteria
Rubbish and nutrient management	<ul style="list-style-type: none"> Plastics and other rubbish and toxins from urban areas need to be dealt with High levels of nutrients lead to algal blooms; better water management and treatment helps to reduce this 	<ul style="list-style-type: none"> Education programs and rubbish traps to reduce pollution are cheap to implement 	<ul style="list-style-type: none"> Education programs allow the community to be involved in caring for the environment
<p>Evaluation: Urban pollution has a significant impact on the marine environment. Rubbish traps and education programs are cost-effective and provide opportunities for the community to take action.</p>			
Scallop fishing	<ul style="list-style-type: none"> Reduction in the number of boats allowed to harvest scallops Tight quotas imposed on boats 'No fish' areas created 	<ul style="list-style-type: none"> Ban on scallop fishing between December 2005 and May 2009 damaged the industry 	<ul style="list-style-type: none"> Reduction in the industry has caused job losses and affected fishing communities
<p>Evaluation: The scallop industry has had to become more sustainable in order to survive in the long term. There have been negative social and economic consequences of the restrictions on the industry but the restrictions are allowing the scallop population to rebound.</p>			
Oil and gas industry	<ul style="list-style-type: none"> Regulations by NOPSEMA that require environmental assessments NOPSEMA coordinates responses to spills to minimise impact 	<ul style="list-style-type: none"> Oil and gas drilling allowed within Bass Strait, providing jobs and economic growth 	<ul style="list-style-type: none"> Oil and gas drilling brings jobs and contributes to the national economy
<p>Evaluation: The industry provides significant economic benefits and the regulations of NOPSEMA help to minimise the environmental impacts. However, drilling for oil and gas represents a very significant threat to the environment in the case of a spill.</p>			

ACTIVITIES

Knowledge and understanding

- 1 Explain why the waters of Bass Strait are typically so rough.
- 2 Describe the impact of human activities on the environment of Bass Strait.
- 3 Outline the sources of pollution in Bass Strait.
- 4 Describe the causes and impact of algal blooms on Bass Strait.
- 5 Describe the management strategies used for reducing plastic pollutants.
- 6 Explain the potential impact of the Tamar Valley pulp mill on Bass Strait.

Applying and analysing

- 7 Construct a mind map to summarise the main impacts of human activities on Bass Strait and the management strategies used to reduce this impact.

Investigating

- 8 Using the internet, conduct research into the Tamar Valley pulp mill. Prepare a summary of the current status of the mill.
- 9 Write a short report outlining how the Bass Strait scallop industry is being managed to make it more sustainable.

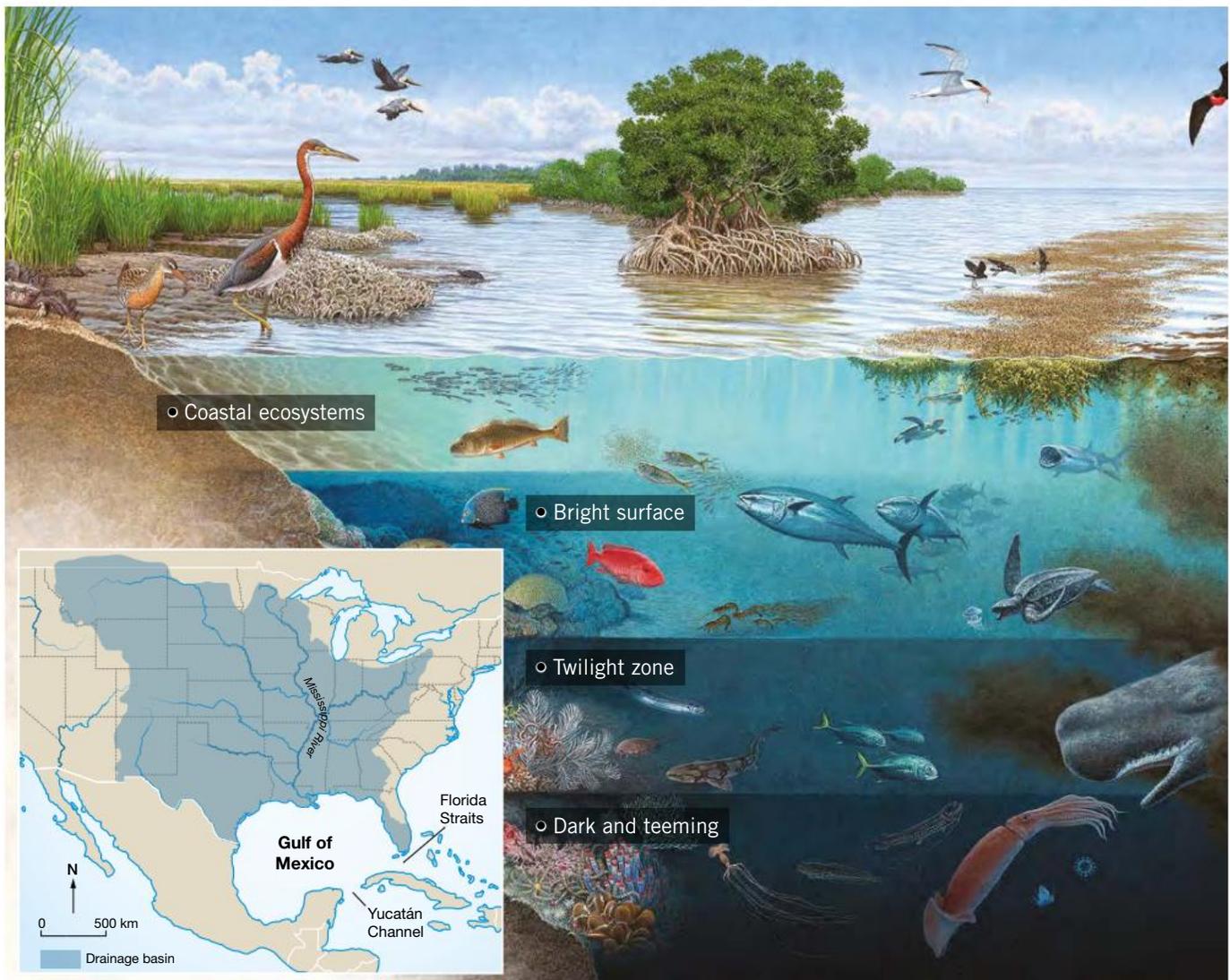
CASE STUDY: Gulf of Mexico

Geography of the Gulf

The Gulf of Mexico is the ninth largest body of water on earth, measuring 1 550 000 square kilometres. Land surrounds much of the Gulf, with only the narrow Florida Straits in the east forming a passage to the Atlantic Ocean, and the Yucatán Channel in the south allowing waters from the very warm Caribbean Sea to enter (see Figure 15.6.1, inset).

The Gulf is deep, with waters in the centre plunging to more than 5000 metres. Many large rivers flow into the Gulf, which means that the water closer to the coast is far less saline than the water in the centre. These different water conditions result in diverse environments.

15.6.1 The Gulf of Mexico's drainage basin (inset map) and coastal and marine habitats



Human impacts

Oil and gas

Human activity has had an enormous impact on the Gulf of Mexico's environment. Deep below the sea floor, huge reserves of oil and gas are being exploited. When accidents occur, oil spills have a dramatic and long-lasting impact on the environment.

DEEPWATER HORIZON

Deepwater Horizon was a huge oil rig owned by UK energy company British Petroleum (BP). On 20 April 2010, while drilling in the Gulf, the rig caught fire after an explosion caused by a build-up of methane gas. The explosion killed eleven crew members and injured seventeen. On the sea floor, the well head was damaged and began leaking oil, which spread horizontally at a depth of about 1 kilometre.

As millions of litres of oil spewed into the Gulf of Mexico, killing marine life, BP used Corexit, sprayed on the surface by aircraft, to break up the oil. Corexit is highly toxic and is banned in many parts of the world. It was only after 2 500 000 litres was sprayed that BP was ordered by the US Environmental Protection Agency to stop. By early May, the waters of the northern Gulf of Mexico were so polluted that the National Oceanic and Atmospheric Agency ordered that all commercial and recreational fishing be stopped. It took about three months to stop the leak.

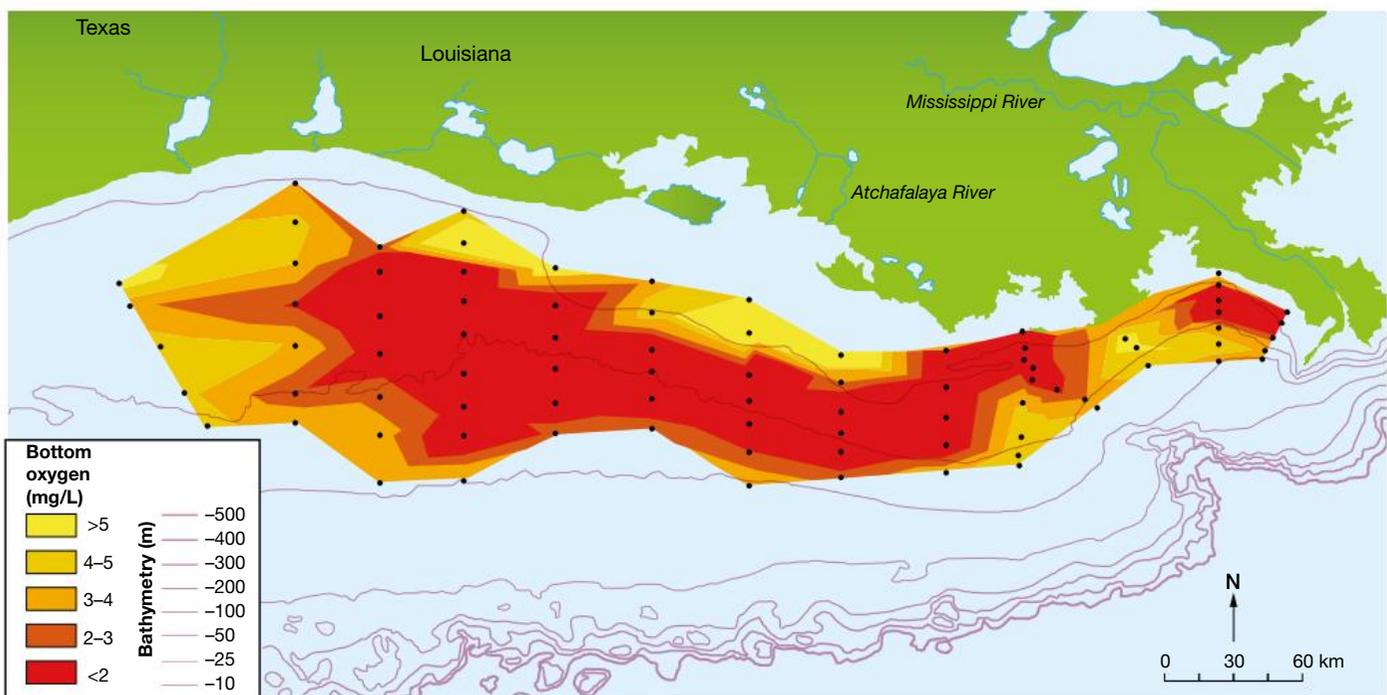
The spill has had a huge impact on the environment. Because the oil leaked at the sea floor, many deep-sea creatures were affected, including deep-water rock reef systems, which have a rich diversity of anemones, sea lilies and whip corals. As the oil rose to the surface, seabirds and surface animals were also affected. The build-up of oil and the toxic Corexit will remain in the Gulf of Mexico environment for decades.

Agriculture

Human activities on land are also taking a significant toll on the Gulf environment. Scientists have discovered an extensive 'dead zone' in the Gulf's marine environment (see Figure 15.6.2). The **hypoxic water** in this zone contains extremely low levels of dissolved oxygen. Located off the coast of Louisiana and Texas, the zone covers an area of more than 20 500 square kilometres. The dead zone appears at the onset of spring, when huge amounts of water flow into the Gulf from the Mississippi River.

The cause of the dead zone is the use of nitrogen-based fertilisers in agriculture, manure from animals and the burning of fossil fuels. About 1.6 million tonnes of nitrogen enters the Gulf of Mexico from the Mississippi River each year from farmland throughout central United States. The excess nutrients promote the growth of algae, which take the oxygen out of the water, leading to the destruction of the food chain.

15.6.2 The Gulf of Mexico dead zone, where dissolved oxygen levels fall below 2 mg/L



Managing the Gulf of Mexico

Management of the Gulf of Mexico presents many challenges. The Gulf is one of the largest bodies of water in the world and is under the control of multiple governments. Its waters contain vast oil and fishing industries that are economically very important. The Gulf coast is home to millions of people, and the waters that flow into the Gulf from the many rivers drain a huge area of land.

Integrated management

In order to manage the Gulf of Mexico effectively, an integrated approach has been adopted (see Table 15.6.3). It deals not just with the marine environment but also with the huge landmass that drains into the Gulf. The northern Gulf of Mexico **watershed** is one of the largest drainage basins on earth. It is over 5 million square kilometres in area and covers thirty-one of the fifty states of the United States of America.

The water that enters the rivers and makes its way into the Gulf of Mexico flows across farmland, urban areas and natural landscapes. This water contains contaminants such as nitrogen-rich fertilisers, which are a major contributor to the Gulf of Mexico 'dead zone'. Environmental management of this issue sometimes takes place thousands of kilometres from the Gulf, and requires integrated approaches from many different agencies, as well as extensive education programs.

SPOTLIGHT

The Gulf of Mexico Program

The Gulf of Mexico Program was developed in 1988 by the United States Environmental Protection Authority to provide a coordinated approach to management of the Gulf. The program is based on undertaking extensive scientific research into the problems facing the Gulf and then bringing together many different agencies, volunteers and non-governmental organisations to work together to solve those problems.

The program has identified five major areas that require attention:

- improved water quality
- habitat conservation and restoration
- ecosystem research
- reduced nutrient flows into the Gulf
- environmental education programs.

Since its establishment, the Gulf of Mexico Program has had a number of important environmental successes. These include substantially improving the water quality of 109 rivers whose waters eventually find their way into the Gulf, and developing education centres and programs.

15.6.3 Evaluation of the management of the Gulf of Mexico

Management strategy	Environmental	Economic	Social
Integrated management	<ul style="list-style-type: none"> • A broad approach, such as the management of watershed, maximises the management of the entire environment 	<ul style="list-style-type: none"> • Strategies help to balance the environmental and economic values of the Gulf 	<ul style="list-style-type: none"> • Programs allow the involvement of community groups and education programs involve individuals
Evaluation: The Gulf of Mexico is so vast it requires management of many different aspects of the environment. It also requires cooperation between many different governments and agencies.			
Fishing industry management	<ul style="list-style-type: none"> • Licence buybacks reduce the number of longline boats • Watershed management reduces risks of hypoxia • 'No-fish' areas created 	<ul style="list-style-type: none"> • Watershed management reduces risks of hypoxia, which can devastate the industry • Need to balance the needs of the oil and fishing industries 	<ul style="list-style-type: none"> • Policies to regulate recreational fishing are in place and need to be maintained • Many Gulf communities rely on the fishing industry for employment
Evaluation: The Gulf fishing industry is very significant. Policies are in the place to improve the sustainability of the industry. The oil industry represents a significant threat, as does hypoxia. Both of these need constant management and attention.			
Oil and gas industry	<ul style="list-style-type: none"> • Enhanced regulations requiring tougher environment standards introduced following Deepwater Horizon explosion • Scientific research prompted by Deepwater Horizon is improving knowledge and reactions to oil spills 	<ul style="list-style-type: none"> • Oil industry adds huge economic growth to the area and provides energy for further economic growth 	<ul style="list-style-type: none"> • Oil and gas drilling brings jobs and contributes to the national economies of the US and Mexico
Evaluation: The industry provides significant economic benefits. However, as shown by the Deepwater Horizon tragedy, the environmental risks are enormous. Better regulations and more research are now in place to manage the industry more effectively.			

In recent years, there has been increasing cooperation between Mexico and the United States in managing the Gulf. The Gulf of Mexico Large Marine Ecosystem Project brings scientists, environmental managers and government officials from both countries to coordinate their management of the Gulf.

