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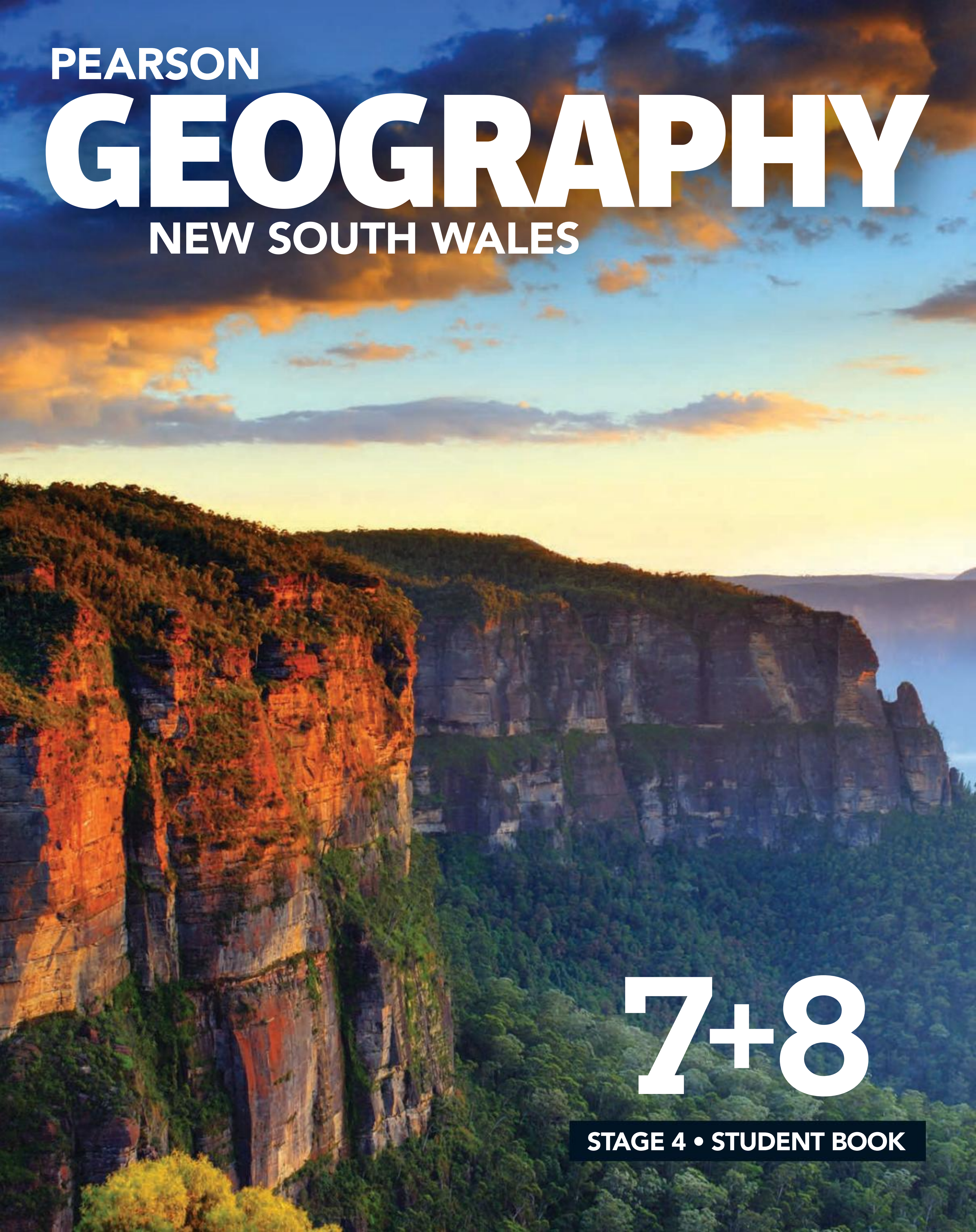
NEW SOUTH WALES



7+8

STAGE 4 • STUDENT BOOK

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GEOGRAPHY

NEW SOUTH WALES

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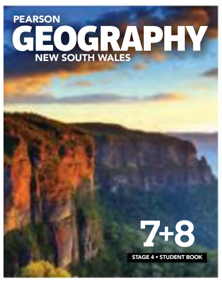

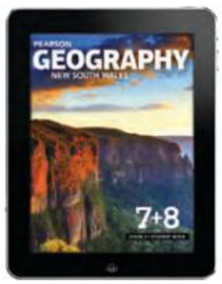

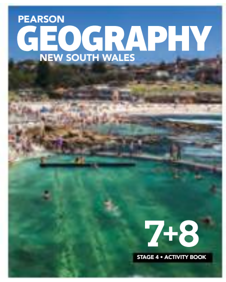

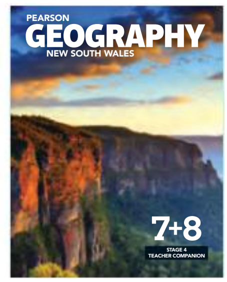

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CONTENTS

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How to use this book

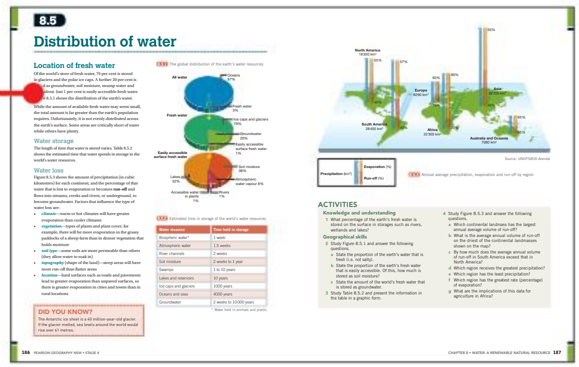
Pearson Geography NSW is fully aligned to the BOSTES Geography syllabus. Units combine content and geographical tools. The following information outlines the features of this book.

Chapter opener

The chapter opener image is designed to engage students and provide a visual stimulus to the chapter themes. Also included is an introduction to the chapter and inquiry questions that link the chapter to the NSW BOSTES Geography syllabus. A glossary provides a ready reference for students to the key concepts and terms in the chapter.

Units

Each chapter of the Student Book is divided into units. Units have been written to develop students' knowledge and understanding of the concepts, skills and processes central to the study of Geography at this level. Units are written to ensure 'Knowledge and Understanding' and 'Inquiry and Skills' are interrelated, as specified by the NSW BOSTES Geography syllabus.



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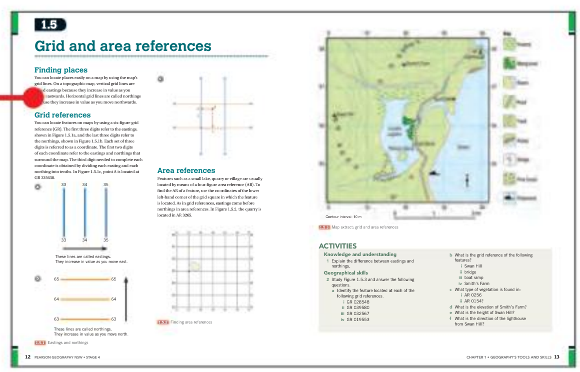
Units designed to improve students' geographical skills. These skills relate to the BOSTES: Geography syllabus – Geographical tools.



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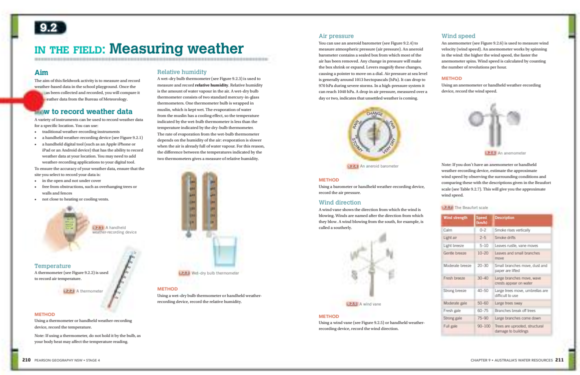
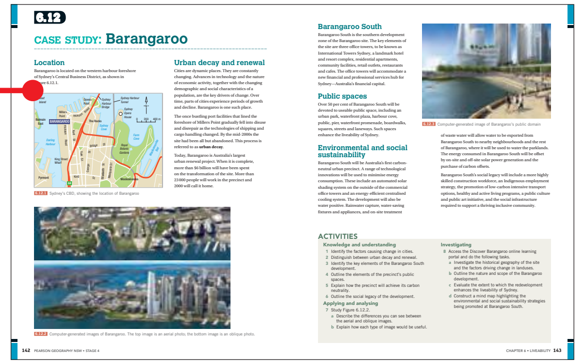


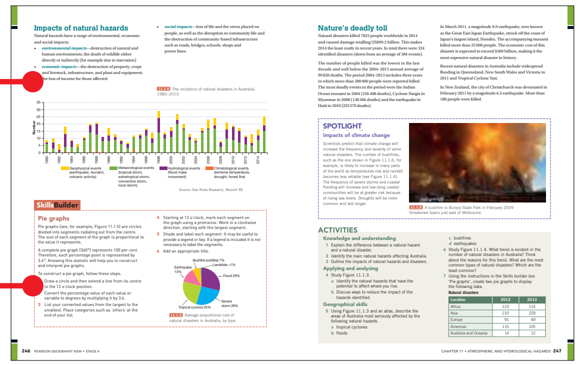
Case studies

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.



Skills builder

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



Spotlight

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

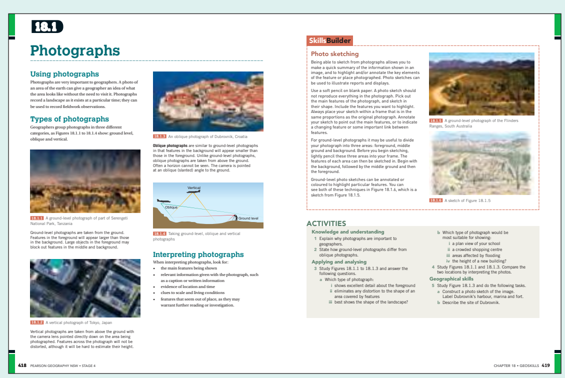
ONLINE RESOURCES

Extra content (online)

Chapters 15, 16 and 17 refer to the NSW BOSTES Geography syllabus unit 'Landscapes and landforms' providing choices of landscape and landform to investigate—alpine landforms, riverine landforms and desert landforms.

Geoskills

A chapter on skills is designed to improve students' geographical skills: mapping, graphing, interpreting satellite images and interpreting photos. These skills relate to the BOSTES Geography syllabus—Geographical tools.



Extension tasks

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

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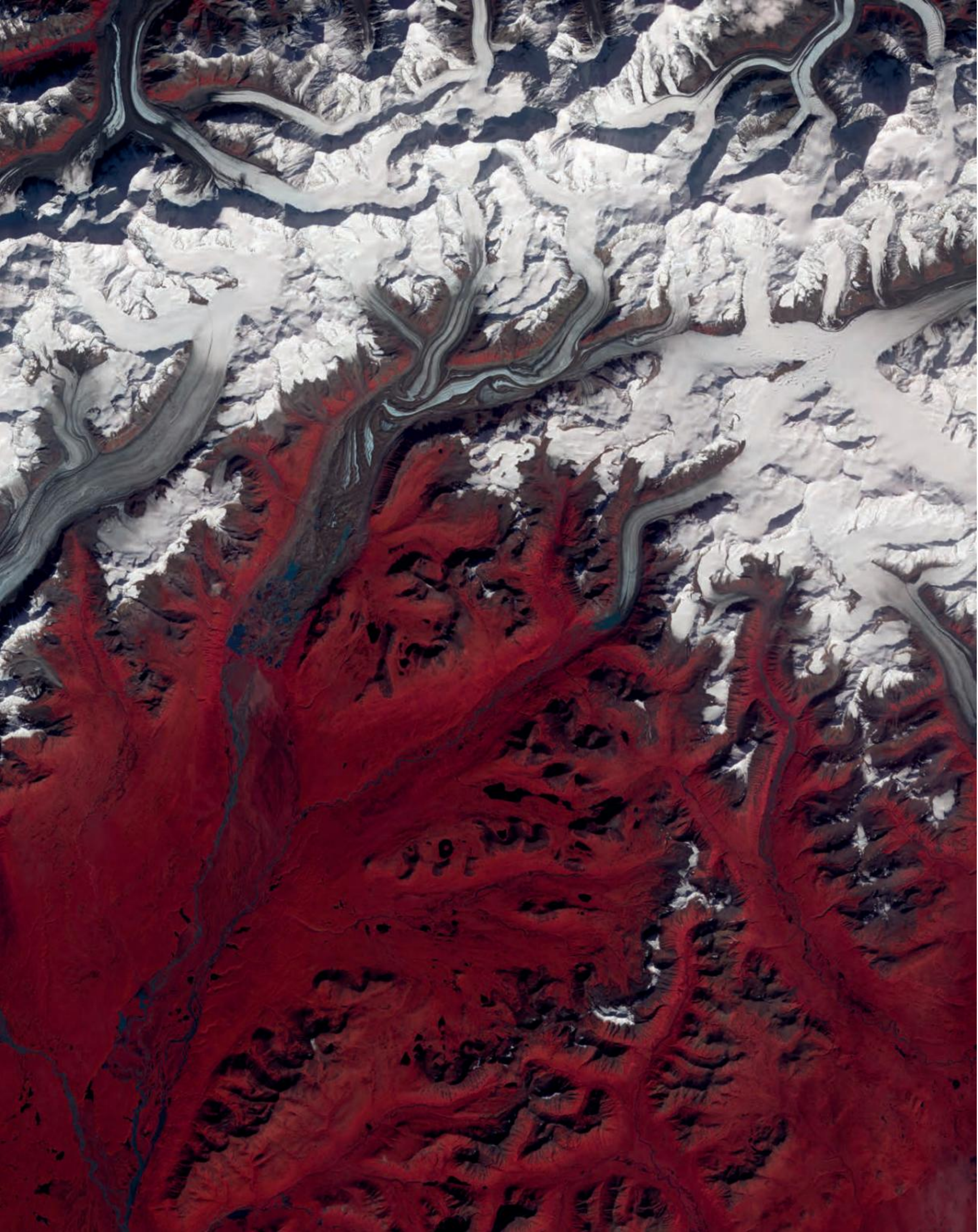


Geography's tools and skills

CHAPTER 1

Geographers use many different tools and skills to investigate the world in which we live. Maps are among the most important of these tools.

A map is a representation of the whole, or a part, of the earth's surface. Increasingly, maps are stored in electronic form and can be read on computer monitors, mobile phone screens and in-car navigation systems. People who make maps are called cartographers.

In this chapter we reflect on the nature of Geography and the elements that make up the biophysical, managed and constructed environments. We also learn how to use maps.

INQUIRY QUESTIONS

- What is Geography?
- What are the distinguishing features of the biophysical, managed and constructed environments?
- What types of maps, photographs and satellite images are used by geographers and what are the conventions used in their construction?
- What are the key skills involved in the interpretation of maps?

GLOSSARY

aspect	the direction that a slope faces
biophysical environment	those environments that are dominated by natural features such as landforms and vegetation; includes the earth's soil, water, air, sunlight and all living things
cartographer	a person who draws maps
change	a transformation brought about by environmental, economic, political, social and/or cultural factors
constructed environment	human-altered landscapes, including all those features that are normally associated with settlements, industries and agriculture
contour interval	the difference in height between two contour lines on a map
contour lines	lines on a map that join places of equal height above sea level
distribution	the population or number of objects per unit of area
elevation	the height of a point or place above sea level
environment	our total surroundings, including the living and non-living features of the earth's surface and atmosphere as well as those features that are altered or created by people
Geography	a structured way of exploring, analysing and understanding the characteristics of the places that make up our world
legend	the part of a map that explains the meaning of the symbols used in the map; sometimes referred to as the key
location	the position of a feature or place on the earth's surface
managed environment	human-altered landscapes dominated by elements of the natural environment, including crop and grazing lands, plantations and planted forests
meridians of longitude	imaginary lines drawn around the earth from north to south
parallels of latitude	imaginary lines drawn around the earth from west to east, parallel to the Equator
population density	a measurement of the number of people per unit of area
relief	a general term describing the shape of the land, including height and steepness
scale	the relationship between the distance between two points on a map and the actual distance on the earth's surface
spot height	the exact altitude or height above sea level of a point on the earth's surface
thematic map	a map designed to illustrate a particular theme; for example annual rainfall or the location of oil resources
topographic map	a detailed, large-scale map illustrating selected features of the physical environment
topography	the shape of the land

1.0 Susitna Glacier, Alaska. The image was taken by NASA's Terra Satellite.

1.1

What is Geography?

Geography explained

Geography is the study of the characteristics of the places that make up our world. Geography is concerned with the processes that shape the earth's surface and the ways in which people interact with environments. It seeks to explain the character of places and the **distribution** (spread) of people, features and events on or near the earth's surface.

Geography dimensions

There are three dimensions in Geography: place, space and environment. All three dimensions interact, as shown in Figure 1.1.1.

Defining environment

The term **environment** refers to our living and non-living surroundings. We usually refer to environments as being either natural, managed or constructed. We use the term **biophysical environment** to identify an environment dominated by natural features such as landforms and vegetation—for example Jim Jim Falls in Figure 1.1.2. It is important to note, however, that there are no longer any purely 'natural' environments—all environments have been **changed** or altered by human activities. For this reason we use the term 'biophysical environment' rather than 'natural environment'.

Managed environments are those in which elements of the natural environment are manipulated for the benefit of humans—for example farmland or a planted forest.

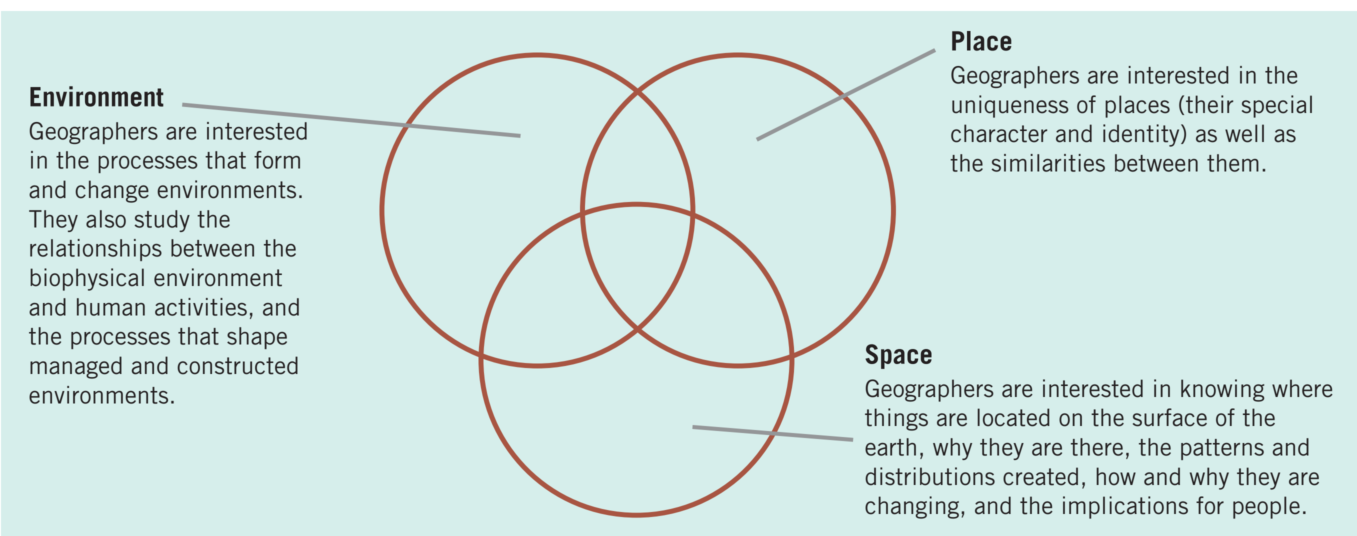
We use the term **constructed environment** when we refer to those elements of the environment that people have created.

By studying Geography, we learn about:

- our changing world
- our place in the world
- the big issues facing humanity
- the impacts that our actions have on the world.

By studying Geography, we are able to:

- lead more enriched lives
- become effective guardians of our future world
- think spatially
- develop a range of skills demanded by employers.



1.1.1 Geography's dimensions: place, space and environment all interact.

1.1.2 Jim Jim Falls, Kakadu National Park, Northern Territory—an example of a biophysical environment

Physical and Human Geography

Geography has traditionally been divided into two areas, Physical Geography and Human Geography

Physical Geography looks at how the earth was formed and how it continues to change. It includes the study of the atmosphere, hydrosphere, lithosphere and biosphere—the four parts of the biophysical environment.

Human Geography looks at people and how, individually or in groups or communities, they interact with the environment. It includes:

- the study of urban, industrial and rural land uses
- the development of countries
- population and population movements
- how economic changes affect people
- issues such as global terrorism, human rights, global inequality, child labour and social justice.

ACTIVITIES

Knowledge and understanding

1 Define Geography.

2 Explain why the term ‘biophysical environment’ is used in preference to ‘natural environment’.

Applying and analysing

3 Distinguish between the biophysical, managed and constructed environments.

4 Collect two images of each of the biophysical, managed and constructed environments and present the images as an annotated collage.

5 a Create a Venn diagram consisting of two intersecting circles. Label one circle with the heading ‘Physical Geography’ and the other circle with the heading ‘Human Geography’.

b Place each of the following topics in the correct circle. You may find that some topics fit into more than one category.

i volcanic activity
ii landuse changes in cities
iii whale migrations
iv landuse change over time
v the distribution of HIV/AIDS
vi how to draw maps
vii plants and animals in rainforests
viii a hailstorm
ix life on the ocean floor
x agricultural landuse in Bali
xi how rivers shape the land
xii changing job opportunities

1.2

Types of environments

Defining environment

In Geography, the word 'environment' is used to describe our total surroundings. The environment includes the living and non-living features of the earth's surface and its atmosphere, as well as those features that have been altered or created by people. Geographers divide environments into three kinds: biophysical environments, managed environments and constructed (or built) environments.

Biophysical

Biophysical environments are those dominated by natural features such as landforms and vegetation. The natural environment includes the earth's soil, water, air, sunlight and all living things. These are often referred to as the elements of the biophysical environment (see Figure 1.2.1). It is important to note that there are no truly 'natural' environments. All environments have, to some extent, been altered by the activities of people.

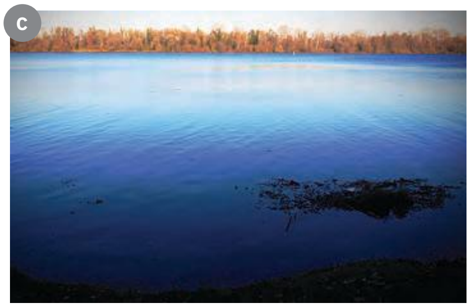
a

Solar energy: the energy (light and heat) produced by the sun. All life on earth depends on solar energy.

b

Lithosphere: the earth's solid outer shell. Geographers study the processes shaping the earth's crust, and how these processes affect people.

c



Hydrosphere: the earth's store of water and how it circulates. Geographers are interested in how people try to control and manage water resources to meet their needs.

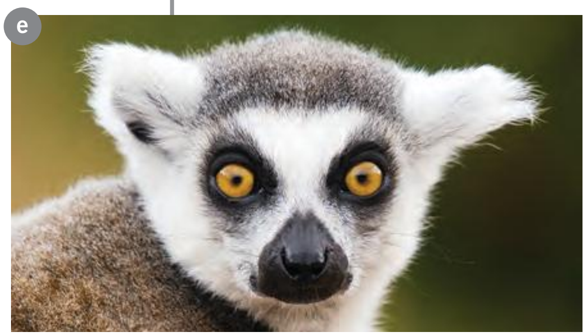
Elements of the biophysical environment

d

Atmosphere: the combination of gases surrounding the planet. Geographers are particularly interested in weather and climate. They investigate:

- how climate affects people, plants and animals
- how the activities of people affect climate.

e



Biosphere: the surface zone of the earth, in which all life exists. Geographers are particularly interested in how living things interact with each other and with the non-living parts of the environment.

1.2.1 Elements of the biophysical environment

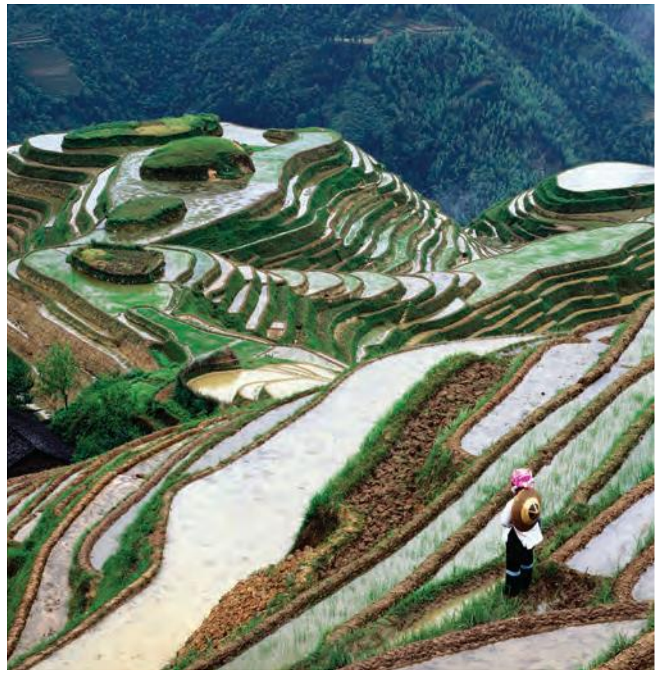
Managed

The managed environment includes human-altered landscapes dominated by elements of the natural environment. Examples are crop and grazing lands (see Figure 1.2.2), plantations and planted forests.

Constructed

The constructed (or built) environment is best defined as those features of the environment that have been created by people. These include all the features normally associated with settlements, industries and agriculture. Features of the built environment include buildings and transport infrastructure (for example roads, railways, airports). The managed and constructed environments are a product of the social, cultural, economic and political systems created by humans (see Figure 1.2.3).

It is important to note that the biophysical, managed and constructed environments always interact. The biophysical environment is affected by the activities of people, and the managed and constructed environments are affected by events within the biophysical environment.



1.2.2 Terraced rice paddies are an example of a managed environment.

a Social

b Economic

c Cultural

d Political

1.2.3 Elements shaping constructed environments

ACTIVITIES

Knowledge and understanding

1. Define the following terms: environment, biophysical environment, managed environment and constructed environment.
2. List the elements shaping the constructed environment.
3. Identify the elements of the biophysical environment and explain what each one is.

Applying and analysing

4. Write down as many features of the biophysical environment as you can think of.
5. Describe how you interact with the biophysical environment, the managed environment and the constructed environment in an average day.
6. Write a paragraph describing how your local area might have looked before people settled there. Write a second paragraph describing how people have transformed or changed the area.

Types of maps

Using maps

Geographers use many different types of maps. Topographic maps are particularly useful, but geographers also use atlas maps of regions, countries, continents and the world. Atlases, websites, textbooks, magazines, television programs, computer databases and even some advertisements use many different kinds of maps.

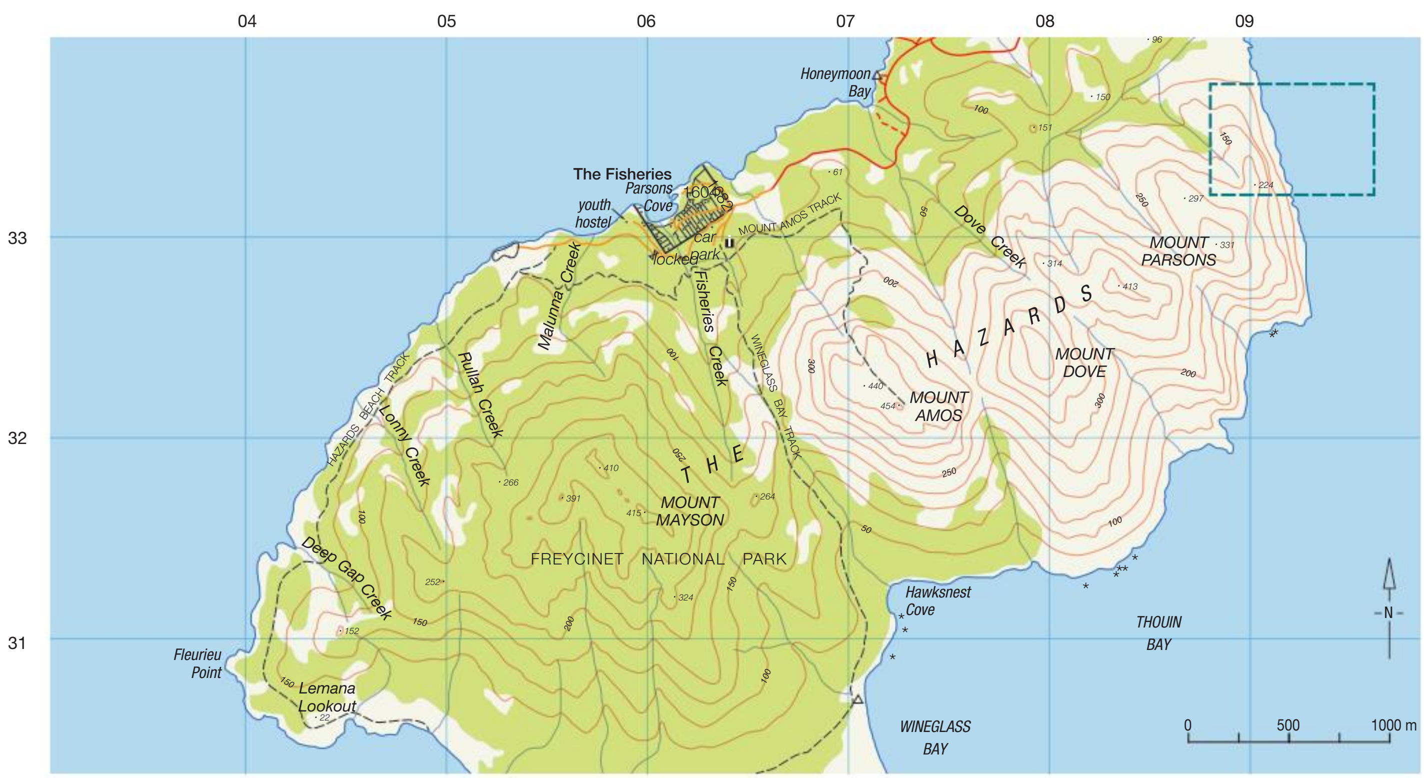
Topographic maps

Figure 1.3.1 is a **topographic map** and shows a small area of the earth's surface in great detail. It shows the shape of the land (**topography**) as well as different types of natural features (such as rivers and vegetation) and cultural features (such as land use, settlement patterns and road and rail networks). Topographic maps use a variety of symbols to represent these features.

Physical and human features maps

The maps in an atlas are often labelled with human (cultural and political) features such as boundaries, countries and cities. Physical (natural) maps show features such as rivers, mountains, plains and lakes.

1.3.1 Topographic map extract, Wineglass Bay, Tasmania



	sealed	unsealed
Road with bridge; with gate		
Walking track (approximate position) with bridge		
Building; Visitor information centre		
Contour with value; Camping; Spot elevation	100	· 440
Medium forest		
Tidal rocks or ledge; Offshore rock		
Reserve boundary; Land parcel boundary and number		1682

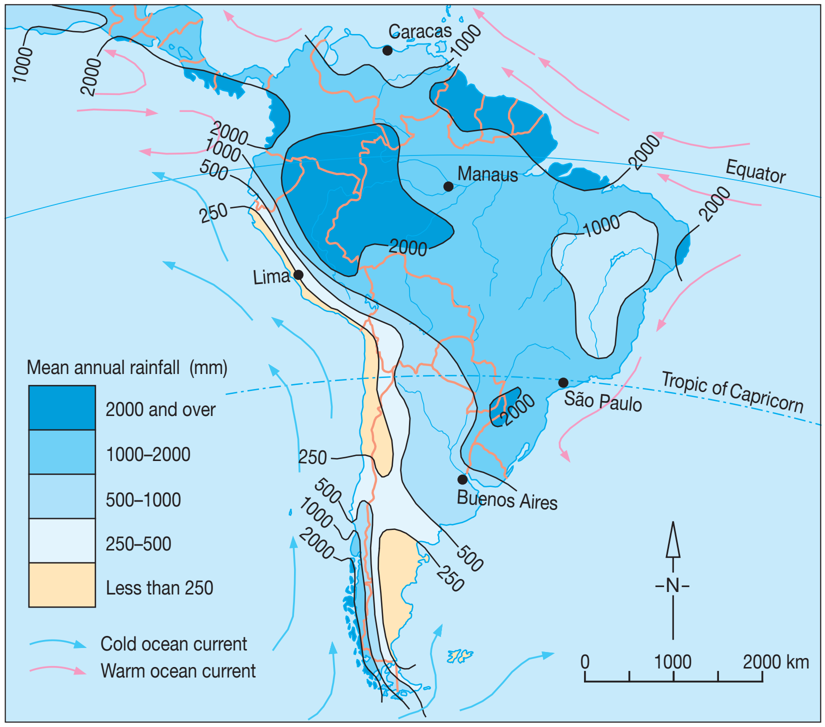
Base image by TASMAP (www.tasmap.tas.gov.au), © State of Tasmania

Thematic maps

Thematic maps are often used to show the distribution of one or more of the following: climate, vegetation types, average rainfall, average temperature, **population density**, various development indicators (for example population growth rates) and agricultural land uses. Figure 1.3.2 is a thematic map showing average annual rainfall in South America. Thematic maps that use a colour scale or shading to show a pattern are called choropleth maps.

Choropleth maps

A choropleth map is a special type of thematic map. This type of map uses graduated shades of one colour to indicate the average values of some property or quantity in a given area. Typically, the darkest shade shows the distribution of the highest data category. Figure 1.3.2 is an example of a choropleth map.

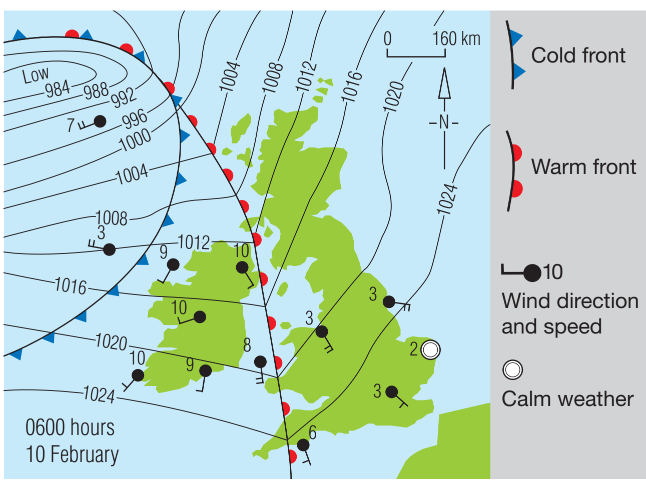


1.3.2 Mean annual rainfall, South America

Source: *Heinemann Atlas* Fifth Edition

Weather maps

Weather maps show weather conditions over particular areas of the earth's surface at a particular time. In Figure 1.3.3 you see the condition of the atmosphere (including air pressure and wind direction and strength) at a certain time. You also see the **location** and direction of warm and cold fronts. From this information, forecasts about the weather can be made several days ahead.



1.3.3 A weather map of the United Kingdom

ACTIVITIES

Knowledge and understanding

1 Copy and complete the following table.

Map type	What it shows	Purpose
Topographic		
Thematic		
Weather		
Street		

Geographical skills

2 Study Figure 1.3.1. List at least three features of each of the biophysical and built environments shown on the topographic map extract.

3 Study Figure 1.3.2. Determine the mean annual rainfall for:

a São Paulo

b Caracas.

4 Pria is a geographer working as a ranger in her local national park. She is researching the impact of feral cats on the native bird population. What type of map should Pria use to display her findings? Explain why you chose this type of map.

1.4

Elements of maps

Maps

Maps play a very important role in the study of Geography. They tell us about places and help us to identify patterns and changes in the landscape.

Maps range from the very simple to the very complex. No map can show every feature of the landscape, as it would then be impossible to read. Maps need to be selective in what they show. **Cartographers** (map makers) use symbols, shading and colour to show how the features of the earth's surface are arranged and distributed. These techniques also make maps easier to read and explain.

Elements of maps

Map essentials include a **B**order, a direction symbol (**O**rientation), a **L**egend, a **T**itle, a **S**cale and a **S**ource—commonly referred to as BOLTSS.

Border

The border of a map can be described as the 'frame' that surrounds it.

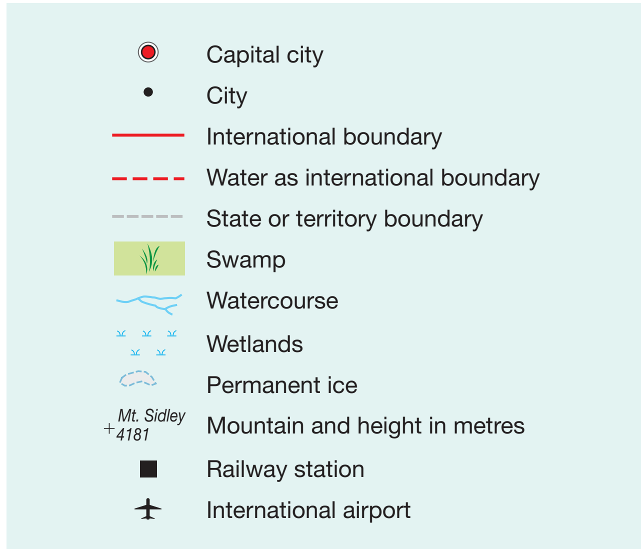
Orientation

To use a map, you need to know where the compass directions are on the map. An arrow shows which way is north. Once you know where north is, you can work out other directions. This process, known as 'orientation,' makes it easier to describe the location of places.

Legend

The **legend** of a map is also called the key. It lists all the symbols that are used on the map and shows what each of them means.

Map symbols are used to show the location of features on a map. Many symbols look like the features they represent (see Figure 1.4.1). The colour used for a symbol may also provide a clue to its meaning (blue for water and green for vegetation). The importance of a feature may be shown by the size of the symbol, the thickness of the line or the size of the font used to label it.



1.4.1 Some common map symbols

Title

A title tells us the purpose of a map. Usually the title has two parts: the name of the place, and what is being shown on the map.

Scale

A map is a graphic representation of part of the earth's surface, drawn to **scale**. The amount and type of detail shown on a map depends on its scale and purpose. For example, a street map of Melbourne with a scale of 1:20 000 (see Figure 1.4.2a) can show a lot more information about the city than a map of Europe with a scale of 1:20 000 000 (Figure 1.4.2b). The street map shows a smaller area in greater detail.

Source

If you use information from other sources when you create your own maps, you need to indicate where that information came from. It is important to correctly cite other work.

1.4.2 Compare these (a) large-scale and (b) small-scale map extracts.

Source: Transport Sydney

Source: *Heinemann Atlas* Fifth Edition

Using scale

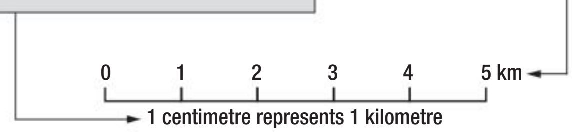
The scale on a map shows how much smaller the map is than the actual area. Using a scale, you can measure distances on the map and calculate the distances they represent on the earth's surface.

The scale on a map can be expressed in three different ways, as shown in Figure 1.4.3:

- as a statement; for example, '1 centimetre (on the map) represents 1000 metres (on the ground), or 1 centimetre represents 1 kilometre'
- as a ratio or representative fraction; for example 1:100 000 or $\frac{1}{100\,000}$
- as a linear scale.

Statement
For example, '1 centimetre on the map represents 1000 metres, or 1 kilometre, on the ground'. This is a statement in words comparing distances on the map with what they represent.

Linear scale
On a linear scale, a line or bar is marked in units that represent real distances —usually kilometres.



Ratio scale
For example 1:100 000. This tells you that 1 centimetre on the map represents 100 000 centimetres (1000 metres or 1 kilometre) on the ground.

1.4.3 Ways of expressing the scale of maps

ACTIVITIES

Knowledge and understanding

1. Explain what a map is.
2. Outline the role maps play in the study of Geography.
3. Explain why maps cannot show every feature of the landscape.
4. State what is used to show how features of the earth's surface are arranged and distributed.
5. List the essential elements of a map.

Geographical skills

6. Design suitable map symbols for the following features.
   - **a** bicycle track
   - **b** bus stop
   - **c** fast-food outlet
   - **d** football field
   - **e** tennis court
   - **f** basketball stadium
   - **g** swimming pool
   - **h** playground
   - **i** racecourse
   - **j** school
   - **k** skate park
7. Draw a sketch map of your school. Make sure it is to scale and has the essential elements of a map.

1.5

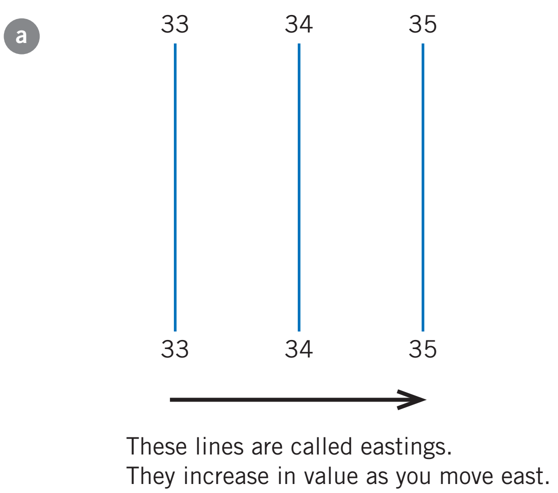
Grid and area references

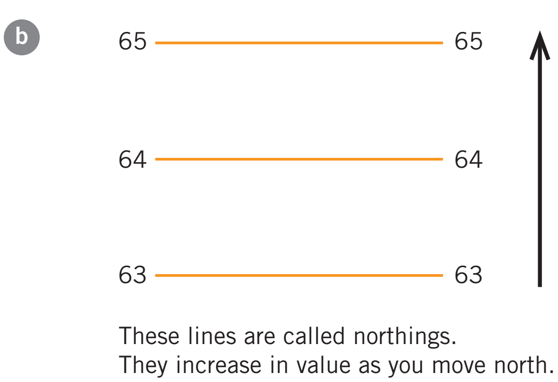
Finding places

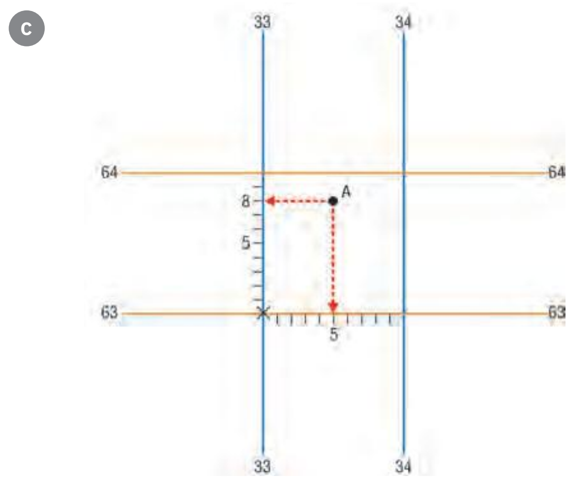
You can locate places easily on a map by using the map's grid lines. On a topographic map, vertical grid lines are called eastings because they increase in value as you move eastwards. Horizontal grid lines are called northings because they increase in value as you move northwards.

Grid references

You can locate features on maps by using a six-figure grid reference (GR). The first three digits refer to the eastings, shown in Figure 1.5.1a, and the last three digits refer to the northings, shown in Figure 1.5.1b. Each set of three digits is referred to as a coordinate. The first two digits of each coordinate refer to the eastings and northings that surround the map. The third digit needed to complete each coordinate is obtained by dividing each easting and each northing into tenths. In Figure 1.5.1c, point A is located at GR 335638.



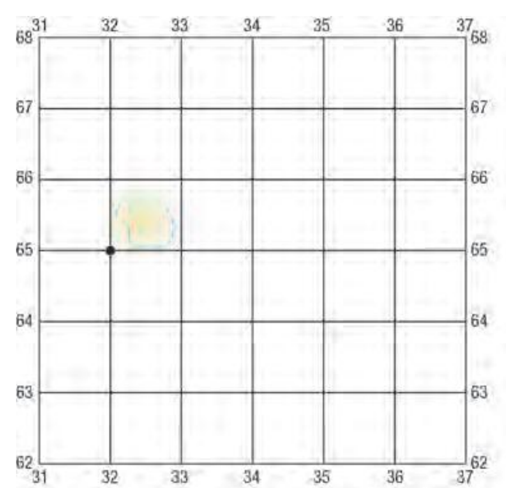




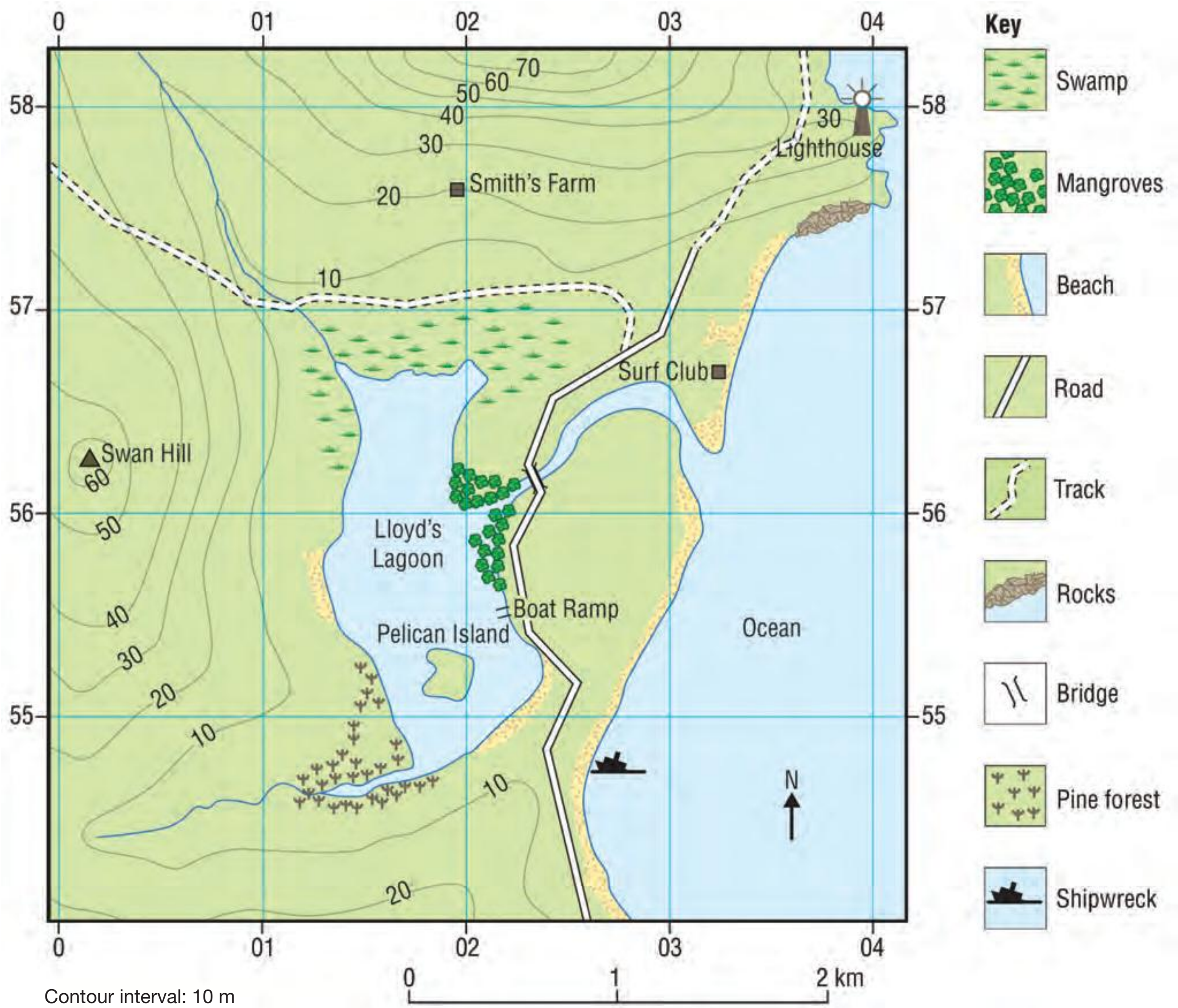
1.5.1 Eastings and northings

Area references

Features such as a small lake, quarry or village are usually located by means of a four-figure area reference (AR). To find the AR of a feature, use the coordinates of the lower left-hand corner of the grid square in which the feature is located. As in grid references, eastings come before northings in area references. In Figure 1.5.2, the quarry is located in AR 3265.



1.5.2 Finding area references



1.5.3 Map extract: grid and area references

ACTIVITIES

Knowledge and understanding

1 Explain the difference between eastings and northings.

Geographical skills

2 Study Figure 1.5.3 and answer the following questions.
   a Identify the feature located at each of the following grid references.
      i GR 028548
      ii GR 039580
      iii GR 032567
      iv GR 019553
   b What is the grid reference of the following features?
      i Swan Hill
      ii bridge
      iii boat ramp
      iv Smith's Farm
   c What type of vegetation is found in:
      i AR 0256
      ii AR 0154?
   d What is the elevation of Smith's Farm?
   e What is the height of Swan Hill?
   f What is the direction of the lighthouse from Swan Hill?

Topography and relief maps

Relief

An understanding of **relief** is central to the study of landscapes and landforms. 'Relief' is the term geographers use to describe the shape of the land, including height and steepness. The main techniques used by cartographers to show relief on topographic maps are spot heights, contour lines and patterns, and layer colouring and landform shading.

Topographic maps

Figure 1.6.1 is a topographic map showing relief features.

Spot height

A **spot height** is shown on a map as a black dot with the height written next to it. Spot heights give the exact height above sea level of particular locations or features.

Contour lines

A **contour line** joins points of equal height above sea level. Thus, every point along the line has the same value.

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.

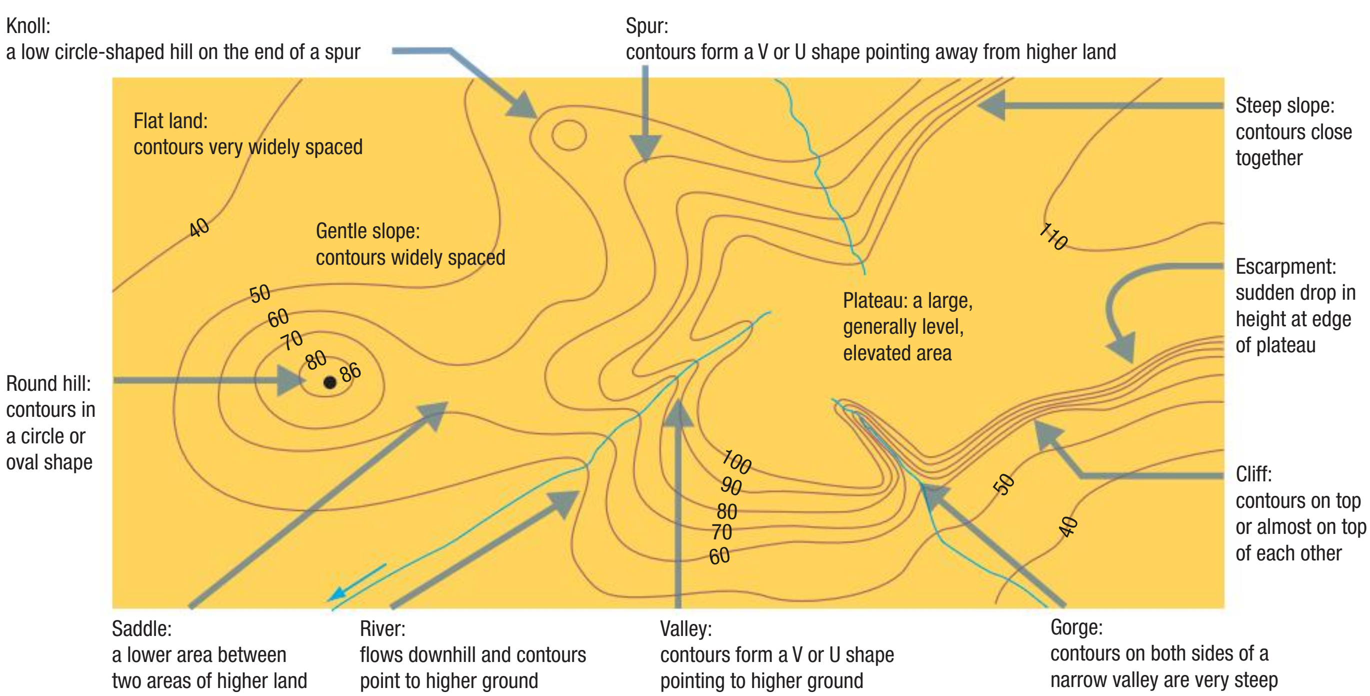
Contour patterns

Each type of topographic feature is represented by its own distinctive contour pattern.

- The spacing of the contours on a map shows the steepness of slopes. Contour lines that are close together show that the area has steep slopes. Widely spaced contour lines indicate that the area is very flat.
- The spacing of contour lines on a map shows the shape of a slope. Evenly spaced contours indicate a uniform slope. 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.

With practice, you can gain a visual impression of the shape of the land by interpreting the patterns made by the contour lines on a map.

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



Layer colouring

Layer colouring is a simple and effective way of showing relief on maps. It involves colouring the area between selected contours in different colours. When it is used in combination with spot heights, and sometimes landform shading, layer colouring can tell you a good deal about the shape of the land.

Isolines

An isoline is a line that joins points of the same value. Examples are equal elevation (contour lines), temperature (isotherms) and barometric pressure (isobars).

Landform shading

Shading can be used on maps, with colours darkening as **elevation** increases. Shading may be used as if the light is coming from one direction, so that one side of a hill is shown in a lighter shade than the other to give it greater definition. Landform shading is sometimes used together with contour lines.

Aspect

Aspect refers to the direction that a slope faces. The aspect of a particular slope can be determined by examining the height and pattern of contour lines.

SkillsBuilder

Estimating heights of landform features

Sometimes you will need to know the height of a map feature, such as the top of a hill or a plain. If there is no spot height on the feature, it is possible to estimate the height by studying the contour lines of the map. Use the following examples as a guide.

Example 1: Estimate the height of the hill at point A.

In Figure 1.6.2, point A lies more than 150 metres above sea level. However, it is obviously less than 200 metres above sea level. Your answer can be expressed in one of two ways:

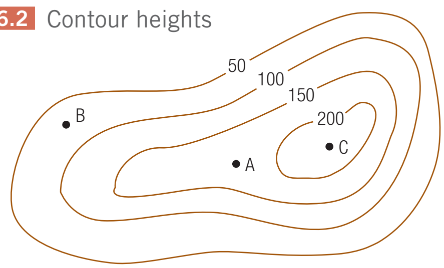
- as a statement—point A is more than 150 metres, but less than 200 metres, above sea level; or
- as an estimate—point A is 175 metres (any number between, but not including, 150 and 200 would be acceptable) above sea level.

Example 2: Estimate the height of point B.

In Figure 1.6.2, point B lies between the 50 and 100 metres contour lines. Your answer can be expressed in one of two ways:

- as a statement—point B is more than 50 metres, but less than 100 metres, above sea level; or
- as an estimate—point B is 75 metres (any number between, but not including, 50 and 100 would be acceptable) above sea level.

1.6.2 Contour heights



ACTIVITIES

Knowledge and understanding

1. Define the term 'relief'.
2. List the techniques used to show relief on maps.
3. Explain what the spacing between contour lines tells us about relief.
4. Study Figure 1.6.1 and answer the following questions.
   a. Describe the difference between a cliff and an escarpment.
   b. What is the spot height shown in Figure 1.6.1?

Geographical skills

5. Study Figure 1.6.1. What is the contour interval?
6. Study Figure 1.6.2. Estimate the spot height for C.

Investigating

7. Study Figure 1.6.1.
   a. List the different landform features.
   b. Find an image of each landform feature from your list.
   c. Copy Figure 1.6.1 and annotate your diagram with the landform images you have collected.

Topographic maps

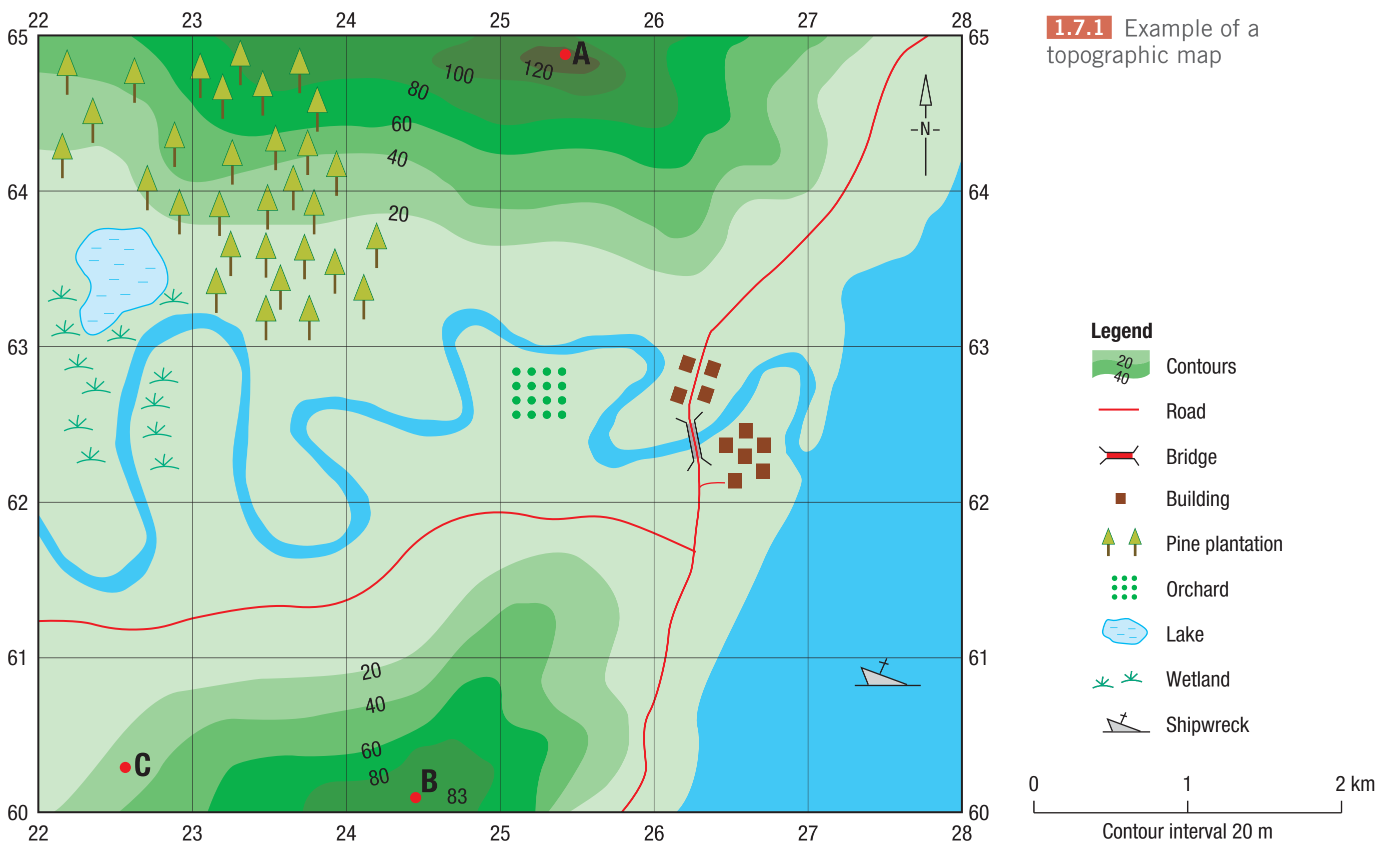
Interpreting topographic maps

Being able to interpret topographic maps is an important geographical skill. It allows you to:

- locate features of the biophysical and constructed environments
- describe distribution patterns
- identify relationships between features.

Many different people use topographic maps for work and recreational purposes. For example, an architect would not start designing a building without knowing the shape of the land, nor would a bushwalker set out on a walk without first studying a topographic map.

Topographic maps generally show a large amount of detail. Figure 1.7.1 is a topographic map showing a town next to the sea. The map includes many of the elements common to topographic maps.

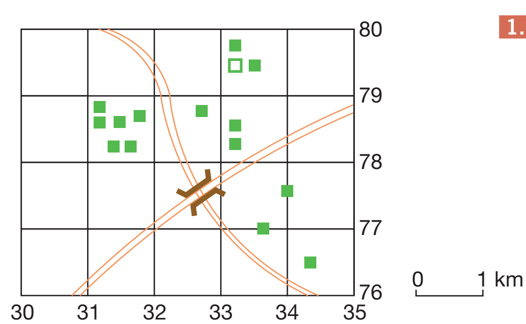


1.7.1 Example of a topographic map

Density

The density of a feature can be determined by counting the number of times that feature occurs within a specific area. Answers should be expressed as the number of features per square kilometre.

For example, in Figure 1.7.2, the density of buildings in AR 3178 is 6 per square kilometre (or 6/km²).



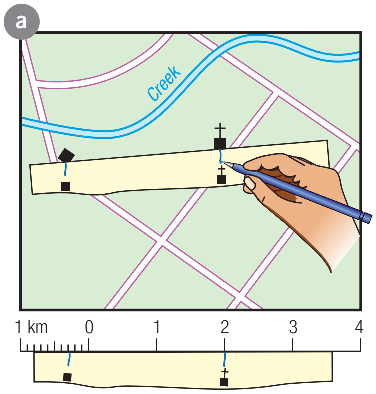
1.7.2 Density

SkillsBuilder

Measuring distances on maps

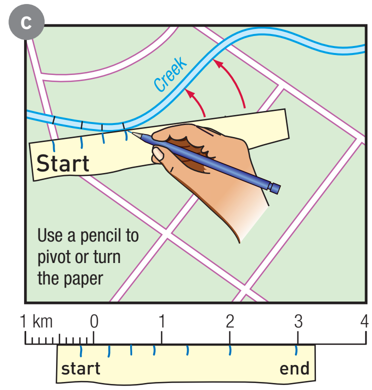
Scale can be used to calculate the distance between places on maps, vertical aerial photographs or satellite images. Figure 1.7.3 shows how to find:

- the straight-line distance between two points
- the distance between two points along a railway line, road, track or river.



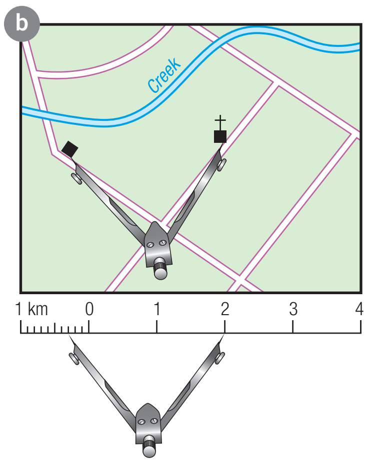
Measuring straight-line distance using paper

Place a sheet of paper between the two points. Mark the two points, then measure the distance along the line scale.



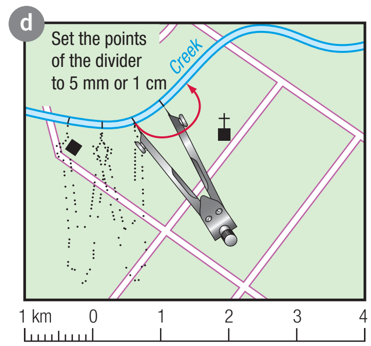
Measuring around a bend using paper

Mark the starting point. Keeping the paper firmly on the map, move your pencil to pivot the paper at each bend or curve to reach the end point. Mark the end point, then measure the distance on the line scale.



Measuring straight-line distance using dividers

Open out the dividers to the distance between the two points. Then measure that distance on the line scale.



Measuring around a bend using dividers

From the starting point, 'walk' the dividers around the curve, counting the number of 'steps' to the end point. If the distance is not an exact number of steps, open the dividers up for the final step. Calculate the total distance of all the steps, then measure that distance on the line scale.

1.7.3 Measuring distances on maps

ACTIVITIES

Geographical skills

Study Figure 1.7.1 and answer the following questions.

- **a** What landform feature is found in AR 2263?
- **b** In what area reference is the orchard located?
- **c** What is the grid reference of point C?
- **d** What features of the built environment are located at:
  - **i** GR 275608
  - **ii** GR 263624?
- **e** What is the straight-line distance between point A and point B?
- **f** What is the direction of the bridge in AR 2662 from the hill in AR 2460?
- **g** In what direction is the river flowing in AR 2262?
- **h** What is the aspect of the slope in AR 2564?
- **i** What is the height of the hill located in AR 2564?
- **j** What is the height of point C above sea level?
- **k** What landuse activity is found in the north-west quadrant of the map?
- **l** What is the density of buildings in AR 2662?

1.8

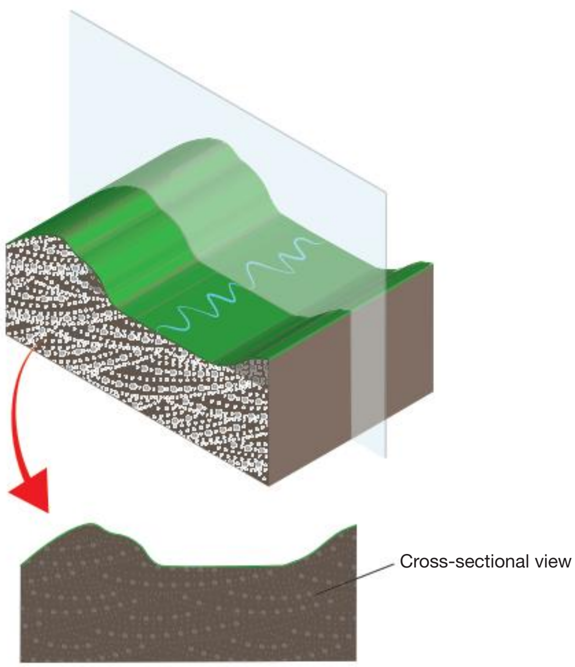
Drawing cross-sections

Cross-sections

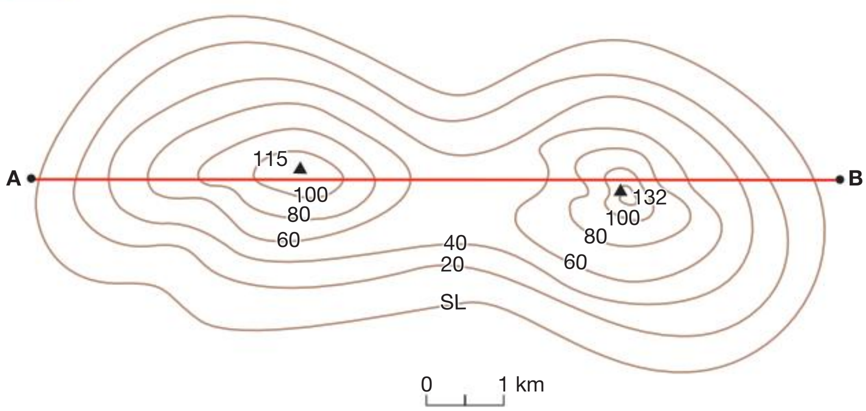
A cross-section provides a side view, or profile, of a landscape. This view enables us to see how the shape of the land influences landuses such as settlement, drainage and vegetation.

A cross-section is shown in Figure 1.8.1. Cross-sections are drawn from topographic maps, such as in Figure 1.8.2, and show the shape of the land.

1.8.1 A cross-section shows a side view, or profile.



1.8.2 Twin peaks and a saddle

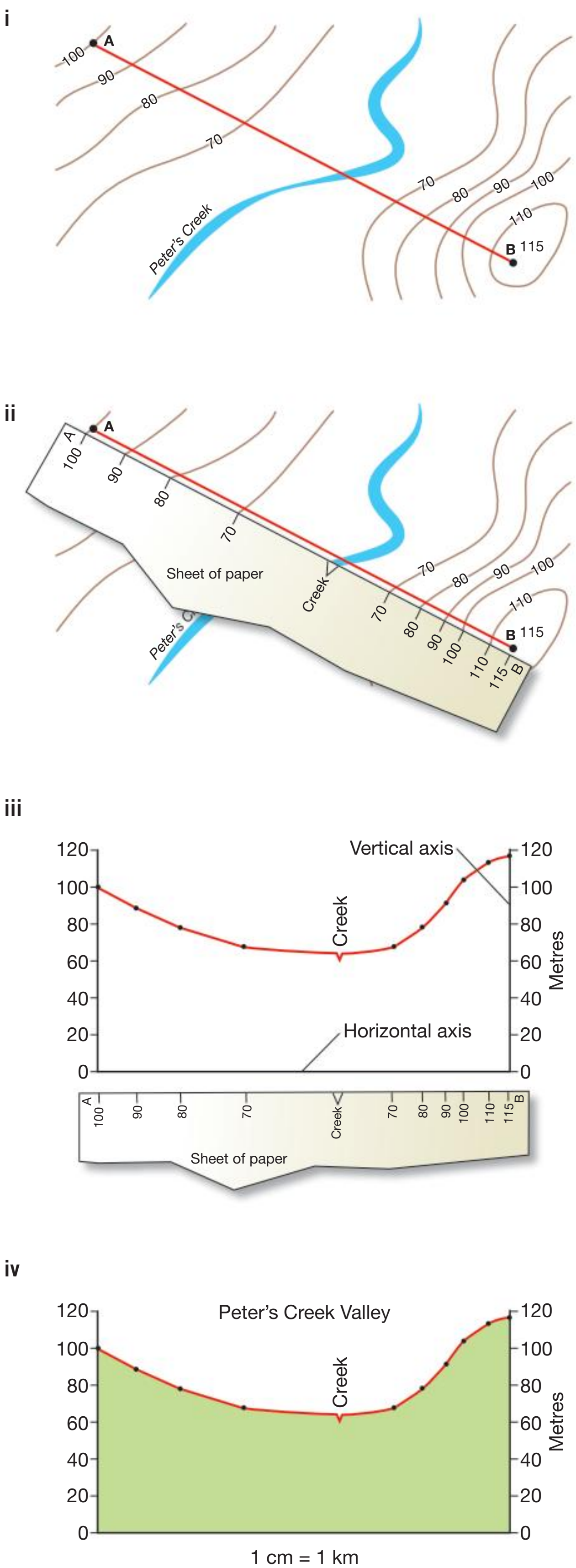


Constructing cross-sections

To draw a cross-section, follow the steps below and refer to Figure 1.8.3.

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*). You may have to estimate the height of your starting and finishing points.
4. On graph or squared paper, draw the horizontal and vertical axes for your cross-section. The length of the horizontal axis should equal the distance between A and B. The vertical axis should use a scale that does not exaggerate your vertical scale too much. You don't want a range of low hills looking like the Himalaya!
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 single, smooth curved line.
7. Label any features intersected by your cross-section, such as rivers and major roads.
8. Finish off your cross-section by:
   - **a** shading in the area below the landform you have drawn
   - **b** labelling the scale on the horizontal and vertical axes
   - **c** giving it a title.

1.8.3 Drawing a cross-section



SkillsBuilder

Calculating vertical exaggeration

Calculating vertical exaggeration (VE) shows how much a cross-section has been exaggerated vertically.

The vertical exaggeration of a cross-section is given as a number. For example, 5× means that the vertical scale is 5 times greater than the horizontal scale. A value of 1× indicates that horizontal and vertical scales are identical. This means that the cross-section has no vertical exaggeration.

To calculate the vertical exaggeration (VE) of a cross-section we use the following formula:

$$\text{VE} = \frac{\text{Vertical scale (VS)}}{\text{Horizontal scale (HS)}}$$

The scale used on the vertical axis of the cross-section

The scale of the map from which the cross-section was drawn

Answers must be expressed as a single number. Vertical exaggeration has no units of measurement, nor is it expressed as a fraction.

For example, to calculate the vertical exaggeration of the cross-section shown in Figure 1.8.3:

$$\text{VE} = \frac{\text{VS}}{\text{HS}} = \frac{\text{1 cm represents 20 m}}{\text{1 cm represents 1 km}}$$

Make sure that the same unit of measurement is used on the top (numerator) and bottom (denominator) of the formula.

$$\text{VE} = \frac{\text{VS}}{\text{HS}} = \frac{\text{1 cm represents 20 m}}{\text{1 cm represents 1000 m (1 km)}}$$

$$\text{VE} = \frac{\frac{1}{20}}{\frac{1}{1000}}$$

Invert the denominator and then multiply:

$$= \frac{1}{20} \times \frac{1000}{1}$$

$$= \frac{1000}{20}$$

$$= 50 \text{ times}$$

ACTIVITIES

Geographical skills

Study Figure 1.8.2. Construct the cross-section A–B. Calculate the vertical exaggeration of the cross-section you have drawn.

1.9

Latitude and longitude

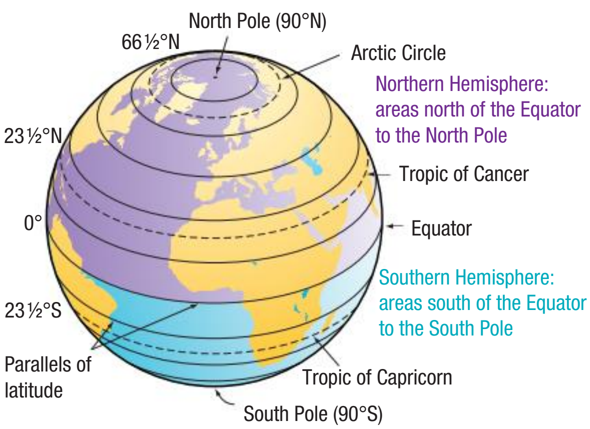
Locating places and features

Most of the maps you will use in your study of Geography include lines of latitude and longitude. These allow you to quickly and accurately locate places and features on the earth's surface.

Latitude

Lines of latitude (see Figure 1.9.1) are imaginary lines that run in an east–west direction around the earth. Because lines of latitude are parallel to each other, they are often referred to as **parallels of latitude**.

The most important line of latitude is the Equator (0°). The Equator divides the earth into two halves: the Northern and Southern hemispheres. All other lines of latitude are either north or south of the Equator.

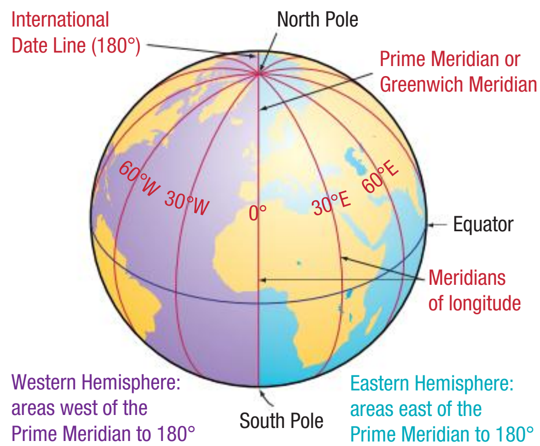


1.9.1 Lines of latitude

Longitude

Lines of longitude (see Figure 1.9.2) run in a north–south direction. They are not parallel to one another; they all converge, or meet, at the North and South poles. Any number of these lines can be drawn. These imaginary lines are called **meridians of longitude**.

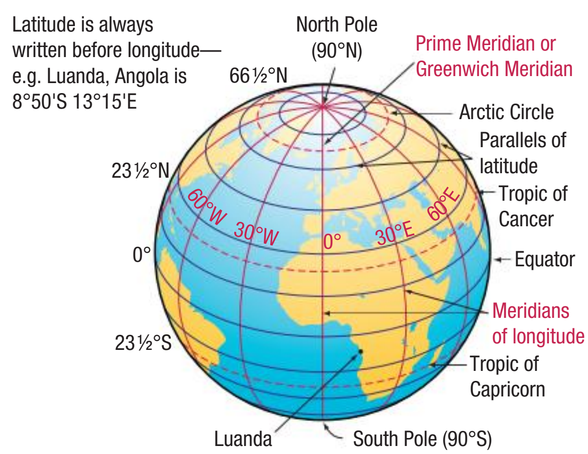
The most important line of longitude is the Prime Meridian (0°), which passes through Greenwich Observatory in London, United Kingdom. All other lines of longitude are located either to the east or to the west of the Prime Meridian. The International Date Line (IDL) is on the opposite side of the world, at 180°. There is a change of day at the IDL. The Prime Meridian and the IDL divide the earth into two halves: the Western and Eastern hemispheres.



1.9.2 Meridians of longitude

Latitude and longitude

Together, lines of latitude and longitude form a grid that allows you to pinpoint places on the earth's surface (see Figure 1.9.3).



1.9.3 Latitude and longitude

SkillsBuilder

Finding places using latitude and longitude

If you are given the latitude and longitude of a place and asked to identify it, follow the steps below.

1. Using a world map, find the general location of the latitude and longitude you have been given.
2. Turn to a map of the region or continent, and locate the latitude and longitude more accurately.
3. Check your answer by finding the place name in the index of the atlas. Most atlas indexes include the latitude and longitude of each place.

Kobe, Japan (see Figure 1.9.4), for example, has a latitude of approximately 35° north of the Equator and a longitude of approximately 135° east of the Prime Meridian. To be even more accurate, each degree (°) can be divided into smaller units, called minutes ('). There are 60 minutes in each degree. Kobe's location using degrees and minutes is latitude 34°40' north, longitude 135°12' east.

Source: *Heinemann Atlas* Fifth Edition

1.9.4 A map extract of Japan, showing latitude and longitude, and features of the biophysical and built environments

ACTIVITIES

Knowledge and understanding

1. Define the terms 'parallel of latitude' and 'meridian of longitude'.
2. Explain the difference between parallels of latitude and meridians of longitude.
3. Describe the location and significance of the Prime Meridian and the International Date Line.

Geographical skills

4. a Study Figure 1.9.4. Name the feature of the physical environment located at each of the following sets of coordinates.
   - i 36°05'N 133°00'E
   - ii 42°30'N 132°00'E
   - iii 35°23'N 138°42'E
   - iv 38°20'N 138°30'E
   - v 41°20'N 140°15'E
   - vi 42°N 129'E
   - vii 33°30'N 135°45'E

   b Study Figure 1.9.4. Name the feature of the human environment found at each of the following locations.
   - i 35°40'N 139°45'E
   - ii 34°23'N 132°27'E
   - iii 31°00'N 130°30'E
   - iv 38°15'N 140°52'E
   - v 43°05'N 141°21'E
   - vi 35°02'N 135°45'E

Landscapes and landforms

CHAPTER 2

Landscapes comprise the physical elements of the earth's surface and the cultural overlay of human activity, some of which stretches back thousands of years. Landscapes reflect the interactions of place and people over time and are important in shaping national identity. Landscapes contribute to our 'sense of place' and form the dynamic (ever-changing) backdrop to our lives. Landforms are the natural features of the earth's surface.

In this chapter we are introduced to the concepts of landscapes and landforms, the processes responsible for their formation and the ways in which people value them. A particular focus is the relationship between indigenous peoples and landscapes and landforms, and the ways in which landscapes help shape national identity.

INQUIRY QUESTIONS

- What are the processes responsible for the formation of landscapes and landforms?
- In what ways are landscapes and landforms valued?
- How is national identity shaped by landscapes?
- What is special about the ways in which indigenous peoples value landscapes and landforms?

GLOSSARY

aesthetic value	the value of a landscape based on its beauty or attractiveness
crust	the thin outer layer of the earth (the lithosphere)
deposition	the accumulation of sediment by the action of erosional agents, such as water and wind
Dreaming	a key spiritual belief of Australian Aboriginal people; describes both the period of creation (the Dreaming) and the stories that come from this period (Dreaming stories)
earthquake	a sudden movement of the earth's crust
erosion	the wearing down, transportation and deposition of material by water, wind and ice
faulting	the fracturing of rock along lines of physical weakness
folding	the buckling of rock due to pressure
landform	a natural feature of the earth's surface, for example a mountain, valley, lowland or volcano
landscape	the overall appearance of an area resulting from the interaction of landforms, vegetation and soils with human elements of the environment, such as transport networks, settlements, farms and factories
mantle	the layer between the earth's core and its crust
mid-ocean ridge	an underwater ridge formed when continental plates move apart, allowing molten material to fill the gap created
national identity	a person's sense of belonging to a nation
ocean trench	an underwater depression created when the edges of oceanic plates are forced down into the earth's mantle
plate	a segment of the earth's crust that is slowly moving due to convection currents in the mantle
plate margins	the areas where the earth's plates meet
plate tectonics	the study of the movement of the earth's plates by currents deep within the earth's liquid mantle
rift valley	a large, elongated depression with steep walls formed by the downward movement of a block of the earth's surface between nearly parallel faults
rock cycle	the recycling of material in the earth's crust
sacred sites	places of significant cultural and spiritual meaning to Aboriginal and Torres Strait Islander people
seafloor spreading	the separation of oceanic plates
volcano	an opening in the earth's surface through which molten rock, lava and ash erupt

2.0 Hallstatt, Austria

2.1

Landscapes and landforms explained

Landforms

Landforms are the natural features of the **landscape**. They include valleys, plateaus, mountains, cliffs, plains, hills, dunes and glaciers.

Landscapes

Landscape is the term used to describe the features of an area. It includes the biophysical elements of landforms, the living elements of land cover, the human elements and changeable elements such as weather conditions.

Culture and landscapes

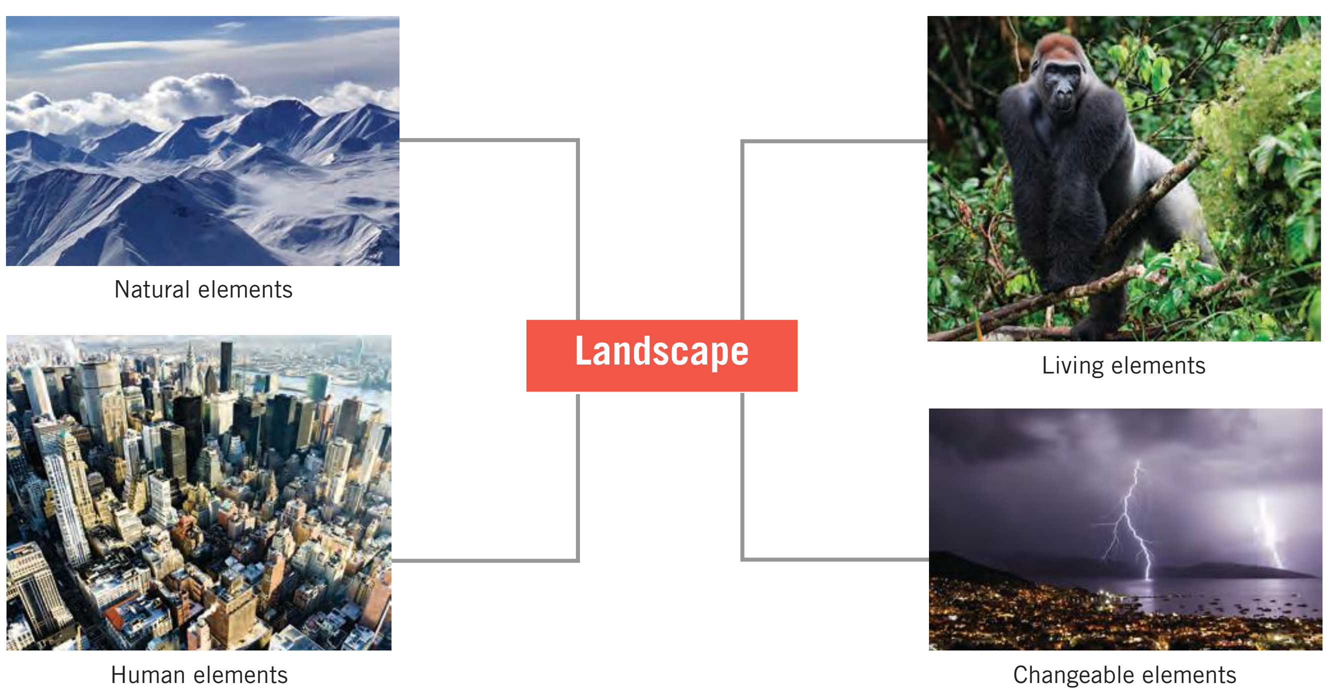
Landscapes combine physical features with an 'overlay' of human activity, as shown in Figure 2.1.1. This overlay may have accumulated over thousands of years and can often easily be identified as elements of managed and constructed environments. Sometimes, however, evidence of human activity is hard to see. Geographers seek to explain how and why places have changed over time.