Managing fishing in the Gulf of Mexico

Extensive fishing industries are found on both the US and the Mexican Gulf coasts. The US Gulf fishing industry is estimated to be worth more than US\$650 million. Shrimp (prawns) are the most important commercial species, with about 80 million kilograms being removed from US Gulf waters every year.

The Gulf of Mexico fishing industry is under threat from unsustainable fishing, damage from oil spills and the effects of hypoxia. Fishing throughout the Gulf is now regulated and restrictions are placed on the size of catches. Mexican authorities have instituted closed seasons for shrimp fishing periodically. During these seasons, commercial shrimp boats are not allowed to take any shrimp at all, in order to allow the population to recover.

There are also concerns over the sustainability of fishing of other species, including the iconic grouper. There are concerns that grouper numbers are in decline and that longline fishing, a method of fishing using fishing lines with thousands of hooks, creates a huge by-catch.

Management approaches have included extensive scientific research into grouper populations and the impact of fishing. An education program for commercial and recreational fishers, as well as fish buyers, aims to encourage more sustainable fishing approaches. A licence buyback program has also been implemented, whereby licences for longline fishing are bought back from commercial fishers to reduce the number of boats. These strategies are beginning to prove effective and the number of groupers in the Gulf is growing.

MANAGING THE GULF'S OIL INDUSTRY

The oil and gas industry represents one of the most significant human uses of the Gulf of Mexico. There are about 4000 wells in the US waters of the Gulf, and more in Mexican waters. These operations provide extensive employment and economic development throughout communities along the Gulf coast. However, they also represent a real and ever-present threat to the environment of the Gulf.

The environmental risks created by oil drilling were dramatically demonstrated by the 2010 explosion of the Deepwater Horizon rig. This tragedy has led to the implementation of new environmental management strategies. The Offshore Drilling Safety Reforms were introduced after the explosion and require more thorough environmental risk assessments and more thorough planning for oil spills.

There has also been a significant increase in scientific research into oil spills. Government agencies and environmental groups have undertaken studies throughout the Gulf to assess the impact of the Deepwater Horizon spill. The Gulf of Mexico Research Initiative (GoMRI) brings together scientists from several universities and non-governmental agencies. GoMRI is now developing better strategies to detect and reduce the impact of oil spills, as well as better remediation strategies for areas affected by oil spills.

ACTIVITIES

Knowledge and understanding

- 1 Define the term 'hypoxic water'.
- 2 Outline the causes of the Gulf of Mexico dead zone.
- 3 Outline the role of the Gulf of Mexico Program.
- 4 List some of the successes of the Gulf of Mexico Program.
- 5 Explain why the Gulf of Mexico Large Marine Ecosystem Project is important.
- 6 Describe the importance of the fishing industry in the Gulf of Mexico to the United States of America.
- 7 Explain how the Deepwater Horizon disaster has affected the management of the oil industry in the Gulf of Mexico.

Applying and analysing

- 8 Construct a table to summarise the challenges facing managers of the Gulf of Mexico. Add the strategies used to overcome these challenges to your table.
- 9 Prepare a short report explaining the strategies used to manage the Gulf of Mexico more effectively.

Geographical skills

- 10 Study Figure 15.6.1.
 - a Describe the location and extent of the Gulf of Mexico and the extent of the landmass drained by rivers flowing into the Gulf.
 - b Briefly describe each of the Gulf marine habitats.
- 11 Summarise the impact of the Deepwater Horizon disaster on the marine environment.



Human wellbeing: India

CHAPTER 16

India is a land of great contrasts. Spread across its 3.3 million square kilometres is a range of biophysical environments. These include deserts (in the west), high mountain ranges (to the north), golden beaches (in the south) and dense rainforests (in the north-east).

The country is also culturally diverse. The most striking aspect of this diversity is the socio-economic variations that occur across the country. While India is an emerging economic and political power with an expanding middle class, it remains burdened by high levels of poverty. India's economic growth and development tend to be skewed towards the southern, western and north-western states, while the north-central, central and eastern states have experienced deteriorating levels of human wellbeing.

INQUIRY QUESTIONS

- What are the main challenges facing India?
- What is the spatial pattern of human wellbeing in India, and what are the factors contributing to this pattern?
- How have NGOs, transnational bodies and governments sought to enhance the wellbeing of India's poor?

In this chapter we focus on the spatial patterns of human wellbeing in India, the factors contributing to these patterns and the strategies being pursued to reduce the variations in the quality of life experienced by people.

GLOSSARY

capitalism	an economic system in which the means of production, distribution and exchange are controlled largely by private individuals or corporations rather than the state	misogyny	a hatred or dislike of women
communal violence	violence as a result of tensions between different ethnic or religious groups	patriarchal attitude	the belief that society and government should be controlled by men
feudalism	a social/political system under which an elite owns land while peasants farm it, often in exchange for protection and a share of the crops and/or livestock produced	protectionism	a policy that shields a country's domestic-based industries from foreign competition by taxing imports
free market	an economic system in which prices are determined by unrestricted competition between privately owned businesses	purchasing power parity (PPP)	a technique used to determine the relative values of different currencies
import substitution	an economic policy that involves replacing foreign imports with domestic production	socialism	the political and economic theory of social organisation that holds that the means of production, distribution and exchange should be owned or regulated by the community as a whole
mixed economy	an economic system in which both the private sector and the state play a role in the economy, reflecting characteristics of both market-based economies (capitalism) and planned economies	socio-economic	relating to or concerned with the interaction of social and economic factors
monsoon	a seasonal wind in the South and South-East Asian region, which blows from the south-west between May and September, bringing rain (the wet monsoon), and from the north-east between October and April (the dry monsoon)	urban decay	the deterioration of the built environment when urban infrastructure falls into a state of disrepair and buildings are left empty for long periods of time

16.0 Boys painted up to celebrate Holi festival, an ancient Hindu religious festival also known as the festival of colours or the festival of love, India, 2010

India: An emerging economic giant

The economy

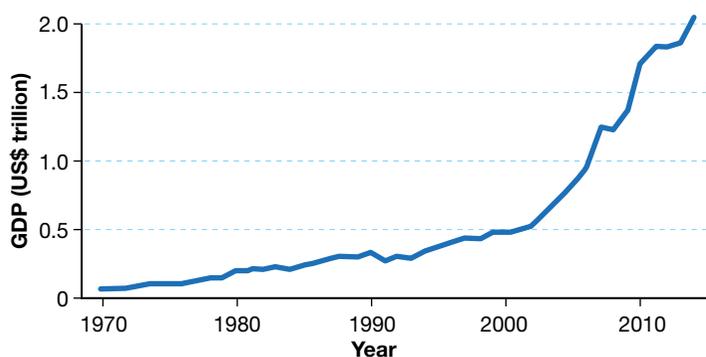
In the period from independence (1947) to 1991, India embraced a **mixed economy** model of economic development that combined features of both **capitalism** and **socialism**. State-owned enterprises, **protectionism** and **import substitution** were features of the country's development policy and practice. In 1991, India embraced a more liberal, **free-market** model of economic development, with the government investing heavily in the infrastructure needed to promote economic growth. Economic growth rates increased, as did per capita income.

Economic growth rates

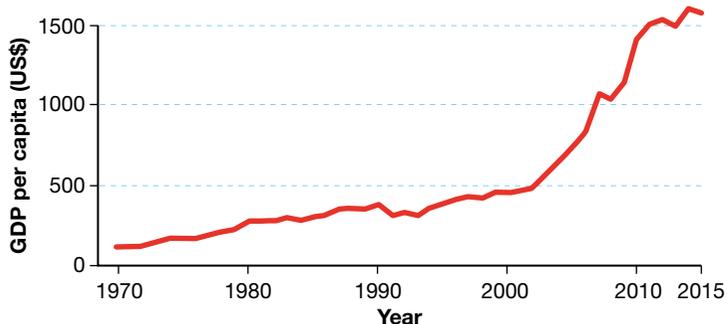
India's annual GDP growth rate peaked in 2010 at 10.5 per cent before declining sharply to 6.3 per cent in 2011, 3.2 per cent in 2012 and 4.4 in 2013, and then increasing to 7.3 in 2014–15. Figure 16.1.1 outlines India's annual growth in GDP since 1970. GDP per capita grew from US\$114.40 in 1970 to US\$455.44 in 2000 and US\$1581.15 in 2015, as shown in Figure 16.1.2. India's engagement in international trade has also increased. In 2011–12, foreign trade grew by 30.6 per cent.

Today, India's economy is the world's tenth largest. Ranked on a GDP per capita basis, however, it is 140th. With a population growth rate of 1.2 per cent, improving GDP per capita is a

16.1.1 India's growth in GDP in US dollars, 1970–2014



16.1.2 India's growth in GDP per capita, 1970–2015

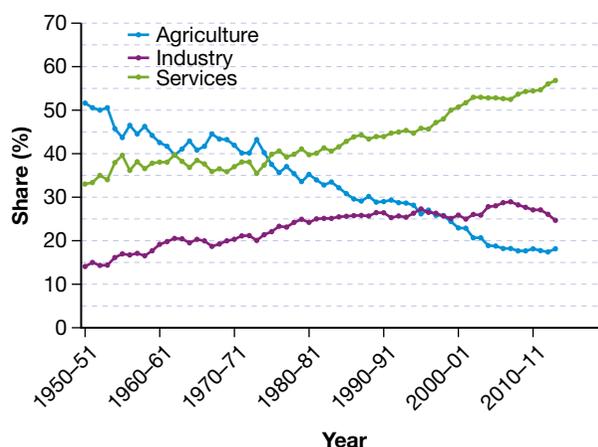


significant challenge. Unemployment is relatively high at 7.3 per cent (2014), and India's central government debt stands at 48.4 per cent of GDP, which is the highest among emerging economies such as China, Brazil and Russia.

Changing composition of economic activity

Figure 16.1.3 outlines the major structural changes in the Indian economy, especially in terms of the contribution made by the different sectors of economic activity to the country's GDP. Agriculture has declined as a share of economic activity, while industry and services have grown. The greatest growth has been in the provision of services, which now account for more than 50 per cent of all economic activity.

16.1.3 Sectoral composition of GDP in India, 1950–2014



Qualitative indicators

Qualitative indicators reveal India's development challenge.

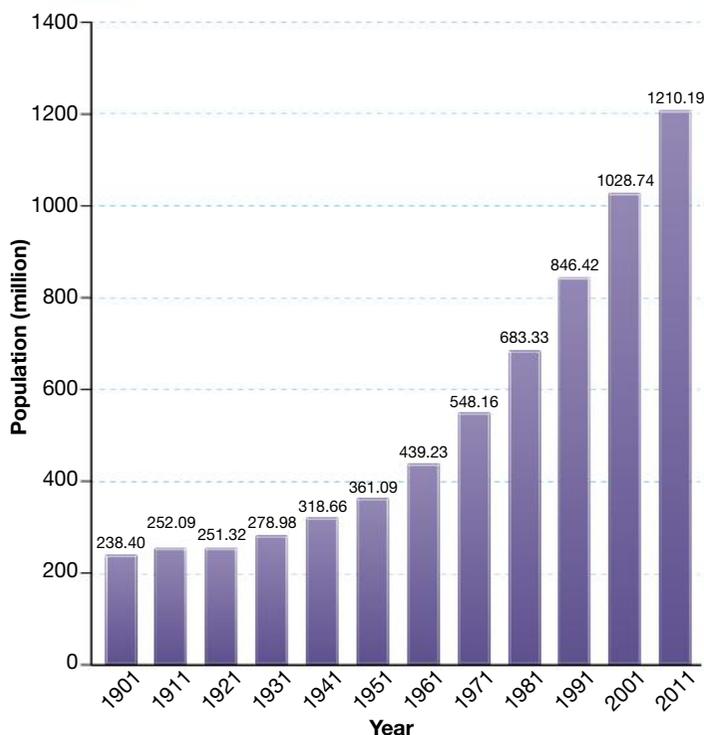
- Life expectancy is 66.2 years.
- Mean length of schooling is 5.1 years.
- Gender Inequality Index score is 0.563, rank 130.
- Human Development Index (HDI) score is 0.609, rank 130.
- Inequality-adjusted Human Development Index (IHDI) value is 0.435, rank 99.

The extent to which the IHDI falls below the HDI is an indicator of the inequality still evident in Indian society. Other indicators also highlight the challenge India faces. For example, a 2011 survey conducted by India's Central Pollution Control Board showed that just 160 out of nearly 8000 towns had sewerage systems and sewage treatment plants. Over 600 million Indians lack even primitive toilet facilities.

The population

Figure 16.1.4 shows the decade-by-decade increase in India's population since 1901. Despite the increase, the fertility rate has decreased, from over 6 children per woman in 1960 to 2.3 in 2015. The decline in fertility has been attributed to increased female education participation rates, urbanisation and rising standards of living.

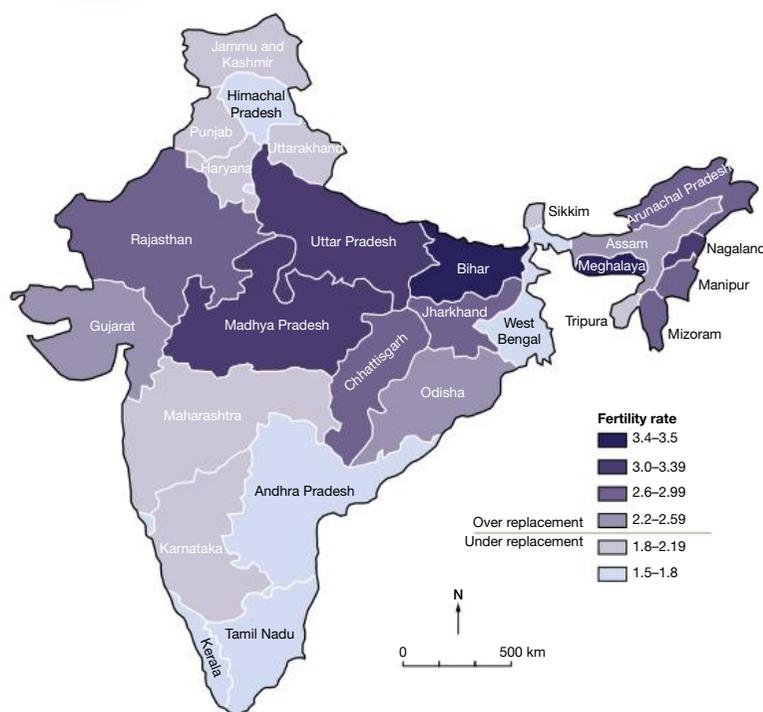
16.1.4 Decadal growth in India's population, 1901–2011



Source: India Population Commission

India's population growth is not uniform throughout the country. Figure 16.1.5 shows that the rate of fertility differs throughout the country; consequently, population growth also varies throughout the country. Fertility rates are still relatively high in India's Hindi-speaking heartland, but below replacement level in the south.

16.1.5 Fertility rates in India, by state and territory, 2012



ACTIVITIES

Knowledge and understanding

- 1 Outline the changes in the approach to economic development in India since independence.
- 2 Outline the evidence that India has a relatively high level of inequality.
- 3 List the reasons given for the decline in fertility rates.
- 4 Explain why the proportion of the population under the age of 15 years is important in terms of future population growth.

Geographical skills

- 5 Study Figure 16.1.1. Using data from the graph, describe the trends apparent in India's GDP since 1980.
- 6 Study Figure 16.1.2. Estimate India's per capita GDP in 1980, 1990, 2000 and 2015. Describe the changes that took place in the rate of growth over this 35-year period.

- 7 Study Figure 16.1.3. Using data from the graph, describe the changes in the relative contribution of each sector of economic activity to India's GDP in the period 1960–2010.
- 8 Study Figure 16.1.4. Using data from the graph, describe the trends in India's decadal population growth.
- 9 Study Figure 16.1.5. Identify the states with the highest and lowest fertility rates. Outline the overall spatial pattern of fertility.

Investigating

- 10 Using the internet, find the most recent Indian GDP and GDP per capita data available. Update Figures 16.1.1, 16.1.2 and 16.1.3. Investigate the reasons for the trends identified.

Patterns of human wellbeing

Variations in human wellbeing

There are great variations in the wellbeing experienced by people across India. These differences have both spatial and social dimensions. In other words, how Indians live depends, to a large extent, on where they live and their social circumstances.