Landscapes are the product of the interaction of people and **place**, and play an important role in creating what geographers refer to as 'sense of place'—the qualities that distinguish one place from another. Landscapes also play a role in shaping people's personal, local and **national identities**.

Types of landscapes

The earth has a vast range of biophysical, managed and constructed landscapes. The earth's biophysical landscapes are those largely unaffected by human activity. They include its icy polar regions; its great mountain ranges (Figure 2.1.2) and vast deserts; the savanna grasslands (Figure 2.1.3); coastal and reef landscapes (Figure 2.1.4); and the tropical and boreal forests. There are also a number of managed and constructed landscapes. These include the world's various agricultural landscapes (Figures 2.1.5 and 2.1.6) and its industrial and urban landscapes (Figures 2.1.7 and 2.1.8).

2.1.1 Elements of landscape




2.1.2 A mountain landscape, New Zealand


2.1.3 Savanna grasslands, Africa


2.1.4 Whitehaven Beach, Australia


2.1.5 Agricultural landscape, Bali


2.1.6 Agricultural landscape, Switzerland


2.1.7 Industrial landscape, China


2.1.8 Urban landscape, Vancouver, Canada

ACTIVITIES

Knowledge and understanding

1 State what is meant by the following terms:
   a landscape
   b overlay of human activity
   c sense of place.
2 Identify the elements of landscapes and give examples of each.
3 Explain why human activity can be difficult to observe. Give an example.
4 Define the term 'landform'.
5 Explain why geographers study landscapes.

Applying and analysing

6 Study Figures 2.1.2 to 2.1.8.
   a Describe the differences between biophysical, managed and constructed landscapes.
   b Rank the landscapes from the one you find most appealing to the one you find least appealing.
   c Write down the criteria you used when determining your ranking.
7 Identify the typical 'Australian' landscape. What are the elements of the landscape that make it uniquely Australian?

2.2

The changing earth

Destruction and formation

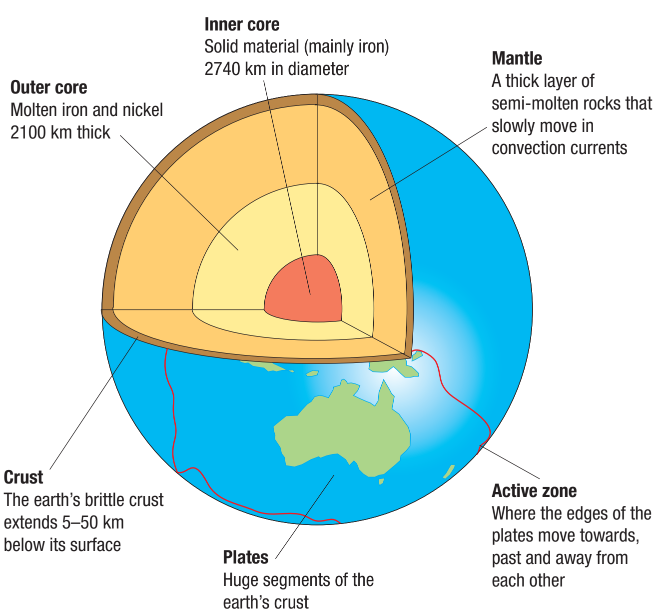
Forces deep within the earth cause the movement of tectonic plates, which in turn creates new landforms. Without these new landforms, the earth's surface would have long ago been reduced to a flat, featureless plain—worn down by the processes of weathering and **erosion**.

Plate tectonics

The earth's thin **crust** is broken into eight vast segments or **plates** (and several smaller plates) that travel slowly across the face of the planet at a rate of about 15 centimetres per year. This movement is caused by currents deep within the earth's liquid **mantle** (shown in Figure 2.2.1). This process is known as **plate tectonics**, or continental drift.

Continents on the move

Scientists believe that all the earth's continents were once part of one large supercontinent, known as Pangaea (a Greek word meaning 'all lands'). Pangaea consisted of two main areas: Gondwanaland (Australia, Antarctica, Africa, India and South America) and Laurasia (Asia, Europe, Greenland and North America). These two main areas began to move apart and break up about 200 million years ago. Over time they 'drifted' to their present locations.



2.2.1 The internal structure of the earth

Types of plate movements

Each of the earth's plates moves in a different way. Two plates may meet at:

- a convergent plate boundary (where one plate moves towards another plate)
- a divergent plate boundary (where one plate moves away from another plate) or
- a transform plate boundary (where one plate moves past another plate).

The places where the plates meet are known as **plate margins**. These are often areas of great stress and activity. Many of the earth's earthquakes, volcanoes and fold mountains are located at the plate margins. Figure 2.2.2 shows the location of the earth's plates and the directions in which they are moving.

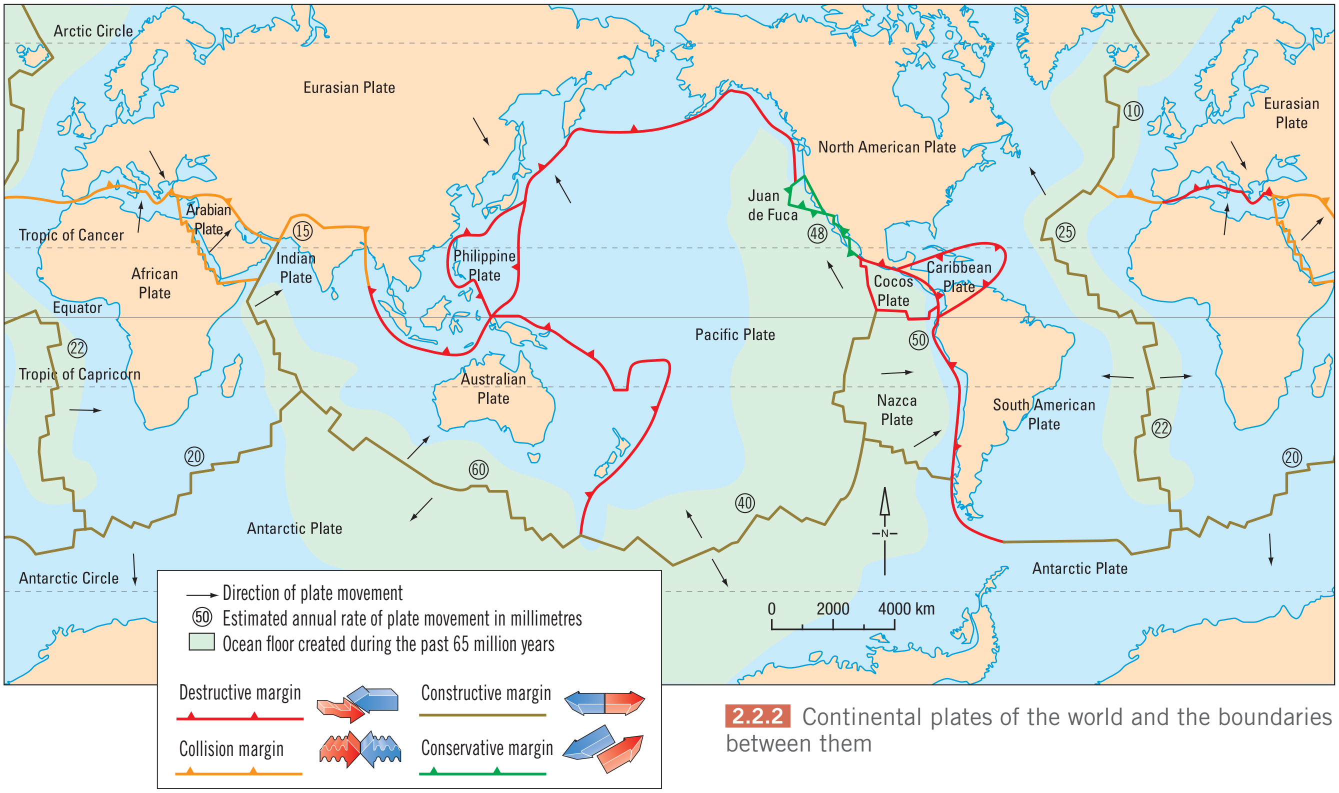
Convergent plate boundary

Collision plate margins

When two plates made of continental crust move towards one another they create a collision zone, as shown in Figure 2.2.3. Because neither plate can sink beneath the other, their crusts crumple upwards to form fold mountains. The Himalaya (see Figure 2.2.4), formed as a result of the collision between the Indian and Eurasian plates, is an example of a fold mountain system. Sometimes pressure builds up over time. Eventually the crust breaks, sending out shockwaves in the form of an **earthquake**.

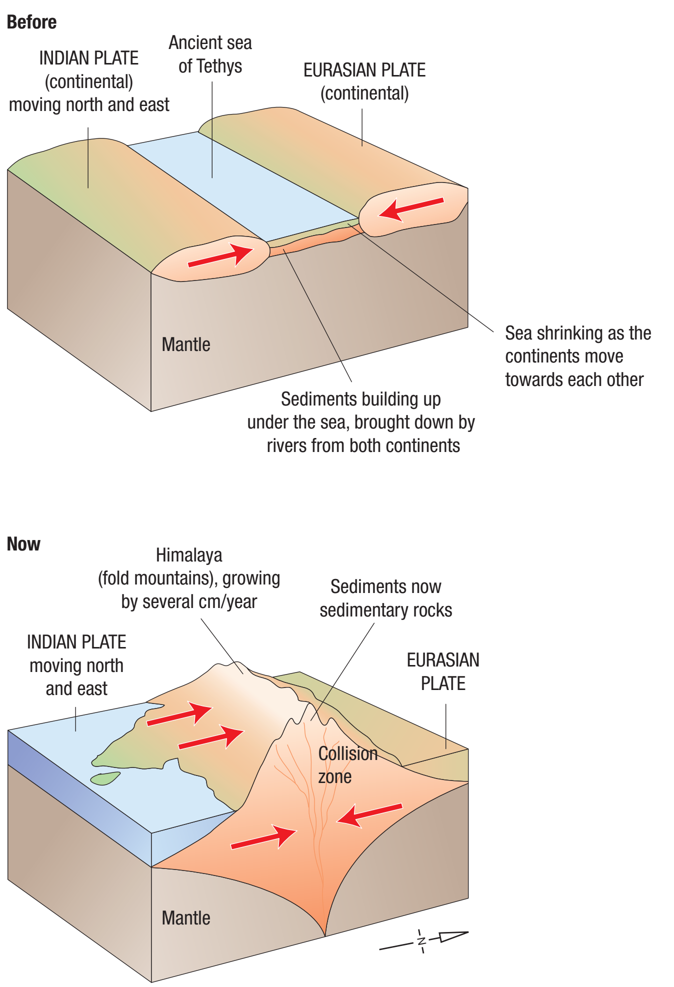
DID YOU KNOW?

At 8850 metres above sea level, Mt Everest is the highest point on the earth's surface. It is not, however, the world's highest mountain. From base to peak, Mauna Kea on Hawaii measures 10 023 metres, 5818 metres of which is below the surface of the Pacific Ocean.



2.2.2 Continental plates of the world and the boundaries between them

2.2.3 A collision plate margin



2.2.4 The Himalayan Mountains are still increasing in height as the Indian Plate moves into the Eurasian Plate at a rate of about 5 centimetres a year.

Destructive plate margins

Destructive plate margins occur where a plate made of heavy (dense) oceanic crust moves towards a plate consisting of lighter (less dense) continental crust. The heavier oceanic crust is forced down under the lighter continental crust, forming a deep-sea trench (shown in Figure 2.2.5).

As the oceanic crust pushes beneath the continental crust, it melts. This is partly due to the friction that builds up between the two plates and partly due to the increase in temperature as it reaches the earth's mantle. This creates magma, which can escape to the surface along lines of weakness in the earth's crust, called faults, to form a **volcano**. Volcanic eruptions at destructive plate margins can be very violent.

Because the plates do not slide smoothly past each other, there is often an enormous build-up of pressure. If the crust breaks, shock waves are sent out in all directions, causing an earthquake.

Divergent plate boundary

Constructive plate margins

When two plates move away from each other, magma rises from the mantle to form new crust. This creates a line of underwater volcanoes along what is called a **mid-ocean ridge**. Sometimes these volcanoes become large enough to emerge above sea level as volcanic islands. The Mid-Atlantic Ridge (see Figure 2.2.6), which was formed by the separation of the North American and Eurasian plates, is an example of a constructive zone.

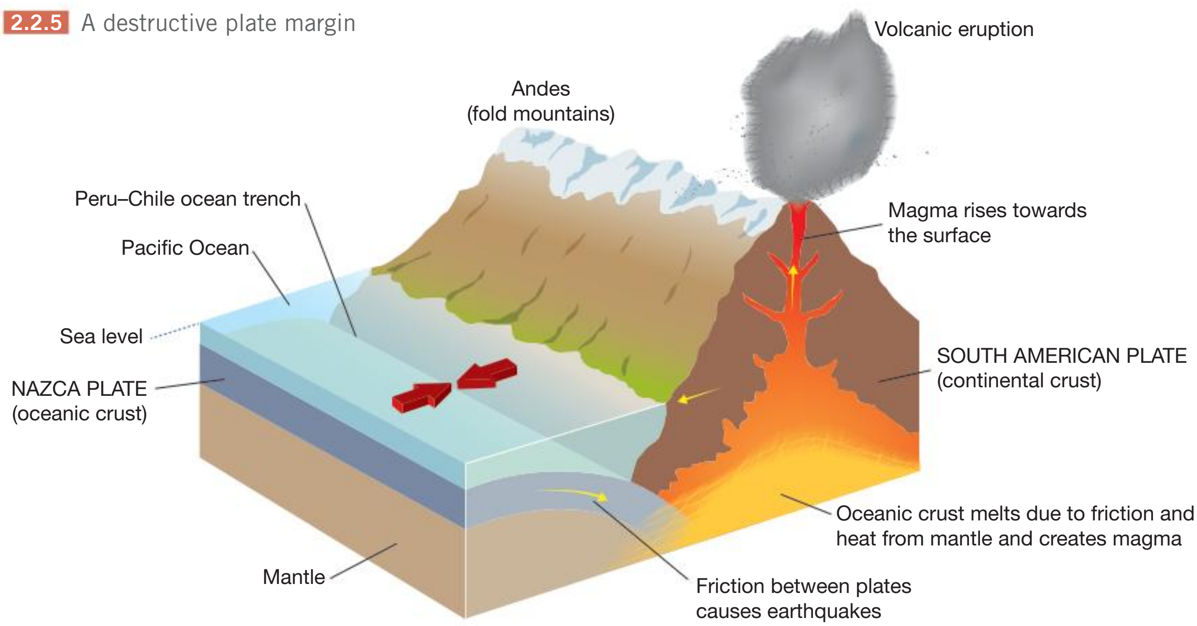
Constructive margins can also be found on land. The East African Rift Valley (see Figure 2.2.7) continues to widen, with new land being created on the floor of the valley.

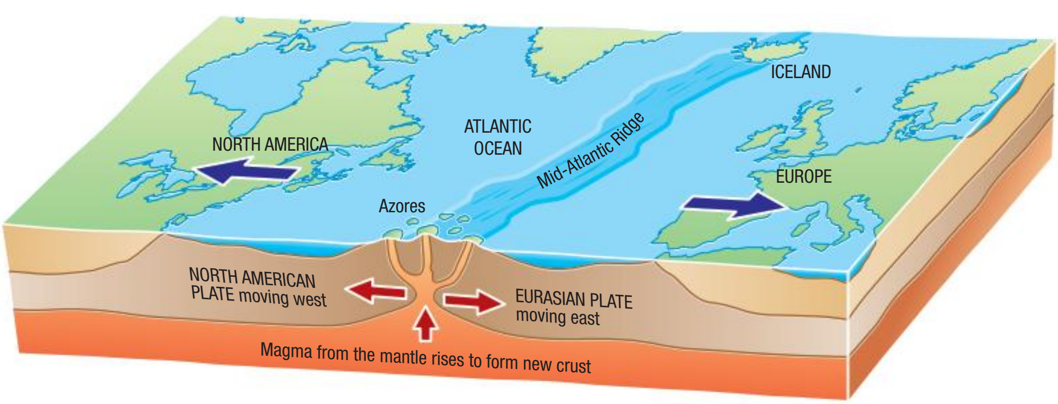
Transform plate boundary

Conservative plate margins

Conservative plate margins occur where two plates move past one another. The San Andreas Fault in California, for example, marks the point at which the North American and

2.2.5 A destructive plate margin

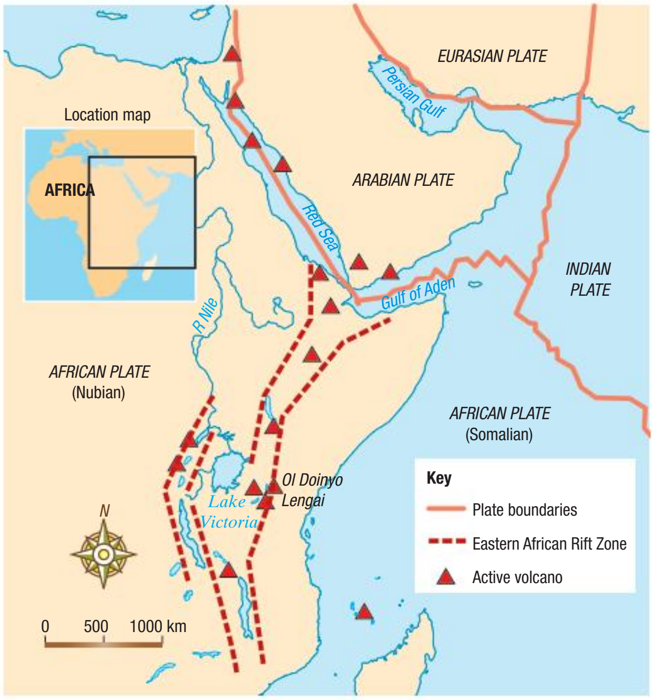




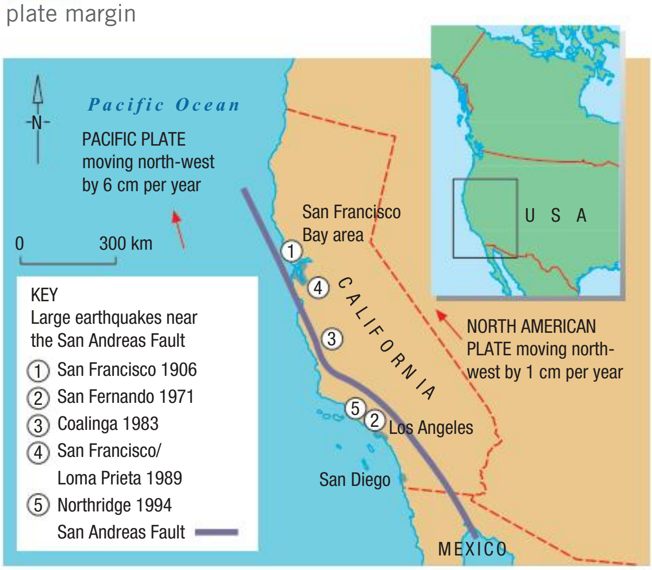
2.2.6 The Mid-Atlantic Ridge was formed by the separation of the North American and Eurasian plates. Each year the Atlantic Ocean widens by about 3 centimetres.

Pacific plates meet. Although the two plates are moving in the same direction, the Pacific Plate is moving faster, causing the plate margins to 'grind' past each other. The tensions between the two plates build up over time. When this tension is suddenly released an earthquake occurs. Minor earthquakes occur almost daily along the fault, but major earthquakes, causing loss of life and destruction of property, are less frequent. The last major earthquake was the 1994 Northbridge earthquake. It measured 6.6 on the old Richter scale and killed 60 people (see Figure 2.2.8).

2.2.7 The Great Rift Valley in eastern Africa was formed through the rifting (tearing apart) and separation of the African, Arabian and Indian tectonic plates.



2.2.8 California's San Andreas Fault: a conservative plate margin



ACTIVITIES

Knowledge and understanding

1 State the name given to the processes involved in the movement of the earth's crust. Explain the causes of this movement.

2 Name the types of plate margins.

3 Describe what happens to the earth's crust in a collision zone.

Geographical skills

4 Study Figure 2.2.2.

a Name two plates that are colliding, moving towards each other, moving away from each other and moving past each other.

b Discuss the plate that is moving the greatest number of millimetres per year.

5 Study Figures 2.2.3 and 2.2.5. Write a paragraph comparing the formation of the Andes Mountains and the Himalayan mountain range.

6 Study Figure 2.2.8. Explain why parts of California experience earthquakes.

2.3

Rocks and the rock cycle

Rock types

Rocks are classified into three different types: igneous, sedimentary and metamorphic.

Igneous rocks

Igneous rocks form when molten material (magma) cools and becomes solid, or solidifies. There are two main types of igneous rocks. They have the same chemical composition but differ in structure depending on where the magma cooled. Intrusive igneous rocks are rocks that form slowly in the earth's crust (underground). Extrusive igneous rocks form when the magma erupts from a volcano and then cools quickly above ground. Igneous rocks are distinguished by their crystal-based structure. The crystals present in intrusive igneous rocks are large due to the slow rate of cooling, while those in extrusive igneous rocks are small because of their faster rate of cooling. Granite (which features relatively large crystals) is an example of an intrusive igneous rock. Basalt (characterised by small crystals) is an example of an extrusive igneous rock.

Sedimentary rocks

Sedimentary rocks form when eroded material carried in water settles to form sediment. Over millions of years, successive layers of sediment build up on top of one another. These layers are slowly compressed and bond to form sedimentary rocks. These layers of rocks can be folded and faulted by forces within the earth's crust.

Sedimentary rocks have a layered appearance and often contain fossils of plants and animals that were trapped in the sediment as it was deposited. Sandstone is an example of a sedimentary rock.

Metamorphic rocks

Metamorphic rocks are formed when existing igneous and sedimentary rocks are compressed and heated without melting. They have the same chemical composition as the rocks from which they were made. Metamorphic rocks are often shiny and hard, and sometimes peel off in layers. Slate and marble are examples of metamorphic rock.

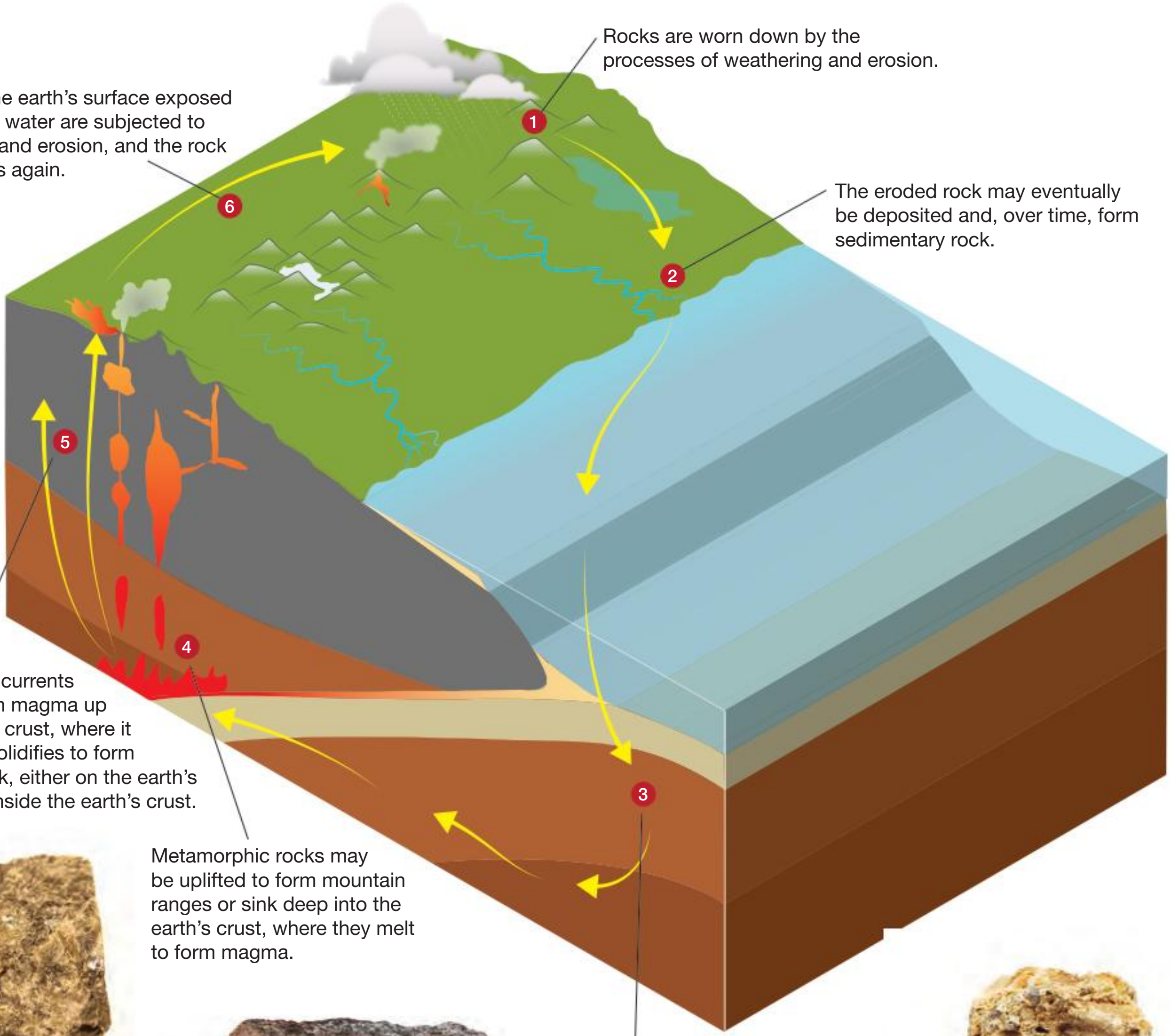
Rate of erosion

Rocks erode at different rates, depending on their hardness. Differential erosion occurs when softer rocks erode faster than more resistant, harder rock. Figure 2.3.1 shows a landform feature characteristic of differential erosion. The softer sedimentary rock has been eroded at a faster rate than the hard caps of these stone pillars.

2.3.1 Rock pillars (known as hoodoos) in Alberta, Canada. The pillars consist of soft sedimentary rock capped by a piece of harder rock. Hoodoos form in semi-arid regions of sedimentary rock that experience occasional heavy downpours. The rain erodes away the softer material, leaving behind columns of rock under hard caps.

The rock cycle

Figure 2.3.2 shows the **rock cycle**. The rock cycle is the process in which material from the earth's crust is recycled to form new rocks.



Igneous rock

Metamorphic rock

Sedimentary rock

2.3.2 The rock cycle

ACTIVITIES

Knowledge and understanding

1 Distinguish between intrusive and extrusive igneous rocks.
2 Explain how sedimentary and metamorphic rocks are formed.
3 State what differential erosion is.
4 Name the different stages of the rock cycle.

Geographical skills

5 Study Figure 2.3.2. Draw your own annotated illustration of the rock cycle.

2.4

Mountain building

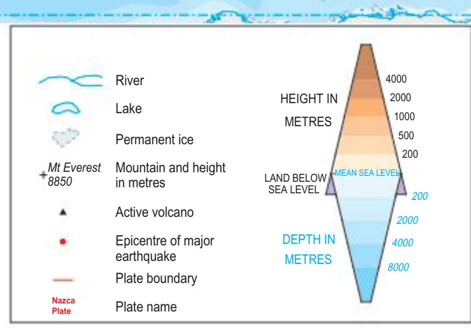
Mountains

Mountains are defined as landform features that, when compared with surrounding landscapes, rise abruptly, and are impressive and noticeable. Factors taken into account when defining such landforms include elevation, relief, steepness and mass.

Location and formation

Figure 2.4.1 shows the location of the world's great mountain ranges—the Andes Mountains of South America, the Rocky Mountains of North America, the Alps of Europe and the Himalaya of Asia. These mountains are found along the active margins of the world's tectonic plates. As the plates press against each other, the pressure increases and layers of rock are compressed and forced upwards, folding and faulting as pressure is released.

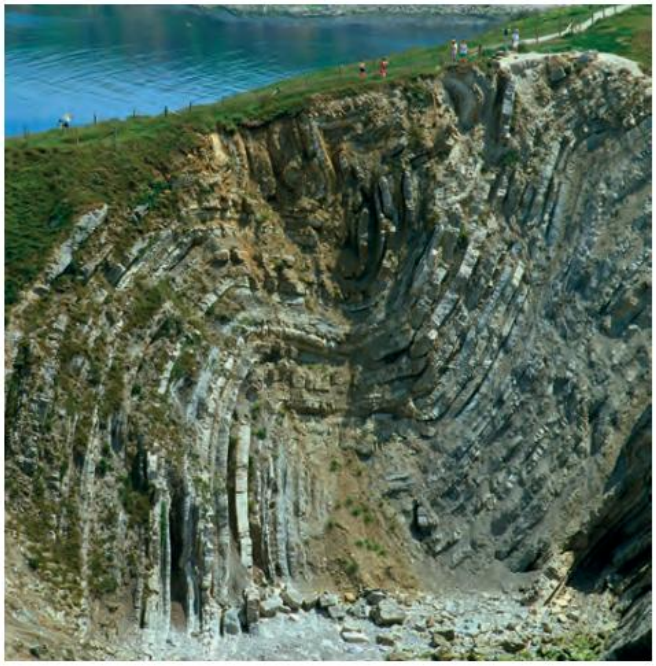
2.4.1 The Earth's tectonic plates, volcanoes and major mountain ranges



Source: *Heinemann Atlas*, Fifth Edition

Because the movement of the plates tends to be very slow, the mountain chains they produce are dominated by folded layers of rock. These mountain chains can, however, include landform features that are the result of faulting and volcanic activity. **Folding** results in wave-like patterns in the earth's crust (see Figure 2.4.2). **Faulting** occurs when there are fractures in the rock structure. Figure 2.4.3 shows both these features. **Rift valleys** and block mountains are examples of large-scale landform features associated with faulting.

As oceanic plates move apart (a process known as **seafloor spreading**), molten material fills the gap, forming a mid-ocean ridge. These ridges extend for 65 000 kilometres through all the earth's oceans. **Ocean trenches** are formed when oceanic plates are forced down into the earth's mantle, where they melt.

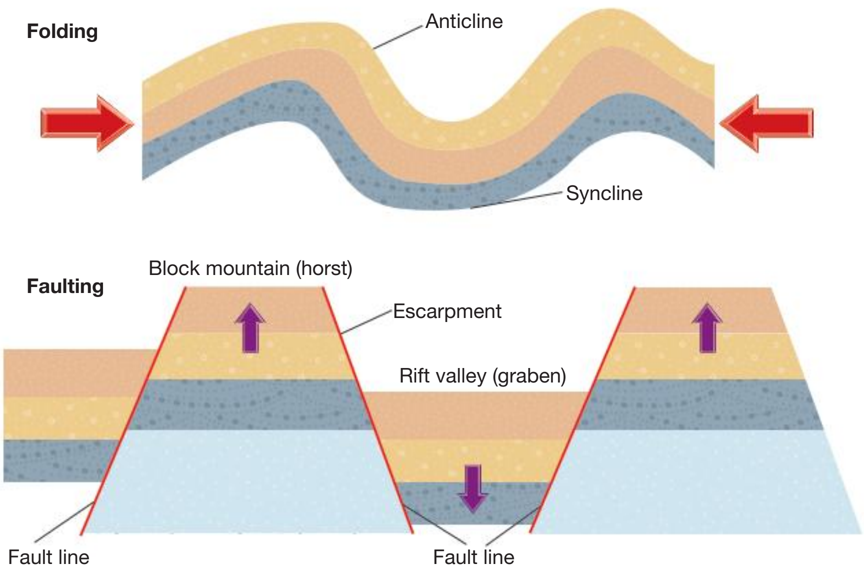


2.4.2 Folded layers of rock

2.4.3 Folding and faulting of rock layers

A rift valley (graben) is a long valley area formed by the sunken land between two or more parallel faults. A series of sinkings at different rates may produce a series of step-like landform features.

A block mountain (horst) is an elevated area of land that has been uplifted between two or more parallel normal faults. The edges of many block mountains may be distinguished by the presence of an escarpment.



ACTIVITIES

Knowledge and understanding

1 Explain the difference between folding and faulting.
2 Identify the processes associated with the formation of rift valleys and block mountains.
3 Outline the conditions under which ocean trenches develop.

Geographical skills

4 Study Figure 2.4.3. Write a paragraph outlining the global distribution of earthquakes and volcanoes.
5 Create a pie graph of each continent's share of the world's mountainous areas using the following data:

Asia (43.65%)
Europe (6.7%)
South America (8.4%)
North America (15%)
Australia and Oceania (1%)
Africa (8.25%)
Antarctica (17%).

2.5

Weathering, erosion and deposition

Weathering

Weathering involves the physical or chemical breakdown into smaller pieces of rocks that do not undergo transportation from their original position.

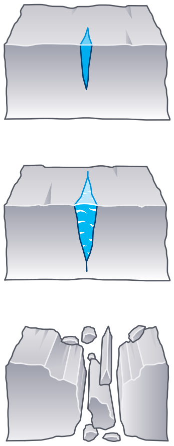
Physical weathering

There are three main types of physical (or mechanical) weathering.

- ***Temperature change*** As rocks are heated by the sun they expand. At night, as temperatures fall, the rocks contract. Over time, this expansion and contraction causes cracks to appear and the rock begins to break down. This process is called exfoliation and is common in deserts in which there are large daily differences in temperature (see Figure 2.5.1).

2.5.1 Changes in temperature have caused the outer layer of this rock to crack and break away.

- ***Freeze–thaw action*** Water collects in the cracks in rocks, and when the water freezes it expands. This places a pressure on the rock and causes the cracks to widen and deepen. The pressure may eventually cause parts of rock to break off, as is illustrated in Figure 2.5.2. The small broken-down rocks are called scree. This type of weathering is common in high mountainous areas where the water freezes.



2.5.2 Freeze–thaw weathering

- ***Organic action*** The growing roots of plants can exert a force that causes cracks in rocks to widen (see Figure 2.5.3). Gradually, the rock breaks down into smaller pieces.

2.5.3 Organic weathering

2.5.4 Jenolan Caves in New South Wales

Chemical weathering

When rainwater mixes with carbon dioxide (which is present in the atmosphere), it forms a weak acid that attacks many of the minerals contained in rock. This acid is especially effective in dissolving limestone. Limestone caves (such as the Jenolan Caves in New South Wales, shown in Figure 2.5.4) are a result of this type of weathering.

Rocks that contain iron are affected by a process known as oxidation. When oxygen and water come into contact with the iron in rocks they change the chemical make-up of the rocks, which take on a rusty appearance. The surface of the rock gradually decays and is eroded away.

Organic acids are produced when water mixes with decaying vegetation. These acids help to break down minerals in rocks.

Erosion

Erosion is the transportation of material that has been weathered (worn away) from one place to another by water, wind and ice. Erosion occurs when rivers carve out deep canyons, glaciers grind out massive valleys, and water drips through limestone to create caves and sinkholes.

The processes of erosion are as follows.

- ***Attrition*** Rocks collide as they are transported and are worn into smoother, rounded stones.
- ***Abrasion/corrasion*** Material rubs against riverbanks or valley sides as it is transported, or is thrown against cliffs by the sea. This acts like sandpaper on the landscape, gradually eroding it.
- ***Corrosion*** Some rocks, especially limestone, are dissolved by the natural acids in water and are carried away by the water.
- ***Hydraulic action*** Riverbanks or cliffs can be worn away by the sheer force of water hitting them, or can be blasted apart as air is forced into cracks.

Agents of erosion

The agents of erosion are water, wind and ice.

Water

Running water is the most powerful agent of erosion, transportation and **deposition**. It is especially effective in very dry areas and where humans have damaged the protective cover of vegetation that binds the soil together. When rain falls on exposed earth it causes deep channels called gullies to form as shown in Figure 2.5.5.

2.5.5 A landscape deeply scarred by running water—Death Valley, United States of America

RIVERS

Rivers shape the land by eroding, transporting and depositing material. In a mountainous area, the river erodes downwards, creating narrow, V-shaped valleys. Away from the mountains, valleys become wider and some of the river's load of sediment is deposited. Closer to the sea, the river weaves, or meanders, across a wide, flat plain, depositing fine particles of soil called alluvium. These alluvial soils are usually very fertile and are often used for agriculture.

WAVES

Coastlines are constantly changing. Some are eroded by storm waves and are dominated by landform features formed by the processes of erosion, such as headlands, cliffs, rock platforms and arches. Other coastlines advance towards the sea as waves deposit large amounts of sand. Such coastlines are dominated by landform features formed by the process of deposition, such as sand dunes, sand bars and spits.

Wind

Wind is a very effective agent of erosion in areas with little or no vegetation, in deserts and in areas where the land has been damaged.

Wind can pick up weathered rock material and, with it, effectively 'sandblast' larger rock features. This process is known as abrasion. It results in sculpted rock formations such as that shown in Figure 2.5.6. On a larger scale, rock-strewn desert surfaces form when strong winds sweep away the finer surface materials. This process is known as deflation.

Ice

Glaciers are slow-moving rivers of compacted snow (glacial ice). They form when compacted snow that has gathered over many years gradually moves downhill under the influence of gravity. Glaciers erode land by transporting rock (see Figure 2.5.7).

Deposition

Deposition is the process by which eroded material is added to a landscape. Water, wind and glacial ice transport weathered and eroded rock. As the speed of water slows, as the strength of a wind declines, or as a glacier melts and retreats, the load it carries is deposited, building up layers of sediment. Depositional landforms include beaches, sand bars and dunes, natural (river) levees and desert sand dunes.

2.5.6 Wind-borne sand grains have worn away the base of a desert rock, leaving this pedestal-shaped feature.

2.5.7 Findel Glacier, Zermatt, Switzerland

Changing landscapes

Weathering is sometimes called the passive, or inactive, agent of erosion because weathered material usually remains in place. Erosion and deposition (the removal and laying down of transported material) are known as active processes because the material is moved from its original position or location. A summary of this process is outlined in Table 2.5.8.

2.5.8 Weathering and erosion in summary

Weathering	
Physical weathering	**Chemical weathering**
Temperature change Freeze–thaw action Organic action	Weak acids (when rainwater and carbon dioxide mix) Organic acids
Erosion	
Erosional processes	**Agents of erosion**
Attrition Abrasion/corrasion Corrosion Hydraulic action Deposition	Running water, rivers and waves Wind Ice

ACTIVITIES

Knowledge and understanding

1 Explain the difference between physical and chemical weathering.
2 Outline the three processes of physical weathering.
3 Explain how chemical weathering helps to weaken and break up rock.
4 Explain why weathering is described as a passive, or inactive, agent of landform development.
5 State what erosion is.
6 Explain the following terms:
- attrition
- corrosion
- abrasion
- hydraulic action.

7 Explain what is meant by the term 'deposition'.

Applying and analysing

8 Identify the conditions under which water is the most effective agent of erosion.

Geographical skills

9 Construct a series of diagrams like those in Figure 2.5.2 to explain how organic weathering occurs.

2.6

Valuing landscapes

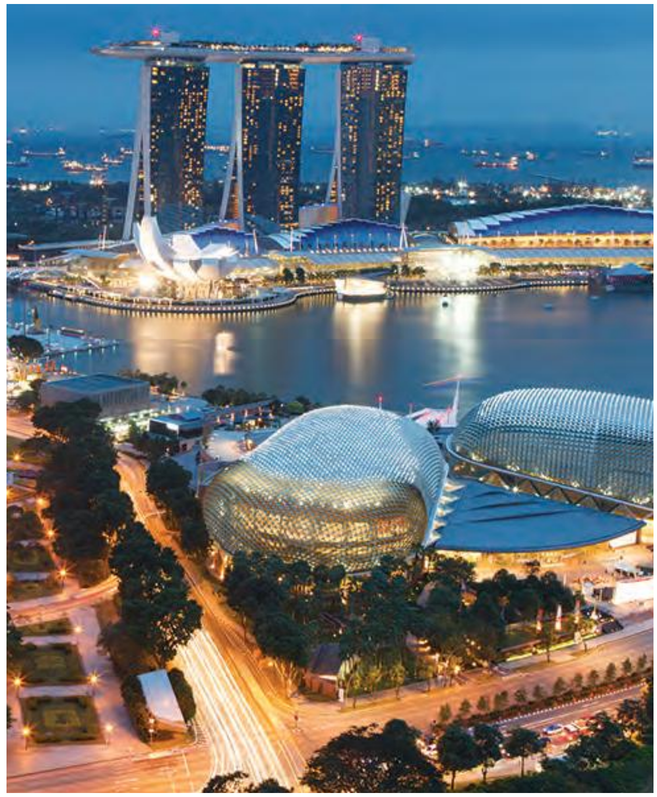
Different values

Landscapes are important to us for many reasons. They are a shared resource—they belong to everyone. They are a living record of our past, and an inspiration for our culture. They provide a wide range of social and health benefits. The value placed on landscapes changes over time. Landscapes are said to have aesthetic, emotional, spiritual and economic value.

Aesthetic value

The term '**aesthetic value**' refers to the idea of attractiveness or beauty. The aesthetic value of all landscapes is not the same, as not all landscapes are equally appealing. People can, for example, appreciate and interpret the same landscape quite differently. What may appeal to one person may not appeal to another. For US retirees seeking a warm, sunny climate, California's Palm Springs is an attractive desert landscape. Others view desert landscapes as hostile places. International tourists travel thousands of kilometres to see the landscapes of Australia's Red Centre, while many Australians head overseas to see the managed and constructed landscapes of South-East Asia (see Figure 2.6.1), Western Europe and North America.

Whether we find a landscape personally appealing depends on a range of factors. These include our emotions or feelings, our attitudes and personal values, and our preferences, experiences and memories.



2.6.1 Singapore

Emotional value

People often develop an emotional attachment to a place or landscape. This attachment usually results from a long-term connection with that place or landscape. While this is especially strong for indigenous peoples, it also applies to people more generally. We all remember, often with fondness, places we went for holidays, and we often develop an emotional attachment to the places in which we live or have lived.

> **DID YOU KNOW?**
>
> In 2014, over 1.1 billion people travelled internationally, generating more than US$1.245 billion in economic activity. This represents 5 per cent of the world's total gross domestic product and one in twelve jobs.

This attachment is different from a simple aesthetic response, such as recognising that a certain landscape or place is special because it is beautiful. For a deeper and lasting emotional attachment to develop, a long-term relationship with a place is normally required. This relationship may be physical or emotional. It might be the place in which we live or a place our mind wanders to from time to time. A snowboarder might, for example, find their thoughts drifting to the mountains on which they snowboard. A bushwalker often develops an emotional attachment to their favourite national park, such as Wollemi National Park, shown in Figure 2.6.2.

Many people find landscapes inspiring. Landscape artists and photographers, for example, seek to capture or portray the beauty of landscapes in their paintings and photographs. These provide an opportunity for people who can't observe the landscapes directly to share the experience.

2.6.2 Wollemi National Park

Spiritual value

Landscapes hold special spiritual significance for some people. Many Aboriginal and Torres Strait Islander people, for example, recognise that features of the landscape such as rivers, mountains and even individual trees have a spiritual value. Through these features, Indigenous Australians connect, by means of song and ritual, to the **Dreaming** and ancestral creator beings. **Sacred sites** are places of special spiritual importance to Indigenous Australians.

Economic value

Landscapes also have an economic value. Some, such as agricultural, industrial and urban landscapes, are in fact the product of economic activity. Others generate economic activity even though they remain in a near-natural state.

Landscapes that are spectacular and/or unique are important tourist destinations. Historic Venice in Italy, for example, attracts nearly 22 million tourists a year; California's Yosemite National Park, more than 4 million; Machu Picchu in Peru, more than 700 000; and Australia's Great Barrier Reef, more than 1.6 million people. Catering for the needs of these visitors creates economic activity and employment. The economic wellbeing of many communities depends on tourism.

Landscapes provide a wide range of opportunities for people to enjoy the outdoors. They vary from the local park through to coastal national parks and remote mountain wilderness areas. All offer relaxation, challenge, inspiration and an opportunity to experience first-hand our natural and cultural heritage.

ACTIVITIES

Knowledge and understanding

1. Explain what we mean when we talk about a landscape's 'aesthetic value'.
2. Name a place or places that have aesthetic value for you.
3. Explain the economic value of landscapes.

Geographical skills

4. Construct a photo sketch of Figure 2.6.1 or 2.6.2.
5. Annotate the sketch, naming as many natural elements of the landscape as you can. Are there any human elements evident?
6. List the possible aesthetic, emotional, spiritual and/or economic value of such a landscape.

2.7

Landscapes and national identity

Building a national identity

Landscapes can play a powerful role in the creation of national identities. People connect with an image of a landscape. This has an impact on how they see themselves as a national community. Landscapes also build a sense of belonging that helps define people's attitudes and perspectives.

A national identity is developed over time. The qualities that develop represent the society and its people. These qualities foster a sense of common beliefs and ideas about identity that people feel they share with others in their society.

We are not born with a national identity. A country's history helps to develop the idea of a national identity. Our awareness and understanding of national identity are shaped by the images of our biophysical and built environment that we see in the media and the arts throughout our lives. National identity becomes the collective personality of the people of a country. It is the foundation of the values we take on as our own and it is often expressed in our behaviour.

The importance of landscapes

Landscapes are important to people. Landscapes are not just scenery or interesting views; they have a lot of meaning for people. Apart from being the backdrop for day-to-day living, landscapes link people to nature, and the past to the present. People create and value the concept of landscapes. For example, the Great Barrier Reef is a valued landscape and there are now laws to protect and preserve areas of the reef. Some landscapes are very special because they symbolise a nation, such as the Eiffel Tower in Paris, France (see Figure 2.7.1).

Landscapes and national identities

Landscapes are shared by the people of a nation and often provide a living history of the past. Some national identities based on these landscapes become so popular that they last long after they are truly representative of the nation. For example, Egypt's pharaohs are long dead but the pyramids at Giza are still an important aspect of Egyptian national identity.

2.7.1 The Eiffel Tower in Paris, France

Australia: from the bush to the beach

When the European settlers arrived in Australia, they encountered an environment very different from Europe. The vast expanses of country—from the outback to the forests and farmlands—became collectively known as 'the bush'. This landscape was uniquely Australian and it evoked many tales of the struggle for survival. Stories of drovers, outback women, bushrangers and even children lost in the bush became legends. By 1900, the landscape of the bush had become the symbol of the new nation, even though the majority of people lived in towns and cities.

The bush may have defined the national identity a century ago, but more recently the beach has become a symbolic landscape. Most Australians live near the coast and the beach culture has become a very important aspect of the Australian lifestyle (see Figure 2.7.2). The character attributes of the bush heroes have been transferred to the lifesavers patrolling surf beaches. They are seen as fit, courageous people who save lives.

Many people consider Australia's national identity as a work in progress, as we are still a young nation. With the majority of the population living in urban centres and the population itself becoming increasingly multicultural, new layers are being added to the country's national identity.

2.7.2 Australian beach culture as seen by cartoonist Peter Nicholson

Cartoon by Nicholson from *The Australian* newspaper: www.nicholsoncartoons.com.au

ACTIVITIES

Knowledge and understanding

1 Explain the relationship between landscape and national identity.
2 Outline how a national identity is built.
3 Explain why there has been a shift in Australia's national identity.

Applying and analysing

4 Study Figure 2.7.2. List the points Nicholson is making in his 'our home is girt by beach' cartoon.
5 Design an annotated visual display of a landscape that in your opinion characterises Australia's national identity—for example Uluru, Sydney Harbour, the Great Barrier Reef or the MCG. Your display should include a list of reasons why you chose this landscape to characterise Australia's national identity.

2.8

Indigenous explanations of landscapes

Importance of landscapes

The relationship with landscape is central to the life of indigenous peoples worldwide. Over thousands of years, indigenous peoples have developed deep spiritual links with their traditional lands.

Creation myths

Indigenous peoples have their own stories about the origins of the world, their people and all living things. This can be seen in their paintings and carvings. Stories are told and retold and have been passed down from generation to generation over thousands of years. The stories are also expressed in song and dance. The rich oral and artistic history of indigenous peoples has created a sense of social continuity and harmony, and taught people how to continue the traditions of their ancestors.

DID YOU KNOW?

Originating more than 50 000 years, or 1600 generations, ago, Australia's Aboriginal culture is one of the oldest continuous cultural traditions on earth.

Supreme beings

Many of the stories passed down from generation to generation involve supernatural beings. This is especially the case in the stories dealing with the creation of the world. They are used to explain the origins of people, plants, animals and even landform features. Supreme beings, in one form or another, appear in ancient myths about creation in most cultures.

Animals

Indigenous peoples see themselves as part of nature and many view animals as their equals. Many ancient stories tell of a time when both humans and animals lived together peacefully, without any fear of each other. Indigenous explanations of the creation of the landscape feature animals in very important roles. In many cases they are credited with saving the human race. Such beliefs reflect the high regard indigenous peoples have for animals. While they may have hunted animals for food and skins, they acknowledged how greatly they relied on animals to support their needs.

SPOTLIGHT

The Iroquois creation myth

The Iroquois Native Americans (see Figure 2.8.1) believed the world was formed on the back of a giant turtle. The first woman, Sky Woman, dropped out of the sky and the water animals saved her from falling into the ocean that covered the earth. After saving her, the animals built an island for her to live on. Without their help, the Sky Woman might have perished and people might have never existed.

Source: Creation Myths—the Relationships of Animals and People

2.8.1 The Iroquois

Aboriginal and Torres Strait Islander people

The Dreaming

According to Aboriginal belief, the landscape can be explained by the Dreaming—especially the time known by many Aboriginal people as Tjukurpa. This was when the great Ancestor Spirits roamed the earth. Before this time, the earth was flat and bleak and empty of any life. When the Ancestor Spirits came up from their dwelling places below the ground, they took the form of humans and animals. They created the features of the landscape, such as rivers, waterholes and mountains. By transforming themselves into these landforms they left evidence of their presence in the landscape. These spirits then created all life on earth—the plants, animals and people.

The tracks of the Dreaming cover Australia. The landscape is embedded with evidence of the Dreaming, which remains a powerful spiritual force for many Aboriginal and Torres Strait Islander people. For them, it still exists today and the network of tracks and sacred sites link the physical world to the Dreaming. Dreaming stories map out significant landscape features, the location of waterholes, places to camp, and places to gather food and hunt animals.

The Dreaming Story of Ngurunderi

In the Dreaming, Ngurunderi and his two sons, in search of Ngurunderi's two wives, who had run away from him, followed a massive Murray cod down the Murray from where the Murray and the Darling rivers meet. As the huge fish swam, its tail swept the water aside, creating billabongs and swamps. Long Island, near Murray Bridge, is said to be a spear thrown by Ngurunderi. Ngurunderi eventually speared the giant cod and proceeded to cut it into small portions. As he threw the small pieces into the river they became the many different species of fish now found in the lakes and streams of the Murray–Darling.

When Ngurunderi discovered his two wives cooking a silver bream, a fish forbidden to women, he was very angry. The women sought to escape on a raft they had built. Ngurunderi pursued them down through the Coorong, creating the natural features of the landscape. When he caught up with the women, who were crossing to Kangaroo Island, he caused the sea to rise. The women drowned and became the rocky islands known as the Pages. Ngurunderi crossed to Kangaroo Island, removed his old skin of life and went to heaven. The Dreaming Story is depicted in Figure 2.8.2.

The fate of Ngurunderi was re-enacted in the traditional funeral ceremonies of the Ngarrindjeri People. The skin of the dead was removed before the remains were cremated on a raised platform.

2.8.2 A mural showing a Dreaming Story of Ngurunderi about the origins of the Murray River, Berri, South Australia

The Squamish

The Squamish are the indigenous people of south-west British Columbia, Canada. Their territory extends northwards from north Vancouver up through the Howe Sound to the Squamish Valley and then towards Whistler—an area of 6732 square kilometres.

2.8.3 Squamish people in traditional dress

Oral tradition

Traditionally, the history, culture and customs of the Squamish were passed onto future generations by spoken word rather than writing. This oral tradition describes and explains the Squamish's relationship to the land and provides important insights into the location of resource sites, hunting grounds, cedar-bark gathering areas, rock quarries, clam-processing camps, and the spiritual and ritual places of their ancestors.

Natural environment

Like indigenous peoples worldwide, the Squamish have a very close relationship with the natural environment. Traditionally, they took from it only what they needed to survive. They used it in a way that was sustainable; that is, in a way that would enable them to maintain their traditional way of life for generations to come. They hunted and gathered just enough salmon, herring, shellfish, seals, berries and plant roots to meet their needs. They also managed the forests sustainably. For example, the cedar bark used to make baskets was stripped from trees in a way that did not threaten the survival of the tree. A vertical strip, just two hands wide, was taken from a tree only once in its lifetime. The volcanic landform known as Black Tusk was, according to the Squamish tradition, created from the Thunderbird's lightning.

Plains Indians, USA

For generations, nomadic Indian tribes such as the Sioux, the Comanche and the Crow roamed the Great Plains of the midwest of North America in search of buffalo. Their worship centred on the Great Spirit, or Wakan Tanka, their creator, who reigned supreme over everything that had ever existed, including animals, trees, stones and clouds. The Plains Indians believed that worshipping the Great Spirit would make them stronger.

Relationship with landscape

The Plains Indians believed that all things had spirits. They held deep beliefs about the creation and sacredness of the natural world and saw creation as an ongoing process. Through their guardian spirits they felt joined to the familiar shapes of their land, the sky and the wild animals they depended on for survival. They did not seek to dominate other creatures. They recognised the powers of nature and through their daily rituals they sought connection with the spirits.

The rituals and traditions of the tribes celebrated what was special about their land. On the Great Plains, elaborate ceremonies were held to honour the sun and the big sky, which were so important to their daily lives.

The Sun Dance

The sun was considered to possess great power because of the warmth and light it shed on the earth. The Indians performed the ritual of the Sun Dance to demonstrate love and respect for the Great Spirit. It was their way of showing gratitude for the good things that may have happened to the tribe or the Great Spirit's help in protecting them or healing a sick person.

The Sun Dance ritual would last for four days from dawn to dusk, during which time no eating or drinking was allowed. The men would dance to drums in a circle around a sacred tree that had been cut down and set up as a pole in the middle. Offerings were made to the Great Spirit under the pole. The dancers stared at the sun and whistled through pipes. Some tribes practised self-torture by piercing the skin on their chests with ropes of hair or leather that were tied to the pole (see Figure 2.8.4). This personal sacrifice was made for the benefit of all the tribe.

DID YOU KNOW?

The Plains Indians used their natural resources wisely, especially the buffalo. They killed the buffalo only as needed, and used the whole animal for food, clothing and shelter. However, white settlers hunted buffalo nearly to extinction.

2.8.4 The Sun Dance was the most important group gathering of the Plains Indians.

Guardian Spirits

The Plains Indians believed that a person's success in life depended on the intervention of a spirit being, which could occur only through a vision. A young man would go on a quest to seek this spirit being. He would go to a lonely spot to pray and fast for many days, and would lapse into a trance. Whatever animal or bird he saw in his dreams became his spirit being, who would be his guardian for life

Plains Indians carried medicine bundles, which contained objects suggested by a Guardian Spirit, such as feathers, animal teeth or claws, pipes and tobacco. The Indians believed that the bundle possessed powers that would bring them good luck, protection, successful hunting and even healing when needed. When a person died, their medicine bundle was buried with them.

ACTIVITIES

Knowledge and understanding

1. Outline the importance of supreme beings and animals in indigenous explanations of landscapes.
2. Explain what the Dreaming is and explain its role in Aboriginal and Torres Strait Islander culture.
3. Describe the relationship of the Squamish people with the land.
4. Describe a sustainable practice of the Squamish people.
5. Explain the role of Guardian Spirits in the life of Plains Indians.

Applying and analysing

6. Compare the Iroquois creation myth and the Aboriginal Dreaming.
7. Consider how the following aspects of Squamish society compare with your own way of life:
   a. relationship with the natural environment
   b. an oral tradition.

Investigating

8. Select a prominent feature of the biophysical environment and look for an Aboriginal Dreaming Story that explains its creation. Present an oral report to the class outlining the Dreaming Story and its connection to the physical environment.

Landscape change, management and protection

CHAPTER 3

People's impacts on landscapes vary from the indirect (for example the long-term effects of human-induced climate change) to those that transform landscapes (for example mining, our large cities and agricultural systems). In this chapter we examine the nature of these impacts and the ways in which landscapes can be protected. Of particular interest are the management practices of Aboriginal and Torres Strait Islander people.

INQUIRY QUESTIONS

- In what ways do humans impact on landscapes?
- Why do we need to protect landscapes and how can this be done?
- How did Aboriginal and Torres Strait Islander people manage the land?
- What role do national parks and World Heritage listing play in the protection of places of natural and cultural significance?

GLOSSARY

conservation	the development and application of management practices to conserve, protect and, where possible, restore landscapes
Country	as used by Aboriginal and Torres Strait Islander people, refers to family origins and associations with particular parts of Australia
deforestation	the clearing of trees, transforming a forest into cleared land
desertification	the spread of deserts
eutrophication	water pollution caused by nutrients leaching from soils as a result of pollution from sewage and use of fertilisers
habitat	an area inhabited by a particular species of animal or plant
land degradation	the downgrading of the productive capacity of land due to the activities of people
megafauna	giant marsupials that once roamed the Australian continent
pollution	any hazardous or potentially hazardous substance released into the environment
preservation	the protection of landscapes (and environments and habitats) from loss or damage
salinity	the build-up of salt in soil and soil surface
soil fertility decline	the deterioration in the physical, chemical and biological properties of soil
waterlogging	a rise in groundwater close to the soil surface
wilderness	extensive, largely undisturbed, areas of the original habitat
World Heritage sites	natural and cultural sites that have been identified by UNESCO as having international significance and being worthy of protection

3.0 Rubbish at the edge of Lake Machhapuchhre, Nepal

3.1

Landscapes—human impacts

Major human impacts

Many of the world's landscapes show the effects of human activity. It can now be argued that there are no longer any truly 'natural' landscapes left. The images of landscapes in this unit show the extent to which the 'cultural overlay' of human activity can transform landscapes.

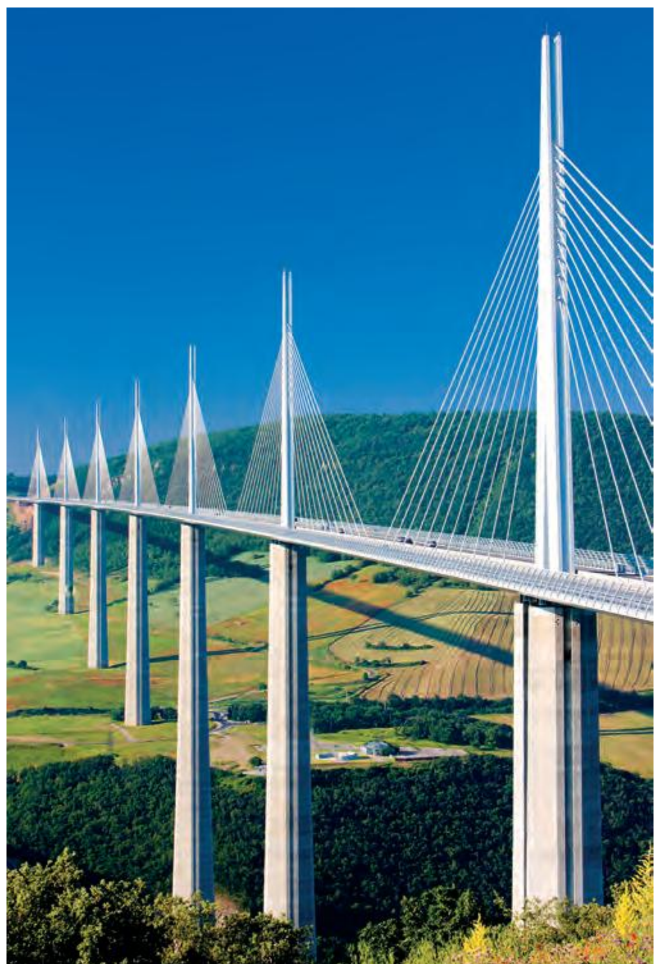
Agriculture

Since farming began about 10 000 years ago, whole landscapes have been transformed to create fields for crops and the raising of animals. Figure 3.1.1 shows irrigated rice terraces that were once rainforests. Swamps and coastal marshes have been drained. Forests have been clearfelled and grasslands ploughed. The removal of trees destroys the roots that help to bind the soil together. Once exposed, the soil can be blown or washed into rivers. In some places, soil erosion has turned once-fertile farmland into barren wasteland.

Transport

Transport infrastructure (such as railways, roadways and airports) occupies large areas of the earth's land surface. Think about, for example, the amount of land devoted to roads and car parks in Australia's big cities. In China, the scale of such infrastructure is enormous. By 2025, China will have added five billion square metres of road paving and 170 mass-transit systems. In Europe, the 2.4-kilometre Viaduc de Millau (see Figure 3.1.2) dominates the landscape of the Tarn Valley.

3.1.1 Irrigated rice terraces, Bali, Indonesia. This landscape has been transformed to produce a high-yielding crop.



3.1.2 The giant Viaduc de Millau, France

3.1.3 The giant Argyle diamond mine in Western Australia illustrates the impact that mining can have on landscapes.

Mining

Mining involves the extraction of valuable minerals and ores from the earth. Open-cut mining is especially noticeable in terms of its impact on landscapes. Mountains can be mined or deep pits dug to reach an ore body. Figure 3.1.3 shows the giant Argyle diamond mine in Western Australia.

Forestry

Forestry can be conducted in two ways. Selective logging involves removal of particular trees from a forest. The trees are selected according to specific criteria (species, diameter or height). Selective logging leaves some trees standing, which allows for natural regrowth, has less impact on the wildlife, and leaves fewer ugly patches in the landscape.

Clearfelling is the practice of cutting down all the trees in an area. It is a practice that can destroy whole **habitats**. Figure 3.1.4 shows the impact of clearfelling in Tasmania.

3.1.4 The impact of clearfelling in Tasmania

Industry

The Industrial Revolution transformed methods of manufacturing and made them more efficient. Since then, factories have been built all over the world. Figure 3.1.5 shows the giant Auchi Prefecture Toyota Motor Plant at Toyota City. Factories consume huge amounts of natural resources and energy, and many give off chemical wastes, resulting in air and water **pollution**.

Urban areas

The world's urban areas cover just 3 per cent of the earth's land surface but account for 50 per cent of the world's population. It is also estimated that there are 75 000 distinct urban settlements worldwide, although many are better regarded as 'clumps' of settlements. Tokyo, shown in Figure 3.1.6, is the world's largest city. The urban area spreads over 30 000 square kilometres and takes in more than 500 connected settlements.

Energy

The infrastructure needed to produce and transport the energy we use is a major feature of many landscapes. This infrastructure includes wind farms (see Figure 3.1.7) and solar collectors, coal- and gas-burning power stations, nuclear power stations and electricity transmission lines that transport the energy to consumers.

3.1.5 The Auchi Prefecture Toyota Motor Plant at Toyota City

3.1.6 Tokyo

3.1.7 Albany wind farm

China to flatten 700 mountains

In late 2012, the UK-based *Guardian* newspaper reported that the China Pacific Construction Group, one of China's largest construction firms, had announced plans to spend US$3.5 billion to flatten 700 mountains, making room for a brand-new city. Called the Lanzhou New Area, the planned city will be some 70 kilometres from Gansu Province's capital city, Lanzhou, in north-western China. Featuring high-rise apartments and office towers, parks and even beaches, the futuristic city will cost billions to construct.

DID YOU KNOW?

Every year humans move about 0.8 Gt (1 Gt = 1 gigatonne = 1 billion tonnes) of earth in house construction, 3.2 Gt in mineral production and 3 Gt in road construction. If all this earth were dumped into the Grand Canyon, it would fill the canyon in about 400 years, or about 0.01 per cent of the time it has taken the Colorado River to carve it!

ACTIVITIES

Knowledge and understanding

1 Define the term 'cultural overlay' in your own words.
2 Explain why 700 mountains are to be flattened.

Applying and analysing

3 Rank each image in this unit according to the extent to which humans have transformed the landscape. Compare your ranking with that of a partner and then with those of another pair of students. Reach agreement on a ranking for your group and share this ranking with the rest of the class.
4 Select three of the landscapes shown in this unit. Describe the main element of the 'cultural overlay' evident in each image. Suggest what the nature of the biophysical environment was before the human transformation.
5 Use the internet to gather images of landscapes dominated by the imprint of humans. Create a wall display using the following organisers: agriculture, transport, mining, forestry, industry, urban areas, energy.

CASE STUDY:
Coastal landscape degradation

Coastal pressures

People have long preferred to live near the coast and have not hesitated to exploit this landscape with little regard for the degradation caused. The mangrove forests that line coastal mudflats and estuaries, as well as sand dunes that accumulate behind beaches, are vital to the coastal landscape. However, they are often the casualties of coastal development. As populations grow and settlements expand, more pressure will be placed on the valuable coastal landscape.

Landscape degradation

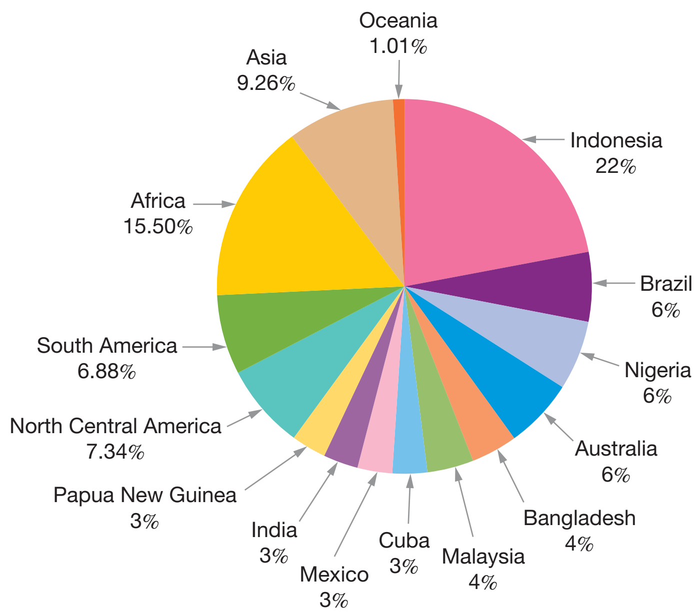
Landscape degradation, or **land degradation**, is the temporary or permanent alteration of a landscape or land resulting from the activities of people. The worst form of degradation results in a permanent reduction of the productive capacity of the land. Degradation can cause:

- **soil fertility decline**
- erosion
- **salinity**
- **waterlogging**
- **desertification**
- pollution
- habitat destruction.

Importance of mangroves and sand dunes

Mangrove forests and sand dunes protect many coastal landscapes. The tangle of roots of a dense stand of mangroves acts as a shock absorber and reduces the impact of large waves. Mangroves also filter sediments that are loaded with excess nutrients and toxic pollutants. Sand dunes also act as a buffer against wave damage from storms and they prevent salt water from reaching the land behind the dunes. As sand accumulates in these dunes it becomes a reservoir that is able to replenish a beach after it has been eroded by big seas. Sand dunes also protect land areas from salt-laden winds.

Mangroves are important because they are able to store carbon. They often store as much as 2000 tonnes of carbon per hectare. When mangroves are destroyed, the stored carbon oxidises and carbon dioxide, or CO_2, is emitted into the atmosphere. Mangroves are an important habitat for marine species—an estimated 80 per cent of commercially caught species are reliant on mangroves.



3.2.1 Country and continent share of global mangrove extent (per cent)
Source: United Nations Food and Agriculture Organization

Mangrove degradation

The world is losing its mangroves at a rate that is three to five times faster than the rate of global **deforestation**, escalating the destruction and damage to the coastal landscape. According to the United Nations Food and Agriculture Organization, between 20 and 35 per cent of the world's mangroves have been lost since 1980. The rates of loss are highest in developing countries of South-East Asia, Africa and South America. In Thailand it is estimated that 86 per cent of mangrove forests have been destroyed. By 2050, it is predicted that in South-East Asia there will be 35 per cent less mangrove forest than in 2000. In as few as one hundred years, the world's mangrove forests may become so degraded and reduced in area that they would be considered to have functionally disappeared.

Causes of mangrove degradation

Exploitation

The increasing population of developing countries has led to an ever-growing need for fuelwood for heating and cooking. This has resulted in the reckless cutting down of mangroves. Mangrove forests have also been cut down for lumber and woodchip production.

Coastal development and land reclamation

Historically, coasts have been favoured for settlement and economic activity. This is especially true for Australia. As large port cities such as Sydney flourished, the mangrove forests within their estuaries were destroyed. At Homebush Bay in Sydney, a land reclamation project was undertaken with the construction of bund walls to prevent tidal inundation. This killed the mangroves that were reliant on the twice-daily tidal flow. Behind the bund wall landfill was brought in to raise the surface beyond tidal reach, thereby creating new land for industry.

Similarly, in Moreton Bay near Brisbane, an estimated 20 per cent of the pre-European mangrove area has been lost to reclamation landfill.

Everywhere the pressures are the same, with an ever-increasing demand for coastal land for residential subdivisions, canal estates, marinas and tourism. With most of the accessible land near large urban centres already taken up, the pressures on the remaining mangroves are mounting.

Pollution

Mangroves were long considered to be dirty, smelly, mosquito-ridden wastelands, and people did not hesitate to dump waste in them. The discharge of nutrient-rich agricultural and urban run-off and toxic contaminants from industry meant that mangroves were damaged (see Figure 3.2.2).

Excessive nutrients cause **eutrophication**, which leads to algal blooms reducing sunlight penetration and the oxygen content of the water. The algae may also cover and block the pneumatophores, which are the specialised roots that the mangrove tree needs to obtain oxygen. Pollutants such as ammonia can cause ulcers on the skin of fish and soften crab shells. When toxic substances settle into sediment they can become a long-term threat to the mangrove ecosystem. The concentration of dangerous chemicals increases up successive levels in the food chain.

3.2.2 Dieback of mangroves (lighter trees) in the Mackay region, Queensland, is attributed to the run-off of chemicals used in sugarcane farming. Thirty square kilometres of mangroves have been affected by severe dieback.

Shrimp aquaculture

The biggest threat to the world's mangrove forests is the rapidly expanding shrimp aquaculture industry in South-East Asia. According to the United Nations Environment Programme, nearly 40 per cent of mangrove destruction worldwide is caused by shrimp aquaculture. Hundreds of thousands of hectares of mangrove forests have been cleared for artificial ponds, which are then filled with large numbers of shrimp (see Figure 3.2.3). Channels are dug to divert water to the ponds, which prevent the mangrove seeds being dispersed by the tides. When the channels stop tidal flushing, mangrove trees die. The mangroves are becoming contaminated by a cocktail of chemicals and antibiotics used to keep the shrimp healthy. The mangrove forests are also being destroyed by the heavy discharge of shrimp effluent and organic waste from this intensive landuse. The waste also pollutes the shrimp farms, resulting in farms being abandoned. An estimated 250 000 farmed hectares now lie abandoned throughout Asia and Latin America.

3.2.3 Enclosed shrimp ponds within the mangrove forests of Kalimantan, Indonesia

Causes of sand dune degradation

Sand dune degradation is caused by sand mining, recreational usage and construction and development.

Sand mining

Sand dunes have often been seen as 'useless' areas. Dunes were readily removed to extract minerals such as rutile, ilmenite and zircon, which typically occur combined with ordinary sand, as well as the sand itself. Large quantities of sand are used to make cement. Millions of tonnes of sand have been removed from the Kurnell dunes to supply the expanding Sydney building market. Many of the dunes in the Caribbean have disappeared altogether as a result of mining activities.

Recreational pressure

The use of beaches as places of recreation is ingrained in Australia's cultural identity. However, the popularity of the beach is leading to considerable damage to the fragile dunes. Even a single vehicle driving over a dune or a few people trampling over the same spot will kill a strip of grass. The practise of 'dune running,' whereby people

SPOTLIGHT

The degradation of Spain's coastal dunes

In Spain, the large-scale urban development carried out on sand dunes during the tourist boom of the 1960s and 1970s resulted in the degradation of the coastal landscape. Extensive dune areas were totally altered and destroyed in the course of massive tourism and road construction projects. The building of harbours and marinas and sand mining for construction accelerated dune erosion. Human trampling, rubbish dumping, excessive recreational pressure and the use of all-terrain vehicles were among the main causes of the degradation of Spanish sand dune systems. Most of the Spanish coastline has been degraded in the chase for the wealth generated by tourism.

3.2.4 Coastal degradation in Fuerteventura, one of the Canary Islands off the coast of Spain train by running up dunes, is also ripping out vegetation. Once the vegetation is gone, the dune is exposed to wind erosion, resulting in blowouts or breaches in the dunes. This can expose inland areas to the reach of water in coastal storms.

Construction and development

Rapid and intensive urban development has taken place along many of the world's coastlines, increasing the human impact on sand dunes. Dune systems are flattened and built over, replaced by buildings, roads, car parks and other urban infrastructure. The desire to build right on the dunes is even more intense in tourist developments, where guests in resorts, hotels and apartments like to walk straight onto the beach (see Figure 3.2.5). With the reservoir of sand in the dunes gone, the beaches become eroded.

Coastal degradation and climate change

With the prospect of more frequent and fiercer storms and cyclones associated with climate change, coastlines are likely to be pounded by more destructive waves. Mangrove forests and sand dunes are going to more important than ever to protect the coastal landscape. It is imperative that they are valued and managed carefully.

3.2.5 Hotels are built next to the beach at Cancún in Mexico, where sand dunes once existed.

ACTIVITIES

Knowledge and understanding

1. Explain how mangrove forests and sand dunes protect coastal landscapes.
2. Describe what is happening to the area of mangrove forests globally.
3. Outline the causes of mangrove degradation.
4. Explain why sand dunes are mined.
5. Describe how sand dunes are damaged by recreational use.

Applying and analysing

6. Create an annotated sketch of a coastal landscape to show how either a mangrove forest or sand dunes provide protection.

Investigating

7. Investigate how dune destruction has affected the coastal landscape of an urban area or a tourist resort and prepare a digital presentation.

3.3

Protecting landscapes

Preservation and conservation

The terms 'preservation' and 'conservation' have different meanings. **Preservation** involves protecting landscapes (and environments and habitats) from loss or damage. **Conservation** involves developing and applying management practices aimed at conserving, protecting and, where possible, restoring landscapes.

Biophysical landscapes

Australia's most highly valued biophysical landscapes are protected by nature conservation reserves, national parks and **wilderness** areas. These are areas of land set aside for conservation purposes, such as the protection of wildlife and habitats, and the preservation of areas with natural features of scientific or recreational value. National parks are large areas of scenic or other natural significance that are open to the general public. Wilderness areas are defined as the most intact, undisturbed natural areas. Wilderness areas and national parks are considered important for the survival of certain species, ecological processes, conservation and recreation. In total, 7.9 per cent of the Australian landmass is set aside for conservation purposes. Marine parks and reserves cover a further 380 200 square kilometres.

Constructed landscapes

Constructed landscapes of cultural importance can include whole streetscapes, individual buildings such as the historic Coolamine Homestead shown in Figure 3.3.1, the work of leading garden designers and architects, notable parks, gardens and avenues of trees, and in some cases, whole towns and cities. In Australia, important landscapes are protected by heritage legislation. In New South Wales, the Office for Environment and Heritage has responsibility for identifying and listing items of heritage significance. The office also oversees the protection and management of listed places and objects. The listing provides the legal framework for managing the approval of any proposed changes so that heritage significance of the listing is retained and not diminished.

3.3.1 Coolamine Homestead, New South Wales, built in 1883, is under the care of the National Parks and Wildlife Service and the Kosciuszko Huts Association.

SPOTLIGHT

Protecting NSW's biophysical and built heritage

The NSW Office of Environment and Heritage (OEH) is responsible for the protection of the state's environment and heritage, which includes the natural environment; Aboriginal country, culture and heritage; and the built heritage. The NSW National Parks and Wildlife Service is one of the OEH's sub-agencies and manages over 7 million hectares of land. The OEH's protection role involves conserving Aboriginal and non-Aboriginal heritage items of the State Heritage Register.

3.3.2 Mungo National Park

ACTIVITIES

Knowledge and understanding

1 Distinguish between the terms 'preservation' and 'conservation'.

2 Outline the role of national parks.

3 State how important elements of the constructed environment are protected in New South Wales.

Geographical skills

4 Construct a photo sketch of Figure 3.3.1 or 3.3.2. Annotate your sketch with the reasons why such a landscape is worth protecting.

Investigating

5 Investigate a constructed environment protected by heritage legislation in your local area and create an annotated visual display.

   a Go to the National Trust website to start your research and select an environment or building to investigate.

   b Include the following in your display:
   - a map showing the location of the environment or building
   - images or illustrations (including historical and new examples)
   - arguments for and against the preservation and significance of the environment or building.

3.4

Indigenous land management

The importance of 'Country'

Land (or '**Country**', as it is often called) is central to the wellbeing of Aboriginal and Torres Strait Islander people. The land is not just the soil and rocks—it is the whole environment. It is at the centre of all spirituality and, together with the 'spirit of country', is central to the issues important to Indigenous Australians.

Australia's Aboriginal and Torres Strait Islander people have managed their land for tens of thousands of years. The land and its natural resources provided for their needs, shaped their history and were fundamental to their culture and spiritual beliefs.

Indigenous ways of life

Traditionally, Australia's Aboriginal and Torres Strait Islander people lived a hunter–gatherer lifestyle, each clan having their own territory that sustained their way of life. They understood and cared for their different environments and adapted to them (see the quote in Figure 3.4.2). Aboriginal society was semi-nomadic, and people moved according to the changing seasons and availability of food. Indigenous Australians were skilled in managing the resources on which they depended. Geographic features such as rivers, lakes and mountains defined the boundaries of their territory or traditional lands.

SPOTLIGHT

Indigenous use of fire

Aboriginal and Torres Strait Islander people made frequent use of fire (see Figure 3.4.1) to keep the country more open and easy to travel through; to promote the growth of fresh green grass, which would attract animals; to signal and hunt; and for the more obvious purposes of warmth and cooking.

There is considerable evidence to suggest that the purposeful use of fire extended from the earliest days of Aboriginal settlement. While fires had always occurred in Australia (due to lightning strikes), it is argued by some scientists that after the arrival of Indigenous people the fires became more frequent and intense. The use of fire transformed the Australian landscape because it advantaged those plants best adapted to fire. Today, we use fire to reduce fuel loads, just as Aboriginal and Torres Strait Islander people did for thousands of years.

3.4.1 *Working the Land*, Joseph Lycett (1817). This painting shows Aboriginal people using fire to hunt kangaroos.

> We cultivated our land, but in a way different from the white man. We endeavoured to live with the land; they seemed to live off it. I was taught to preserve, never to destroy.

3.4.2 Tom Dystra, Aboriginal elder

Environmental impacts

The idea that Aboriginal and Torres Strait Islander people lived in harmony with nature for tens of thousands of years without significantly changing the Australian environment, while an attractive one, especially for Indigenous Australians, has been challenged by scientists in recent years.

Loss of megafauna

Some scientists believe that Indigenous Australians had a far-reaching impact on the environment. It is now thought that Indigenous Australians hunted some of Australia's biggest animal species (the so-called **megafauna**) to extinction and, in the process, transformed the continent's landscape. Australia's Indigenous peoples are now believed to have been responsible for the extinction of most of the sixty or so species of giant marsupials that once roamed the continent. There were also large reptiles, including giant goanna-like creatures and large, land-based crocodiles. Having survived for millions of years, these giant marsupials and reptiles became extinct quite suddenly and not long after the arrival of humans in Australia.

The extinction of the megafauna had, for a long time, been explained by climatic change. Scientists now argue that there were no climatic changes significant enough to bring about the animals' extinction. The last Ice Age, for example, occurred after the extinctions.

3.4.3 An artist's impression of Australia's ancient megafauna

Hunting is now thought to have been the main cause of the loss of the megafauna. The larger animals reproduced slowly and they were slow-moving and found it difficult to hide from hunters armed with spears.

The extinction of the large plant-eating megafauna resulted in an increase in the amount of vegetation. This, in turn, provided fuel for fire. The increase in the frequency and intensity of fire eventually changed the vegetation of the continent, with the fire-tolerant species thriving.

After bringing about these changes, Aboriginal and Torres Strait Islander people settled into a way of life that established a balance with the environment they had created. This continued for tens of thousands of years until Europeans arrived in 1788.

ACTIVITIES

Knowledge and understanding

1 Describe the Aboriginal and Torres Strait Islander way of life.
2 Outline how the thinking about the environmental impact of Aboriginal and Torres Strait Islander people has changed in recent times.
3 State the possible causes for the extinction of Australia's megafauna.
4 Explain how the extinction of the megafauna affected the Australian landscape.
5 Outline the reasons why Aboriginal and Torres Strait Islander people used fire.
6 Describe the impact that regular burning has on the landscape.

Applying and analysing

7 Study the quote by Tom Dystra in Figure 3.4.2. Discuss the nature of the relationship between Aboriginal and Torres Strait Islander people and 'Country'.

3.5

Australia's national parks

3.5.1 Australia's diverse natural landscapes (clockwise from top left): Daintree National Park, North Queensland; Kakadu National Park, Northern Territory; Freycinet National Park, Tasmania; Uluru–Kata Tjuta National Park, Northern Territory

National parks

National parks are areas that are protected for the benefit of present and future generations. These diverse areas are largely untouched by human activity and occupation (see Figure 3.5.1). Many are home to unique plant and animal species, and habitats that are of scientific, educational and recreational value. Many include unique landform features or landscapes of great beauty. These protected areas are managed according to the principles of sustainability.

The impact of visitors in national parks is carefully managed. Visitors are able to enter under special conditions (see Table 3.5.2).

3.5.2 Rules to manage the impact of people visiting national parks

Rules	Reason
Vehicles and mountain bikes are restricted to main roads	Vehicles and mountain bikes destroy plants and cause erosion
Pets are prohibited	Pets can scare or kill native animals
Rubbish must be disposed of properly or taken home	Rubbish can be unsightly and pollute the environment
Tread lightly—keep on designated tracks	Avoids damage to plant and animal habitats
Do not pick wild flowers	Flowers are food for birds and insects and produce the seeds from which new plants grow
Use the toilet facilities provided, not the bush	Protects water quality
Take care not to touch historic artefacts (e.g. Aboriginal rock art)	Such sites are fragile and easily damaged
Use the barbecues provided and don't light fires in the open	Fire can destroy vegetation and kill animals
Leave plants, animals, rocks, soil and shells as you find them	Disturbing these elements of the natural environment threatens plant and animal habitats
Avoid releasing introduced species of plants and animals either accidentally or deliberately (e.g. illegal dumping)	Introduced species overwhelm native plants and animals, changing habitats

Wilderness areas

Wilderness areas are large, undisturbed biophysical areas. They are the last truly wild places, where the impact of people has been minimal. Wilderness is considered important for the survival of certain species and habitats. It is also valued for cultural, spiritual, moral and aesthetic reasons. It is also a valued recreational resource.

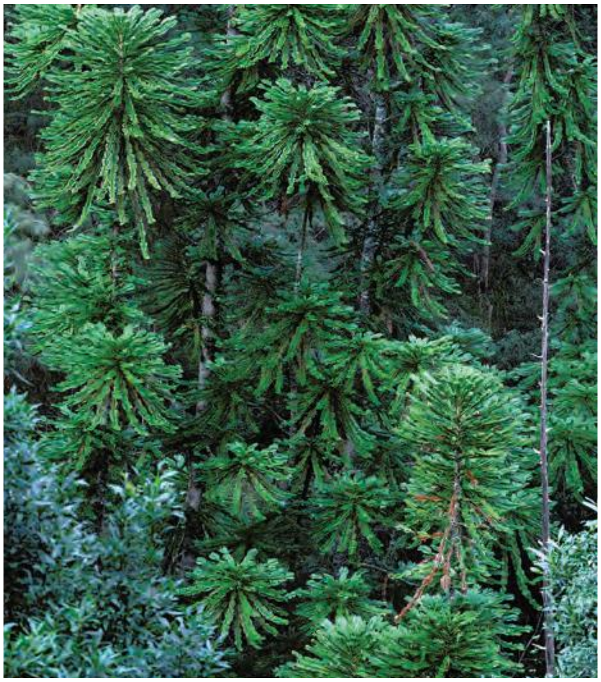
Wilderness areas are given the highest level of protection. Their wilderness values and pristine condition are protected by the limiting of activities likely to damage flora, fauna and cultural heritage.

SPOTLIGHT

Wollemi National Park

The Wollemi National Park is located just 150 kilometres north-west of Sydney. It is an area of untamed wilderness, wild rivers and spectacular landscapes. This maze of canyons, cliffs and undisturbed forest is the largest wilderness area in New South Wales and forms part of the Greater Blue Mountains World Heritage Area. It is also home to the Wollemi pine (see Figure 3.5.3). Discovered in 1994, this ancient tree species grows in a deep gorge in a small pocket of temperate rainforest.

The Wollemi pine is classified as critically endangered. A recovery plan has been developed to ensure that this species remains viable in the long term.



3.5.3 Wollemi pine, Wollemi National Park, New South Wales

Australia's landscapes

Australia has some of the world's most distinctive and spectacular natural landscapes. Many are protected through recognition as national parks and World Heritage Areas, as well as through the National Landscape initiative. The initiative gives landscapes more protection, closely linked to their economic value as a tourist destination. The purpose of the initiative is to promote tourism and improve visitor experiences; increase the role of protected areas in local economies; and build broader community support for protecting our natural and cultural assets.

There are currently sixteen national landscapes: the Wet Tropics, the Great Barrier Reef, Australia's Red Centre, Flinders Ranges, the Australian Alps, the Great Ocean Road, Australia's Coastal Wilderness, Australia's Timeless North, Australia's Green Cauldron, Greater Blue Mountains, the Kimberley, Kangaroo Island, Great South West Edge, Ningaloo–Shark Bay, Sydney Harbour and Tasmania's Island Heritage.

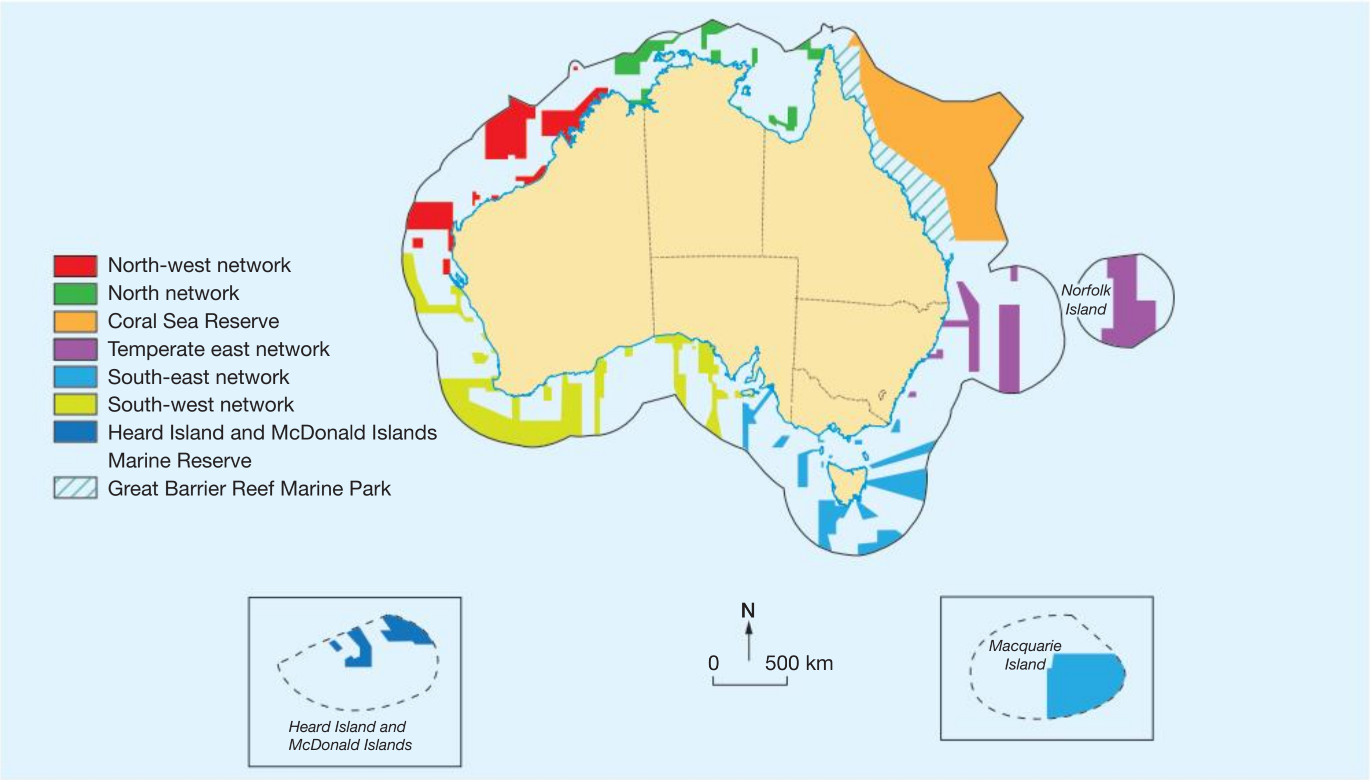
Australia's biosphere reserves

The world's system of biosphere reserves is an initiative of the United Nations Educational, Scientific and Cultural Organization (UNESCO). United Nations member countries nominate areas of outstanding environmental importance that meet a set of guidelines established by UNESCO. The area is then recognised under UNESCO's Man and the Biosphere Programme, which aims to promote sustainable development. The reserves include protected areas, and are managed with a view to both conservation and sustainable use of natural resources. Australia currently has fourteen biosphere reserves, including NSW's Kosciuszko National Park, Victoria's Croajingolong and Wilsons Promontory National Parks; Queensland's Great Sandy Biosphere Reserve; South Australia's Mamungari Conservation Park; and Western Australia's Fitzgerald River National Park, shown in Figure 3.5.4.

Protected marine areas

Australia has the world's third-largest area of protected marine territory—an area larger than the Australian landmass (see Figure 3.5.5). Australia's oceans provide food and recreation, and much of Australia's oil and natural gas production is drawn from the rock strata below these waters. There is also an extraordinarily high level of biodiversity. With this great natural wealth comes responsibility. We need to ensure that our oceans, and the life in them, remain healthy and productive so that future generations can enjoy them as we do.

3.5.4 Fitzgerald River National Park, Western Australia



3.5.5 Australia's protected marine areas

Source: Commonwealth of Australia

ACTIVITIES

Knowledge and understanding

1 State the qualities of landscapes nominated as national parks that make them worth protecting.
2 Explain what wilderness is.
3 Outline how the criteria for recognition as an Australian National Landscape differ from the criteria for other protected areas.

Applying and analysing

4 Complete the following table with arguments for and against the following statement: *To fully protect our most fragile landscapes we should close protected areas to recreational landuses.*

For	Against

Geographical skills

5 Study Figure 3.5.5 and do the following tasks.
  a Name three marine protected areas.
  b Compare the size of the Coral Sea Reserve to the other protected areas.
  c Name the protected area that extends the furthest from the Australian landmass (including Tasmania).
  d There are large areas not included in the proposed protection zones. List reasons why this might be the case.

Investigating

6 Select one of the biosphere reserves identified in the text or another Australian national park. Construct a multimedia presentation outlining the qualities that make these landscapes worth protecting. Include in your presentation:
  a a map of the reserve or park
  b a description of the qualities of the reserve or park that warrant this level of protection, giving:
    i flora and fauna information
    ii topography of the area
    iii Aboriginal and Torres Strait Islander links
  c an overview of the history of the park or reserve
  d a list of the activities permitted and not permitted in the park
  e information about the management of the reserve or park, noting:
    i particular environmental issues (feral animals, invasive weeds, etc.)
    ii development demands (building hotels)
    iii number of tourists who visit.

3.6

Australia's alpine national parks

National parks

Australia's unique alpine areas are protected by a system of eleven national parks and reserves covering 1.6 million hectares and stretching south from Canberra through the Brindabella Range to the Snowy Mountains of New South Wales, and along the Great Divide through eastern Victoria.

The alpine environment

The climate, soils and landforms of the region change as altitude increases. As a result, there are a variety of environments in which different plant communities dominate. These, in turn, provide habitats for a wide range of native animals. Many of these plants and animals are found nowhere else in the world, and some are threatened or endangered. Many species are found both within and outside the alpine national parks and reserves (shown in Figure 3.6.1).

More than 40 species of native mammals, 200 bird species, 30 reptiles species, 15 amphibian species, 14 native fish species and many species of invertebrates are native to the Australian Alps. The region is the only part of mainland Australia that has reliable winter snow cover. The plant species that grow there have evolved special characteristics in response to the harsh environment. This includes sub-zero temperatures, burial by snow for months at a time and a short growing season.

Figure 3.6.2 shows the highest part of the Alps, above the tree line. Here alpine heaths, herbfields, bogs and fens are found. Plants include the yellow billy buttons, pink trigger plants, and white snow and silver daisies. Below the tree line, the alpine woodlands are dominated by snow gums, montane and wet sclerophyll forest, alpine ash and mountain gum.

3.6.1 Australian Alps national parks

3.6.2 Lake Cootapatamba, New South Wales, formed by ice spilling from Mount Kosciuszko's southern face

Landforms

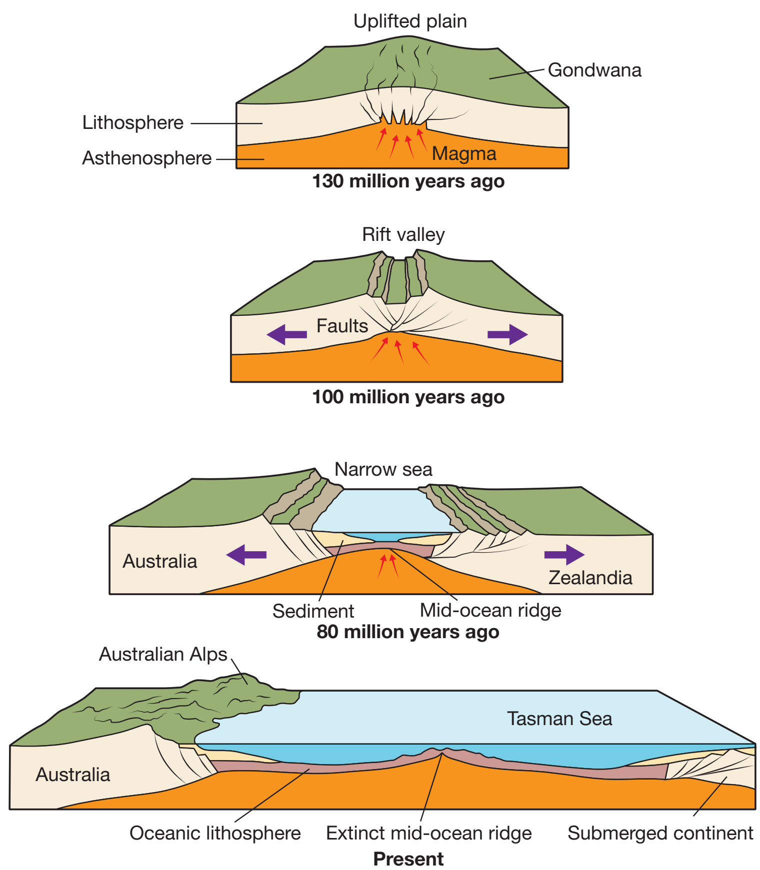
There is a range of distinctive landform features in the Australian Alps, some of which date from the last glacial age, which peaked about 20 000 years ago. The climate of the highest peaks of the Main Range, near Mount Kosciuszko, was cold enough for glaciers to form. Evidence of this glaciation can still be found. Figure 3.6.3 shows how the Australian Alps were formed. The process started about 130 million years ago when magma pushed up to create an uplifted plain. About 100 million years ago, a rift valley was created and the landmass began to spread apart. The sea floor spreading continued, a narrow sea became the Tasman Sea and the Australian Alps were formed.

Human impacts

Indigenous Australians visited the Alps for thousands of years, leaving little obvious evidence of their presence. The impact of Europeans has, however, been much more obvious and severe. The first European explorers visited in the early 1800s and graziers followed in the 1820s. Gold miners arrived in the 1850s, hoping to strike it rich. Skiing was introduced to Australia at Kiandra goldfields in New South Wales in the 1860s. The past 60 years have seen the development of large hydro-electric and water supply schemes, extensive road infrastructure, ski resorts and other tourist facilities. Tourism is central to the economy of the region and Kosciuszko National Park receives more than 3 million visitors each year.

While the alpine landscape may appear rugged and, at times, a harsh environment, it is actually very fragile and sensitive to disturbance. Careful management is needed if this unique environment is to be protected for the benefit of future generations.

3.6.3 The formation of the Australian Alps



ACTIVITIES

Knowledge and understanding

1. Describe the biodiversity of the alpine region and outline the factors that influence this diversity.
2. State what is special about the landform features surrounding Mt Kosciuszko.
3. Outline the nature of the human impacts on the alpine environment over time.
4. Explain why Australia's alpine environments need protecting.

Applying and analysing

5. Hypothetical: *It has recently been proposed that local graziers be allowed to graze their cattle in the alpine areas of the Kosciuszko National Park. The NSW State Government is considering the request.* Consider this statement and list the arguments for and against allowing farmers to graze their stock in Australia's alpine region.

Geographical skills

6. Study Figure 3.6.1.
   a. Describe the shape of the national park network through the Australian Alps.
   b. List and name the number of national parks in the Australian Alps.
   c. List the smallest and largest national parks.

3.7

World Heritage listing

Our common heritage

One of the most important international treaties for protecting and managing globally significant natural and cultural sites is the United Nations Educational, Scientific and Cultural Organization's (UNESCO) World Heritage Convention.

Africa's Serengeti National Park is important for its wildlife. Peru's Machu Picchu and Egypt's pyramids are archaeological treasures. Germany's Volklingen Ironworks tells the story of industrialisation. Italy's Venice and India's Taj Mahal are architectural masterpieces. Auschwitz Concentration Camp and the Hiroshima Peace Memorial remind us of the horrors of war.

These special places are just a few of the natural and cultural sites that have been identified as having international significance. They are special because they represent the common heritage of all the world's people and they are treasures to be protected for the benefit of present and future generations. These special places have been identified as **World Heritage sites**.

Making the grade

To be included on the World Heritage List, a site must have global natural or cultural significance and satisfy the strict criteria outlined by UNESCO. A cultural site could, for example, be a masterpiece of creative genius, have great architectural merit, be associated with ideas or beliefs of universal significance, or be an outstanding example of a traditional way of life representative of a particular culture. A natural site may represent a significant stage in the earth's history, represent ongoing ecological and biological processes, contain the natural habitat of endangered species, or be a place of great scenic beauty.

SPOTLIGHT

Palmyra, Syria

Palmyra was a thriving metropolis in the desert east of Damascus in Syria. It was part of the Roman Empire and was an important oasis and a stop for caravans travelling the Silk Road from China to Europe. The city-state reached its peak in the late third century, when it was ruled by Queen Zenobia and briefly rebelled against Rome. Zenobia's rebellion failed, and Palmyra was re-conquered and destroyed by Roman armies in AD 273.

The city's colonnaded avenues and impressive temples were preserved by the desert climate, and in the twentieth century the city was one of Syria's biggest tourist destinations.

In August–September 2015, Islamic State of Iraq and Syria (ISIS), or Islamic State (IS), destroyed Palmyra's most famous and treasured landmarks. ISIS justifies the destruction of such sites and artefacts by claiming that their actions are consistent with their extreme interpretation of Islamic tradition. By leaving no trace of previous cultures or civilisations ISIS argue that they are able to establish their own identity and leave their mark on history. There are also more practical reasons for their actions. They have used the sale of plundered artefacts to fund their activities.

3.7.1 The Temple of (Bel) Baal Shamin in Palmyra, Syria, blown up by ISIS in August 2015

3.7.2 The Monumental Arch, another of Palmyra's treasures destroyed by ISIS

The UNESCO World Heritage List began in 1979. By mid-2012 there were 936 sites on the list (including 183 natural, 725 cultural and 28 mixed sites), spread across 153 countries. When a country nominates a site it must agree to conserve it for future generations.

By mid-2012 Australia had nineteen World Heritage sites.

Heritage listing

The main benefit of a World Heritage listing is that people become aware of the special nature of the site, and pressure is exerted on governments to protect the site. This means that when a site is threatened there is enough public interest to make it an issue for community debate and action.

Some sites may be endangered by war, pollution, poaching, lack of maintenance, the damming of rivers, illegal logging or similar activities. Such sites are often placed on the World Heritage Endangered List.

Listing, however, does not always guarantee protection. The civil war in Syria has resulted in all World Heritage areas there being placed on the Endangered List.

Protecting sites

Governments that sign up to the World Heritage Convention agree to protect listed cultural and natural sites located within their borders.

Such protection includes:

- developing community-based planning programs that protect sites
- establishing a body whose responsibility it is to protect a site
- developing scientific and technical studies and research that help to protect sites against potential dangers
- putting in place the appropriate legal, scientific, administration and financial measures to protect sites
- recognising that the protection of sites is the responsibility of the international community
- undertaking not to damage, directly or indirectly, any World Heritage site.

3.7.3 UNESCO's World Heritage Endangered List, 2015

Country	World Heritage site
Afghanistan	Minaret and archaeological remains of Jam; archaeological remains of the Bamiyan Valley
Belize	Belize Barrier Reef Reserve System
Bolivia	City of Potosi
Central African Republic	Manovo-Gounda St Floris National Park
Chile	Humberstone and Santa Laura Saltpeter Works
Colombia	Los Katios National Park
Côte d'Ivoire	Comoé National Park and Mount Nimba Strict Nature Reserve
Democratic Republic of the Congo	Virunga National Park; Garamba National Park; Kahuzi-Biega National Park; Okapi Wildlife Reserve; Salonga National Park
Egypt	Abu Mena
Ethiopia	Simien National Park
Georgia	Bagrati Cathedral and Gelati Monastery; historical monuments of Mtskheta
Guinea	Mount Nimba Strict Nature Reserve
Honduras	Rio Plátano Biosphere Reserve
Indonesia	Tropical rainforest heritage of Sumatra
Iran	Bam and its cultural landscape
Iraq	Ashur (Qal'at Sherqat); Hatra; Samarra archaeological city
Jerusalem	Old City of Jerusalem and its Walls
Madagascar	Rainforests of the Atsinanana
Mali	Timbuktu; Tomb of Aski
Niger	Air and Ténéré Natural Reserves
Palestine	Birthplace of Jesus: Church of the Nativity and the Pilgrimage Route, Bethlehem; Land of Olives and Vines—Cultural Landscape of Southern Jerusalem, Battir
Panama	Fortifications on the Caribbean side of Panama: Portobelo-San Lorenzo
Peru	Chan Chan archaeological zone
Senegal	Niokolo-Koba National Park
Serbia	Medieval monuments in Kosovo
Solomon Islands	East Rennell
Syria	Ancient City of Aleppo; Ancient City of Bosra; Ancient City of Damascus; Ancient Villages of Northern Syria; Crac des Chevaliers and Qal'at Salah El-Din; Site of Palmyra
Tanzania	Ruins of Kilwa Kisiwani and ruins of Songo Mnara
Uganda	Tombs of Buganda Kings at Kasubi
United Kingdom	Liverpool—Maritime Mercantile City
United States of America	Everglades National Park
Venezuela	Coro and its port
Yemen	Historic town of Zabid; Old City of Sana'a; Old Walled City of Shibam

Source: UNESCO World Heritage Endangered List, 2015

Palace and Park of Fontainebleau, France

Listed: 1981

Criteria: Cultural

Description: Used by the kings of France as royal hunting lodge, the palace is surrounded by a huge park. The Italianate structure combines Renaissance and French artistic traditions.

Machu Picchu, Peru

Listed: 1983

Criteria: Cultural

Description: Machu Picchu is located 2430 metres above sea level, in the middle of a tropical mountain forest. It was probably the most amazing urban creation of the Inca Empire; its giant walls, terraces and ramps seem as if they have been cut naturally in the continuous rock escarpments.

Wood Buffalo National Park, Canada

Listed: 1983

Criteria: Natural

Description: Located on the plains in the north-central region of Canada, the park (which covers 44 807 square kilometres) is home to North America's largest population of wild bison. Another of the park's attractions is the world's largest inland delta, located at the mouth of the Peace and Athabasca rivers.

Iguazú National Park, Argentina

Listed: 1984

Criteria: Natural

Description: At the heart of this park is one of the world's most spectacular waterfalls. The semicircular falls (80 metres high and 2700 metres in diameter) feature numerous cascades that produce vast sprays of water.

Venice, Italy

Listed: 1994

Criteria: Cultural

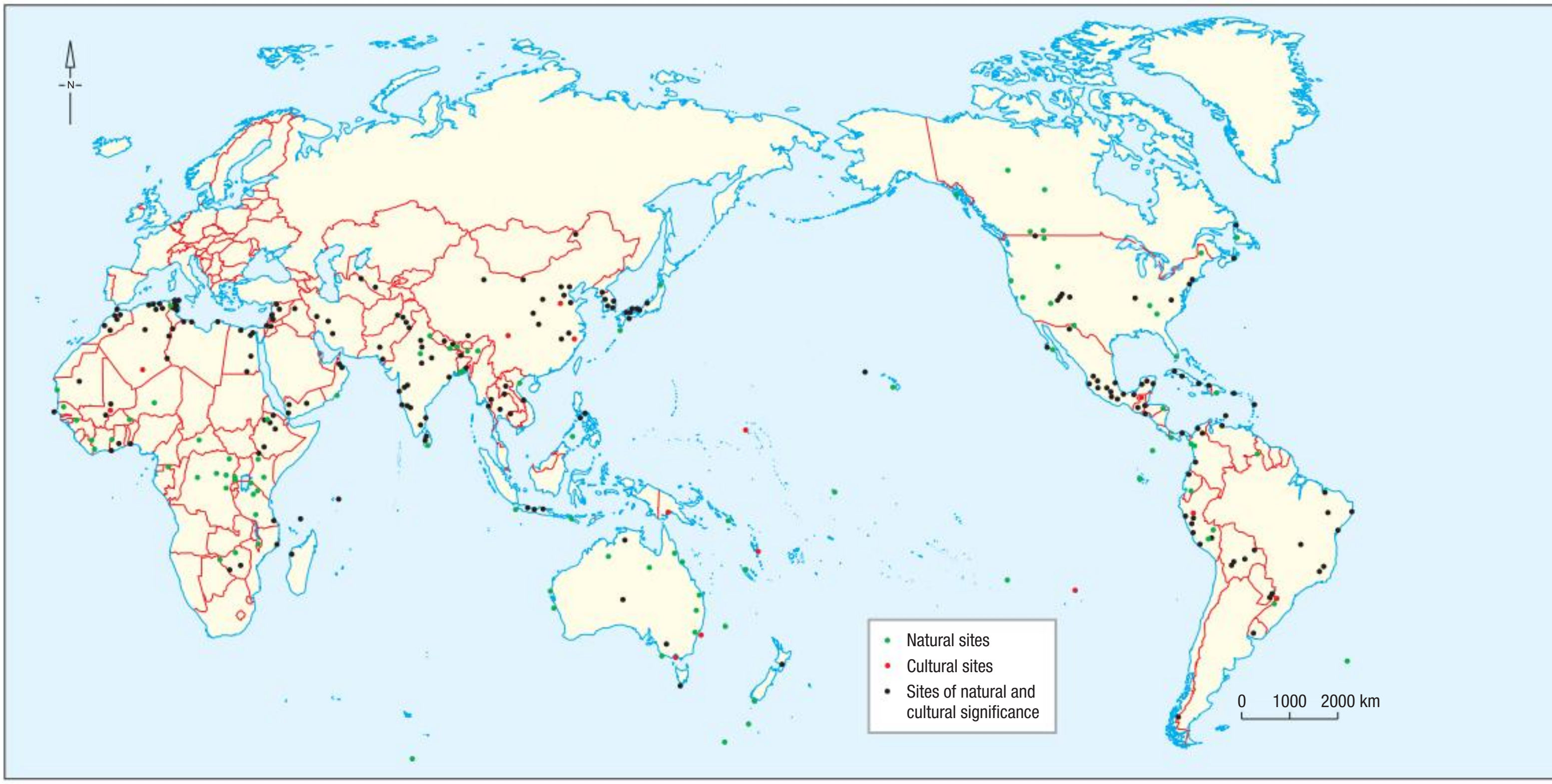
Description: Founded in the second century BC in northern Italy, Venice prospered under Venetian rule from the early fifteenth century to the end of the eighteenth century.

The Pyramids of Giza, Egypt

Listed: 1979

Criteria: Cultural

Description: Built to house the remains of Egypt's rulers, these vast structures are considered one of the Seven Wonders of the (ancient) World.

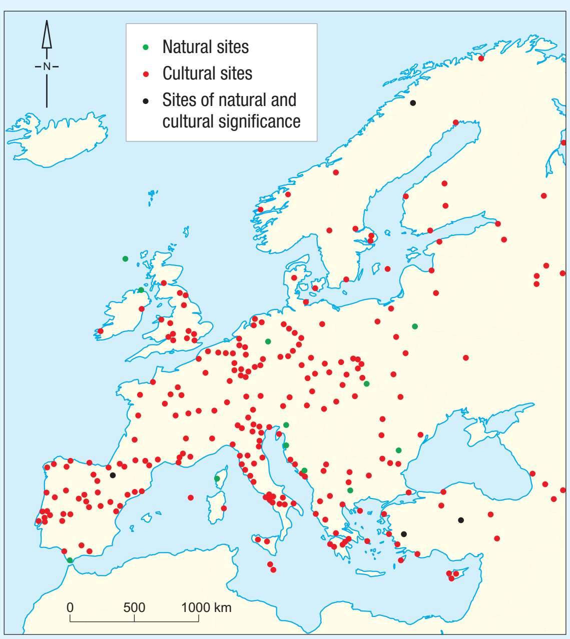


Grand Canyon National Park, Arizona, USA
Listed: 1979
Criteria: Natural
Description: Carved by the Colorado River, the Grand Canyon (nearly 1500 metres deep) is the most spectacular gorge in the world. Its horizontal strata retrace the geological history of the past two billion years. There are also prehistoric traces of human occupation.

Taj Mahal, India
Listed: 1983
Criteria: Cultural
Description: An immense mausoleum of white marble, built in Agra between 1631 and 1648 by order of the Mughal emperor Shah Jahan in memory of his favourite wife. The Taj Mahal is universally admired as a masterpiece of the world's cultural heritage.

The Great Wall, China
Listed: 1987
Criteria: Cultural
Description: In c. 220 BC, sections of earlier fortifications were joined to form a united defence system against invasions from the north. Construction continued up to the Ming dynasty (1368–1644), when the Great Wall became the world's largest military structure.

Auschwitz Concentration Camp, Poland
Listed: 1979
Criteria: Cultural
Description: The fortified walls, barbed wire, platforms, barracks, gallows, gas chambers and cremation ovens show the conditions within which the Nazi genocide took place in the former concentration and extermination camp of Auschwitz–Birkenau, the largest in the Third Reich. One and a half million people, among them a great number of Jews, were put to death in the camp. Protected as a reminder of humanity's cruelty to fellow human beings.



3.7.4 Distribution of World Heritage sites

ACTIVITIES

Knowledge and understanding

1 Explain the factors that determine whether a site qualifies for World Heritage listing.
2 Explain why World Heritage sites are special.
3 Describe the process to protect endangered World Heritage sites.

Applying and analysing

4 Do you think the responsibilities of national governments under the World Heritage Convention are sufficient to protect the sites?

Geographical skills

5 Study Figure 3.7.4 and do the following tasks.
   a Name the continent/s with the most World Heritage sites.
   b Name the continent/s with the most World Heritage natural sites.
   c Name the continent/s with the most World Heritage cultural sites.
   d Is there a pattern for the location and type of heritage sites? Describe the pattern.
6 Study Table 3.7.3 and do the following tasks.
   a Draw up a table and with seven columns. Label each column with one of the seven continents: Africa, North America, South America, Europe, Asia, Australia and Antarctica.
   b Place each of the World Heritage locations under threat in the correct column.
   c List the continent/s that have the most number of World Heritage areas under threat.
   d List the continent/s that have no World Heritage areas under threat.
   e Describe the pattern to the location of World Heritage sites under threat.

Investigating

7 Select one place from Table 3.7.3 to investigate further. Present your research as an annotated visual display. Include the following information:
   a a map of the site
   b an explanation of why the site is considered important
   c an overview of the threats to the site
   d a description of programs in place to protect the site from the threats, and an analysis of these programs.

3.8

CASE STUDY: Machu Picchu

Protection

Built as a retreat for the rulers of the Inca Empire, Machu Picchu is one of the 'New Seven Wonders of the World' and a popular tourist destination. World Heritage listing ensures that this amazing contribution to the world's cultural heritage will be protected for the benefit of future generations.

Location

Machu Picchu is located on a Peruvian mountain ridge, 2430 metres above sea level and 80 kilometres to the north-west of Cusco, the historic capital of the Inca Empire. Today, tens of thousands of tourists each year walk the Inca Trail, a narrow mountain path, to visit Machu Picchu (see Figure 3.8.1), and many more arrive by train or bus.

History

The construction of Machu Picchu began around AD 1450, when the Inca Empire was at its strongest. It is now believed that the city was built as a secret religious or ceremonial site by the Inca emperor Pachacuti. Machu Picchu was abandoned as an official site for Inca rulers in 1572 after the Spanish conquest of South America.

Historically, the location of Machu Picchu was a closely guarded military secret, and its position was able to be readily defended. A rope bridge across the Urubamba River provided a secret entrance for the Inca army. Another removable bridge to the west of the city spanned a 6-metre gap in a stone path cut into the cliff face 570 metres above the valley floor. Because the site remained unknown to the Spanish invaders it is the most intact cultural site of the Incas.

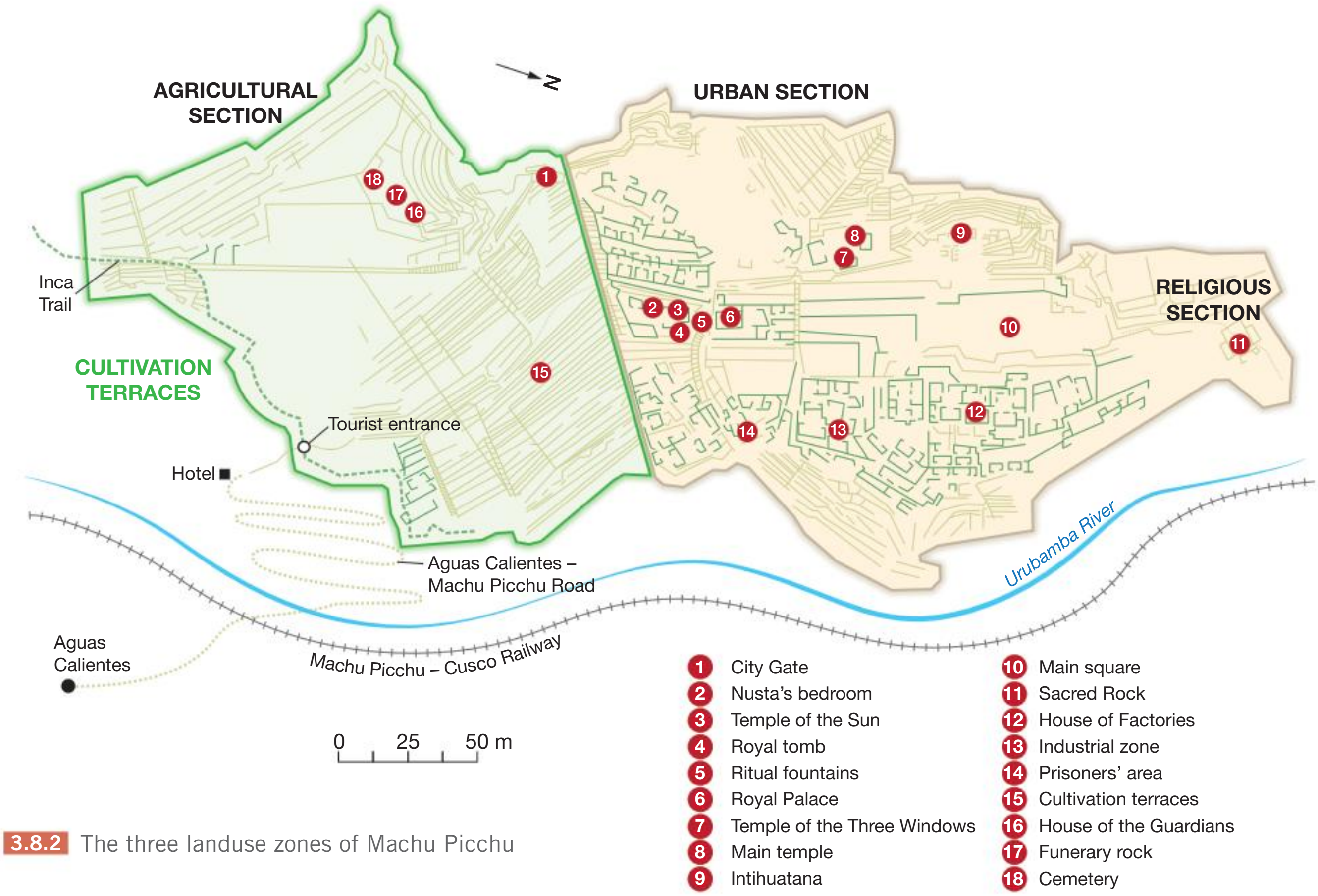
Construction

Machu Picchu was built in the classical Inca style, with polished dry-stone (granite) walls. Many of the stone blocks weigh 50 tonnes or more yet are so precisely fitted together that a thin knife blade cannot be inserted into the mortarless joints.

3.8.1 Machu Picchu

Layout

Machu Picchu was divided into three distinct landuse zones—agricultural, urban and religious—as shown in Figure 3.8.2. The urban and religious sectors were divided into two (the east and west sectors) by wide plazas. The agricultural sector, which is located outside the city's wall, was subdivided into upper and lower sectors. The city's structures—terraces, walls, palaces, baths, temples, storage rooms and some 150 houses—were arranged so that the function of the buildings matched the form of their surroundings. The agricultural terracing and aqueducts, for example, take advantage of the natural slopes, and the lower areas contain buildings occupied by farmers. The most important religious areas are located at the top of the ridge, overlooking the Urubamba Valley far below. The agricultural terraces used to grow crops to feed the population were watered by natural springs, making the city largely self-sufficient.



3.8.2 The three landuse zones of Machu Picchu

ACTIVITIES

Knowledge and understanding

1. Explain why Machu Picchu is referred to as the 'lost city' of the Incas.
2. State the role of Machu Picchu in the time of the Inca Empire.
3. Identify the features of the site of Machu Picchu that made it the ideal location for a 'secret' city.

Geographical skills

4. Study Figure 3.8.1 and describe the landscape surrounding Machu Picchu.
5. Study Figure 3.8.1 and discuss the advantages and disadvantages of living in such a location.
6. Study Figure 3.8.2 and describe the layout of Machu Picchu.

Investigating

7. Undertake research into the Inca civilisation. Present your findings as an illustrated extended report that includes:
   - a history and geographical boundaries of the Inca Empire
   - b population distribution
   - c economy
   - d social structure
   - e religion
   - f architecture
   - g urban centres (including Cusco)
   - h the Inca civil war and the Spanish Conquest.

Coastal landforms

CHAPTER 4

Coastlines are dynamic environments, undergoing constant change. The main agents of change are waves, tides and currents. The formation and shape of a coast is also influenced by its geology—the harder the rock, the less likely it is to be affected by eroding forces.

Coastal landforms can be divided into two major categories—erosional and depositional. Erosional coasts are those dominated by cliffs and wave-cut platforms. Depositional coasts are those dominated by landforms made up of eroded materials, for example beaches and sand dunes.

Coastlines are especially vulnerable to the impacts of human-induced climate change. Global warming is predicted to accelerate the rate of coastal erosion.

INQUIRY QUESTIONS

- What are the processes shaping the world's coastlines?
- What are the principal erosional and depositional coastal landforms and how do they develop?
- How can coastal landscapes be protected and managed sustainably?

GLOSSARY

backwash	the return flow of water down a beach after a wave has broken
berm	a small wall of earth or sand at the back of the swash zone
blowout	a gap, or break, in the dune system formed by the inland movement of sand; often caused by the destruction of dune vegetation
clinometer	an instrument for measuring slope angles
corrasion	the process by which surging water bombards a cliff with rock fragments and drags other fragments backwards and forwards over rock surfaces, wearing them away; also called abrasion
depositional coast	a coastline dominated by landforms made up of eroded materials
erosional coast	a coastline dominated by landforms created by erosion
fetch	the length of water over which wind has blown
foredune	the sand dune closest to the beach
groyne	a wall of rocks or timber built to trap sand on a beach
hydraulic action	the process whereby waves breaking against a cliff cause air to be compressed in the cracks in the rock, resulting in the cracks widening and the rock loosening and breaking away over time
joint	a gap in layers of solid rock
longshore drift	the process whereby sand is moved along a beach shoreline as a result of waves approaching the shore at an angle; also called littoral drift
notch	a small undercut at the base of a cliff
ocean current	a flow of water in the ocean with a different temperature or salinity from the water through which it is passing
riprap	a barrier built from large rocks or boulders to protect the shoreline
sand dune	a hill of sand shaped by the wind
sand bar	an area of sand deposited in shallow water
swash	the rush of water up a beach after a wave breaks
tide	the rise and fall of sea levels caused by the gravitational forces exerted by the moon and the sun, and the rotation of the earth
wave-cut platform	a flat rock surface found at the base of a cliff or headland

4.0 An erosional coastline: Twelve Apostles, Victoria

4.1

Processes shaping coastlines

Coasts

Coasts are very complex environments that are constantly being changed by the forces of nature. Waves pound the coastline, sometimes bringing sediments such as sand onto the beach and at other times striking the coast with so much force that they erode its landforms.

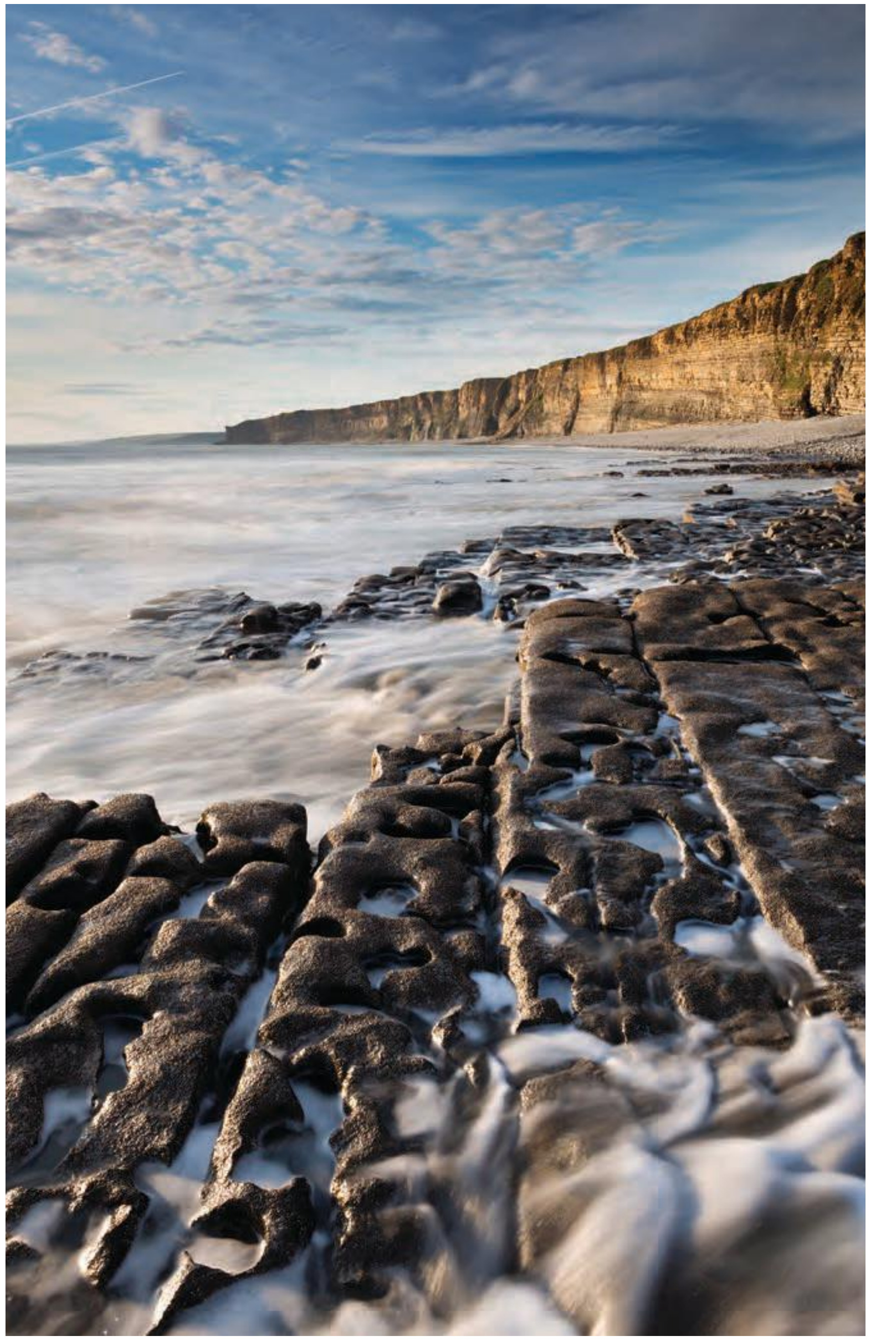
Coastline types

Coastal landforms are categorised into two main types—erosional and depositional coastlines. **Erosional coasts** are formed by the powerful action of waves and other forces that weather and erode rock. The Victorian and South Australian coastlines are mostly erosional coastlines. Figure 4.1.1 shows an erosional coast. **Depositional coasts** are made up of eroded materials transported along the coast. The Queensland and northern Western Australian coastlines are mostly depositional coasts. Figure 4.1.2 shows a depositional coast.

Waves

Of all the processes shaping coastlines, waves are the most important. They play a role in both erosion and deposition. The sea's surface is constantly moving. When wind blows across the surface of the sea, energy is transferred from the wind to the water surface. A wave is energy travelling through the water.

In the open sea, far away from land, waves move as ocean swell in a circular motion. As the wave approaches the shallow shoreline it begins to interact with the seabed. The seabed disturbs the circular motion of the wave, causing it to rise up, and then gravity eventually causes it to break. This process is shown in Figure 4.1.3.



4.1.1 An erosional coastline, Nash Point, Wales, United Kingdom

4.1.2 A depositional coastline, Fraser Island, Queensland

Swash and backwash

When a wave breaks it creates turbulence in the water. This turbulence is called **swash**. As the swash water surges up the beach it carries sediment it has picked up with it. As the energy in the wave is gradually lost, most of the water soaks into the sand. The remaining water, called **backwash**, flows back down the beach and into the sea.

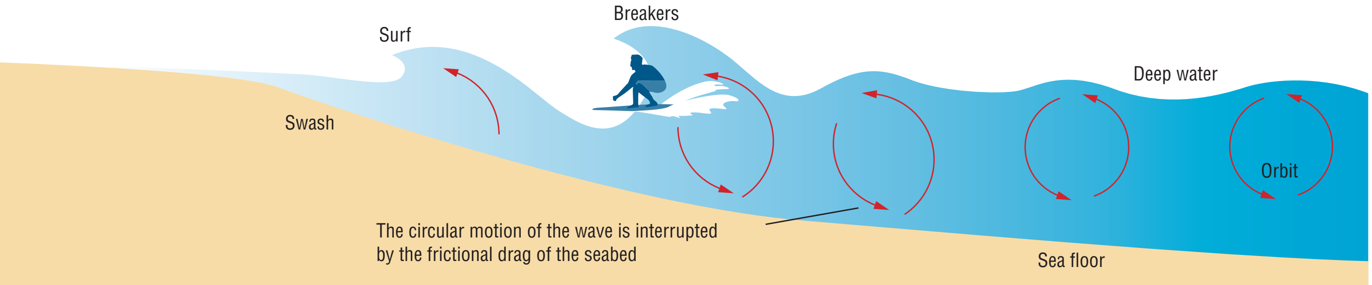
Constructive and destructive waves

Waves are very powerful—the energy within them is strong enough to wear down solid rock and cause widespread destruction to coastal zones, especially during storms. However, waves are also builders of the coastal system. They are able to carry and deposit large amounts of sediments and play an important role in constructing the coastal system.

When a low-energy wave crashes on a beach, it has less backwash and most of its sediment is dropped during the swash, so it becomes a constructive wave. However, if the wave has considerable energy, much of this energy will return to the sea in the backwash. In this instance, the wave can continue to pick up sand in the backwash and return it to the sea, becoming a destructive wave.

In Australia, waves are generally constructive during summer in southern Australia and during the dry season in northern Australia. During this time the beach expands as sand is deposited onto the beach. This sand builds up depositional landforms such as sand dunes. Wave size is determined by speed of wind, duration of wind and **fetch**.

4.1.3 Waves increase in height when the wind blows strongly, for a long time and over a long distance (fetch). When they enter shallower water the circular movement of energy is disturbed. The forward movement of the wave causes it to break as surf.



In the winter months, there is an increase in the number of large storms and strong winds in southern Australia. This type of weather results in the creation of destructive waves. These are waves with huge amounts of energy that wear away coastal areas. Destructive waves erode beaches and headlands, and cause considerable damage.

Weathering

Although waves are the most important agents of erosion, there are other agents that impact on the wearing down of a coast.

- Salt-spray weathering gradually breaks up the surface of rock because the salt particles expand and contract as they dry out in the sun.
- Plant weathering breaks up rock, as plants send tiny roots into **joints** (gaps within the rock).
- Animal weathering occurs when sea creatures attach themselves to rock. The animals produce chemicals that attack minerals in the rock, breaking it down.

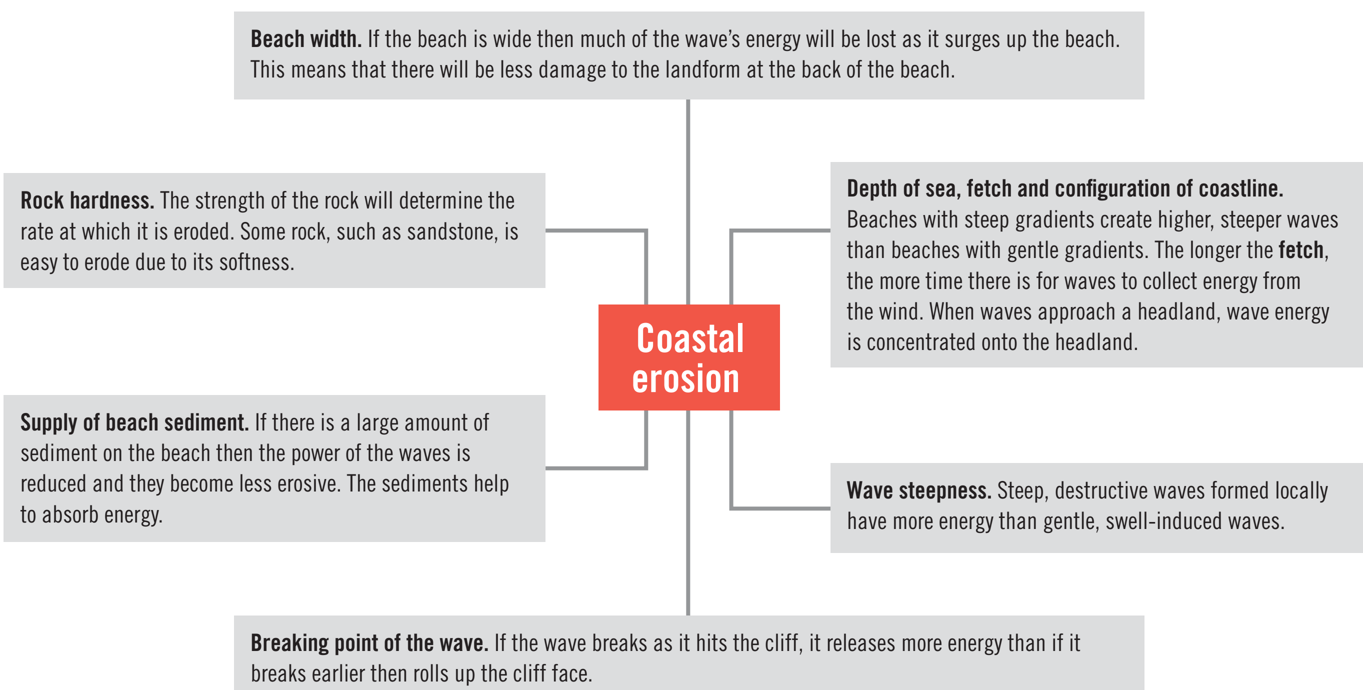
Erosion

Erosion is the transporting of material that has been weathered (worn away) from one place to another. There are two types of erosion: wind and water. In the coastal environment, water erosion occurs mostly through waves and the coastal rivers that carry swash sediments from inland areas out onto the coast. Wind erosion is very important in the formation of sand-based landforms such as coastal dunes. The factors affecting the rate of erosion are shown in Figure 4.1.4.

There are six main types of coastal erosion.

- ***Wave pounding*** Large waves transport huge amounts of energy. When waves break against rocks they weaken the rock's structure, causing small pieces of rock to break away.
- ***Hydraulic pressure*** When a wave strikes against a rock surface a small amount of air is trapped in cracks within the rock face. As the air is compressed by the weight of the water, pressure is exerted on the rock. Over time this weakens the rock face.
- ***Corrosion/solution*** This process is similar to the formation of rust on metal. A chemical reaction between air, the salt in the seawater and the rock surface causes small particles of rock to disintegrate.
- ***Abrasion/*corrasion** As a wave breaks it throws sand, small rocks and sometimes even large boulders against rocky coastlines. This action gradually wears away the rock, much like sandpaper does to a piece of wood.
- ***Attrition*** When a large piece of rock falls away, the waves gradually wear it down into smaller rock particles and eventually sand.
- ***Land-based erosion*** Water running from the land can also erode the coastal environment.

4.1.4 Factors affecting the rate of erosion along a coastline



Deposition

Many of the features you see at the coast (such as beaches, sand bars and sand spits) are built up by deposition. Waves and currents move sand along the coast and deposit it in large piles or strips. Beaches are the best known of these features and are formed only where there is a good supply of sand and some form of protection to prevent the sand from being eroded away.

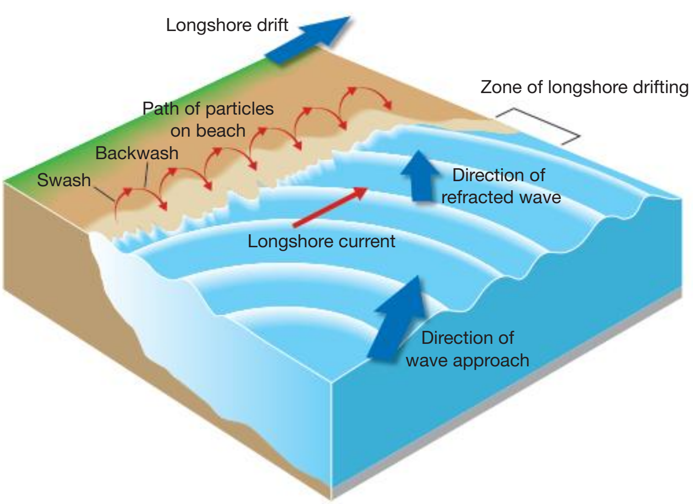
Tides and currents

Tides are caused by the gravitational pull of the moon on the oceans. Figure 4.1.5 shows this effect. Tides vary greatly in height from one place to another. While most places have an average of a few metres between high and low tides, there are places where the height of the tide rises by 20 or 30 metres.

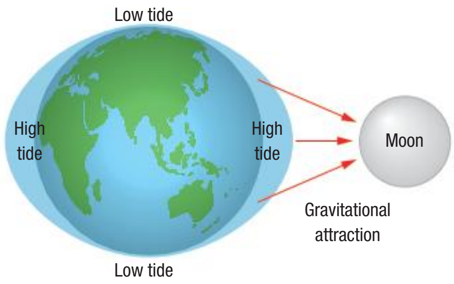
Ocean currents play a very important role in distributing sediments and also in regulating temperatures. Ocean currents carry cool water away from the North and South poles towards the Equator and warm water from the Equator towards the poles. In this way they help to create milder climates.

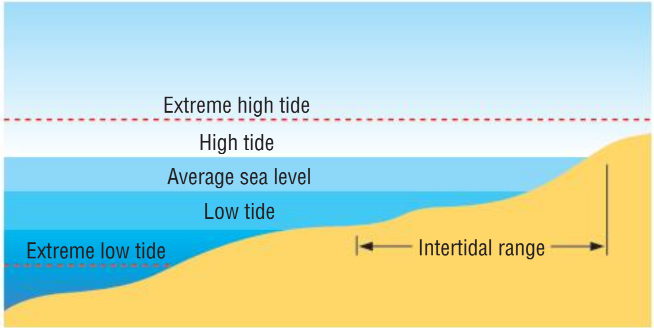
Longshore drift

Along many coastlines a special type of current known as **longshore drift** occurs. This current plays a major role in the movement and deposition of sediment, and is very common along the eastern coast of Australia. Longshore drifts, shown in Figure 4.1.6, run parallel to the coastline, carrying the sediments that destructive waves have eroded from beaches. These sediments can be carried very long distances. The prevailing wind also affects longshore drift.



4.1.6 Longshore drift





4.1.5 The effects of gravitational pull by the moon and the sun cause the daily and monthly pattern of tides.

ACTIVITIES

Knowledge and understanding

1. Distinguish between erosional and depositional coasts.
2. Explain how waves form.
3. Explain what weathering is.
4. Outline the various forms of weathering that shape the coastal environment.
5. Name three landform features associated with the process of deposition.

Geographical skills

6. Study Figures 4.1.1 and 4.1.2.
   a. Construct a Venn diagram and list the similarities and differences between the coastal landscapes shown in the photographs. Include a definition explaining the differences between erosion and deposition.
   b. Construct a mind map of all the different ways that the coast is changed by natural processes.
7. Study Figure 4.1.6. Explain, in your own words, the process of longshore drift.

4.2

Erosional landforms

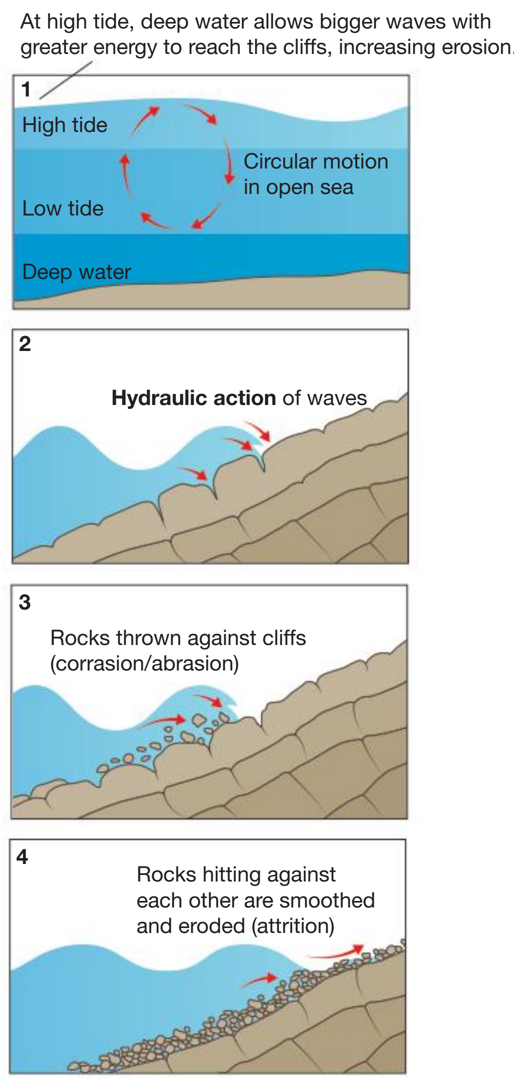
Power of waves

Many coastlines are made up almost entirely of rock. Wave erosion dominates these coasts. Storm waves undermine cliffs and gradually wear away headlands. Sometimes the largest waves that break on coasts are caused by storms hundreds of kilometres away. The wind may be so strong that it builds up huge waves that travel uninterrupted across the sea.

As waves move from the deep ocean towards the shallower waters of the coast their circular motion is affected by the frictional drag of the ocean floor. This causes the bottom of the wave to move more slowly than the crest and the circular motion is increasingly distorted; the wave increases in height until it finally plunges forwards as a breaker. The energy of the wave is released and the work of erosion, transportation and deposition takes place. This process is outlined in Figure 4.2.1. On exposed coasts, these are the dominant processes in the area between low and high tides. Waves are most active during storms, when high winds create large, high-energy waves.

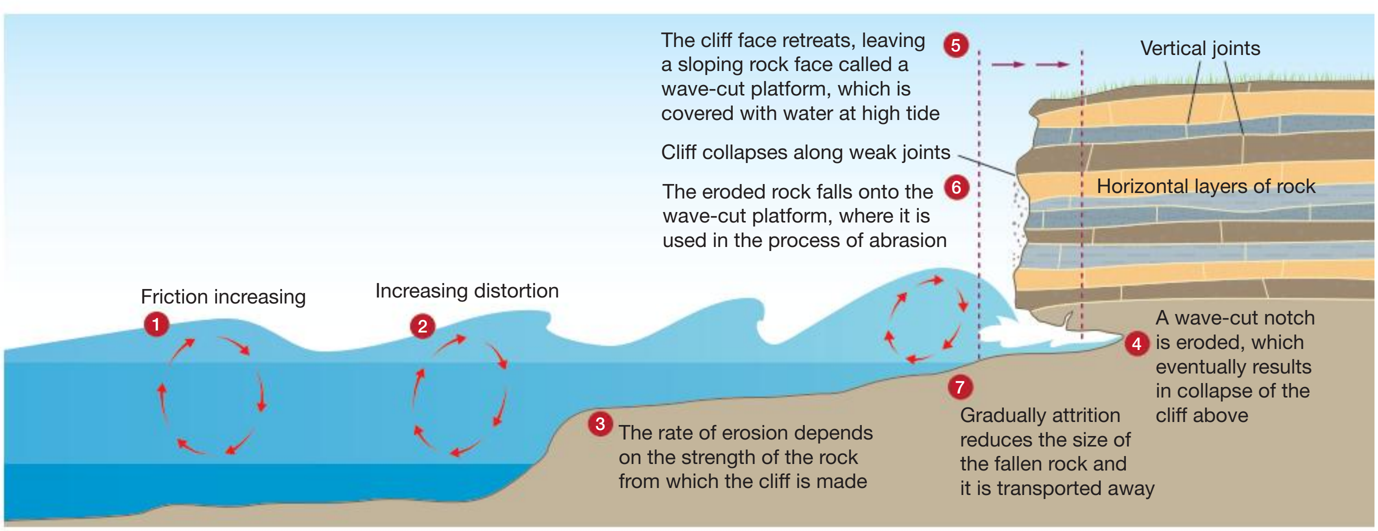
Coastal erosion

On coasts with cliffs, wave action is concentrated at the base of the cliff. This process is outlined in Figure 4.2.2 and illustrated in Figure 4.2.3. Coastal erosion occurs very quickly when the cliffs are formed from softer rock, such as sandstone.



4.2.1 Processes of wave erosion

4.2.2 Coastal processes and landform features on a rocky coast

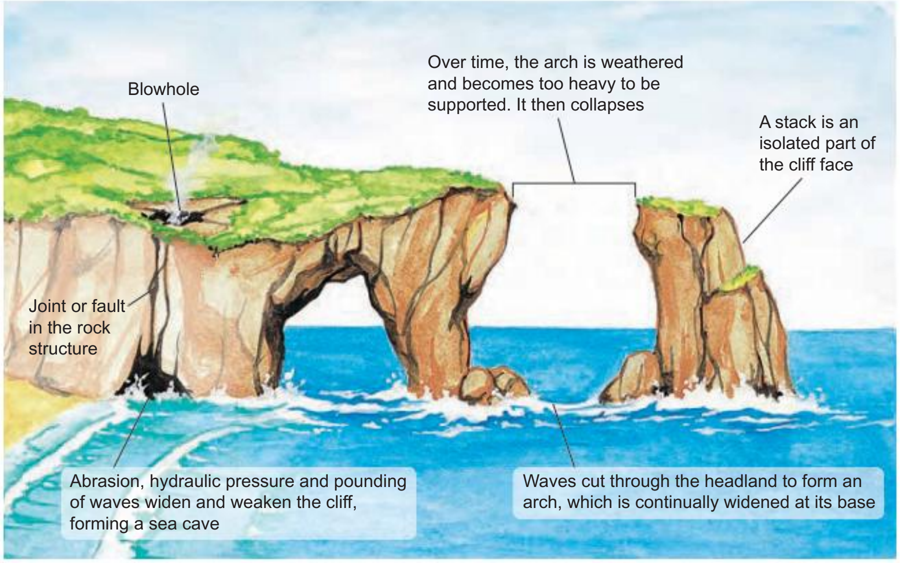


4.2.3 Cliff face, notch and wave-cut platform, Newfoundland, Canada

Stacks and arches

Some sections of rock within a cliff face may be more erosion-resistant than others. The softer rock around more resistant rock is eroded more quickly, leaving the harder rock as an outcrop along the coast. The sea may then eventually erode the less resistant rock on all sides of this outcrop. The resistant rock is left as a small island or stack, shown in Figure 4.2.4.

Occasionally, the stack may be left linked to the headland by an arch. This arch will eventually fall as more weathering and erosion occur.



4.2.4 Formation of sea caves, arches and stacks

ACTIVITIES

Knowledge and understanding

1 Explain the power of waves and the effect of shallow water.

2 Explain why cliffs erode at different rates.

Applying and analysing

3 Study Figures 4.2.3 and 4.2.4. With knowledge gained from the text and your own research, write a report explaining the events and processes responsible for the formation of stacks and arches.

4 Construct a photo sketch of Figure 4.2.3. Annotate your sketch with the names of coastal landform features mentioned in this unit.

4.3

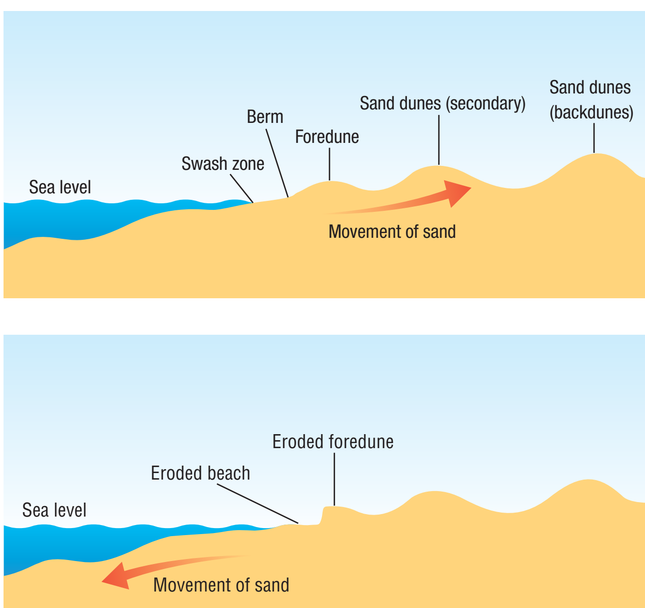
Depositional landforms

Beaches

Beaches are familiar landforms seen on many coastlines. They can be made up of any deposited material, including shingle (small, rounded pebbles), but most beaches are made from sand. The sand is distributed along the beach by wave movements. It may be brought to the coast by rivers, or it may be deposited by waves from eroded rock material along the coast.

Because beaches are made up of loose material, their location depends on the actions of the waves and rivers. Sand is continuously being deposited on beaches or taken away from beaches by waves. Beaches will form only in a place where there is a good supply of sand, and where there is enough protection to give the sand a chance to build up. On most beaches there is a continuous cycle of erosion and deposition. In seasons of strong winds and storms, the sand is taken from the beach and is often stored offshore as **sand bars** in shallow waters. In seasons of calmer seas and light winds, the sand is gradually deposited on the beach.

Figure 4.3.1 shows this cycle of erosion and deposition. The cycle affects not only the size and shape of the beach but also the dunes behind the beach. When storm waves are very large, they erode the beach and may also eat into the dunes.



4.3.1 Sand deposition and erosion

Beach components

All beaches have three main components.

1 The swash zone—this is the most active part of the beach and is where the waves crash onto the beach and run up and back down. In this part of the beach the sand is always wet.
2 The **berm** and **foredune**—a ridge of sand called the berm develops at the top of the swash zone where waves lose their energy and begin the backwash. The waves deposit sand up to this point. The foredune begins after the berm.
3 Coastal sand dunes—dunes are landforms created by the wind. Dried sand is picked up by winds blowing from the sea and deposited over the land.

Dune formation

Behind a beach there are often **sand dunes**. These are built by the wind blowing loose, dry sand from the beach inland, where it accumulates to form a number of dunes called the foredune (or primary dune), secondary dune and backdune. The sand in the dunes is anchored, or stabilised, by plants, such as those shown in Figure 4.3.2.

Dunes are a very important part of the sand cycle. They prevent storm waves from extending into low-lying areas behind the beach. For a sand dune system to exist there has to be a large supply of sand, long periods of dry weather and frequent onshore winds.

As sand begins to accumulate in a dune, plants start to settle and grow. The first colonisers bind the sand together with their roots. This creates a more stable environment in which more and different plants can grow. Each following group of plants is taller and more complex, as the growing conditions are gradually improved by earlier plants.

Dunes are found along many beaches in Australia. They have been used for recreation, mined for sand and rare minerals, used as rubbish dumps, built over for housing and, in many areas, completely removed. People are now much more concerned about conserving dunes in their natural state. There is more public awareness and understanding of how easily dunes can be damaged. Planning rules now protect dune systems in many coastal areas.

4.3.2 The sand in these Tasmanian dunes is anchored, or stabilised, by plants.

Sand spits, bars and tombolos

Sand spits form in shallow water where waves dump sand, creating a narrow strip of land, as seen in Figure 4.3.3. The water behind the spit is usually very calm and it is common for mangroves or salt marshes to develop there. In some places, a sand spit forms across the mouth of a bay, joining two headlands. This is known as a bar. A tombolo is a rare form of spit that forms between the mainland and an island.

4.3.3 A sand spit, Fingal Bay Tombolo, Port Stephens, New South Wales

ACTIVITIES

Knowledge and understanding

1. Identify the conditions necessary for a dune to build up.
2. Outline how plants anchor the surface of a sand dune.
3. Explain what causes the changes in erosion and deposition on a beach.
4. Explain the difference between spits, bars and tombolos.

Applying and analysing

5. Describe the destructive effects on sand dunes of some human activities carried out on or near dunes, such as mining, building houses, walking, boating and planting trees.

4.4

Managing coastal landscapes

Natural events

Coastal landforms need to be carefully managed. There are many natural events that can cause damage to coastlines. For example, large storms create powerful waves that can erode depositional landforms such as beaches and sand spits. Coasts have evolved to deal with these natural events and, over time, they repair themselves.

Human activities

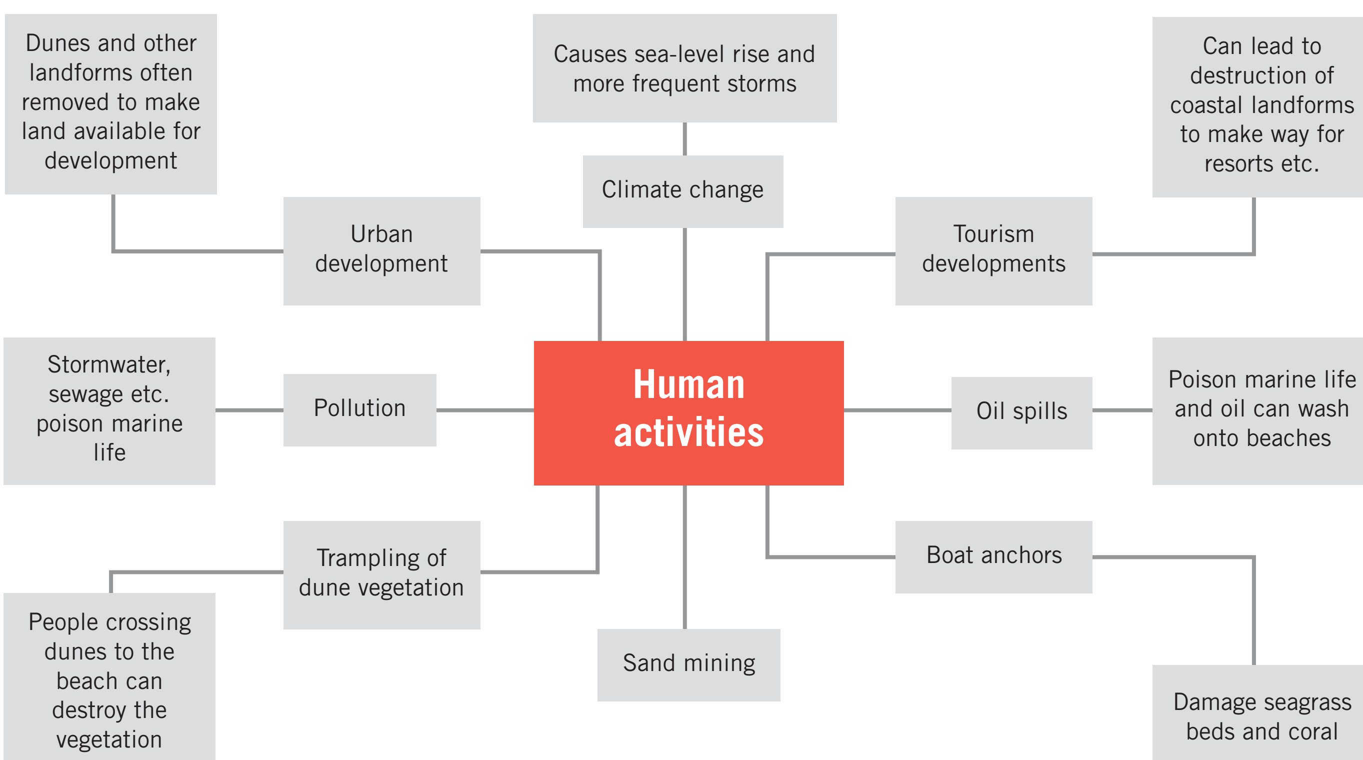
Human activities have a great impact on coasts. Thirty-eight per cent of the world's population live within 100 kilometres of the coast and 44 per cent live within 150 kilometres. In addition, many of the world's largest cities are found on the coast. As a result, there is significant competition for the resources of coasts. As the world's population continues to grow, and more and more pressure is placed on coastal environments, the need for careful management becomes ever greater. Figure 4.4.1 outlines some of the main human activities that threaten coastal environments.

Managing beaches

After a day of heavy human activity at the beach, the tide gradually washes away most of the signs of usage and redistributes the sand. However, humans can permanently damage beaches in more indirect ways.

Longshore drift is a natural process that shifts sand along the beach. If interruptions to this movement are built along the beach, the sand piles up against them, while other parts are deprived of sand. If the supply of sand is reduced (for example by building on the dunes or by damming rivers, which stops the supply of sand from rivers), the beaches may not be replenished sufficiently by longshore drift. This means that sand is stripped away at a faster rate than it can be replaced.

4.4.1 Human activities that threaten coastal environments



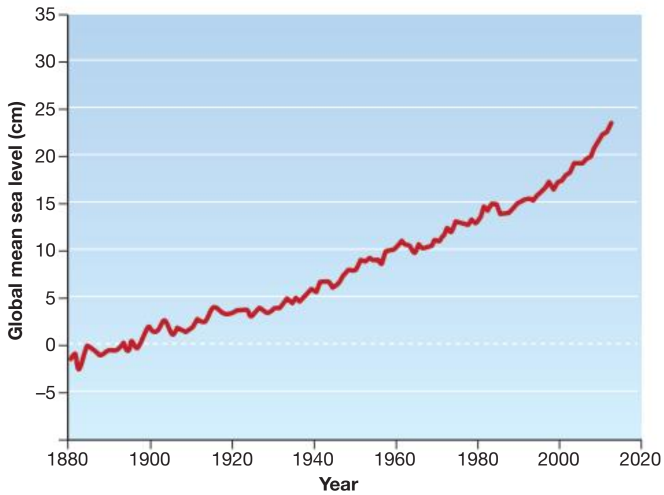
SPOTLIGHT

Climate change and coastal landforms

Climate change is one of the most significant threats to the coastal environment. Global temperatures have been steadily rising for many decades and the overwhelming majority of scientists now believe that this is due to humans burning fossil fuels, such as oil and coal, and the resulting release of CO_2 gas into the atmosphere.

Climate change will have two main impacts on coastal environments.

1. ***Sea-level rise*** As sea temperatures rise due to global warming, the seawater expands. This is called thermal expansion. The melting ice caps in Antarctica and Greenland release huge quantities of water into the sea (Figure 4.4.2). High sea levels pose a real risk to low-lying coastal areas, making them susceptible to flooding.
2. ***Increased storm activity*** Warmer temperatures create ideal conditions for large storms, especially cyclones. Climate change is leading to more frequent and more intense storms, and this is creating more erosion and damage along coastlines, as shown in Figure 4.4.3.



Source: CSIRO

4.4.2 Global sea-level rise, 1880–2010. Rising sea levels are a major threat to coastal landforms. Note: Historical sea levels were recorded using tide gauge records; more recent records use satellite technology.

4.4.3 Coastal erosion, New South Wales

Building groynes

To overcome these problems, **groynes** may be erected to slow down longshore drift, as shown in Figure 4.4.4. These trap sand so that it piles up on one side of the groyne. This means, however, that on the other side of the groyne the sand level is lower.

If the sand supply is limited, a scheme of artificial sand replenishment may be undertaken. This involves sand being taken from a beach with plenty of sand, or dredged from offshore, and transported to a depleted beach by truck or pipeline. Shifting and dumping sand by truck is reasonably effective and inexpensive in the short term. Building pipelines to bring sand from other beaches or from offshore is a more expensive approach but is often much more effective. Figure 4.4.5 shows a range of coastal management strategies.

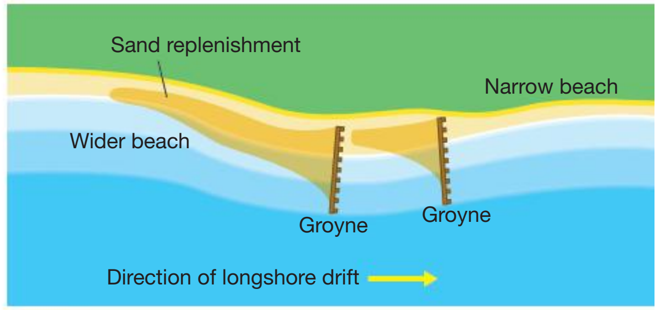
Managing dunes

Dunes are the most fragile part of the beach. Erosion of sand dunes is a major problem in many areas. It occurs whenever vegetation is removed, allowing the sand to blow away and the dune to shift. If a large section of a dune is blown away, a large, bare depression called a **blowout** forms. Strategies used to manage blowouts include the planting of new stabilising groundcover plants. To prevent the destruction of plant cover, walkways are often built through the dunes to keep people on set paths. The remainder of the dunes is then fenced off.

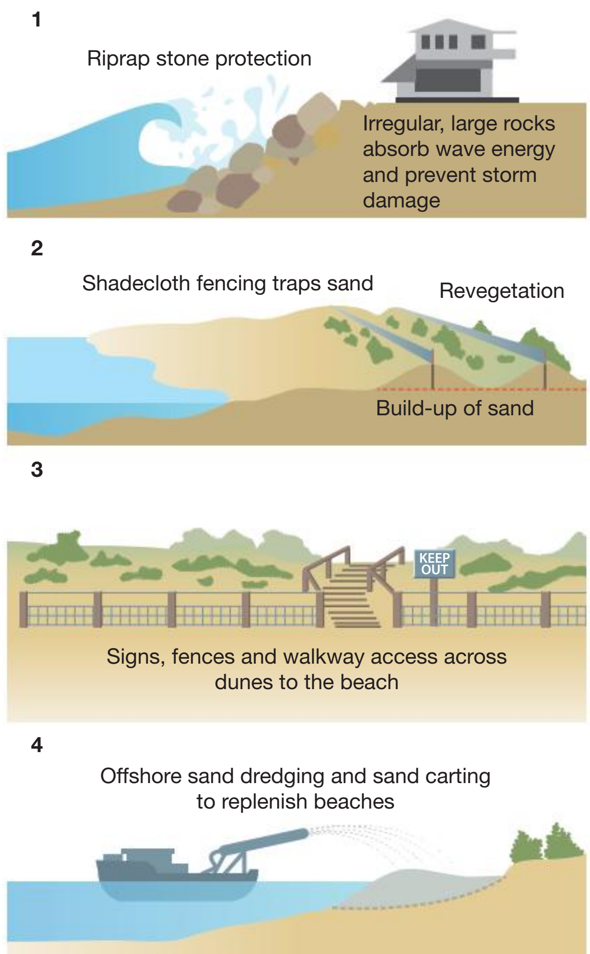
Managing coastal landuses

To ensure that the best use is made of coasts, careful planning and consistent management are required. In the past, most coastal areas were developed without any overall plan. Only when problems arose and it was recognised that the coastal land was under pressure was a plan developed. Therefore, any plans developed had to accept and take into account many of the existing landuses. Planners could only slowly change landuses because of the rights that owners had over their land.

Management now involves large-scale landuse plans, together with day-to-day administration of development permits to make sure that anything that is built or altered fits into the overall planning aims. Local councils usually administer these processes. Their aim is to make sure that new developments do not interfere with existing landuses and the rights of residents, and that whatever is built is for the future benefit of the area.



4.4.4 The natural movement of sand along a coast by longshore drift can be altered by constructing groynes or replenishing beaches with sand.



4.4.5 Some of the strategies used to manage coastal environments

Management options

There are four main options for managing coastal environments.

- ***Use hard engineering*** Building sea walls (see Figure 4.4.6 for an example), groynes, **riprap** and other hard structures is very expensive and these structures are often unsightly.
- ***Use soft engineering*** Building up beaches with sand-replenishment schemes can be expensive and must be maintained over the long term. It does not have as much negative visual impact as hard engineering.
- ***Discourage building and development*** This is a long-term measure. It needs the cooperation of local, state and national governments. It is often unpopular with local residents and developers.
- ***Do nothing*** This may be possible in sparsely populated areas but is increasingly impossible in highly populated areas.

4.4.6 Sea walls are examples of 'hard engineering' used to protect coastal development. While such walls absorb the power of the waves, they are expensive to build and maintain, and can cause more erosion because they reflect much of the energy of the waves; that is, as the wave bounces off the wall it carries away with it sand from the beach.

ACTIVITIES

Knowledge and understanding

1 Outline the damage that natural events can cause to coastal areas.
2 Describe the impact of climate change on coastal environments.
3 Explain why artificial sand replenishment is used on some beaches.
4 Explain why development plans and permits are necessary for coastal areas.

Applying and analysing

5 Study Figure 4.4.1.
   a Describe one human impact on coastal environments and develop some strategies for dealing with the issue.
   b List the controls that you think should be put on coastal development. Do you agree that governments and councils should be able to control all building and development along all coastal areas? Use a SWOT analysis to help you with your discussion.
6 Take on the role of an advertising agent. You have been commissioned by the state government to design a poster campaign to help reduce the damage done to sand dunes by people.
7 Write a report outlining the importance of dune systems and describing the strategies that can be used to manage dune systems.

4.5

IN THE FIELD: Investigating coasts

Aim

The aim of this fieldwork is to investigate a coast. Coastlines are wonderful places to undertake fieldwork and there are many different activities you can do to investigate the geographical processes taking place along coastlines.

Preparation

The following equipment will be required to investigate a coast:

- ruler and measuring tape
- ranging pole (a pole on which measurements are marked)
- stopwatch
- camera
- compass
- three tennis balls
- anemometer, a hand-held weather device or a copy of a Beaufort scale
- clinometer
- hand lens.

Select a beach that is easy to access at a variety of locations, as you will need a shoreline long enough to carry out activities.

Wind direction and speed

To measure wind direction and speed, complete the following steps. This enables you to identify the relationship between wind direction and speed.

STEP 1

With the aid of a compass, record the direction from which both the waves are coming and the wind is blowing. Are they the same? What is the relationship between wave direction and wind direction?

STEP 2

Using an anemometer, a hand-held weather device or a copy of a Beaufort scale, estimate the wind speed.

STEP 3

Using a stopwatch or an appropriate app on your smart phone, count the number of waves breaking on the shore in one minute. Compare your count with the information in Table 4.5.1. Describe the potential impact of the waves observed.

Investigating longshore drift

To investigate longshore drift and the direction of water and sediment movement along a beach, complete the following steps.

STEP 1

Throw three tennis balls into the water in this order—one in the middle of the surf zone, one on the water's edge and one as far out as you can throw it. Before you do so, guess which ball will travel the furthest along the beach.

STEP 2

Mark the point on the beach where you cast the balls into the water. It is important that the balls be in a straight line perpendicular to the beach.

STEP 3

Follow the progress of the balls. Use a tape measure to measure the distance travelled along the beach by the balls. Take the measurement every five minutes. Record your data.

STEP 4

Record the direction the balls travelled over the course of the activity. The results of this activity will show you the direction in which water (and therefore sediment) is moving along the beach.

STEP 5

Using a camera, identify any landform features along the section of coastline that are a result of the process of longshore drift.

Identify any biophysical or constructed features of the landscape that would disrupt the movement of sediment associated with longshore drift.

4.5.1 Potential impact of waves on beaches

Number of waves per minute	Potential impact
6–9	Beach is being built up
0–5	Beach is stable
11–15	Beach is being eroded

Investigating waves

Waves can be either destructive or constructive. Destructive waves are powerful and cause erosion of the coastline. They are usually associated with storms. They commonly occur in winter in southern Australia but are more frequent during the summer cyclone season in northern Australia.

Constructive waves are much less powerful than destructive waves. Instead of eroding the coastline they deposit sediment on the beaches and in this way 'construct' the coast. They are usually associated with calmer weather, common during summer in southern Australia and winter in the north.

Constructive waves tend to be surging or spilling waves. Usually, the water is cloudier, as it contains sediment. You can often actually see the sand in the wave as it breaks.

Destructive waves are usually plunging and collapsing waves. The water is usually clear, although as these waves are very powerful there is often a lot of 'white water' associated with them.

STEP 1

Choose a location high up, such as a headland, and look carefully at the waves.

STEP 2

Take photos of the waves you observe and use Figure 4.5.2 to help you identify them.

4.5.2 Types of waves

a

A collapsing wave occurs when the whole wave becomes unstable and collapses on top of itself.

b

A plunging wave forms when the crest of the wave curls over the front face and falls into the base of the wave. This produces large amounts of foam and a high splash. It is often called a dumper.

c

A surging wave occurs when the crest of the wave remains unbroken while the base of the wave moves up the beach.

d

A spilling wave occurs when the wave crest becomes unstable and topples down the face of the wave. This wave is often referred to as a roller.

Constructing a transect

A transect is a straight line that joins two points. Geographers use transects to show how things change. For example, you can construct a transect to see how the shape of the land (topography) changes. This is called a cross-section. You can also construct transects that show vegetation, soils and human activities.

By constructing a transect through a coastal dune you can see how they change as you move further inland away from the beach. You can investigate topography, vegetation and soil, as well as the impact of humans.

Remember, as you collect your data, stay on the paths through the dunes so you don't damage the fragile vegetation.

STEP 1

Working in small groups, begin to record the data for your transect. To construct your cross-section you will need a tape measure and a **clinometer** (a instrument that measures the angles of slopes). Figures 4.5.3 and 4.5.4 show you how to make and use a simple clinometer.

STEP 2

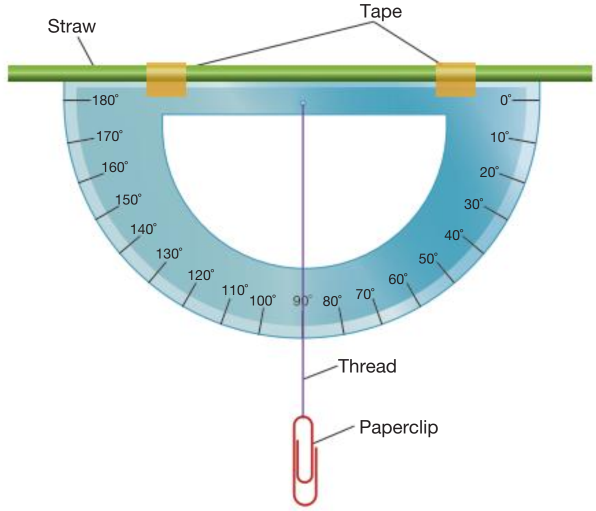
Use the tape measure to calculate the horizontal distance between the dune features, for example from the beach berm to the foredune. Then use the clinometer to measure the steepness of the incline (or decline). Record the distance and the angle for each feature.