Spatial variations in human wellbeing

Economic growth and development have been most rapid in India's southern, western and north-western states, while the north-central, central and eastern states have experienced deteriorating **socio-economic** standards. This economic and social difference is a legacy of India's socio-economic, political and cultural complexity.

Historical influences

Historically, some states were more prosperous than others, resulting in variations in socio-economic development across the various regions of India. The south and the west of India have traditionally been much more affluent than the north and the east. Also, the various invasions experienced by the north (including those of the Greeks and Mongols) held back the developmental prospects of the region for centuries. The north was also the part of the country that suffered the most exploitative aspects of British colonialism, a legacy that continues to be reflected in the regional socio-economic polarisation: the southern and western regions achieve advances in human wellbeing, while the north and east struggle to deliver improvements in people's quality of life. The south largely escaped the disruptive impacts of invasion and colonialism, and has less poverty.

Economic policy after 1991

The economic and development policies pursued by the Indian government after 1991 have tended to reinforce existing patterns of spatial inequality. This is because the economic growth that resulted from the policy change has been focused in particular regions. While western states such as Maharashtra and Gujarat, and southern states such as Andhra Pradesh and Kerala, are making progress in reducing poverty and raising living standards, India's northern states, especially Uttar Pradesh, and eastern states, including Bihar and Odisha (formally Orissa), are among the country's poorest.

Andhra Pradesh is an example of a state that has benefited from the shift in economic policy. It is one India's most developed states, with a booming information technology industry based in its capital city, Hyderabad. There has also been an effort to develop the state's rural areas. As a result, it has been able to lower its poverty rate to 9 per cent, well below the India-wide average of 22 per cent. By way of contrast, in Odisha, a state in which corruption is widespread, the poverty rate is 33 per cent. This can, at least in part, be explained by the entrenched culture of **feudalism** found in rural areas.

While India has experienced relatively high rates of economic growth over the past decade or so, many minorities (and regions) appear to have been marginalised by the policies.

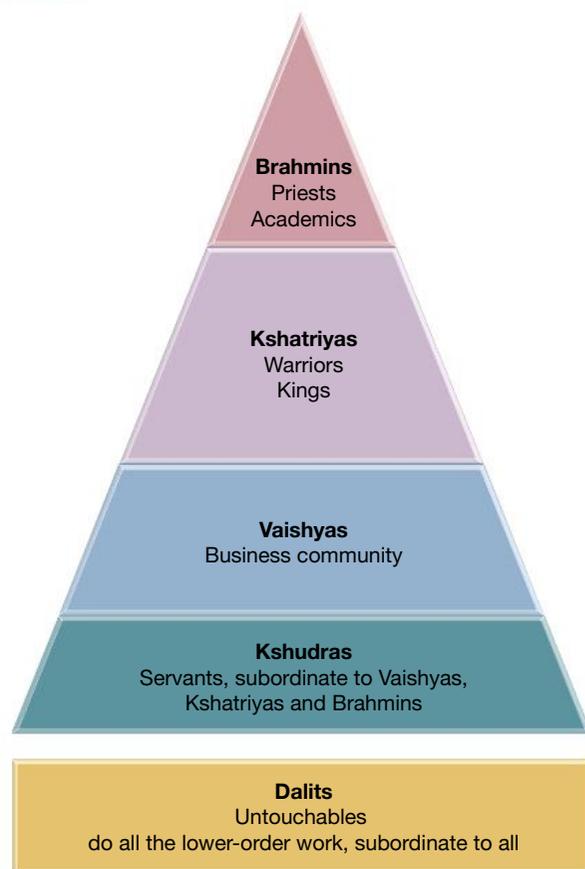
Social patterns in human wellbeing

Since 1991, India has focused on the promotion of corporate services such as telephony and ICT rather than on developing the country's manufacturing base. As a result, large segments of the Indian population have been excluded from the development process. In opening its markets to global competition, India's small-scale self-employed population (a large percentage of whom are Muslims) has been especially disadvantaged. As a result, one-third of the 200 million Muslims living in India continue to live below the poverty line. More generally, the top 5 per cent of Indian households own 38 per cent of total assets, while the bottom 60 per cent own just 13 per cent (see Figure 16.2.1).

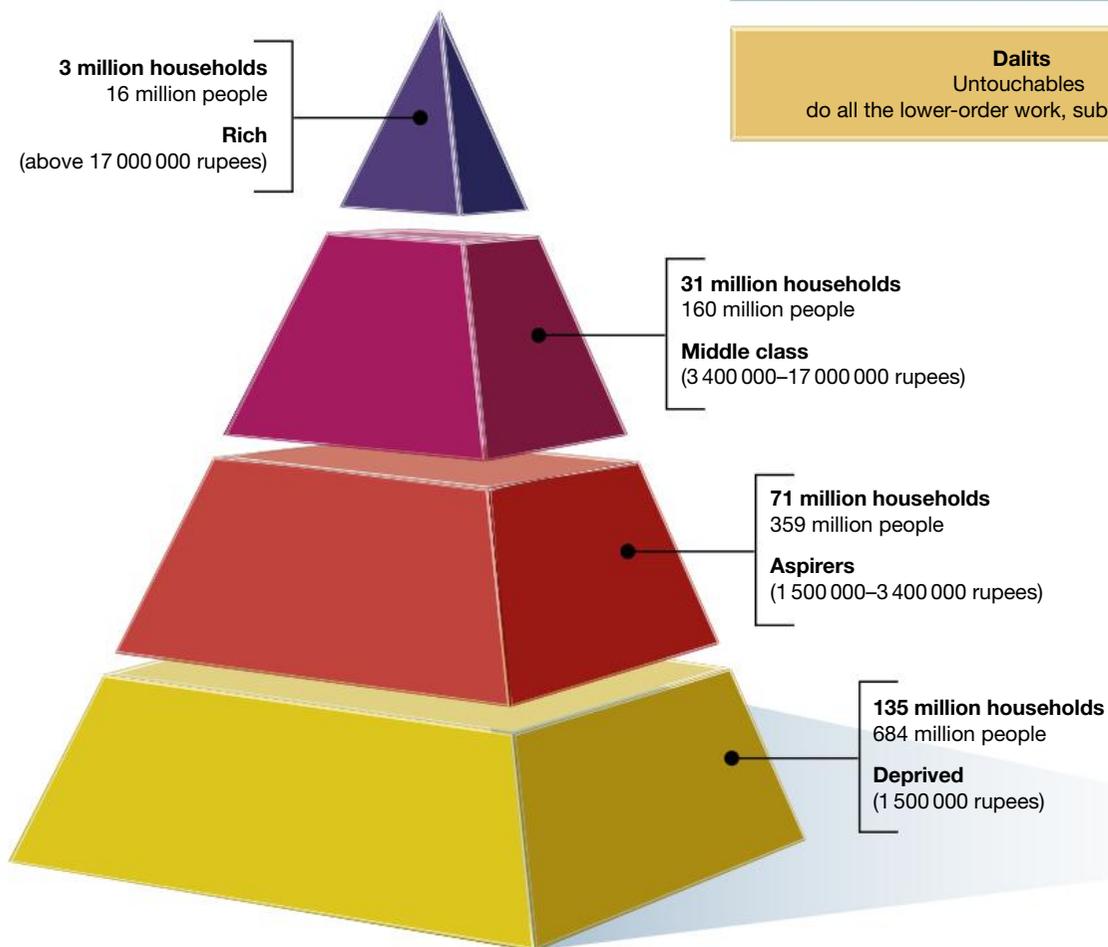
India's caste system still casts a shadow over the lives of many Indians, especially those of the Dalit caste (the untouchables). Dalits are at the bottom of the Hindu caste system (see Figure 16.2.2). Despite laws to protect them, they still face widespread discrimination in India. While India's constitution bans the practice of untouchability—members of India's higher castes will not touch anything that has come in physical contact with the Dalits, the lowest caste—the practice is still widespread. Examples of discrimination include the local barber refusing to cut the hair of a Dalit man, a group of children being forced to eat lunch separately from their classmates, and a woman who is required to walk for hours to fetch water because she is not allowed to use the public tap in her village. Very few people manage to break out of the cycle of poverty and caste that they are born into. Untouchability helps to lock Dalits, who traditionally do the dirtiest manual jobs, in their occupations.

Caste still shapes the way the India is run. The Indian government and bureaucracy are dominated by the upper castes and the caste system helps to explain why 15 per cent of the population is kept on the very margins of society by the circumstances of their birth.

16.2.2 Indian caste system



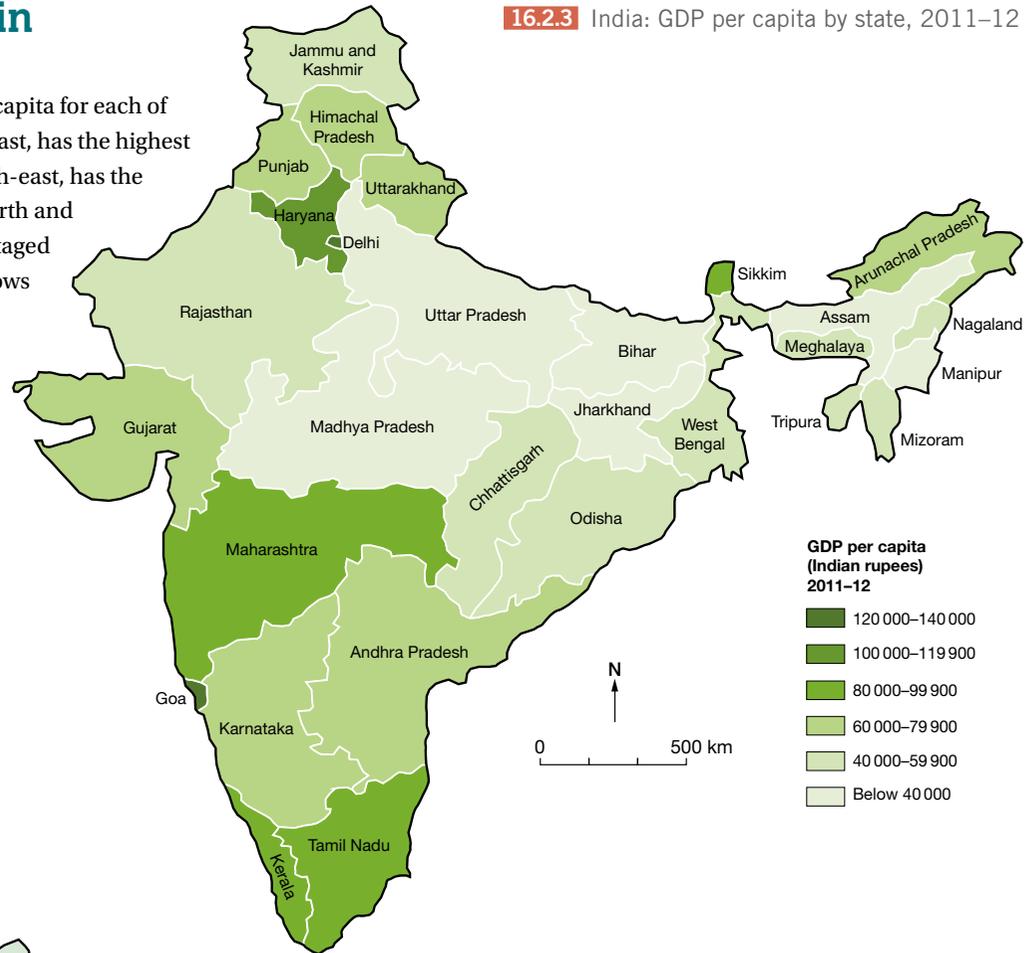
16.2.1 Household income pyramid, 2012



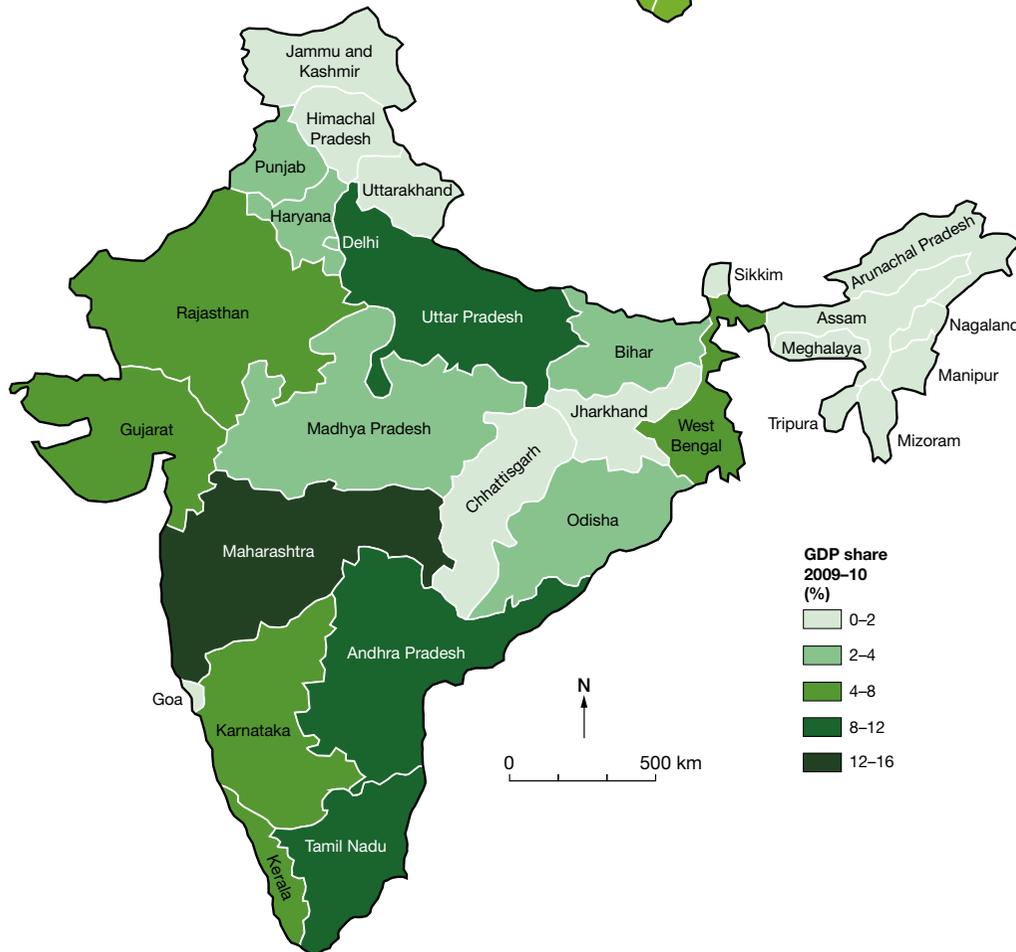
Spatial patterns in GDP

Figure 16.2.3 shows the GDP per capita for each of India's states. Goa, on the west coast, has the highest GDP per capita. Bihar, in the north-east, has the lowest. Generally, states in the north and north-east are the most disadvantaged on this measure. Figure 16.2.4 shows that states such as Maharashtra, Uttar Pradesh, Andhra Pradesh and Tamil Nadu dominate India's economy in terms of their share of total GDP.

16.2.3 India: GDP per capita by state, 2011–12



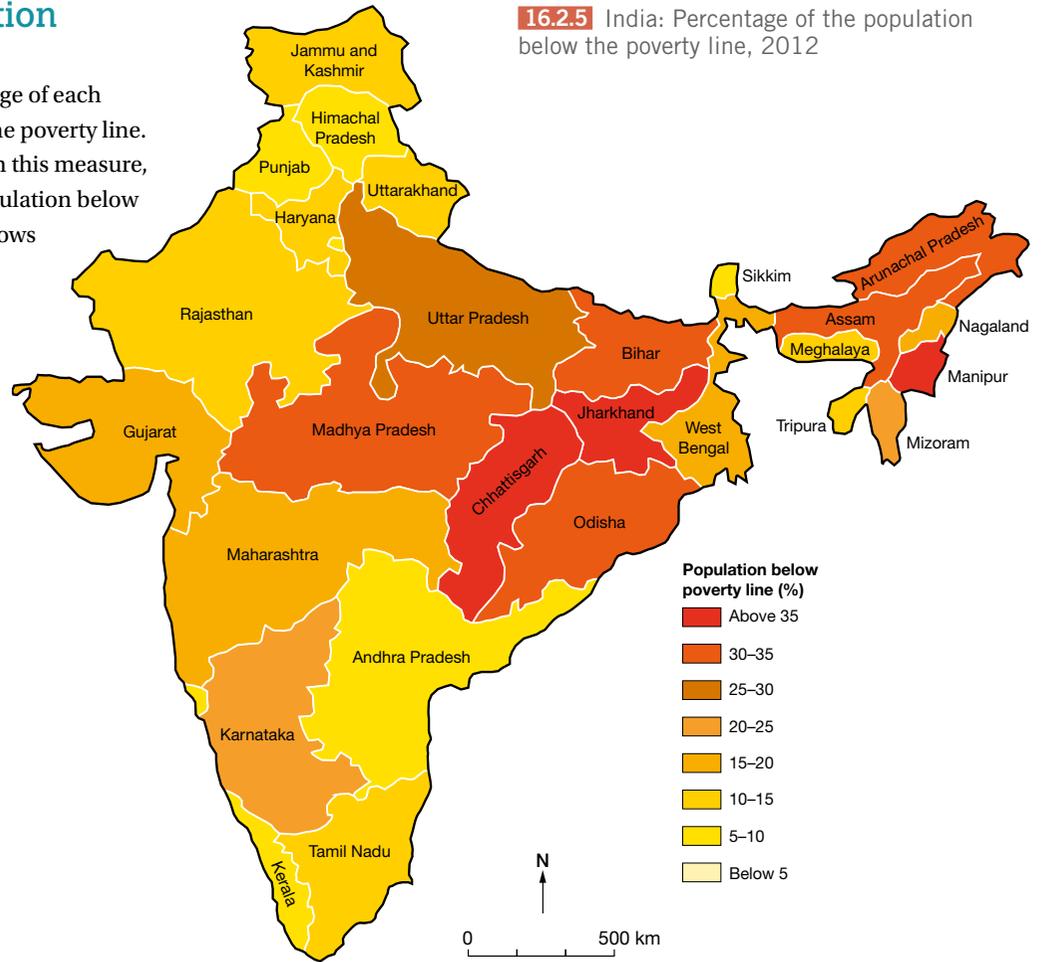
16.2.4 Share of India's GDP by state, 2009–10



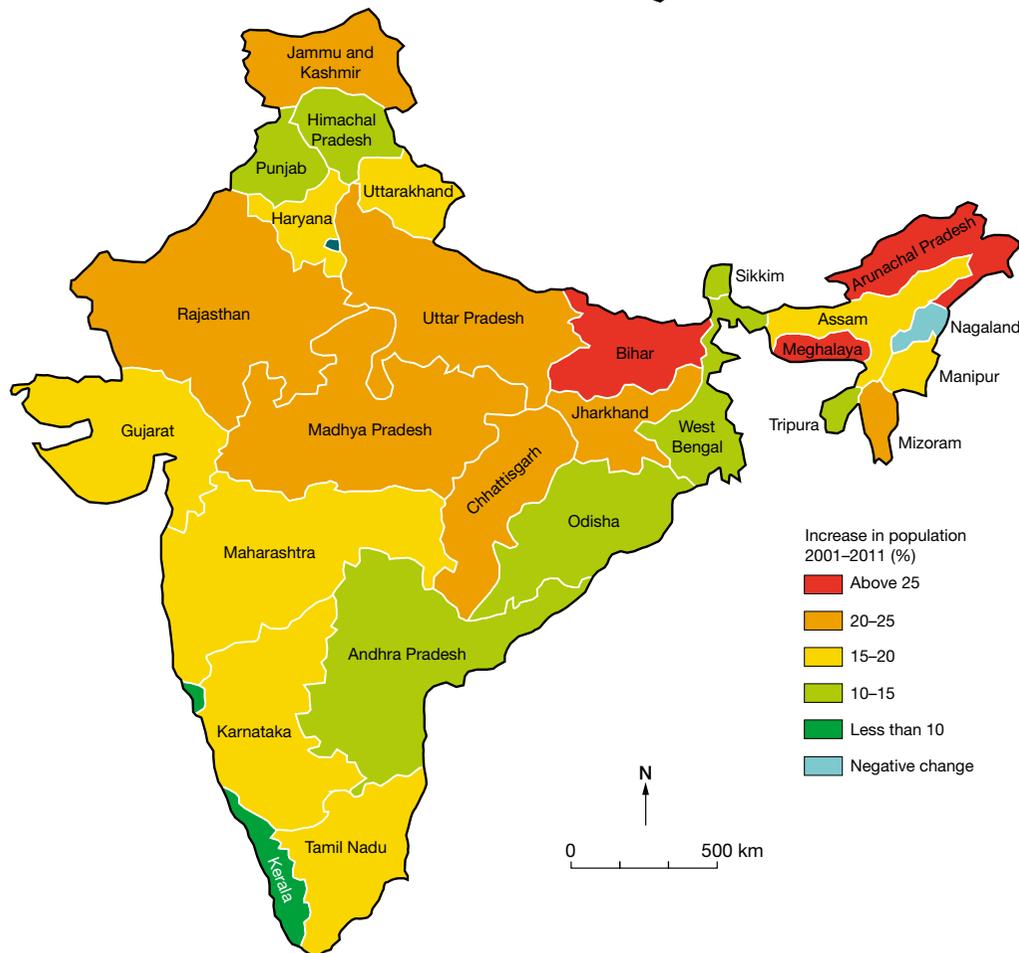
Poverty and population increase

Figure 16.2.5 shows the percentage of each state's population living below the poverty line. Chhattisgarh is the worst state on this measure, with nearly 40 per cent of its population below the poverty line. Figure 16.2.6 shows population increase by state.

16.2.5 India: Percentage of the population below the poverty line, 2012



16.2.6 Spatial variations in population growth, 2001-11





16.2.9 Students in a government-run school in a slum area on the outskirts of Jammu

ACTIVITIES

Knowledge and understanding

- 1 Describe the general spatial pattern of economic growth and development in India.
- 2 Identify the historical influences on the pattern of wellbeing in India.
- 3 Outline the consequences of the economic and development policies pursued by the Indian government after 1991.
- 4 State the impact of India's approach to economic development on the small-scale, self-employed population.
- 5 Outline how the caste system continues to cast a shadow over the lives of many Indians.

Geographical skills

- 6 Study Figure 16.2.1. Using the data shown in the income pyramid, describe the distribution of household income in India.
- 7 Study Figure 16.2.3.
 - a Identify the Indian states with GDP per capita of 60 000 rupees and above.
 - b Describe the distribution of these states.
- 8 Study Figure 16.2.4.
 - a Identify the Indian states that each account for more than 8 per cent of India's GDP.
 - b Which state has the greatest share?
- 9 Study Figure 16.2.5.
 - a Identify the states with more than 20 per cent of their population below the poverty line.
 - b To what extent does the pattern reflect the spatial pattern shown in Figure 16.2.4?
- 10 Study Figure 16.2.6.
 - a Identify the regions of India that show the greatest rates of population increase in the decade 2001–11.
 - b Which regions experienced the lowest rates?
- 11 Study Figure 16.2.7.
 - a Describe the general pattern of life expectancy.
 - b To what extent does the pattern of life expectancy reflect the spatial pattern shown in Figure 16.2.5?
- 12 Study Figure 16.2.8.
 - a Name the states in which female literacy rates are the lowest.
 - b How do these compare with the pattern of disadvantage shown in Figure 16.2.5?
 - c Explain the relationship between the two indicators of human wellbeing.

Contrasts in human wellbeing

Barriers to development

There is a range of barriers to the development of India's states. Some of the most significant of these are climate-related natural hazards, terrorism, corruption, communal unrest and the status of women.

Climate-related natural hazards

Natural disasters in India, many of them climate-related, hamper efforts to combat poverty and enhance human wellbeing. Droughts, flash floods, cyclones and landslides brought on by torrential rains pose the greatest threat.

Flooding is the most common natural disaster in India (see Figure 16.3.1). The heavy south-west monsoonal rains cause the Brahmaputra and other rivers to overflow their banks, flooding surrounding areas. The floods can kill thousands and displace millions. The **monsoon** rains, especially when excessive or early, may ruin crops.

Most of India receives a high level of rainfall. As a result, almost all of India is flood-prone, and flash floods and torrential rains have become increasingly common in central India in recent decades, coinciding with the rising temperatures linked to global warming.

16.3.1 India's monsoons often bring widespread and destructive flooding.



India's geographical position also means that it is affected by tropical cyclones. These disrupt the lives of millions of Indians living in coastal areas. Tropical cyclones are particularly common in the northern reaches of the Indian Ocean in and around the Bay of Bengal. Cyclones bring heavy rains, storm surges and winds, which often isolate affected areas. In the North Indian Ocean Basin, the cyclone season runs from April to December, with peak activity between May and November.

Terrorism

Development is hindered in places affected by internal and external social and political instability. From time to time, tensions arise with both China and Pakistan. India is also facing a growing number of home-grown threats, which are potentially more serious than cross-border disputes.

Terrorism in India can be categorised as either external or internal. External terrorism emerges from neighbouring countries; internal terrorism emanates from religious or **communal violence** and political and/or economic factions.

Since the partition of India and Pakistan in 1947, there has been conflict over the state of Kashmir. Kashmir, a predominantly Islamic state, is part of India, where the majority of people are Hindus. Extremist terrorist groups, especially the Kashmiri separatist forces operating from bases in Pakistan, have often targeted Mumbai. For example, in 2008 Mumbai was attacked and 164 people were killed over a period of four days at twelve locations.

The cost of maintaining the security force need to safeguard against such attacks is a major drain on Indian finances and diverts resources from development-based initiatives.

Corruption

Corruption involves a lack of integrity or honesty, and usually takes the form of bribery. Corruption, like terrorism, eats away the country from the inside. Corruption has been deeply entrenched in India's bureaucratic and political system for decades. Some politicians and bureaucrats have amassed a great deal of private wealth, much of it 'black money', which has been deposited, untaxed, in overseas accounts. This form of corruption results in a significant loss of revenue. Estimates put the loss of taxable income at US\$420 billion over the past decade. Levels of corruption vary across India.

Communal unrest

Tensions can arise between India's cultural and ethnic groups. Hundreds of people are killed each year in religious-based violence between Muslims and Hindus. Figure 16.3.2 shows police arresting rioters in Hyderabad during communal violence between Hindu and Muslim mobs.

16.3.2 Riot police arrest, Hyderabad



Status of women

Indira Gandhi became India's first female prime minister in 1966, and today a number of women hold high office in politics and business. Many sport and business leaders are women, and a generation of newly empowered young women are going out to work in large numbers. However, many women in India still face prejudice, violence and neglect. India has a gender-based imbalance in the population due to female foetuses being aborted and baby girls killed after birth. It is estimated that about 12 per cent of females disappear at birth, 25 per cent die in childhood, 18 per cent die during the reproductive years, and 45 per cent die at older ages.

Deeply entrenched **patriarchal attitudes** and widespread **misogyny** in many parts of the country need to be addressed to raise the status of women.

Human wellbeing in India's states

Odisha

Odisha (formerly Orissa) is located on India's east coast on the Bay of Bengal. While some economic progress is evident, the state remains one of the country's poorest.

Nearly a third of the state's population lives below the poverty line and the infant and maternal mortality rates are some of the highest in the country. Forty per cent of all children under 3 years of age are underweight. Orissa also has India's second highest proportion of scheduled caste and tribal people.

Tribal communities constitute almost half of the state's poor. The literacy rate in these communities is one of the lowest in the country.

16.3.3 India's states



Agriculture and agriculture-related industries are Odisha's main form of economic activity and employ about 76 per cent of the total working population. Raising the living standards of those in rural areas is a major challenge.

The state's developing industries are largely based on its mineral reserves. Odisha accounts for a fifth of India's coal, a quarter of its iron ore and a third of its bauxite. Also important is the development of the information technology sector. Strategies to promote industrialisation include the upgrading of transport infrastructure: road networks, an international airport at Bhubaneswar, major ports and a rail network connecting the state to the rest of India.

Floods and cyclones are the main obstacles to Odisha's development, as many of the most populated areas are situated near the Bay of Bengal.

Bihar

Bihar is located in north-eastern India. It is one of the country's poorest states, lagging behind others in terms of social and economic development. Corruption is widespread and presents a major hurdle for improvements in human wellbeing. Rapid population growth also makes it difficult to raise living

standards. Bihar, with a population of 103 million people, is India's third most populous state after Uttar Pradesh and Maharashtra. In the decade to 2011, the state experienced a 25 per cent growth in its population, which is among the highest in India; and with a fertility rate of 3.7, it is only going to increase further. Nearly 90 per cent of the population lives in the rural areas.

There are substantial variations in development across the state, with north Bihar lagging behind due to low agricultural productivity, poor irrigation facilities and high vulnerability to floods.

About a third of Bihar's population lives below the poverty line, which is much higher than the national average of 22 per cent. However, if factors beyond income are considered (for example in the Multidimensional Poverty Index, which takes health, education and living standards into account), about 79.3 per cent of the state's population lives below the poverty line. Poverty in Bihar results from low per capita landholding, a very small industrial base and limited opportunities in the service sector. Poor infrastructure and resourcing of social, health and education sectors compound the problems. Due to limited opportunities in the state, there is large-scale seasonal migration of farm workers to other parts of the country.

Bihar's performance on other human development indicators, such as health, education and sanitation, is also below the national average. For example, Bihar has the country's lowest literacy rates at 63.82 per cent. Adult illiteracy affects skill attainment and income potential. The percentage of underweight children is 55.9 per cent. Tube wells are the most important source of drinking water in the state, with nearly 91 per cent of the population dependent on them.

Terrorism is a major issue in Bihar. Various insurgency groups frequently attack local police and politicians. Poor governance and the law and order system in the state have helped increase the disruption caused by such groups. Bihar has witnessed many massacres by terrorist groups.

Maharashtra

Maharashtra is India's wealthiest state and its second most populous after Uttar Pradesh. Maharashtra accounts for 18 per cent of the country's industrial output and 13.4 per cent of its GDP. The state's GDP per capita is more than 83 400 rupees per person per year, more than three times that of Bihar and 40 per cent greater than the all-India average. Only 17 per cent of its people live below the poverty line, compared with the all-India figure of 22 per cent. Mumbai, the state's capital, is India's largest city and its financial capital. The city houses the headquarters of India's major corporate and financial institutions.

Most of the state's industrial enterprises are clustered around Mumbai. The main industries are chemicals, processed foods, refined petroleum, machinery and equipment, textiles, basic metals, pharmaceuticals and motor vehicles. The service sector also makes an important and expanding contribution to the state's economy. About two-thirds of the population is rural and lives in villages. Fifty-five per cent of people are dependent on agriculture for their income.

The government of Maharashtra actively seeks industrial investments from domestic as well as foreign institutions. It has invested heavily in the infrastructure required to support economic growth.

Maharashtra, or more specifically Mumbai, is one of India's major cultural centres. Mumbai is the largest film production centre in India (often referred to as Bollywood), and one of the largest in the world.

Andhra Pradesh

Andhra Pradesh is India's fifth most populous state and one of its wealthiest. Agriculture is the backbone of Andhra Pradesh's economy. The state is known as India's 'rice bowl' and it is also the leading producer of cash crops such as tobacco, groundnut, chillies, turmeric, oilseeds, cotton, sugar and jute.

While Andhra Pradesh is one of the country's most industrialised states, manufacturing accounts for a small percentage of the state's income. Industries such as shipbuilding, aeronautics and the manufacture of electrical equipment, machine tools and drugs have clustered around Hyderabad and Vishakhapatnam.

The service sector of the state accounts for 43 per cent of the state's GDP and employs 20 per cent of the workforce. In recent years, Hyderabad has emerged as a major information technology centre. The city is now home to 1300 information technology firms, including Microsoft, Google, IBM, Yahoo, Dell and Facebook.

ACTIVITIES

Knowledge and understanding

- 1 Outline the climate-related hazards that affect development in India.
- 2 Describe the nature of terrorism in India and outline its impacts.
- 3 Explain how corruption detracts from the development potential of Indian states.
- 4 State how violence in India affects the country.
- 5 Explain how the status of Indian women hinders development.