STEP 3

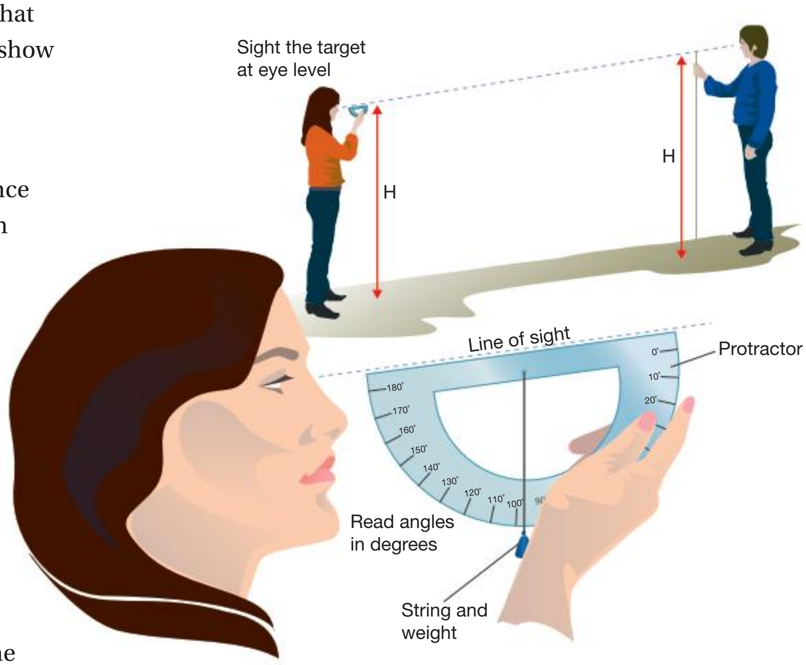
At each feature also investigate the soil and the vegetation. Using a hand lens and a ruler, measure the size of the grains of sand and note their colour. Usually, the grains become smaller the further away they are from the beach, and the soil becomes darker, as it contains more organic material. Record this data on your table. For each feature write a description of the vegetation and take a photo. Lastly, record any evidence of human impacts.

STEP 4

Figure 4.5.4 shows how to use the clinometer. For your transect, measure the angles of the slope each time there is a change. For example, start at the berm and work backwards to measure the change in angle to the foredune, and so on. You will need to use a common marker, for example a metre ruler or even the top of your partner's head.



4.5.3 Making a simple clinometer. Clinometers are special instruments that show the steepness of a slope by measuring its angle. If you don't have access to a clinometer you can make one using a simple protractor, some string or thread and a weight, such as a paperclip.



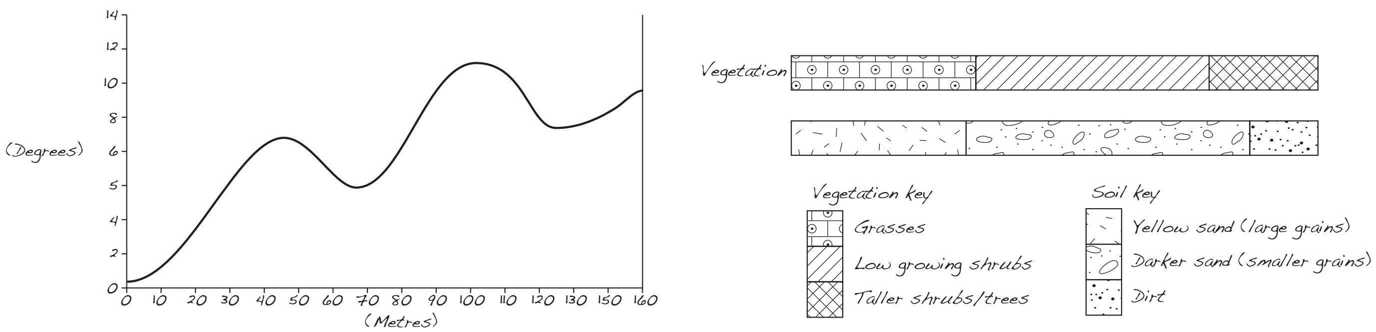
4.5.4 Using a simple clinometer

STEP 5

Back at school you will need to draw up a frame in which to construct your transects. Along the base of the frame make a scale and then include scales for the horizontal distance as well as the changes in angle measured in degrees.

STEP 6

Transfer the data from your field trip and join the dots with a line. Add boxes to record soil and vegetation. You will need to develop a key for this. Figure 4.5.5 shows an example of a series of simple transects.



4.5.5 Example of transects

ACTIVITIES

Aim

To investigate a coastline

Instructions

1 Select a suitable beach to investigate and obtain a map of the area investigated.
2 Investigate waves.
  a Observe and collect images.
  b Paste and annotate your images.
3 Record the wind speed on the beach.
4 Measure wave direction and speed.
5 Investigate longshore drift and record your data in a table like the one below.

Longshore drift record sheet					
Time (minutes):	10	20	30	40	60
Ball 1: Furthest out					
Ball 2: Surf zone					
Ball 3: Beach zone					

6 Construct a transect of the beach area being investigated. Use the table below as a guide.
7 Provide a field sketch of the beach area being studied.

Evaluation

8 Comment on your findings, including the following information in your response.
  a Identify the relationship between wind speed and direction.
  b Describe the impact of the wave speed and direction on the beach. For example, is the beach being built up, is it stable or is it being eroded? Explain.
  c Describe the impact of the direction of water movement on the distribution of sediment (i.e. longshore drift) in this section of the coastline.
  d Identify any landform features along the section of coastline that are a result of the process of longshore drift.
  e List any natural or constructed features of the landscape that would disrupt the movement of sediment associated with longshore drift.

Conclusion

9 Describe what you have learnt about coasts.

Data record sheet						
Dune feature	Distance from the berm (m)	Change in angle	Soils		Vegetation description	Evidence of human impact?
			Grain size (mm)	Soil colour		

Geomorphic hazards

CHAPTER 5

The earth is a restless planet, continually shifting under our feet. Powerful processes deep inside the earth's crust create volcanoes and earthquakes, push up mountains and pull continents apart. The earth's rocks provide clues to how these forces have shaped and changed our planet over billions of years.

In this chapter we focus on a range of landscape hazards, including earthquakes, volcanoes, coastal erosion, mass movement, mudslides and avalanches.

INQUIRY QUESTIONS

- What are the causes and consequences of selected environmental hazards?
- What are the challenges of living in areas of risk?

GLOSSARY

caldera	a volcanic landform feature formed when a violent eruption blasts away the top of an existing volcanic cone or shield
dormant volcano	a volcano that is said to be 'sleeping', as it has not erupted for a period of time but may still erupt
epicentre	a point on the earth's surface that is directly above the centre (focus) of an earthquake
extinct volcano	a volcano that has not erupted for a long period and will not erupt again
focus	a point under the earth's surface at which a sudden movement in the earth's crust occurs; the origin of an earthquake
hot spot	a location where hot molten magma from deep within the earth rises up through the crust to reach the surface
lahar	a mudflow formed when volcanic material mixes with water
lava	molten rock at the earth's surface
magma	molten rock below the earth's surface
magnitude	the energy released by an earthquake
Moment Magnitude scale	a scale used by seismologists to measure the energy released by an earthquake
pumice	a very light and porous volcanic rock
reclaimed land	land that has been gained from the sea or wetlands, such as waterlogged land that has been drained of water; or that has been restored for human use, such as a former quarry that has been filled in
seamount	a volcanic topographic feature rising from the sea floor
volcanic cone	a cone-shaped volcanic landform made up of layers of lava and volcanic ash
volcanism	the processes associated with volcanoes and volcanic activity
volcanologist	a person who studies volcanoes

5.0 Earthquake damage and destruction in Bhaktapur, Nepal, April 2015

5.1

Earthquakes

Location

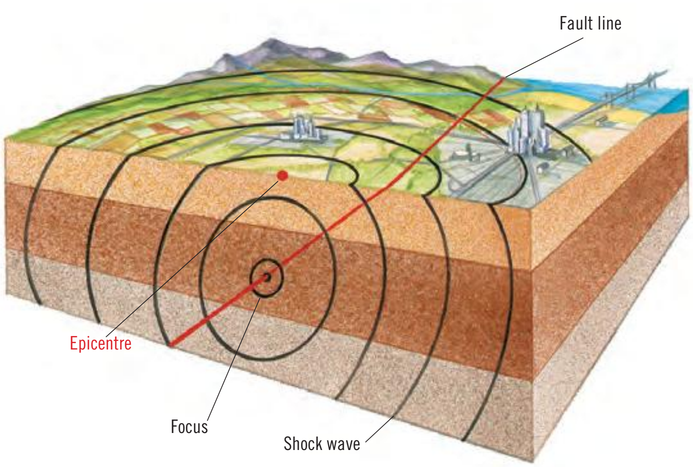
Earthquakes occur when energy that has built up in the earth's crust is released. While earthquakes are most commonly associated with the movement of the earth's plates, smaller, often less destructive earthquakes can occur well away from plate margins. These earthquakes are usually associated with fault lines (lines of weakness) in rock.

Shock waves

When the built-up energy within the earth's crust is released, shock waves go out in all directions. The point underground at which the sudden movement occurs is called the **focus**. The place at which the shock waves first reach the earth's surface is called the **epicentre**, as shown in Figure 5.1.1.

Measuring earthquakes

A seismograph measures the duration, **magnitude** and direction of an earthquake. The magnitude (or amount of energy released by an earthquake) is given a measurement on the **Moment Magnitude scale** outlined in Table 5.1.2. The Moment Magnitude scale replaced the Richter scale in 2002. Each point on the scale is ten times greater than the point below. This means, for example, that the Mexico City earthquake of 1985 (magnitude 8.0) was ten times stronger than the earthquake that struck San Francisco in 1989 (magnitude 7.0).



5.1.1 The focus, epicentre and shock waves of an earthquake

5.1.2 The Moment Magnitude scale

Magnitude	Effects	Average number per year worldwide
2.5 or less	Usually not felt, but can be recorded by seismograph	900 000
2.5 to 5.4	Often felt, but only causes minor damage	30 000
5.5 to 6.0	Slight damage to buildings and other structures	500
6.1 to 6.9	May cause a lot of damage in very populated areas	100
7.0 to 7.9	Major earthquake. Serious damage	20
8.0 or greater	Great earthquake. Can totally destroy communities near the epicentre	One every 5 to 10 years

Effects of earthquakes

Primary effects

Primary effects are effects that are directly related to the earthquake, such as collapsed buildings and open fissures.

Secondary effects

Secondary effects are the short-term effects of the earthquake, such as fires caused by broken gas pipes and electrocution caused by downed power lines.

Tertiary effects

Tertiary effects are the long-term effects of an earthquake, such as homelessness, business failure, disease outbreaks and famine.

Place and effect

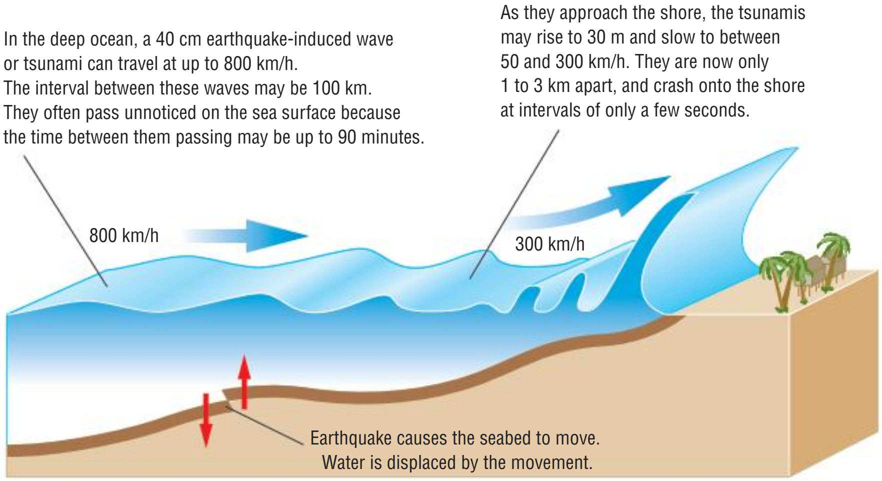
While the strength of an earthquake is important, other factors can also influence the extent of damage and loss of life. These include:

- distance from the epicentre—energy waves lose their intensity as they spread out
- level of preparation—building structures designed to withstand earthquakes means that the number of deaths caused by collapsing buildings is greatly reduced
- population density—damage and destruction in densely settled urban centres are more severe than in rural areas
- time of day—whether people are at home or out and about makes a difference to the number of deaths and injuries
- season—the secondary effects of earthquakes are much worse in winter
- type of land that cities are built on—silt and **reclaimed land** tend to magnify the effects of earthquakes.

Tsunamis

A tsunami is a series of ocean waves caused by underwater land movement. Movement can be caused by a landslide, a meteor strike or an earthquake, as shown in Figure 5.1.4. Tsunami waves are surges of water tens of metres high. The length of time between waves can range from minutes to hours. Although the impact of tsunamis is limited to coastal areas, their destructive power can be enormous.

5.1.3 The primary devastation caused by the 2015 earthquake in Illapel, Chile. The earthquake, which was offshore, caused a tsunami.



5.1.4 Formation of a tsunami

ACTIVITIES

Knowledge and understanding

1 State what an earthquake is. Explain why and where earthquakes occur.
2 Define the terms 'focus' and 'epicentre'.
3 Identify the instrument used to measure the magnitude of earthquakes.
4 State the difference between the primary, secondary and tertiary effects of earthquakes.
5 Outline the reasons why some places are more seriously affected by earthquakes than others.

Applying and analysing

6 Decide whether an earthquake measuring 7.0 on the Moment Magnitude scale in a remote rural area will cause less or more damage than a 6.0 earthquake in a big city during winter. Explain your answer.

5.2

CASE STUDY: Asia's tsunamis

Indian Ocean

On 26 December 2004, an undersea earthquake with an epicentre off the west coast of Sumatra triggered a series of devastating tsunamis that killed more than 225 000 people in eleven countries surrounding the Indian Ocean, and inundated coastal communities with waves up to 30 metres in height. Officially known as the Great Sumatra–Andaman earthquake, the event is more commonly referred to as the Asian tsunami or the Boxing Day tsunami. Indonesia, Sri Lanka, India, and Thailand were hardest hit (see Figure 5.2.1).

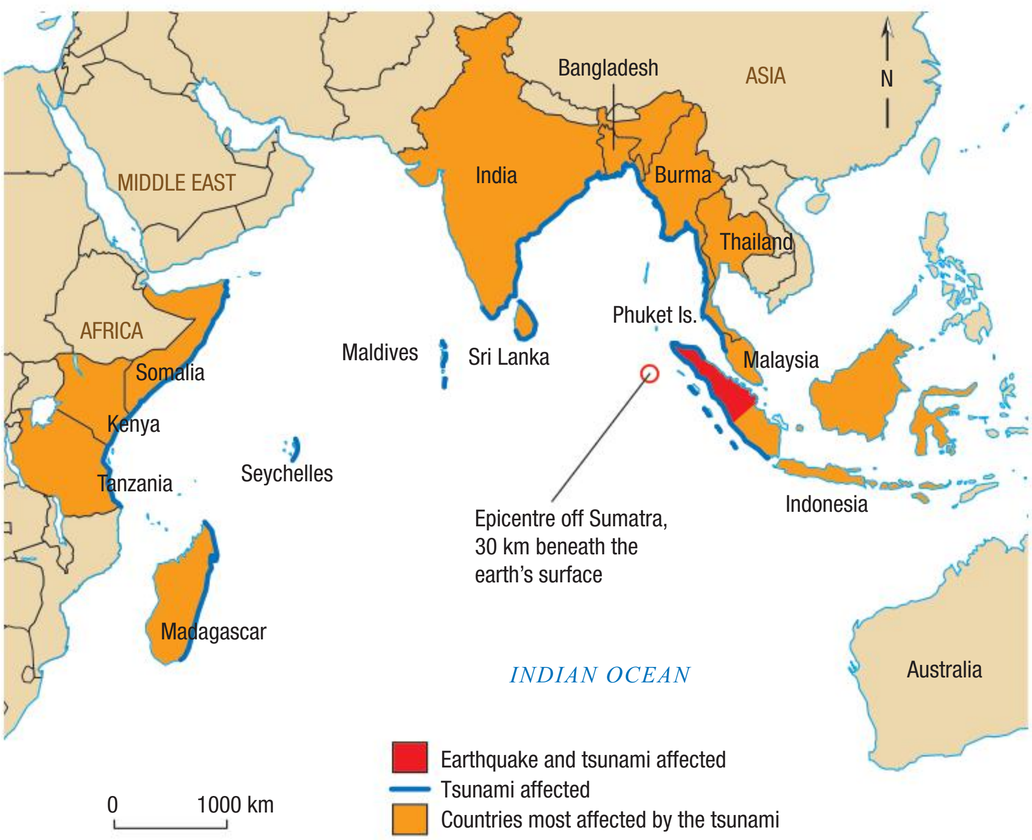
The quake, which lasted approximately 10 minutes, had a magnitude between 9.1 and 9.3—the second-largest earthquake ever recorded. So great was the movement, it caused the entire planet to vibrate by as much as 1 centimetre. The extent of the damage and the plight of those affected shocked the world and led to a worldwide humanitarian response. More than US$14 billion of humanitarian aid was given to the countries affected.

East Japan

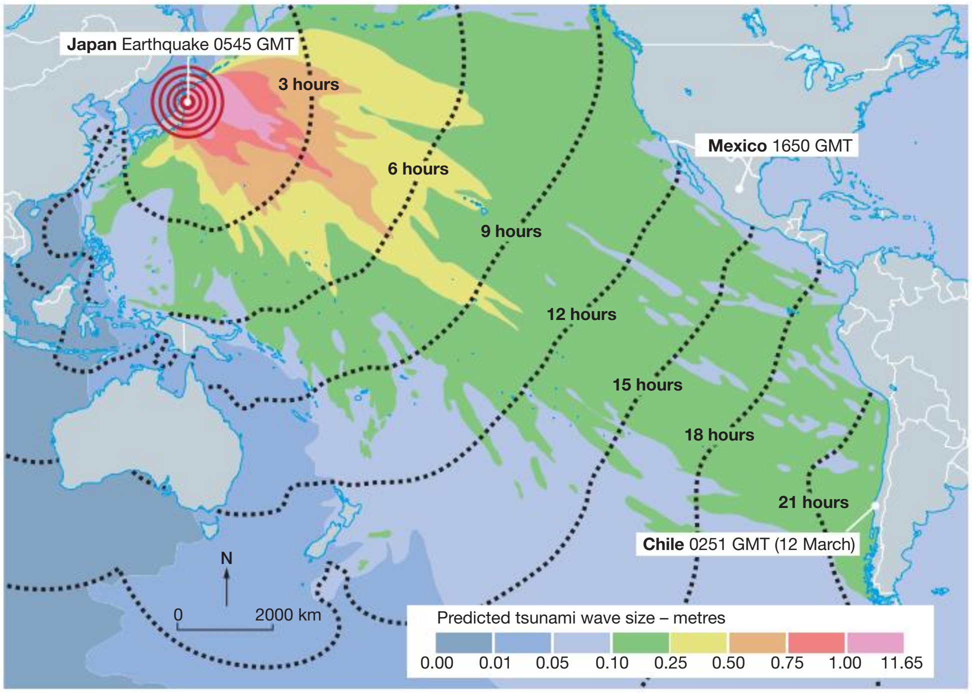
On the afternoon of 11 March 2011, a 9.0 magnitude undersea earthquake occurred at a depth of 32 kilometres, 70 kilometres off the east coast of Japan. It was one of the most powerful earthquakes ever recorded, moving the island of Honshu, Japan's largest, 2.4 metres to the east.

The earthquake caused a 180-kilometre-wide section of the seabed to lift by 5 to 8 metres. The resulting displacement of water triggered a massive tsunami that reached heights in excess of 40 metres. The surging waters travelled up to 10 kilometres inland, sweeping aside all that lay in their path (see Figure 5.2.2). More than 15 800 people died, 27 000 were injured and over 3000 remain missing, presumed dead. Over a million buildings were destroyed or partially damaged. More than 4.4 million households were left without electricity and 1.5 million without water. The tsunami also triggered a meltdown at the Fukushima Daiichi Nuclear Power Plant. Residents within a 20-kilometre radius of the plant were evacuated and still cannot return to their homes. Figure 5.2.3 shows the travel times of the waves of the tsunami.

5.2.1 The source and extent of the Asian tsunami, 26 December 2004



5.2.2 The cost of rebuilding in Japan after the earthquake and tsunami damage was US$360 billion.



5.2.3 Estimated travel times of the waves generated by the 2011 Great East Japan earthquake

ACTIVITIES

Knowledge and understanding

1 Copy and complete the following table.

	Earthquake and tsunami	
	Indian Ocean	Great East Japan
Earthquake details		
Damage		

Applying and analysing

2 Study Figure 5.2.2. Comment on the scale of the disaster shown in the photograph. As a class, discuss the descriptive terms used in your individual responses.

Geographical skills

3 Study Figure 5.2.1. Describe the extent of the 2004 tsunami's impact. How far did the wave of destruction travel?

4 Study Figure 5.2.3. Determine how long the tsunami took to travel to:

a Mexico

b Papua New Guinea

c the North Island of New Zealand

d South America.

5.3

Volcanoes

Location

Volcanic eruptions occur when molten material (**magma**) forces its way to the earth's surface through cracks or faults in the earth's crust. The molten material that flows from a volcano is called **lava**. The most active volcanoes lie in lines that coincide with the collision zones of the earth's plates.

Volcanic landform features

Volcanic eruptions can produce landforms in a rapid and spectacular manner. Some eruptions are explosive, while others are not—it depends on the thickness of the magma. Figure 5.3.1 shows magma that is thin and runny, flowing easily out of a volcano. Such a lava flow is rarely a threat to human life because it moves slowly enough for people to escape, but it can destroy towns and villages in its path.

5.3.1 A lava flow

5.3.2 Volcanic bombs

If the magma is viscous (thick), gases cannot escape easily. Pressure builds up until the gases escape violently and explode. Figure 5.3.2 shows this type of eruption, as magma blasts into the air and breaks into pieces called volcanic bombs. Explosive volcanic eruptions can be deadly. Molten material can shower down on the surrounding countryside. When hot volcanic material mixes with water from streams, **lahars** (mudflows) form. These can bury whole villages.

Over time, layers of lava and volcanic ash build up a **volcanic cone** (see Figure 5.3.3), or shield. A **caldera** crater forms when a violent eruption blasts away the top of an existing volcanic cone or shield.

Classifying volcanoes

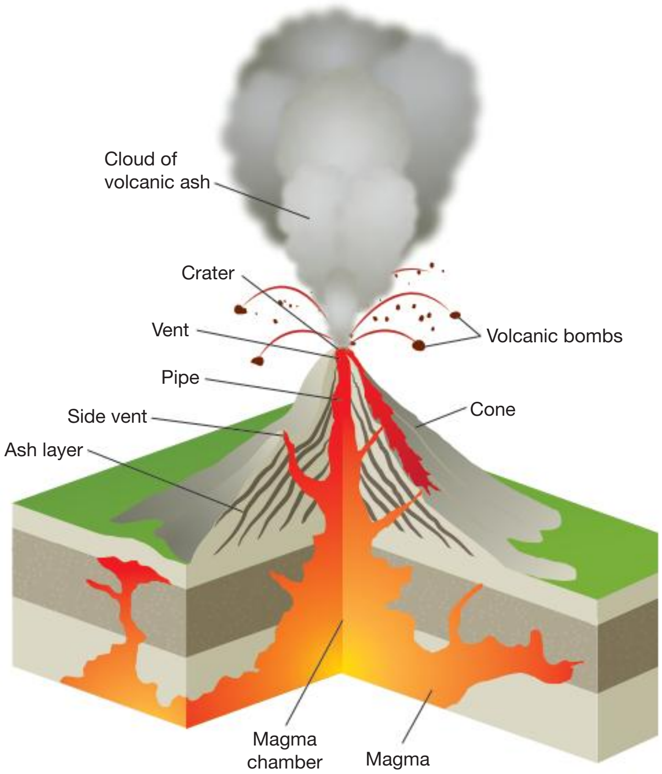
Volcanoes can be classified according to their shape.

Strato volcanoes

Strato, or composite, volcanoes are the most common type of volcano and are formed from layers of lava and ash, as shown in Figure 5.3.3. Their lava tends to be viscous and flows very slowly. This causes them to form steep-sided volcanic cones. Examples are Mt Fuji in Japan and Mt Taranaki in New Zealand.

Shield volcanoes

Shield volcanoes are among the world's largest volcanoes. They develop a broad base because the very fluid lava from which they are made runs downhill rather than piling up. Examples are the Kilauea and Mauna Loa volcanoes of Hawaii.



5.3.3 A cross-section through a strato volcano formed of layers of lava and ash

Calderas

While calderas are the least common form of volcano, they are often huge and potentially very explosive. When they erupt they tend to collapse in on themselves and so they don't build up a cone. Famous calderas are Yellowstone in the United States of America and Greece's Santorini caldera in the Aegean Sea, shown in Figure 5.3.4.

Recent volcanic activity

Some of the world's great mountains and many of the islands that dot the world's oceans are the result of past volcanic activity. There are 550 known active (that is, still capable of erupting) volcanoes on earth. Large eruptions may result in short-term climatic change as millions of tonnes of volcanic ash and smoke are released into the atmosphere, reducing the amount of sunlight reaching the earth's surface. Table 5.3.5 lists some volcanic eruptions that have caused great loss of life.

5.3.4 The Greek island of Santorini clings to the rim of a collapsed volcanic caldera.

5.3.5 Volcanic eruptions that have caused great loss of life

Year	Place	Impact
1815	Tambora, Indonesia	92000 people died, mostly in Indonesia—because of starvation caused by the loss of crops and livestock
1883	Krakatoa, the Sunda Strait, Indonesia	The resulting tsunami between Java and Sumatra killed 36000 people
1902	Pelee, Martinique	Poisonous volcanic gases and pyroclastic flows killed 36000 people
1985	Nevado del Ruiz, Colombia	A wave of mud smothered 23000 people
1991	Mt Pinatubo, the Philippines	900 people were killed, mostly from collapsing roofs

ACTIVITIES

Knowledge and understanding

1 Explain why some volcanic eruptions are violent while others are not.
2 Explain what volcanic bombs and lahars are.
3 Describe how volcanic eruptions can bring about short-term climatic change.

Applying and analysing

4 Study Figure 5.3.5.
   a List the main causes of loss of life.
   b Which cause killed the most people? Explain why.

5.4

Volcanoes transforming landscapes

Active volcanism

Volcanic activity is always occurring somewhere in the world. However, sometimes there is an eruption on a vast scale, an eruption so massive that it transforms landscapes.

Current areas of active **volcanism** include the Bagana and Manam volcanoes in Papua New Guinea; Dukono and Semeru in Indonesia; Karymsky and Shiveluch in Russia; Kilauea in Hawaii; Mt St Helens in the United States of America, shown in Figure 5.4.1; Colima in Mexico; Fuego and Santa Maria in Guatemala; Masaya in Nicaragua; Arenal in Costa Rica; Sakura and Suwanose in Japan; Sangay and Tungurahua in Ecuador; Soufriere Hills in Montserrat, West Indies; and Stromboli and Etna in Italy. There are many more inactive, or **dormant**, volcanoes and thousands of **extinct volcanoes**.

Even low-level volcanic activity can cause great inconvenience and economic loss. In April 2010, a relatively small eruption in Iceland disrupted air travel for six days across twenty countries in western and northern Europe. Flights were grounded and hundreds of thousands of travellers had their travel plans disrupted.

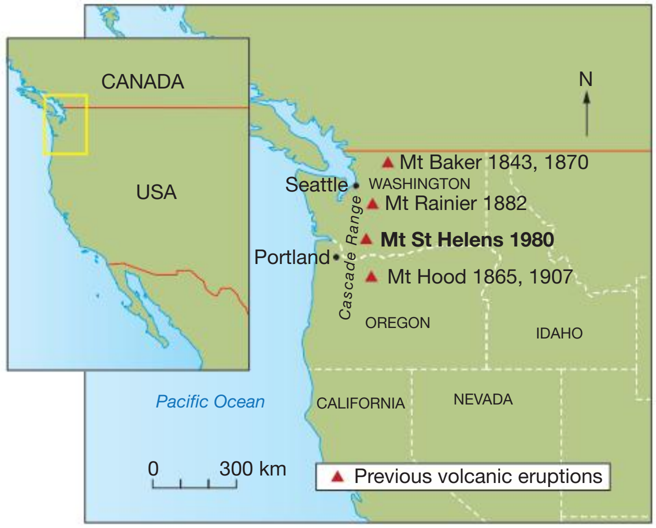
5.4.1 The Mt St Helens eruption, United States of America, 1980

Mt St Helens

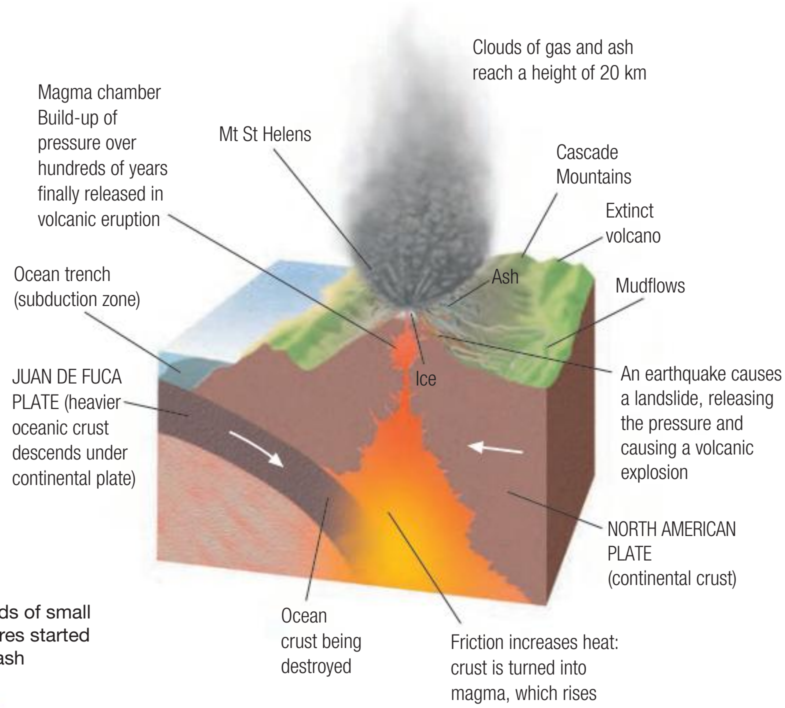
One of the most spectacular volcanic eruptions of recent times was the Mt St Helens eruption of 18 May 1980. The volcano, located in the Cascade Mountains of the United States of America (see Figure 5.4.2) had been dormant for over a century. Figure 5.4.3 shows the causes of the eruption. At 8.32 a.m. an earthquake of magnitude 8.1 rocked the earth directly beneath the mountain. The earthquake was caused by the Juan de Fuca Plate colliding with and descending under the lighter North American Plate. The earthquake started an avalanche, which was followed by a massive blast of gas, rock, ash and ice. The devastating effects are outlined in Figure 5.4.4.

- One hundred and twenty metres of the summit vanished, and in its place was a crater 2 kilometres wide, 4 kilometres long and 1.5 kilometres deep.
- Three hundred and eighty square kilometres of land to the north of the mountain was stripped of its vegetation.
- Volcanic ash, carried by the wind, spread 1500 kilometres to the west.
- Sixty-two people died.

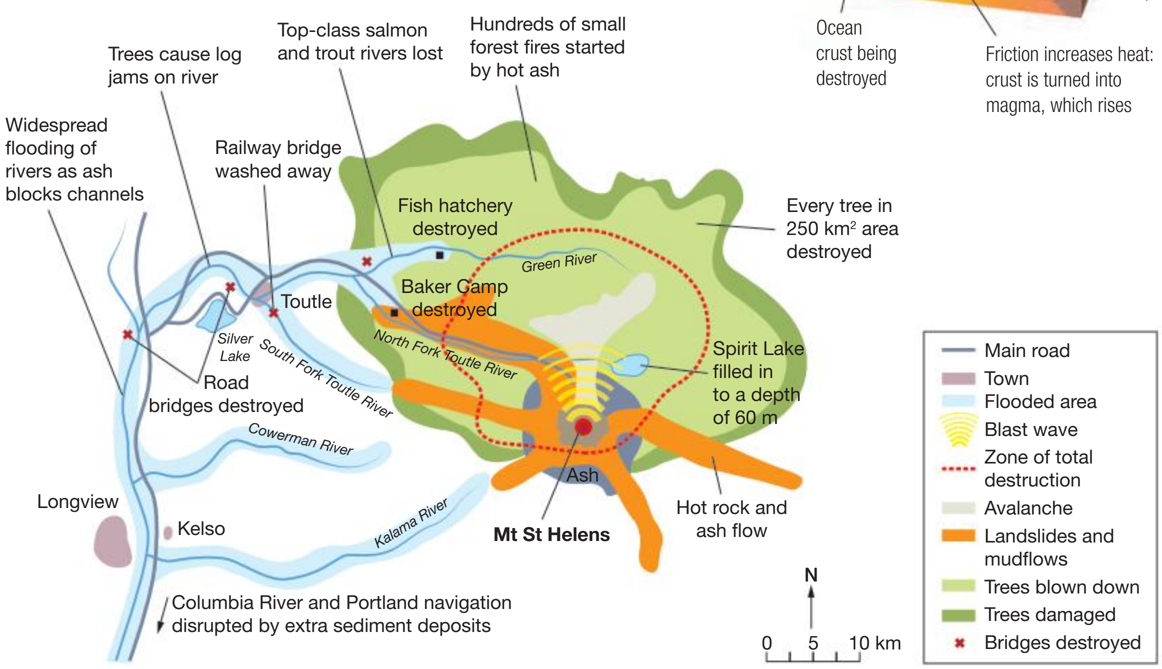
5.4.2 Location of Mt St Helens



5.4.3 Causes of the Mt St Helens eruption



5.4.4 Damage caused by the Mt St Helens eruption, 1980

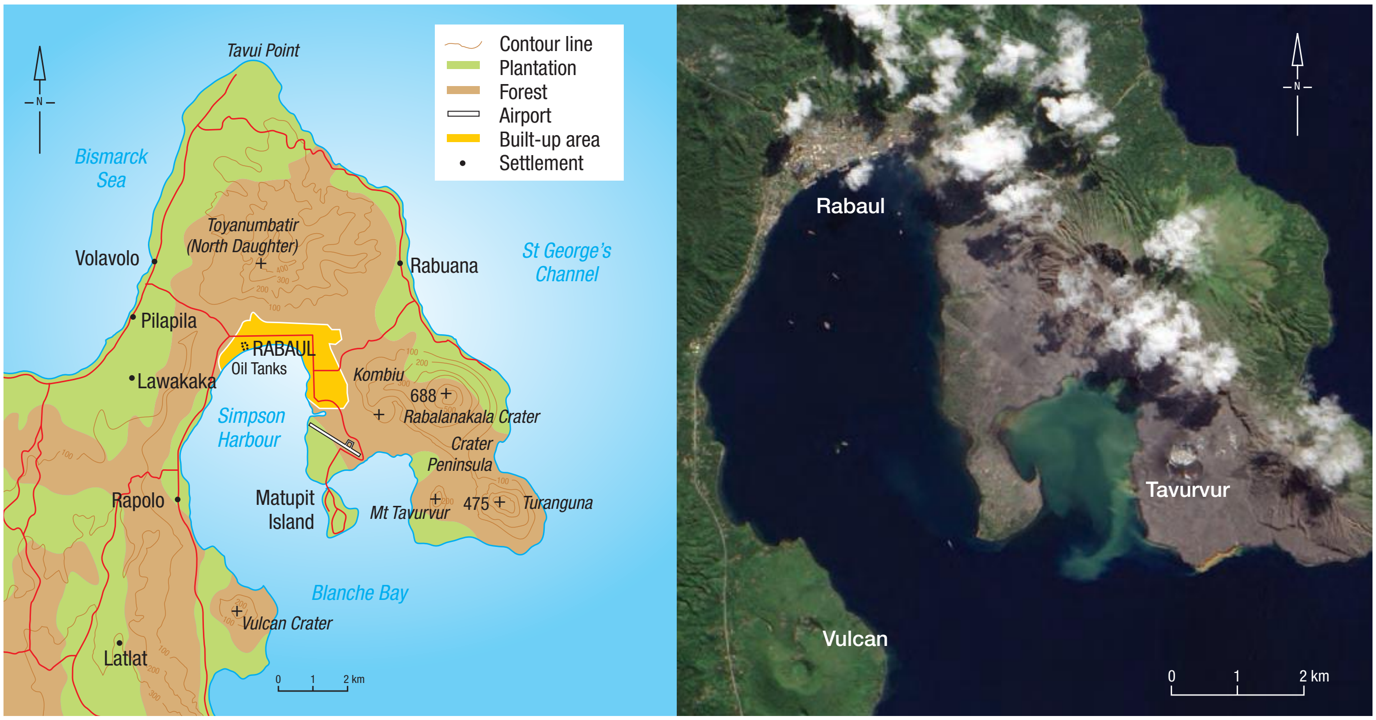


Rabaul

In September 1994, the town of Rabaul on the island of New Britain in Papua New Guinea was devastated by the eruption of two nearby volcanoes: Tavurvur and Vulcan. The location of these volcanoes is shown in Figure 5.4.5. Volcanic ash, 75 centimetres deep, covered the town and damage to property was severe. Most of the town's buildings collapsed under the weight of the ash (Figure 5.4.6). Rabaul's Simpson Harbour became clogged with floating **pumice**. The detection of early warning signs by **volcanologists** allowed authorities to evacuate the town's 53 000 inhabitants.

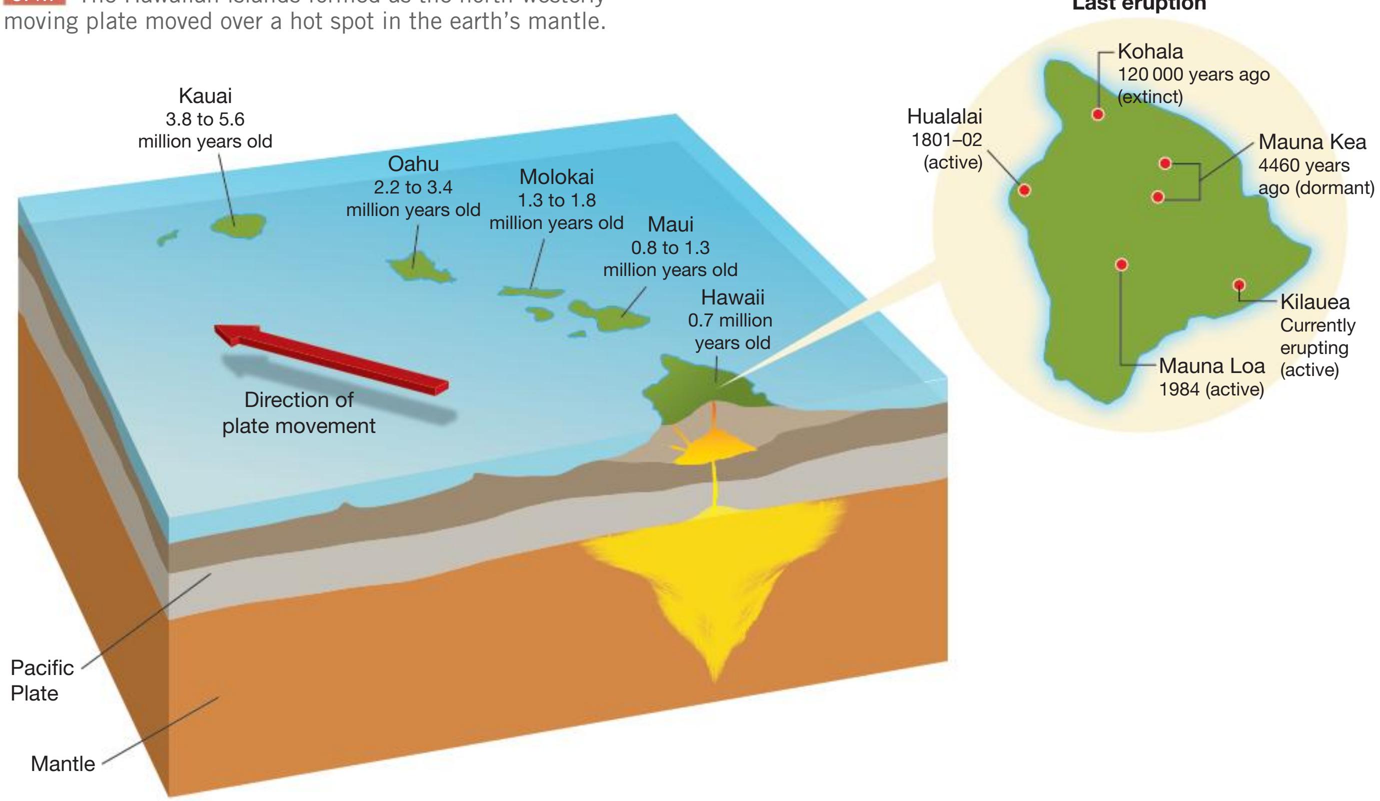
Rabaul's harbour is a large caldera, about 10 kilometres in diameter. Its collapsed floor is the result of a large, explosive eruption that took place some 1400 years ago. That eruption partly emptied the underlying magma chamber (the reservoir of molten rock feeding the volcano). Many smaller eruptions have occurred since, mostly from minor cones that have developed near the rim of the caldera. After the 1994 eruption, Rabaul was rebuilt on a new site.

5.4.5 The Rabaul caldera and the Tavurvur and Vulcan volcanoes



5.4.6 Rabaul was buried in volcanic ash to a depth of 75 centimetres.

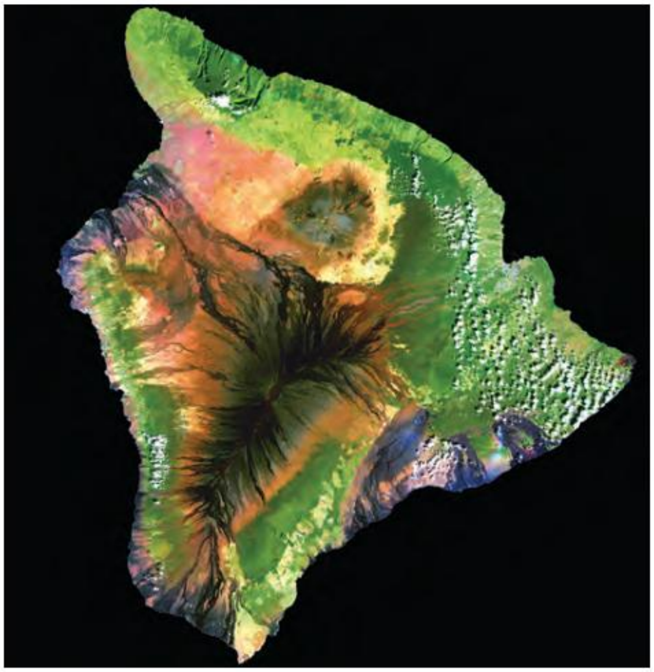
5.4.7 The Hawaiian islands formed as the north-westerly moving plate moved over a hot spot in the earth's mantle.



Hawaii

Hawaii is a chain of volcanic islands in the north Pacific Ocean. It consists of hundreds of islands spread over a 2400-kilometre-long archipelago. The five largest of these islands—Hawaii ('Big Island'), Maui, Oahu, Kauai and Molokai—are located at the south-east end of the archipelago. The islands are the exposed peaks of a great undersea mountain range known as the Hawaiian-Emperor **Seamount** Chain.

Figure 5.4.7 shows the formation of the Hawaiian archipelago. The volcanic islands formed over millions of years as the north-westerly moving plate moved over a **hot spot** in the earth's mantle. As the Pacific Plate moved, a new volcano or island was formed over the hot spot. Currently, the hot spot is under Hawaii's 'Big Island', shown in Figure 5.4.8.



5.4.8 Satellite image of Hawaii's 'Big Island'

ACTIVITIES

Knowledge and understanding

1 Study Figure 5.4.3. Explain the cause of the Mt St Helens eruption.

2 Study Figures 5.4.3 to 5.4.6. List the damage caused by the Mt St Helens and Rabaul eruptions.

3 Study Figure 5.4.5. Draw a sketch map of the Rabaul caldera. Locate the now abandoned Rabaul township and the volcanic vents Tavurvur and Vulcan.

4 Study Figure 5.4.7. Explain how hot spots have created the Hawaiian archipelago.

5.5

Mass movements

Movement and water

Mass movements occur when rock material moves downhill under the influence of gravity. These movements may be rapid, as in the case of rock falls, landslides, earthflows, mudflows and slumps; or slow, as in the case of soil creep.

Water plays an important role in most types of mass movement. It acts as a lubricant, weakening the binding properties of the soil and rock material. The amount of water is important. Think about building sand castles at the beach. Water is needed to bind the sand together, but too much water results in the castle collapsing.

Slow movements

Soil creep

Soil creep is a long-term process. Over time, soil moves downslope under the influence of gravity. As a general rule, the steeper the slope, the faster the creep. Leaning fences and power poles, and the curved trunks of trees, are all evidence of creep, as illustrated in Figure 5.5.1.

Rapid movements

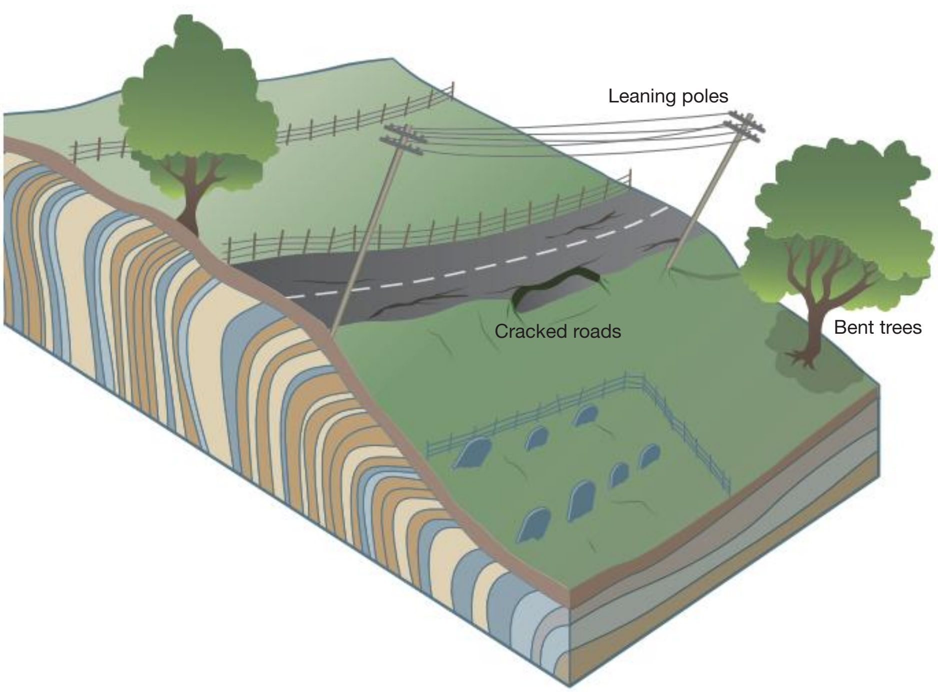
Rock falls

A rock fall occurs when weathered rock material moves downslope but is not enough to cause a landslide. Rock falls usually occur on very steep slopes such as cliff faces. Earthquakes, expanding ice, plant roots, the undercutting action of waves and water penetration may all dislodge rock material. The rock accumulation at the base of the cliff is called talus. A rockfall and talus can be seen in Figure 5.5.2.

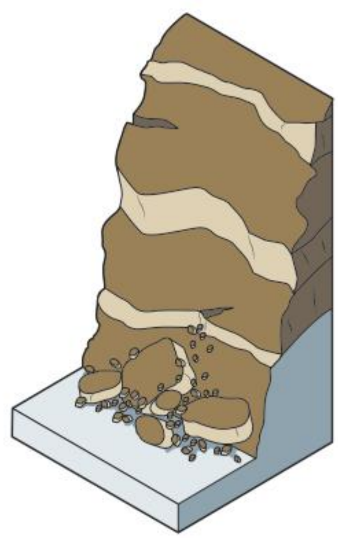
Slumps

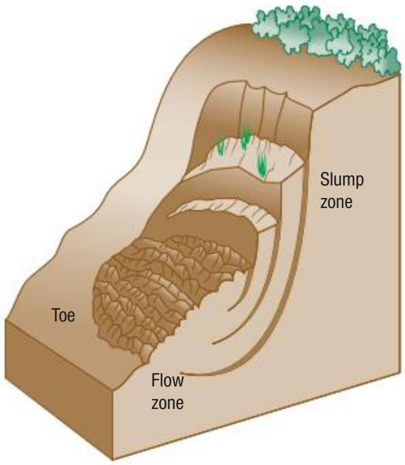
A slump occurs when a well-defined mass of soil or rock layers moves downslope. Slumps can be initiated by earthquakes, water saturation and the freezing and thawing of a mass of soil or rock layers. Figure 5.5.3 shows an earthflow with slump features in the upper section.

5.5.1 Evidence of soil creep



5.5.2 Rock fall and associated talus slope





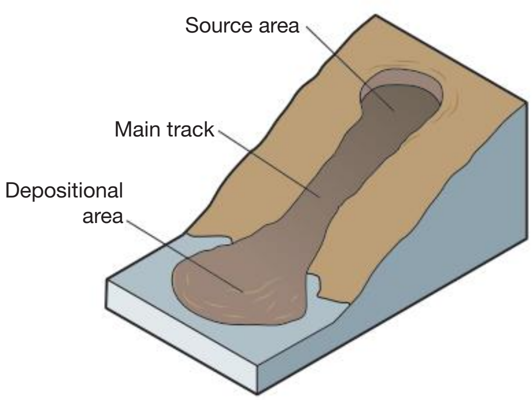
5.5.3 An earthflow with well-developed slump features in the upper section

Mudflows

A mudflow (or mudslide) is the downhill movement of saturated earth and debris, made fluid by rain or melted snow. Mudflows are often able to build up great speeds (up to 80 kilometres per hour). Mudflows are most likely to occur in areas that have been stripped of their vegetation, on slopes that have been altered for the construction of buildings, and on roads and other areas to which surface run-off has been redirected.

Earthflows

Figure 5.5.4 shows an earthflow, which is the downslope flow of saturated fine-grained materials. The materials most commonly involved are small rocks, clay, fine sand and silt. When the earth cannot hold any more water, the flow begins. The rate at which the earth flows depends on the amount of water present: the higher the water content, the greater the speed, or velocity. Figure 5.5.5 shows the damage caused by an earthflow after heavy rainfall.



5.5.4 When soil and rock cannot hold any more water they start flowing.

5.5.5 A large landslide triggered by heavy rains buried nearly thirty homes in China's Zhejiang Province on the evening of 13 November 2015.

ACTIVITIES

Knowledge and understanding

1. Define the term 'mass movements'.
2. Outline the role of water in mass movements.
3. Explain the difference between landslides and earth- and mudflows.

Applying and analysing

4. Study Figure 5.5.1. List the types of damage caused by soil creep.
5. Study Figure 5.5.5. Describe the damage you observe in the image.

5.6

Mudslides

Mudslides around the world

Mudslides and landslides often occur with little, if any, notice and the results can be deadly. The following hazard 'snapshots' illustrate the deadly consequences of such disasters.

La Paz, Bolivia

In February 2011, at least 400 homes were destroyed after torrential rains caused a massive slump and mudslide in La Paz, the capital of Bolivia. The slump and slide caused widespread damage in the poor neighbourhood of Callapa. Roads cracked and houses were buried under mud and debris, as shown in Figure 5.6.1. Fortunately, no one was killed. Residents had started evacuating the neighbourhood a day or so earlier when the hillside, saturated after prolonged rainfall, began to slide and cracks appeared in streets and homes.

Rio de Janeiro, Brazil

In early 2011, a series of floods, mudslides and landslides in the Brazilian state of Rio de Janeiro killed at least 903 people. It was one of the worst natural disasters in Brazilian history. In a 24-hour period between 11 and 12 January 2011, the local weather service registered more rainfall than would be normally expected for the entire month. Flooding of many areas in the region immediately followed. The soil on the region's steep hillside quickly became saturated and in many places collapsed, with devastating effects. Rescuers can be seen among the damage in Figure 5.6.2.

5.6.1 Four hundred homes were destroyed after torrential rains sparked a massive slump and mudslide in La Paz, the capital of Bolivia.

5.6.2 Officials and volunteers search for the dead after the floods and mudslides that killed more than 900 people in the Brazilian state of Rio de Janeiro on 16 January 2011.

Gansu, China

The Gansu mudslide of 8 August 2010 killed more than 1600 people when a massive torrent of mud engulfed houses and demolished multistorey blocks of flats. The disaster followed a period of heavy rain during which water built up behind a dam of debris blocking a small river near the city of Zhouqu. When the debris dam collapsed, 1.8 million cubic metres of mud and rocks swept through the city. The surge levelled an area 5 kilometres long and 300 metres wide, the mud measuring up to 5 metres deep. More than 300 low-rise homes and more than a dozen multistorey buildings were destroyed. One village was entirely buried. Figure 5.6.3 shows rescuers at work at the site of the disaster.

5.6.3 Rescuers work at the scene of a mudslide in Zhouqu County, Gansu Province, China, in August 2010.

ACTIVITIES

Knowledge and understanding

Copy and complete the following table.

Location	Type and cause/s of landslide	Damage
La Paz		
Rio de Janeiro		
Zhouqu		

Discuss the similarities and differences between these landslides.

Avalanches

Avalanche causes

An avalanche is a sudden, downslope movement of a mass of snow. Avalanches are triggered when the snow pack (the extent of the snow) becomes overloaded due to natural factors such as earthquakes or heavy snowfalls, or by human agents such as skiers, snowboarders and snowmobile riders.

Avalanche damage

Avalanches can reach speeds of 130 kilometres per hour within just 5 seconds. The size and impact of an avalanche is influenced by the snow type and the rate at which it accumulates, the temperature, the nature of the sliding surface, the trigger, and the angle and aspect of the slope. Figure 5.7.1 shows an avalanche in action. Note the steep slope of the mountain.

Powerful avalanches can cause large rocks, trees, and other debris to move downslope, adding to their destructive power. Avalanches cause loss of life, destroy settlements and disrupt transport when they block roads and railway lines.

Because of their ability to move enormous amounts of snow rapidly over large distances, avalanches are a major hazard to life and property in mountainous regions.

Avalanches kill more than 150 people each year. Ninety per cent of avalanche deaths are the result of snow slides triggered by the victim or someone in the victim's party. Skiers, snowboarders and riders of snowmobiles are the most frequent triggers of avalanches.

Avalanche control

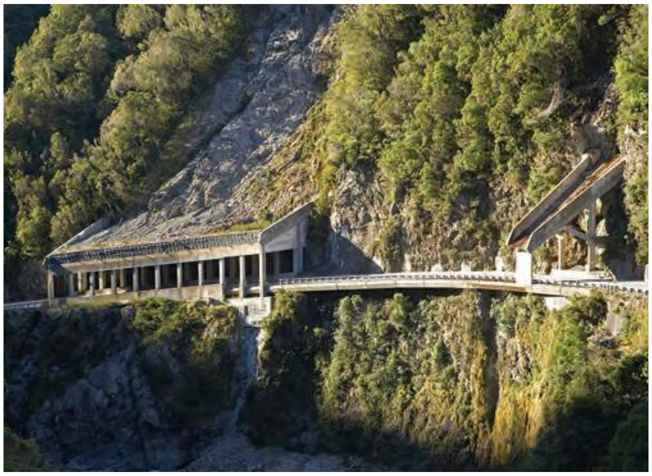
In populated alpine regions, avalanche control is an important management issue. Avalanche control begins with an assessment of the level of risk. This involves studying the topography, vegetation pattern and seasonal distribution of snowfall to determine the areas likely to be affected by avalanches. Once the avalanche risk areas have been identified, threatened elements of the constructed environment such as roads, railways, settlements and ski resorts can be protected. Avalanche prevention plans involve monitoring the snow pack and constructing structures to protect people and property.

5.7.1 Two mountaineers were swept away by this avalanche on Europe's Mont Blanc. Fortunately, they escaped.

Avalanche control includes the following measures.

- Management of the snow pack, by setting off small detonations, prevents large and dangerous snow packs from forming.
- Snow racks (see Figure 5.7.2) and avalanche bridges (see Figure 5.7.3) can be built to protect towns, roads and railway lines.
- Dams, ditches and earth mounds can be built to deflect and slow an avalanche.
- Trees can be planted, as forested areas will slow an avalanche and may prevent one from occurring.
- Avalanche awareness programs educate and protect people engaged in recreational activities in alpine regions.

5.7.2 Snow racks are used to retain snow, thereby reducing the risk of avalanches.



5.7.3 Avalanche bridges are used to protect vital transport infrastructure.

Surviving avalanches

If you are ever caught in an avalanche, try to get out of the avalanche pathway as quickly as possible. Figure 5.7.4 outlines safety tips for skiers and snowboarders riding in avalanche-prone areas.

5.7.4 Avalanche safety checklist

Avoiding avalanches
• Be aware when an avalanche is likely to occur, especially on steep slopes after heavy snowfalls. • Always follow avalanche warnings and never ski or board alone in avalanche-prone areas. • Avoid crossing steep slopes. • If skiing or boarding in a group, always spread out. That way, if some of you are trapped in an avalanche, the others can dig you out. • Avalanches can happen without notice. Be prepared and know what to do.
If caught in an avalanche
• Do not attempt to out-ski or board the avalanche. It will be travelling faster than you can ski. Try skiing towards to edge of the avalanche, where the mass of snow is thinner and less powerful. • Try to stay on the surface, grab onto a tree or rock, or thrust yourself upward by kicking.
If you are knocked over
• Use a swimming-like stroke to avoid being covered in snow. • When you come to a stop, curl up into a ball and use your hands to cover your face. Rotate your head to make an air pocket. • To see which way is up, spit into your hands and feel which way the saliva runs. Remember, you may be in complete darkness unless you are close to the surface. • If you can see a hint of daylight, try to push one hand to the surface to attract attention. • Breathe steadily to preserve energy and oxygen.

ACTIVITIES

Knowledge and understanding

1 Explain what an avalanche is and the conditions under which avalanches take place.

2 List the factors that determine the nature of the avalanche.

3 Outline what can be done to manage, or control, the avalanche threat.

Applying and analysing

4 Study Figure 5.7.4. Produce a podcast to educate people engaged in alpine recreational activities about avalanche safety.

5.8

Living in areas of risk

Predicting hazards

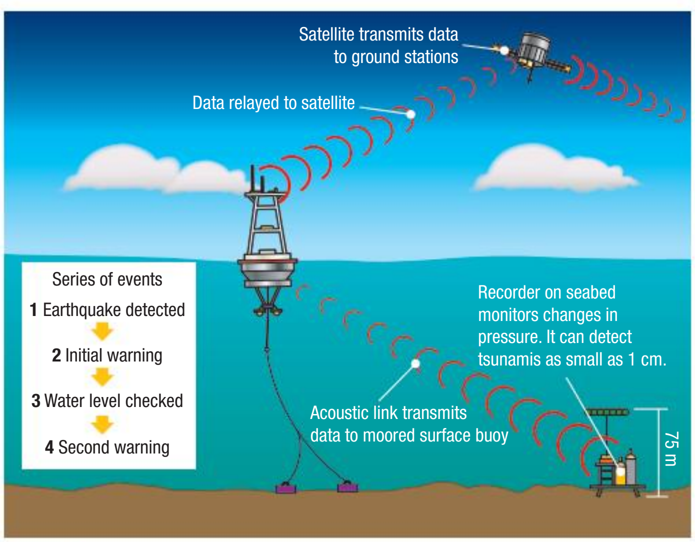
Scientists study the earth's crust in order to understand the processes involved in plate movements. As a result, they are able to assess the risk of earthquakes and volcanic eruptions. With this knowledge, authorities are able to plan for, and respond to, natural hazards such as earthquakes and volcanic eruptions.

Earthquake prediction

Scientists study the past frequency of large earthquakes in order to determine the future possibility of similar large shocks. Where this possibility is high, special building laws can be made. Authorities can also plan emergency responses to earthquakes.

Tsunami warning systems

Tsunami warning systems are used to detect tsunamis and issue warnings to minimise the loss of life and the damage to property. A tsunami warning system consists of two equally important parts: a network of sensors to detect tsunamis, shown in Figure 5.8.1, and a communications infrastructure to issue alarms in time for people to evacuate coastal areas.



5.8.1 A tsunami warning system

Volcano monitoring

There are currently about 500 active volcanoes in the world. About fifty of these volcanoes erupt each year. Volcanologists monitor high-risk volcanoes so that they can determine the level of risk and forecast eruptions. Experts now issue alerts using a classification system. In the United States of America, volcanoes are now classified according to the following stages: normal, advisory, watch or warning.

Adapting to threats

The forces involved in earthquakes and volcanic eruptions are so great that they are beyond the control of humans. All we can hope to do is minimise their impact and make sure we are ready to respond in the event of a natural disaster.

Earthquakes

When an earthquake strikes, land may move up and down, and from side to side. Modern engineering techniques are used to construct buildings that can withstand such movements.

In earthquakes, the biggest danger is not the earthquake itself, but falling debris and collapsing buildings. Broken glass becomes deadly and falling concrete can crush people. Engineers have designed windows and walls that will not break when shaken by the intense motion caused by earthquakes, and specially designed foundations absorb the energy of the earthquake and allow buildings to flex rather than shake violently.

Tsunamis

Natural barriers such as sand dune systems, mangroves, plantations and native forests can reduce the impact of tsunamis. During the 2004 Indian Ocean tsunami, some coastal communities escaped with little loss of life and damage to property because trees such as coconut palms and mangroves absorbed the tsunami's energy. For example, while the entire Nagapattinam district in the state of Tamil Nadu, India, was severely affected by the tsunami, the town of Naluvedapathy emerged virtually unscathed.

This was due to the presence of a very large windbreak of 80 000 casuarina trees planted in 24 hours in 2002 as part of a Guinness World Record.

Tree planting along tsunami-prone coastlines has been recommended as a cheap and long-lasting way of reducing the effects of tsunamis and as an alternative to the building of expensive barriers. In India's worst tsunami-hit state, Tamil Nadu, tree planting has begun along the coastline to act as a barrier against future tsunamis.

In coastal areas where it is not possible to use forest barriers, for example in existing urban areas, concrete walls are constructed and seawater barriers that deploy automatically when tsunami waves approach shorelines are built, such as the barrier and gate shown in Figure 5.8.2.

5.8.2 A tsunami barrier and gate, Numazu, Japan

Volcanoes

Worldwide, an estimated 500 million people live near active volcanoes. Fortunately, the loss of life from volcanic eruptions has been relatively low. A notable exception was the Mt Pinatubo eruption (in the Philippines) of 1991. Despite the large-scale evacuation of people in the days leading up to the eruption—itself a demonstration of the effectiveness of eruption prediction by volcanologists—847 people were killed. Most died when roofs collapsed under the weight of accumulated ash. Mt Pinatubo's dense forest was home to several thousand indigenous people, the Aetas, many of whom were displaced by the eruption.

SPOTLIGHT

Surviving earthquakes

If you are indoors, remain there and:
- take shelter under a sturdy table or desk, stand or crouch in a strong doorway in a load-bearing wall, or brace yourself in an inside corner of the room
- shield your head with a blanket, doona or cushion
- stay clear of windows, mirrors or other glass that might shatter
- keep clear of bookcases, cabinets and other pieces of heavy furniture that might topple or spill their contents
- stay away from fireplaces, and any area where bricks might fall from the chimney.

If you are outside:
- quickly move into an open space where nothing can fall on you
- stay clear of power lines and poles, trees or branches, building facades, chimneys, or anything else that might fall.

If you are in a city centre:
- avoid falling glass and masonry by taking shelter in a strong doorway or under a large vehicle
- don't use elevators or stairs during the quake.

ACTIVITIES

Knowledge and understanding

1 Explain why scientists study the earth's dynamic crust.

2 Outline the ways in which we can respond to a high-level earthquake risk assessment.

3 Identify the ways in which coastal communities can be protected from the impacts of a tsunami.

Applying and analysing

4 Study Figure 5.8.1. Explain how a tsunami warning system operates.

Investigating

5 Investigate the ways in which buildings can be made earthquake-resistant.

6 Investigate a recent volcanic eruption. Identify the ways in which people were informed about the impending eruption and the actions they were able to take to minimise the impacts of the eruption.

7 Research the different ways to respond to hazards and develop a poster highlighting how people should respond in the case of a natural disaster such as an earthquake, a tsunami or a volcanic eruption.

5.9

Investigating a geomorphic hazard

Investigation principles

Throughout this chapter there has been the opportunity to explore a range of geomorphic hazards causing change to landscapes across a range of scales. In this unit there is the opportunity to apply the inquiry process to investigate one geomorphic hazard of personal interest, which has recently occurred or is currently occurring in a particular place.

The inquiry process involves acquiring, processing and communicating geographical information using a range of geographical tools (such as maps, fieldwork and visual representations) where appropriate.

INQUIRY QUESTIONS

- What are the causes and impacts of a geomorphic hazard in a chosen place?
- Are there responses to minimise the impacts of this hazard occurring in the future?

5.9.1 The aftermath of a Mt Sinabung volcano eruption, North Sumatra, Indonesia

Scaffolding an investigation

Tables 5.9.2a–d, scaffold an inquiry process which will help you geographically investigate one geomorphic hazard.

Table 5.9.2a

Part 1: Gathering raw data	
Highlight the chosen type of geomorphic hazard to investigate	Avalanche Coastal erosion Earthquake Landslide Mudslide Tsunami Volcano Other:………………..
Describe the spatial distribution of this type of geomorphic hazard throughout the world	
Identify the place of the chosen geomorphic hazard using absolute and relative location	
Identify the date, time and duration of the chosen geomorphic hazard	
Represent all of the above information on a map, using spatial technologies where appropriate	

Table 5.9.2b

Part 2: Acquiring geographical information	
Develop at least one **geographical question** to investigate the chosen geomorphic hazard in a specific place	*The inquiry questions at the beginning of this unit can be adapted to complete this section of the scaffold if required*
Develop a **justified hypothesis** in response to this geographical question	
Identify at least two **primary research** methodologies appropriate to the geographical question	*This may not be appropriate for all inquiries due to the nature and location of the chosen geomorphic hazard* **Quantitative (data)** / **Qualitative (information)**
Identify at least two **secondary research** methodologies appropriate to the geographical question	**Quantitative (data)** / **Qualitative (information)**
Collect, select and record the data and information gained from your research methodologies	

Table 5.9.2c

Part 3: Processing geographical information	Cause(s)	Impact(s)	Response(s)
Select data and information for its usefulness			
Analyse data and information to propose a response	**Judgement**: e.g. sudden and unexpected, or unforeseeable, or predictable etc.	**Judgement**: e.g. extensive, or minimal, or life-threatening, or permanent or temporary etc.	**Judgement**: e.g. effective, or ineffective, or good/bad for the short term/long term, or organised etc.
Decide how to represent data and information	e.g. annotated diagram	e.g. photographs and column graphs	e.g. flow charts and pie graphs
Apply two of the concepts listed in the next column to the conclusions drawn from your research findings	place, change, interconnection, scale, sustainability *There is no hierarchical order in which to apply the concepts; some concepts may be applied more than once depending on the nature of the investigation*		
Identify and outline whether your research findings support the justified hypothesis?	[ ] Yes, all of it …………………………………………………………… [ ] No, none of it ………………………………………………………….. [ ] Partially or with qualification ……………………………………..		

Table 5.9.2d

Part 4: Communicating geographical information	
Circle the preferred presentation option	as a prezi or Powerpoint a speech in a folder a video a newsflash other……………
Reflect on learning to propose suitable action	

ACTIVITIES

Investigating

Go to the websites of to Geoscience Australia (GA) or the United States Geological Survey (USGS) and search for recent geomorphic hazards to begin your investigation.

Liveability

CHAPTER 6

The term 'liveability' is used to describe the extent to which a place is able to support a quality of life that maximises residents' wellbeing. For people who have the means to choose where they live, liveability of places is important. People want to live in neighbourhoods that are good places in which to raise families. They want a choice of housing types, recreational activities, shops and services within walking distance, and easy access to quality schools and open space.

Place is one of the key concepts in Geography. The term 'place' is used to describe a part of the earth's surface that has been named and given meaning by people. The places we are most familiar with are often those in which we live. In Geography, we often say that a town, suburb or neighbourhood has a 'sense of place'—distinctive characteristics or features that make it unique. In a sense, every place has its own identity.

INQUIRY QUESTIONS

- What is meant by the concept of liveability and how it can be measured?
- How do perceptions of liveability vary from person to person according to age, education, income, cultural background and other factors?

GLOSSARY

accessibility	the extent to which a product, device, service, or environment is available to as many people as possible
demographic	relating to the different groups of people who make up populations
good	a tangible (or touchable) thing that meets a human need
human rights	the basic rights to which all people are entitled, irrespective of their citizenship, nationality, race, ethnicity, language, gender, sexuality or ability
liveability	the qualities of a place (city, town, suburb or neighbourhood) that contribute to the quality of life experienced by those who live or visit there
perception	how something is seen or regarded by someone
quality of life	the happiness, wellbeing and satisfaction that a person experiences. Among the many factors that influence quality of life are a person's family circumstances, income and access to services
relative location	a place's location in relation to other places
sea change	a lifestyle-related change that involves moving from an urban settlement to a coastal community
sense of place	the distinctive characteristics or features of a place that make it unique
service	a non-tangible good—this is, a good that cannot be touched, held, handled, looked at, smelled or tasted
site	an area of land on which one or more buildings are constructed
social connectedness	the relationships people have with others
spatial	relating to a characteristic of a location and/or an area
spatial inequality	the distinct geographical divisions between poor and wealthy populations
telework	work that involves the use of telecommunications technologies as a substitute for physical travel
tree change	a lifestyle-related change that involves moving from an urban settlement to a rural or semi-rural community

6.0 Sydney

6.1

Deciding where to live

The decision

There are many factors that people think about before choosing where to live. Some of these are emotional; some are responses to circumstance at a particular time. Because the decision-making process is such a personal one, there is no complete list of factors. The following are some of the most common factors affecting the choices people make about where to live.

Attachment to place

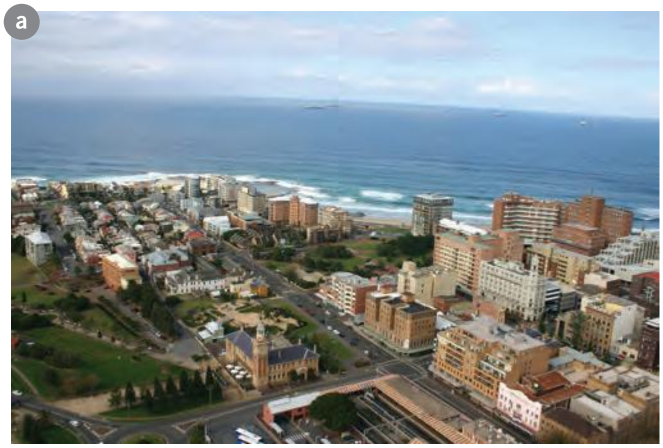
We all develop an attachment to places that are special to us. It may be the place in which we were born and grew up. It may be a place we visited on holidays. It may be somewhere we have always wanted to live. These are powerful forces that influence the choices we make.

Distance from family and friends

Being close to family and friends is a powerful factor influencing people's decisions about where to live. Family and friends provide emotional and practical support and meet one of our most basic social needs—the need for companionship.

6.1.1 (a) Newcastle, (b) Tennant Creek and (c) Sydney—examples of places to live

a



b

c

Employment opportunities

Earning an income to support yourself and your family is an important factor in deciding where to live.

Affordability

The greater a person's income and/or wealth, the wider their range of options for where to live. The wealthy can afford to buy or rent housing in the most desirable suburbs. The choices of people on lower incomes are limited to areas where housing is relatively cheap or rents are affordable. This accounts for the **spatial inequalities** we see in Australia's large cities.

Stage of life

The factors influencing people's decisions about where to live change throughout the life cycle. When you are young, you live where your parents decide to buy or rent a home. In your 20s, you may live in rented group housing with friends.

Lifestyle considerations

The way of life a person aspires to is an important influence. Some people opt to live in the country; some find the casualness of the coastal lifestyle more appealing; some like the buzz of the inner city. Some people like areas that are diverse, crowded and colourful, while others seek out places that are quiet, isolated and natural.

Personal safety

Perceptions about the level of crime in an area influence people's decisions. People who can afford to live elsewhere avoid areas with high crime rates.

Environmental factors including climate

People's decisions about where to live are sometimes influenced by climate, aesthetics and environment. The increasing number of people moving to the south-eastern corner of Queensland can be linked to Queensland's climate and beaches. Others move to the hills and mountains surrounding some of our large cities for their scenic beauty, milder temperatures and lower humidity.

For many people, especially older people, access to quality health care is important. For young families, access to good schools may be important. Some people will buy a house in a particular suburb so that their children can attend a well-regarded school nearby.

DID YOU KNOW?

Of all Australians aged 15 years and over, 27 per cent have been living in their current home for 15 years or more, 30 per cent have been there for 5–14 years, and 43 per cent have moved within the last 5 years.

Culture and ethnicity

New immigrants often settle in suburbs with an established community of people from a common cultural or ethnic background. This provides them with a support network that makes settling into their new homeland easier. As a result, parts of our cities become associated with people of particular cultural backgrounds.

Travel time and transport options

Some people choose to live close to where they work. Others are willing to travel, sometimes over long distances, to live in a place that is more affordable or appealing. Access to public transport is an important factor for people living in large, congested cities.

The choices people enjoy

For a majority of the world's population, the choice of where to live is restricted by issues such as poverty, culture, **human rights** and individual freedoms. For many people, there is little choice. Life is a daily battle for survival. In some places, conditions in rural areas have deteriorated to a point where people have been forced to migrate to large cities.

ACTIVITIES

Applying and analysing

1. Draw a mind map showing the factors that influence people's decisions about where to live.
2. Write each of the factors affecting where people choose to live on a separate piece of paper. Rank these from the most important to the least important. Compare your ranking with those of others in the class. Explain your reasoning.

Investigating

3. Interview your parents or guardian. What factors did they take into account when selecting the place in which you live?

Liveability of places

Perceptions of liveability

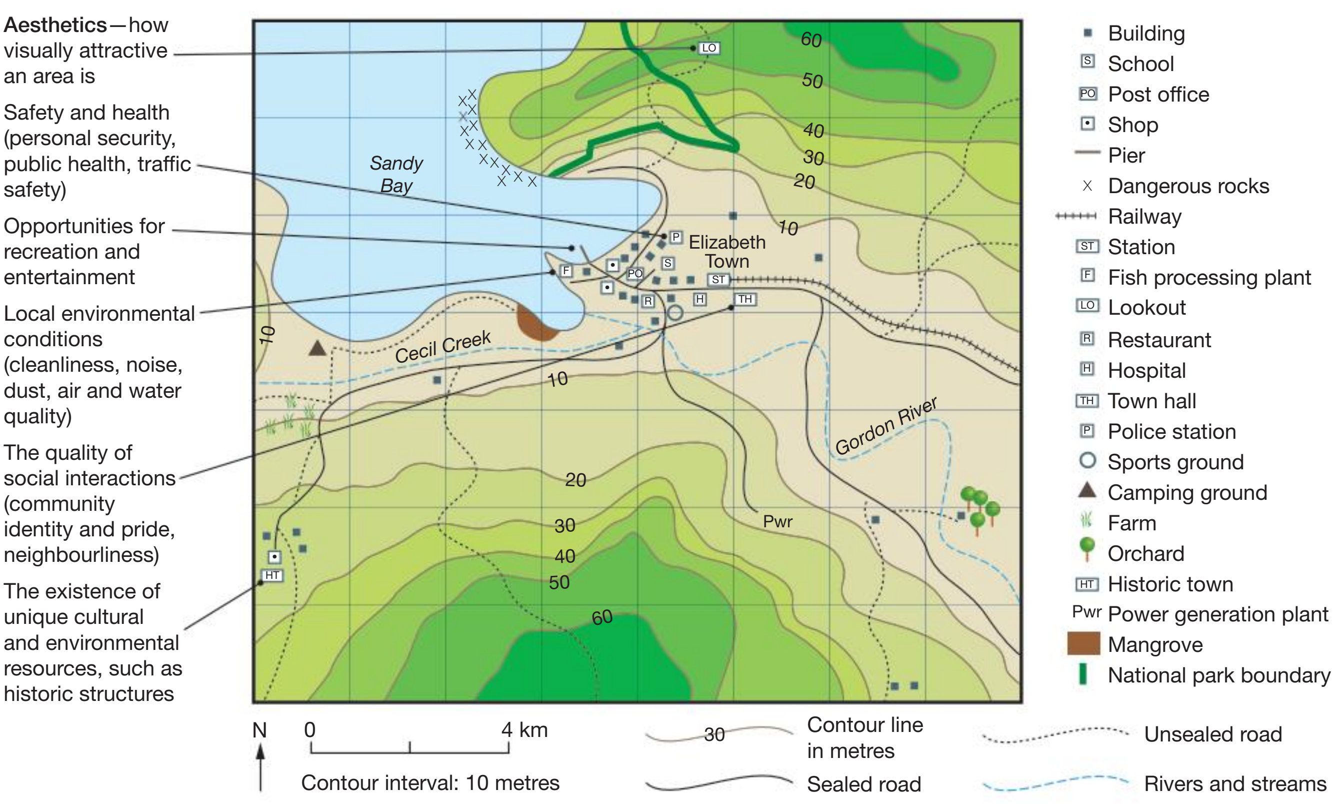
Some cities, towns and neighbourhoods are seen as being better places to live in than others. These **perceptions** differ from person to person depending on what each one considers to be important. The way a person sees the world around them is influenced by factors such as their age, gender, income or wealth, ethnicity and family type.

The **liveability** of a city, town or neighbourhood depends on the environmental and social quality of the area and how it is perceived by residents, workers, customers and visitors. The term '**quality of life**' is sometimes used as an alternative to 'liveability'. Some of the factors people take into account when they judge a place's liveability are shown in Figure 6.2.1.

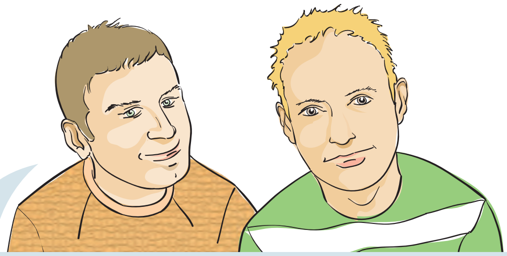
The liveability of places is largely affected by public places where people interact with others in the community. Public places include streets, parks, sporting facilities, shopping centres, public transport interchanges and other public facilities. This means that the liveability of a city, town or neighbourhood is influenced by public policy and planning decisions.

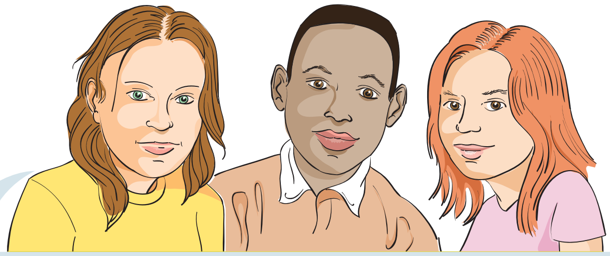
The liveability of a place has a direct impact on the people who live, work or visit there. In areas considered to be 'nice' places in which to live and work (that is, as having high liveability), property values and levels of business activity are higher. In neighbourhoods that are perceived to have low levels of liveability, housing is cheaper because people are less likely to choose to live there.

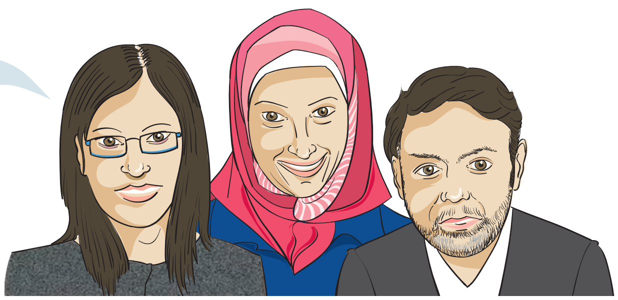
6.2.1 Topographic map of Elizabeth Town (population 10 000)



6.2.2 Different people perceive the world differently. They base their perceptions of liveability on many factors.







ACTIVITIES

Knowledge and understanding

1 Define 'liveability'.

2 List the factors that help determine people's perception of the world around them.

Analysing and applying

3 Study Figure 6.2.1.

  a List the community facilities in Elizabeth Town and the surrounding area.

  b Would you describe Elizabeth Town as a liveable place? Explain.

4 Study what the people in Figure 6.2.2 say about the places they live in. Identify each of the different groups represented. As a class, discuss how each person's perception of liveability differs, and the reasons why these differences might exist.

5 Write two short statements outlining the liveability of the place you live in from:

  a your parents' perspective

  b your perspective.

  Compare your answers with those of others in the class. What factors do the answers to part a have in common with the answers to part b? What differences are there?

6 List the liveability criteria you would use to describe the ideal place in which to live.

6.3

Sense of place

Characteristics of place

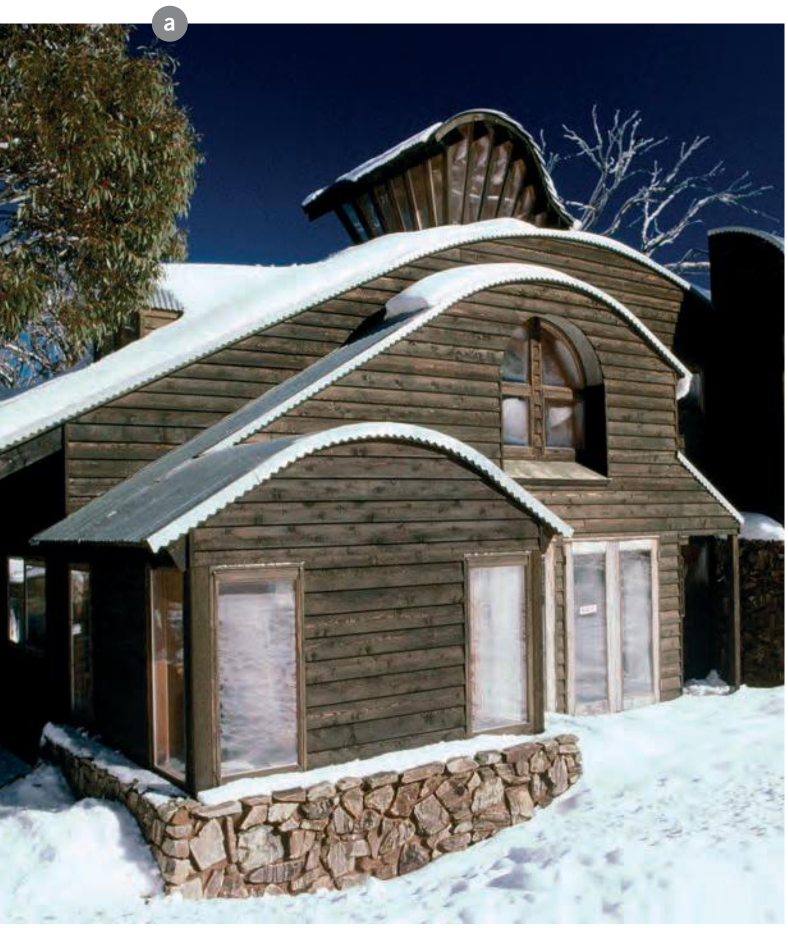
Geographers often refer to a particular location as a having a '**sense of place**'. This means that the place has distinctive characteristics or features that make it unique.

The factors that contribute to a sense of place include:

- relative location
- the site or the shape of the land (topography)
- the range of functions provided
- **spatial** patterns
- social, cultural and economic characteristics of the place.