Applying and analysing

- 6 **a** List the barriers to development identified in this unit and rank the impact these barriers have from the greatest to the least. Justify your ranking.
- b** Would you add any more barriers to the list? Explain.

Investigating

- 7 Select two Indian states, one relatively wealthy and the other poor.
 - a** Undertake research to complete the table below for the selected states. Include details for the four states discussed in this unit.
 - b** Investigate the developmental indicators and the factors either promoting or hindering development and efforts to promote human wellbeing.
 - c** Present your findings as a multimedia presentation.

	Odisha	Bihar	Selected poor state	Maharashtra	Andhra Pradesh	Selected relatively wealthy state
GDP per capita						
HDI score						
Inequality-adjusted HDI						
Fertility rate						
Life expectancy						
Child mortality rate						
Literacy rate						

Enhancing human wellbeing

Government-based initiatives

Governments set the policy framework that governs the ways economies operate and develop. The policies can either promote or hinder development. In recent decades, India's government has:

- created a large, well-educated workforce able to meet the needs of corporations investing in India (for example, the call-centre industry depends on speakers of English) and to provide valuable expertise in the area of research and development
- maintained relatively low wages that attract foreign and local investment into an economy that is now less centrally controlled and directed
- exploited a wealth of industrial and agricultural resources, which can provide raw materials for industries
- invested in transport infrastructure, including road, rail, ports and airports
- promoted a growing middle class, with disposable income to purchase locally made goods and services, such as computers and motor vehicles.

The Indian government has also put in place an ambitious Five-Year Plan (2012–17), India's twelfth such plan. The plan includes expensive infrastructure projects in water supply, energy expansion, manufacturing development, and transportation; rebuilt irrigation systems; new factories; new power plants; larger coal mines; modernisation of a substandard electricity grid; expansion of the national rail transport network, and more urban subways. The goals of the plan are to:

- keep annual economic growth above 7 per cent
- add tens of millions more citizens to the ranks of the middle class
- achieve these objectives in a way that significantly reduces the pressure that India's growth is putting on its water, land, air and mineral resources.

While human wellbeing has been enhanced by such policies and plans, not all people have experienced the benefits of economic growth.

DID YOU KNOW?

India's mobile subscribers totalled 980 million in 2015, with around 350 million of those users having a smart phone. Yet only around half of the population had access to proper sanitation.

Bringing electricity to India's rural poor

In 2015, India produced nearly 1106 billion kilowatt-hours of electricity, 65 per cent of which came from coal. However, almost 200 billion kilowatt-hours of power were lost due to the country's old and inefficient electricity grid. In other words, one-fifth of the electricity produced never reached the customer. Not only was the electricity wasted, so too were the billions of cubic metres of water used to generate the lost electricity, and hundreds of millions of tonnes of carbon were needlessly emitted. While this energy is wasted, four hundred million Indians, or one-third of the population, still live without electricity, according to the Indian government.

Rather than going to the expense of constructing expensive Western-style electricity production and distribution infrastructure, small, locally based energy projects are seen by many as the most effective response. India's latest Five-Year Plan promotes the idea of a decentralised power grid. This involves connecting homes, village by village, to local solar-powered installations (see Figure 16.4.1). Progress has, however, been slow. In 2012–13, 754 megawatts of solar-powered electricity were installed, compared with 1699 megawatts of wind energy generation and 60 000 megawatts of energy fuelled by coal and natural gas.

Transnational institutions aiding development

The World Bank and the United Nations Development Programme (UNDP) are two transnational institutions that work with people at all levels of society to drive and sustain the kind of development that enhances people's wellbeing. In 2014, the UNDP had forty-five projects across India, the main purposes of which were environment and sustainable development (38 per cent of funding), democratic governance (28 per cent) and poverty reduction (34 per cent). The World Bank currently funds seventy-eight development-related projects worth US\$23.6 billion.



16.4.1 Solar power can make a big difference to people's quality of life.

World Bank

WATER AND SANITATION PROJECTS

In early 2014, the World Bank entered into a US\$500 million agreement to improve rural water supply and sanitation services in four of India's poorest states—Assam, Bihar, Jharkhand and Uttar Pradesh. Support for the initiative dates from 1991. Since that time, the bank has contributed more than US\$1.4 billion, benefiting 24 million rural households in more than 15 000 villages. Such initiatives meet a real need. Only a third of India's households have access to tap water and domestic toilets.

OTHER PROJECTS

Other projects focus on the development of transport infrastructure, for example Mumbai's massive rail and road infrastructure development and state highway projects in Gujarat and Rajasthan. The bank also invests in education, with a US\$500 million project to increase access to good-quality secondary education. Watershed initiatives, coastal disaster risk management, AIDS control initiatives and low-income housing initiatives are also among the projects funded by the World Bank.

International NGOs

Given the immensity of the challenges faced by India, it is not surprising that the world's best known NGOs can be found operating throughout the country.

CARE International focuses on the most marginalised people through its large-scale projects in education, health and HIV/AIDS and emergency response. In particular, CARE focuses on empowering women and girls to improve their situations and to be leaders in the communities. CARE works with the poorest of the poor in more than 100 districts, in a total of eleven states across India.

Among the many initiatives of the Save the Children organisation is a network of 150 *balwadis* in northern Mumbai. These provide pre-primary education for children between the ages of 3 and 5 years, which helps build a strong foundation for the formal years of schooling. The children who attend the *balwadis* typically come from the slum communities. They have very limited access to clean water and sanitation facilities. Most of these children are first-generation learners from families on very low incomes.

Indian-based NGOs

India has thousands of NGOs, ranging from those that work right across India to those that work at local levels. For the most part, these bodies are effective in reaching the most marginalised and vulnerable people in Indian society. Programs include working with other organisations to build canals (see Figure 16.4.2). The Bharatiya Agro Industries Foundation (BAIF) is one such NGO. Founded in 1967, the foundation seeks to promote sustainable living in rural India.

Enhancing the wellbeing of Khondla's farmers

While Indian authorities are slow to recognise it, enhancing human wellbeing begins in villages such as Khondla, in the state of Chhattisgarh. In the village, some 336 kilometres to the north of Raipur, the state's capital, the BAIF is working with rice farmers to design and develop a low-cost irrigation and water conservation project. The Indian-based NGO's environmental objective is to recharge the area's groundwater reservoirs, which local farmers say have been declining in recent years. The project includes all the village's farmlands and all 300 farm families.

The NGO's social objective is to raise people's standard of living. The success of the initiative is being measured in terms of larger harvests and increased crop yields. Small dams, channels and gravity are used to capture the rainfall that pours off the surrounding ridge and distribute it to the village's rice paddies (see Figure 16.4.3). Farm incomes have grown as output and yields have increased.

The initiative highlights one of the key development issues in India—the struggle between local projects that are seen to make a difference to the lives of people living in the country's 600 000 villages, such as Khondla, and the very costly and complex industrial modernisation promoted by the national government.

The total cost of the BAIF project is just US\$160 000. It is an environmentally safe and relatively low-cost way of addressing the challenges of food production and water security.

Persistent inequalities

While some progress has been made in reducing poverty in India, significant inequalities still exist.

- According to the World Bank, India's poverty rate declined from 37.2 per cent of the population in 2005 to 29.8 per cent in 2010.

16.4.2 Canal project funded by the World Bank





16.4.3 Increased rice production has helped raise the standard of living for the people of Khondla, Chhattisgarh.

- If the percentage of the population living on US\$1.25 a day (**purchasing power parity—PPP**) is used as a poverty line, the decline has been from 41.6 to 32.7 per cent.
- If the percentage of the population living on US\$5.00 per day (PPP) is used, the reduction in poverty is a marginal decline from 97.3 per cent in 2005 to 96.3 per cent in 2010.
- In absolute terms, 394 million Indians lived in poverty in 2010, down from 469.3 million in 2005.
- The richest 20 per cent of Indians account for 52.81 per cent of income, while the poorest 20 per cent of people make do with just 8.54 per cent of income.
- In rural India, about 34 per cent of people live on less than US\$1.25 a day, down from 44 per cent in 2005.
- In urban India, 29 per cent of the population lived on less than US\$1.25 in 2010, down from 36 per cent in 2005, according to the World Bank.
- On a state-by-state basis, GDP per capita ranges from 192 652 rupees in the state of Goa and 175 812 in Delhi to just 24 681 in Bihar.

ACTIVITIES

Knowledge and understanding

- 1 Outline the government-based initiatives designed to promote development in India.
- 2 State the objectives of the Indian government's ambitious Five-Year Plan (2012–17).

Applying and analysing

- 3 Copy and complete the following table, assessing each NGO program on how it will benefit in the following areas.

Criteria	World Bank: Bringing electricity	Indian-based NGOs: Khondla's farmers	International NGOs: Water and sanitation
Environmental			
Economic			
Social			

Investigating

- 4 Using the internet, investigate the range of development-related initiatives funded by the World Bank in India. Select one of these to investigate in detail. Prepare a short written report, outlining the nature of the initiative and its impact on people's wellbeing.

Access to water in India

Water use

The demand for water in India is growing rapidly, driven by population growth and rising standards of living, at least for some. This demand, combined with the pollution of surface water, has resulted in increased groundwater extraction. As a result, water tables are dropping quickly and the situation is not sustainable. The link between water and food security and health in India means that urgent solutions are required.

Access to an improved water source

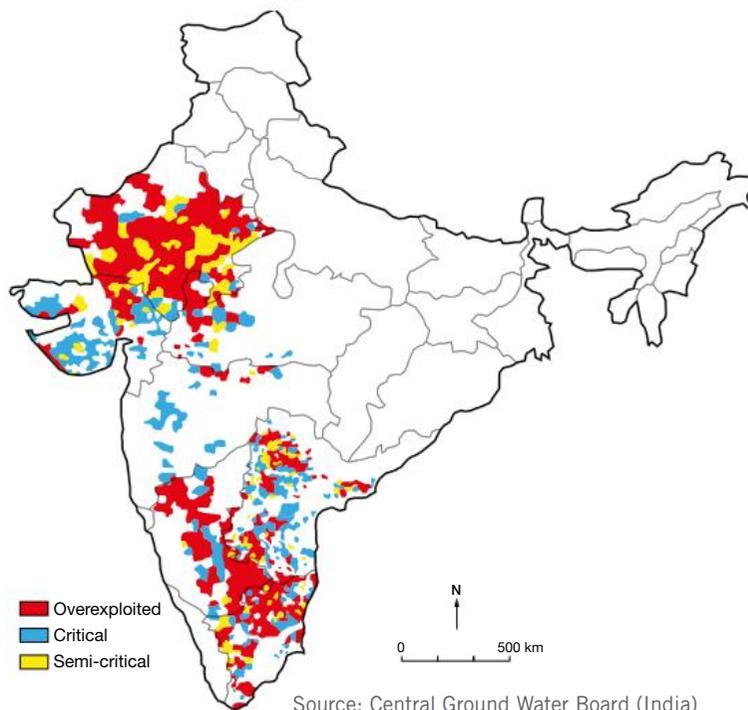
While 92 per cent per cent of Indians have access to an improved water source, only 25 per cent have it piped to their homes—the remainder obtain it from communal sources. These figures compare favourably with the figures on access to sanitation—only 35 per cent of Indians have access to sanitation. The difference in access to improved water sources and sanitation reflects the priority given to the construction of water-related infrastructure in the past. This is a significant improvement since 1990, when only 72 per cent had access to an improved source, and only 18 per cent had access to sanitation. In rural areas, where most Indians continue to live, 84 per cent have access to an improved water source, while only 21 per cent have access to sanitation.

Groundwater

Groundwater is a critical resource in India, accounting for over 65 per cent of irrigation water and 85 per cent of drinking water supplies. While the nation's average annual rainfall is high by world standards, much of it (up to 80 per cent) falls during the summer monsoon (that is, from early June to September) and is highly variable. The combination of these climatic conditions and a range of human-related pressures has driven India's households, farmers and industry to depend increasingly on groundwater rather than surface water.

A large proportion of India's surface water supplies are unsafe for drinking or farming—more than 70 per cent of India's surface water resources are polluted by human waste or toxic chemicals. Groundwater is widely seen as a safe alternative. This dependence on groundwater is leading to a rapid deterioration in the nation's groundwater resources, as is shown in Figure 16.5.1. It is estimated that 60 per cent

16.5.1 Groundwater supplies under threat in India



Source: Central Ground Water Board (India)

of the country's groundwater stores will be in a critical state of degradation within 20 years. Wells are having to be dug deeper and deeper as the water table is dropping by up to 33 centimetres a year in some places.

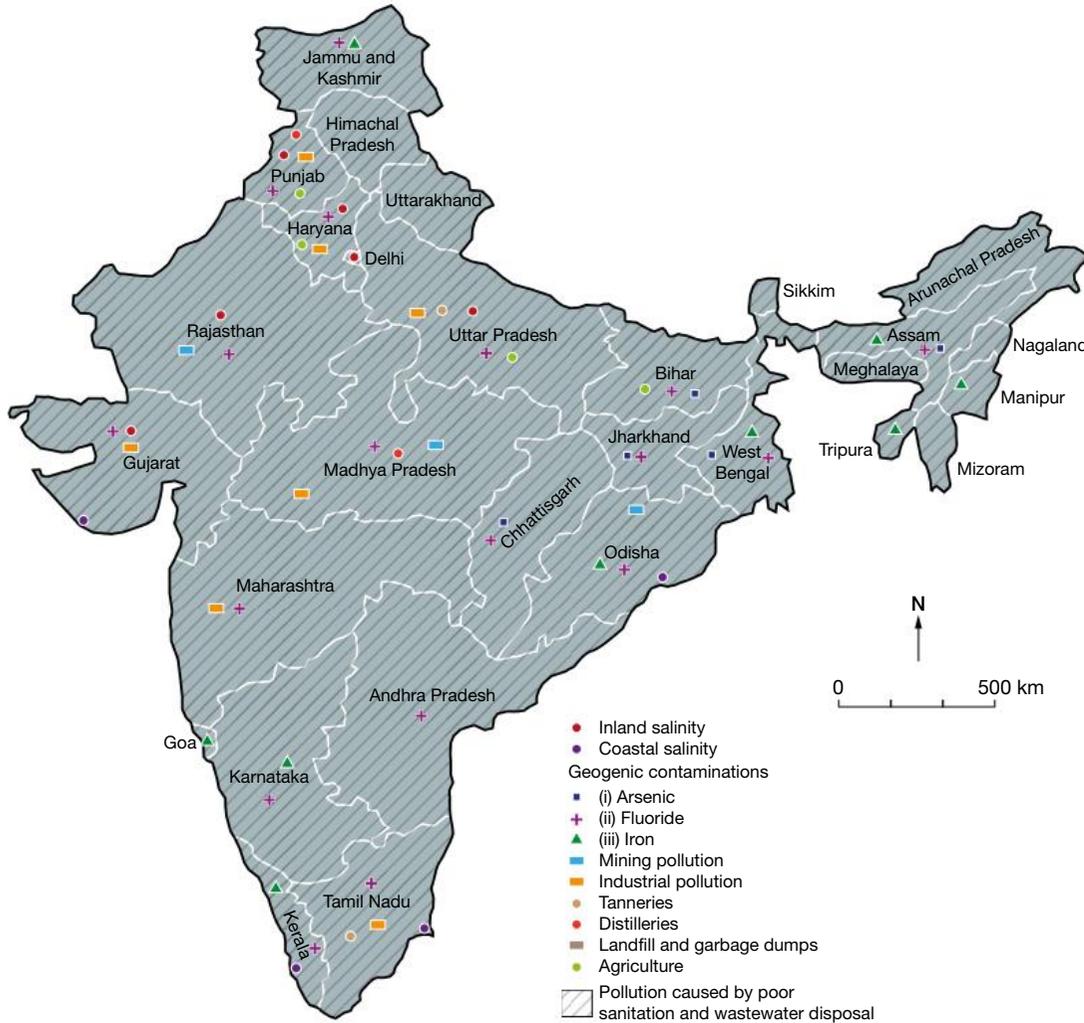
The decline in India's groundwater resources is due to a number of factors. Groundwater enables irrigated agriculture in areas located far from rivers. In urban areas, the water supply infrastructure is often poor and unreliable. As a result, well drilling is typically regarded as the most cost-effective way of obtaining household water. In Delhi, an estimated 40 per cent of the water transported through the mains system is lost through leakage. For many residents, the only alternative to bores is expensive supplies purchased from water trucks.

In rural areas, subsidised electricity makes it cheap for farmers to pump groundwater from wells. The low cost of the water encourages excessive water withdrawal and inefficient irrigation practices. In order to feed a growing and more affluent population, it is anticipated that agricultural water demand will double between 2014 and 2030.

Water contamination

As wells are drilled ever deeper, the water that is extracted often contains elevated levels of arsenic, fluoride and other harmful chemicals. Arsenic poisoning is now widespread in the lower Ganges River Valley. The health impacts include headaches, confusion, severe diarrhoea and drowsiness. As the poisoning develops, convulsions occur.

16.5.2 Groundwater pollution



When the poisoning becomes acute, diarrhoea, vomiting, blood in the urine, cramping muscles, hair loss and stomach pain may occur. Arsenic poisoning can ultimately result in a victim lapsing into a coma and dying.

Falling water tables can also result in contaminants entering the water table from external sources such as surface water polluted by sewage, agricultural fertilisers and industrial waste. Saltwater penetration is a problem in coastal areas. Figure 16.5.2 shows the extent of groundwater pollution in India.

ACTIVITIES

Knowledge and understanding

- 1 State why it is important that the issue of India's dwindling groundwater supplies is addressed.
- 2 Outline the level of access to improved water sources in India. How does this compare with access to sanitation? Why is there a difference?
- 3 Explain why India's groundwater stores are declining.
- 4 State why groundwater can be used as a substitute for surface water.
- 5 List the contaminants of groundwater and outline the health impacts of arsenic poisoning.

Applying and analysing

- 6 Discuss the challenge of providing access to improved sources of water for India's urban population. Is the provision of communal sources of water acceptable? Explain your answer.

Geographical skills

- 7 Study Figure 16.5.1. Describe the spatial distribution of groundwater supplies under threat.
- 8 Study Figure 16.5.2. Describe the spatial distribution of groundwater pollution.

Access to sanitation, Mumbai

Mumbai's slums

A project funded by the World Bank, the Mumbai Municipality Slum Sanitation Program, is bringing an improved quality of life to people living in slums of Mumbai. The city is home to 6.9 million slum-dwellers, who live in approximately 2000 slum areas spread throughout the metropolitan area. Fifty-four per cent of the city's population lives in such conditions.

Lack of sanitation infrastructure

During the development of Mumbai, the construction of sewerage infrastructure was given a lower priority than solid waste disposal, stormwater drainage and water supply. As a result, only a small area of the city has a sewerage collection and treatment system. Most of the city's slums are not serviced by sewer lines. In these areas, wastewater drains into septic tanks.

Mumbai's slums are, as a consequence, inadequately serviced by public or communal toilets. These facilities, constructed by

Maharashtra Housing and Area Development Authority or the city's water supply and sewerage department, typically do not have water or electricity connections, and are now mostly in poor condition due to the lack of maintenance.

As a result of their poor condition (see Figure 16.6.1), together with long queues, especially in the morning, many slum-dwellers defecate in the open. Women often prefer to defecate in the open instead of using the dirty toilets. Furthermore, men and women's toilets are often not separated. This reduces the sense of privacy and can lead to the harassment of women.

The 'pay and go' toilets provided by the city in places such as railway stations and bus stops are difficult for the poor to access because of the fee charged for their use (typically 2 rupees per person). The unsatisfactory processes involved in the collection and treatment of sewage within the slums results in the spread of disease and the degradation of the natural environment.

16.6.1 A men's public toilet in a slum in Mumbai, India



Mumbai Municipality Slum Sanitation Program

The aim of the Mumbai Municipality Slum Sanitation Program (MMSSP) is to improve the inadequate sanitary conditions in Mumbai's slum areas through the provision of communal toilet blocks.

The success of the initiative is based on community engagement. The participatory approach was a condition of the World Bank funding. The community has been involved in the planning, design, construction, operation and maintenance of the toilet blocks. Giving the slum-dwellers a sense of ownership and responsibility for the facilities is expected to improve the operation and maintenance of the toilet blocks.

The first phase of the project (completed in December 2005) involved the construction of 328 toilet blocks with more than 5100 separate compartments. These toilets were planned to serve the needs of 250 000 people, or 50 people per toilet cubicle. The second phase of the project aimed to add an additional 35 000 toilets. The community blocks are for the benefit of a specific community, not for public use.

Ninety per cent of the World Bank funding was directed towards the improvement of the centralised sewerage system (for example with additional treatment plants and extended sewer lines), while 10 per cent of the funding was used to build the communal toilet blocks, which averaged US\$1400 per block.

Communal toilets

Each block consists of a two-level structure built of reinforced concrete. It houses an average of ten to twenty pour-flush toilets that require half a bucket of water for flushing (see Figure 16.6.2). Most of the waste is directed to septic tanks when it is not possible to connect with a sewer line. Each has

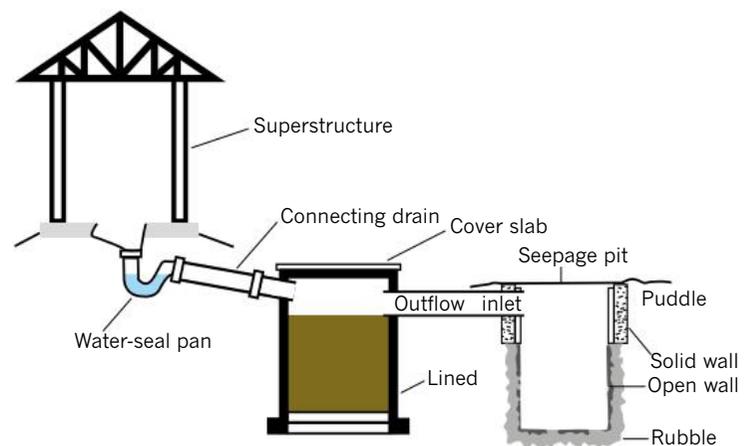
an overhead water tank and electricity. The blocks are open 24 hours a day. The sludge that is produced in the septic tanks is removed and carted away to dumping grounds by tankers. The liquids are taken out and disposed of into stormwater drains. Many of the blocks are not accessible by tankers due to the density of building and lack of open space for constructing access roads. In these areas, people have to take out the sludge manually.

To use the facilities, residents must either pay a monthly fee for a family pass or pay on a per-use basis. The money collected pays for cleaning and maintenance.

Project outcomes

The outcomes of the program include improved public health as a result of the improved sanitation facilities and the empowerment of slum-dwellers, who have been given a voice in the decision-making process. There is also an increased awareness of the importance of sanitation and personal hygiene. The human wellbeing of the city's slum-dwellers has been enhanced.

16.6.2 Pour-flush toilets are a relatively cheap response to the needs of people in unplanned urban settlements.



ACTIVITIES

Knowledge and understanding

- 1 Outline the nature of the sanitation issue in Mumbai.
- 2 Explain why Mumbai lacks the required infrastructure.
- 3 State the consequence of slum-dwellers not having access to communal toilets or being unable to afford to use 'pay-as-you-go' facilities.
- 4 Outline the approach to sanitation provision adopted by the MMSSP and funded by the World Bank.
- 5 Identify the social and environmental impacts associated with the MMSSP.

Applying and analysing

- 6 As a class, discuss the social and environmental advantages and disadvantages of communal toilet facilities such as those built under the MMSSP. Use this information to construct a mind map.
- 7 As a class, brainstorm why the construction of sewerage infrastructure, like that found in Australian cities, would be an impractical response to the sanitation needs of people living in Mumbai's slums.

Child exploitation in India

Forms of exploitation

India's challenges are many, but the exploitation of children is one of the more serious. All forms of modern slavery and exploitation are found in India, from severe forms of inter-generational bonded labour to the worst types of child labour, commercial sexual exploitation and forced marriage. Millions of Indian citizens are engaged in forced labour as a result of debt bondage, and people trafficking is widespread.

Cross-border migration

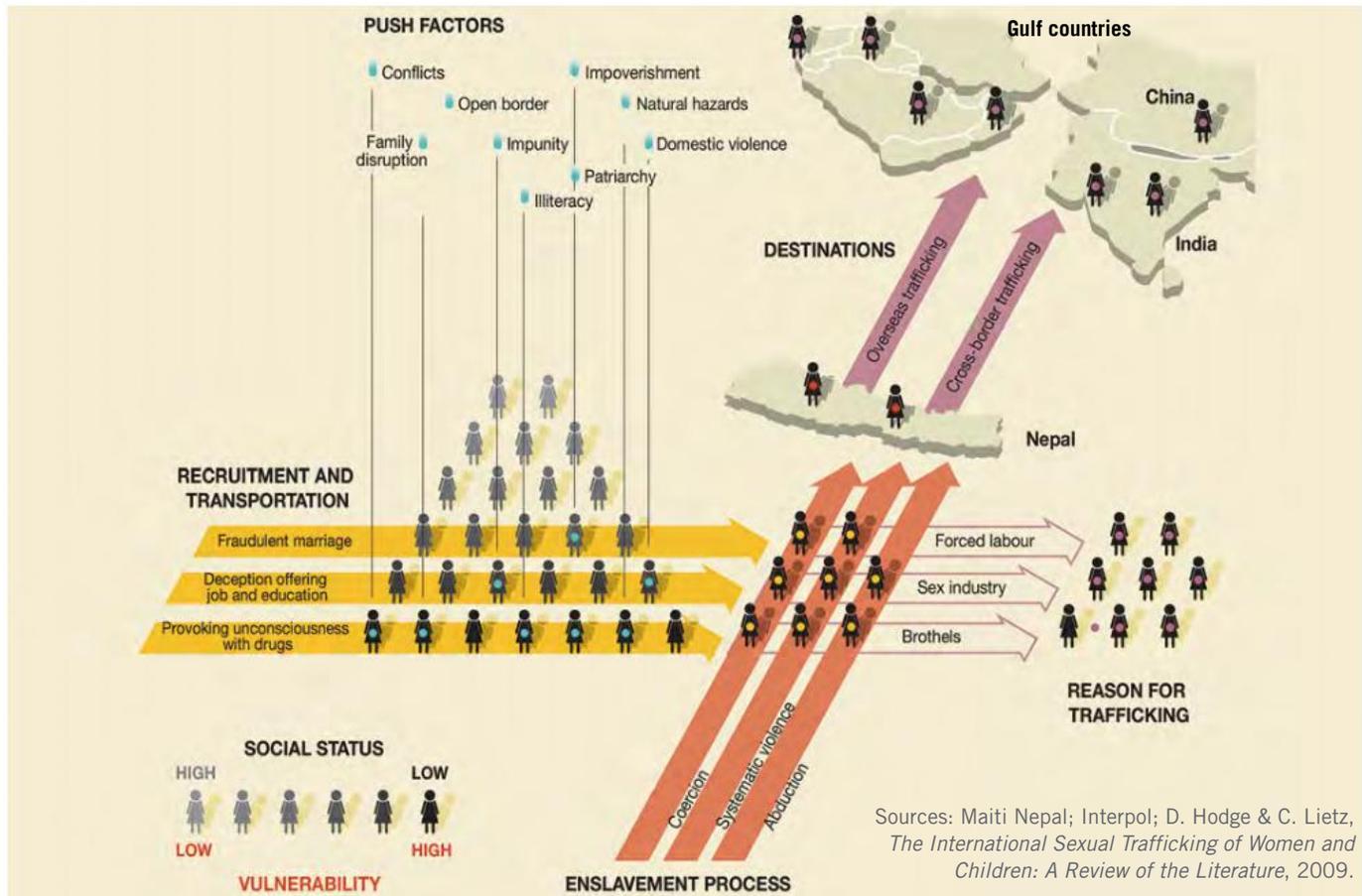
Cross-border migration occurs on a massive scale. Low-skilled migrant workers, many of them children, are at particular risk of exploitation. Large numbers of Nepali and Bhutanese migrants, who are exempt from Indian migration visa regulations, fall victim to recruiters and exploiters who take advantage of their vulnerability. Figure 16.7.1 outlines the

human trafficking patterns between Nepal, India and other countries, and the push factors involved.

People trafficking

Ninety per cent of trafficking in India is internal, rather than international. Some internal migrants are lured from poor rural communities to relatively wealthy cities by brokers on the false promise of employment. Trafficked men, women and children make up significant shares of the workforce in industries such as construction, textiles, brick making, mines, fish and prawn processing and hospitality. However, many of India's enslaved people have not moved from one place to another—they are enslaved in their own villages. Many are trapped in debt bondage to a local landowner or born into slavery because of caste, customary, social and hereditary obligations.

16.7.1 Patterns of human trafficking in Nepal



For people enslaved in their own area, corruption, land grabs and asset domination by high-caste groups leave them without protection. Government benefits such as the National Employment Guarantee, food rations, primary health care and pensions simply cannot be accessed because of the lack of effective public administration. Some enslaved people do not officially exist—they have no birth registration or identification documents—which makes it difficult for them to access entitlements.

Forced labour

Forced labour takes place in factories and on farms. It is especially common in brick making, leather tanneries, mining and quarrying, the textiles and garments industries, domestic work and forced begging. Bonded labour, whether through debt or other forms of 'bondage' of workers, is widespread in quarrying, brick making, construction and mining.

Sexual exploitation

The sexual exploitation of Indian children is widespread. Commercial sexual exploitation has traditionally taken place in specific areas, but is now more widely dispersed and is increasingly found in rural areas and at transport hubs, roadside restaurants and houses in suburban areas. Commercial sexual exploitation is increasingly arranged through the use of mobile phones, making it harder for authorities to locate and tackle.

Other forms of exploitation

Non-labour-based forms of modern slavery, such as forced marriage, illegal adoptions and organ trafficking, all occur in India. Forced marriage is partly a result of the gender imbalance in some parts of the country. Marriage brokers in states with the greatest shortage of women import young girls from poorer states. The girls are forced into marriages arranged by the broker in return for a fee. The low status of women and the widespread occurrence of domestic violence in Indian society put victims at risk of modern slavery. Commercial surrogacy, while legal in India, is a practice open to potential exploitation.

Causes of exploitation

Poverty and caste system

Poverty and India's caste system are the main causes of child exploitation in India. The World Bank estimates that almost 30 per cent of Indians live below the international poverty line of less than US\$1.25 per day. Indians most likely to be forced into slavery are those from the 'lower' castes (Dalits), and the indigenous communities (Adivasis), especially women and children.

SPOTLIGHT

Debt bondage (or bonded labour)

Debt bondage is a person's pledge of their labour or services (or that of their children) as repayment for a loan or other debt. The labour or service required to repay the debt may not be specified, and the duration of the bond may be undefined. Debt bondage can be passed on from generation to generation. Debt bondage was legally abolished in India in 1976, but remains widespread in practice.

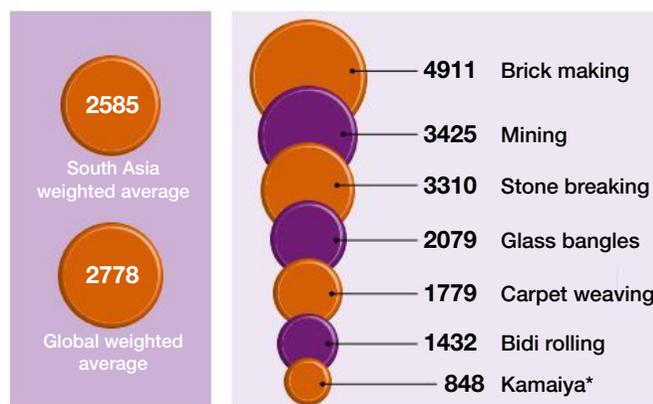
It is estimated that there are 18 to 20.5 million bonded labourers in the world. The majority live in four countries: Bangladesh, Nepal, Pakistan and India. Proposals to abolish bonded labour include:

- enforcing existing anti-forced-labour laws
- raising minimum wages
- enacting reforms that enable low-caste peasants to own land
- expanding financial credit to the poor
- opening new markets to labourers
- mounting public awareness campaigns.