Relative location and site

'**Relative location**' is a term used to describe a place's location in relation to other places. A place's relative location and site shape its character, form and function.



Relative location can have a range of meanings, and can influence a place in different ways.

- A place's latitude is one example of relative location: the constructed features of places close to the Equator are quite different from those of places closer to the poles.
- Distance from the sea is another example: inland towns are quite different from places located on the coast.
- Distance from larger urban centres is another example: places close to larger urban centres might serve what is known as a 'dormitory' function—that is, residents return there to sleep, and commute to the larger centre each day for work.

The nature of the site on which a place develops is also an important influence on its character, form and function. The shape of the land (topography), the aspect (or direction it faces), the presence of a river (and whether it is navigable) or the nature of a coastline might all be important factors. A town could, for example, be located next to a river, wrap around the base of a mountain or spread along a coastline to take advantage of views and access to beaches.

6.3.1 (a) Chalet at Dinner Plain in the Victorian Alps and (b) a traditional Queenslander house

6.3.2 Sydney's redeveloped Darling Harbour precinct houses the city's main convention, entertainment and exhibition infrastructure.

Functions

Places can differ in the functions they perform. Some places produce food. This results in features and characteristics that will be different from a place that has a residential function. Other common examples of places with a particular function are:

- ports
- rural service centres
- resort destinations
- educational centres
- administrative centres
- commercial centres
- industrial centres.

Most places are multifunctional. While one function may dominate, others are also evident. Canberra is Australia's administrative and political capital, but it is also a commercial centre and a tourist destination, and supplies all the goods and services a city of 358 000 people needs.

The functions that a place performs contribute to its character and distinctiveness. Canberra's Parliament House, public service office complexes, museums, parklands, galleries, monuments and memorials all contribute to the city's uniqueness or sense of place.

Spatial patterns

The way that features in the landscape are arranged and connected helps to determine what a place is like. This spatial pattern will vary from one place to another. The density of features in the environment can differ: for example, the number of trees or buildings per square kilometre can vary from one place to another. Or the density of objects may be the same but they may be arranged differently—clustered or scattered. How the objects are clustered can be a further difference between places. The pattern of clustering could follow a major road or be focused on a central point such as a town square.

The redeveloped Darling Harbour precinct, shown in Figure 6.3.2, is an example of a clusters pattern. The city's main convention, entertainment and exhibition infrastructure is located together in an area that is accessible by public transport.

Social, cultural and economic characteristics

One place can differ from another as a result of a variety of social and cultural factors. These include population density, the age and ancestry of the people, and their income. These factors are evident in the way that open spaces are used or the range of goods and services that are provided. For example, a significant number of people with a common ancestry living in one place will give a neighbourhood or suburb a particular sense of place. Think about any of the culturally distinctive neighbourhoods in a large Australian city you know.

AGE

The **demographic** profile of the population can influence what a particular place is like. A place dominated by families with young children will be quite different in character from a place where older people or singles are in the majority. While most places have a mix of ages, some, such as retirement villages, may exclude people on the basis of age.

POPULATION DENSITY

Population density refers to the number of people living within a given area, usually 1 square kilometre. Some places have a very high population density while others have a low population density. One of the most densely populated cities on earth is Tokyo, Japan, where the average population density is 6000 people per square kilometre. Even within densely populated cities such as Tokyo, there are often places that are more densely populated than others.

ANCESTRY

A person's ancestry is their family background, including their ethnic or racial background. Ancestry can have a significant influence on place. It creates what are termed cultural landscapes, where the environment is a reflection of the practices, traditions and beliefs of a culture. Sometimes these cultural landscapes are so distinct or strong that they can be identified with particular ethnic groups. Most ethnic enclaves are vibrant and rich places. The 'Little India' district in Singapore, for example, is a place where the Indian, Sri Lankan and Bangladeshi cultures are shared with a wider community.

Melbourne, like Sydney, is a city that is influenced by a great variety of ancestry. One-quarter of the city's population were born overseas. In all, 180 countries are represented and 233 languages are spoken within Melbourne.

SPOTLIGHT

Shinjuku

Shinjuku is a major centre for business within Tokyo. Its population density is a staggering 17 140 people per square kilometre. However, because of the large number of people who visit for work or shopping, the number of people in the location at one time can appear much greater. Shinjuku can get very crowded.

Shinjuku's train station is the busiest in the world. Over 3.5 million people use this train station each day (see Figure 6.3.3). In order to deal with the huge volumes of people, Shinjuku, like many other areas in Tokyo, has extensive underground pedestrian areas. On the street, movement for people can become quite difficult.

6.3.3 The crowded Shinjuku train station

6.3.4 Jerusalem contains many religious buildings.

RELIGIOUS BELIEFS

Religion is expressed most notably in the architecture and the festivals of a place. Places of worship have traditionally been among the most visible buildings in a town or city. For example, Jerusalem, a holy city for Christians, Jews and Muslims, is dominated by places of worship (see Figure 6.3.4). The Cathedral of Notre Dame in Paris is an important element of the city's landscape, as are St Paul's Cathedral and Westminster Abbey in London.

EDUCATION, OCCUPATION AND INCOME

There is a clear link between education, occupation and income in almost all places in the world. The general view is that the higher the level of education, the better the occupation and therefore the higher the income. This also means that people will tend to live in locations that match their income.

In Australia, areas close to the centre of the city were once seen as grimy and harsh places. Increasingly, most of these inner-city areas are being occupied by people employed in highly skilled occupations, with higher incomes and higher levels of education. We call this process 'gentrification'.

Some places have a unique concentration of one group of occupations. People working in the creative arts industry, for example, often benefit from living near each other, where they can share and develop ideas. An example is the artists' colony of Montsalvat in Eltham, Victoria. Twelve buildings set amid established gardens are home to a number of artists.

ACTIVITIES

Knowledge and understanding

1. Identify the factors that contribute to a sense of place.
2. Outline how relative location and site affect the character, form and function of places.
3. Explain what is meant by the term 'multifunctional'.
4. State how places differ spatially.
5. Outline how social, cultural and economic characteristics influence sense of place.
6. Explain what an ethnic enclave is.
7. Explain how places are affected by the ancestry of their inhabitants.
8. State how religion can affect places.
9. Describe the links between education, occupation and income.

Applying and analysing

10. Study Figure 6.3.1. Describe how climate has influenced the architectural style of the homes shown.
11. List at least three benefits of living in places where many different ethnic groups are represented in the population.

Investigating

12. Select one of the factors that shape sense of place. Think about the neighbourhood in which you live. Investigate how has it been shaped by its relative location, site, climate, demographic profile or economic, cultural or social characteristics.

6.4

Perceptions of liveability

Different priorities, different choices

Different people use different criteria when making judgements about the liveability of places. The factors that influence people's perceptions include their age, income, household type, gender, cultural background and education.

Age

A person's age is one of the most important factors affecting their perceptions of liveability. Adults, for example, are most likely to focus on factors such as good transport links and access to work and shops. Teenagers might be more likely to value entertainment and sporting facilities, and access to shopping malls. While some factors appeal to all age groups, others are perceived as more or less important depending on people's individual needs.

Household type

Household type is also important. People without children may have different liveability preferences from people with children. Access to child care, playgrounds, good schools and detached houses with gardens are often important considerations for parents. People without children might prefer inner-city living with access to work, restaurants and entertainment venues.

6.4.1 Tamworth Show cattle judging. Agricultural shows are major community events across rural Australia.

6.4.2 Christmas markets are an important community event in many European cities.

Income and education

Income is another important consideration. The higher someone's income, the greater the range of choices they have of where to live. People often choose to live in the most liveable suburb or neighbourhood where they can afford to buy or rent a property. People with the lowest incomes are often forced to live in those parts of the city perceived to be the least liveable.

Cultural background

People's cultural background can also influence their perceptions of liveability. Immigrants, for example, often see ethnic-based community support networks as an important consideration. It is not unusual to find people with a common ethnic background living in a particular neighbourhood.

Liveability ratings

Some general categories that can be used to assess liveability are:

- perception of public safety
- housing affordability
- friendliness and consideration
- community cohesion (the degree to which residents cooperate and interact)
- attractive and well-maintained public spaces
- walkability and its impact on how people interact and experience their neighbourhood
- accessibility and transport choices that reduce commuting times and allow people to access goods and services and recreation facilities
- quality of independent mobility (for example, special buses) for children, the elderly and people with special needs
- recreational facilities such as sportsgrounds, restaurants, cinemas
- utilities (electricity, water, sewerage systems)
- educational facilities
- health services and facilities
- environmental factors such as climate, open space, air and water quality
- telecommunications infrastructure, especially broadband and mobile phone coverage.

City versus country

Many people have a strong preference for living in either the city or the country. Those who live in the city might say they prefer living there because of:

- the greater range of jobs available
- access to a wide range shops and service providers
- greater choice of schools
- more entertainment choices
- the excitement of a faster pace of life
- access to a wide range of medical facilities.

People who live in the country might say they prefer living there because of:

- the space around them and the lack of crowds
- cleaner air and less pollution
- safer and friendlier neighbourhoods
- cheaper housing
- more opportunities for outdoor activities.

Some of the preferences listed above are influenced by the spread of technologies such as the National Broadband Network. The use of the internet for work and educational, medical and social needs is changing the reasons why some people need to live, or want to live, in a particular place. It is, for example, making **telework** possible. Telework involves the use of telecommunications technologies as a substitute for physical travel. Thanks to telework, people who are self-employed may be able to work from a home office. This can help improve liveability by reducing traffic congestion.

ACTIVITIES

Knowledge and understanding

1. Outline the factors that affect people's perceptions of liveability.
2. Contrast the different perceptions of liveability for:
   a. older people and teenagers
   b. people with children and people without children.
3. Describe how a person's income can influence the liveability choices they make.

Applying and analysing

4. Study the lists of factors focusing on the differences in liveability between the city and country. Some of these contrasts in preference are based on facts and others are based on opinions. Copy the table below and write each factor in the correct column.

Fact	Opinion

6.5

Attachment to Country

The importance of land

Land means different things to people of different backgrounds. Non-indigenous people tend to regard land as a resource, as something to be bought, sold and owned, or simply as 'home'. For indigenous peoples worldwide, the relationship is much deeper. They see land as having spiritual, physical, social and cultural value.

Aboriginal and Torres Strait Islander people

Australia's Indigenous people, the Aboriginal and Torres Strait Islander people, consider that the land owns the people and that every aspect of their lives is connected to the land. They have a strong spiritual connection to the land. In Aboriginal society, law and life originate in, and are governed by, the land.

The connection to land contributes significantly to Indigenous people's identity and sense of belonging. In non-Indigenous society, a person's home is the structure in which they live, but for Aboriginal and Torres Strait Islander people 'home' means their traditional lands—the lands on which their ancestors hunted and gathered food, and held ceremonies and gatherings. Many Indigenous Australians are drawn back to their traditional lands, which they refer to as their Country. Returning to Country, even just to visit, brings a sense of wellbeing that non-Indigenous Australians find difficult to understand.

SPOTLIGHT

Torres Strait Islander people, the sea and the four winds

The Torres Strait lies between Cape York Peninsula, in Far North Queensland, and Papua New Guinea. The waters of the Strait are dotted with reefs and sand banks, as well as the islands that are home to the Torres Strait Islander people. The sea is central to Torres Strait Islander culture. The people of the region travel by sea and rely on the sea for fish and other resources. They are skilled navigators, and they have a detailed knowledge of the sea and the wind as well as the land. Knowledge of the winds is especially important because the wind affects both the conditions for growing food on land and the conditions at sea. The Islanders have names for the four major winds (Naygay Gub, Sager Gub, Zey Gub and Kuki Gub), and each of these names is associated with one of the major clans of the region. People inherit a wind name from their father.

6.5.1 Many Torres Strait Islanders are skilled navigators.

6.5.2 The land and the sea are central to Aboriginal and Torres Strait Islander art forms such as dance.

Stewardship of Country

The health of the land is central to Indigenous culture. Traditionally, Aboriginal and Torres Strait Islander people saw themselves as being part of the land, not separate from it. As a consequence of this, many still feel strongly that they have a responsibility to care for their traditional lands, or Country.

Plants, animals and ecosystems are at the core of Aboriginal and Torres Strait Islander people's attachment to the land and the sea. Plants and animals are valued as part of Country. The continued use of wild foods ('bush tucker') and traditional medicines allows Indigenous Australians to pass on their cultural knowledge, and to use and maintain places of cultural value.

Care of cultural sites

This spiritual and cultural connection to the land also obliges Aboriginal and Torres Strait Islander people to look after cultural sites, including Dreaming sites, archaeological sites, waterholes and burial grounds. The land and the sea are also central to Indigenous art, such as theatre, dance, music and painting (see Figure 6.5.2).

The Dreaming and Country

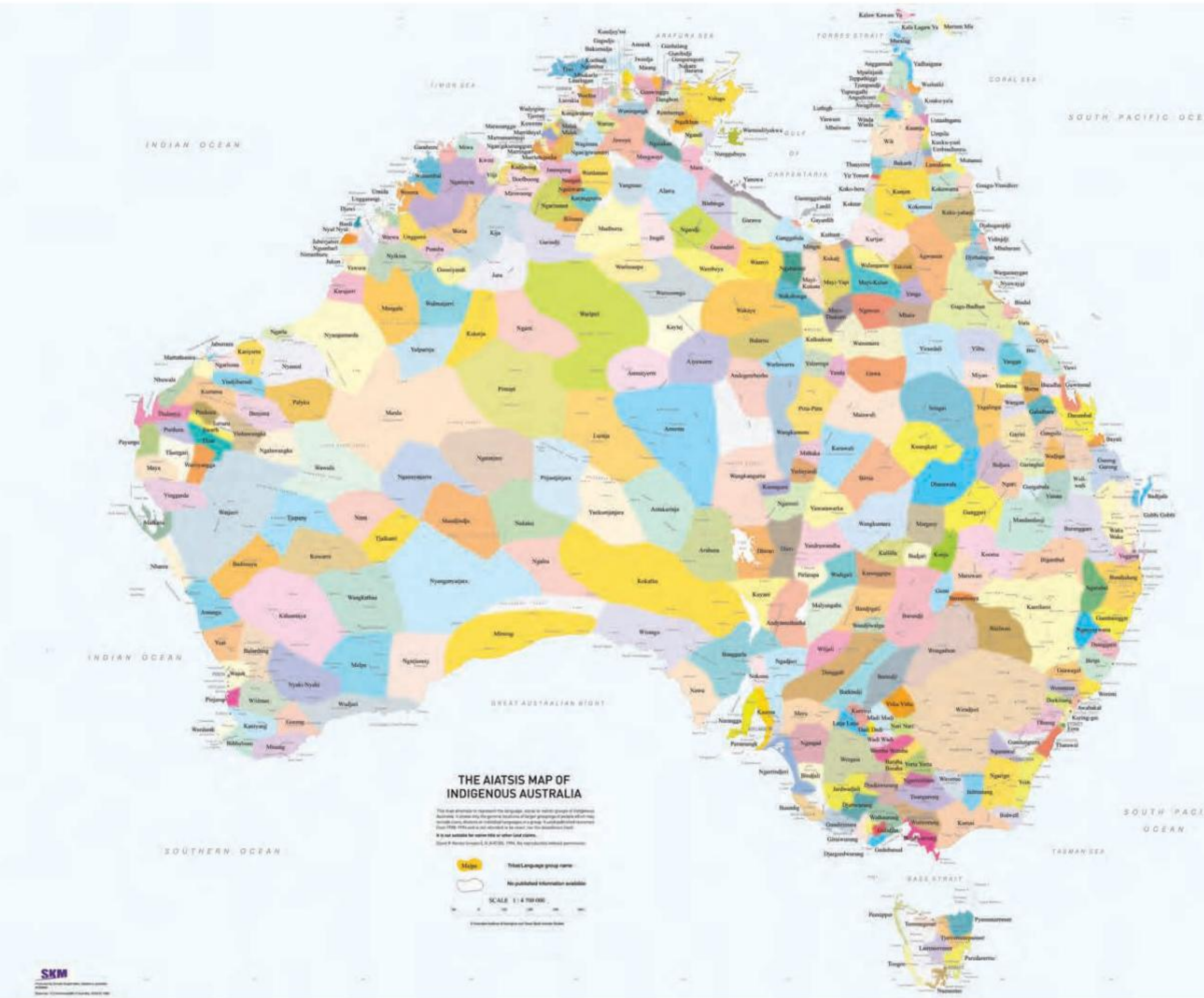
Central to Aboriginal culture, along with the connection to Country, is the idea of the Ancestral Spirits or Beings that created the land and forever remain within it. The time when Ancestral Spirits or Beings were creating the landscape and, with it, human groups and their societies, is known as the Dreaming. The cultural values of the Dreaming were embedded in the traditional lands of each group, which they recognised as their Country. Different cultural and language groups have their own words for this concept. The Anangu of the Central Desert, for example, know it as Tjukurpa or Wapar, depending on the particular language group they belong to.

Cultural diversity

Australia has always been rich in cultural diversity. Each language group has its own Country, and has developed its own culture, including customs, beliefs, totems and relationships with the land. Yet Australians of European descent have not always acknowledged this fact, or even been aware of it. When Europeans first arrived, they applied the name 'Aborigines', a term that refers to the original inhabitants of any country, to all Indigenous Australians. There was little or no recognition of the hundreds of different language and kin groups that had existed for tens of thousands of years across the continent (see Figure 6.5.3).

Aboriginal people today call themselves by the name of the language or territory group to which they belong, such as Pitjantjatjara, Wiradjuri or Ngarrindjeri, or use terms such as Murri or Koorie. Torres Strait Islander people use the name of their own island community, such as Yam or Boigu.

6.5.3 This map attempts to represent the language, social or nation groups of Aboriginal Australia. It shows only the general locations of larger groupings of people which may include clans, dialects or individual languages in a group. It used published resources from 1988–1994 and is not intended to be exact, nor the boundaries fixed. It is not suitable for native title or other land claims. David R Horton (creator), © Aboriginal Studies Press, AIATSIS, 1996. No reproduction without permission.



Acknowledgement of Country

An 'acknowledgement of Country' is a way in which all people can show respect for Aboriginal and Torres Strait Islander heritage and the ongoing relationship of traditional owners with the land.

Acknowledgement can take many forms. Most commonly, it involves spoken or written recognition of the traditional owners of the land on which people are gathered. Alternatively, more specific recognition can be given to the language group on whose land an event takes place. An Indigenous person of the language group on whose land the event is being held may perform a 'welcome to Country'.

Aboriginal rock art

Aboriginal rock art is found all around Australia. It forms a rich record of the long history of Aboriginal life and culture. Rock engravings near Olary, in South Australia, are more than 35 000 years old. Some paintings found in north-western Arnhem Land, in the Northern Territory, show Macassan traders from Sulawesi and their boats. The Macassans are believed to have been the first people from outside Australia to have made contact with Aboriginal people.

Rock art of Kakadu

For more than 50 000 years, or more than 2000 generations, the Bininj/Mungguy People have been the custodians of an area that today forms part of Kakadu National Park. Kakadu contains 5000 identified rock art sites, and there are thought to be many more sites that have not been catalogued. Some of the paintings are believed to be more than 20 000 years old.

The subjects depicted in Kakadu's rock art include the day-to-day activities of the Bininj/Mungguy People, and the animals they hunted. Animals were a common subject, as it was thought that painting them would ensure that they remained plentiful, and that it would bring success in hunting. Many paintings show ceremonies; some of these paintings are considered sacred and may only be viewed by Aboriginal elders.

The paintings at Ubirr and Nourlangie Rock (see Figure 6.5.4) are some of the most famous in Kakadu. Among them are excellent examples of X-ray art, which depicts the internal organs of people and animals as if viewed using X-rays. The thylacine, or Tasmanian tiger, appears in a painting at Ubirr, though it has been extinct on the Australian mainland for at least 2000 years.

6.5.4 Rock painting at Nourlangie Rock, in Kakadu National Park

ACTIVITIES

Knowledge and understanding

1. Explain in your own words the relationship between Aboriginal and Torres Strait Islander people and land.
2. Describe how Europeans viewed Aboriginal and Torres Strait Islander people when they settled in Australia.
3. Explain the importance of 'acknowledgement of Country'.

Geographical skills

4. Study Figure 6.5.3.
   a. List the names of the regions in which each language group is placed.
   b. Tribal/language groups are larger in the Desert region than in the Southeast region. Explain why this might be the case.
   c. List other regions in which tribal/language groups are smaller than in the Desert region.

6.6

Environmental quality and liveability

The positive and negative

A good way of thinking about the ways in which environmental factors affect liveability is to classify them as either pull or push factors.

Places in which the pull factors outweigh the push factors are normally regarded as being the more liveable. As a result, people compete to buy homes in these areas and houses become more expensive.

Areas in which the push factors dominate are often seen as being less desirable places in which to live. Housing therefore tends to be more affordable (relatively low-cost). High-income, wealthy individuals and families are able to afford to live in the most environmentally favourable places. For example, waterfront suburbs or residential areas with spectacular views are often popular and thus more expensive places in which live.

Pull factors

Lifestyle

Some people rank lifestyle-related factors above all others when they make judgements about the liveability of places. Some are attracted by the lifestyle attractions of the coast while others prefer the mountains or bush. Some people prefer a rural lifestyle. Common to all these places is the attraction of the biophysical environment and the often quieter, slower-paced lifestyle that these places offer.

Aesthetics

For some, an aesthetic appreciation of the biophysical and constructed environments is a major factor in rating the liveability of places. Many people feel that their quality of life is made better by what they see and how they interact within a place. In many instances, aesthetic considerations are closely related to people's lifestyle considerations. Winter sports enthusiasts, for example, may find the beauty of mountain landscapes inspiring and a key to their emotional wellbeing.

Urban design

Good-quality urban design contributes to the liveability of cities. A well-designed city, town or suburb will attract people to visit, live and work. Good urban design can have a positive influence on physical and mental health by providing opportunities for better lifestyles and community interaction. Darwin's Wave Lagoon, shown in Figure 6.6.1, is an example of a community facility that attracts people to an area.

Special places

People often have places that are special to them. Indigenous Australians, for example, have a strong spiritual attachment to the place in which they were born—their Country. Others have places they associate with enjoyable times in their past, perhaps a place where they spent holidays when they were young.

Climate

While many people have a preferred climate that influences their perceptions of the liveability of places, most will seek to avoid climate extremes—places that are either very hot or very cold; or very dry or very wet. Places with warm summers and mild winters are popular with many people, but especially retirees. The shift of people to Queensland's Gold and Sunshine Coasts from the southern states can be explained, at least in part, by the attractions of the region—warm climate, beaches and a relaxed lifestyle.

Recreational spaces

Many people rate a place's recreational spaces highly in terms of liveability. These are places where people can engage in sporting and leisure activities. The range and quality of these places are important and are closely related to people's preferred lifestyle choices.

6.6.1 Darwin's Wave Lagoon is a safe, stinger- and crocodile-free wave and swimming lagoon.

Heritage

Protecting the unique heritage values of an area is important for some people's perceptions of a place's liveability. For example, in some suburbs planning laws ensure that the architectural heritage of the constructed environment is maintained. In others, whole streetscapes, street plantings and long-established parks and gardens are protected to retain an area's 'leafy' and historical character.

Push factors

Pollution

Air and water pollution affect not only people's health, but also their perceptions of a place's aesthetics and amenity. Air pollution is associated with large cities and industrial complexes. While the quality of air in Western cities has improved as a result of the shift away from heavy industry and manufacturing, and advances in fuel and engine technologies, air pollution remains a major environmental issue in the cities of the developing world.

Congestion

Traffic congestion, often a result of under-investment in public transport, robs people of time with their families, or participation in sport and leisure activities. It also has an economic cost because it adds to the expense of doing business. Traffic congestion has a negative impact on people's perceptions of the liveability of places.

Climatic extremes

People will normally avoid living in places where there are extremes of climate. Many people find hot and humid climates unpleasant to live and work in, while very cold climates affect people's ability to engage in a range of day-to-day activities, especially in winter.

Vulnerability to natural disasters

People are aware of the risks associated with living in particular places. They will, whenever possible, avoid living in places that are vulnerable to natural disasters. If they do choose to live in such places they will seek to reduce the risk. They can, for example, live in homes designed to resist the forces of nature.

Water shortages

A shortage of water places limits on the number of people a place can support. It also affects lifestyle-related activities such as gardening and water-based recreation. Water shortages can also affect affordability.

ACTIVITIES

Knowledge and understanding

1 Discuss the difference between pull and push factors.

Applying and analysing

2 Rank pull and push factors from the most to the least important. Explain why you ranked the factors in this order.
3 Identify any additional environmental factors that affect people's perceptions of the liveability of places.

Access to services

Services

The ability to access the services needed to support an acceptable standard of living is an important factor in determining the liveability of places. It is also an important consideration in where people choose to live.

A **good** is a tangible (or touchable) thing that meets a human need, while a **service** is a non-tangible good—this is, it cannot be touched, held, handled, looked at, smelled or tasted (see Figure 6.7.1). The term '**accessibility**' refers to the extent to which a service is available to as many people as possible. Accessible services include:

- childcare facilities and schools
- cultural and entertainment venues
- healthcare services
- public transport
- aged care facilities and residential care services
- recreational and sporting facilities
- service stations and motor mechanics
- clubs, restaurants and cafes
- banks and other financial institutions
- high-speed broadband
- legal advice
- shopping malls and other retail outlets
- road systems
- places of worship
- sporting and leisure venues
- police, ambulance and fire services.

Changing needs

People's needs change throughout their lives. An important marker of liveability is how well cities support the wellbeing of people at different life stages. There are some services that all people need access to, such as shops. There are others that relate to a person's stage of life or circumstances. For young families, childcare, schools and healthcare services are important. For retirees, healthcare services, aged care and other support services are an important consideration. For young people, access to public transport, shopping malls and entertainment venues might be important. For those with a disability, accessible public transport and buildings, and the support services they need, are important. For those in the workforce, access to public transport or an uncongested road network is important.

6.7.1 Newcastle Ocean Baths is an example of a recreational and sporting facility that helps make Newcastle a good place to live.

6.7.2 A public housing estate in outer Sydney. Those living in poor neighbourhoods of large cities are most at risk of locational disadvantage.

OLDER AUSTRALIANS

An increasing proportion and number of older people will require different housing, better access to health and transport services, more accessible public transport and pedestrian areas that are easier for people with poor mobility or disabilities to manage. In Australia, the proportion of the population that reported a disability in Australia in 2009 was 18.5 per cent, or just more than four million people.

Locational disadvantage

Locational disadvantage results when households find it difficult to access the goods and services that enable them to improve their wellbeing over time. Those living in the poor neighbourhoods of large cities are most at risk of experiencing locational disadvantage. Most of these neighbourhoods are found on outer edges of cities, where housing is more affordable. These suburbs are the most likely to be isolated from many of the services on which people depend, such as health care, child-support agencies, counselling, public transport and legal aid.

The concentration of the economically and socially disadvantaged in such neighbourhoods often results in these areas becoming associated with high rates of crime, drug dependency, domestic violence, urban decay and vandalism. In some neighbourhoods the problem becomes so bad they become known as 'no-go' areas.

ACTIVITIES

Knowledge and understanding

1 Explain why accessibility to services is an important element of liveability. How does the concept vary from person to person depending on their age or life circumstances?

2 Explain what is meant by the term 'locational disadvantage'.

Applying and analysing

3 Working in groups, brainstorm a list of the services you have consumed in the last two weeks.
   a Create a mind map of the services you have used.
   b How well serviced is the place in which you live in terms of the services you listed? For how many did you have to leave the place in which you live?

Investigating

4 Interview an aged person or a person with a disability. Ask them to outline the types of services they use regularly and whether they are available in the place in which they live. Also ask them to assess the accessibility of the services.

6.8

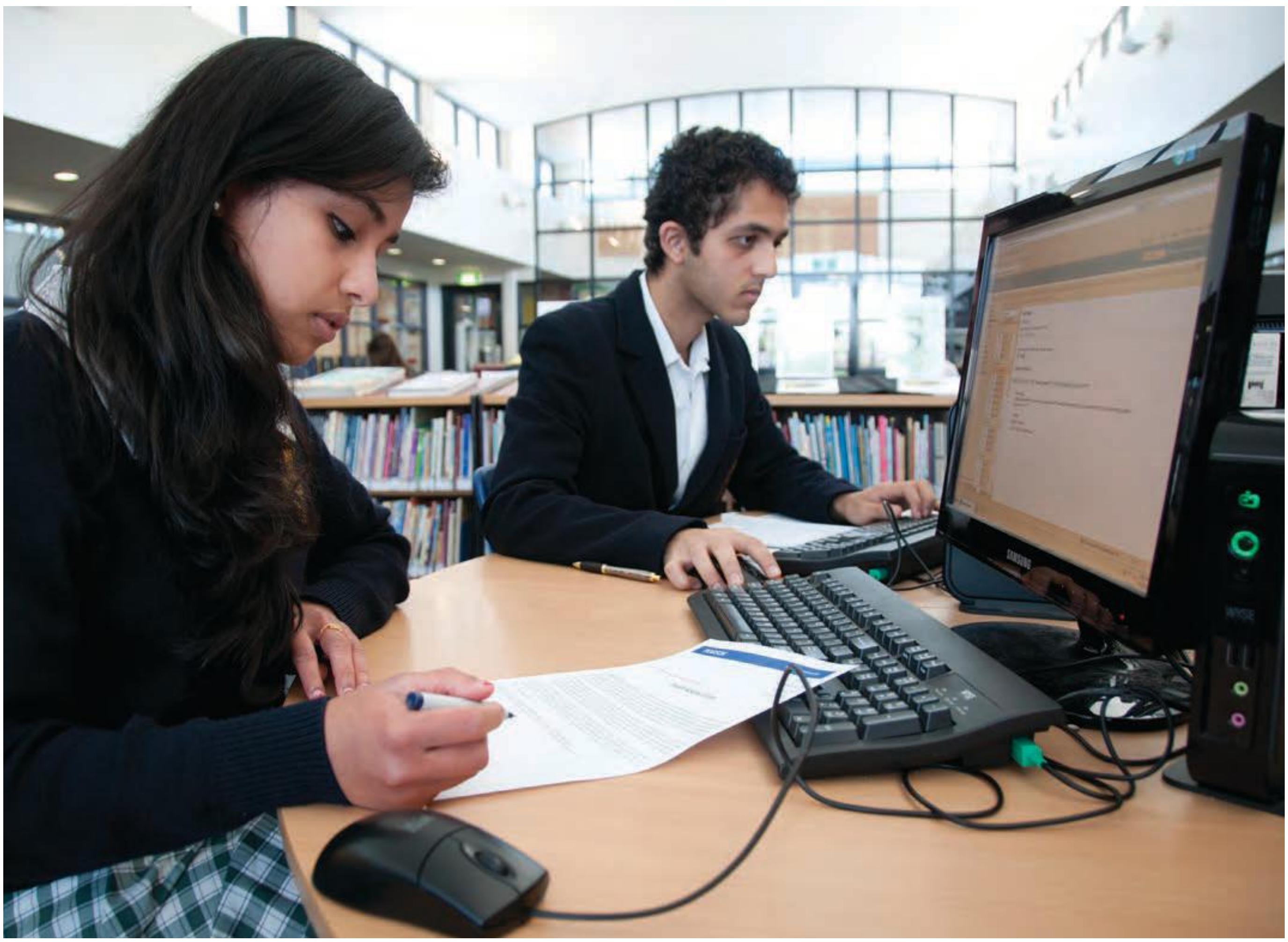
Social connectedness

Defining social connectedness

Social connectedness is the extent to which people come together and interact. At an individual level, social connectedness involves the quality and number of connections a person has with other people in a social circle of family, friends and acquaintances. These connections develop in response to a person's interests and participation in cultural or leisure-based activities. A person's social connectedness can change over time and connections can be built to different places. Social connectedness can also extend from the local to the global, often due to the influence of technology.

Role of technology

Traditionally, social connectedness developed mostly between known family, friends and community members through regular face-to-face interaction at events in local or familiar places. Nowadays, most social connections are developed and maintained through the use of technologies such as Skype and Facetime, email and instant messaging systems, and social media platforms such as Twitter, Facebook, Tumblr and Instagram.



6.8.1 Students broaden their social connectedness and enhance their learning using technology.

The increased availability and use of technology has led to a change in the nature and locations of social connection. Research indicates that a range of age groups now conduct most of their social interaction through technology rather than meeting face-to-face. On average, each Australian owns three internet-enabled devices, such as laptops, smart phones and tablets

The increase in availability of online learning opportunities as well as free and publically accessible wi-fi connections outside the home, school and workplace could help explain why 49 per cent of Australia's population connect daily with others via social networking sites and typically will have 297 contacts identified as 'friends or followers'. While this may seem a lot of friends for each person, only 39 per cent of Australian social network users report seeing these 'friends' in a face-to-face context. An increased level of access to technology in metropolitan, regional and remote areas of Australia is encouraging the development of online social connectedness for a significant proportion of the population.

Changing connections

The Australian Bureau of Statistics reports that there is a growing appreciation of the importance of individuals being connected with, and valued by, people beyond their immediate family and close friends. An increased number of connections can occur through online and/or face-to-face participation in cultural, sporting (see Figure 6.8.2), community and educational activities. When social connections occur through frequent, sustained and meaningful interaction, a person's sense of belonging and shared identity with a range of people and places is enhanced, thereby contributing to improved wellbeing and enriching society as a whole.

6.8.2 Sporting activities enable people to increase their social connectedness.

ACTIVITIES

Knowledge and understanding

1 Define social connectedness.
2 Outline the main cause and effect of change in people's social connections.
3 Describe the importance of maintaining social connections.

Applying and analysing

4 Explain how your social connections developed and identify some of the places you are now connected to as a result of these interactions.
5 Construct a mind map to show the types of social connections occurring between you and others.
6 Find a photograph (it can be one of your own) that demonstrates social connectedness. Annotate this photograph with information about location, type of social connection, number of people involved and why this social connection is important to you.
7 Describe how you use technology to develop and maintain your social connections.

6.9

Measuring liveability

Liveability surveys

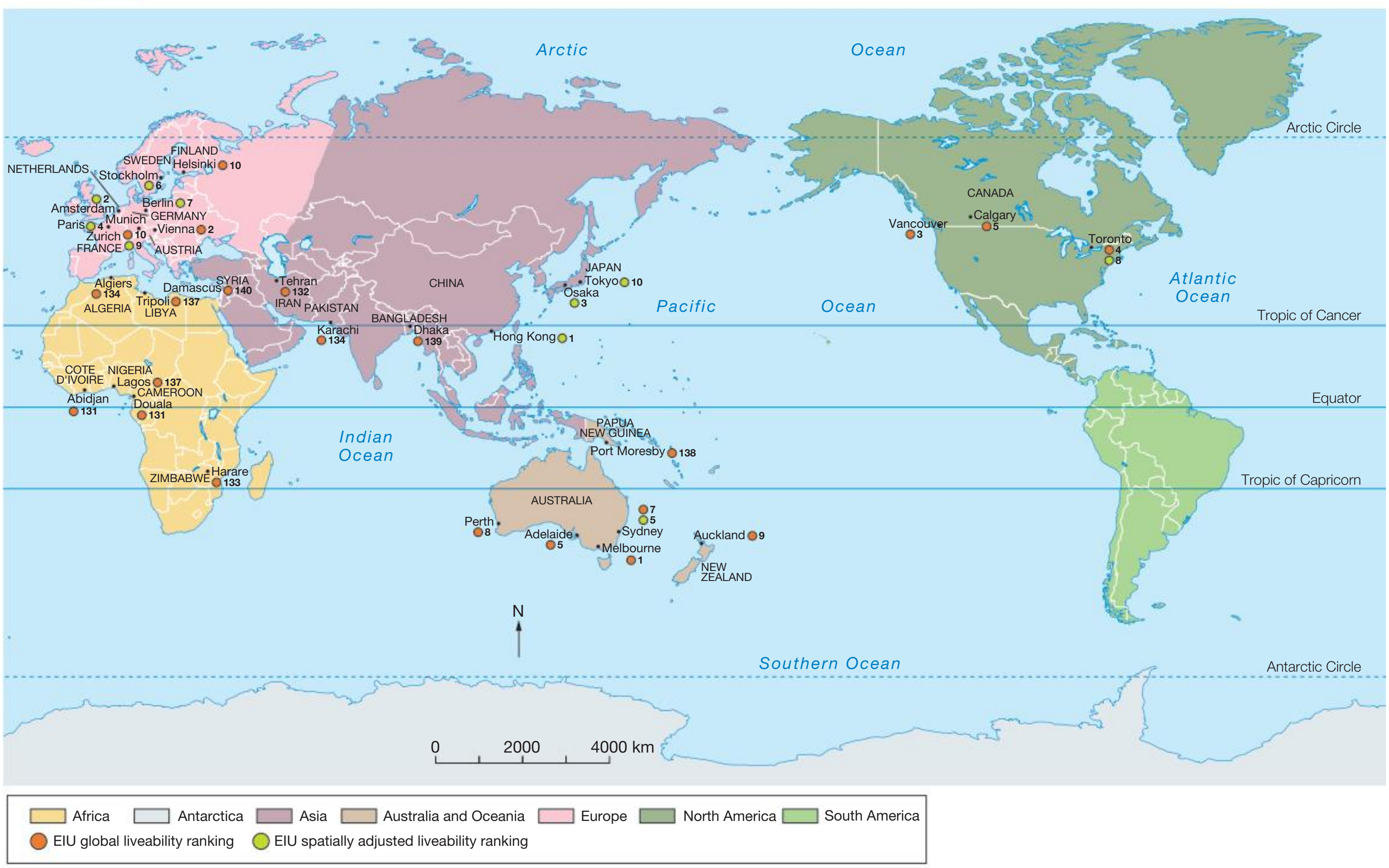
There are a number of liveability rankings published each year that compare cities around the world. The London-based Economist Intelligence Unit (EIU) publishes one of these. Each city is given a rating on thirty criteria across five broad categories:

- ***stability***—the city and country are free from war and conflict, crime rates are low and the government is stable
- ***health care***—access to hospitals and doctors is good
- ***culture and environment***—air and water pollution are low, and there are green spaces, restaurants and entertainment facilities
- ***education***—there is good access to high-quality schools and universities, and high levels of literacy for both males and females
- ***infrastructure***—roads, public transport, telecommunications and power sources are accessible and reliable, and there is access to good sanitation and a safe water supply.

The ratings are then totalled to give each city a score.

The EIU's 2015 liveability report ranked cities in Australia, Austria, Canada, New Zealand, Finland and Switzerland as the top ten most liveable cities in the world. Cities in Africa, Papua New Guinea and South Asia were ranked among the least liveable cities (see Figure 6.9.1).

6.9.1 The world's ten most liveable and least liveable cities, as ranked by the Economist Intelligence Unit, 2015



6.9.2 The EIU's new spatially adjusted liveability ranking judged Hong Kong the world's most liveable city in 2015.

New criteria

In 2012, the EIU experimented with an alternative method of ranking cities, which added new spatial criteria:

- population density (urban sprawl)
- connectivity (proximity to other cities)
- green space
- air quality.

The new method, known as the spatially adjusted liveability ranking (SALR), compared only half as many cities overall, and Melbourne, Vancouver and Vienna, among others, were not considered. In 2015, European cities filled five of the top ten positions, with three from Asia, one from North America and one from Australia. Hong Kong (see Figure 6.9.1) was ranked first, and Sydney came in fifth.

Alternative surveys

Another annual survey is the quality of living survey conducted by the New York–based firm Mercer, the world's largest human resource consulting firm. European cities dominate Mercer's ranking, with cities in Australia, New Zealand and Canada also ranked highly. Vienna, the capital of Austria, was Mercer's top-ranked city in 2015. Singapore, ranked 26 in 2015, was the first Asian city ever to rank in the top thirty.

The London-based lifestyle magazine *Monocle* has published an annual list of the most liveable cities since 2007. Tokyo, Japan, was ranked the most liveable city in 2015, followed by Vienna, Austria. Melbourne was ranked fourth and Sydney fifth. The criteria used in this survey include personal safety and crime, climate, environmental issues, urban design and architecture, health care, public transport and international connectivity.

ACTIVITIES

Knowledge and understanding

1 Describe the criteria used to determine the liveability of a city, town, suburb or neighbourhood.

Applying and analysing

2 Why do you think Australian cities rank highly on all the liveability rankings?

3 Rank the seven categories used by the lifestyle magazine *Monocle* from 1 (the most important) to 7 (the least important). Justify your response.

4 Would you add any new categories to *Monocle*'s list of criteria? Why, or why not?

Geographical skills

5 Study Figure 6.9.1 and do the following tasks.

   a List the continents in which the top ten most liveable cities are located according the EIU's 2015 global liveability ranking (GLR).

   b List the continents where the GLR locates the ten least liveable cities.

   c List the continent (other than Antarctica) that has no city in either the top ten or the bottom ten in the GLR.

   d Name the only Australian city in the top ten according to the spatially adjusted liveability ranking (SALR).

   e Describe the differences in location between the top ten cities in the GLR and those in the SALR.

6.10

IN THE FIELD: Investigating neighbourhoods

Aim

The aim of this fieldwork activity is to investigate your local neighbourhood. You will need to undertake research online and in the field. After you collect your data, you will assess your neighbourhood and the facilities available.

Choosing a neighbourhood

People choose to live in a particular neighbourhood for a variety of reasons. These reasons include:

- attachment to a place
- being close to family and friends
- employment opportunities
- affordability
- life-cycle stage
- lifestyle considerations
- personal safety
- environmental factors, including climate
- educational and healthcare facilities
- culture and ethnicity
- commuting time and public transport options.

Landuse map

A landuse map is a thematic map showing the distribution of different landuses. The steps below explain how to construct a landuse map of your neighbourhood.

STEP 1

Access an outline map of your local neighbourhood. Local council websites can usually provide a map. You can also use an online digital map service such as Google Maps. Print a copy.

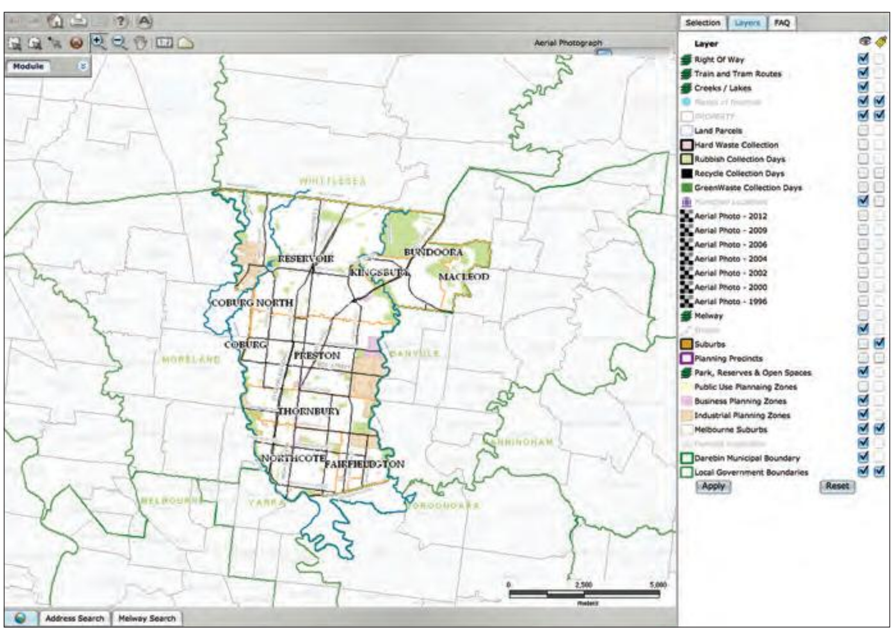
STEP 2

Using your outline map, conduct a landuse survey of your local neighbourhood. Make a legend for your map that contains the following landuse categories. Colour-code these landuses on your map. Use Figure 6.10.1 as a guide.

- low-density residential
- high-density residential
- commercial
- recreational
- place of worship
- medium-density residential
- transport
- retail
- industrial
- educational
- bike paths

STEP 3

Take digital photographs of the diversity of landuses found in your local neighbourhood. Link these images to your landuse map.



6.10.1 A map of a neighbourhood on a local council website

A multimedia presentation

STEP 1

Use a digital recording device such as a flip camera to capture footage of your local area. Select scenes that are representative of your neighbourhood, such as:

- residential areas
- commercial areas
- educational and healthcare facilities
- religious sites
- transport services
- recreational sites
- special events/festivals/celebrations.

STEP 2

Record interviews with members of your community. Ask them to reflect on what it is like to live in your neighbourhood. You may choose to select people who have lived in the area for varying lengths of time. This will help you to determine if things have changed over time—and, if so, in what ways they have changed.

STEP 3

Combine your footage into a multimedia presentation by adding a commentary, music and even text to highlight what is especially important in your neighbourhood.

Survey of retail businesses and services

STEP 1

Access an outline map of your local neighbourhood, as described earlier under 'Landuse map'. Zoom in on a local retail centre. You may live in a neighbourhood with more than one retail centre; if so, select just one retail centre to survey. Print a copy of the map.

STEP 2

Using the list below, conduct an audit of the number and type of retail and service providers found within your local retail centre.

- supermarket
- butcher
- hairdresser
- cafe
- restaurant
- hotel
- medical consulting rooms
- service station
- real estate agent
- solicitor's office
- shoe store
- fruit shop
- newsagent
- chemist
- takeaway food outlet
- post office
- club
- dentist
- bank or credit union
- travel agent
- spa
- clothing store

STEP 3

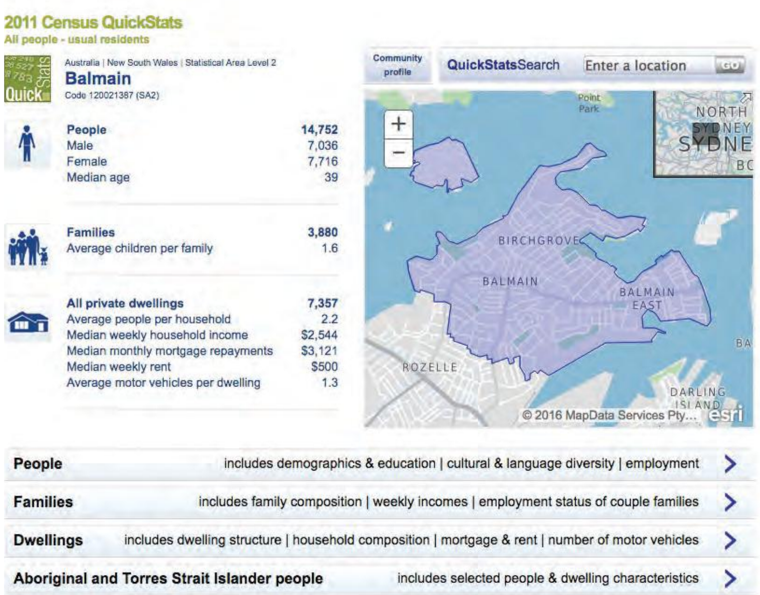
On your map, locate and label the different types of shops and commercial businesses found in your local retail centre. Photos can be taken of examples of each activity. Make a record of any businesses that have closed, or are up for sale or vacant.

Statistical profile

STEP 1

Access the QuickStats page on the Australian Bureau of Statistics (ABS) website. To do this, go to the ABS home page and select **Census Data** from the list on the left. On the Data and analysis page, select **QuickStats** from the list on the left. Type the name of your neighbourhood in the QuickStatsSearch box and click **Go** to access Census data related to your neighbourhood (see Figure 6.10.2).

6.10.2 Location QuickStats page on the ABS website



STEP 2

Use the Census data provided to develop a profile of your local neighbourhood. Include information related to:

- the total number of people
- age
- gender
- place of birth
- languages spoken at home
- marital status
- family type
- employment status and occupation.

Climate profile

STEP 1

Go to the Bureau of Meteorology website. On the home page, click **Climate and Past Weather**. Under 'Weather and Climate Data', click **Weather and climate data** to access the Climate Data Online page. You can choose the data you wish to access using either the **Select using Text** (see Figure 6.10.3) or **Select using Map** (see Figure 6.10.4) tab.

STEP 2

USING SELECT USING TEXT

In section 1 of the tab, select **Weather & climate**. Under 'Statistics', click the **Monthly** button.

In section 2, type the name of the location you want to investigate in the box. Click the **Find** button. Click to select your chosen location from the list. Click the Bureau station closest to your location.

In section 3, click the **Get Data** button.

USING SELECT USING MAP

In the **Data** tab, under 'I would like', select **Climate statistics**.

Under 'Zoom to', type the name of the location you want to investigate in the box. Click the **Search** button. Under 'Select town', click to select your chosen location from the list.

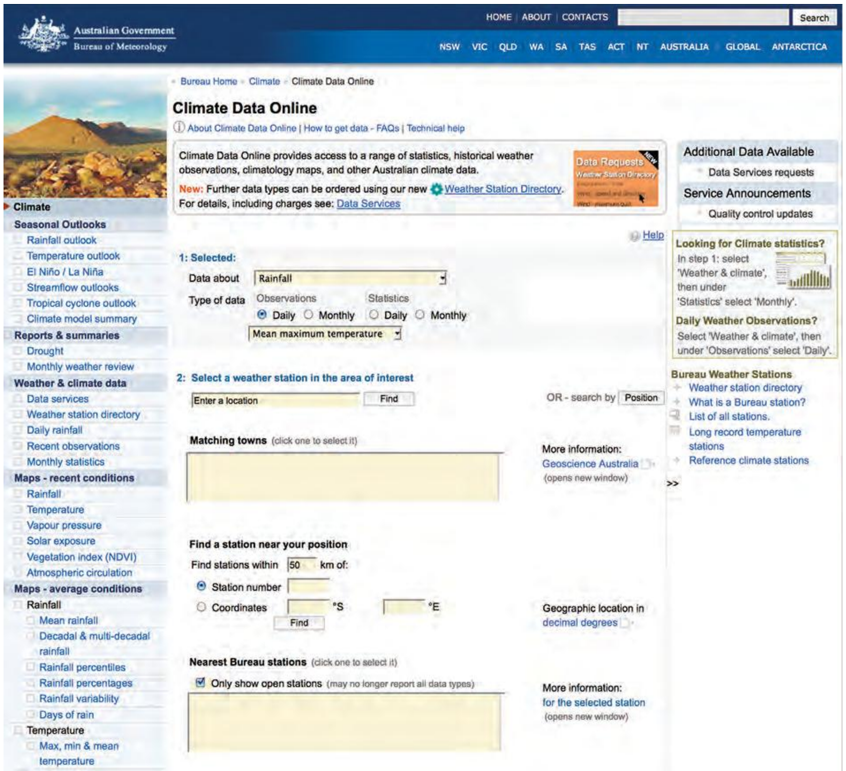
On the map, click the symbol of the weather station closest to your chosen neighbourhood. Click **Monthly climate stats**.

STEP 3

Create a climate graph of your local neighbourhood.

Use the following statistics:

- mean maximum temperature
- mean minimum temperature
- mean rainfall.



6.10.3 Selecting climate data using text

6.10.4 Selecting climate data using a map

ACTIVITIES

Aim

To investigate the liveability of your local neighbourhood and assess the facilities available

Method

1. Construct a landuse map of your neighbourhood. Add to your landuse map the photographs you have taken and mount a wall display showing the diversity and location of various landuses in your local neighbourhood.
2. Complete a statistical profile of your local neighbourhood.
3. Audit the retail businesses and services located in your local neighbourhood.
4. Complete a climate profile of your local neighbourhood.

Option 1: A multimedia presentation

Use a digital recording device to record footage of your local area and interview residents.

Option 2: Local history

Investigate the historical background of your local neighbourhood. Include in your response:

- the origin of the name of your local neighbourhood
- Aboriginal and Torres Strait Islander history
- European history.

Option 3: Meeting special needs

Using the data collected in Method steps **1–4** above, identify the groups within the local neighbourhood that have special needs (for example the elderly, the disabled, young children, teenagers). Identify how the needs of one such group are being met or not met in the local neighbourhood.

Evaluation

1. Describe the mix of retail outlets and service providers located in your local neighbourhood centre.
2. Do the facilities provided match the statistical profile of the area, or are there types of retailing and services missing? Explain your answer.
3. Look at the climate profile of your neighbourhood. Are the types of services provided appropriate for the climate? Explain your answer.
4. Choose five features from the following list of neighbourhood facilities that you would value having in your local neighbourhood:
   - skateboard bowl
   - public housing
   - indoor sports complex
   - church
   - youth club
   - shopping mall
   - nursing home
   - aquatic centre
   - internet cafe
   - restaurant or takeaway food outlet (e.g. McDonald's or KFC)
   - motorway interchange
   - railway station
   - primary school
   - secondary school
   - corner shop
   - factory
   - adventure playground
   - football field
   - cinema complex
   - service station.

   a. Refer to the rating scale below and rate how close to your home you would be happy to have each of these five features.

   b. List those features that you would value in your local neighbourhood but would not want too close to your home. Explain your answer.
   c. Suggest three different groups of people in your local neighbourhood who might disagree with your choices. How and why might their views differ?

Conclusion

If you could, would you make any changes to your local neighbourhood? Why, or why not?

6.11

Urban, rural or remote

Urban areas

Most Australians now live in large cities, usually near the coast. Because of their large populations, cities are able to provide a wide variety of services. For example, the largest hospitals are all located in big cities because that is where the need is greatest. Large cities also provide a range of entertainments and recreational activities not found in smaller centres. Urban areas also have better employment opportunities. This is one of the key advantages of living in an urban area.

Some Australians dislike living in cities, however, and **tree changes** and **sea changes** have become popular forms of escape.

Overcrowding is one of the main disadvantages of city living. A large population means that there is higher demand for housing, and this causes prices to rise. Traffic and public transport congestion is another problem. Heavy traffic also leads to increased air pollution. There is also a perception that crime is more common in cities.

Rural and remote areas

The environment is one of the key advantages of living in rural and remote areas. There are fewer people, cars and factories. As a result, rural areas tend to be cleaner. Fewer people means more space. The demand for housing is often lower, resulting in cheaper house prices and more affordable rent.

The key disadvantage of living in rural and remote areas is that access to services declines as the distance from the city increases. Australians living in very remote regions, such as far northern Western Australia, may have to travel hundreds of kilometres to the nearest shop. Health care can be so far away that doctors fly to their patients (see Figure 6.11.1).

6.11.1 People living in remote Australia live so far from health services that they rely on the Royal Flying Doctor Service for their health care.

Why more young Australians are choosing a sea change

Erin Munro

If there was one television show that permeated the Australian consciousness towards the end of the 20th century, it was ABC's *SeaChange*. Starring Sigrid Thornton as a bigwig city lawyer who moves to a small coastal town, the program led to a life-imitating-art phenomenon that saw more and more urban dwellers up sticks and opt for a quieter life by the sea.

Alan Stokes, executive director of the National Sea Change Taskforce, which formed in 2004 in response to the rapid migration of urban dwellers to the coast, says that the majority of people seeking a sea change tend to be in their 20s and 30s.

'It's mainly younger people in most areas that are predominantly the people that move in,' he says. 'There are quite a few coastal areas that have a very high median age, but the people who were moving back then [in 2004—and I tend to think it's the same now—were younger people with families.'

Stokes cites three main causes for the high numbers of younger Australians migrating to coastal towns: lifestyle, employment, and property prices.

'It's a very attractive proposition, to live down at the Surf Coast in Victoria or Central Coast in New South Wales or the Sunshine Coast in Queensland,' he says. 'What we've found is that often it happens that a family might go to an area like that on holiday, and then at some stage during that time think to themselves, "wouldn't it be great if we lived here permanently?"'

Lower property prices in regional areas can be enticing for city folk, says Alan Stokes. If selling a home in a city such as Sydney or Melbourne, you can replace it for much less in a small town, and those entering the property market for the first time will usually have a lower mortgage.

Popular areas for young sea changers include New South Wales' Central Coast, as well as Shoalhaven and Nowra further south, and in Victoria, the Surf and Bass coasts are proving popular with the same cohort.

Real estate agent Jack Wilson from Raine and Horne Terrigal – Avoca Beach has noticed the influx as well, especially among young families.

Regional employment opportunities can be a barrier to those who would like to make the move, but Wilson says that 'a lot of people are coming to the coast and doing their own thing,' such as working from home or contracting. Others keep their city jobs and commute, believing that sacrificing extra hours on travel is worth it for living the beach lifestyle the rest of the time.

Stokes believes growing connectivity is making the transition from city to country easier than ever before.

'It's really interesting when you're talking about people in their 20s and 30s… because there are a growing number of people who can take their job anywhere,' he explains. 'Broadband is opening up that option for a lot of people who wouldn't have previously thought it was viable.'

Source: *The Age*, 26 May 2015

ACTIVITIES

Knowledge and understanding

1 Outline the advantages of living in large cities and other urban areas.
2 Identify the disadvantages of city living.
3 Describe what attracts people to a rural lifestyle.

Applying and analysing

4 Think about the location in which you live. Is it urban, rural or remote? List the advantages and disadvantages in living where you do.
5 Read the newspaper article 'Why more young Australians are choosing a sea change' and do the following tasks.
   a List some of the main reasons people undertake a sea change.
   b Explain how broadband internet access has made making a sea change easier for some people.
   c Outline the disadvantages of a sea change.
   d What types of things do you think people should check before they decide to make a sea change?

6.12

CASE STUDY: Barangaroo

Location

Barangaroo is located on the western harbour foreshore of Sydney's Central Business District, as shown in Figure 6.12.1.

6.12.1 Sydney's CBD, showing the location of Barangaroo

Urban decay and renewal

Cities are dynamic places. They are constantly changing. Advances in technology and the nature of economic activity, together with the changing demographic and social characteristics of a population, are the key drivers of change. Over time, parts of cities experience periods of growth and decline. Barangaroo is one such place.

The once bustling port facilities that lined the foreshore of Millers Point gradually fell into disuse and disrepair as the technologies of shipping and cargo handling changed. By the mid-2000s the site had been all but abandoned. This process is referred to as **urban decay**.

Today, Barangaroo is Australia's largest urban renewal project. When it is complete, more than $6 billion will have been spent on the transformation of the site. More than 23 000 people will work in the precinct and 2000 will call it home.

6.12.2 Computer-generated images of Barangaroo. The top image is an aerial photo; the bottom image is an oblique photo.

Barangaroo South

Barangaroo South is the southern development zone of the Barangaroo site. The key elements of the site are three office towers, to be known as International Towers Sydney, a landmark hotel and resort complex, residential apartments, community facilities, retail outlets, restaurants and cafes. The office towers will accommodate a new financial and professional services hub for Sydney—Australia's financial capital.

Public spaces

Over 50 per cent of Barangaroo South will be devoted to useable public space, including an urban park, waterfront plaza, harbour cove, public, pier, waterfront promenade, boardwalks, squares, streets and laneways. Such spaces enhance the liveability of Sydney.

6.12.3 Computer-generated image of Barangaroo's public domain

Environmental and social sustainability

Barangaroo South will be Australia's first carbon-neutral urban precinct. A range of technological innovations will be used to minimise energy consumption. These include an automated solar shading system on the outside of the commercial office towers and an energy-efficient centralised cooling system. The development will also be water positive. Rainwater capture, water-saving fixtures and appliances, and on-site treatment of waste water will allow water to be exported from Barangaroo South to nearby neighbourhoods and the rest of Barangaroo, where it will be used to water the parklands. The energy consumed in Barangaroo South will be offset by on-site and off-site solar power generation and the purchase of carbon offsets.

Barangaroo South's social legacy will include a more highly skilled construction workforce, an Indigenous employment strategy, the promotion of low-carbon intensive transport options, healthy and active living programs, a public culture and public art initiative, and the social infrastructure required to support a thriving inclusive community.

ACTIVITIES

Knowledge and understanding

1. Identify the factors causing change in cities.
2. Distinguish between urban decay and renewal.
3. Identify the key elements of the Barangaroo South development.
4. Outline the elements of the precinct's public spaces.
5. Explain how the precinct will achieve its carbon neutrality.
6. Outline the social legacy of the development.

Applying and analysing

7. Study Figure 6.12.2.
   a. Describe the differences you can see between the aerial and oblique images.
   b. Explain how each type of image would be useful.

Investigating

8. Access the Discover Barangaroo online learning portal and do the following tasks.
   a. Investigate the historical geography of the site and the factors driving change in landuses.
   b. Outline the nature and scope of the Barangaroo development.
   c. Evaluate the extent to which the redevelopment enhances the liveability of Sydney.
   d. Construct a mind map highlighting the environmental and social sustainability strategies being promoted at Barangaroo South.

6.13

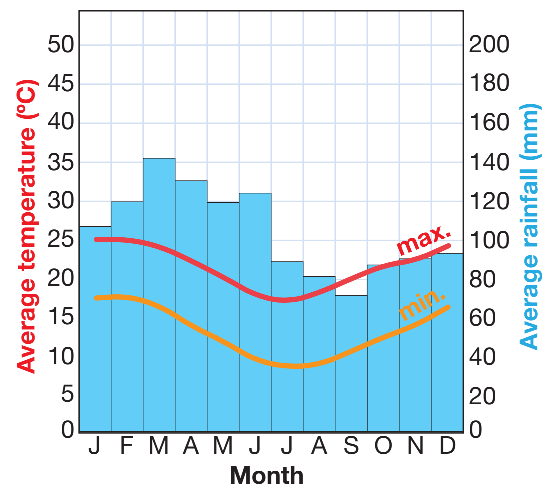
CASE STUDY: Gerringong

Location

Gerringong is a popular coastal town located on New South Wales's south coast (see Figure 6.13.1). The area has golden beaches, rugged sea cliffs and rolling green hills that sit under the Illawarra escarpment to the west. While the beaches and sun attract many tourists in summer, Gerringong is a vibrant, close-knit community for those who have chosen to live there.

A coastal environment

People are attracted to Gerringong by the region's environment. The mountains come close to the sea, and the rolling hills that connect them to the coast are always green—a result of a temperate climate and good rainfall (see Figure 6.13.2). The fertile, red soil that has formed on top of the underlying basalt rock supports lush vegetation.



6.13.2 Climate graph for Gerringong, New South Wales

6.13.1 South coast, New South Wales

Gerringong's history

Aboriginal history

This area was rich in the resources sought by Aboriginal people as they moved along the coast over many thousands of years. Family groups of the local Wodi-Wodi people camped here. They also had tracks along the top of the escarpment to the west of the coastal plain, and hunted the plentiful wallabies of the rainforest.

The ocean provided a ready supply of pipi, fish and oysters. Fresh water was available in the creeks that ran into Werri Lagoon. Ochre (a pigment extracted from clay and used for ceremonial purposes) was found throughout the area.

European history

European colonists first explored this part of the New South Wales coast during the drought of 1813. Cattle were unloaded onto the area's beaches from open boats so they could find feed. As the colony grew, the resource most sought after was timber, especially the highly valued red cedar.

DID YOU KNOW?

The name of the town of Gerringong is derived from an Aboriginal word meaning 'a fearful place'.

6.13.3 Oblique aerial photograph of Gerringong. Prominent landforms that are visible in the photograph include Werri Beach, a dairy farm, Werri Lagoon (foreground) and some of the headlands that jut out into the sea.

Cedar cutters moved into the rainforests along the escarpment and, by the 1820s, the area became a major supplier for Sydney. Early government surveyors selected the sites of harbours and townships, and Gerringong became a gazetted township in 1829.

Once the land was cleared and the fertility of the soil discovered, dairying became a flourishing industry. A boat harbour at Gerringong was used to transport the cedar and dairy products to Sydney. Once the supply of cedar was used up, dairying became the most important industry and the town grew to provide services (see Figure 6.13.3).

While Gerringong has long been a valued holiday destination, tourism has expanded rapidly in recent decades as developers have invested in new housing and tourist accommodation—some of which has been built on former dairying farms. As a result, Gerringong's population has expanded to 3500 over the last 20 years.

SPOTLIGHT

Retiring to Gerringong

'My wife and I work and live in Sydney, but I spent my teenage years in the Shoalhaven district and grew to love the Illawarra region as well. We brought our children to the Gerringong district on family holidays from their early years, and we purchased a property in which we intend to live when our Sydney working days are over. It is a family haven and a place we all love, even though the children are now all adults. Members of our extended family and friends also come here. We have made many friends within the local community and attend the Anglican church here when we can. People know each other in the town and you hear warm greetings whenever you are shopping or walking.

'The area has a mix of farming, tourism and support services as well as a town in which many people who commute to Wollongong (and even southern Sydney) live. The population grows rapidly in summer, and on holiday weekends, as it is a comfortable two-hour drive from central Sydney. There are regular train services to Gerringong on the Sydney network. Recreational activities include surfing, boating, fishing, bushwalking in nearby parks, whale watching, sports and community activities.

'There is a modern government primary school, and there are government and non-government schools in Kiama, Nowra and Shellharbour. Medical and legal practices are in town. Local shopping is fine for the basics and the larger centres nearby provide all the major shopping and entertainment activities. The population is not large, and therefore a number of specialty businesses have started and failed over the years. The locals love their Rugby League team, the Gerringong Lions, but all sports for men and women are enthusiastically participated in.

'The scenery is spectacular as the town sits on the coast with a background of the Illawarra escarpment. Saddleback Mountain towers to the north and is often shrouded in cloud. We feel this beautiful place is a true family home.'

Dr Timothy Wright

Sense of community

The residents of Gerringong enjoy living in a close, supportive community. They are involved in numerous organisations that draw them together. The Gerringong Surf and Lifesaving Club provides a voluntary service for beachgoers by setting up a patrolled area at weekends and on public holidays. The club encourages children to join, and the Nippers (junior lifesavers) can be seen on the beach most Sunday mornings during the summer (see Figure 6.13.4). In winter, the town gets behind the local Rugby League team, the Gerringong Lions, which is coached by Michael Cronin, a noted international player. When the Lions reach a grand final, most of the town turns up to cheer them on. Other community organisations include church groups of various denominations.

6.13.4 Nippers learning, gaining confidence and having fun in a safe beach environment in Gerringong

SPOTLIGHT

Gerringong through my eyes

'Children from Gerringong attend the local primary school and then Kiama High School. Students at Kiama High have the option of doing surfing for sport. Students and teachers meet at the beach at 6 a.m. and surf until around 7.15 a.m. These students are then allowed to leave school early that afternoon, while others do sports such as fishing, golf, lawn bowls and weights.

'Gerringong has a large Rugby League playing community. On Monday afternoons, many of the town's families and teenagers gather at the main oval for a friendly touch competition. It is a very social occasion, and is a major meeting for many residents.'

Josh Gorrie, aged 16

6.13.5 Population pyramid for Gerringong

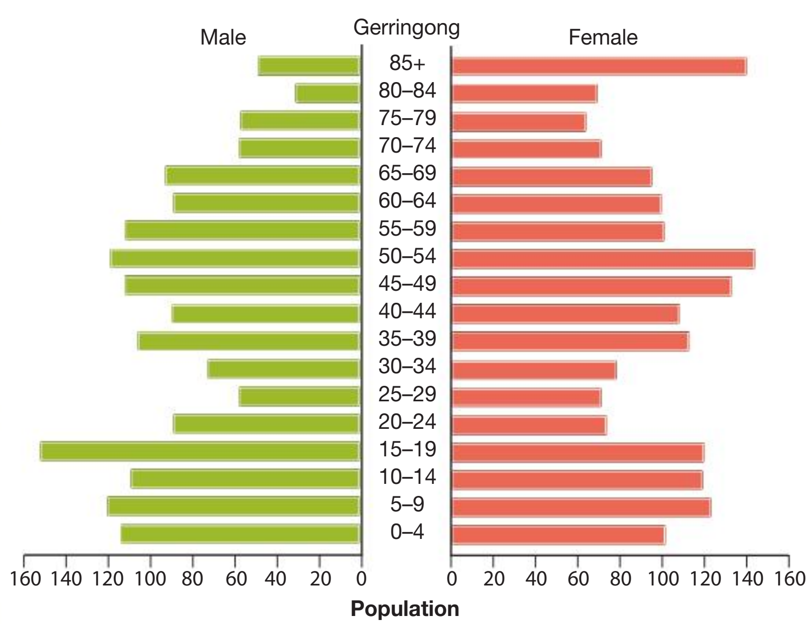


Figure 6.13.5 outlines the population profile for Gerringong. People of all ages are offered many opportunities to be part of the community. Young musicians have the opportunity to perform at regular concerts organised by the Gerringong Music Club.

Gerringong also appeals to retirees. For those who are active, there is much to do: surfing, fishing, bushwalking and cycling. It is an especially scenic area that inspires artists who have studios in the town. The less mobile aged people who live in the Mayflower retirement village are also made to feel very special. Each year, just before Christmas, the local Rotary Club organises a street parade, and players from the Gerringong Lions push the aged residents down the street in wheelchairs. People in Gerringong actively work together to protect their beaches. Figure 6.13.6 shows a group of volunteers removing weeds and planting vegetation to protect the sand dunes and beach.

DID YOU KNOW?

Gerringong Surf and Lifesaving Club's annual Captain Christie Ocean Swim is based on a local legend. The story goes that, in 1882, a sailor challenged Captain William Christie to swim from Gerringong Boat Harbour around the rocky headland to Werri Beach. The captain rose to the challenge and won a bottle of whisky for his efforts.

6.13.6 Members of the Gerringong community actively come together to protect their beaches. Werri Beach Dunecare is a project in which volunteers remove weeds and plant new vegetation around Werri Lagoon.

ACTIVITIES

Knowledge and understanding

1. Explain why people choose to live in Gerringong.
2. What is the meaning of the town's name?
3. Describe the resources of this coastal environment that have been used by Aboriginal people and by Europeans.
4. Explain why Gerringong has developed such a strong sense of community.
5. Outline the reasons why Gerringong appeals both to young people and to those considering retirement.

Geographical skills

6. Study Figure 6.13.2 and do the following tasks.
   a. Calculate the mean annual temperature range.
   b. Describe and account for Gerringong's high annual rainfall and the distribution of this rainfall.
7. Using Figure 6.13.3, draw an annotated photo sketch of Gerringong.

Investigating

8. Using the internet, write a brief description of the accomplishments of three of the following people who have lived in Gerringong: Michael Cronin, Rod Wishart, Sally Fitzgibbons, Dean Bowen and Jack Druce.
9. Access the website of the Gerringong Surf and Lifesaving Club. Write a paragraph outlining why the club would appeal to young people living in Gerringong.

CASE STUDY: Paraburdoo

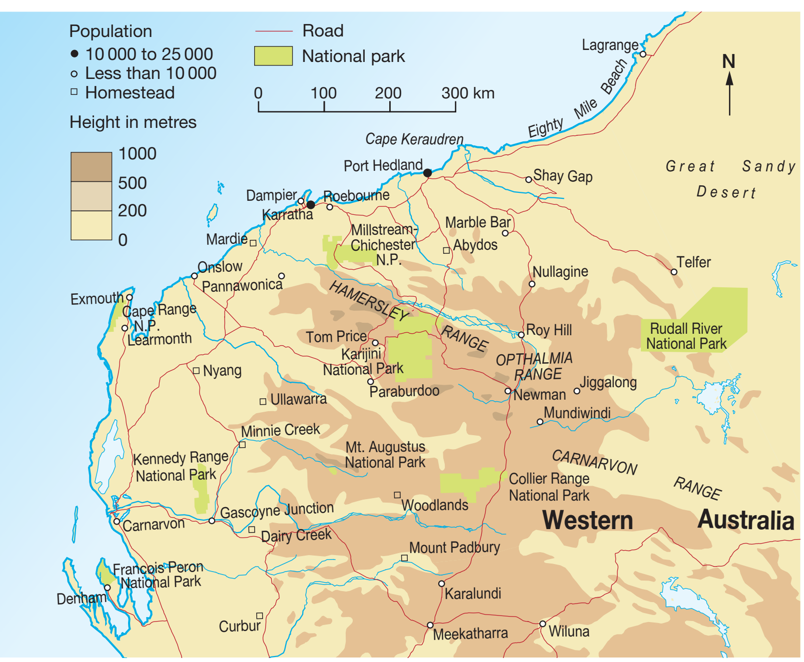
Location

Paraburdoo is a mining town in the heart of the remote Pilbara region in the north-west of Western Australia, as shown in Figure 6.14.1. Paraburdoo was purpose-built in the early 1970s to support Western Australia's iron ore industry. Today, most of the town's residents still work in mining operations or supporting services.

The Pilbara environment

The Pilbara is a vast, dry and sparsely populated area, renowned for its scenic landscapes and red earth. The Pilbara covers 502 000 square kilometres. It is rich with mineral deposits, especially iron ore. Western Australia contains the oldest known rock formations in the world. In fact, it is the immense age of the Australian continent that makes it so rich in minerals. The Pilbara is about 3.5 billion years old, and it is in rocks of this age that bands rich in iron ore are found between layers of other rocks.

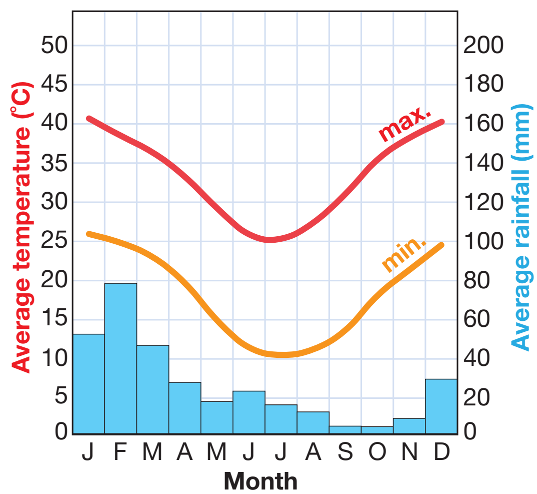
6.14.1 Paraburdoo is located in the Hamersley Range of Western Australia.



Source: *Heinemann Atlas* Fifth Edition

Given its location, nearly 300 kilometres from the coast and 24 kilometres north of the Tropic of Capricorn, it is apparent why Paraburdoo has such a hot, dry climate. Extremely high temperatures can be reached: the highest recorded temperature is 48.9°C. The average annual rainfall is a low 310 mm (see Figure 6.14.2).

6.14.2 Climate graph for Paraburdoo



SPOTLIGHT

Paraburdoo through my eyes

'Living in a mining town is very different. The workers are young and wages are high, which is what attracts us, as we have to do without many things that are taken for granted elsewhere. Fresh food arrives on a truck only once a week. High school students have a long day, leaving at 6.45 a.m. to travel by bus to Tom Price. Tee-ball and motocross are popular with the children, but competition is limited.

'Families that move to Paraburdoo generally only stay for 5 years. There is a sense of isolation from living on the edge of a desert that we can only cope with for so long. Others are fly-in, fly-out workers.'

Rio Tinto truck driver

6.14.3 Mt Tom Price open-cut iron ore mine, Pilbara region

Aboriginal history

Aboriginal people have lived in, and managed, the environment of the Pilbara for over 30 000 years. Their survival depended on knowing where to find waterholes, and their movements followed the seasons as they gathered root vegetables, fruit, eggs and honey, and hunted kangaroos and reptiles.

The name of the town Paraburdoo is derived from an Aboriginal word, *pirupardu*, which can be translated as 'meat feathers'. This refers to the white cockatoos that live in the area, which were a ready supply of food for the Aboriginal people.

European history

Exploration for iron ore in the Pilbara (see Figure 6.14.3) began in the early 1960s, yielding promising results. Few people lived in the region, so the mining company Rio Tinto built whole towns for mineworkers and their families. Paraburdoo was one of the company towns purpose-built in 1970, and it grew very quickly. The population has since remained steady at between 2000 and 2500.

As the mining boom has accelerated, production has been expanded in response to the huge demand from China.

DID YOU KNOW?

The film *Red Dog* was based on a dog commonly seen around the Pilbara. It relates miners' stories of the dog, which became a legend in the area.

6.14.4 A Pilbara legend is portrayed in the movie *Red Dog*.

ACTIVITIES

Knowledge and understanding

1. Explain why people choose to live in Paraburdoo, but stay for only a few years.
2. Outline how the town of Paraburdoo got its name.
3. Describe how the resources of this environment have been used by Aboriginal people and by Europeans.

Applying and analysing

4. Write a personal account of how your life would change (if at all) should your family move to Paraburdoo.
5. Study Figure 6.14.2. Describe what it would be like working in the mining industry in the Pilbara during January and February.

Investigating

6. Undertake library or internet research to determine what iron ore is used for.
7. Undertake internet research to:
   a. explain why the climate in the Pilbara is so hot and dry
   b. investigate the legend associated with the movie *Red Dog*. Assess the accuracy of the movie's portrayal of the life of this dog in the Pilbara.
8. Access the website of the mining company Rio Tinto and prepare a short report on its history and its operations in the Pilbara.


KEEP
CLEAR
CAF

Enhancing liveability

CHAPTER 7

We now know that some places are perceived as being more liveable than others. We also know that liveability can be used as a measure of the quality of life, wellbeing and happiness experienced by people living in a neighbourhood or town. Enhancing the liveability of places is the role of governments, planners, groups and individuals. Plans and initiatives to enhance liveability may be local and small-scale; for example a Neighbourhood Watch program or the establishment of a community garden. They may also be large-scale; for example public transport infrastructure, urban renewal building projects or community services such as education, health care and recreational facilities.

In this chapter we focus on liveability and how it can be improved. Of particular interest are the ways the quality of life of those living in our large cities can be enhanced.

INQUIRY QUESTIONS

- How can the liveability of places be enhanced, with specific reference to inner-city neighbourhoods, shopping centres, recreational spaces and schools?
- What are the criteria for enhancing a neighbourhood?

GLOSSARY

accessible	easily entered, especially in the context of giving elderly people and those with disabilities easy access to places and services
infrastructure	the physical structures that allow a society to function, such as buildings, roads, water pipelines, sewers, electricity distribution systems, railways and airports
housing density	the number of dwellings (houses, apartments, townhouses) in a specific area
master-planned housing estate	a settlement that is carefully planned and is usually constructed in a previously undeveloped area
suburbanisation	the process by which people and businesses move out from central areas of cities and into the suburbs
urban consolidation	the result of planning policies designed to increase population densities in existing built-up areas
urban sprawl	the outward spread of a city and its suburbs

7.0 Sydney is reintroducing trams to the city centre to improve liveability by reducing traffic congestion.

7.1

Methods of enhancing liveability

How to improve liveability

There are many ways in which the liveability of a city, suburb or town can be improved. Enhancing liveability benefits people who live in, work in or visit an area. It increases property values and business activity, and it can improve public health and safety.

Liveability is greatly influenced by the type and condition of public spaces—those places where people naturally interact with each other and their community. Public spaces include streets, parks, transportation terminals and other public facilities. These are affected by public policy and planning decisions.

Transport options

Liveability is improved when planners and governments develop safe, reliable and affordable transport choices that decrease people's dependence on cars. Other benefits of this include reduced traffice congestion, improved air quality, reduced greenhouse gas emissions and improvements in public health.

SYDNEY METRO

The new Sydney Metro is Australia's largest public transport infrastructure project and the country's first fully automated metro rail. Due for completion in 2019, the Metro will feature eight new railway stations in the city's rapidly growing north-west (see Figure 7.1.1). The Metro will greatly increase access to Sydney's major employment hubs, reducing commuting times and therefore enhancing people's quality of life.

Affordable housing

Another way to enhance liveability is to expand the housing choices for people of all ages, incomes and racial and ethnic backgrounds. Building medium- and high-density housing close to major transport and activity centres increases mobility and lowers the combined cost of housing and transportation.

Social places

Facilities such as aquatic centres, libraries, indoor and outdoor sporting facilities, town squares, playgrounds and skate parks can provide attractive public spaces where people can gather and interact.

Open space

Open space helps people to interact with the natural environment. Open spaces need to include both passive places, where people participate in recreational activities such as walking and picnicking, and active places, where people can participate in sport and children can play.

Biophysical environment

A place's impact on the environment can be reduced through energy efficiency and recycling programs. Degraded land can be rehabilitated by planting native vegetation, and rural landscapes can be protected by slowing the rate of **urban sprawl**. Vacant land near transport, activity and employment centres provides opportunities to promote **urban consolidation**.

7.1.1 Kellyville Station, Sydney Metro. Sydney Metro is Australia's first fully automated metro railway.

Support for communities
Existing communities can be improved by investing in public transport-focused and mixed-use developments (for example integrating residential and commercial places). The community can be involved in important planning decisions.

Facilities and activities
People's lives can be enriched by participating in cultural and community activities such as theatre groups, choirs, bands and orchestras.

Celebrating diversity
Celebrating the ethnic and cultural diversity of the community can enrich people's lives and promote social harmony and personal wellbeing. Examples of this approach are community festivals, celebrations and events.

Accessibility
All public and commercial spaces should be **accessible** to people with limited mobility, especially the elderly and those with disabilities.

Economic wellbeing
Promoting selected economic activities can create employment close to where people live. Providing the right educational opportunities enables people to develop the skills they need to gain secure, rewarding work.

Healthy lifestyles
Providing facilities and services such as sporting venues, fitness trails, medical services, clinics and hospitals promotes good health and personal wellbeing.

Coordinating government activities
Governments at different levels can build on the unique characteristics that define places by investing in healthy, safe and walkable neighbourhoods, whether they be rural, urban or suburban. Planning for the future can include, for example, increasing access to smart energy choices such as locally generated renewable energy.

Enhanced streetscapes
The liveability of places can be improved by enhancing streetscapes—the visual elements of a place's streets. These include the road, adjoining buildings, street furniture, fences, trees, nature strips and open spaces, all of which combine to form a street's character. Pedestrian-friendly streets create opportunities for people to meet and interact, helping to create community networks.

Calming traffic
Traffic calming involves the construction of roadway design features that lower vehicle speeds. This can reduce traffic volumes, noise and air pollution, and improve safety, especially for residents.

ACTIVITIES

Knowledge and understanding
1 List the benefits of affordable transport.
2 State the benefits of open spaces.

Applying and analysing
3 Individually rank the strategies for enhancing the liveability of places. Explain the reasons for your ranking.
4 Study Figure 7.1.1. Does the Sydney Metro development meet any of the strategies for improving liveability discussed in this unit? Explain your answer.
5 Select four of the strategies for improving liveability that you would implement in your suburb or town.
   a Explain why you chose those particular strategies.
   b Describe how these strategies would improve the liveability of your town or suburb.

7.2

Taking action

Improving liveability

The liveability of places directly impacts on the people who live and work there, or choose to visit. While the planning decisions of governments determine many aspects of liveability, individuals and groups can take action to improve the liveability of their neighbourhood.

Enhancing public spaces

The liveability of a neighbourhood is largely determined by the condition of shared public spaces—the places where people interact with each other. These include streets, footpaths, parks, transport terminals and other public facilities. Even though state and local governments carry out the planning, construction and maintenance of these spaces, there is a growing trend for community-based groups to set up projects to improve public spaces.

'Farming (or gardening) the footpath' has been happening for some time in cities around the world. In programs of this kind, local residents plant fruit trees, vegetables and herbs, as well as flowers and native plants, on nature strips, next to the footpath and also in community gardens (see Figure 7.2.1). Not only does this beautify neighbourhoods, it provides food for the residents. Residents are drawn closer together through their involvement in such projects, which have been especially popular with young people. There has been an increase in interest in Australian cities, with **community gardens** being established in many suburbs.

In Totnes, in the United Kingdom, volunteers have been planting young chestnut and walnut trees along streets and in parks and other green spaces since 2007. In time, these trees will be harvested and will provide an important food source for local communities. A similar project has been undertaken in Glandore, a suburb of Adelaide, where citrus trees have been planted along the nature strips, underneath taller eucalypts.

Protecting liveability

The responsibility for approving developments within neighbourhoods rests with government. Local residents, however, are able to influence decision-making processes by either supporting or opposing proposals. When development-related issues arise, activists have a range of strategies available to them to mobilise public opinion and influence decision-makers.

Assessing liveability

An individual's perception of the quality of their community is a combination of many factors that influence their day-to-day living. From their personal experiences they build a perception of their neighbourhood's worth. One way to assess liveability is to survey and score a neighbourhood or town (see Table 7.2.2).