Labour laws

It is difficult to collect data about the informal economy in India. Figure 16.7.2 outlines the estimated value of worker exploitation in South Asia, mainly India.

16.7.2 Estimated value of exploitation by industry in South Asia, 2011, US\$ (million)



*A system of bonded farm labour that was once common in Nepal and was banned in 2000

India has rigid labour laws and numerous regulations that prevent the growth of an organised sector in which work protections would be easier to monitor, and work more productive and higher paying. The unintended effect of India's complex labour laws has been the growth of the informal sector. After the agricultural sector, which employs 60 per cent of child labour, the informal manufacturing and retail sectors are the largest employers of child labour. The dominance of family-operated enterprises in the informal sector also encourages the exploitation of child labour.



Addressing exploitation

While India has ratified a number of key international conventions relevant to child exploitation, enforcement has been inconsistent. Bonded labour has been criminalised in India, under the Bonded Labour System (Abolition) Act since 1976, but enforcement has been weak. Amendments to the Penal Code in April 2013 criminalised all forms of human trafficking in accordance with the definition in the UN Trafficking Protocol. The amended Penal Code is broad enough to include most forms of forced labour, bonded labour and forced marriage. It remains to be seen whether the Penal Code will be used in this way.

Other recent actions give some hope that exploitation can be addressed. In October 2012, the Supreme Court issued a judgment requiring all states to carry out surveys to identify and release those in bonded labour. Other important Supreme Court interventions include mandating rural and urban local bodies to report cases of bonded labour to the District Magistrates, who are able to implement laws protecting the rights of the exploited. The enactment of the Protection of

Children from Sexual Offences Act in 2012 and the recent increase in activity of the National Commission for the Protection of Children's Rights are important measures that demonstrate the government's renewed commitment to fight the exploitation of children. There has also been a focus on brothel raids and the rescue of victims.

NGOs have also been active in supporting the exploited, and have campaigned for more effective government intervention (see Figure 16.7.3). Unfortunately, there have been reports of human rights defenders being targeted for their anti-slavery work. Attacks on activists, as well as victims, commonly occur when workers are assisted to leave the workplace at which they have been enslaved. NGOs also complain about the complicity or interference of government officials keen to avoid upsetting powerful slaveholders and traffickers. Some accept bribes to turn a blind eye to exploitation. The justice system is very slow generally, so victims have no confidence in its capacity to deliver a result. Penalties are small, especially compared with the profits being made.

SPOTLIGHT

Bonded child labourers, India

Ferozabad is the centre of the glass industry in India. Estimates of the number of children working in glass factories range from 8000 to 50 000—exact numbers are difficult to obtain. Anti-Slavery International estimates that 70 to 80 per cent of the children working in glass factories are bonded by debt incurred by their parents, usually on advances of loans. Most of the children belong to the landless agricultural sector, and are expected to continue working until their parents' loans are paid off.

The children, some as young as 8 years old, have to live at the factories and look after themselves.

Conditions in the factories are horrendous and workers do not wear protective work gear—no gloves, shoes or eyewear. The heat from the furnace can reach temperatures of 1400 to 1600 degrees Celsius and there is little ventilation. Injuries are commonplace, with cuts from broken glass and burns from the furnaces and molten glass. Long-term health is also affected; soot and dust cause respiratory diseases such as asthma and bronchitis, and eye problems.

16.7.4 Children working in a glass factory



ACTIVITIES

Knowledge and understanding

- 1 List the types of child exploitation found in India.
- 2 Identify the areas of employment in which illegally trafficked people are found working.
- 3 Outline the difficulties that internally trafficked and locally enslaved people experience.
- 4 Explain the term 'debt bondage'.
- 5 Outline the recent developments in the distribution of sexual exploitation.
- 6 Explain why forced marriage is a major problem.
- 7 Outline the causes of exploitation. Why is the growth of the informal sector especially significant?
- 8 Outline the actions being taken to address the exploitation. What impediments are there?

Applying and analysing

- 9 Discuss the following statement.
For many people living in developing countries putting their children to work is a necessity and should not be viewed as exploitation.
- 10 Develop a poster campaign highlighting the evils of child exploitation.

Investigating

- 11 Investigate one NGO working to end child exploitation in India. Present your findings as an illustrated report.

India's squatter settlements and slums

16.8.1 The squalid living conditions of an Indian squatter settlement



India's urban poor

Despite the economic gains and poverty reduction achieved in recent years, India still has 260 million people living below the poverty line. This makes the country home to 22 per cent of the world's poor. While most of these people live in rural areas, increasing numbers are to be found in the country's large cities. About one in six of India's city dwellers are homeless, or crowd into the city's squatter settlements, or live in urban slums.

India's low-income urban housing settlements fall into two categories: officially recognised settlements located within the city, called *bastis*; and unrecognised settlements located in marginal land (squatter settlements). The *bastis* are spread

throughout the city, often occupying valuable land. People who are too poor to rent or buy homes in the *bastis* usually find shelter in the squatter settlements. These typically occupy vacant private land or unused public spaces—land adjacent to railway lines, canals and highways, and under bridges.

Living conditions

The living conditions in India's slums and squatter settlements are, by Western standards, often squalid (see Figure 16.8.1). In squatter settlements, the constant fear of demolition discourages people from upgrading their simple dwellings. Squatter settlements are overcrowded and lack basic utilities, such as water, electricity and sanitation.

Indian census

In 2011, Indian authorities completed a census (see Figure 16.8.2) that included India's vast slum population for the first time. A slum was defined as a residential area in which the dwellings were unfit for human habitation by reasons of dilapidation, overcrowding and lack of ventilation, light or sanitation.

The census revealed that 13.8 million households or about 64 million people lived in urban slums and squatter settlements nationwide—that is 17.4 per cent of all urban households. More than one-third of slum homes surveyed had no indoor toilets and 64 per cent were not connected to a sewerage system. About half of the households lived in only one room or shared with another family.

Despite this hardship, 70 per cent had televisions and 64 per cent had mobile phones. Most overcame the lack of government infrastructure by rigging up elaborate, mostly illegal, connections to the electricity grid.

Indian urbanisation

India's urbanisation levels are relatively low by developing world standards. The bulk of urban migration is projected to take place over the next 20 to 25 years, resulting in an additional 300 million urban dwellers. Many of these new arrivals will crowd into the large urban slum districts and squatter settlements.

While only about a quarter of India's population is urban, this fraction represents 309 million people. At least twenty-three Indian cities have more than a million residents. The largest of these is Mumbai (12.4 million) followed by Delhi (11 million), Bangalore (8.4 million) and Hyderabad (6.8 million).

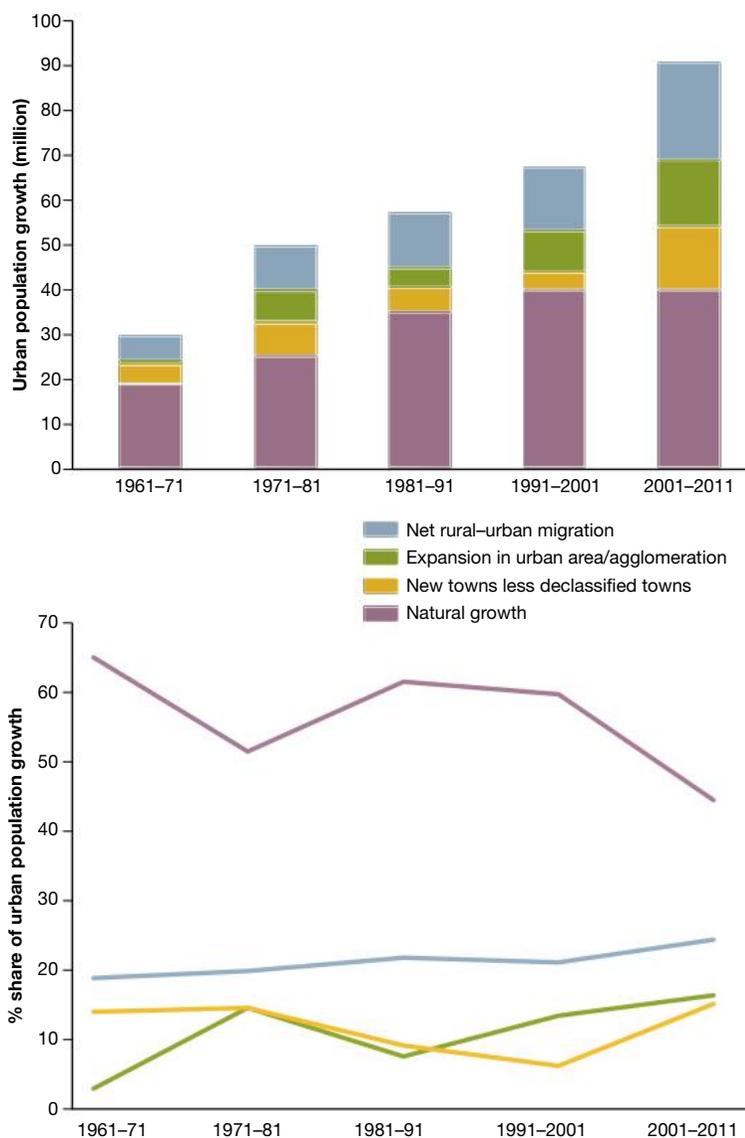
Kolkata

The city of Kolkata (Calcutta) has a population of over 4 million people. Adding the population of the metropolitan area takes the total to over 14 million people. About 4 million people live in Kolkata's slums, and another 1 million live in illegal squatter settlements. Just 20 000 units are added to the city's housing stock each year, a number well short of the 50 000 units needed.

Most of Kolkata's *bastis* have fallen into a state of **urban decay** since the 1980s, principally because municipal governments lack the funds needed to maintain basic services. *Bastis* frequently have inadequate access to water, sanitation, sewerage, drainage and waste disposal. They are also overcrowded and crime is a growing problem. While the *bastis* offer legally recognised tenure, which provides stability to residents, tenure also increases the price of housing. This excludes many of the urban poor.

Those too poor to live in the *bastis* find shelter in the squatter settlements that occupy vacant public and private land outside

16.8.2 Components of India's urban population growth, 1961–2011



Source: IHS analysis, based on Census of India, 2011

the city centre. Occupants of such settlements are denied land tenure rights and receive no services. The threat of eviction is ever present.

The Indian government has initiated several programs to improve housing conditions for the poor. The most significant of these—the Jawaharlal Nehru National Urban Renewal Mission—aims to improve basic services and secure tenure in poor urban neighbourhoods. Another initiative—the National Slum Development Program—uses a combination of physical infrastructure and social services to upgrade slums, provide clean water, upgrade drainage and sewers and construct community bathrooms and shared toilets.

Other initiatives include simplifying legal processes, conferring land title or tenure status on squatters, and increasing access to housing finance for low-income people.



16.8.3 Oblique aerial photograph of Dharavi. The density of housing is clearly evident in this image.

Dharavi

Dharavi, in Mumbai, is one of the world's largest slums (see Figure 16.8.3). It was established in the 1880s, during the British colonial era, to house the rural poor migrating to the city and the workers of polluting factories relocated from the peninsula on which Mumbai (then called Bombay) was located.

Today, Dharavi is a multi-religious, multi-ethnic district with over 1 million people packed into just 217 hectares. About 60 per cent of the population is mainly Hindu, while 30 per cent is Muslim. The rest are mainly Christian or Buddhist. Among the Hindus, about 20 per cent are Dalits—members of the lowest caste—who work in animal skin production, tanneries and leather goods factories.

Over the years, the slum-dwellers of the district have suffered from numerous epidemics, including typhoid, cholera, leprosy and polio, and other disasters. Often the spread of these diseases is linked to poor sanitation. Authorities estimate that there is just one toilet for every 1440 residents. As a result, residents use local waterways as toilets. This leads to the spread of contagious diseases.

Like many other slum districts and squatter settlements, Dharavi has an active informal economy in which numerous household-based enterprises employ many of the slum

residents. The annual turnover of business is estimated to be more than US\$650 million a year. Industries include leather tanning, textile production and pottery.

Few of those living in Dharavi own the land on which they live. Seventy per cent belongs to the government, which is unwilling to give it to the slum-dwellers for free. Instead, the residents are treated as squatters.

REDEVELOPMENT

The Maharashtra state government has plans to redevelop Dharavi and transform it into a modern township (see Figure 16.8.4), complete with proper housing and shopping



16.8.4 Artist's impression of a redeveloped Dharavi

complexes, hospitals and schools. It is estimated that the project will cost US\$2.1 billion. There has been significant local opposition to the plans, largely because existing residents are due to receive only a small allocation of land (about 25 square metres each). Also, only those who lived in the area before the year 2000 are to be resettled.

The city of Mumbai has embarked on an ambitious program to house the city's poor. With the financial support of the World Bank, authorities have built 60 000 low-cost housing units for slum-dwellers. They have also invested US\$8 billion in the construction of new roads and a metro rail system. The task, however, is enormous. The city needs to build 1 000 000 new housing units if it is to adequately house the city's poorest residents.

SPOTLIGHT

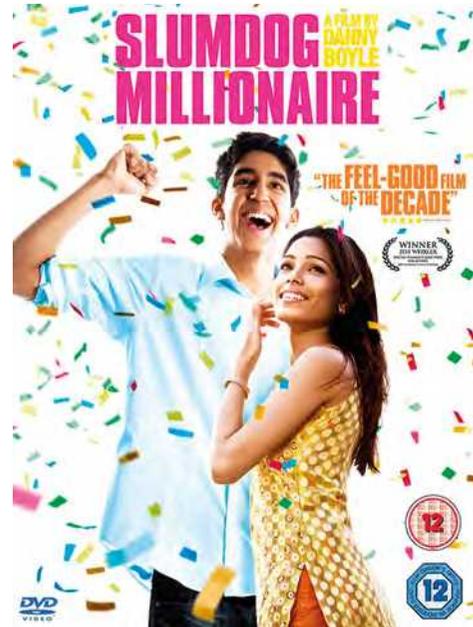
Slumdog Millionaire

The 2008 British film *Slumdog Millionaire* won eight Oscars, including Best Picture and Best Director, at the 2009 Academy Awards.

In the film, a Mumbai teenager, who grew up in the city's slums, becomes a contestant on the Indian version of 'Who Wants To Be A Millionaire?' He is arrested on suspicion of cheating, and while he is being interrogated, scenes from his life in the slums of Mumbai are played, to explain why he knows the answers to the questions asked.

Despite the film's success, there was controversy over the way it portrayed Indians. Some people argued that the film promoted Western stereotypes about poverty in India. Others alleged that the slum-dwellers were depicted in ways that violated their human rights. Social activists in Mumbai protested that the film exploited the poor for the purposes of profit, and that its title was offensive and demeaning, and insulted their dignity.

The child actors featured in the film continue to live in makeshift shacks in the slums of Bandra, a suburb of Mumbai.



16.8.5 *Slumdog Millionaire* movie poster

ACTIVITIES

Knowledge and understanding

- 1 Outline the scale of the housing crisis in India.
- 2 Differentiate between *bastis* and 'squatter settlements'.
- 3 Describe the living conditions of the slums and squatter settlements.
- 4 Define the term 'slum' in your own words.
- 5 Outline the nature and extent of the shelter crisis in Kolkata. What has been the government's response?
- 6 Outline the role that Dharavi plays in the economic life of Mumbai.

Applying and analysing

- 7 View selected scenes from the film *Slumdog Millionaire*. Write a paragraph or two expressing your reaction to the living conditions in Mumbai's slums. Share your reaction with others in the class.
- 8 Study Figures 16.8.3 and 16.8.4. Describe the nature of the community depicted and what it might be like after the area is redeveloped.
Do you think that those currently living in Dharavi will benefit from such a proposal?

Geographical skills

- 9 Study Figure 16.8.2 then answer the following questions.
 - a What was the largest contributor to urban growth in the period 1961–71?
 - b What contribution did net rural–urban migration make to urban population growth in 2001–11?

Investigating

- 10 Using the internet, locate descriptions of the lived experience of people who live in India's *bastis* or squatter settlements. Share your stories with others in your class. What do these depictions have in common?