7.2.1 Community garden, Sydney

7.2.2 Form for conducting a neighbourhood liveability survey

Criteria		Score				
		Poor				Good
Law and order	• Amount of petty crime	1	2	3	4	5
	• Amount of violent crime	1	2	3	4	5
	• Graffiti and vandalism	1	2	3	4	5
	• Personal safety	1	2	3	4	5
Economics	• Employment opportunities	1	2	3	4	5
	• Affordable housing	1	2	3	4	5
	• Access to consumer goods and services	1	2	3	4	5
Environment	• Humidity and temperature	1	2	3	4	5
	• Urban design	1	2	3	4	5
	• Architecture	1	2	3	4	5
	• Parks and gardens	1	2	3	4	5
	• Streetscapes	1	2	3	4	5
	• Maintenance of public spaces	1	2	3	4	5
Culture	• Community recreational facilities	1	2	3	4	5
	• Places of worship	1	2	3	4	5
	• Restaurants	1	2	3	4	5
	• Public libraries	1	2	3	4	5
	• Entertainment centres	1	2	3	4	5
Education	• Availability of private schools	1	2	3	4	5
	• Availability of public schools	1	2	3	4	5
	• Quality of educational institutions	1	2	3	4	5
Health care	• Quality of private health care	1	2	3	4	5
	• Quality of public health care	1	2	3	4	5
	• Aged care facilities	1	2	3	4	5
Infrastructure	• Quality of road network	1	2	3	4	5
	• Quality of public transport	1	2	3	4	5
	• Quality of telecommunications infrastructure	1	2	3	4	5
	• Availability of good-quality housing	1	2	3	4	5
	• Provision of utilities: water, electricity, sewerage	1	2	3	4	5
	• Cycleways	1	2	3	4	5

ACTIVITIES

Knowledge and understanding

1. List the types of public spaces in which people interact with each other.
2. State the role of government in managing public spaces.
3. Describe the concept of 'farming the footpath'.

Applying and analysing

4. Rank your local neighbourhood on each of the criteria listed in Table 7.2.2, using the scale from 1 to 5. Tally the total score out of 150.
5. Repeat Activity **4** for a nearby neighbourhood. Develop a class ranking of neighbourhoods.

7.3

Better cities

Central business districts

At the heart of the modern city is the central business district, or CBD. Being at the core of cities, CBDs are important places for work. Many CBDs are now also becoming popular places to live. A key question is how the liveability of such places can be enhanced.

The need for open space

A city's main commercial and business-related functions and its major public institutions, such as town halls, libraries, museums and theatres, are located in its CBD. In modern cities, large buildings dominate the urban landscape, and there is little open space. This lack of open public spaces, such as plazas and parklands, is one of the criticisms of many CBDs around the world. Such places are important not just for environmental reasons but also as places for relaxation and recreation. In recent years, there has been a trend towards redesigning inner cities to make room for public spaces and to create green zones within the city.

Sydney's Barangaroo redevelopment, along the eastern shore of Darling Harbour, has large areas reserved for open public space. Figure 7.3.1 shows an artist's impression of a new development in the heart of western Sydney, Parramatta. As the city expands, plans have been developed to transform the city centre by adding recreational spaces such as this 'city beach' to be developed on the shores of the Parramatta River.

7.3.1 The Water Square, to be developed on the shores of the Parramatta River

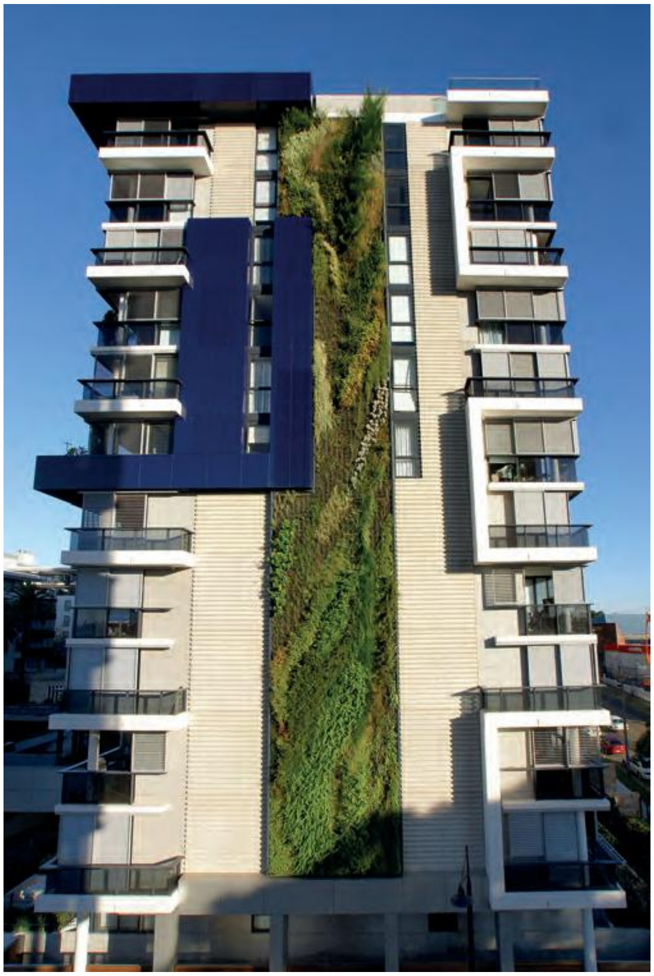
Greener buildings

Not only are CBDs being redesigned to make them better places in which to live and work, the buildings in them are being transformed. New technologies mean that buildings can be more environmentally friendly.

'Green' buildings are structures that are efficient in their use of energy and other resources. The greenest buildings are those that minimise energy and water use, protect the health of their occupants, improve the productivity of workers and reduce waste and pollution.

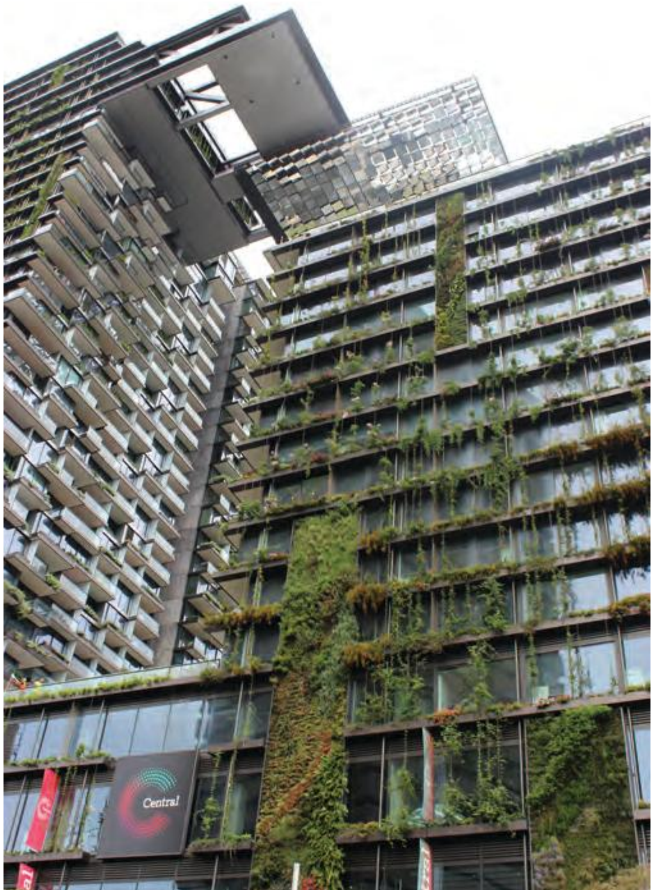
Among the greenest buildings are those with vertical gardens and roof gardens. Vertical gardens consist of special supporting frames, secured to the side of the building, that are planted with shrubs and other smaller plants. An automated watering system is installed to sustain plant life.

At a height of 33 metres, the vertical garden of the Trio apartment building in Sydney is among the world's tallest (see Figure 7.3.2). An even larger vertical garden is being constructed in the nearby Central Park development on the edge of Sydney's CBD (see Figure 7.3.3).



7.3.2 The Trio apartment building in Sydney has one of the world's tallest vertical gardens.

In addition to contributing to the beauty of our CBDs, vertical gardens have important environmental benefits: the plants act as insulators, helping to reduce the amount of energy needed for cooling and heating.



7.3.3 One Central Park, Sydney, was designed by award-winning French architect Jean Nouvel. The tower's facade is clad in vertical gardens designed by French artist Patrick Blanc.

Other strategies

Additional strategies to enhance the liveability of CBDs are:

- enhancing public spaces and streetscapes with quality paving and street furniture, plantings and outdoor dining options
- reducing traffic congestion by discouraging vehicle access, imposing parking restrictions, providing low-impact public transport options such as trams, developing pedestrian-only areas and constructing dedicated cycleways
- encouraging a range of after-dark activities in places such as cafes, restaurants, wine bars, theatres and other entertainment venues
- enhancing public safety by the use of surveillance cameras, street lighting and additional police patrols
- encouraging a mix of retailers, including convenience stores and supermarkets.

Barangaroo parklands

From as early as 1820, this north-western section of the edge of Sydney's CBD served a variety of port-related functions. As well as wharves, there were boatbuilding and boat repair facilities. It continued to be an important waterfront area until the early part of the twenty-first century, when the container terminal on the site was moved to Port Botany.

An important part of the project is the development of Headland Park. The park opened in August 2015 and contains more than 75 000 native plants, included 600 mature large trees. The park contains walking trails, cycle tracks and a cove for small boats.

The park has greatly enhanced the liveability of Sydney by returning to public use parts of the harbour foreshore that have been off limits for more than a century. It also provides an important recreation space for the surrounding population of residents and workers.

The park and the nearby area are named after Barangaroo, who was a powerful Aboriginal woman at the time of the first British settlement in Sydney. She commanded authority from the early colonists and fiercely maintained traditional customs.

7.3.4 The construction of Headland Park at Barangaroo is transforming a former dock, top, into public space, bottom.

SPOTLIGHT

Barangaroo South: energy efficiency

When complete, Barangaroo South will be Australia's first carbon-neutral community. This will be achieved by designing buildings and public spaces that are energy efficient.

Barangaroo South's three commercial towers have been designed to achieve a six-star Green Star Design rating. Residential buildings will meet a five-star standard. To achieve a six-star rating a building is judged against a set of criteria, including energy efficiency, the quality of the indoor environment, accessibility to public transport, water use, the nature of the materials used in construction, ecological impacts, CO_2 emissions and the degree of innovation.

Green Star-certified buildings typically produce 62 per cent fewer greenhouse gas emissions and use 66 per cent less electricity than average Australian buildings. They also use 51 per cent less water than average buildings and recycle 96 per cent of their construction demolition waste, compared with the average recycling rate for new construction projects of 58 per cent.

ENERGY EFFICIENCY

The buildings of Barangaroo South will have a number of energy-efficient design features.

Building alignment
The alignment of the three commercial towers on an east–west axis will help improve their environmental performance. It will, for example, reduce their exposure to the sun on hot summer afternoons.

Solar shading systems
An automated shading system, fixed to the facades of the three commercial towers, will reduce solar heat gain, lower air-conditioning costs, and reduce glare while maximising natural daylight.

Energy-efficient cooling system
Barangaroo South will feature a District Cooling Plant using water drawn from the harbour rather than building-specific cooling systems. This will significantly decrease the energy required to cool the buildings.

Renewable and low-carbon intensive energy
Electricity consumption in Barangaroo South will be partially offset by a combination of on-site and off-site renewable energy initiatives. These include the purchase of renewable energy sourced from an off-site solar farm in regional NSW and the installation of 6000 square metres of on-site solar panels.

Transport carbon offsets
The 23 000-strong workforce, 1200 residents and the estimated 33 000 daily visitors will be encouraged to use green travel options such as ferries, buses, light rail, trains and the network of bikeways being developed by the City of Sydney. The carbon emissions generated by all modes of transport will be offset through the purchase of carbon offsets.

WATER MANAGEMENT

When complete, Barangaroo South will be 'water positive'. This means that the precinct will export more recycled water than it uses. To achieve this a 90 000-litre rainwater tank will be used to store captured water. A water recycling system, capable of processing one million litres of wastewater each day, will be included in the development. The treated water will be used for toilet flushing and garden watering in Barangaroo South and nearby neighbourhoods. Another water-saving initiative is the installation of water-efficient fixtures and appliances.

ACTIVITIES

Knowledge and understanding

1 Outline the role and features of a typical CBD.
2 State the advantages of 'green' buildings.
3 Explain what a vertical garden is. What are the advantages of vertical gardens?
4 Describe the benefits of Headland Park at Barangaroo.

Applying and analysing

5 Write a report outlining the various ways in which the liveability of CBDs can be enhanced.
6 Develop a plan for an open public space in a CBD. Think carefully about the facilities and features you would like to include.

Investigating

7 In pairs, brainstorm a list of the ways in which the Barangaroo development enhances the liveability of Sydney. Record your findings in a table.
8 Investigate another example of a green building. What are its green features?

7.4

Urban housing densities

Density

Australian urban areas are often classified according to their **housing density** (the number of dwellings per unit of land). Housing density can be low, medium or high. Compared with other cities in the world, Australian cities have quite low housing densities, but this is beginning to change.

Low-density housing

The term 'low-density housing' refers to single-storey or two-storey houses that are detached—not attached to another house. Such houses have a front yard and a back yard. The low housing densities in Australian cities reflect Australians' preference for suburban living.

From the 1950s, private car ownership made it possible for many people to live some distance away from where they worked. As a result, many people moved from the crowded, older suburbs of the inner city to the new, low-density suburbs. These new suburbs were not well provided with public transport because people could drive their cars. Australia's suburbs are now dominated by low-density housing.

Building new suburbs is expensive because of all the **infrastructure** that is needed, such as roads, sewers, electricity poles, gas lines, schools, shops, parks and community services. Over time, the average size of a house block has decreased and houses have become larger. The number of houses in low-density suburban areas ranges from eight to fifteen per hectare.

Medium-density housing

'Medium-density housing' is the term used to describe residential developments in which more people live than in low-density housing. Medium-density developments typically feature between twenty-five and forty-five dwellings per hectare, but can hold up to eighty dwellings. Housing types typical of medium-density developments are semi-attached and attached (multi-unit) housing units (townhouses, villas and three-storey walk-up apartments). Many **master-planned housing estates** now feature a mix of medium-density housing types, such as those in Figure 7.4.1.

In response to increasing populations and the high cost of creating new suburbs, governments have encouraged the construction of medium-density housing, especially near major transport interchanges. Governments sometimes rezone land so that housing can be built on land that used to have a different function. This policy is known as **urban consolidation**, and aims to increase population densities in existing urban areas. In this way, governments hope to slow the rate of **urban sprawl** (the outward growth of suburbs).

Urban consolidation is not always a popular idea. Urban consolidation involves the demolition of existing low-density housing in established residential suburbs, and its replacement with medium-density dwellings. Many people complain that this alters the look and feel of the neighbourhood.

Medium-density housing has existed for many years in Australian cities. Before the introduction of cars, most suburbs were dominated by housing of a similar density to modern medium-density housing. The rows of terrace houses found in the inner suburbs of cities such as Sydney and Melbourne are an example of this.

7.4.1 Medium-density housing, Sydney

Master-planned estates

Master-planned housing estates are large-scale, integrated housing developments undertaken by a single developer. The physical and social infrastructure of the estate is planned by the developer. Master-planned estates include housing, shops, schools and community facilities. They are usually located on a city's urban–rural fringe (where a city's edge meets the country), but they are increasingly found on sizeable urban renewal sites.

High-density housing

There is no clear definition of high-density housing. It is generally considered to refer to more than sixty or eighty dwellings per hectare and a height of five or more storeys. Australian cities now feature many such buildings (see Figure 7.4.3). Apartment living is popular with 'empty-nesters'—older people whose children have left home—and couples without children.

SPOTLIGHT

Australia's suburban McMansions

The term 'McMansion' was first used in the United States of America in response to the increasing size of new homes there. Over time, the typical Australian home has grown, too, from one with three bedrooms, one bathroom and separate living areas, to an open-plan, four-bedroom home with multiple bathrooms, including an ensuite. Popular extras, such as rumpus and media rooms, walk-in wardrobes and kitchen pantries, add to the overall size of modern homes. The average floor area of a newly built Australian home is 227.6 square metres. This is an increase of 40 per cent on the average in 1985 of 162.2 square metres. The average new home built in Australia (see Figure 7.4.2) is 10 per cent bigger than one built in the United States and 9 per cent bigger than in New Zealand. On average, our homes are the biggest in the world.

7.4.2 Low-density suburban housing: Australian new homes are, on average, the world's largest.

7.4.3 High-density housing: apartment blocks in Sydney

ACTIVITIES

Knowledge and understanding

1 Define 'housing density'.
2 Explain how increased car ownership led to the growth of low-density suburbs.
3 Distinguish between low-, medium- and high-density housing.
4 Outline how governments promote urban consolidation.
5 Explain what a master-planned estate is.

Applying and analysing

6 Copy and complete the following table, listing the advantages and disadvantages of each type of housing.

	Advantages	Disadvantages
Low-density		
Medium-density		
High-density		

7.5

Urban consolidation

Increasing population density

Since the 1990s, governments in Australia have attempted to encourage more people to live in established suburbs. Urban consolidation is designed to increase population densities in existing urban areas, and to limit the loss of surrounding rural areas to urban sprawl.

Growth of urban sprawl

The **suburbanisation** of Australian cities really began with the introduction of trams and the development of suburban rail networks. New suburbs developed along railway lines. The railways were the dominant influence on city development from the 1860s until about 1920.

The arrival of the car meant that people had more choices of where to live and were no longer restricted to living near railway lines. This affected cities in two ways: spaces between major transport corridors were filled (people did not need to live close to public transport, so areas once empty of houses began to be developed); and urban areas grew outwards, a process often referred to as 'urban sprawl' (see Figure 7.5.1). Urban sprawl is very costly. New suburbs need expensive infrastructure: utilities such as electricity, water and sewerage; schools and hospitals; commercial centres; roads and public transport.

7.5.1 Urban sprawl increases the demand for expensive new infrastructure.

Urban consolidation

To slow the rate of urban sprawl, governments have introduced policies and programs to promote urban consolidation. Urban consolidation involves the construction of medium-density to high-density housing in already built-up areas in the inner and middle ring of suburbs (see Figure 7.5.2). It also increases the range of housing types available.

The signs of urban consolidation can be seen throughout Australia's cities. In more popular locations, where land is often much more expensive, multistorey apartment buildings are constructed. In inner-city locations, old industrial sites and land occupied by old port facilities are being redeveloped into high-density residential and commercial neighbourhoods.

Landuse zoning

The main way in which governments encourage urban consolidation is through their control of the planning process. Governments identify neighbourhoods that are close to major transport nodes, and change the landuse zoning rules in these areas to favour medium-density and high-density housing. Developers then buy up low-density housing or industrial/commercial sites and construct higher density housing units.

The urban consolidation debate

Policies promoting urban consolidation are often debated, especially by the residents of neighbourhoods that are affected. While those in favour of such policies see urban consolidation as a way of slowing urban sprawl, and of making greater use of existing infrastructure, those opposed see it as a threat to the character and liveability of existing neighbourhoods (see Table 7.5.3).

7.5.2 An artist's impression of medium-density urban consolidation in Maribyrnong, Victoria

7.5.3 The case for and against urban consolidation

The case for	The case against
• Urban consolidation reduces our reliance on cars. This improves air quality and reduces greenhouse gas emissions. It also reduces the congestion, noise and accidents associated with cars in urban areas. • Slowing urban sprawl protects agricultural land on the outskirts of cities. • Low-density sprawl is very expensive, so urban consolidation reduces infrastructure costs. • The social isolation and inequality experienced by those living in sprawling suburbia is reduced. In the outer suburbs there are limited local services and few transport alternatives to the car. The elderly, women and young teenagers are particularly disadvantaged. • The priority given to private transport and private low-density housing in sprawling suburbia often results in neglect of public transport and public spaces, particularly in the inner city.	• The impacts of urban sprawl have already been reduced as building blocks have become smaller. • The claim that existing inner-city infrastructure is not being used to capacity is exaggerated. • Increasing population density in already crowded areas reduces the liveability of neighbourhoods. Traffic congestion increases and parking becomes more difficult. • Existing facilities such as sporting fields, schools, hospitals and public transport interchanges struggle to cope with the increased population density. • 'We have lost our privacy. Our backyard is now overlooked by a five-storey apartment building. The building blocks out the sun in winter.' • 'The heritage streetscapes of our neighbourhood are being destroyed. Beautiful old homes have been bulldozed to make way for apartment buildings.'

ACTIVITIES

Knowledge and understanding

1 Outline how changes in transport affected Australian cities.
2 Define 'urban sprawl' and 'urban consolidation'.
3 What are the main arguments against allowing our cities to continue to spread outwards?

Applying and analysing

4 Study Figures 7.5.1 and 7.5.2. Describe the contrast you see between the two images.
5 Why do governments promote urban consolidation?
6 Write a short paragraph in response to the following statement: *The advantages of urban consolidation outweigh the disadvantages.*

7.6

Transport and cities

Car ownership and congestion

Traffic congestion affects the liveability of a city. In many cities around the world, the number of cars is increasing and traffic congestion is getting worse.

Car ownership is a good indicator of transport use in cities. In Australia, only about 13 per cent of city-based households do not have a car, while nearly 50 per cent have two or more cars. In London, 43 per cent of households don’t have a car. Rather than drive to work, most Londoners either walk, cycle or take public transport. In Shanghai, China, only 18 per cent of households have cars.

Population densities

Table 7.6.1 shows that the world’s most densely settled cities are found in South and East Asia. European cities also have high population densities. Australian cities (and many of those in North America) have low population densities. This is because much of the growth of these cities occurred in the years after World War II, when private car ownership was becoming more common.

Density and sustainability

It is generally thought that high-density urban areas are more sustainable than low-density, car-dependent cities. As a general rule, the lower the urban density, the greater the amount of energy consumed (see Figure 7.6.2). The main reason for this is that high-density cities have a greater reliance on public transport. Low-density cities often do not have the public transport infrastructure needed to move large numbers of people. Residents must rely on their cars.

Urban population density is only one factor influencing the type of transport that people use. People living in cities with a concentration of economic activity in the central business district (CBD) are more likely to use public transport, ride bicycles or walk to work. In cities where economic activities are spread across the urban area, people are more likely to drive to work.

In Australia, the growth in the CBD-based financial services sector has led to a small but significant increase in public transport use. As well, more people are walking or cycling to work. This trend is reinforced by the growing preference for inner-city living.

7.6.1 Population densities of selected cities, 2015

City	Country	Population (million)	Area (km^2)	Population density (per km^2)
Asia				
Jakarta	Indonesia	30.5	3 225	9 500
Shanghai	China	23.4	3 820	6 100
Karachi	Pakistan	22.1	945	23 400
Mumbai	India	17.7	546	32 400
Dhaka	Bangladesh	15.6	360	43 500
Europe				
Moscow	Russia	16.1	4 662	3 500
Paris	France	10.8	2 845	3 800
London	UK	10.2	1 738	5 900
North America				
New York	USA	20.6	11 642	1 800
Los Angeles	USA	15.0	6 299	2 400
Chicago	USA	9.1	6 856	1 300
Toronto	Canada	6.4	2 287	2 800
San Francisco	USA	5.9	2 797	2 100
Australia				
Sydney	Australia	4.0	2 037	2 000
Melbourne	Australia	3.9	2 543	1 500
Brisbane	Australia	1.9	1 972	1 000
Perth	Australia	1.7	1 566	1 100
Adelaide	Australia	1.1	852	1 300
Canberra	Australia	0.4	472	900

Source: Demographia World Urban Areas, 2015

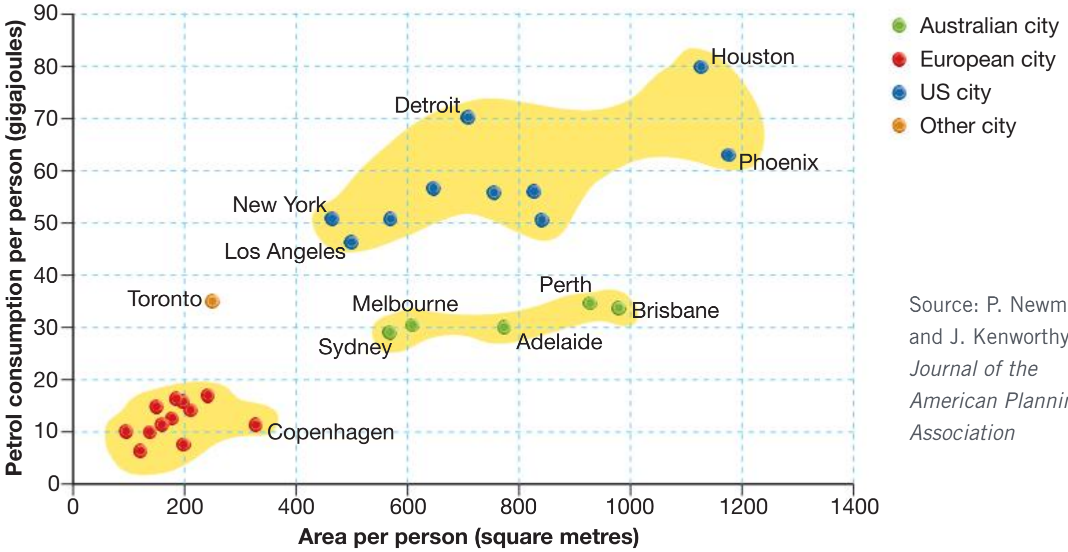
‘Smart growth’ strategies

The ‘smart growth’ initiative in North America is an approach to designing neighbourhoods. The initiative focuses on building:

- facilities that encourage people to walk
- bicycle lanes
- mixed-use buildings that include shops and housing.

In Europe, the terms ‘compact city’ and ‘urban intensification’ are used to describe similar planning models.

7.6.2 Relationship between urban population density and petrol consumption



Source: P. Newman and J. Kenworthy, *Journal of the American Planning Association*

SPOTLIGHT

Sydney bike paths

In Sydney, of those households closest to the CBD, 30 per cent don't own a car. Over 32 000 people living in the City of Sydney use their bikes at least once a week. To promote the riding of bikes, the City of Sydney is building a 200-kilometre bike network of dedicated bike paths separated from cars and pedestrians. It is also offering free courses on riding in the city and bike care and maintenance at the Sydney Park Cycling Centre.

7.6.3 Bike paths separated from traffic and pedestrians are safer for cyclists and encourage more people to ride their bikes.

ACTIVITIES

Knowledge and understanding

1 State where the world's most densely settled cities are located.
2 Explain why European cities have population densities greater than those found in North America and Australia.
3 State why high-density cities are generally considered more sustainable than low-density cities.
4 Explain how the distribution of economic activity affects the sustainability of cities.
5 Outline the relationship between car ownership and urban population density.
6 Outline the aims of 'smart growth' strategies.

Geographical skills

7 Study Figure 7.6.2. Write a paragraph comparing Australian cities with cities in Europe and the United States of America.

7.7

Better shopping centres

Impact of shopping centres

Suburban shopping malls have a significant impact on the environment. With their huge car parks, they encourage car use. They also consume vast amounts of energy on lighting and air-conditioning to keep people comfortable. But shopping centres are changing.

Design of shopping centres

Because shopping centres have huge car parks, they encourage us to travel there by car rather than use public transport. They also consume vast amounts of energy. Think of the features of the typical large shopping mall. It has few, if any, windows, so a lot of artificial lighting is needed. It is climate-controlled by huge air-conditioners to keep people comfortable so that they will stay longer and spend more money.

Shopping centres are, however, beginning to change. Architects and designers are looking at ways to reduce the environmental impact of shopping complexes, and they are becoming more like traditional street-based shopping districts. Shops are laid out along open pedestrian malls. Because these areas are open, they do not need to be lit or air-conditioned, and this greatly reduces energy use.

7.7.1 Rouse Hill Town Centre makes use of an open plan shopping mall, using natural light and ventilation to massively reduce energy usage.

The Rouse Hill Town Centre, in Sydney's north-west (see Figure 7.7.1), was constructed in the mid-2000s. It won architectural acclaim throughout the world for its innovative, energy-saving design. During its first full year of operation, the centre achieved an ecological footprint 32 per cent lower than that of a standard New South Wales regional shopping centre.

Shopping centres of the future

The Orion Springfield shopping centre in Ipswich, in south-east Queensland, has been designed to minimise its environmental impact. It is considered the most environmentally friendly shopping centre in Australia and has attained a six-star rating, the highest level possible, from the Green Building Council of Australia.

Like the Rouse Hill development, Orion Springfield has open pedestrian malls that link low-rise shopping areas. Sun-shading devices such as trees, shade sails and verandahs reduce the energy needed for climate control. Special features reduce water usage. Huge water tanks capable of holding 780 000 litres collect rainwater. This is then mixed with recycled water to flush toilets, clean bins, fill the centre's water features and water its gardens.

Designers have even planned ahead for the centre's eventual demolition. The structure's steel frame has been designed for easy disassembly, allowing at least 95 per cent of the steel to be recycled.

7.7.2 Top Ryde City Shopping Centre, which not only includes a shopping centre but an indoor-outdoor restaurant precinct, multi-screen cinema complexes and other types of entertainment ventures as well as residential towers

Integrated centres

Another important trend is to build integrated commercial–residential complexes. One is the new Top Ryde City shopping and residential complex in suburban Sydney (see Figure 7.7.2). This massive complex includes three department stores and more than 200 other retail outlets, restaurants, a large food court, cinemas and a public library. On top of the complex are three large, multistorey apartment buildings with resort-style facilities. Underneath is a bus transit hub. Residents claim that they rarely have to leave the complex. 'Everything you need is just downstairs,' says one person who lives there.

Promoting sustainability

There are a variety of ways in which to reduce the environmental footprint of retail complexes. These include:

- design that takes into account the path of the sun and increases the effectiveness of sunshades and wall insulation
- double-glazing to reduce heat transfer
- high-efficiency air-conditioning systems
- energy-efficient lighting
- motion detectors for toilet and staircase lighting
- 'green roof' strategies such as solar panels and water-harvesting capabilities
- indoor gardens to reduce heat
- slow-down technologies for escalators and travellators
- recycling bins.

Traditional shopping strips

The liveability of neighbourhoods can be improved by upgrading existing local shopping strips. Many local shopping strips have adapted, and now thrive because they are more accessible and convenient than the big shopping centres. Some have become flourishing cafe and restaurant strips and make an important contribution to the night-life of communities.

ACTIVITIES

Knowledge and understanding

1. List the environmental impacts of shopping malls.
2. Explain how, and why, the design of shopping malls is changing.
3. Explain how traditional shopping strips have adapted to the competition from big shopping malls. How does this change enhance the liveability of neighbourhoods?

7.8

Better recreational spaces and schools

Better recreational spaces

In densely populated cities, there will always be competing demands for the limited supply of land. As the world's population becomes increasingly urbanised, there is a growing demand for recreational spaces. It is important to ensure that our recreational spaces are well designed and that they meet the varied needs of the community. It is also important that government authorities insist on recreational space being part of all future developments.

Recreational spaces provide important health benefits by giving people somewhere to exercise and somewhere to relax. Benefits of this kind are sometimes referred to as 'wellness'. Fresh air itself has numerous health benefits. A recent study from California, in the United States of America, for example, found that the air outside was on average 25 to 62 per cent cleaner than the air people breathe inside buildings.

In Australia, one of the best examples of recreational spaces is the Geelong Youth Activities Area, shown in Figure 7.8.1. The area has won a number of design awards, including the 2010 Australia Award for Urban Design. It caters for many different activities. There are outdoor areas for large events such as music festivals, there are basketball courts and spaces for BMX and skateboarding, and there is wireless internet connection throughout. Importantly, young people were involved in the design of the area, and it is a place where activities popular among young people are not just tolerated, but promoted. For example, there are 'skateable' surfaces where skateboarding tricks are encouraged.

7.8.1 The award-winning Geelong Youth Activities Area provides a range of activities for the city's young people.

7.8.2 (a) Before 2002, a freeway ran through Seoul, South Korea, where once the Cheonggyecheon River had flowed. (b) The Cheonggyecheon River redevelopment saw the freeway demolished, the river returned and parklands built.

Reclaiming recreational space

Reclaiming Seoul's river

Seoul, the capital of South Korea, has a population of more than 10 million people. This huge city has a reputation for heavy traffic and high pollution levels, and for being a 'concrete jungle'. In 2005, however, the city hit international headlines for an amazing parkland project.

Running through the centre of Seoul is the Cheonggyecheon River, whose name means 'clear valley stream'. By the 1970s, the river was heavily polluted, and run-down buildings were found along its concrete-lined channel. It was very far from being a clear valley stream. As the average wealth of South Koreans grew, so did the number of cars they owned. The Cheonggyecheon River was filled in and converted into a road. Later, a six-lane elevated freeway was constructed.

In 2002, Lee Myung-bak, who was mayor of Seoul at that time, announced an extraordinary plan to tear down the freeway and build a 12-kilometre-long park along the course of the old river. At the time, the freeway carried more than 160 000 cars a day and was considered crucial to Seoul's economy.

Within two years, the freeway was gone and so were the cars. The loss of the freeway forced people to rethink their travel habits. Public transport use increased. The Cheonggyecheon River was restored and began to flow again, and the people of Seoul were given a beautiful new park to enjoy. One amazing outcome of the project is that the average temperature around the park has fallen by up to 3 degrees Celsius. This is because the hard concrete surfaces that once absorbed heat have been replaced by grasses and water. The Seoul experience was so successful that similar projects are being planned in Shanghai, China.

7.8.3 Goods Line, Sydney, has transformed an abandoned railway line into a recreational space.

Reclaiming railways

The Goods Line, shown in Figure 7.8.3, is located in Ultimo in the inner city of Sydney. It is an urban renewal project modelled on the Highline in New York. The Goods Line opened in 2015 and has transformed an abandoned railway line into a recreational space linking new office and apartment buildings and the new building in the University of Technology, Sydney, to Central Station.

Better schools

Until recently, the design of schools had not changed very much in hundreds of years. Most schools still have separate classrooms with desks in neat rows and a board at the front of the room. Learning is beginning to change, however, and the way we build schools is also beginning to change.

Today, there is much greater use of technology in classrooms. Even very young primary school students have access to computer-based learning. It is common for students to be working not just with other students in their class, but with students on the other side of the world—for example when doing maths problems on the internet.

SPOTLIGHT

Schools of the future

At the Hellerup School, there are few classrooms. Instead, there are many rooms of different sizes that can be used for meetings between students and teachers. There are large open spaces where students can work by themselves or in small groups, as well as small rooms for quiet work.

Hellerup, and schools such as Dandenong High School in outer Melbourne, take a non-traditional approach to learning. As a result, they need buildings that serve different purposes and that are flexible. For example, a class may work together for part of a lesson and so need a larger space, then work in small groups on a research task and so need a different type of space.

In Dandenong, web-based learning programs such as Moodle help students to stay connected with teachers and peers. Students access these online resources through a range of technologies. At Hellerup, students are encouraged to use their smart phones as a way of communicating with teachers and also to help with research tasks.

7.8.4 Hellerup School in Denmark has adopted a different design approach.

ACTIVITIES

Knowledge and understanding

1 Explain why it is important that authorities insist on the provision of recreational spaces in new urban developments.

2 Describe the benefits of well-designed recreational spaces.

3 Discuss why the Geelong Youth Activities Area is considered to be well designed.

4 List the reasons why schools need to be redesigned.

5 Explain why flexible spaces are important in modern school design.

Applying and analysing

6 List ideas for transforming your local park or school playground into a better recreational space. Construct a sketch map showing the key features of your design. To accompany your map, prepare a short report outlining the key features and the reasons you have included them.

7 Read the text on reclaiming cities for parkland, then do the following activities.
   a Describe the impact of Seoul's growth on the Cheonggyecheon River.
   b How has the river been transformed in recent years?
   c Outline the redevelopment of the Goods Line.
   d What have been the benefits of the Goods Line recreational space to the Ultimo district?
   e Why do you think the construction of the space has brought these benefits?

8 Write an extended response comparing the design of your school to that of Hellerup School.

Water: A renewable natural resource

CHAPTER 8

Water is our most precious natural resource; we can't live without it. Under the right conditions it is a renewable resource, with rain and snowfall regularly topping up storages. However, water is a very unevenly distributed resource. Shortages of clean water can impact negatively on human wellbeing and slow the rate of economic development. As countries struggle to access declining water supplies, the potential for outbreaks of armed conflict grows.

In this chapter we focus on the importance of water, the water cycle, the global distribution of water resources and the various ways in which people use water.

INQUIRY QUESTIONS

- What are the different ways in which people value water?
- What is the difference between weather and climate?
- What are the different forms that water takes at different stages of the water cycle?
- What are the principal water storages?
- What are the direct, indirect and competing uses for water?

GLOSSARY

air mass	a body of air with similar temperature, humidity and pressure
atmospheric pressure	the pressure/weight of the atmosphere at sea level
aquifer	a layer of rock that can store significant quantities of water
blue water	fresh surface water and groundwater, i.e. lakes, rivers and aquifers
catchment	the area drained by a river and its tributaries; a river basin or drainage basin
climate	the long-term weather pattern for a place or region
coalescence	the merging of two or more water droplets or particles into one
condensation	the change from water vapour to liquid water in the form of dew, fog or cloud droplets
drainage basin	the area drained by a river and its tributaries; a catchment or river basin
freezing level	the altitude at which the temperature is 0° Celsius
green water	the precipitation on land that does not run off or become groundwater, but is stored in the soil or temporarily stays on top of the soil or in vegetation
grey water	water generated from domestic activities such as washing clothes, dishwashing and bathing
humidity	the amount of moisture in the air
photosynthesis	the process by which green plants make glucose (sugar), using water, carbon dioxide and sunlight
precipitation	any moisture reaching the surface of the earth, such as rain, hail, snow and sleet
run-off	the movement of surface water down slopes
sanitation	the infrastructure related to the collection and disposal of sewage (human waste)
soak	a hole, dug in a riverbed, into which groundwater soaks
spring	a place where underground water rises to the earth's surface
tributary	a smaller river or stream that flows into a larger one
virtual water	the volume of fresh water that is consumed (or polluted) when a product is created
water cycle	the processes by which water circulates between the earth's oceans, atmosphere and land
water footprint	the total volume of fresh water used by an individual, a household, a business, a community or a country
water table	the level at which under-rock strata are saturated by water
watershed	the boundary between catchments
weather	the daily atmospheric conditions of a place

8.0 A woman carries water in Africa.

8.1

The importance of water

Water and life

Water is essential to all forms of life on earth. Plants and animals depend on water, and access to clean, fresh water is essential to the wellbeing of humans. Without water, the earth would be a dusty, lifeless planet.

Plants (producer organisms) are the basis of the earth's food chain. Plants produce energy (glucose) in a process called **photosynthesis**. Photosynthesis (from the Greek words *photo*, meaning 'light', and *synthesis*, meaning 'putting together') involves the production of sugar using the sun's energy (light), carbon dioxide (CO_2) and water, with oxygen a 'waste' product. Water is critical to this process. Water, containing dissolved nutrients obtained from the soil, is drawn into the plant through its root system.

Photosynthesis can be represented by the following word equation:

carbon dioxide + water + light energy →
glucose (sugar) + oxygen

Photosynthesis is the most important biochemical process—nearly all life depends on it.

Water is also critical to the metabolic processes of animals. It is, for example, the solvent in which the body's waste products are dissolved and then expelled.

Water and human wellbeing

The human body is largely made of water—between 55 and 78 per cent, depending on a person's body size. To function properly, the body needs between 1 and 7 litres of water a day. The actual amount depends on a person's level of physical activity, and the temperature and humidity. Most water is taken in via food and drink. During exercise people need to drink more water.

The main role of water is to remove waste from the human body. It also provides the basis of saliva (which aids in digestion) and the fluid that surrounds the body's joints. It also helps the body to regulate its temperature through perspiration.

Aesthetic, spiritual and recreational value of water

The aesthetic appreciation of landscapes is one of the most important ways that people relate to the biophysical environment. Water views are especially valued. The prices paid for waterfront properties and those with water views are an indication of the value attached to the scenic amenity of such landscapes.

Water also is central to the practices and beliefs of many religions. Water cleanses. It washes away impurities. Almost all Christian churches have initiation rituals (for example baptism) involving the use of water.

For Hindus all water is sacred. Holy places are usually located on the banks of rivers, coasts, seashores and mountains. Sites where two or more rivers meet carry special significance and are especially sacred.

Muslims must be ritually pure before approaching God in prayer. Some mosques have a courtyard with a pool of clear water in the centre, but in most mosques water for washing is found outside the walls.

In Judaism, ritual washing is intended to restore or maintain a state of purity. Ritual washing includes washing the hands,

8.1.1 Water plays an important role in the rituals of many of the world's great religions.

8.1.2 Water in its various states is a major recreational resource.

or the hands and the feet, or total immersion, which must done in 'living water'; that is, in the sea, a river, a **spring** or a mikveh (a bath used for the purpose of ritual bathing).

Water-based recreational activities are among the most popular forms of leisure. Inland waterways, for example, are popular for boating, water skiing, swimming, fishing, and canoeing. Coastal waters are popular for surfing, windsurfing, diving, boating and fishing.

The importance of water to indigenous cultures

While Western culture does pay some attention to the spiritual value of water, it is very much a secondary consideration. The dominant value system that determines how water is used is an economic one. In indigenous societies, on the other hand, the situation is reversed. The dominant cultural perspective places great importance on spiritual aspects of water and water bodies such as lakes, streams, and springs.

The Western idea that water is a resource to be exploited for the benefit of people therefore stands in contrast to the value that Aboriginal and Torres Strait Islander people place on water. They see water as part of their responsibility for the care of the land.

Economic value

Water is an economic good. We use it in crop, fibre and livestock production, manufacturing, and energy production. Water is, as a result, considered to be a cost of production.

Putting a price on water is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources. If the price of water is set too low it will be wasted. If it is set too high people are denied access to an essential resource.

ACTIVITIES

Knowledge and understanding

1. Explain why water is so important to life on earth.
2. Outline the aesthetic, spiritual, recreational and economic value of water.

Applying and analysing

3. Demonstrate why access to clean, fresh water is important to human wellbeing.
4. List all the different ways in which you have used water in the past week.
5. Construct a mind map illustrating the value of water.

8.2

Weather and climate

Definitions

To fully understand the global distribution of the earth's water resources it important that we understand the factors that determine **weather** and **climate**. The words 'weather' and 'climate' mean different things. Weather is the day-to-day condition of the atmosphere at a particular place; climate is the long-term weather pattern for a place or region.

Weather

Weather includes all the daily changes in temperature, **precipitation**, wind, sunshine, **humidity** (the amount of moisture in the air) and **atmospheric pressure**.

To understand weather, you need to understand atmospheric pressure. Atmospheric pressure is the weight of the air pressing down on the earth's surface. When air is heated by the energy of the sun, it rises. This forms areas of low pressure. When air cools, it sinks towards the earth's surface. This forms areas of high pressure. The location of high-pressure and low-pressure systems helps us predict the weather. High-pressure systems are usually associated with settled, or fine, weather. Low-pressure systems are generally associated with unsettled weather. Figure 8.2.1 shows how high-pressure and low-pressure systems form.

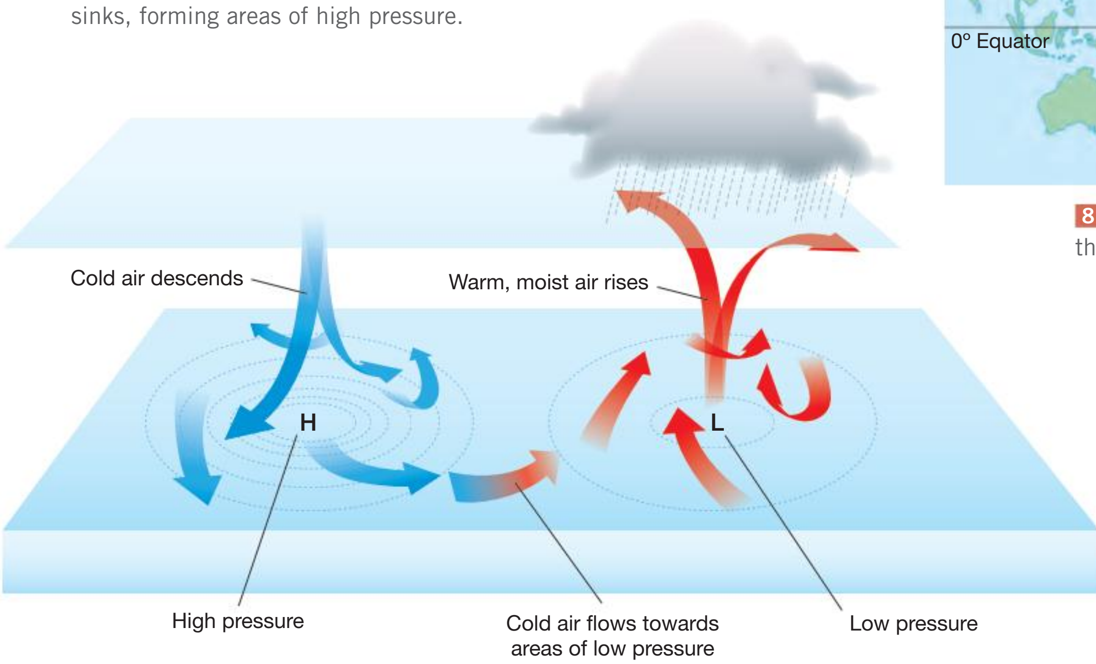
Climate

Climate is the average weather experienced in a place over many years. The climate of a place depends on its latitude, its altitude (height above sea level), its aspect, how close it is to the sea, ocean currents and the season. The factors that contribute to this long-term pattern are discussed below.

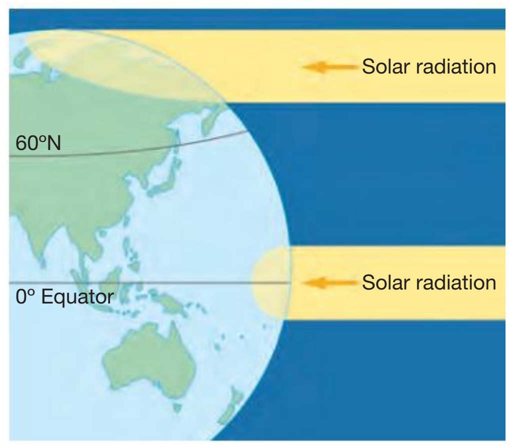
Factors affecting temperature

LATITUDE

As Figure 8.2.2 shows, solar energy has twice the area to heat at 60° north (and 60° south) that it has at the Equator. Therefore, average temperatures are lower at higher latitudes.



8.2.1 When air near the earth's surface is heated rapidly, it rises, forming areas of low pressure. As the air cools, it sinks, forming areas of high pressure.



8.2.2 The impact of latitude on the heating of the earth's surface

SEASONAL DIFFERENCES

The angle at which the earth tilts as it revolves around the sun influences:

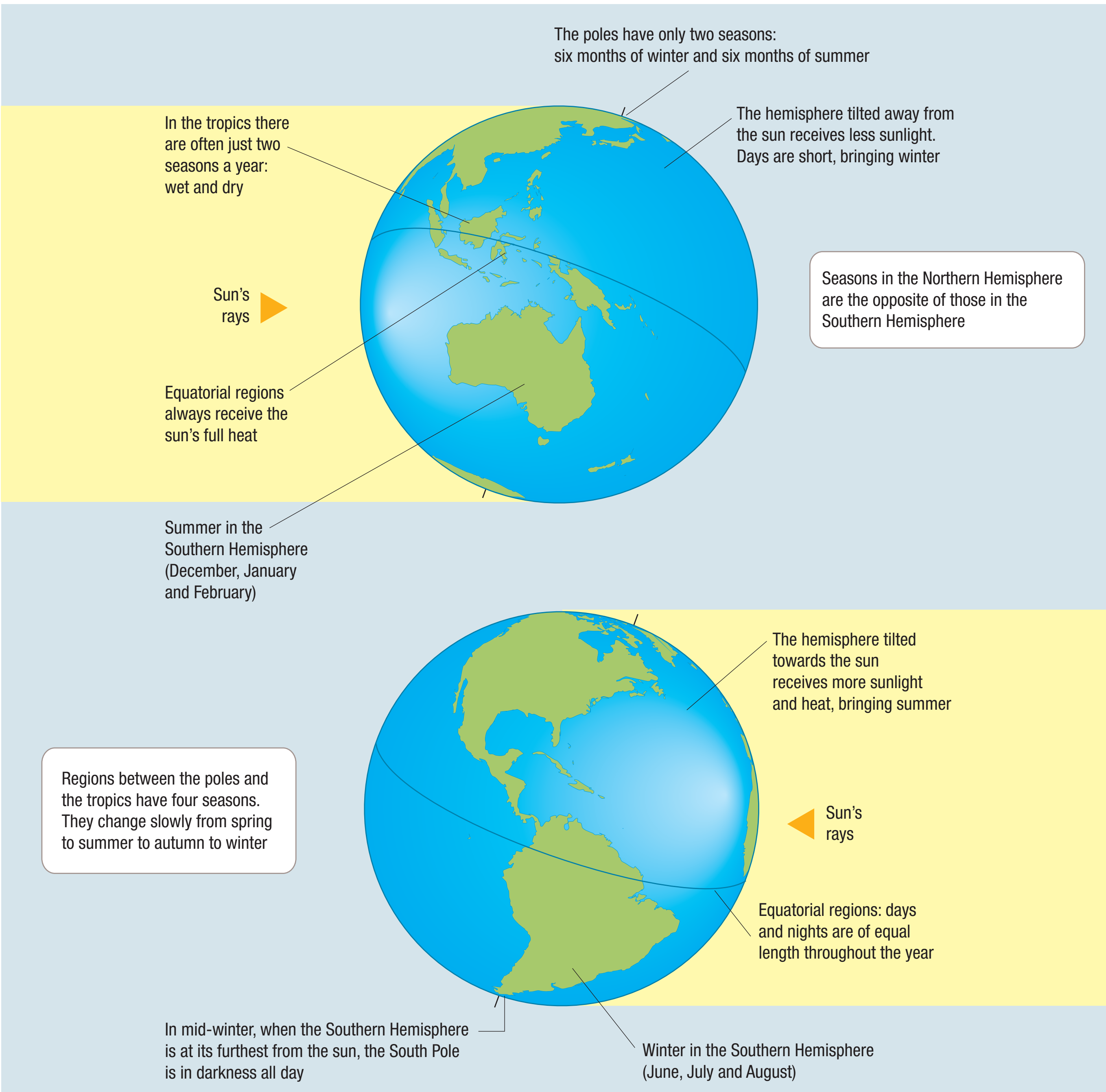
- the angle at which the sun's rays reach the earth
- the changing seasons
- the number of daylight hours.

Figure 8.2.3 shows that from December to February the Southern Hemisphere is tilted towards the sun. From June to August, the Northern Hemisphere is tilted towards the sun. This is why the Northern Hemisphere has its summer in the middle of the year, while Australia is having its winter.

Because the earth's axis is tilted at an angle of 23.5°, there are seasonal differences in the daily number of daylight hours. The shorter the day, the less opportunity there is for the earth and its atmosphere to absorb heat.

ASPECT

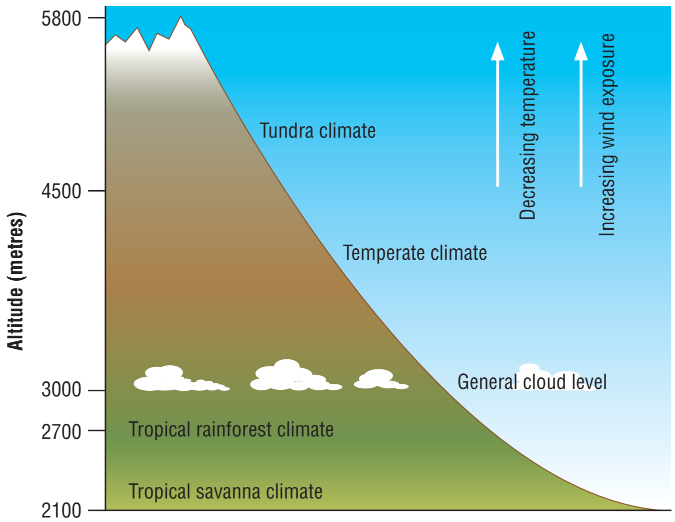
The direction in which a feature faces is known as its aspect. A feature that faces the sun will generally be warmer than one that does not.



8.2.3 The seasons of the earth are the result of the earth's revolution around the sun and the tilt of the earth on its axis.

ALTITUDE

Because of their altitude (elevation), or height above sea level, mountain areas are cooler than areas at lower elevations. Mt Kilimanjaro is Africa's highest mountain. At 5894 metres above sea level, its top is permanently covered with snow, even though it is only just south of the Equator. On average, temperature drops by approximately 6.5°C with every 1000 metres of increase in elevation (see Figure 8.2.4).



8.2.4 The relationship between increasing altitude and changes in climate

Factors affecting temperature and rainfall

Several factors influence both temperature and rainfall.

PREVAILING WINDS

The prevailing wind direction is the direction from which the wind blows most often. The temperature of the prevailing wind is affected by the area it blows from and over. When prevailing winds blow over warm bodies of water, they often bring rain.

DISTANCE FROM THE SEA

Distance from the sea influences both temperature and rainfall.

Temperature

The sea gains and loses its heat much more slowly than the land; the sea maintains more even temperatures. Places near the coast therefore experience smaller differences in temperature than inland places. Places away from the coast can have higher temperatures during the day and lower temperatures at night because of the speed at which land gains and loses heat.

Rainfall

Winds blowing off warm seas carry a lot of moisture. Because of this, places near the coast often receive higher rainfall than those further inland. By the time the winds reach inland areas, they have lost most or all of their moisture.

OCEAN CURRENTS

The temperature of ocean currents also influences both temperature and rainfall.

Temperature

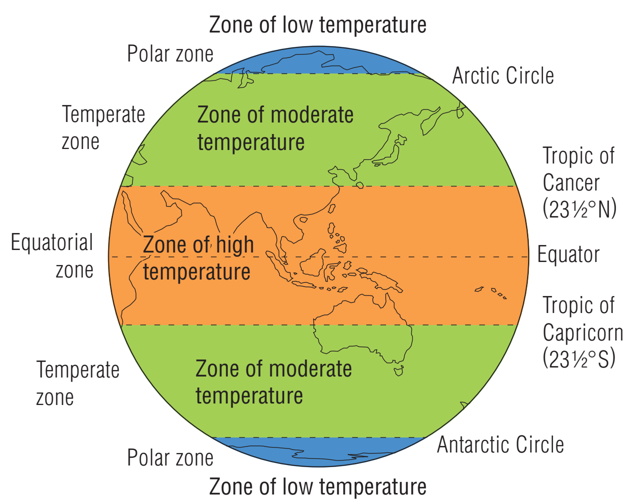
Oceans absorb heat during the day and release it slowly during the night. This helps keep coastal areas much warmer than inland areas.

Rainfall

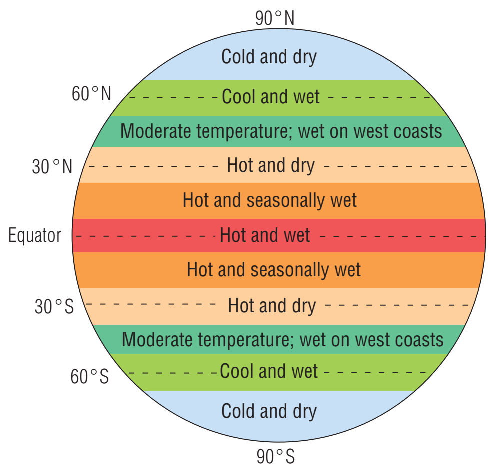
Water evaporates much more quickly from oceans affected by warm ocean currents. As a result, nearby coastal areas are likely to have higher levels of rainfall. Areas affected by cold ocean currents are likely to experience lower rainfall as a result of lower evaporation rates.

MOUNTAIN BARRIERS

Mountains act as barriers to the movement of air. When warm, moist air meets a mountain, it is forced to rise. As the air cools, the moisture condenses and rain falls on the windward side of the mountain—the side facing the wind. This process is known as orographic rainfall. The air that then flows over the mountain is much drier. Deserts are often found on the leeward (sheltered) side of large mountain ranges. This is known as the rain shadow effect.



8.2.5 The broad temperature zones of the world



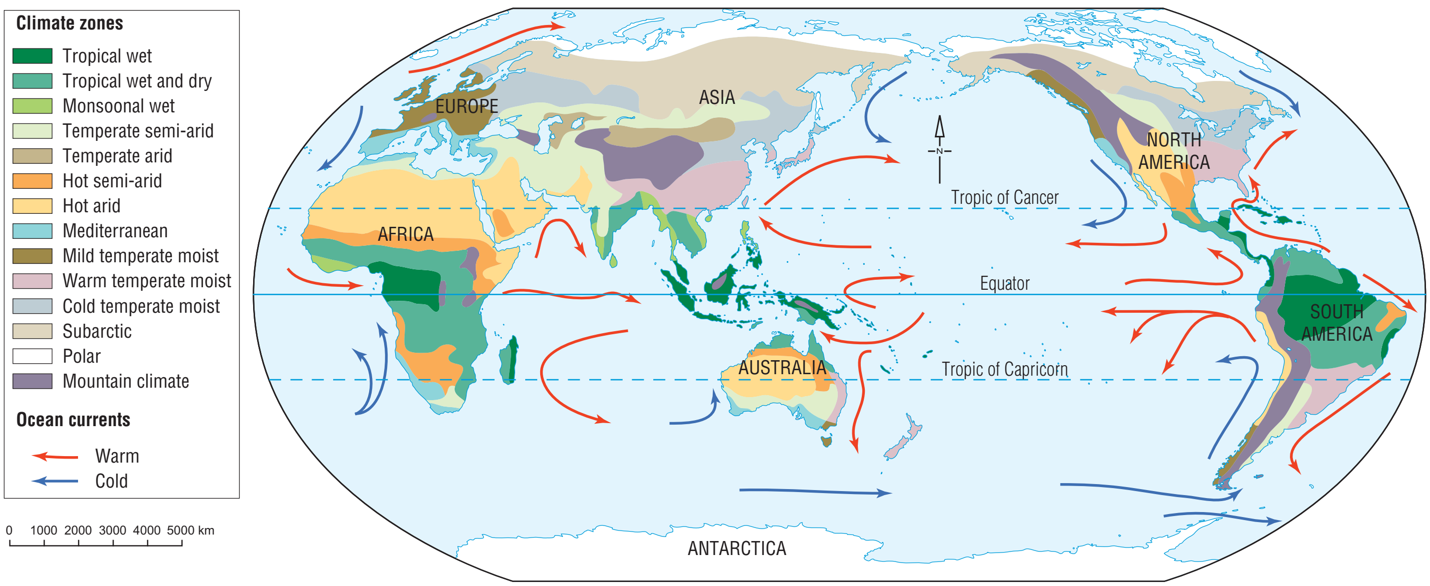
8.2.6 The broad rainfall zones of the world

World climate pattern

There are three very broad zones of climatic difference across the world. They are shown in Figure 8.2.5. These differences in climate are caused by the different amounts of heat received from the sun.

These three broad zones are only a general indication of climatic difference. A more specific indication can be made by adding rainfall patterns. Figure 8.2.6 shows the broad rainfall zones of the world.

The variety of climate zones across the world results from interactions between temperature and rainfall. These zones are shown in Figure 8.2.7.



8.2.7 Ocean currents and climate zones

ACTIVITIES

Knowledge and understanding

1 Explain the difference between weather and climate.

2 Study Figure 8.2.1 and complete the following table.

	How the system develops	Weather associated with the system
High-pressure system		
Low-pressure system		

3 Explain how latitude, seasonal differences, aspect and altitude affect temperature.

4 Describe how prevailing winds, distance from the sea, ocean currents and mountain barriers affect both temperature and rainfall.

Geographical skills

5 Study Figure 8.2.7 and do the following tasks.

a Name the two lines of latitude between which the tropical climate zones are located.

b Identify the continents where the monsoonal climate zones are located.

c Name one continent that does not have a mountain climate zone.

d Identify the types of climates that are associated with cold ocean currents.

8.3

The water cycle

A closed system

The **water cycle**, or hydrological cycle, is often referred to as a 'closed system' because the same water has been circulating since the earliest days of the planet. No water is added and none is taken away. Humans interact with the water cycle in many ways, some of which pollute the water and disrupt the cycle.

Movement and change

Water is always moving and changing: it changes its form (ice and snow, liquid water or water vapour) and its location. Water can be used by humans, animals and plants during its journey through the cycle, but it always goes back to nature.

Since the beginning of industrial civilisation, the uses people make of water have multiplied. The water cycle is shown in Figure 8.3.1.

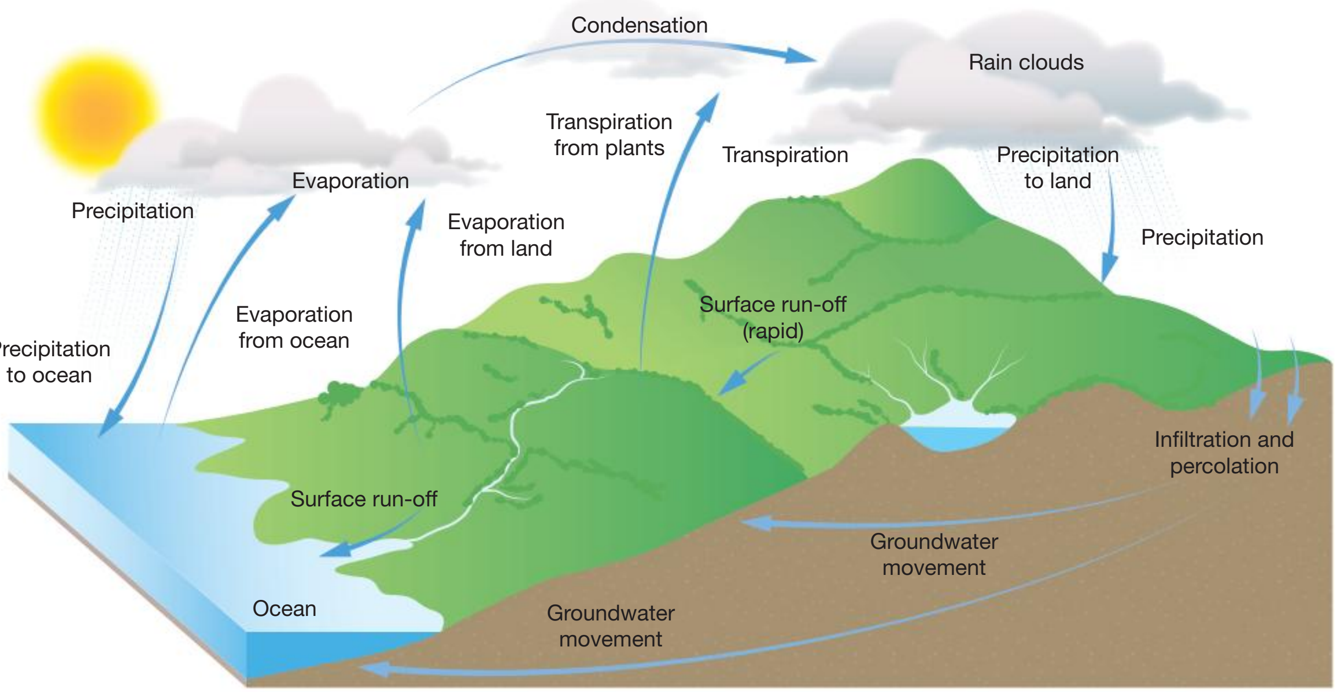
8.3.1 The water cycle

Evaporation
The process by which water is changed into water vapour. Water can evaporate from any moist surface, but about 84 per cent of the water vapour in the atmosphere comes from the oceans.

Transpiration
The process by which the water absorbed by plants passes into the atmosphere from the plant surface, mainly from the leaves

Condensation
The changing of water vapour into droplets of liquid water in the form of dew, fog or clouds

Precipitation
Any or all of the forms of water, whether liquid (e.g. rain) or solid (e.g. hail, snow), that fall from clouds and reach the ground



Infiltration
The movement of water from the land surface into the soil

Groundwater
Water beneath the earth's surface that fills pores between materials such as sand, soil and gravel

Groundwater movement
The slow underground movement of water. Subsurface water may eventually return to the surface (e.g. as a spring) or seep into the oceans, lakes or river channels.

Run-off
The movement of surface water down slopes

8.3.2 A snow-making machine, or 'snow gun', Thredbo, New South Wales

Human impacts

Humans interact with the water cycle in a variety of ways, by:

- building structures, such as levee banks, to protect farmland and settlements from flooding
- storing water in dams in areas where rainfall is unreliable
- using canals and pipelines to transport water from one area to another
- sinking wells and bores to extract groundwater
- using water and gravity to generate hydro-electricity
- using large bodies of water such as oceans or lakes to dump sewage and pollutants
- clearing land for agriculture, mining and urban development
- creating artificial precipitation, for example snow making (see Figure 8.3.2).

ACTIVITIES

Knowledge and understanding

1 Explain why the water cycle is referred to as a 'closed system'.
2 Describe the difference between evaporation and transpiration.

Applying and analysing

3 Select four dot points from the section 'Human impacts'. Describe how each action affects the water cycle; for example 'Storing water reduces run-off'.
4 Imagine you are a molecule of water. Write a short story about your movement through the water cycle.
5 Construct a diagrammatic representation of the water cycle. On your illustration, label the main processes involved in the water cycle. Use colour coding to identify those processes that involve a change in state and those that involve a change in the physical location of water.

8.4

Precipitation

Types of precipitation

Precipitation is the term given to any form of moisture that reaches the earth's surface from the atmosphere. Rain, hail, snow and dew are all forms of precipitation.

Rain

Rain occurs when growing cloud droplets become too heavy to remain in the cloud and, as a result, fall towards the earth's surface. Rain can also begin as ice crystals that join together to form large snowflakes. As the falling snow passes through the **freezing level** into warmer air, the flakes melt to become raindrops.

The smallest raindrops reaching the earth's surface are over ten times the size of the average cloud droplet. **Coalescence** is the merging of the smallest cloud droplets to create larger droplets of water. These larger droplets then fall as rain or snow.

DID YOU KNOW?

Approximately 505 000 cubic kilometres of water fall as precipitation each year, 398 000 cubic kilometres of this over the oceans. Given the earth's surface area, this means that the globally averaged annual precipitation is 990 millimetres.

8.4.1 A summer storm brings rain to Sydney.

Hail

Hail is made up of hailstones, or large, frozen raindrops that are produced in intense thunderstorms. As water droplets rise rapidly in a storm, they form ice pellets that continue to grow until they begin to fall under the force of gravity. On reaching the bottom of the cloud, some of these ice pellets are carried back to the top of the cloud. As the ice pellets once again fall through the cloud, another layer of ice is added and the hailstone grows even larger. Once the hailstone becomes too heavy to be supported, it falls out of the cloud towards the earth's surface. The hailstone reaches the ground as ice since it does not spend enough time in the warm air to melt before it lands.

Snow

Snowflakes originate as tiny ice crystals in clouds where the temperature is at or below freezing point (0°C). As an ice crystal rises and falls within a cloud, it grows by combining with other ice crystals, and takes on the six-sided shape of a snowflake, shown in Figure 8.4.2. When the snowflake becomes heavy enough, it falls towards the ground. If the temperature in the lower atmosphere and at ground level is at or below 0°C, snow will gather. In places where the temperatures remain mostly below zero, fallen snow is compressed to form an ice sheet or a glacier, and can sometimes be stored in this form for thousands of years.

8.4.2 The snowflake is made up of hundreds of tiny ice crystals.

Dew

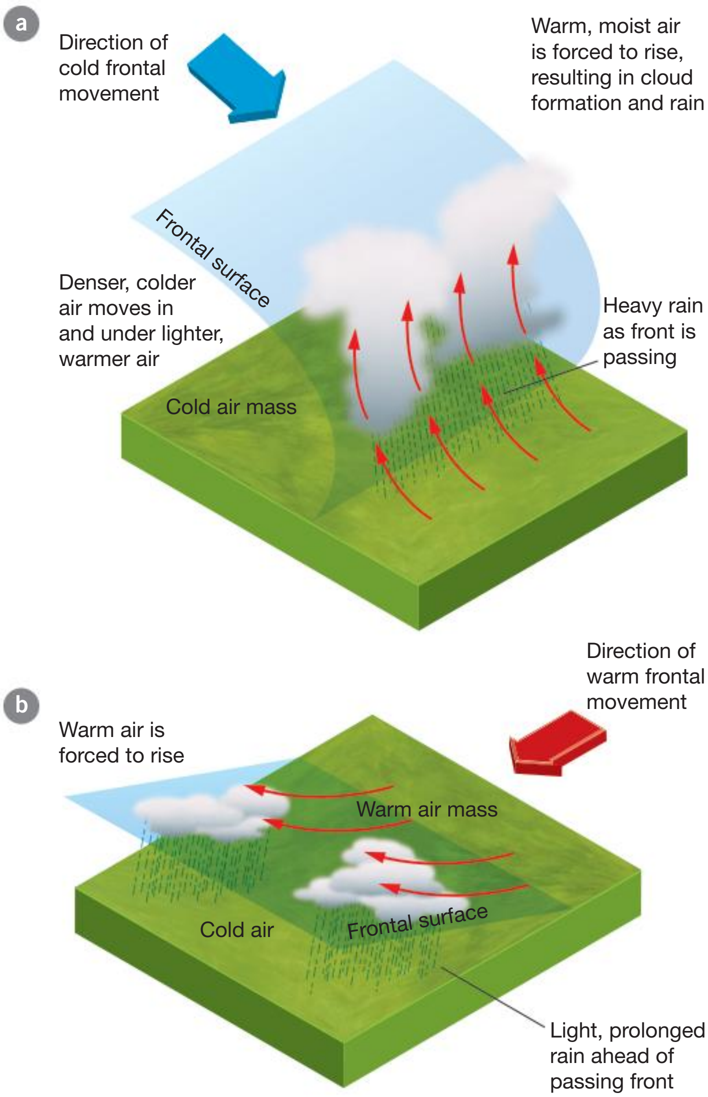
Water vapour in the air will form droplets known as dew (see Figure 8.4.3) when the air comes into contact with a cold surface. The temperature at which this occurs is known as the dew point. When temperatures are low enough, dew becomes ice and is called frost.

8.4.3 Dew forms when moist air comes into contact with a cold surface.

Rising air and precipitation

Under normal conditions, the temperature of the air decreases as altitude increases. Cold air cannot hold as much moisture as warm air. Any water vapour that the rising air cannot hold condenses into water droplets (or ice crystals) and forms clouds. Warm, moist air is pushed up into the atmosphere and forms rain in three ways: through frontal and orographic uplift, and convection.

8.4.4 Frontal rainfall associated with the passage of (a) a cold front and (b) a warm front



Frontal rainfall

Frontal rainfall occurs when a cold and a warm **air mass** meet. The point at which they meet is known as a front.

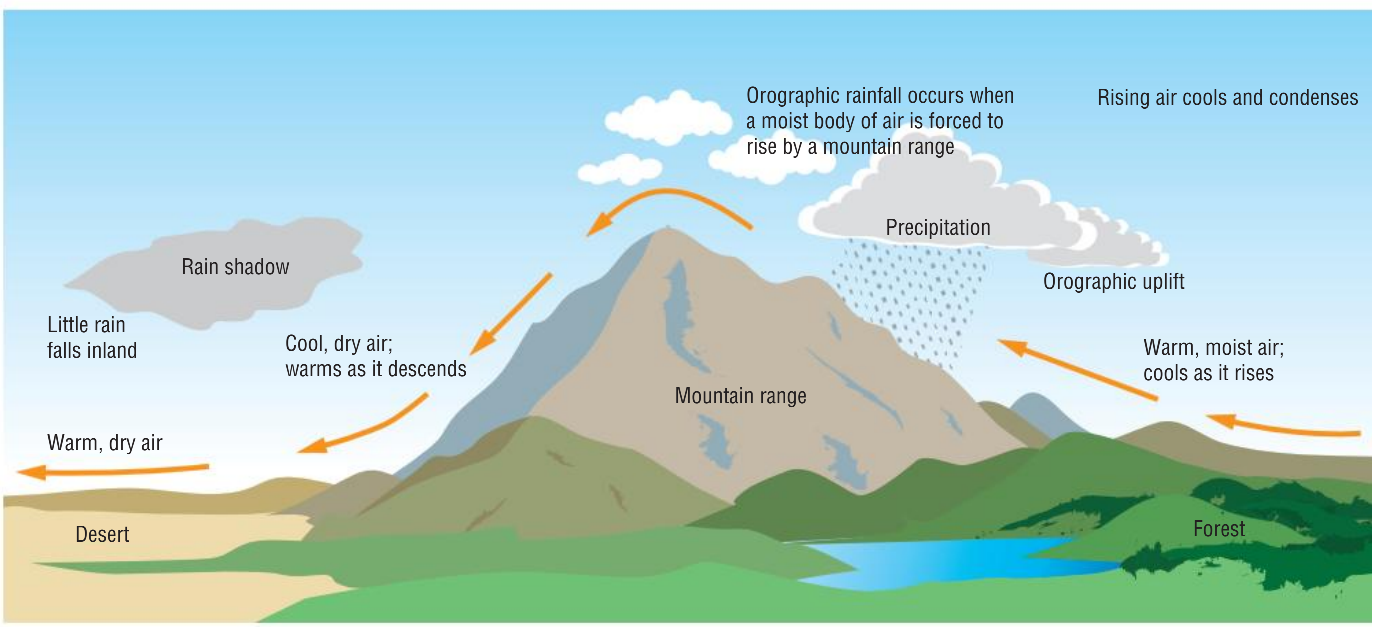
When a cold air mass meets a warm air mass, the cold air, which is heavier or denser than the warm air, forces the warm air to rise. As the warm air is pushed upwards, it cools.

When the air rises and is no longer able to hold all its water as water vapour, it begins to condense and form clouds. This often results in heavy precipitation associated with the passing of storms, as shown in Figure 8.4.4a.

When a warm air mass meets a cold air mass, the warm air mass (which is lighter and less dense than the cold air) rises above the denser and heavier cold air mass. This resulting rainfall extends over a wide area, as shown in Figure 8.4.4b.

Orographic rainfall

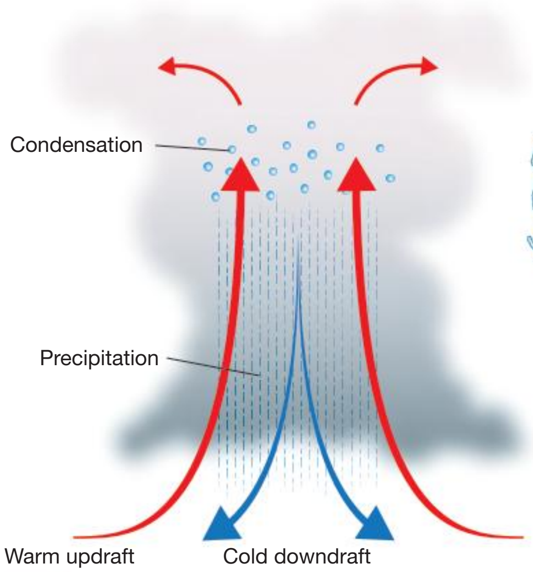
Orographic rainfall, shown in Figure 8.4.5, occurs when a mountain range forces a moist body of air to rise. As the air rises, it cools. The water vapour then begins to condense and form clouds, and finally falls as rain or snow. Only a little rain makes it beyond the mountain range, producing what is called the rain shadow effect.



8.4.5 Orographic rainfall

Convectional rainfall

Convectional rainfall, outlined in Figure 8.4.6, occurs when the energy of the sun heats the earth's surface and causes water to evaporate (changes it from a liquid to a gas). Warm, moist air then rises, cooling as it does so. Eventually, the air reaches a point called the **condensation** level (or dew point), where it has cooled to such an extent that the water vapour condenses and turns back to a liquid form. This process of condensation high in the atmosphere results in the development of clouds. As the clouds continue to grow, the weight of the water droplets increases, eventually leading to precipitation.

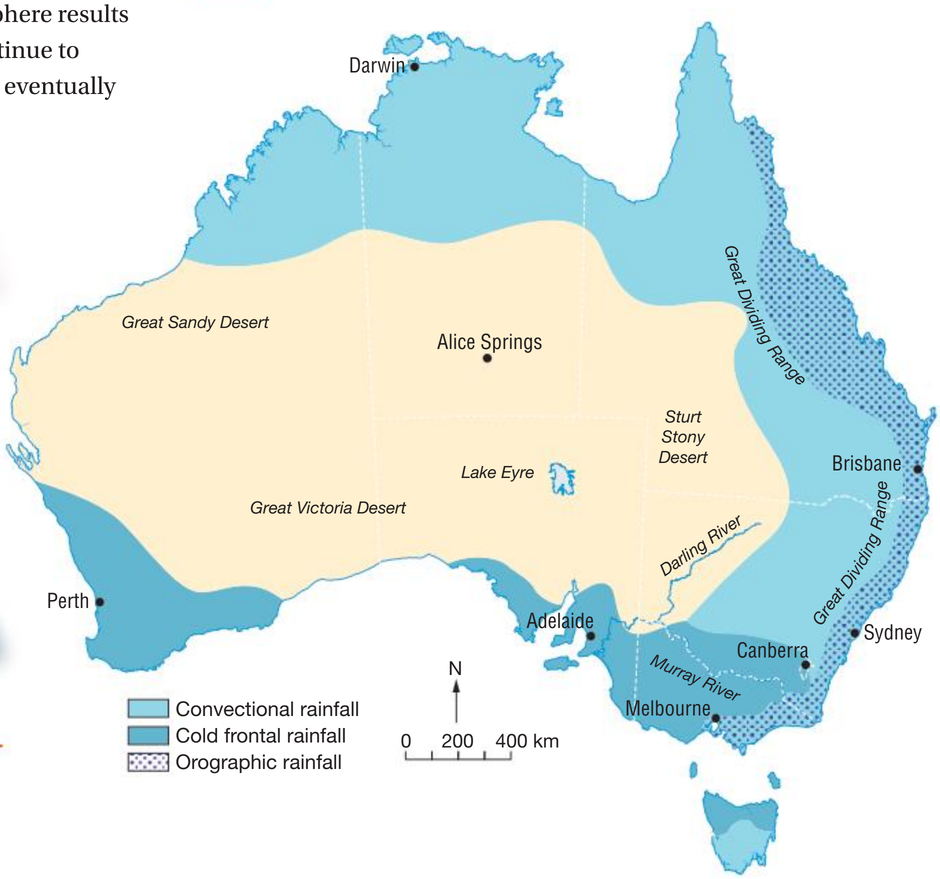


8.4.6 Convectional rainfall

Rainfall in Australia

The topography of the land, distance from the Equator and presence of ocean currents all influence the location of rainfall in Australia. Figure 8.4.7 shows the types of rainfall that different parts of Australia experience. Note that some locations experience more than one type of rainfall.

8.4.7 Distribution of different types of rainfall in Australia



ACTIVITIES

Knowledge and understanding

1. List the forms of precipitation.
2. Describe the conditions under which rain develops.
3. Explain the process of coalescence.
4. Explain how dew forms.
5. Explain why rising air is important to the process of precipitation.

Applying and analysing

6. Construct an annotated sketch or flow chart explaining convectional rainfall.
7. Draw a raindrop, a hailstone and a snowflake. Next to each, describe the conditions required for its formation and explain how it forms.
8. Study Figure 8.4.4. Outline how precipitation differs depending on whether it is associated with the passage of a cold front or a warm front.

Geographical skills

9. Study Figure 8.4.7 and do the following tasks.
   a. Find your present location and name the type of rainfall that occurs there.
   b. Describe the locations where the three different types of rainfall are experienced in Australia.
   c. Name the type of rainfall that is not found in Australia.

8.5

Distribution of water

Location of fresh water

Of the world's store of fresh water, 79 per cent is stored in glaciers and the polar ice caps. A further 20 per cent is stored as groundwater, soil moisture, swamp water and permafrost. Just 1 per cent is easily accessible fresh water. Figure 8.5.1 shows the distribution of the earth's water.

While the amount of available fresh water may seem small, the total amount is far greater than the earth's population requires. Unfortunately, it is not evenly distributed across the earth's surface. Some areas are critically short of water while others have plenty.

Water storage

The length of time that water is stored varies. Table 8.5.2 shows the estimated time that water spends in storage in the world's water resources.

Water loss

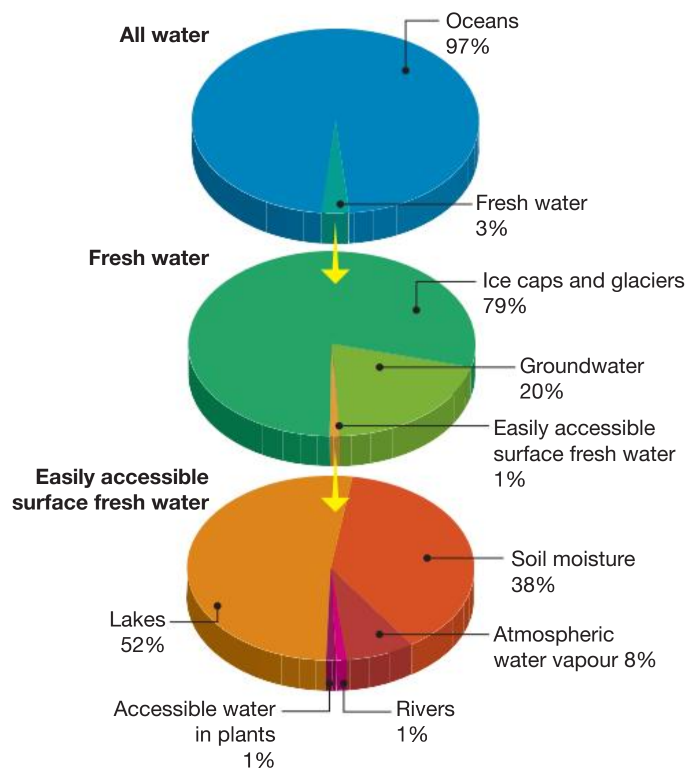
Figure 8.5.3 shows the amount of precipitation (in cubic kilometres) for each continent, and the percentage of that water that is lost to evaporation or becomes **run-off** and flows into streams, creeks and rivers, or underground, to become groundwater. Factors that influence the type of water loss are:

- ***climate***—warm or hot climates will have greater evaporation than cooler climates
- ***vegetation***—types of plants and plant cover; for example, there will be more evaporation in the grassy paddocks of a sheep farm than in denser vegetation that holds moisture
- ***soil type***—some soils are more permeable than others (they allow water to soak in)
- ***topography*** (shape of the land)—steep areas will have more run-off than flatter areas
- ***location***—hard surfaces such as roads and pavements lead to greater evaporation than unpaved surfaces, so there is greater evaporation in cities and towns than in rural locations.

DID YOU KNOW?

The Antarctic ice sheet is a 40 million-year-old glacier. If the glacier melted, sea levels around the world would rise over 61 metres.

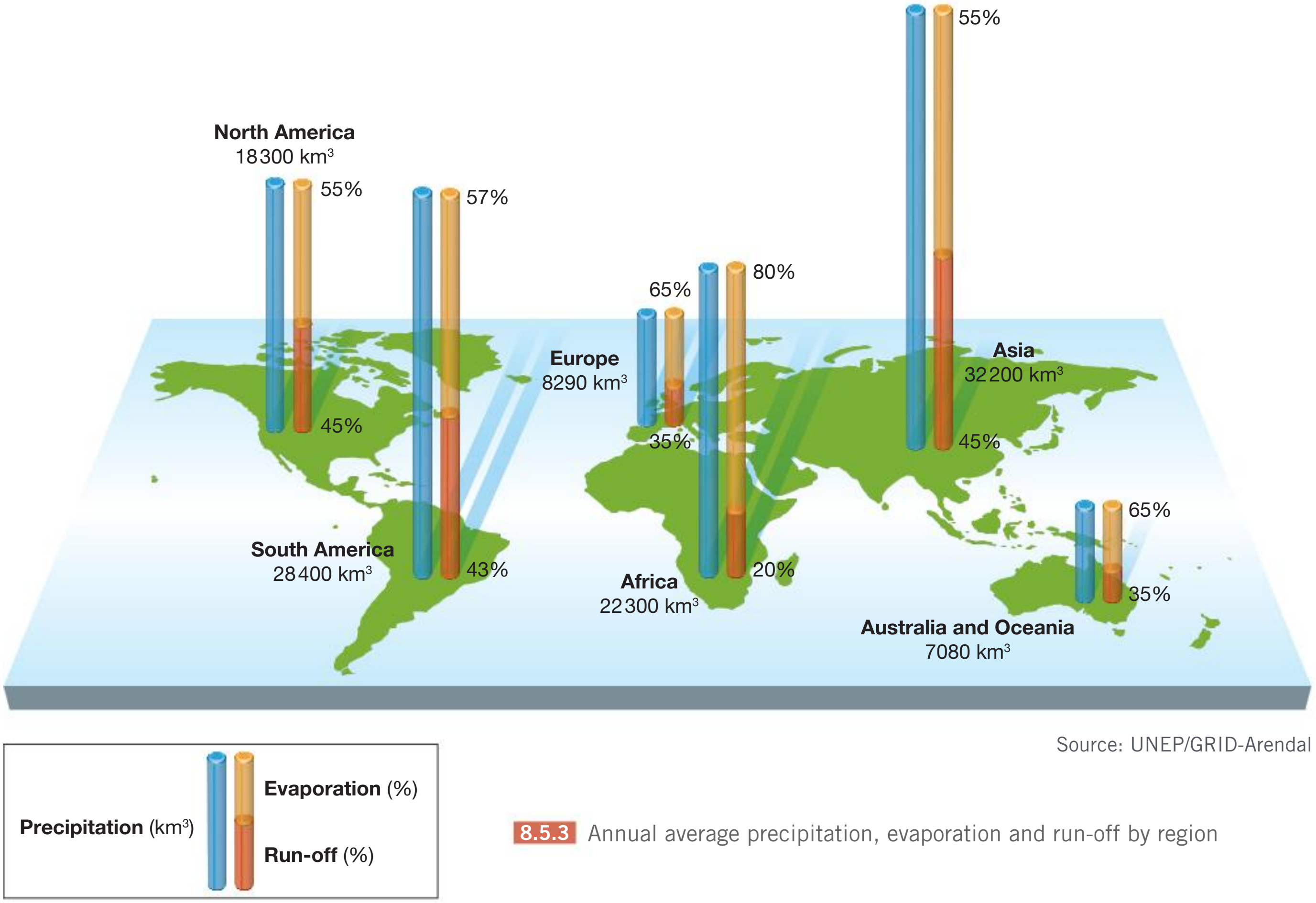
8.5.1 The global distribution of the earth's water resources



8.5.2 Estimated time in storage of the world's water resources

Water resource	Time held in storage
Biospheric water*	1 week
Atmospheric water	1.5 weeks
River channels	2 weeks
Soil moisture	2 weeks to 1 year
Swamps	1 to 10 years
Lakes and reservoirs	10 years
Ice caps and glaciers	1000 years
Oceans and seas	4000 years
Groundwater	2 weeks to 10 000 years

* Water held in animals and plants



8.5.3 Annual average precipitation, evaporation and run-off by region

ACTIVITIES

Knowledge and understanding

1 What percentage of the earth's fresh water is stored on the surface in storages such as rivers, wetlands and lakes?

Geographical skills

2 Study Figure 8.5.1 and answer the following questions.
- a State the proportion of the earth's water that is fresh (i.e. not salty).
- b State the proportion of the earth's fresh water that is easily accessible. Of this, how much is stored as soil moisture?
- c State the amount of the world's fresh water that is stored as groundwater.

3 Study Table 8.5.2 and present the information in the table in a graphic form.

4 Study Figure 8.5.3 and answer the following questions.
- a Which continental landmass has the largest annual average volume of run-off?
- b What is the average annual volume of run-off on the driest of the continental landmasses shown on the map?
- c By how much does the average annual volume of run-off in South America exceed that in North America?
- d Which region receives the greatest precipitation?
- e Which region has the least precipitation?
- f Which region has the greatest rate (percentage) of evaporation?
- g What are the implications of this data for agriculture in Africa?

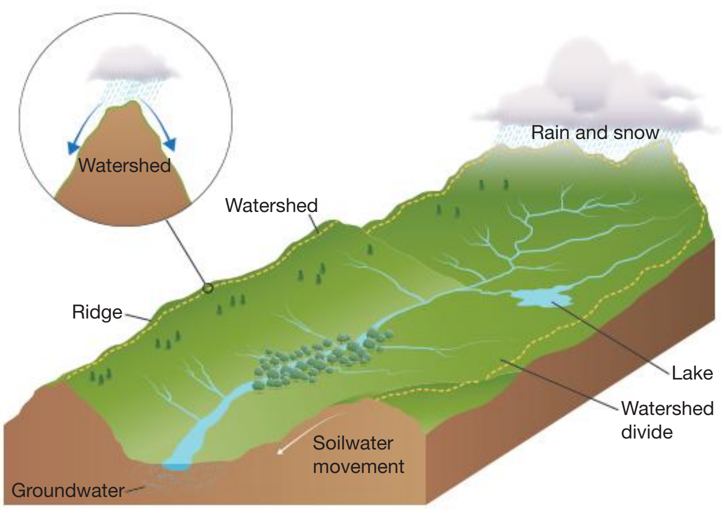
8.6

Catchments

A river catchment

A river **catchment**, or **drainage basin**, is an area of land from which water drains into a river. Every part of the earth's land surface is part of a catchment. Neighbouring catchments are divided by **watersheds,** and rivers are arranged within catchments in drainage patterns.

When precipitation falls to the ground, water moves over the land and finds its way into streams or down into the ground. While some of this water evaporates into the atmosphere, and some is stored as groundwater, the rest is slowly discharged into rivers. This is why rivers continue to flow even when there is no rainfall or precipitation. Figure 8.6.1 shows a catchment in a mountainous area. The figure also shows a watershed (also known as a drainage divide) separating neighbouring catchments. In flat areas, the watershed may be difficult to identify.



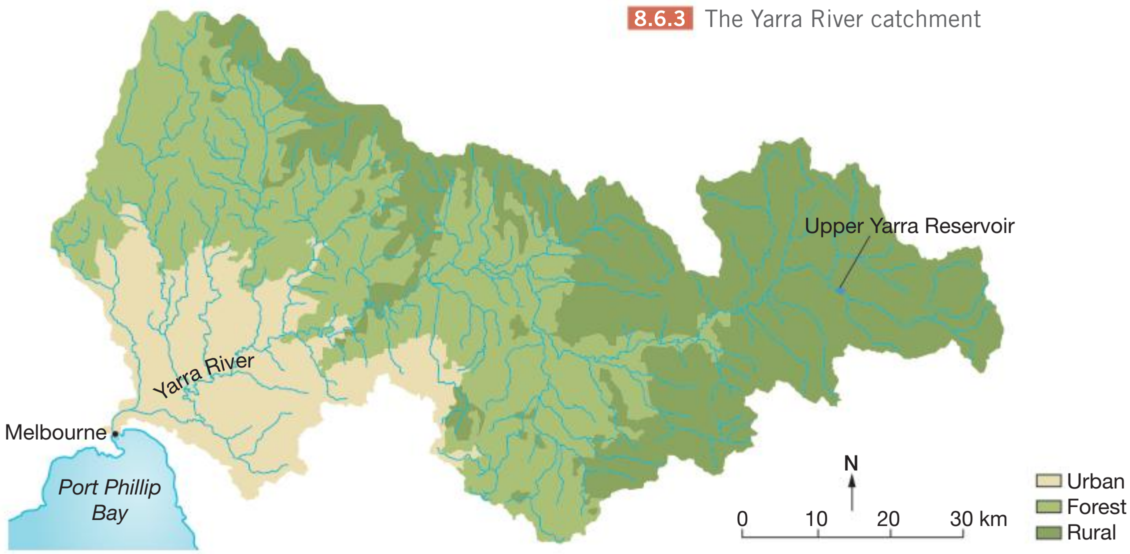
8.6.1 A catchment and dividing watershed. A watershed is the point at which precipitation falls and flows into either one of two neighbouring water catchments.

Catchment sizes

Catchments vary greatly in the area they cover. They range from small urban or coastal catchments to catchments covering thousands of square kilometres. The Amazon River Basin in South America covers approximately 7 050 000 square kilometres, as shown in Figure 8.6.2. Melbourne's Yarra River catchment covers 4078 square kilometres (see Figure 8.6.3), while the Murray–Darling catchment covers parts of three states and an area of 1 061 469 square kilometres, or approximately one-seventh (14 per cent) of the total area of the Australian continent.

Not all rivers flow into the sea. Some rivers flow inland, into inland seas, lakes or wetlands. For example, the Diamantina River, which has its source in central Queensland, flows into Lake Eyre, South Australia. Because all rivers and streams have their own catchment, it is not unusual to find catchments within catchments. Each **tributary**, for example, will have its own catchment area.

8.6.2 The Amazon River Basin



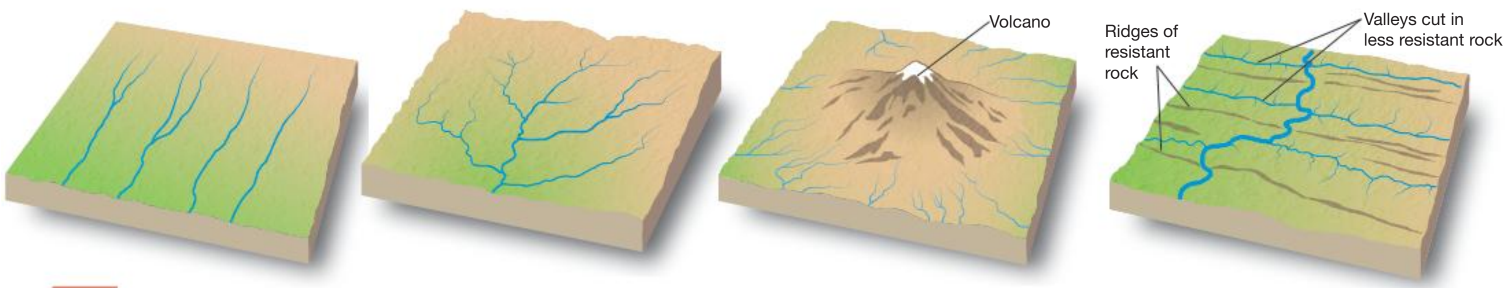
8.6.3 The Yarra River catchment

Parallel
A drainage pattern commonly found on newly uplifted land and where rivers and tributaries flow downhill more or less parallel to each other

Dendritic
A tree-like drainage pattern with tributaries converging on the main river channel. Common in areas dominated by one rock type.

Radial
Commonly found in areas dominated by dome-shaped mountains or volcanic cones. Rivers flow outwards from a central point like the spokes in a wheel.

Trellis (or irregular)
A drainage pattern that develops in areas dominated by areas of harder, more resistant, rocks and softer, less resistant, rock



8.6.4 Common drainage patterns found in catchments

Drainage patterns

The arrangement of rivers within a catchment is known as the drainage pattern. Most drainage patterns develop over a long period of time and their development is heavily influenced by the geology and landforms of the catchment. The most common patterns are shown in Figure 8.6.4.

The importance of catchments

In a river catchment, soil, plants, animals and water all function together. Any change affecting one of these elements will have an impact on the others. The protection and management of catchments is important because they are where all our food is grown and where our drinking water comes from. Catchments are therefore part of our life support systems.

ACTIVITIES

Knowledge and understanding

1 Explain the difference between a catchment and a watershed.
2 Discuss why catchments are important.
3 Why do rivers continue to flow even when it has stopped raining?

Geographical skills

4 Study Figures 8.6.2 to 8.6.4 and answer the following questions.
   a What is the name of the drainage pattern in the Amazon River Basin and the Yarra River catchment?
   b In which direction does the Amazon River flow?

8.7

Groundwater

Source of groundwater

When precipitation reaches the earth's surface, some of it flows into streams or lakes, some is used by plants, some evaporates and returns to the atmosphere, and some soaks into the ground and becomes groundwater.

Using groundwater

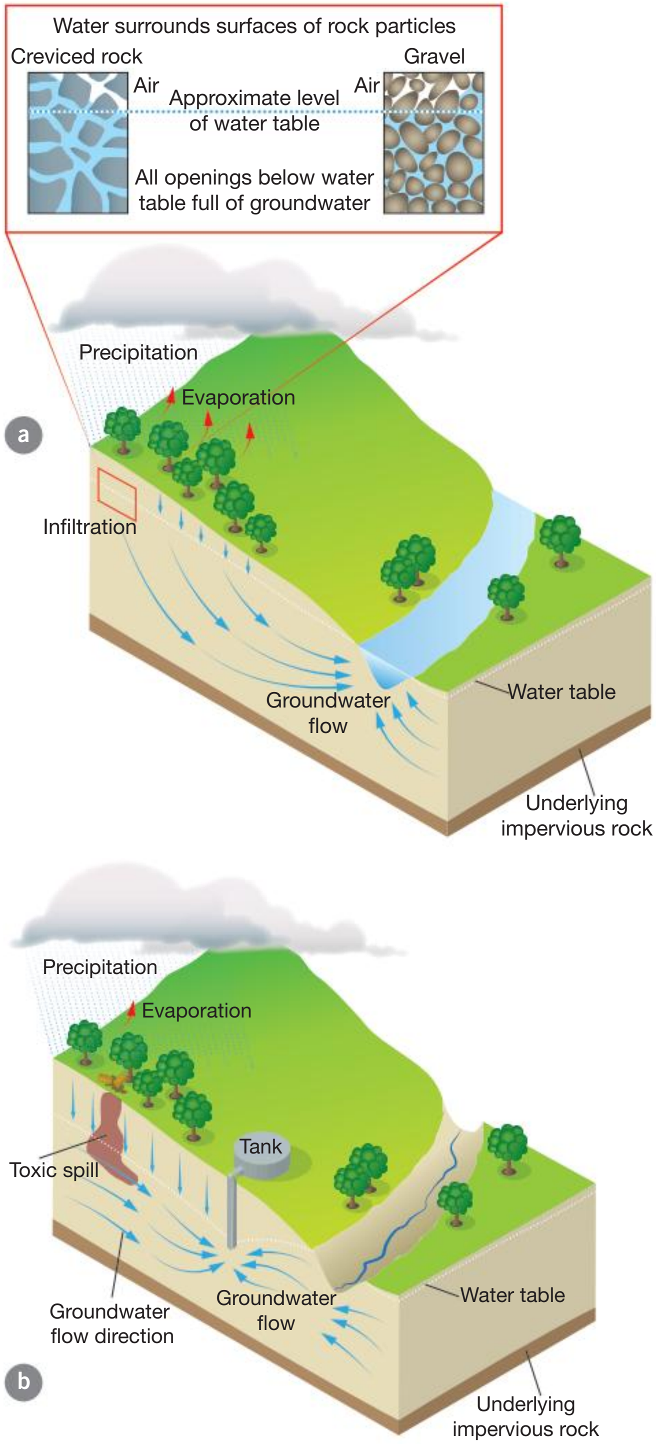
Groundwater is water found below the earth's surface in soil pore spaces and cracks in rock structure. The layer of soil and rock in which the water is found is called an **aquifer**. The depth at which soil becomes completely saturated with water is called the **water table**, as shown in Figure 8.7.1.

Throughout the world, groundwater is pumped or drawn from wells drilled or dug down into aquifers. This water is used for agricultural, domestic and industrial purposes. If it is used at a rate that is slower than the rate at which the aquifer can be replenished (or recharged), groundwater can sustain communities indefinitely. If groundwater is used at a rate faster than the rate of recharge, the water table falls and collecting water becomes more difficult.

Today, an estimated 2.2 billion people, or one-third of the world's population, rely on groundwater as their main source of water. In rural India, 50 per cent of irrigation water and 80 per cent of drinking water comes from underground (see Figure 8.7.2), through three million hand-pumped wells. In Europe, 75 per cent of the water used comes from aquifers. The next biggest users are the United States of America (51 per cent) and Asia (32 per cent). Twelve cities of more than 10 million people—including Bangkok, Shanghai, London and Kolkata—rely on underground water reserves. Fifteen per cent of the water used in Australia comes from groundwater sources.

DID YOU KNOW?

Two of the world's biggest cities, Mexico City and Jakarta, are sinking. This is due to groundwater being extracted underneath the cities. Some areas of Mexico City are sinking at a rate of 2.5 centimetres per year.



8.7.1 (a) Groundwater in natural conditions; (b) exploited groundwater resources

8.7.2 Villagers in India draw groundwater from a communal well.

SPOTLIGHT

The Great Artesian Basin

The Great Artesian Basin is the largest and deepest confined aquifer in the world. It covers an area of 1.7 million square kilometres, or 23 per cent of the Australian continent (see Figure 8.7.3). The basin is 3000 metres deep in places and is estimated to contain 64 900 cubic kilometres of groundwater.

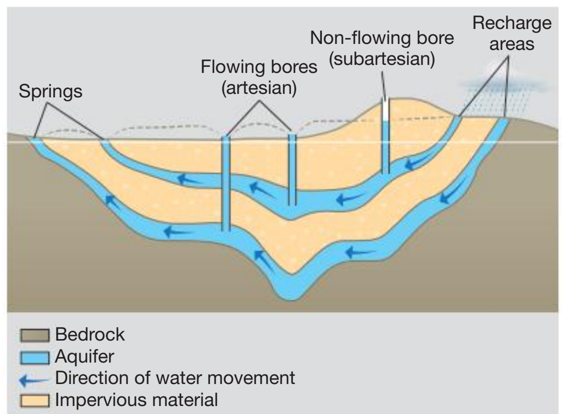
Water infiltrates the exposed sandstone aquifers along the western slopes of the Great Dividing Range, and is confined within the aquifers by impermeable layers of rock (layers that water cannot penetrate). For the most part the trapped water flows towards the south-west. In the northern section of the basin, however, some water flows towards the north-west and north (see Figure 8.7.3).

Natural discharge from the Basin occurs at springs—the points at which groundwater flows at the surface. These springs helped to sustain groups of Aboriginal people for tens of thousands of years and are a valuable resource for wildlife.

Because the aquifer is confined between impermeable layers of rock, it is held under pressure. When a bore is drilled into an aquifer, the pressurised water rises to the surface. When water flows from the bore without assistance, the bore is described as an 'artesian' bore. If the water has to be pumped to the surface, the bore is described as 'subartesian' (see Figures 8.7.4 and 8.7.5).

Other large aquifers include the Ogallala Aquifer in the United States of America; the Guarani Aquifer underlying parts of Argentina, Brazil, Paraguay and Uruguay; the Yarkon–Taninim Aquifer (Israel–Palestine); and the Bas Saharan Basin in Africa.

8.7.3 Location of Australia's Great Artesian Basin



8.7.4 Cross-section of the Great Artesian Basin

8.7.5 A bore taps water from the Great Artesian Basin.

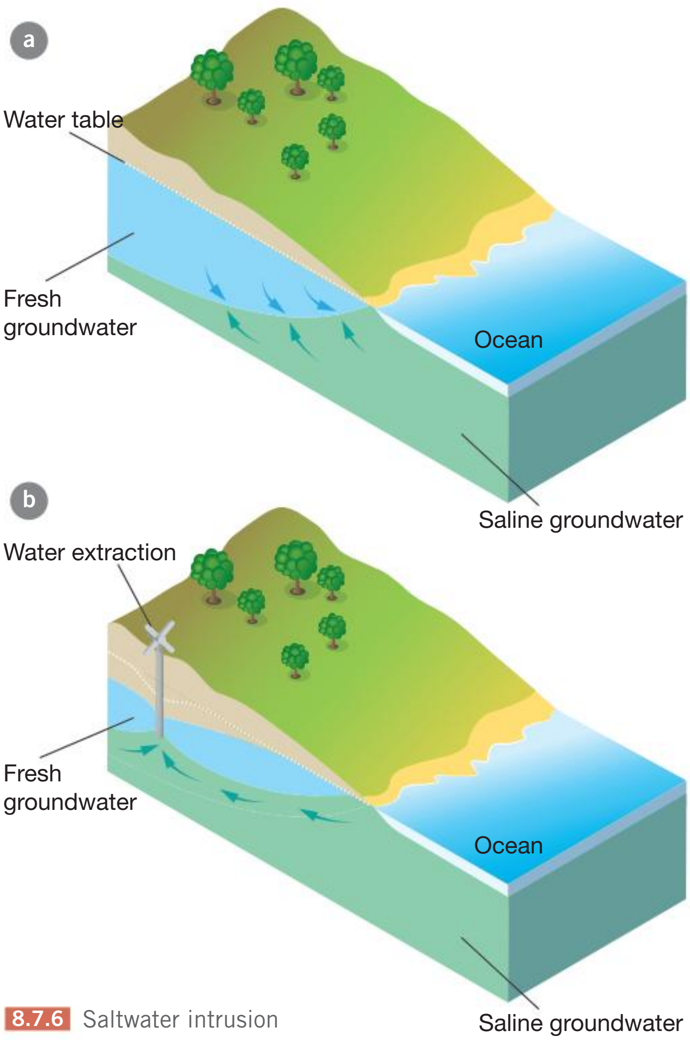
Groundwater as a renewable resource

If the rate of groundwater extraction is equal to, or less than, the rate at which it is replenished, groundwater can be classified as a renewable resource.

Advantages of groundwater

Groundwater is a popular source of water in many parts of the world. It has the following advantages.

- It is a reliable source of water because it is not affected by drought (at least in the short to medium term).
- It can be accessed in the place where it is needed. There is no need for expensive infrastructure such as pipes to transport water.
- Because the quality of groundwater is usually high, the expense of treating water to a standard fit for human consumption is minimised.



8.7.6 Saltwater intrusion

Threats to groundwater supplies

There are a number of threats to the quantity and quality of groundwater. These include the following:

- Excessive pumping from an aquifer can allow salt water to seep in and pollute the groundwater. This is called saltwater intrusion. See Figure 8.7.6b.
- Overuse can cause the water table to drop below the base of a well. The well then needs to be dug deeper or the settlement that relies on the well may have to be abandoned.
- Excessive withdrawals of groundwater can cause the ground above the aquifer to subside (drop).
- The aquifer can become polluted by toxic chemicals, including pesticides and fertilisers. These can enter the food chain, where they can cause birth defects and other serious medical conditions.

ACTIVITIES

Knowledge and understanding

1 Explain how groundwater is stored below the earth's surface and used around the world.

2 Describe the threats to groundwater resources.

Geographical skills

3 Study Figure 8.7.1. Outline the impact that water extraction can have on groundwater. Explain how a toxic spill in one part of the catchment can affect people's drinking water in another.

4 Study Figure 8.7.3.
  a Describe the flow of water within the Basin and identify the area where aquifer recharge takes place.
  b Estimate the greatest distance the water travels from the intake area.
  c *The Great Artesian Basin is more important to South Australia than New South Wales, Queensland and the Northern Territory.* Discuss.

5 Study Figure 8.7.6. Explain how salt water can penetrate and pollute a freshwater aquifer.

Investigating

6 Select one of the other aquifers listed in the Spotlight box 'The Great Artesian Basin'. Undertake internet research. Write a report similar in structure to 'The Great Artesian Basin'. Remember to include a map.

8.8

Water use

Types of water

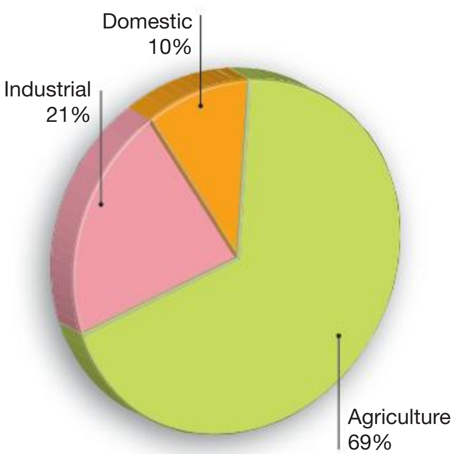
Blue water is a term commonly used to describe the earth's fresh surface water and groundwater—that is, the water in freshwater lakes, rivers and aquifers. The term **green water** is used to describe water stored in the soil or present in vegetation. **Grey water** is wastewater. It comes from domestic activities such as washing clothes, washing dishes and bathing. Grey water can be recycled and used to water gardens and sporting fields.

Where water is used

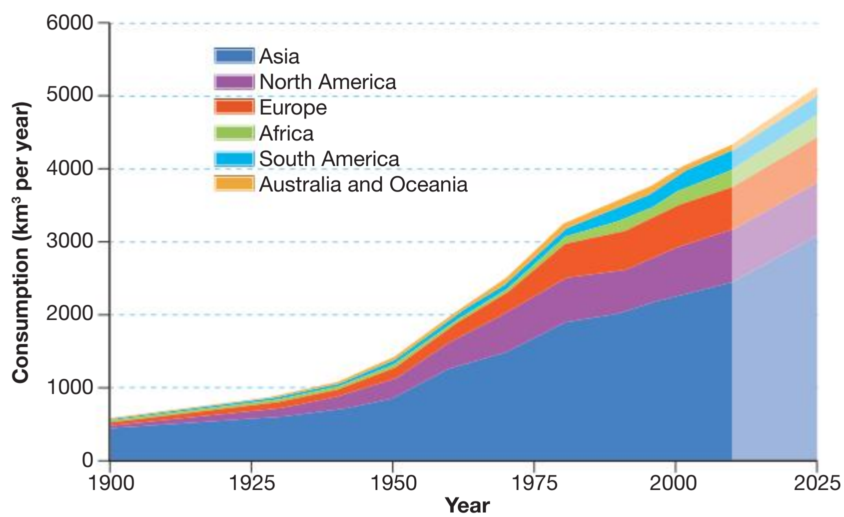
About 69 per cent of all available fresh water is used for agriculture (see Figure 8.8.1). A further 21 per cent is used in industry. Major industrial users are power plants, refineries and manufacturing plants. It is estimated that just 10 per cent of worldwide water use is for household purposes. These include drinking, bathing, cooking, **sanitation** and watering of gardens.

Per capita water use

Water consumption can be very high. The amount used per person per day is 575 litres in the United States of America, and 193 litres in Germany. Compare this with the 20–30 litres per person per day that is considered enough to meet basic human needs. Figure 8.8.2 shows past, current and predicted water consumption.



8.8.1 Global water use by sector: agriculture, industry and domestic uses



8.8.2 Global water consumption, 1900–2025

SPOTLIGHT

Bottled water

Global sales of bottled water in 2015 amounted to 2.34 billion litres. The value of bottled water sales was in excess of US$60 billion. At about $3.00 per litre, bottled spring water is more expensive than petrol, which sells for approximately $1.40 per litre.

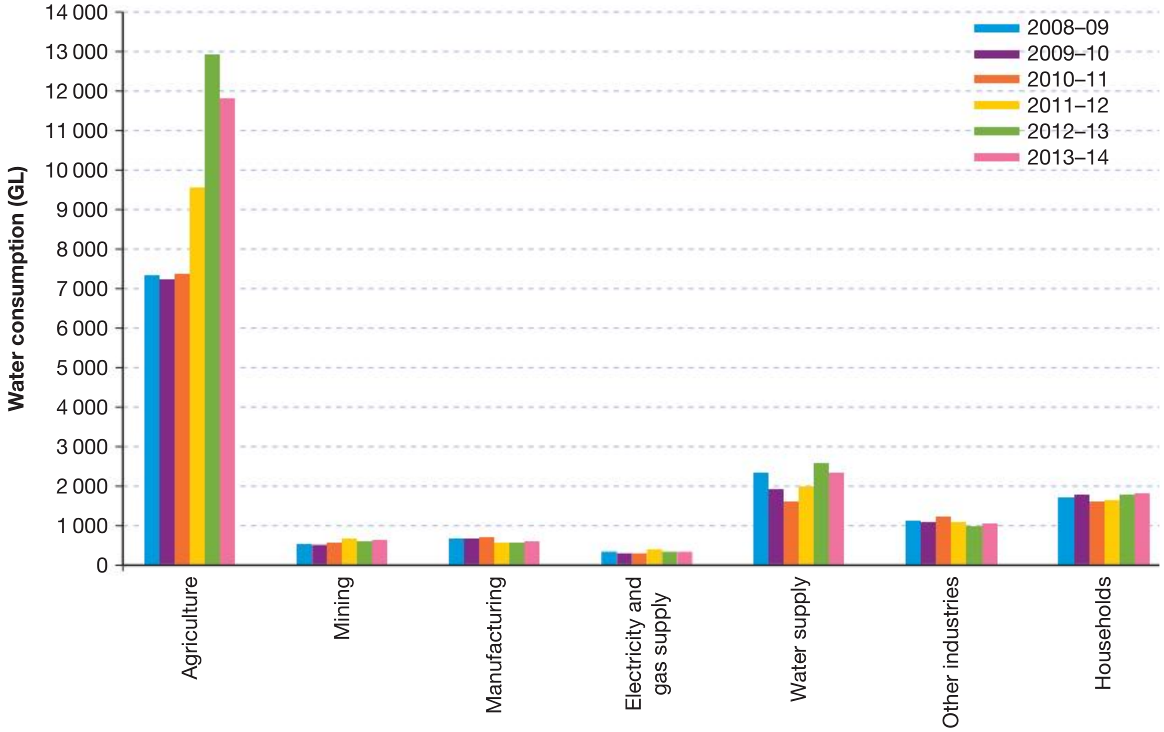
Apart from being more expensive than petrol, bottled water is an environmental problem worldwide.

- Plastic bottles are made out of oil, and the production of these bottles emits hundreds of times more greenhouse gases than the equivalent amount of tap water.
- Australia's annual bottled water use creates more than 60 000 tonnes of greenhouse gas emissions, or about the same amount that 13 000 cars generate over the same time.
- Relatively few bottles are recycled (approximately 36 per cent), and hundreds of millions of bottles each year end up in landfill or as rubbish on our streets.

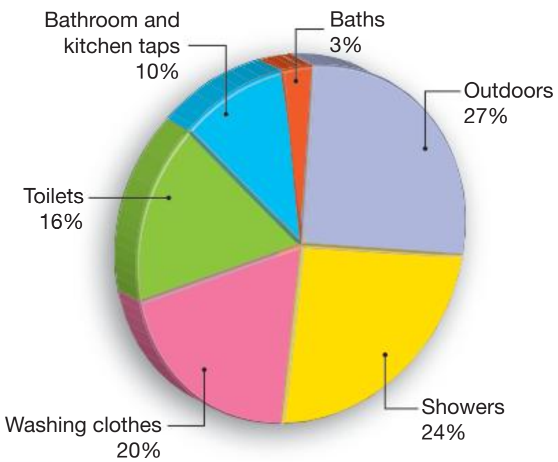
Water use in Australia

Australia has one of the highest per capita (or per person) rates of water use in the world. The largest consumer of water in Australia is the agriculture sector. While two-thirds of all the people on earth use less than 60 litres each of water a day, the average Australian uses more than twice that amount during a single shower, and about 493 litres a day in total.

Figure 8.8.3 shows water use in Australia by different sectors of the economy, and Figure 8.8.4 further analyses water use in Australian households.



8.8.3 Water use in Australia by different sectors of the economy Source: ABS



8.8.4 Typical household water use in Australia

DID YOU KNOW?

A chicken is made up of 75 per cent water. For an elephant, the figure is 70 per cent.

ACTIVITIES

Knowledge and understanding

1 State the estimated basic water need of people. How does this compare with the average Australian household water use?

2 Distinguish between 'blue', 'green' and 'grey' water.

Applying and analysing

3 Develop a plan to reduce bottled water use in Australia. Your plan should include reasons for your decisions and an explanation of how the plan should work.

Geographical skills

4 Study Figure 8.8.2. Describe the change in global water consumption since 1900. Suggest reasons for this.

5 Study Figure 8.8.4. Identify the three largest areas of household water use in Australia. Do you think these would be the three largest areas of water use in your household? Explain.

8.9

Water footprint

Definition

A **water footprint** is the total volume of fresh water used by an individual, a household, a business, a community or a country. For an individual, it includes water used directly (for example for drinking, bathing, cooking and washing clothes) and water used indirectly (for example in producing things such as food, paper, electricity, steel and cotton clothes).

Water use and footprint

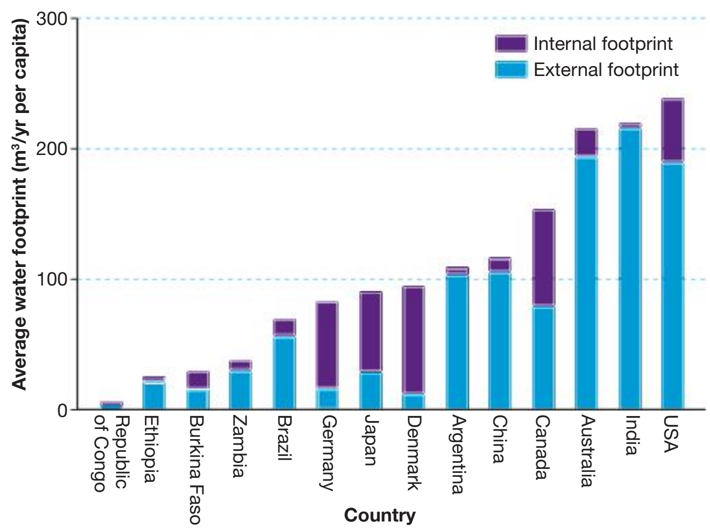
The water footprint of countries can be used to determine and compare global water use. National water use consists of two parts:

- the internal water footprint, which is the water used inside the country
- the external water footprint, which is the water used to produce goods and services that are imported from other countries.

Figure 8.9.1 shows internal and external water use for selected countries.

Water use includes **virtual water**. The virtual water content of a product is the amount of fresh water that is used when the product is created. An example of virtual water is the water used in coal power stations (see Figure 8.9.2). Countries can both import and export virtual water.

If, for example, your family buys an imported car (which uses approximately 150 000 litres of water during the production process), you are using another nation's water. As a general rule, the more economically advanced a country, the greater both its internal and its external water footprint.



8.9.1 Average water footprint and proportion of water use sourced externally, for selected countries

8.9.2 Steam rising from power station cooling towers in the Latrobe Valley, Victoria. Water used in manufacturing processes is commonly referred to as virtual water.

Australia's water footprint

In 2008–09, Australia's total domestic water use was 14 101 gigalitres (1 gigalitre is approximately the amount of water in 500 Olympic swimming pools). This is a decrease of 25 per cent from 2004–05, when 18 767 gigalitres of water were used. Water use in Australia has decreased because of drought and the introduction of water restrictions.

Average household water use in Australia equals 80 500 litres per person per year.

A family's water footprint

Water supply authorities want to reduce the amount of water that households use. They do this in various ways:

- through public education campaigns
- through the price they charge for water
- by installing water-efficient appliances
- in some cases, by imposing water restrictions.

An Australian 'water wise' household's water use is shown in Table 8.9.3. Individual figures will, of course, vary. The amount your household uses depends on such things as how much time you spend at home, how often you have visitors, the size of your garden and whether you have a pool.

To encourage people to use less water, there are a number of online water footprint calculators. There are also apps you can download onto your mobile phone that calculate your water footprint, tell you how much water is used in the production of selected goods and track your use of water, gas and electricity.

8.9.3 Water consumption of a 'water wise' Australian household

People per household	Water consumption
1	239 litres/day
2	360 litres/day
3	458 litres/day
4	542 litres/day
5	619 litres/day
6	689 litres/day

Source: Sydney Water

DID YOU KNOW?

The total global water footprint is 7450 billion cubic metres per year. This is an average of 1240 cubic metres per year for every person on earth.

Reducing water use

There are many ways in which households can reduce their direct water footprint (that is, their home water use).

Examples include:

- installing dual-flush toilets and water-saving showerheads, dishwashers and clothes washers
- turning off the tap when brushing your teeth
- using less water in the garden (for example by planting drought-resistant plants, mulching garden beds and using drip irrigation)
- collecting rainwater and using grey water for irrigation.

ACTIVITIES

Knowledge and understanding

1 State what is meant by the term 'water footprint'.
2 Distinguish between a country's 'internal' and 'external' water footprint.
3 State what the term 'virtual water' refers to.
4 Discuss why Australia's water footprint has been decreasing.

Analysing and applying

5 Develop your own example of the trade in 'virtual water'.

Geographical skills

6 Study Figure 8.9.1 and do the following tasks.
   a List the five countries with the highest water footprint per capita.
   b Compare the internal footprint of each of those five countries with its external footprint.
   c Identify the countries that have a larger external water footprint than internal water footprint. Provide reasons why this might be so.
   d The United States of America has the third-largest population of all the world's countries but the highest water footprint per capita. Discuss why this is so.

Investigating

7 Access one of the many online water footprint calculators. Calculate your water footprint.

8.10

Virtual water

Definition

Virtual water is the water used in the production of goods and services we use. For example, to produce a McDonald's Big Mac takes about 2400 litres of water, most of which is used to grow the grain that feeds the cattle.

Water in food production

If we know how much virtual water is needed to produce a product, then we can use that knowledge to help us to use water more wisely.

The majority of the virtual water that we use goes into the production of food (see Figure 8.10.1). A typical breakfast can consume up to 1100 litres of water—140 litres for a cup of coffee, 120 litres for eggs, 240 litres for milk and 80 litres for each piece of toast (not including butter or jam).

Large amounts of water are also used to produce many of the manufactured goods we use each day, as shown in Figure 8.10.2.

> **DID YOU KNOW?**
> The annual global trade in virtual water exceeds 800 billion tonnes, or the equivalent of ten Nile Rivers.

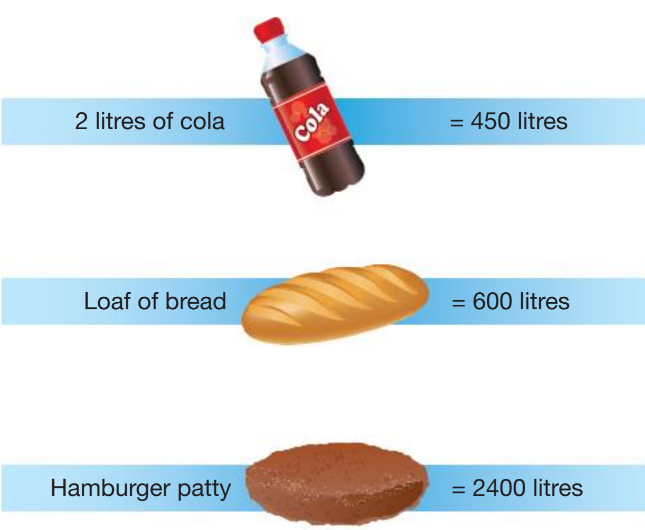
Trade in virtual water

Trade in virtual water refers to the idea that when goods and services are exchanged, so is the water that was used to produce them.

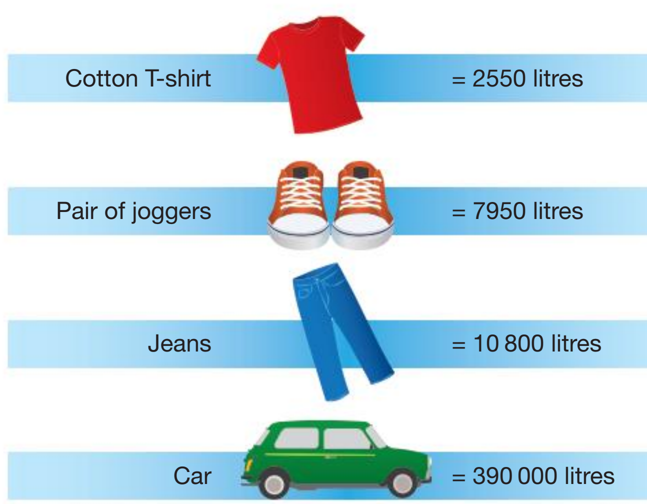
How the trade works

When a country imports 1 tonne of wheat, that country saves about 1300 cubic metres of its own water. If water is scarce in that country, the water that it saves can be used for other purposes. If, however, water is scarce in the exporting country, it has exported 1300 cubic metres of water that is no longer available for other purposes.

For some countries it makes sense to save real water by importing the virtual water embedded in grain or meat. The Netherlands, Jordan, the United Kingdom, Japan and South Korea depend on virtual water imports for more than 62 per cent of their water needs. Large exporters of virtual water—mostly in the form of wheat, corn, soybeans and other food crops—are the European nations, the United States of America, Australia and Brazil.



8.10.1 The amount of water used to produce selected foods



8.10.2 The amount of water used to produce selected consumer products

SPOTLIGHT

Coffee's big thirst

Coffee is one of the most important agricultural products traded in the world. Producing coffee, however, requires a lot of water. It takes about 21 000 litres of water to produce 1 kilogram of roasted coffee. A standard cup of coffee needs 7 grams of roasted coffee, so each cup of coffee 'costs' 140 litres of water. Assuming that a standard cup holds 125 millilitres of coffee, we need more than 1100 drops of water to produce one drop of coffee.

International trade in coffee products is responsible for 80 billion cubic metres of virtual water exports. Among all the crop and livestock products, coffee is at the top of the list of global virtual water flows.

In total, the world's population needs 120 billion cubic metres of water per year in order to enjoy coffee. This is about 6 per cent of the world's total international virtual water flows.

8.10.3 Australians bought 23 million kilograms of coffee products in 2012. That is 1.26 billion cups, costing consumers about $3 billion.

ACTIVITIES

Knowledge and understanding

1 State how much water is used in creating a McDonald's Big Mac.

2 State why it is important to know the amount of virtual water involved in producing goods and services.

3 Explain the concept of 'trade in virtual water'. What are the implications of this concept for countries with scarce water resources?

Applying and analysing

4 Study Figure 8.10.1 and the information under 'Water in food production', and calculate the amount of virtual water required to produce:
   a breakfast: 2 slices of toast and 1 cup of coffee
   b lunch: a hamburger in bread and a 500 mL bottle of cola.

5 Study Figure 8.10.2. Think about how many pairs of jeans you own. How much water was required to produce them?

Investigating

6 Study the Spotlight box 'Coffee's big thirst'. Use this as a guide to investigate the amount of water required to develop, produce and run one of the following products:
- mobile phone
- television
- portable media player such as an iPod
- tablet computer such as an iPad
- desktop or laptop computer
- other technological device.

Develop an oral report, supported by a multimedia presentation, outlining the findings of your research.

8.11

The importance of water: Indigenous communities

Aboriginal people and the environment

The history of Aboriginal people in mainland Australia spans at least 50 000 years (or more than 2000 generations). For most of this time, the majority of Aboriginal people lived semi-nomadically as hunter-gatherers. In doing so, they developed a close relationship with the land and its resources, including water.

Aboriginal people have always had a very close relationship with the land. They learnt to adapt to the environment and at the same time to exploit its resources. They understood the rhythms of nature and its signals, and could live from the land without depleting the supply of food and water.

In recent years, there has been a debate about the degree to which Aboriginal people modified the environment. One controversy focuses on the role that Aboriginal people may have played in the extinction of the marsupial megafauna (big land animals that evolved after the dinosaurs). Some people argue that natural climate change led to the extinction of the megafauna; others claim that, because the megafauna were large and slow, they were easy prey for hunters. Another possibility is that their extinction was indirectly caused by the way in which Aboriginal people modified the environment, particularly through the use of fire. Aboriginal people practised regular burning. Over time, plant species that found it difficult to survive this use of fire were replaced by fire-tolerant species such as eucalypts.

Aboriginal people and water

Most Aboriginal people were semi-nomadic; that is, they moved from place to place in search of food and water. Each group moved over a well-defined area with boundaries that were respected by other groups. They established camp sites around waterholes such as springs, **soaks** and billabongs. When travelling through arid regions, groups of Aboriginal people would move from waterhole to waterhole. Their shelters were simple and temporary, and were made of materials that were available locally. Some Aboriginal groups led a more sedentary life, staying in the place they had settled.

The ability to find water was vital, especially in arid areas. Aboriginal people were skilled in finding 'hidden' water in the root hollows of trees such as the boab tree. They knew exactly where to dig for soaks in sandy riverbeds, even in times of severe drought. In some parts of Australia, the locations of waterholes were recorded on sacred boards, which served as maps. Given the importance that water played in the survival of Aboriginal people, it is not surprising that many waterholes feature in Aboriginal Dreaming stories.

Murray–Darling Basin

Despite a history in the region spanning tens of thousands of years, Aboriginal people today own less than 1 per cent of the land in the Murray–Darling Basin. Many Aboriginal people nevertheless retain a strong link with the Basin's rivers and a desire to protect and preserve the rivers. In 1998, twenty-one groups of traditional landowners from the southern part of the Murray–Darling Basin formed an organisation called the Murray Lower Darling Rivers Indigenous Nations. A similar organisation, the Northern Murray–Darling Basin Aboriginal Nations, was formed in April 2010. It comprises representatives of twenty-two Aboriginal Nations from the northern part of the Basin and representatives of other Aboriginal and Torres Strait Islander organisations.

Ngarrindjeri elder Tom Trevorrow sums up the traditional owners' approach to the management of water and other resources in this way:

> Our traditional management plan was: don't be greedy, don't take any more than you need, and respect everything around you. That's the management plan—it's such a simple management plan, but so hard for people to carry out.

Source: *A Yarn on the River: Getting Aboriginal Voices into the Basin Plan*, Murray–Darling Basin Authority, Canberra

SPOTLIGHT

Managing the Barmah Forest wetlands

The Barmah Forest is found on the flat flood plain of the Murray River, about 220 kilometres north of Melbourne. The forest is one of the largest stands of river red gums found in Australia. These trees are under threat, but they provide habitat to more than 200 different bird species and many other animals. Since 2010, the Barmah Forest has been protected in a national park.

The Yorta Yorta people, who are the traditional custodians of the Barmah Forest, play an important part in the management of the park environment. Over many years of European settlement, the wetlands of the forest have suffered. The use of four-wheel drive vehicles, logging, grazing and the activities of feral animals have all taken their toll on the environment.

Some of the important fish species within the wetland have now disappeared, but, by using the knowledge of the area's Indigenous custodians, scientists are gaining an understanding of the role of these fish in the broader environment.

A partnership has been formed between the Yorta Yorta people and the Goulburn Broken Catchment Management Authority, the government agency responsible for managing the wetlands. Each group is learning from the other, and the Yorta Yorta people are able to pass on their knowledge of the wetlands to the scientists, helping them to make better decisions.

8.11.1 A representative of the Yorta Yorta people monitoring work in Barmah National Park

ACTIVITIES

Knowledge and understanding

1 Describe the nature of the relationship between Aboriginal people and the land.

2 Outline the extent to which Aboriginal people modified the Australian environment.

3 Outline the role that water availability played in the Aboriginal way of life.

Applying and analysing

4 Study the Spotlight box 'Managing the Barmah Forest wetlands' and answer the following questions.

a Why is the Barmah Forest considered so important?

b Outline the reasons the forest is threatened.

c How have the Aboriginal traditional custodians of the Barmah Forest become involved in its management?

d What do you think are the advantages of having Aboriginal traditional custodians involved in the management of Barmah Forest?

8.12

The importance of water: Sayan village, Bali

Bali

Bali is an island province of Indonesia located to the east of Java. The island is home to Indonesia's small Hindu minority, who make up more than 90 per cent of Bali's population of 4.2 million people.

Until the 1980s, the Balinese economy was largely agriculture-based. Today, 80 per cent of the island's economic activity is generated by tourism. Despite this, agriculture, in particular the growing of rice, is still the island's biggest employer. Fruit, vegetables and coffee are also grown. Fishing is also an important economic activity.

Sayan

Sayan is a village located 5 kilometres to the west of Ubud in central Bali. Water is critical for the growing of paddy rice, the basis of the community's economic and spiritual wellbeing.

Paddy rice

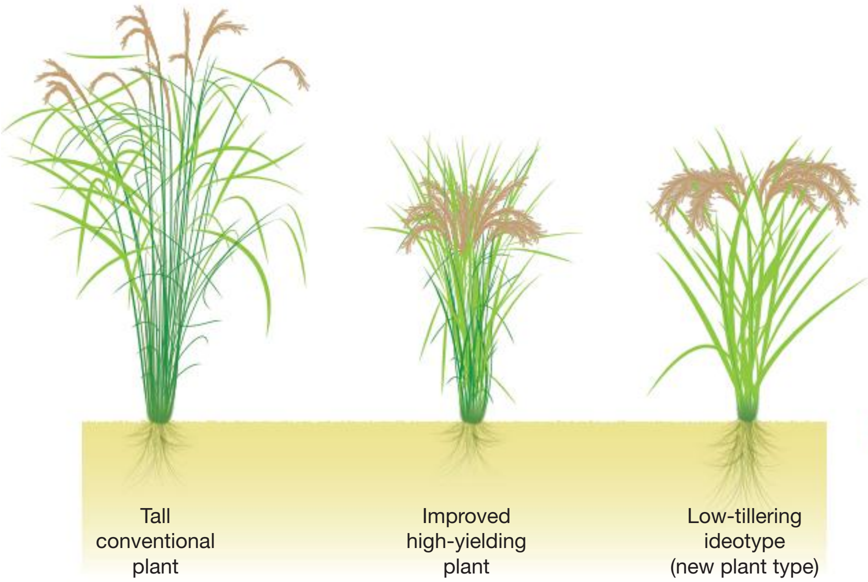
The term 'paddy rice' is the name given to rice grown in semi-aquatic environments such as the flooded paddy fields seen in Figure 8.12.1. Paddy fields dominate the landscape of rice-farming areas throughout East, South and South-East Asia. The paddies can be built on river flood plains or carved into steep hillsides as terraces. Their construction and maintenance requires a great deal of labour, and the crops need large quantities of water for irrigation. Getting the water to the paddy often involves complex water transfer systems, many of which have been in place for hundreds of years.

Flooded paddies provide an ideal environment for rice growing and prevent the growth of weeds that would compete with the rice plants for nutrients.

Rice varieties

Sayan rice farmers plant high-yielding varieties of rice that allow three growing seasons each year (see Figure 8.12.2). Because fertilisers and pesticides are expensive, farmers plant seeds in small nursery plots before planting out the seedlings in accurately spaced rows in flooded paddy fields. This is a very labour-intensive process, but it increases the amount of rice grown.

8.12.1 Bali's terraced paddy fields—an example of a managed environment



8.12.2 New varieties of rice have relatively thick stems and are less likely to bend and fall over under the weight of the grain they carry.

Irrigated paddy rice in Bali

Because of the mountainous nature of the landscape surrounding Sayan, farmers have terraced much of it to create small plots of arable land. Many of these terraces are more than 2000 years old. Farmers, working with hand tools, carved the stepped terraces out of steep hillsides. Generation after generation of farmers have extended the terraces and kept them in order. They have done this out of necessity: rice is the islanders' main food.

The water needed to grow the rice comes from the rugged, mountainous interior of the island. To transport it to where it is needed involves a complex system of canals, tunnels, pipes, dams and dykes. The farmers use this system to flood or drain the rice fields at the right time.

The *subak*

Supplying these small terraced plots with water dominates communal life in Sayan. Just like their ancestors, today's rice farmers are members of a community cooperative called a *subak*.

The *subak* system involves much more than just managing water storage and supply, and draining rice terraces. It is a complex part of an artificial ecosystem developed over thousands of years. It is also part of Balinese culture. Every Balinese village has a *subak*, and all rice farmers must join and participate in its activities. This helps to ensure that the limited irrigation water is given out fairly and that a limited number of farmers tap into the flowing water at the same time. Importantly, it ensures that a farmer does not block the water from flowing downwards to rice terraces below. The *subak* is a major reason why a farmer is able to get up to three crops per year from the one paddy.

The *subak* also plays an important role in the spiritual life of rice-growing communities. Every month, the *subak* members will come together in the village temple to discuss matters concerning the *subak*: water supply, the harvest and the celebration of the anniversary day of the *subak* water temple. They worship Dewi Sri, the rice goddess.

ACTIVITIES

Knowledge and understanding

1. Describe the ways in which Bali is different from the rest of the Indonesian provinces.
2. Explain how Sayan's farmers have adapted the rice-growing agricultural system to the province's topography.
3. Outline the role and responsibilities of the *subak*.

Applying and analysing

4. Create a PMI on the benefits of taking a collaborative approach to the management of water resources. Consider how the relationship between people's spiritual beliefs and the management of an environmental resource such as water can contribute to the long-term stability of a managed environment.

Investigating

5. Select one of the following rice-growing countries and investigate the way in which the irrigation and growing of rice is managed in that society. What are the similarities and differences between it and Sayan in Bali?
   - Australia
   - India
   - Madagascar
   - Malaysia
   - Thailand
   - Vietnam

Australia's water resources

CHAPTER 9

Australia's rainfall is variable and unreliable. Long droughts are common. As a result, water scarcity is an important environmental issue, and the water that is available needs to be managed very carefully.

The rate at which people have extracted water from Australia's river systems and underground aquifers is not sustainable. As well, precipitation patterns are changing as a result of climate change. These two facts are placing increasing demands on water across the country. Looking to the future, Australia will face major challenges in ensuring sustainable water supply in the face of a drying climate and rising demand.

In this chapter, we focus on Australia's water resources and their management.

INQUIRY QUESTIONS

- Why is Australia's rainfall so variable?
- How has Australia addressed the issue of water scarcity?
- How are water resources managed in Australia?

GLOSSARY

environmental flow	the amount of water that must flow in a river to maintain healthy, natural ecosystems
habitat	a place with a particular set of environmental conditions where a particular organism lives
leaching	the removal of salt from the upper layer of soils by the downward movement of water
pasture	an area of grassland that is suitable for grazing animals
relative humidity	the amount of water vapour in the air, represented as a percentage
river basin	the area from which water drains into a river system
water buyback	the process by which a government buys back irrigation water permits from farmers

9.0 Snowy River, New South Wales

9.1

Australia's weather and climate

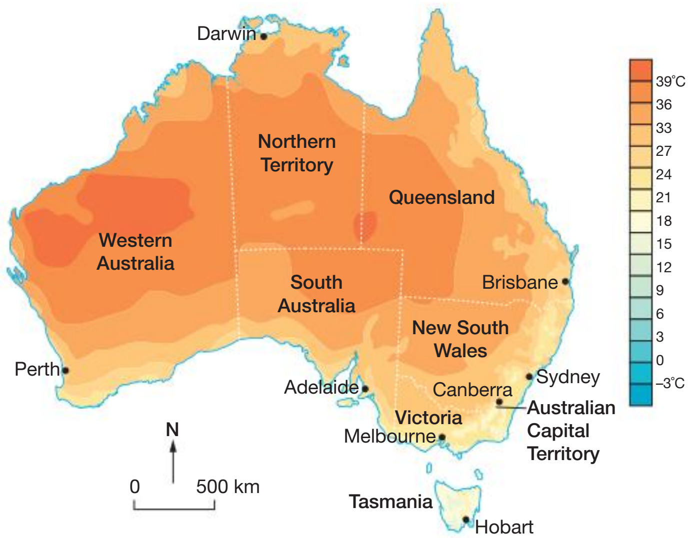
The biophysical environment

The variety or diversity of Australia's unique biophysical environments reflects the great variation in climatic conditions. The type of vegetation, the mix of flora and fauna, and the soils of an area are a product of the interaction between temperature and precipitation.

Ecosystems

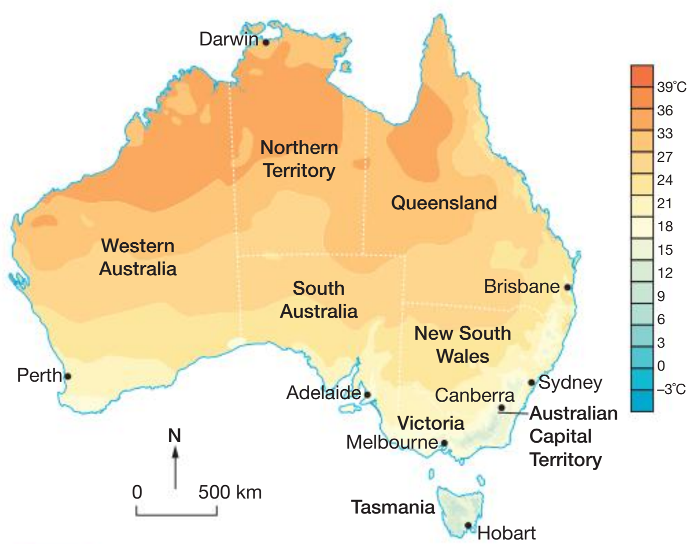
The desert ecosystems of central Australia are a product of low rainfall, high daytime temperatures and high evaporation, while Tasmania's temperate rainforests show the influence of high rainfall and more moderate temperatures.

Climate is also a major influence on the Australian lifestyle and landuses. Summer and winter variations in maximum temperature and rainfall, as well as annual averages, are shown in Figures 9.1.1 to 9.1.6.



9.1.1 January average maximum temperature

9.1.2 July average maximum temperature

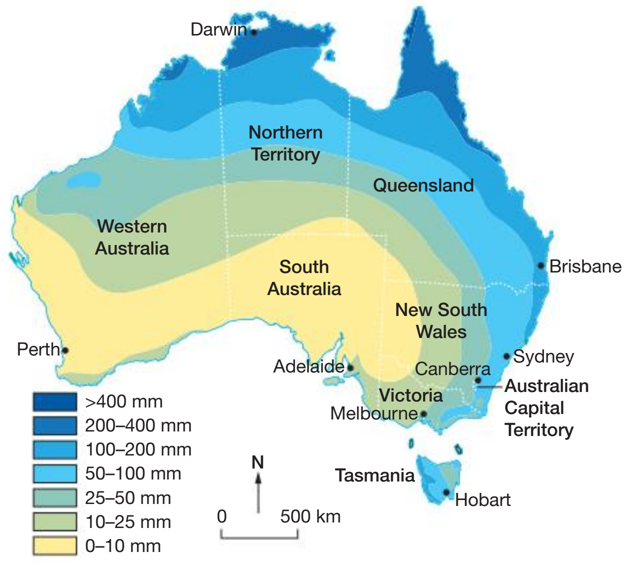


9.1.3 Annual average maximum temperature

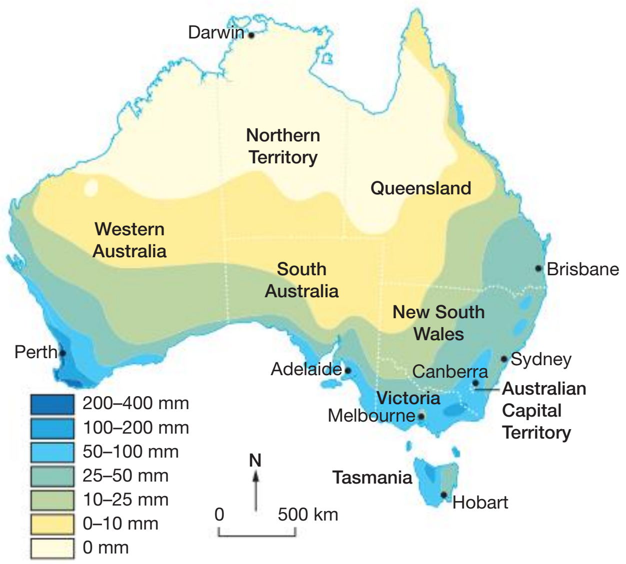
DID YOU KNOW?

Weather and climate records in Australia:

- Hottest temperature: 50.7°C at Oodnadatta airport, SA
- Coldest temperature: –23°C at Charlotte Pass, NSW
- Highest rainfall (daily): 907 mm at Crohamhurst, Qld
- Highest rainfall (monthly): 5387 mm at Bellenden Ker, Qld
- Highest rainfall (annual):12 461 mm at Bellenden Ker, Qld



9.1.4 January average rainfall



9.1.5 July average rainfall

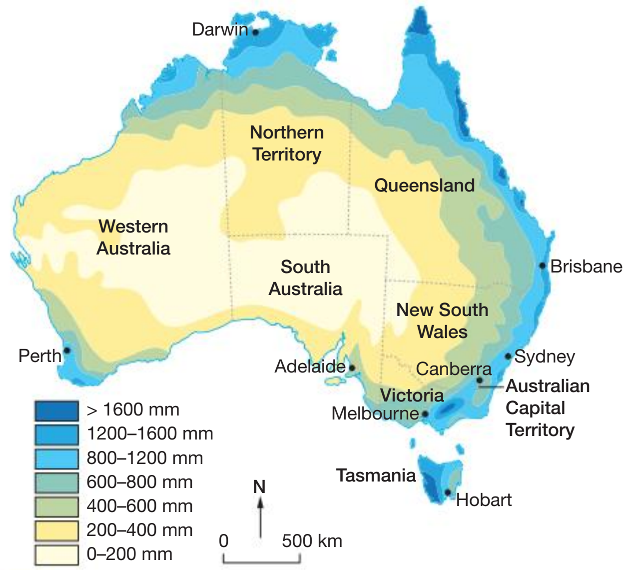
Why Australia is dry

Compared with the earth's other continental landmasses, Australia is very dry. More than 80 per cent of the continent has an annual rainfall of less than 600 millimetres; only Antarctica receives less precipitation than Australia.

Four factors contribute to the dryness of the Australian landmass. These are outlined below.

Cold ocean currents

Cold ocean currents located off the west coast of Australia result in low rates of evaporation from this cold body of water. Consequently, little or no moisture moves onto the continent from the ocean (see Figure 9.1.7).



9.1.6 Annual average rainfall

Flat continent

The absence of any significant mountain ranges over most of the continent means that there is little opportunity for rainfall caused by orographic uplift. In the east, the Great Dividing Range limits the amount of rainfall inland.

High-pressure systems

Because of Australia's mid-latitude location (between 20° south and 35° south), its climate is dominated by high-pressure systems. These are usually associated with stable atmospheric conditions; that is, clear skies and gentle winds.

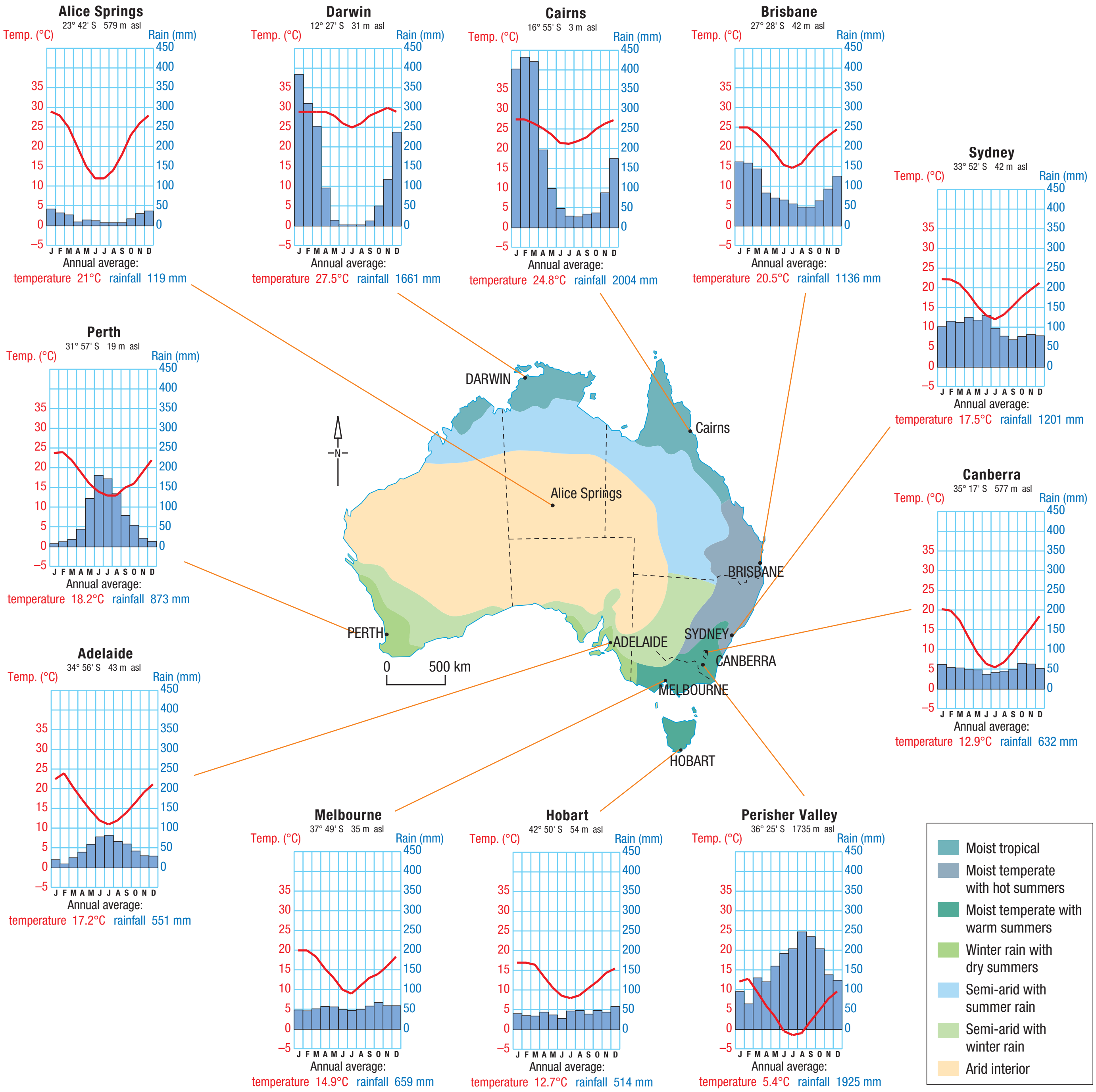
Shape of the continent

Australia has a compact shape and no significant bodies of water extend very far inland. This means that moist winds do not reach inland Australia, and this keeps rainfall low.

9.1.7 Because of the dominance of cold ocean currents, deserts extend right to the coast in parts of Western Australia.

Climate statistics

The pattern of Australia's climate is shown in Figure 9.1.8. The climate graphs show the average rainfall and temperature for Australia's capital cities and other selected locations.



9.1.8 Australia's climatic regions

ACTIVITIES

Knowledge and understanding

1 List Australia's climatic regions.

2 Name the climatic region of Australia in which you live.

Applying and analysing

3 Explain why summers in northern Australia might be described as 'uncomfortable'.

4 As a class, list the ways in which climate affects the activities of people in Australia.

Geographical skills

5 Plan a trip around Australia for the following activities. Explain which region of Australia you will visit for each activity, and in which month(s) of the year.
   - a a beach holiday
   - b skiing and snowboarding
   - c alpine bushwalking
   - d waterskiing
   - e cross-country mountain biking

6 Sketch an outline map of Australia, and draw on it the boundaries of each climatic region. Annotate your map with a brief description of the climate experienced in each region.

7 Study Figure 9.1.8 and do the following tasks.
   - a Describe the distribution of the following climatic regions.
     - i moist tropical
     - ii moist temperate with hot summers
     - iii moist temperate with warm summers
     - iv winter rainfall with dry summers
     - v semi-arid with summer rain
     - vi semi-arid with winter rain
     - vii arid interior
   - b Describe the different climates you would experience on a journey directly from:
     - i Adelaide to Darwin
     - ii Brisbane to Alice Springs.

8 Study Figure 9.1.8 and do the following tasks.
   - a Which location has the lowest average annual rainfall?
   - b Which location has the highest average annual rainfall?
   - c Which location has the lowest average temperature?
   - d Which location has the highest average temperature?
   - e Which location has the smallest annual range of temperature?
   - f Which location has the largest annual range of temperature?
   - g Estimate the average July temperature experienced by Darwin, Brisbane, Sydney and Hobart. Comment on the pattern shown. Account for this pattern.
   - h Describe the seasonal distribution of rainfall received in Darwin and Cairns.
   - i Describe the seasonal distribution of rainfall received in Adelaide and Perth.
   - j Divide the climate graphs into those that show:
     - i most rainfall in summer
     - ii most rainfall in winter
     - iii even rainfall distribution throughout the year.

9 Study Figures 9.1.1 to 9.1.3 and do the following tasks.
   - a Write a paragraph describing the January pattern of maximum temperatures.
   - b Write a paragraph describing the July pattern of maximum temperatures.
   - c Write a paragraph describing the annual pattern of maximum temperatures.

10 Study Figures 9.1.4 to 9.1.6 and do the following tasks.
   - a Write a paragraph comparing the January and July patterns of rainfall.
   - b Write a paragraph describing the pattern of average annual rainfall.

9.2

IN THE FIELD: Measuring weather

Aim

The aim of this fieldwork activity is to measure and record weather-based data in the school playground. Once the data has been collected and recorded, you will compare it with weather data from the Bureau of Meteorology.

How to record weather data

A variety of instruments can be used to record weather data for a specific location. You can use:

- traditional weather-recording instruments
- a handheld weather-recording device (see Figure 9.2.1)
- a handheld digital tool (such as an Apple iPhone or iPad or an Android device) that has the ability to record weather data at your location. You may need to add weather-recording applications to your digital tool.

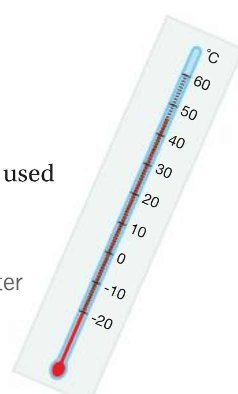
To ensure the accuracy of your weather data, ensure that the site you select to record your data is:

- in the open and not under cover
- free from obstructions, such as overhanging trees or walls and fences
- not close to heating or cooling vents.

9.2.1 A handheld weather-recording device

Temperature

A thermometer (see Figure 9.2.2) is used to record air temperature.



9.2.2 A thermometer

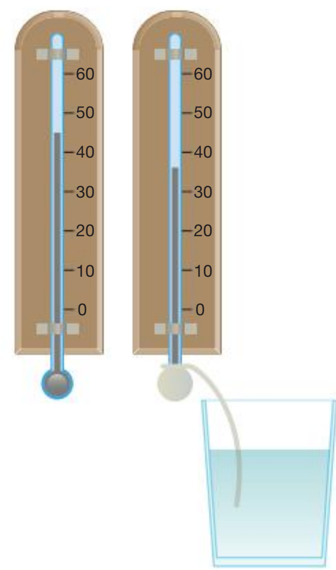
METHOD

Using a thermometer or handheld weather-recording device, record the temperature.

Note: If using a thermometer, do not hold it by the bulb, as your body heat may affect the temperature reading.

Relative humidity

A wet–dry bulb thermometer (see Figure 9.2.3) is used to measure and record **relative humidity**. Relative humidity is the amount of water vapour in the air. A wet–dry bulb thermometer consists of two standard mercury-in-glass thermometers. One thermometer bulb is wrapped in muslin, which is kept wet. The evaporation of water from the muslin has a cooling effect, so the temperature indicated by the wet-bulb thermometer is less than the temperature indicated by the dry-bulb thermometer. The rate of evaporation from the wet-bulb thermometer depends on the humidity of the air: evaporation is slower when the air is already full of water vapour. For this reason, the difference between the temperatures indicated by the two thermometers gives a measure of relative humidity.



9.2.3 Wet–dry bulb thermometer

METHOD

Using a wet–dry bulb thermometer or handheld weather-recording device, record the relative humidity.

Air pressure

You can use an aneroid barometer (see Figure 9.2.4) to measure atmospheric pressure (air pressure). An aneroid barometer contains a sealed box from which most of the air has been removed. Any change in pressure will make the box shrink or expand. Levers magnify these changes, causing a pointer to move on a dial. Air pressure at sea level is generally around 1013 hectopascals (hPa). It can drop to 970 hPa during severe storms. In a high-pressure system it can reach 1040 hPa. A drop in air pressure, measured over a day or two, indicates that unsettled weather is coming.

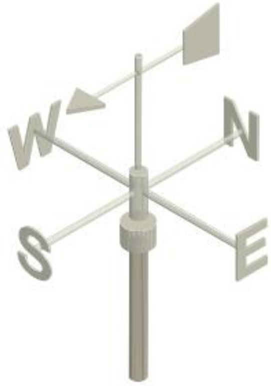
9.2.4 An aneroid barometer

METHOD

Using a barometer or handheld weather-recording device, record the air pressure.

Wind direction

A wind vane shows the direction from which the wind is blowing. Winds are named after the direction from which they blow. A wind blowing from the south, for example, is called a southerly.



9.2.5 A wind vane

METHOD

Using a wind vane (see Figure 9.2.5) or handheld weather-recording device, record the wind direction.

Wind speed

An anemometer (see Figure 9.2.6) is used to measure wind velocity (wind speed). An anemometer works by spinning in the wind: the higher the wind speed, the faster the anemometer spins. Wind speed is calculated by counting the number of revolutions per hour.

METHOD

Using an anemometer or handheld weather-recording device, record the wind speed.

9.2.6 An anemometer

Note: If you don't have an anemometer or handheld weather-recording device, estimate the approximate wind speed by observing the surrounding conditions and comparing these with the descriptions given in the Beaufort scale (see Table 9.2.7). This will give you the approximate wind speed.

9.2.7 The Beaufort scale

Wind strength	Speed (km/h)	Description
Calm	0–2	Smoke rises vertically
Light air	2–5	Smoke drifts
Light breeze	5–10	Leaves rustle, vane moves
Gentle breeze	10–20	Leaves and small branches move
Moderate breeze	20–30	Small branches move, dust and paper are lifted
Fresh breeze	30–40	Large branches move, wave crests appear on water
Strong breeze	40–50	Large trees move, umbrellas are difficult to use
Moderate gale	50–60	Large trees sway
Fresh gale	60–75	Branches break off trees
Strong gale	75–90	Large branches come down
Full gale	90–100	Trees are uprooted, structural damage to buildings

SkillsBuilder

Making and using a simple rain gauge

Making a rain gauge

To make a rain gauge (see Figure 9.2.8), you will need an empty clear-plastic 2-litre drink bottle and a ruler.

1 Cut off the top of the empty drink bottle, turn the top part upside down and push it into the bottom part to act as a funnel. The larger opening of the funnel should be the same size and shape as the bottom of the bottle.

2 Measure out and mark a scale in millimetres (mm) on the outside of the bottle. Alternatively, you could tape the ruler to the outside of the bottle. Either way, make sure the scale is vertical and that zero is at the bottom.

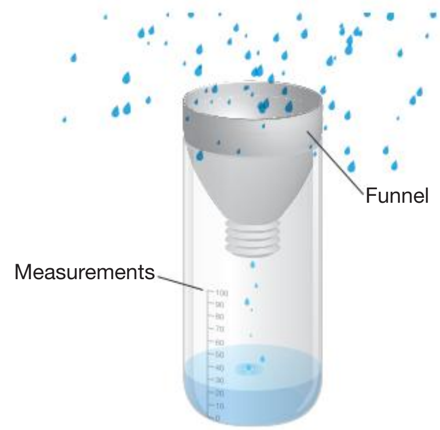
Measuring rainfall

1 Find a location for the rain gauge where it will not collect any run-off of rainwater—for example from overhead trees, roofs or signs. There is a minimum distance that official rain gauges must be from such obstructions. For example, if a nearby tree is 5 metres tall, the rain gauge must be at least twice that distance (i.e. 10 metres) away.

2 To measure rainfall, hold the rain gauge so that your eye is level with the top surface of the water. Read the rainfall in millimetres from the scale (or the ruler) on the outside of the bottle.

3 To measure precipitation in the form of hail or snow, remove the funnel. Allow the ice or snow that collects in the bottom of the bottle to melt, and then measure it as in Step 2 (above).

4 Record your rainfall data and include the date and time of measurement.



9.2.8 A simple rain gauge

Rainfall

A rain gauge is used to measure the amount of rainfall received in a 24-hour period. Rainfall is measured in millimetres. A funnel collects the rainfall and directs it into a measuring tube.

METHOD

1 Place a rain gauge outside, free from obstruction.

2 Measure the amount of water in the rain gauge. After you have measured the water, empty the rain gauge. You will need to measure rainfall at the same time each day.
Note: If you do not have access to a rain gauge, you can create your own. See the Skills builder box 'Making and using a simple rain gauge.'

DID YOU KNOW?

Rain can be light, medium or heavy.

Raindrops are usually larger than 0.5 mm in diameter, while drizzle is smaller than 0.5 mm in diameter.

How to access weather data

Bureau of Meteorology

The Bureau of Meteorology (BoM) is Australia's national agency for weather, climate and water. The BoM has numerous monitoring stations throughout Australia to record weather, climate and water data. You will find the weather station closest to where you recorded your weather data.

METHOD

1 Go to the Bureau of Meteorology (BoM) website. On the home page, select **Climate and Past Weather**, then click **Weather & climate data** to go to the Climate Data Online page.

2 In section 1 of the **Select using Text** tab, choose **Weather & climate** from the drop-down menu. Under Statistics, click the **Monthly** button.
In section 2, type in the box the location where you recorded your data. Click the **Find** button. Click to select your location from the list, then click the weather station closest to your location.
In section 3, click the **Get Data** button.

SPOTLIGHT

Clouds

The names of clouds are derived from Latin words that describe their appearance—for example cirrus (a lock of hair), cumulus (a heap), stratus (from *stratum*, a blanket or covering)—or other characteristics, such as nimbus (a shower of rain).


9.2.9 Cirrus and cumulus clouds

ACTIVITIES

Aim

To investigate weather data and the extent to which weather varies in an area

Method

1 Select a suitable site in the school grounds or local community at which to record weather data. Ensure you use the same location each day at the same time.
2 Select the weather-recording device or instruments that you will use to collect your data.
3 Collect weather data on temperature, relative humidity, air pressure, rainfall (precipitation), wind speed and wind direction over a five-day period.
4 Copy the fieldwork data table below and record your findings. Include a description of the weather for each day.

Fieldwork data table
Date: ____________ Time: ____________
Location: ____________

	Day 1	Day 2	Day 3	Day 4	Day 5
Temperature (°C)					
Relative humidity (%)					
Air pressure (hPa)					
Precipitation (mm)					
Wind speed (km/h)					
Wind direction					
Weather description					

5 Access the Bureau of Meteorology website and select your nearest capital city or the main town closest to your school or local community. Copy the table below into your workbook and add in the average monthly weather data on temperature, relative humidity, air pressure, rainfall (precipitation), wind speed and wind direction.

Average monthly data table
Date: ____________ Location: ____________

	Monthly average
Temperature (°C)	
Relative humidity (%)	
Air pressure (hPa)	
Precipitation	
Wind speed (km/h)	
Wind direction	

Evaluation

6 Analyse the weather data you collected by answering the following questions.
   a Is there a link between air pressure and the weather? Explain.
   b How do wind speed and direction affect the temperature?
   c Can you see any patterns in the information you collected?
   d Compare the weather data you collected with the monthly average for the area. Is there a similarity or a difference between them? Explain.
   e Why do you think there might be a similarity or a difference?

Conclusion

7 What do the results of this activity tell you about weather conditions between, and within, areas?

9.3

Water in Australia

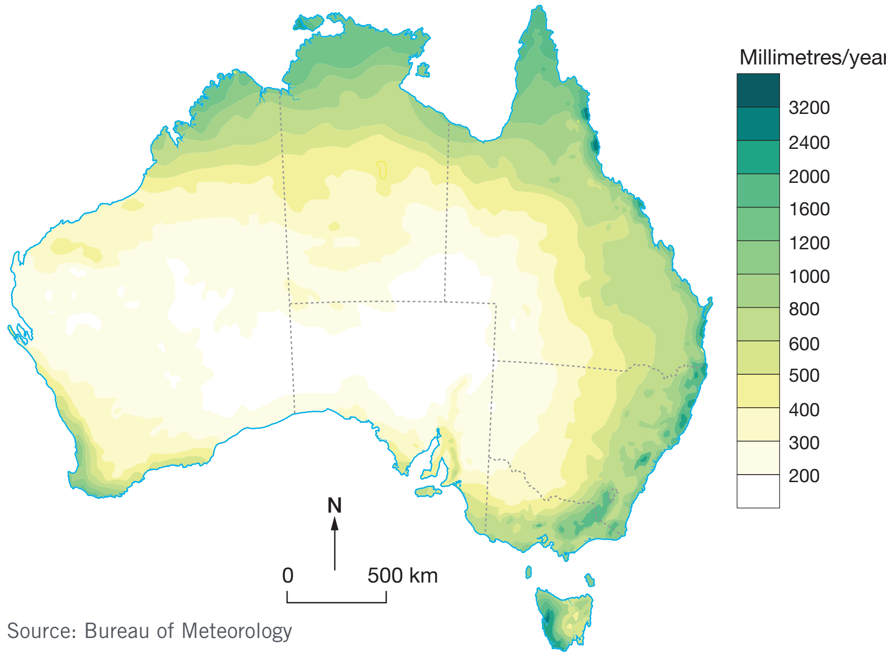
Water availability

Australia is a dry continent. Prolonged droughts, broken by flooding rains, are common. This creates a range of challenges for the managers of water resources.

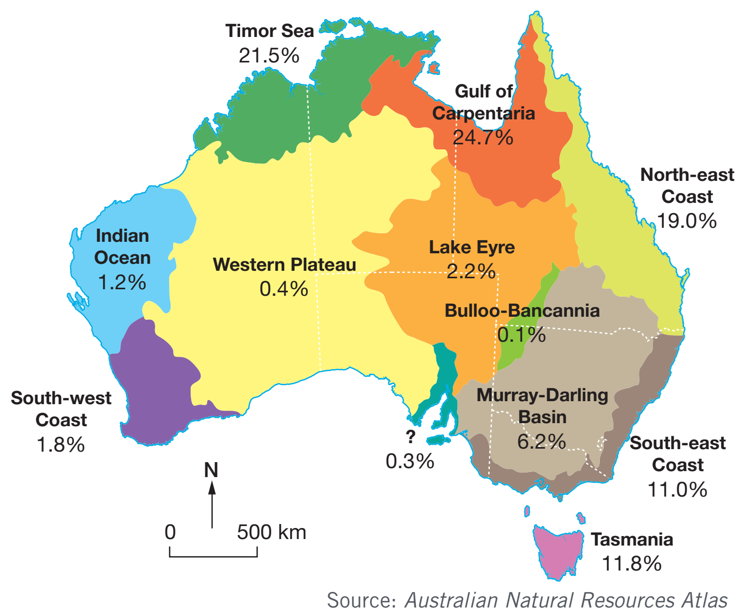
Australia's rainfall is unreliable and highly variable. Average annual rainfall is 469 millimetres per year (see Figure 9.3.1). While this is not very low, only 12 per cent of the water runs off into rivers. The remaining 88 per cent either evaporates or soaks into the ground.

In the more populated south-eastern states, water in dams, rivers and lakes is being used at a high rate. In response, all Australians, both in the city and in rural areas, are being encouraged to use less water. Strategies that encourage people to use less water and to use water more wisely include increasing the price of water and promoting water recycling and water trading.

In northern Australia, a large number of river systems have not been dammed. This means that the wetlands, rainforests, eucalypt savannas and native grasslands associated with these river systems do not lose access to a water supply. As Figure 9.3.2 shows, nearly two-thirds of Australia's water run-off occurs in this northern region. However, rainfall in northern Australia is highly seasonal, with heavy rains in summer and little rain in winter. The water that falls there is a potential resource, but it would have to be stored and transported to where it is needed. Building dams and pipelines to transport water would be very expensive.



9.3.1 Average annual rainfall in Australia



9.3.2 Rainfall run-off by major drainage division

Storing water

Because Australia's rainfall is so unreliable and variable, water run-off needs to be collected and stored in dams, moved to where it is needed and used with care in drier times. Australia has 447 large dams and, as Table 9.3.3 shows, they store nearly 84 000 gigalitres (GL) of water—equivalent to 168 Sydney Harbours. This water is used mainly to meet urban needs and for irrigation, flood mitigation and the production of hydro-electricity (see Figure 9.3.4). Australia also has several million farm dams, which are estimated to contain 9 per cent of all stored water.

The biggest 'store' of water is Australia's vast underground aquifers. These aquifers provide 25 780 GL of groundwater a year. This water is suitable for farming and domestic use, and for irrigated agriculture.

9.3.3 Storage capacity of large dams by state or territory

State or territory	Storage capacity (GL)
Australian Capital Territory	120
New South Wales	24 629
Northern Territory	280
Queensland	10 657
South Australia	258
Tasmania	23 652
Victoria	12 109
Western Australia	12 148
Australia	83 853

Source: National Water Commission, 2012

Learning from the past, looking to the future

For Australia's Aboriginal and Torres Strait Islander people, water and land are connected. This is significantly different from how other Australians have viewed water and land. Non-Indigenous Australians have in general seen the two as being separate, and have seen both as resources to be used for profit. However, this view is beginning to change. Water managers are beginning to understand that land and water cannot be managed independently of each other.

Due to changing climate and increasing demand for water, Australia faces major challenges in ensuring that it has a sustainable water supply. Any program aimed at securing Australia's future water security will include taking action on climate change, using water wisely, securing additional sources of water and supporting healthy river systems.

9.3.4 The 140-metre-high Gordon Dam, on Tasmania's Gordon River, is the tallest dam in Tasmania. It stores water for the production of hydro-electricity. The associated Gordon Power Station is Tasmania's largest power station.