Activity 1

Worldviews

People often disagree on the seriousness of environmental issues. Take global warming, for example. Despite the overwhelming scientific evidence that human activities—especially the use of fossil fuels—are affecting global temperatures, there are people who believe that the dangers of climate change have been greatly exaggerated. Others believe it is all just a hoax. Such disagreements generally arise out of differing environmental worldviews—how people think the world works and what they believe their role in the world should be. A person's environmental worldview also takes into account their environmental ethics—what they believe is right and wrong in terms of their behaviour towards the environment.

HUMAN-CENTRED

According to this view, people are the planet's dominant species and we should manage the earth's resources and natural systems for our own benefit. This 'management-based' approach suggests that technological advances and better management can be used to address the environmental damage caused by the exploitation of resources and systems.

NATURE-CENTRED

People who hold such a worldview believe that humans have an obligation to the environment as well as themselves. They believe that all forms of life have the right to exist and that humans are not any different from other species—humans are equal to other species.

SUSTAINABLE

Somewhere in the middle of these extremes is the concept of sustainable development. Sustainable development involves the use of the earth's resources and natural systems in ways that meet the needs of the present generation without affecting the ability of future generations to meet their own needs. It is a worldview that still sees humans as the dominant species, but holds that they can and should manage the earth mostly for human benefit.

Study each of the worldviews expressed in Figure 17.1.1.

- Identify the statement that most closely resembles a self-centred, nature-centred and sustainable worldview.
- Try writing a statement that expresses your worldview.

17.1.1 Environmental worldviews



Activity 2

Music and the environment

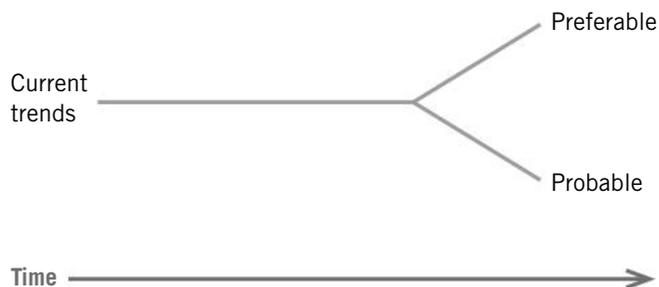
Using the internet, compile a list of ten songs about the environment by artists with whom you are familiar. Select one of these songs for closer analysis then answer the following questions.

- What is the message conveyed by the song's lyrics?
- Develop a pictorial multimedia presentation featuring relevant images of the environment. Add your song as a soundtrack.
- Share your work with the rest of the class.

Activity 3

Mapping the future

At any point in time, any number of alternative futures are possible. Preferable futures are those futures that could exist under the best of circumstances. Probable futures are those that seem most likely to occur. Timelines are an effective way of exploring probable and preferable futures.



17.1.2 Using a timeline to explore probable and preferable futures

Using Figure 17.1.2 as a guide, complete the following tasks.

- Beginning with 'current trends', identify the key elements of the present situation. Examples of current trends are water use, the price of oil, air or water pollution, deforestation and overfishing.
- Fill in the 'probable' timeline by asking what changes are most likely to happen. Your teacher will give you an idea of the period of time you should take into account.
- Fill in the 'preferable' timeline. The question to ask yourself is 'What would I personally prefer to happen here?'
- Compare your timeline with those developed by others in your class.

Activity 4

Global citizenship

Study the views shown in Figure 17.1.3.

- Are the views presented examples of good global citizenship? Prepare a series of statements presenting an alternative perspective.
- Find someone in the community who is a good global citizen to interview. Your interview should be presented as an oral report. You should describe the person's qualities and outline the contribution the person makes to the wellbeing of society and/or the environment.

Before you interview the person, consider the following tasks, to ensure you are prepared.

- Decide how you will interview the person: via the phone, in person, via email, Skype or Google Hangouts, etc.
- Consider how you will record their answers: written, audio or video.
- Write down the questions you want to ask. Start with 'ice breaker questions', which encourage people to talk about themselves. Remember to ask 'open-ended questions', such as 'tell me about a time when ...'

17.1.3 Some negative attitudes about global citizenship



Activity 5

Developing a plan of community action

Become actively involved in a geographical issue affecting your local community. Develop your own campaign by following the steps below.

- Become informed about the issue.
- Develop strategies to increase community awareness about the issue. For example, you could make posters that explain or illustrate the issue. Display these around the community. You could also seek publicity for your campaign by contacting the local media and writing letters to the editor for publication in your local newspaper.
- Try to influence decision makers. Write letters or emails to local Members of Parliament and members of the local council. Outline your views on the issue in a clear and concise manner, and ask for their support.
- Evaluate your campaign. What was successful and what changes would you make if you were to be involved in another campaign?

Activity 6

Global warming: Cartoon interpretation

- Study the cartoons shown in Figures 17.1.4 to 17.1.6, and identify the perspective or point of view of the cartoonist. Copy and complete the table below.

	Figure 17.1.4	Figure 17.1.5	Figure 17.1.6
Location			
Images			
Themes			

- In your opinion, which cartoon has the most impact and which has the least impact. Why?
- Source two more cartoons with alternative views of climate change. Using the format in question a, interpret the themes of the cartoons.

17.1.4 Global warming, by Wilcox



17.1.5 Global warming, by Leahy



17.1.6 Moir's view on global warming scepticism



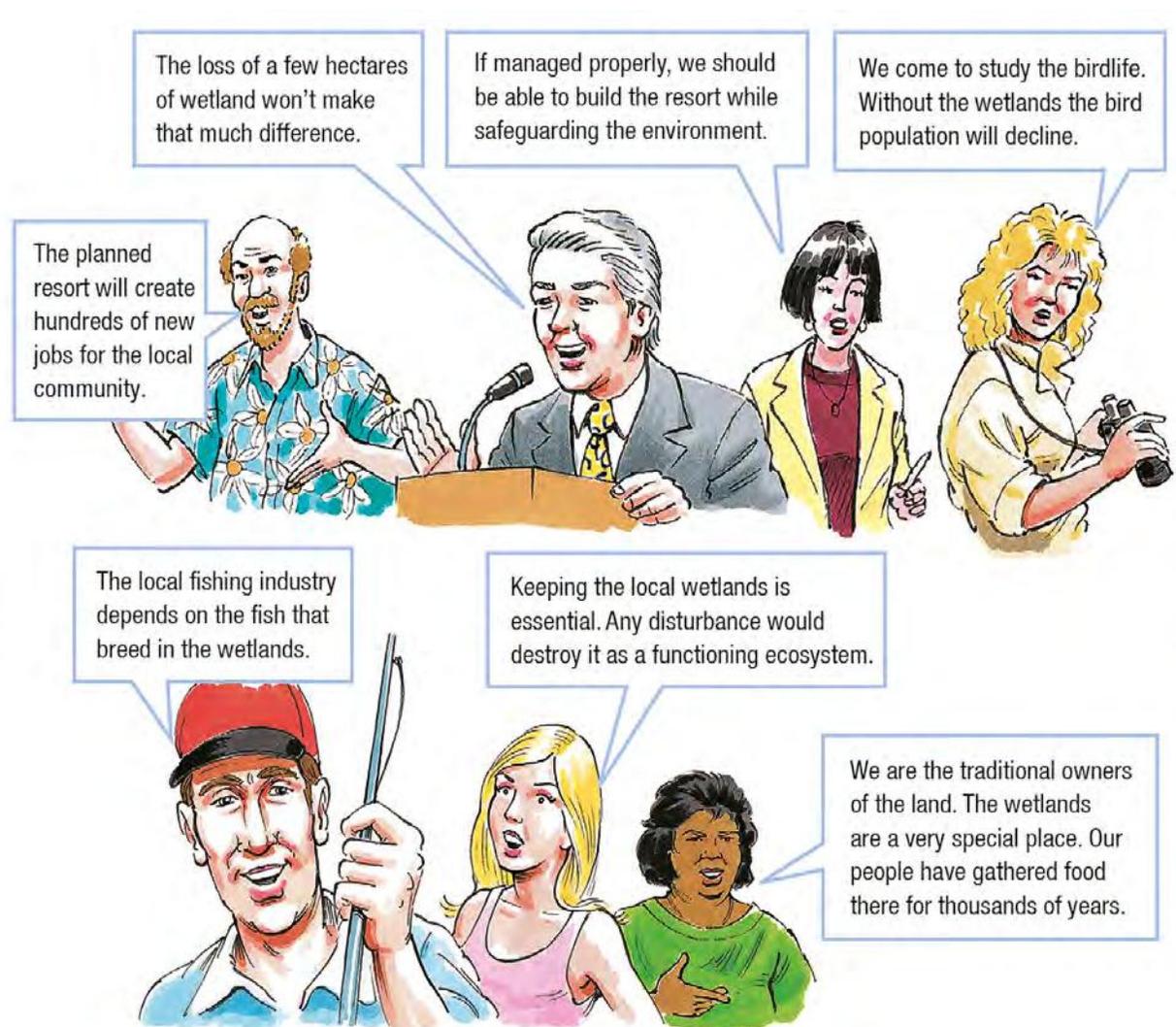
Activity 7

Hypothetical wetlands under threat

A developer wishes to construct a large resort on land now partly occupied by a freshwater wetland. The resort will include a hotel, golf course, marina and housing estate, and will create 300 new jobs in the local community, which has high levels of youth unemployment. Local environmental groups object to the development on the grounds that it will destroy a valuable wetland ecosystem. They are using the legal system to achieve their objectives. You are a judge of the Land and Environment Court.

Study Figure 17.1.7.

- List the statements that are in favour of building the resort and its facilities. Then list the statements that are not in favour of it going ahead.
- Which set of views do you agree with? Why?
- In small groups, discuss the statements about the proposed development. Reach agreement on what you think should happen. Be prepared to defend your group's viewpoint when you report to the class.
- Examine both sides. Have the people on each side of the discussion present the case for the other side, using exact arguments.
- Conduct a class debate on the following topic: *The resort should go ahead.*



17.1.7 Different attitudes towards a wetland development

Activity 8

Sustainable futures

We can use the earth's non-renewable resources for short-term gain, or we can plan for a future time when those resources are no longer available. Some countries have made provision for the future by establishing sovereign wealth funds (SWFs). An SWF fund is a government-controlled investment fund. It invests some of the revenue from the use of non-renewable resources for the benefit of future generations. The money is invested in stocks, bonds, real estate or other financial products to provide a continuing source of income.

Norway, for example, requires companies that extract the oil reserves beneath the North Sea to pay a tax. The revenue raised will be used to fund public pensions. Australia has an SWF, which is called the Future Fund. The Future Fund was established in 2006, and it manages the revenue received from the privatisation of Telstra and from budget surpluses. It will be used to pay the future superannuation entitlements of Commonwealth public servants.

As a class, discuss whether Australia needs an SWF, similar to Norway's, to preserve the benefits of the mining industry for future generations.

- List the arguments for and against the establishment of an SWF.
- Investigate and describe the non-renewable resources that could contribute tax revenue to an SWF.
- Identify the types of things such a fund should be used to pay for in the future. Decide whether you support the establishment of such a fund.
- Write a letter outlining your view on the issue as if you were writing it to the Prime Minister.

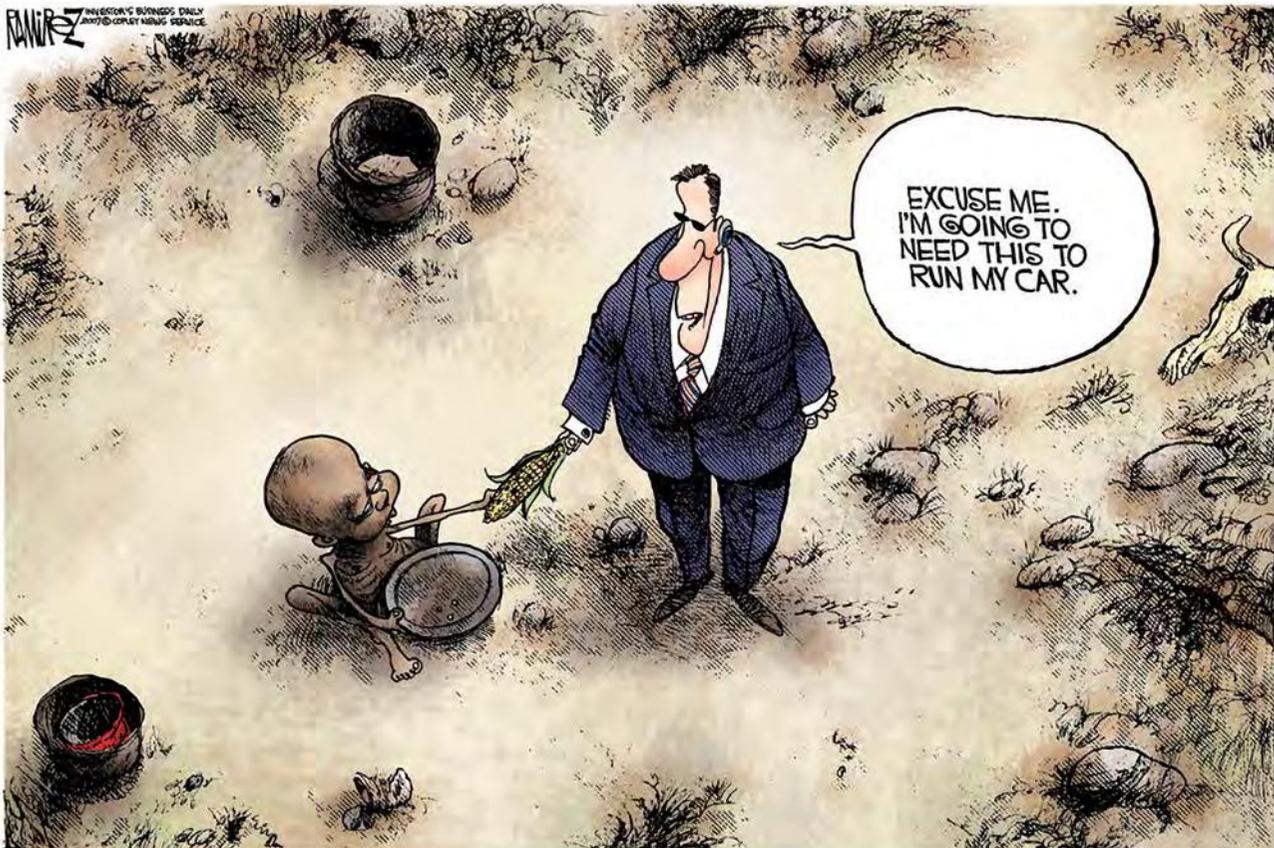
Activity 9

Development issues: Cartoon interpretation

Study Figure 17.1.8.

- As a class, brainstorm all the development-related issues raised by this cartoon.
- Make a copy of the cartoon and annotate it, using the points raised in the discussion.

17.1.8 Competition for the use of natural resources



By permission of Michael Ramirez and Creators Syndicate, Inc.

Activity 10

Speech interpretation

... It [reconciliation] begins, I think, with the act of recognition. Recognition that it was we who did the dispossessing. We took the traditional lands and smashed the traditional way of life. We brought the diseases. The alcohol. We committed the murders. We took the children from their mothers. We practised discrimination and exclusion.

It was our ignorance and our prejudice. And our failure to imagine these things being done to us. With some noble exceptions, we failed to make the most basic human response and enter into their hearts and minds. We failed to ask—how would I feel if this were done to me?

As a consequence, we failed to see that what we were doing degraded all of us ...

Source: from a speech by Paul Keating, former prime minister of Australia, at Redfern Park in Sydney, 10 December 1992

Study the extract from Paul Keating's famous Redfern address.

- Explain, in your own words, what Keating is saying in the extract.
- Why do you think this speech is considered to be very important for the reconciliation process?
- Why would some people object to a prime minister making such a statement? Do you think the statement is justified? Explain.
- What is meant by the term 'empathy'?

Activity 11

Alternative futures

Study Figure 17.1.9.

- Reflect on how your view of the relationship between people and the environment has changed since you commenced your studies of secondary school Geography in Year 7.
- Which of the photos now best fits your view of the relationship between people and their environment?
- Write a paragraph about each photo, indicating whether you agree with the view presented. Explain why.

17.1.9 Alternative futures



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