ACTIVITIES

Knowledge and understanding

1. State the factors that complicate the management of water resources in Australia.
2. State why so little run-off finds its way into Australia's rivers.
3. Explain why the run-off from Australia's northern rivers is best described as a *potential* resource for use in other parts of Australia.
4. Identify Australia's principal stores of water.

Geographical skills

5. Study Figure 9.3.1. Describe the general pattern of annual rainfall in Australia.
6. Study Figure 9.3.2. Identify the drainage divisions with the highest and lowest run-off rates. What are the implications of this for the management of Australia's water resources?
7. Study Table 9.3.3. Explain why the amount of stored water varies from state to state.

9.4

Water supply in Australia

Water distribution

Australia is a continent of extremes. There is an abundance of water in the tropical north, where few people live, and relative scarcity in the more populated southern parts of the continent. In addition, neither north nor south receives reliable rainfall all year round.

Addressing past mistakes

Poor management of water resources has led to an over-allocation of water to farmers (irrigators), especially in the Murray–Darling Basin. There is also increasing competition between irrigators and mining, urban and industrial users of water. As a result, there has been a major deterioration in the health of many river systems and their environments throughout Australia.

For Australia to have environmentally sustainable and productive river systems, water needs to be managed better and used more efficiently. **Water buybacks** (paying irrigators to give back some of their allocated water) and the use of more efficient irrigation technologies are two strategies that could help to guarantee an **environmental flow** for river systems. Such plans are difficult to implement. Irrigators and river-dependent communities fear that their economic wellbeing will be affected.

Grand plans

Since European settlement, many proposals have been put forward to transport water from the north of Australia to the south. Some notable examples are described below.

The Bradfield Scheme

In 1938, John Bradfield, the designer of the Sydney Harbour Bridge, presented a plan to the Queensland government to divert water from northern Queensland's coastal rivers across the Great Dividing Range into central Australia. The aim of the scheme was to droughtproof much of inland Queensland and South Australia.

South-east Queensland water grid

In 2007, the Queensland government commissioned a report on a proposal to transport water from the north-east of Australia by diverting it from the Burdekin River to south-east Queensland, where it could be moved between various storage dams by pipelines.

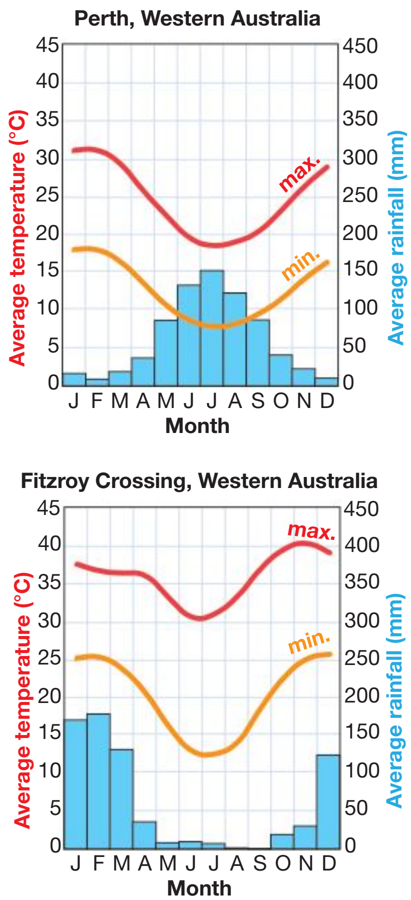
Northern New South Wales

It has been suggested that water from coastal rivers of northern New South Wales could be diverted into river systems west of the Great Dividing Range.

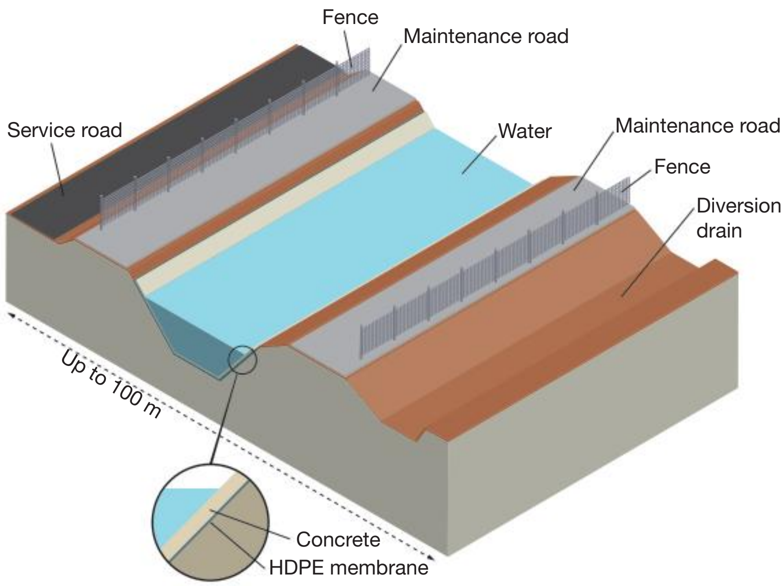
The Kimberley–Perth Canal

Plans to build a 2500-kilometre canal from Western Australia's Kimberley region to Perth (see Figure 9.4.1) received considerable media and political attention between 2006 and 2008. At this time, Perth was suffering one of its worst-ever droughts. The Kimberley region receives higher rainfall than Perth at different times of the year, as shown in Figure 9.4.2. Rivers in the region could also supply water.

9.4.1 The Watering Australia Foundation's proposed route for the Kimberley–Perth Canal



9.4.2 Climate graphs for Perth and Fitzroy Crossing. The Kimberley's summer rains could be diverted by canal to meet Perth's water needs.



9.4.3 Cross-section of the proposed Kimberley–Perth Canal

Alternatives to the canal proposal included a pipeline to transport the water from north to south, and transporting the water by sea in tankers or in large water bags towed by tugboats. The construction of a desalination plant proved to be a cheaper alternative.

Reality check

The cost of capturing and storing water, then transporting it from north to south, would be enormous. Even if cost were not an issue, the concept is not without its problems. These include:

- the lack of suitable locations for building a dam, given that much of northern Australia is flat
- the variability of rainfall across northern Australia
- environmental impacts in the catchments being harvested
- the current and potential uses of the north's water resources.

Alternatives

Alternative ways of addressing the issue of water scarcity in Australia are:

- reducing consumption by improving efficiency of rural and urban water use
- pricing water at a level that discourages waste
- recycling and desalination.

ACTIVITIES

Knowledge and understanding

1 Explain why effective water management is essential in Australia.
2 List the errors that were made in water management in the past.
3 Outline the aim of John Bradfield's water diversion scheme.

Applying and analysing

4 Create a PMI chart about moving water from the north of Australia to the south. Consider the economic, environmental and social costs.

Geographical skills

5 Study the climate graphs in Figure 9.4.2.
   a Describe how the climates of Perth and Fitzroy Crossing differ.
   b What is the link between the seasonal pattern of rainfall received by each station and proposals to transport water from the north to the south?

Water management in Australia

Competing demands for water

Australia is the driest inhabited continent on earth. It is essential that we carefully manage our water resources. Water is needed for our urban areas, for agriculture and also for industry. In addition, water is vital for the environment.

Water for Australia's cities

Most of Australia's large urban centres are located along the coastline. These coastal areas receive higher rates of rainfall than inland Australia. Even so, most cities face a challenge to meet the water needs of a growing population. In recent years, Brisbane, Sydney, Melbourne and Adelaide have all had to place restrictions on how and when people can use water. Many smaller cities and towns have also had to impose water restrictions.

Figure 9.5.1 summarises some of the strategies that cities around Australia are beginning to use to secure their water supplies for the future.

9.5.1 Some of the strategies used in Australian cities to secure water supplies

Managing the impacts of irrigation

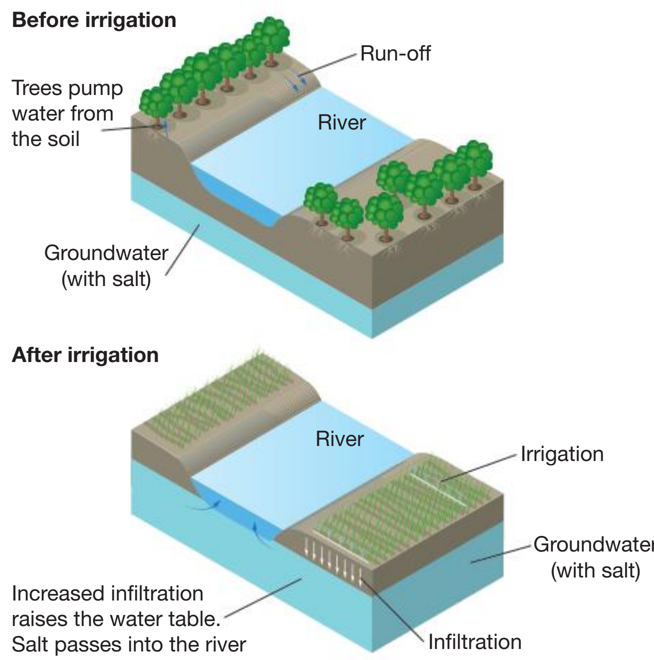
Irrigation allows us to grow crops in areas that are normally too dry. Unless irrigation water is managed carefully, it can have serious environmental impacts. One of the most serious impacts is salinity, or an excess of salt in the soil. There are two types of salinity.

Dryland salinity

Salinity of soils and water is a natural characteristic in semi-arid and arid climates. This salinity results from low, unreliable rainfall and high rates of evaporation. Soils become salty when there is not enough rainfall to remove the salt; this process is known as **leaching**. Flat landscapes and inward-draining regions (such as the Lake Eyre Basin) do not have the advantage of rivers running through them that can carry salt to the sea.

Irrigation salinity

Irrigation salinity occurs when irrigation water seeps down into the soil, causing the water table to rise. When this happens, dissolved salts move up into the root zone of plants. Dissolved salt can also move towards watercourses (see Figure 9.5.2). This results in an increase in the salinity of rivers.



9.5.2 Irrigation salinity. Irrigation water causes the water table to rise, bringing dissolved salt to the surface.

SPOTLIGHT

Total catchment management

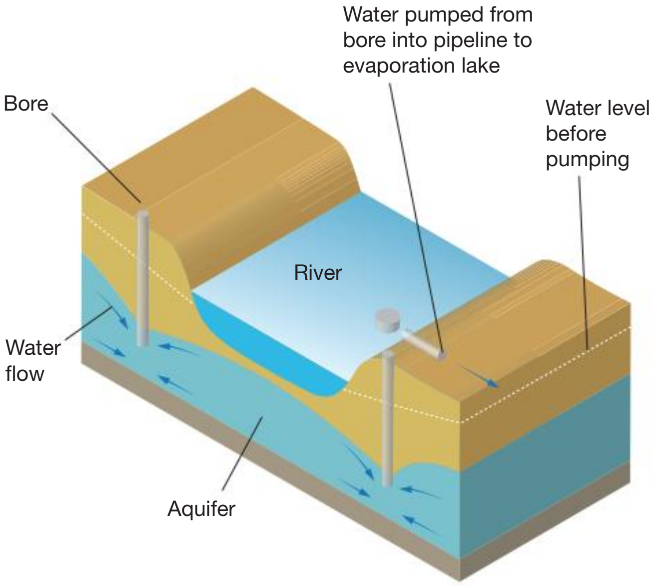
The best way to protect water quality in our waterways is to manage the whole catchment. Sources of pollution need to be identified, and pollutants (such as sewage, industrial pollution, agricultural fertilisers and pesticides, and salty groundwater) need to be captured and treated before they find their way into a catchment's waterways.

There is also a need to manage the amount of water taken from rivers for irrigation and for urban and industrial uses. Scientists now talk of maintaining an adequate environmental flow to protect the health of river and wetland ecosystems.

9.5.3 Two views of the Snowy River, showing the level of the river (a) when most of its flow had been diverted into the Murray–Darling Basin and (b) after water was released to stimulate environmental flow

Solutions

While it is unlikely that there will be a total solution to the salinity problem in Australia, steps can be taken to stop water tables from rising. One way to do this is by pumping and draining water, as shown in Figure 9.5.4. A second way is by planting deep-rooted vegetation, which reduces the amount of water reaching the water table by increasing the rate of transpiration.



9.5.4 Expensive engineering can be used to lower water tables and protect waterways. The disposal of the salt that accumulates is another significant problem.

ACTIVITIES

Knowledge and understanding

1 Explain why it is important that water resources are carefully managed in Australia.
2 'Total catchment management' refers to protecting waterways. What needs to be identified so that this protection can commence?
3 Explain the concept of an environmental flow.

Applying and analysing

4 Study Figure 9.5.1. Write a paragraph outlining the strategies used in Australian cities to manage water resources.
5 Study Figure 9.5.2. Write a paragraph outlining the relationship between irrigation and salinity.
6 Study Figure 9.5.4. Write a paragraph outlining how an engineering response can be used to address irrigation salinity.

Investigating

7 Working in small groups and taking the perspective of a government department responsible for managing water in your town or city, prepare a brochure, a digital presentation or the script for a television or radio advertisement about strategies that could be used to reduce water usage.

9.6

CASE STUDY:
The Murray–Darling Basin

Geography

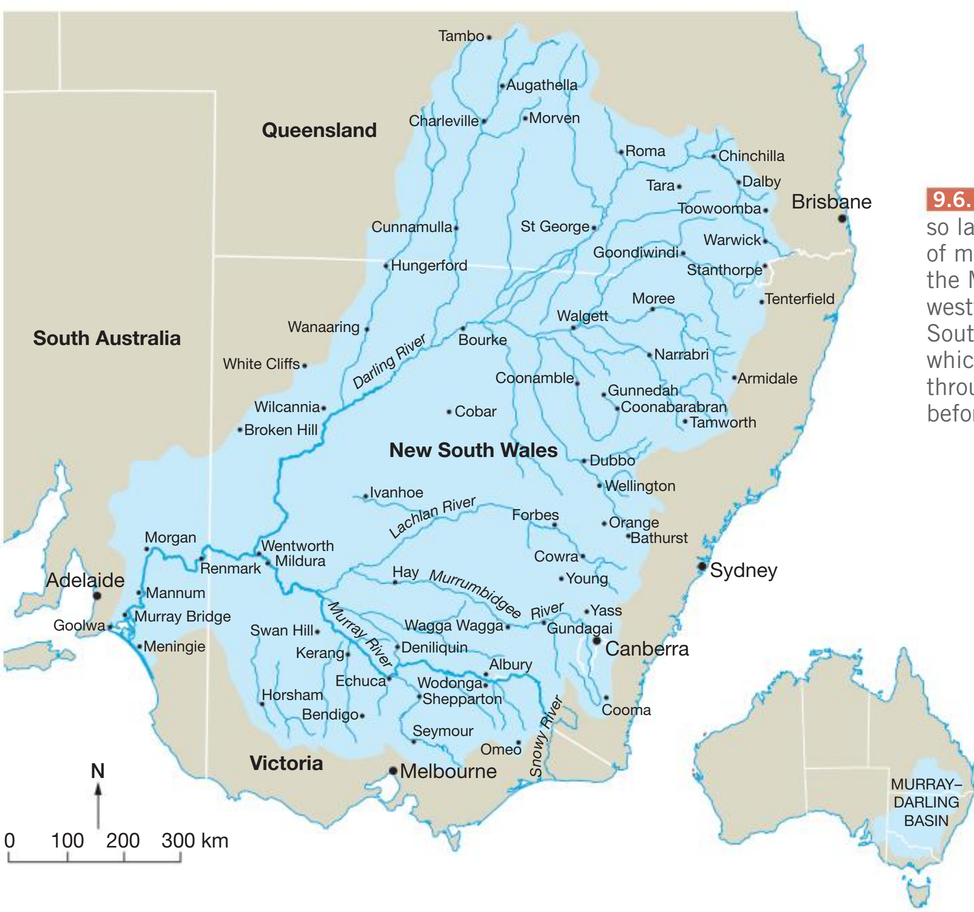
The Murray River is Australia's longest river, with a length of approximately 2508 kilometres. It has its source in the Australian Alps and drains the western side of the Great Dividing Range. At Wentworth, the Murray River is joined by the Darling River. The Darling River is approximately 1545 kilometres in length and begins its journey in southern Queensland. The Murray then flows into South Australia. It turns south near the town of Morgan, and continues southwards to reach the Southern Ocean near Goolwa. The catchment or **river basin** (the area over which rain falls that eventually flows into the river) of the Murray and the Darling, shown in Figure 9.6.1, covers about one-seventh of Australia's landmass.

Ecosystem

The ecosystem of the Murray–Darling Basin is very diverse. The aquatic environment contains a number of important fish species, including the very large Murray cod. There are also complex communities of mussels and other important animals, including the Murray crayfish and freshwater turtles.

More than 7000 wetlands are found along the Murray and its tributaries. These wetlands are an important **habitat** for a whole range of animals, including birds, frogs and other amphibians, and larger, land-based animals, such as wallabies and kangaroos.

A very important part of the Murray–Darling Basin, and one of its most threatened environments, is the river red gum forests (see Figure 9.6.2). These trees have evolved over thousands of years to live on the flat flood plains adjacent to the river. They provide important habitats for many species.



9.6.1 The Murray–Darling River Basin is so large that it includes the catchments of many large rivers. These include the Murrumbidgee River, which flows westwards across south-western New South Wales, and the Darling River, which flows southwards from Queensland through far western New South Wales before flowing into the Murray.

9.6.2 A Murray River wetland dominated by river red gums

Economic importance

The Murray–Darling Basin is Australia's most important food-producing area because approximately 40 per cent of Australia's food is produced there. It is where 98 per cent of oranges and 54 per cent of apples are grown. All of Australia's rice is grown in the Basin. Of the food that Australia exports, 39 per cent comes from the Murray–Darling Basin. Exporting food grown in the Basin creates billions of dollars worth of trade.

The Murray–Darling Basin is also an important destination for recreation and tourism. People travel to the area to make use of its rivers for boating, water skiing, swimming and canoeing. Each year in December, canoeists paddle 404 kilometres down the Murray during the five-day Murray Marathon event.

The most important economic benefit of the Murray–Darling Basin is to the 1.26 million people who live in Adelaide and rely on the Basin for their water supply.

Human impacts

Since European settlement, the Murray–Darling Basin environment and its ecosystems have undergone major changes.

Land clearing

There has been extensive land clearing across the Basin. The native scrub and river red gum forests have been replaced with **pastures** for grazing animals. Large areas have also been cleared for rice, wheat and other cereal crops, as well as citrus fruits and vineyards.

Water extraction

Large amounts of water are needed to support agriculture and communities across the Basin. Water is extracted from the Basin's rivers for this purpose.

Water diversion

The Snowy River rises on the eastern side of the Australian Alps and flows south towards Bass Strait. Between 1949 and 1974, a huge system of tunnels and dams was built to divert the majority of the Snowy River's water into the Murray River. First, the water is stored in huge dams. Then it is sent westwards across the mountains through tunnels. This water is also used to generate hydro-electricity.

Habitat destruction

Land clearing for agriculture and urban development, as well as the flooding caused by the huge dams and lakes used for irrigation, has led to the destruction of many wetlands and forests. Important habitats for waterbirds and countless other animals have been lost.

Turbidity and nutrient run-off

Turbidity is a measure of the cloudiness of water. It increases when soil and other materials enter the water. High levels of turbidity reduce the amount of sunlight that penetrates the water, and this affects plants growing in the water.

Nutrients such as fertilisers can flow into rivers from nearby farms and cause algae to grow. When large blooms of algae die, the bacteria responsible for their decomposition remove oxygen from the water, reducing aquatic life further by limiting access to vital oxygen.

Soil salinity

The origins of the Murray–Darling Basin stretch back more than 500 000 years. At that time, the area was covered in a shallow saltwater sea. As the sea retreated, it left a deposit of sand, which still covers the area, as well as salt. This means that the soils of the Basin contain huge amounts of salt.

Typically, the salt was once trapped deep in the soil. As the land has been cleared and irrigated, the salt has come to the surface with rising groundwater. Before land clearing, trees acted as huge pumps, sucking up large amounts of water and keeping the water table deep below the surface. The removal of the trees has allowed the groundwater to rise towards the surface, bringing the salt with it. This salt scars the surface and becomes poisonous to plants, and subsequently destroys the environment, as shown in Figure 9.6.3.

River regulation

The process of river regulation involves the construction of weirs, dams and other engineering works in and around rivers. Such regulation has changed the nature of the rivers of the Murray–Darling Basin. The regular flooding that once came each spring with the alpine snowmelt has been replaced by a more regular flow. Constructions in the river prevent fish from swimming up and down the river, making breeding more challenging.

River mouth

As a result of extracting water and building dams and weirs to control the river, less water flows down the Basin's rivers. This means that sediments such as sand, which are normally carried along by the water, build up in the rivers. The mouth of the Murray at Lake Alexandrina, near Goolwa, often requires dredging to keep it open (see Figure 9.6.4).

9.6.3 Soil salinity brings salt to the surface, killing trees and destroying habitats, on Disher Creek, South Australia.

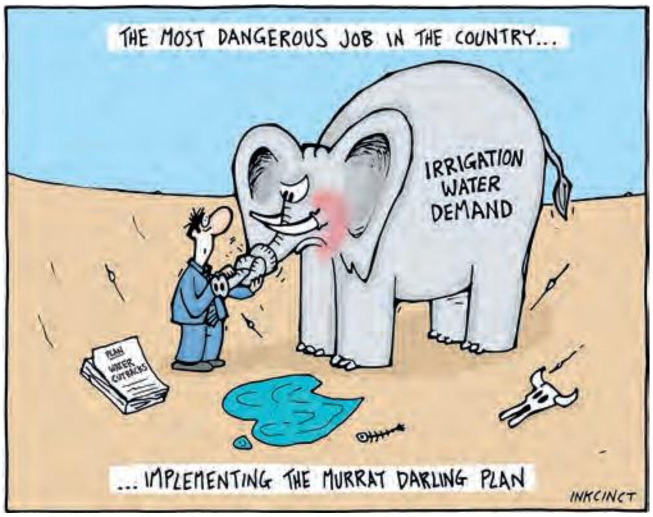
9.6.4 So much water is taken out of the Murray for irrigation and town use that the mouth of the river often fills with sand and needs to be dredged.

Management

The Murray–Darling Basin is so important to Australia's environment and economy that it requires careful management. After much debate, laws were pass in late 2012 to return water to the system for environmental purposes. Initially, an amount of 2750 gigalitres was allocated annually. After environmentalists and the South Australian government argued that this was not enough to protect the river's ecosystem, the allocation was increased to 3200 gigalitres, to be achieved by 2019. This water will be allowed to flow down the river, flushing it of sediment and salt. It will also help to reduce turbidity and the build-up of nutrients that promote the growth of algae.

Other strategies being used to solve the problems of the Murray include:

- the installation of fish ladders to help fish migrate upriver, past dams and weirs
- reductions in land clearing and increased planting of trees
- careful management of wetlands.



9.6.5 There are many competing demands on the water in the Murray–Darling Basin.

ACTIVITIES

Knowledge and understanding

1 Explain the importance of the Murray River.

2 Copy and complete the following table.

Problem	Cause	Impact	Solution
Salinity			
Habitat loss			
Turbidity			
Nutrient run-off			
River regulation			
Water extraction			
Land clearing			

Applying and analysing

3 Using Figure 9.6.1 and the text, write a paragraph describing the location of the Murray–Darling Basin. List all the states across which the Basin is located.

4 List the reasons why it is important to protect the Murray River. Summarise your findings using a mind map.

Investigating

5 Select one of the impacts of human activity on the Murray–Darling Basin. Using the internet and library sources, prepare a digital presentation outlining how humans cause this impact and how it affects the environment of the Basin.

Water scarcity and management

CHAPTER 10

Rapid world population growth, unsustainable use of water and changes to patterns of precipitation resulting from climate change are placing increasing demands on water resources all over the world. In many parts of the world, ecosystems are under stress as the water on which they rely is being used for agriculture and other purposes. Such concerns highlight how important it is to manage the world's water resources in industry and homes.

In this chapter we focus on water scarcity and resource management on a global scale. In particular, we look at strategies to increase the supply of water and conserve existing sources.

INQUIRY QUESTIONS

- What are the causes of water scarcity?
- How can the supply of water be increased and existing resources conserved?
- How can individuals and households contribute to the conservation of water resources?

GLOSSARY

aqueduct	an artificial channel built to transport water
brine	a very salty solution
contaminated water	water that is unsafe to drink because it is not clean
dam	a structure built across a river to control the river's flow and create a reservoir
deep aquifer	a deep underground layer of water stored in rock; this water is difficult to access except with expensive drilling
desalination	the removal of salts from seawater or other saline (salty) solutions
desertification	the expansion of deserts due to overgrazing, soil erosion, climate change or prolonged drought
green energy	energy (electricity) produced using renewable resources, such as wind or sunlight, without creating greenhouse gases
groundwater	water beneath the earth's surface that fills pores or tiny spaces in materials such as sand, soil or gravel
hydro-electricity	electricity generated by using the energy of falling water
Millennium Development Goals	ten goals of the United Nations General Assembly; the goals include eradicating extreme poverty and hunger, improving maternal health and ensuring environmental sustainability
reservoir	a large natural or artificial lake used as a source of water supply
reverse osmosis	a process used to remove contaminants and salts from salty water
Sustainable Development Goals	seventeen new development goals that replace the Millennium Development Goals; they aim to address the three dimensions of sustainable development (social, economic and environmental), as well as peace, justice and effective institutions by 2030
water scarcity	a situation in which the demand for water is greater than the amount available
water stress	the negative effect that water scarcity can have on people and environments

10.0 The California Aqueduct, United States of America

10.1 Water scarcity

Defining water scarcity

Water scarcity occurs when the demand for water exceeds the amount available. Water scarcity can lead to **water stress**, which affects people and environments. Many of the world's water-stressed countries are in Africa.

Types of scarcity

Water scarcity can be either physical or economic. Physical scarcity occurs when where there is not enough water to meet all demands, including those of ecosystems. Economic scarcity occurs when there has not been enough investment in the infrastructure needed to store and transport water to where it is needed.

Water stress

Water stress is the negative effect on people and environments that can result from water scarcity. Africa has the largest number of water-stressed countries. Most of these are found in North Africa.

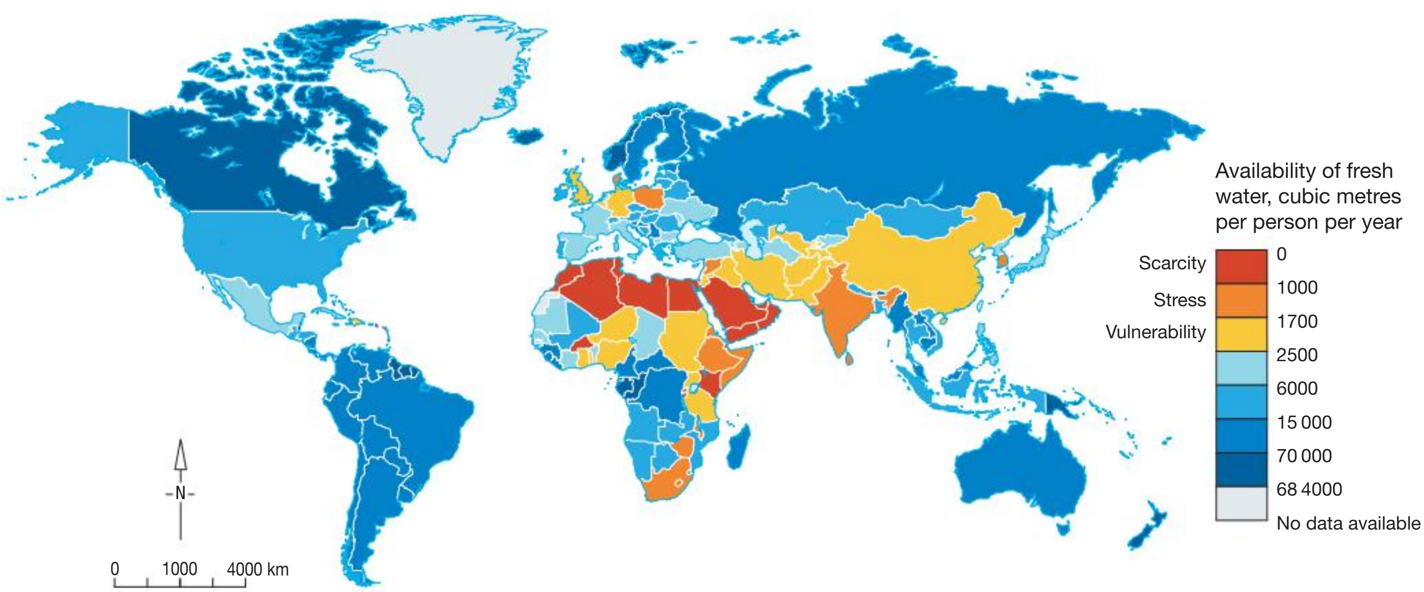
Reasons for scarcity

Water scarcity can occur in areas where there is plenty of rainfall. The quality of the water available determines whether there is enough to meet the needs of households, farmers, industry and the environment.

Figure 10.1.1 shows water availability in the world. Approximately 1.2 billion people, or almost one-fifth of the world's population, live in parts of the world where water scarcity is already a problem, and 500 million people are approaching that situation. Another 1.6 billion people face water shortages due to a lack of infrastructure to extract water from rivers and aquifers. Rapid population growth, urbanisation and increases in water use by households and industry are making the situation worse. The total amount of available fresh water is changing due to climate change, which is causing glaciers to recede, river flows to reduce and lakes to shrink. Many aquifers have been over-pumped and are not refilling quickly.

Effects on water quality

Water scarcity results in people having to rely on unsafe sources of drinking water. Maintaining personal hygiene is difficult. There is often not enough water to bathe or wash clothes properly. Much of the world's fresh water has become too polluted or salty for use in households, industry and agriculture.



10.1.1 World water availability

Contaminated water also increases the risk of infection from waterborne diseases such as cholera, typhoid and dysentery. Water scarcity can lead to diseases such as trachoma (which can lead to blindness), plague and typhus. Contaminated, stagnant water provides a breeding ground for mosquitoes, which are carriers of diseases such as dengue fever and malaria.

The use of wastewater in agriculture is growing and puts people at risk from crop contamination. More than 10 per cent of the world's people consume food grown using wastewater that contains various chemicals or disease-causing organisms.

Solutions

To avoid a global water crisis, industries and cities will need to find ways to use water more efficiently. Farmers will have to increase productivity to meet growing demands for food without greatly increasing their water usage. People need to take personal responsibility and learn how to conserve and protect water resources.

Target 10 of the United Nations **Millennium Development Goals** was to halve the proportion of people without access to safe drinking water and basic sanitation by 2015. This goal has been replaced by the new Sustainable Development Goal, Target 6. This new target focuses on 'clean water and sanitation'. Water is an essential resource to sustain life.

SPOTLIGHT

Water scarcity in Africa

Fourteen countries in Africa already experience water stress. Another eleven countries are expected to join them by 2025. By this time, an additional 50 per cent of the continent's estimated population of 1.45 billion people will experience either water stress or water scarcity. In sub-Saharan countries, nearly 51 per cent of the population (300 million people) lack access to a supply of safe water, and 41 per cent lack adequate sanitation.

10.1.2 Searching for water in a dry riverbed in northern Kenya

ACTIVITIES

Knowledge and understanding

1. Explain the difference between *physical* and *economic* water scarcity.
2. Describe the nature and extent of water scarcity in Africa.
3. List the percentage of the world's population that is affected by water scarcity.
4. List the types of water issues that affect people around the world.

Applying and analysing

5. Can places with high rainfall experience water scarcity? Explain.
6. Study Figure 10.1.1.
   a. List the continents experiencing water scarcity, water stress or water vulnerability.
   b. List the continents not experiencing water scarcity, water stress or water vulnerability.
   c. List reasons for the different answers to parts **a** and **b**.

10.2

Access to clean water

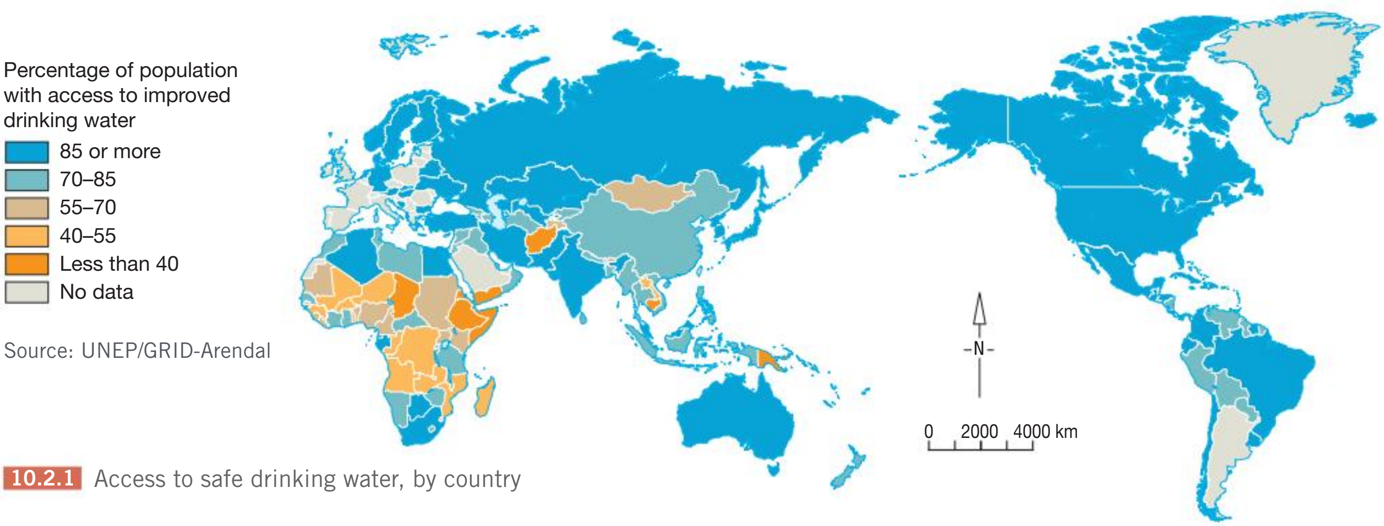
Water access issues

Access to safe water and access to sanitation are important. The contamination of water sources by human waste, and the waterborne diseases that result from this contamination, are a source of great human suffering.

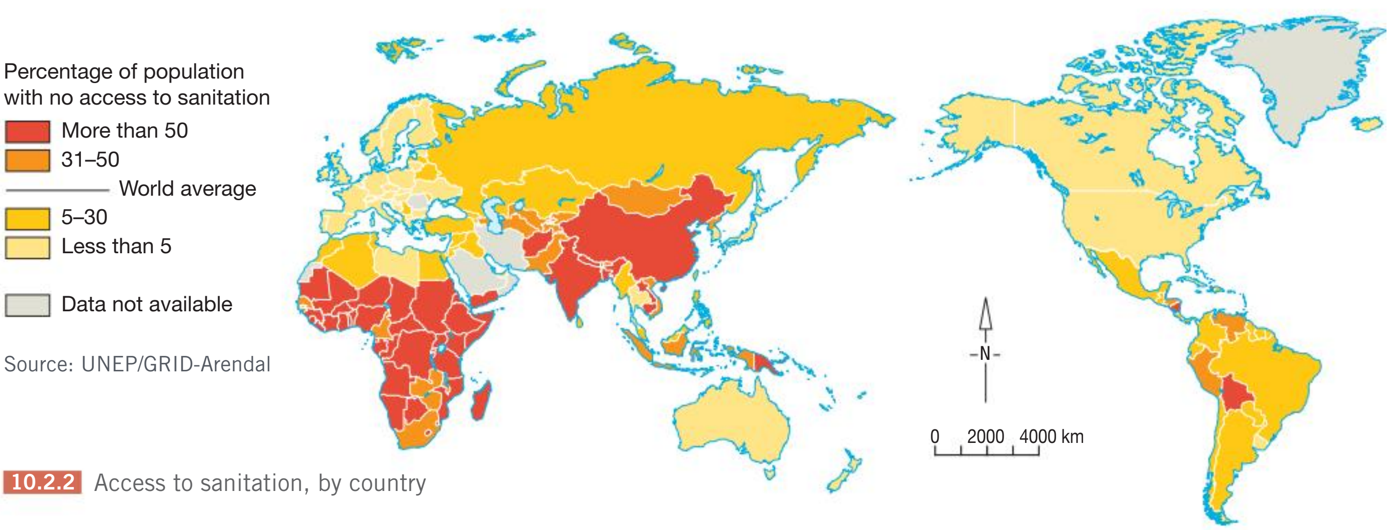
Access to water is a global health issue. According to the World Health Organization (WHO), one in six people do not have access to reliable, safe drinking water, and 2.6 billion people (40 per cent of the world's total population) lack access to basic sanitation.

Figures 10.2.1 and 10.2.2 show global access to safe or improved water, and places with little or no access to sanitation.

Access to water is also an economic issue because it is vital for reducing poverty and producing food and energy. It is especially an issue for women and children in developing countries. In many developing countries, women and children are responsible for finding and carrying the household's daily supply of water from distant wells, as shown in Figure 10.2.3.



10.2.1 Access to safe drinking water, by country



10.2.2 Access to sanitation, by country

10.2.3 Collecting enough water for drinking, cooking and basic hygiene for a family of six can mean carrying heavy water containers from a distant source for an average of 3 hours a day.

Waterborne diseases

Waterborne diseases occur when people drink contaminated drinking water. When the same contaminated water is used in the preparation of food, people can get a range of foodborne diseases. Diseases transmitted through contaminated water include diarrhoea, cholera, dysentery, typhoid and hepatitis A.

Sanitation

Sanitation is a basic need and a way to safeguard people's health. It prevents the spread of disease.

For many countries it is a challenge to provide the infrastructure (toilets, storage facilities, pumping stations, sewerage, water pipelines and treatment works) needed to prevent contamination. Infrastructure is expensive, and rapid rates of urbanisation often make it difficult for authorities to keep pace with population growth and provide proper sanitation. The solutions do not need to be expensive or high-tech. The construction of communal toilets is an example of a low-cost response.

Lack of toilets forces people to use public spaces. This increases the risk of transmitting disease. The Ganges River in India, for example, has approximately 1 billion litres of raw sewage dumped into it every day. This is frightening when you consider that just 1 gram of human waste in untreated water may contain 10 million viruses, 1 million bacteria and 100 worm eggs.

In India, it is estimated that 80 per cent of all health problems and one-third of all deaths are due to contaminated water. Building toilets can have an immediate impact on public health, and can reduce death rates from diarrhoea by up to a third.

Providing toilets has a number of other benefits. Toilets in schools encourage children, and particularly girls, to attend school. For example, if a school has no toilets, girls generally do not attend school during menstruation, and their education is disrupted. Hygiene education campaigns and the promotion of hand washing (when included in the school curriculum) can reduce diarrhoea cases by up to 45 per cent.

DEVELOPMENT GOALS

The United Nations Millennium Development Goals (MDGs) had a target of 75 per cent sanitation coverage worldwide by 2015. It was estimated that it would cost US$14 billion per year to meet that target. The economic benefits of sanitation are impressive. Every US$1 invested in improved sanitation provides a US$9 return in value. Those who benefit most are children living in disadvantaged communities.

These goals have been replaced by the new **Sustainable Development Goals**, which aim to build on the work of the MDGs. The new Goal 6 aims to 'ensure availability and sustainable management of water and sanitation for all' by the year 2030.

Growing cities

People living in the world's rapidly growing slums have very limited access to safe water for household use. A slum dweller may have access to between 5 and 10 litres per day, while a person in the same city on a middle income may use 50 to 150 litres per day.

In some cities with poor infrastructure, nearly 30 per cent of freshwater supplies are lost because of leaking pipes. In some large cities, pipes that leak can lose up to 70 per cent of their water.

10.2.4 Children play in a polluted drain in Manila, in the Philippines. Rapid urbanisation has overwhelmed efforts by the authorities to meet people's needs for clean water and sanitation.

SPOTLIGHT

World Vision making a difference

Australians take clean water for granted, but in many countries it is still considered a luxury. In Indonesia, four out of five mothers have no option but to give their families bacteria-infected water because of polluted wells. In one Indonesian community, World Vision is addressing these water concerns.

Indonesia has some of the world's worst sanitation. UNICEF has found that 53.4 per cent of Indonesian families use a water source located within 10 metres of an open toilet. This falls short of the universal standard for water safety. Water this close to a toilet is the ideal breeding ground for bacteria that cause diarrhoea, typhoid and other waterborne diseases.

In 2005, the isolated East Nusa Tenggara province in Indonesia faced particularly large challenges. Piping was limited, so some families sourced their water from wells more than an hour's walk away—and these wells were often polluted. More than 38 per cent of children under five in the province suffered from diarrhoea.

In the same year, World Vision began a project with the community to provide information about the importance of good hygiene and sanitation. School classes emphasised the importance of basic hygiene so children would bring this knowledge home to their families. A media campaign and prizes for best sanitation practices also helped get word out.

As well as providing advice on safe water sources, World Vision worked with the community to improve their water supply. World Vision assisted in building 25 kilometres of gravitational piping, a water reservoir, five water tanks and toilets in more than 800 households.

Today, 75 per cent of households have toilets. This has greatly helped to separate waste and clean water. Surveys show that knowledge about basic hygiene has improved throughout the area. Most importantly, diarrhoea in children under five years of age has decreased dramatically. By 2008, there were only 11.7 per cent of children infected.

Source: World Vision Australia website, 2012

ACTIVITIES

Knowledge and understanding

1 How many people in the world do not have access to clean water?

2 List the effects of poor sanitation on the health and wellbeing of people.

3 What are the benefits of improved sanitation and clean water?

Applying and analysing

4 Outline the strategies being used to meet the sanitation needs of people. Why has this approach been adopted?

5 'Improving sanitation is essential to ensure a clean water supply.' Is this statement correct or incorrect? Explain.

6 What impacts can a lack of access to a clean supply of water have on human wellbeing? Present your key points as a mind map.

Geographical skills

7 Study Figure 10.2.1. With the aid of an atlas, identify the parts of the world where less than 60 per cent of the population have access to safe drinking water.

8 Study Figure 10.2.2. With the aid of an atlas, identify the regions of the world that experience the lowest levels of per capita access to sanitation.

9 Study Figure 10.2.4. Explain why people living in such conditions are exposed to the threat of waterborne diseases. Undertake research to find out why such living conditions are common in many of the developing world's large cities.

Investigating

10 Waterborne diseases often become a problem in the period following major natural disasters.
   - a Explain why they become an issue.
   - b Select one of the waterborne diseases, and identify the source, symptoms, treatments and long-term effects of the disease.
   - c Describe programs put in place after natural disasters to reduce the impacts of waterborne diseases. (Refer to the Spotlight box 'World Vision making a difference' as a guide.)

10.3

Africa: Managing water resources

Water distribution

The distribution of freshwater resources in Africa is uneven and unreliable. Areas such as the Sahara and the Sahel in the north, and the Kalahari in the south, suffer from long periods of drought, while the tropical belt of mid-Africa has plenty of water.

The problem

Water scarcity has always been a problem in Africa. Africa's share of the world's population is 14 per cent, yet its share of global fresh water is about 10 per cent. With its population projected to double from just over 1 billion in 2012 to 2 billion in 2050, the situation can only get worse.

- Most Africans living in rural areas do not have safe and reliable access to water. On average, Africans use only 30 to 40 litres of water per day for domestic consumption.
- More than 300 million people in Africa still lack access to safe water and adequate sanitation. In Sub-Saharan Africa, just 51 per cent of the population have access to safe water and 45 per cent to sanitation.
- Africa is a dry continent. More than 40 per cent of Africa receives less than 200 millimetres of rainfall a year. Drylands and deserts together cover 60 per cent of the entire land surface.

The Millennium Development Goals increased access to an improved drinking water source throughout Africa. However, success was greater in northern Africa than Sub-Saharan Africa. In this region, over 30 per cent of the population still do not have access to safe water.

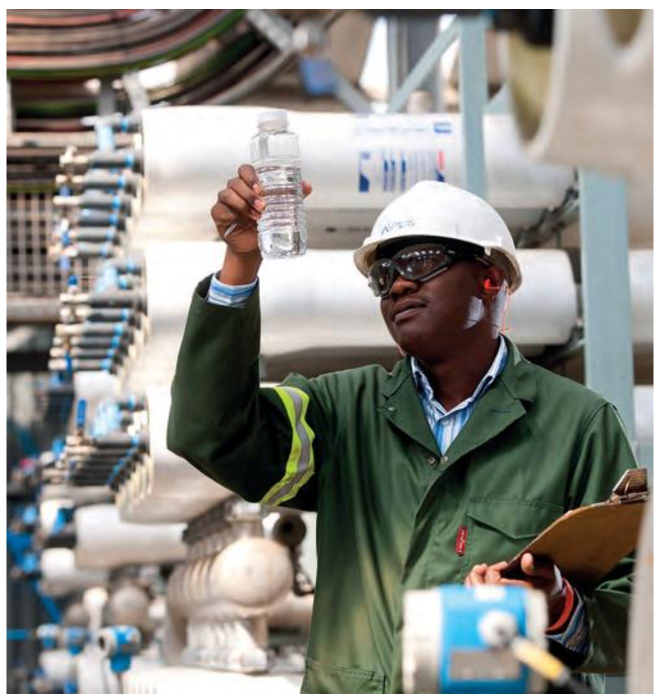
The challenges

The water-related challenges facing Africa are enormous.

- Africa aims to achieve access to improved water supply and sanitation for 95 per cent of people by 2025.
- Africa aims to increase the area of irrigated land by 100 per cent by 2025.
- To meet the increased demands of agriculture, hydro-electric power, industry, tourism and transportation, Africa has to increase the development of its water resources by 25 per cent by 2025.
- Africa has to manage droughts, floods and **desertification** more effectively.
- It is a priority is to restore the environment through the supply of sufficient water for environmental sustainability and the conservation of watershed ecosystems.

A contemporary response

There are three broad approaches to water management. The first approach involves capturing and storing more water. This is the main approach taken by most African governments. The second involves realising that people need to conserve water in order to get more use out of every drop, for example through efficient irrigation techniques. Thirdly, people need to do things differently with the water available, for example include building reclamation or recycling plants such as the one in Namibia shown in Figure 10.3.1. Africa's **groundwater** stocks are enormous, but they could be depleted if they are used faster than they can be replenished. Sustainable approaches to water management will be essential.

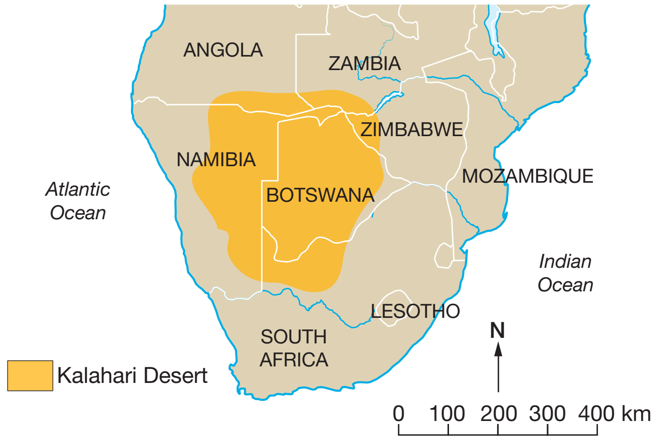


10.3.1 Water reclamation in Namibia. Water is re-used for irrigation and domestic consumption.

SPOTLIGHT

The San people of the Kalahari

The San people (sometimes referred to as the Bushmen of the Kalahari; see Figure 10.3.2) are the indigenous people of southern Africa. Traditionally, they have lived as hunter-gatherers, hunting game with poisoned arrows. In their dry environment the San get their water from baobab trees, plant roots (as shown in Figure 10.3.3) and desert melons. They often store water in springbok bladders and the blown-out shells of ostrich eggs. They also dig sip wells—holes that they dig in the earth and fill with soft grass. A reed is used to suck water from the hole, and send it bubbling up the reed to fill an ostrich egg.



10.3.2 For more than 20 000 years, the San have occupied a vast territory spanning parts of modern-day South Africa, Zimbabwe, Zambia, Botswana, Namibia and Angola.

10.3.3 San Bushman drinking sap squeezed from a tuber

ACTIVITIES

Knowledge and understanding

1. List the water-related challenges facing Africa.
2. Explain how the San people of the Kalahari learnt to live with water scarcity.

Applying and analysing

3. Explain how the three broad approaches to water management will help ease Africa's water problems.

Geographical skills

4. Study Figure 10.3.2. Name the countries in which the Kalahari Desert is located.
5. Study Figure 10.3.3. Describe the living conditions of the San people with the help of the image and the information in this unit.

10.4

Increasing water supply

Demand for water

The global demand for water will continue to increase as the world's population heads towards 7.9 billion in 2025. Not only will we need to increase the amount of fresh water available, we will also need to use existing supplies more carefully.

Solutions

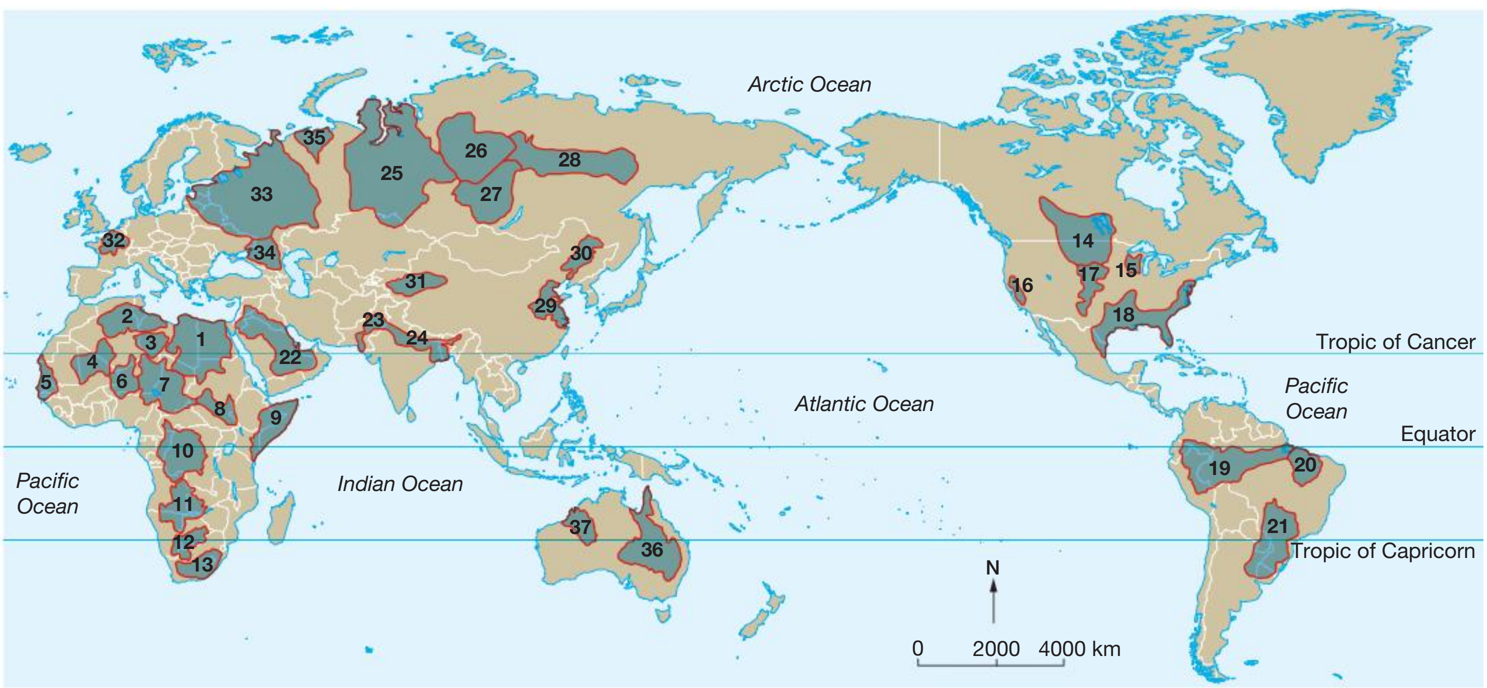
Ways of increasing the water supply include:

- extracting more groundwater
- building dams and reservoirs
- transporting water
- desalination.

Extracting groundwater

Most aquifers are a renewable resource unless the groundwater they contain either becomes contaminated or is removed faster than it can be refilled by rainfall. At present, water tables in many places are falling because water is being withdrawn faster than the rate of natural recharge.

The world's **deep aquifers** are a largely untapped potential source of additional groundwater (see Figure 10.4.1). Tests indicate that some of these aquifers hold enough water to support billions of people for centuries. Unfortunately, deep aquifers are not considered a renewable resource because they have taken millions of years to reach their current state and cannot be replenished on a human timescale.



Source: WHYMAP

Large aquifer systems

1 Nubian Aquifer System
2 North-west Sahara Aquifer System
3 Murzuk–Djado Basin
4 Taoudeni–Tanezrouft Basin
5 Senegalo-Mauritanian Basin
6 Iullemeden–Irhazer Aquifer System
7 Chad Basin
8 Sudd Basin
9 Ogaden–Juba Basin
10 Congo Intracratonic Basin
11 Northern Kalahari Basin
12 South-east Kalahari Basin
13 Karoo Basin
14 Northern Great Plains Aquifer
15 Cambro-Ordovician Aquifer System
16 California Central Valley Aquifer System
17 High Plains–Ogallala Aquifer
18 Gulf Coastal Plains Aquifer System
19 Amazonas Basin
20 Maranhao Basin
21 Guarani Aquifer System
22 Arabian Aquifer System
23 Indus Basin
24 Ganges–Brahmaputra Basin
25 West Siberian Artesian Basin
26 Tunguss Basin
27 Angara–Lena Artesian Basin
28 Yakut Basin
29 North China Plain Aquifer System
30 Songliao Basin
31 Tarim Basin
32 Parisian Basin
33 East European Aquifer System
34 North Caucasus Basin
35 Pechora Basin
36 Great Artesian Basin
37 Canning Basin

10.4.1 The world's large aquifer systems

In addition:

- little is known about the impact of withdrawing this water on the geology of the area
- some deep aquifers underlie more than one country, which makes them a potential source of conflict
- the cost of tapping this resource would be very high.

Dams and reservoirs

A **dam** is a structure built across a river to control the river's flow. The dammed water creates a **reservoir**, or lake, behind the dam. The main purpose of a dam is to capture and store water run-off. The water is then released when needed to control floods, generate electricity (**hydro-electricity**) or supply water for irrigation and for towns and cities. Reservoirs also provide opportunities for recreational activities such as swimming, fishing and boating.

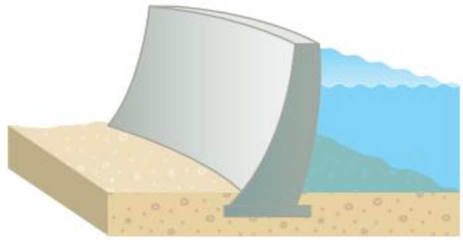
There are now more than 45 000 large dams worldwide (22 000 of these are in China). Together, they capture and store about 14 per cent of the world's surface water run-off, provide water for almost half of all irrigated crop land, and supply more than half of the electricity used in 65 countries. These dams have increased the reliable availability of water for human use by nearly one-third.

Large dams have both benefits and drawbacks. While they greatly increase water supplies in some areas, they also disrupt ecosystems and displace people.

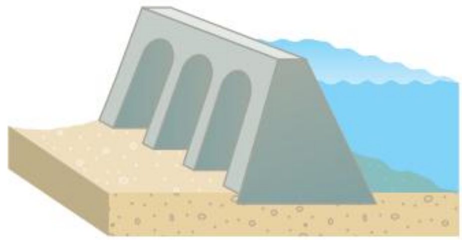
Dams can be classified into different types according to their structure (see Figure 10.4.2).

Transporting water

Water can be transported over long distances using dams, pumps, tunnels, pipelines and lined canals, or **aqueducts**. The California Water Project in California, USA, is one of the world's largest water transfer projects. It moves water from water-rich northern California to water-poor southern California, where it is mainly used in agriculture. In Australia, the Snowy Mountains Scheme takes water from the Snowy River, on the eastern side of the Great Dividing Range, and diverts it westwards into the Murray and Murrumbidgee river systems, where it is used for irrigation. There are some people in Australia who argue in favour of building large dams in northern Australia and piping the water south into the Murray–Darling river system.

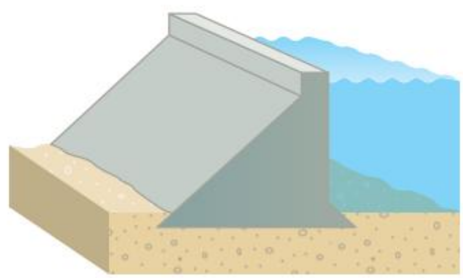


Arch dam
This has a curved shape. The inside of the curve faces downstream.



Buttress dam
This has a series of buttresses located on the side of the dam facing downstream.

Embankment dam
This is made of a huge pile of rocks and earth. The dam relies on its sheer bulk to hold back the water.



Massive dam
This is built of concrete and relies on its size and weight to withstand the pressure of the stored water.

10.4.2 Dam types

DID YOU KNOW?

- Worldwide, big dam construction has displaced up to 80 million people from their homes and flooded an area of productive land equivalent to twice the size of Victoria.
- Only 21 of the earth's 177 longest rivers run freely from their source to the sea.

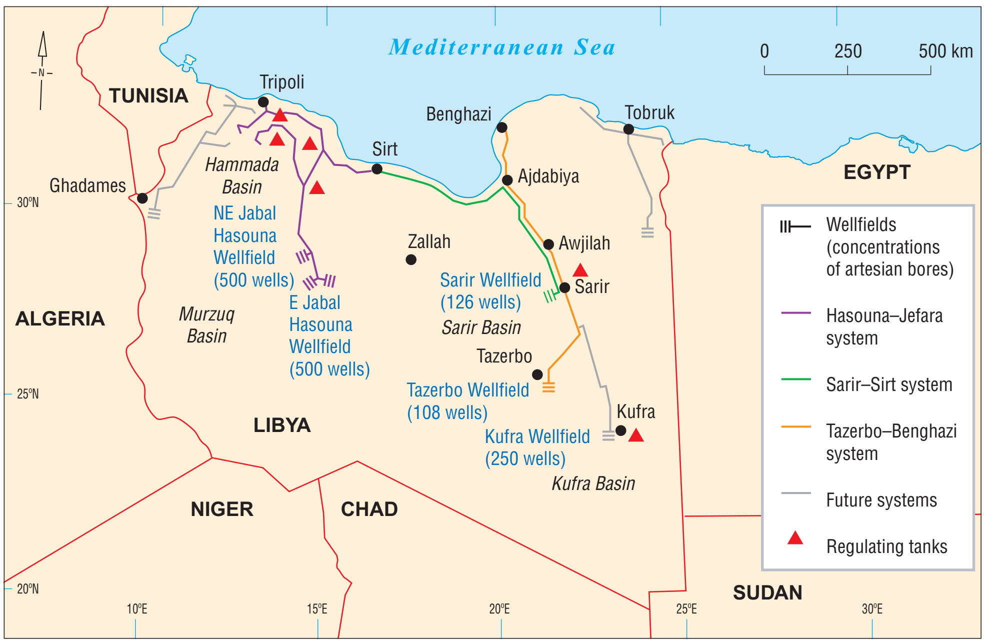
SPOTLIGHT

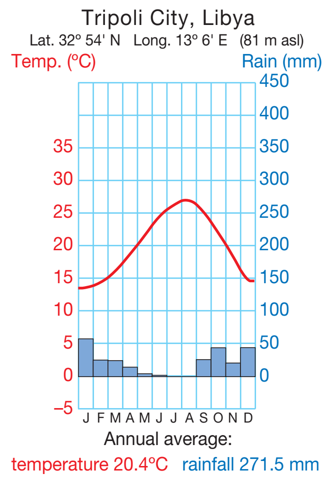
Securing Libya's water supply

While drilling for oil in Libya in the 1960s, engineers discovered huge reserves of water in aquifers beneath the Sahara Desert. This vast store of water had accumulated over some 70 000 years, much of it at a time when rainfall in northern Africa was much higher than it is now.

To develop its economy, Libya needed to use this water. In the 1970s, the country made huge profits by exporting oil to the countries of the developed world. Much of this money was invested in the Great Man-Made River Project (see Figure 10.4.3). Construction started in 1983 and is still in progress. When completed, the project will improve access to water for over five million people and will irrigate dry areas so that the country can become self-sufficient in food production. The project will also generate electricity, which will help to promote industrial development.

To extract the water, more than 1300 wells, most over 500 metres deep, have been dug, and a network, some 3500 kilometres long, of pipelines 4 metres in diameter has been partially built and is still under construction. Three major reservoirs (at Ajdabiya, Sirt and Benghazi) store 35 gigalitres of water. The project has made 135 000 hectares of land available for production. Large quantities of fruit and vegetables, as well as 270 000 tonnes of crops and 760 000 tonnes of fodder, are now grown on irrigated land.





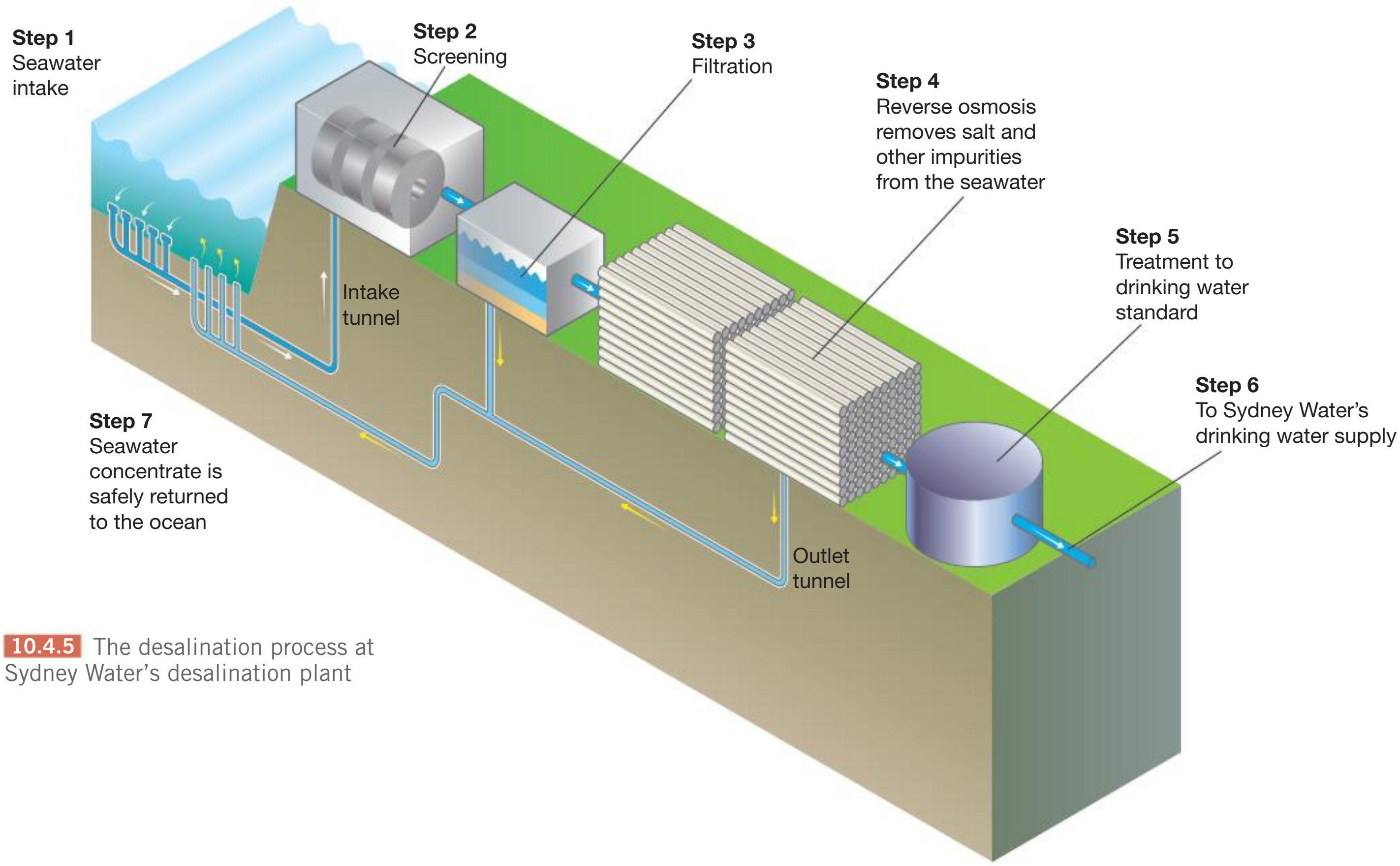
10.4.4 Climate graph for Tripoli, Libya's capital

10.4.3 Libya's Great Man-Made River Project. Libya is a hot, dry country. The rainfall that does fall is limited to a narrow coastal zone. Seventy per cent of Libya's five million people live in the coastal cities of Tripoli and Benghazi.

Desalination

Desalination is a process that involves removing the dissolved salt from ocean water. The process most commonly used is called **reverse osmosis**. This involves forcing water, under high pressure, through a filter that is fine enough to remove the salt. Today, there are more than 14 500 desalination plants operating in more than 125 countries. Australia has six desalination plants either in operation, waiting to be used or under construction. Desalination is an energy-intensive process that is very expensive.

Desalination plants are very expensive to build and operate, and they use enormous amounts of electricity. They can have a serious impact on nearby marine ecosystems from either the toxic chemicals used to kill algae or the **brine**, or concentrated seawater by-product, that has to be dumped back into the sea. When operated at capacity, Sydney's desalination plant (see Figure 10.4.5) supplies 15 per cent of Sydney's water needs. A large wind farm has been built to provide **green energy** for the plant.



10.4.5 The desalination process at Sydney Water's desalination plant

ACTIVITIES

Knowledge and understanding

1 List the ways in which the supply of water in an area can be increased.

2 State the condition under which groundwater can be considered a renewable resource.

3 Outline the potential benefits and dangers associated with extracting water from the world's deep aquifers.

4 State the role played by dams.

5 Identify the infrastructure needed to transport water.

6 Study Figure 10.4.5. Explain the process of desalination.

Applying and analysing

7 Discuss, as a class, the various options outlined in this unit for increasing water supplies. List the benefits and costs of each approach. Decide which is the most beneficial in terms of:

a the economic benefits

b minimising the environmental impact.

8 Study Figure 10.4.2. Identify the type of dam pictured in Figure 10.5.2 (Unit 10.5).

9 Study Figure 10.4.4. Describe the climate of Tripoli. Explain why water extraction, storage and transport are essential in Libya.

Investigating

10 Investigate the California Water Project. What has been the environmental cost of the undertaking?

11 Study the Spotlight box 'Securing Libya's water supply'. Using the internet, find another example of a large-scale water transfer project. Present your findings as an oral report supported by a multimedia presentation.

12 Investigate one of Australia's desalination plants. Why was it built? Is it necessary? What are the environmental impacts of the plant?

10.5

Big dam projects

Water shortages

Water shortages have increased the pressure on governments to fund engineering solutions. The infrastructure needed to store and transport water is very expensive and its construction often has significant social and environmental costs. The construction of dams can also contribute to international tensions when a river system flows through more than one country.

Arguments for big dams

- Stored water meets the needs of people and promotes economic growth.
- Dams supply secure and reliable water for irrigation, both upstream and downstream.
- Dams provide protection against drought.
- Destruction caused by flooding to downstream settlements and farms is reduced.
- Food production and industrial output increase.
- Reservoirs can be used to promote aquaculture.
- Hydro-electric power stations generate renewable electricity without producing greenhouse gases.
- Reservoirs can be used for recreational activities such as boating and fishing.

Arguments against big dams

- The seasonal pattern and volume of river flow is changed.
- The release of very cold water from deep in the dam disrupts the ecology of the river.
- Reservoirs flood large areas of fertile agricultural land and wildlife habitat.
- People's livelihoods are disrupted and communities are destroyed.
- Fish are prevented from swimming upstream or downstream.
- Water is lost through evaporation, especially in large, shallow dams.
- Less water is available for downstream users.
- The pressure created by the weight of the dam wall and body of water can cause earthquakes.
- Historic and culturally significant sites can be flooded.
- Damming rivers cuts off the supply of fertile sediments to the flood plain, resulting in reduced fertility and soil depth.
- Reduced sediment flows can increase coastal erosion.
- Sediment or soil is trapped behind the dam. The amount of sediment increases and reduces the amount of water the dam can store.
- The reduction in the volume of fresh water reaching river estuaries degrades the habitat where 80 per cent of the world's fish breed.

10.5.1 Location of the Three Gorges Dam, China

10.5.2 China's massive Three Gorges Dam

Three Gorges Dam

China's massive Three Gorges Dam project, shown in Figure 10.5.2, was built to provide hydro-electricity, stop seasonal flooding and ensure a reliable water supply for surrounding regions. However, the project cost just under US$39 billion (way over budget), and 1.24 million residents and 13 000 farmers were forced to move. The 600-kilometre-long reservoir flooded an area of 632 square kilometres containing more than 1300 important archaeological sites and some of China's most spectacular landscapes.

DID YOU KNOW?

Scientists have suggested that dams have increased the time taken by the earth's rotation by eight-millionths of a second since the 1950s. This is because of the shift of water from oceans to reservoirs.

ACTIVITIES

Knowledge and understanding

1 Explain why the construction of large dams can be controversial.

Applying and analysing

2 Construct and annotate a sketch of a dam. Note the arguments for and against big dams: the upstream, downstream and wider effects.

3 Write a short report about the following statement: *The advantages of large dams outweigh any disadvantages*. Include in your response examples from dams you have studied.

Investigating

4 Undertake internet research to locate an example of a big dam project. Write a report outlining the proposed benefits of the project and note the concerns of any groups opposed to the undertaking.

10.6

Reducing household water use

Conserving water

Conserving water is almost always more effective and less costly than trying to provide a new supply of water. The key idea in water conservation is that there are many ways in which we can use water resources more sustainably.

Price

Increasing the price of water is one way to reduce water use. When water is cheap, people do not use it wisely; when the price of water rises, people use it more carefully. But, while higher water prices encourage conservation, they can make life difficult for farmers and households on low incomes.

In irrigation

About 60 per cent of the water used in agriculture does not make it to the plants. Flood irrigation systems of agriculture (for example paddy rice cultivation) typically lose 40 per cent of their water through evaporation, seepage and water run-off. With advanced systems of centre pivot irrigation and drip irrigation, between 90 and 95 per cent of the water gets to the crops.

Strategies for reducing irrigation water waste include:

- using the most efficient irrigation technology available (for example drip irrigation)
- lining canals to reduce seepage
- irrigating at night to reduce evaporation
- monitoring soil moisture and only applying water when necessary
- avoiding growing water-thirsty crops in arid areas
- irrigating with treated grey water
- pricing water at a level that encourages conservation.

In industry and at home

While agriculture is the biggest user of water, industrial and domestic consumption are also significant. In developing countries, between 30 and 60 per cent of the urban water supply is lost through leaking water mains. Even in the cities of the developed world, leakage can account for between 20 and 30 per cent of the water supply. Fixing these leaks is cheaper than building additional storage capacity.

Strategies for reducing water waste in urban and industrial settings include:

- redesigning manufacturing processes so that they use less water
- recycling water, especially in industry
- landscaping public parks and private gardens with plants that have low water needs
- using drip irrigation systems in gardens
- fixing leaking water mains
- using water-saving fixtures in commercial and residential properties
- collecting domestic grey water and using it to water lawns and non-food plants
- purifying and re-using water from homes and commercial buildings
- pricing water at a level that encourages conservation.

Personal responses

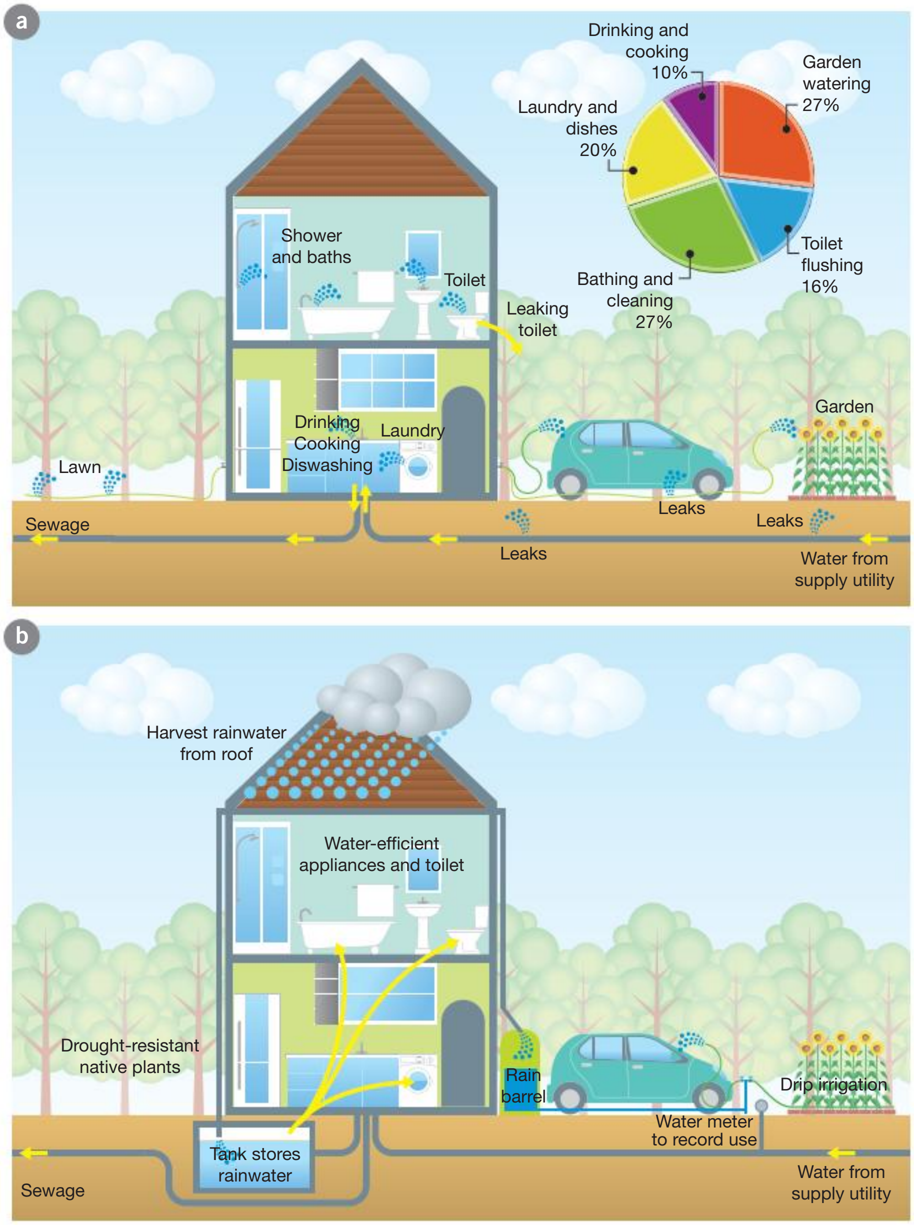
There are a number of actions individuals can take to reduce water consumption (see Figure 10.6.1). These include:

- installing water-saving household appliances, showerheads and toilets
- taking shorter showers
- turning off the tap when cleaning our teeth
- washing clothes only when we have a full load
- using grey water on lawns and gardens
- washing the car using a bucket rather than a hose
- fitting timers to all garden hoses
- planting plants and grasses with low water demand
- watering lawns and gardens early in the morning or late in the afternoon
- installing drip irrigation systems.

Sustainable water use

In addition to personal responses, there are a range of programs to use the earth's fresh water more sustainably. These include:

- wasting less water and promoting water conservation through education programs
- researching and developing new technologies for efficient water use and recycling
- ensuring that aquifers are used sustainably
- maintaining water quality by protecting forests, wetlands and other natural systems that store and release water
- developing agreements between countries that share water resources
- slowing population growth
- pricing water at a level that encourages conservation (the higher the price, the less water will be used).



10.6.1 Making a home water wise: (a) before, and (b) after

ACTIVITIES

Knowledge and understanding

1. State what is meant by water conservation.
2. Describe how water pricing can be used to reduce water waste.
3. Discuss how irrigation water can be used more effectively.
4. State the ways in which the sustainable use of water can be promoted.
5. Study Figure 10.6.1. Identify the ways in which this Australian household has become more water wise.

Applying and analysing

6. Draw up a poster promoting water conservation in one of the following locations.
   - an urban environment
   - an industrial setting
   - a rural environment

Investigating

7. Respond to the following statement: *I am only one person. How will changing my behaviour make a difference when it comes to water conservation?* Give your response as an oral presentation. Include images, data and other resources to support your response.

Atmospheric and hydrological hazards

CHAPTER 11

Humans have always attempted to control their environment. With the aid of technology we can move mountains, clear vast forests, change arid lands into fertile fields and divert the flow of rivers. There are, however, elements of our surroundings that remain beyond our control. From time to time, nature reminds us of its power and our own vulnerability. Extreme events within biophysical environments can destroy whole communities.

We cannot control the weather, but we can study the processes that cause weather hazards and disasters. This allows us to better predict extreme weather events and to develop better ways of managing their effects.

In this chapter we explore the ways in which weather-related natural hazards impact on communities. In particular, we focus on storms, tornadoes, tropical cyclones, floods, heatwaves and droughts.

INQUIRY QUESTIONS

- What are the causes, impacts and spatial extent of atmospheric and hydrological hazards?
- How do individuals, groups and governments respond to the impact of natural disasters?
- What management strategies can be used to reduce the impact of future natural disasters?
- What is the likely impact of climate change on the occurrence, frequency and extent of a hazard you have studied?

GLOSSARY

air pressure	the weight of the air pressing down on the earth's surface at a particular location
drought	a prolonged period of below-average rainfall
flash flood	a flood resulting from an intense storm dropping large amounts of rain in a short time
flood	an event in which land that is normally dry becomes covered by water; a flood is caused by an overflow of water from a river or stream or the release of water from a dam
heatwave	a short period (usually no longer than a few days) of well-above-average temperatures
hyperthermia	overheating of the body
inundate	to cover with water
natural disaster	a serious disruption to a community or region caused by a natural hazard
natural hazard	an event in the biophysical environment such as a storm, cyclone, flood or drought
rapid-onset flood	a flood that occurs with little or no warning
slow-onset flood	a flood that may last for one or more weeks—sometimes months
storm surge	a rapid rise in the height of the ocean along a coastline caused by storm winds pushing water towards land
tornado	a violent, rotating column of air extending from the base of a thunderstorm to the ground
tropical cyclone	an intense low-pressure system over tropical waters, usually with strong winds and heavy rain

11.0 Tornado, New Mexico, United States of America

11.1

Hazards and disasters

Natural hazards and disasters

As we go about our daily lives it is easy to forget that our biophysical environment contains potential threats to life and property. Many of these threats are related to weather and climate. They include severe storms, tropical cyclones, tornadoes, floods, heatwaves and drought.

Natural hazards are extreme and unusual natural events. When natural hazards impact on people, they are referred to as **natural disasters**.

It is important to remember that weather-related hazards and disasters are only one of several types of natural hazards that affect people. Other natural hazards and disasters include events associated with the earth's surface and those associated with the ocean. Table 11.1.1 lists different types of natural hazards and Figure 11.1.2 shows examples of weather-related hazards.

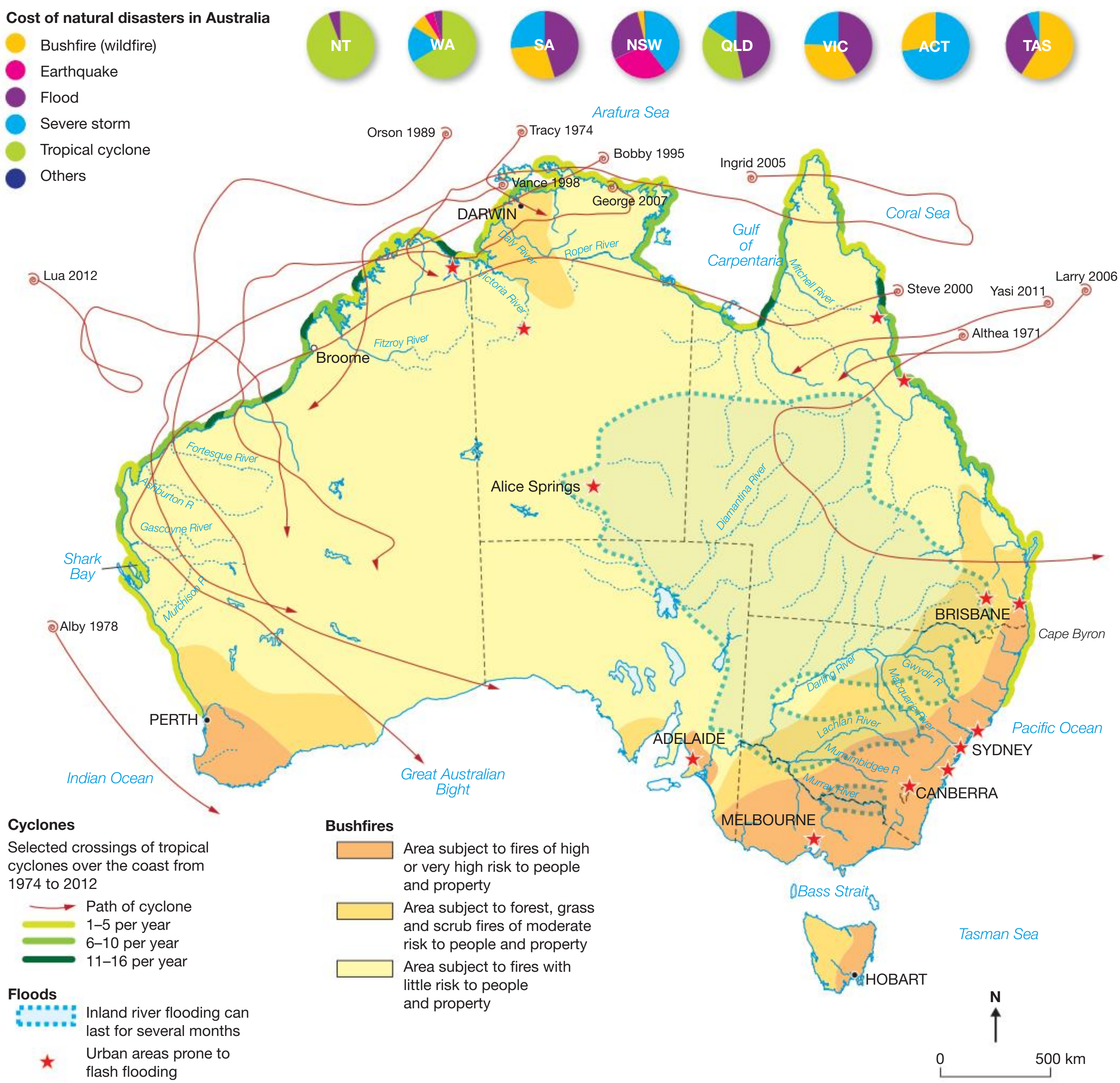
11.1.1 Natural hazards

Events associated with the earth's atmosphere (weather-related hazards)
• Major floods: the result of prolonged heavy rain • Flash floods: the result of heavy and intense downpours • Tropical cyclones: high-speed winds, heavy rain and storm surges • Droughts: prolonged periods of below-average rainfall • Bushfires: the result of dry conditions, high temperatures and high winds • Storms: high winds, lightning and heavy rainfall
Events associated with the earth's surface
• Earthquakes and tremors: sudden, often violent movements in the earth's crust • Landslides and slumps: sudden downhill movements of soil and rock
Events associated with the ocean
• Coastal erosion: the result of storm-induced waves • Storm surges: large waves caused by storms • Tsunamis: very large, earthquake-induced waves

11.1.2 Weather-related hazards and disasters: (a) storm, (b) flood, (c) heatwave, (d) bushfire, (e) drought

Natural hazards and disasters in Australia

Since the European settlement of Australia, more people have died from heatwaves than any other natural hazard. The types of natural disasters and their distribution are shown on the map in Figure 11.1.3. The most costly natural hazards in economic terms have been drought and flood. The most costly single events, however, have been Darwin's Cyclone Tracy (1974), the Newcastle earthquake (1989), the Sydney hailstorm (1991), the Canberra bushfires (2003), Cyclone Larry (2006), the Newcastle storm (2007), the Gippsland floods (2007), Victoria's Black Saturday bushfires (2009), and the Queensland floods and Cyclone Yasi (2011). The graph in Figure 11.1.4 shows the frequency of natural disasters between 1980 and 2014.



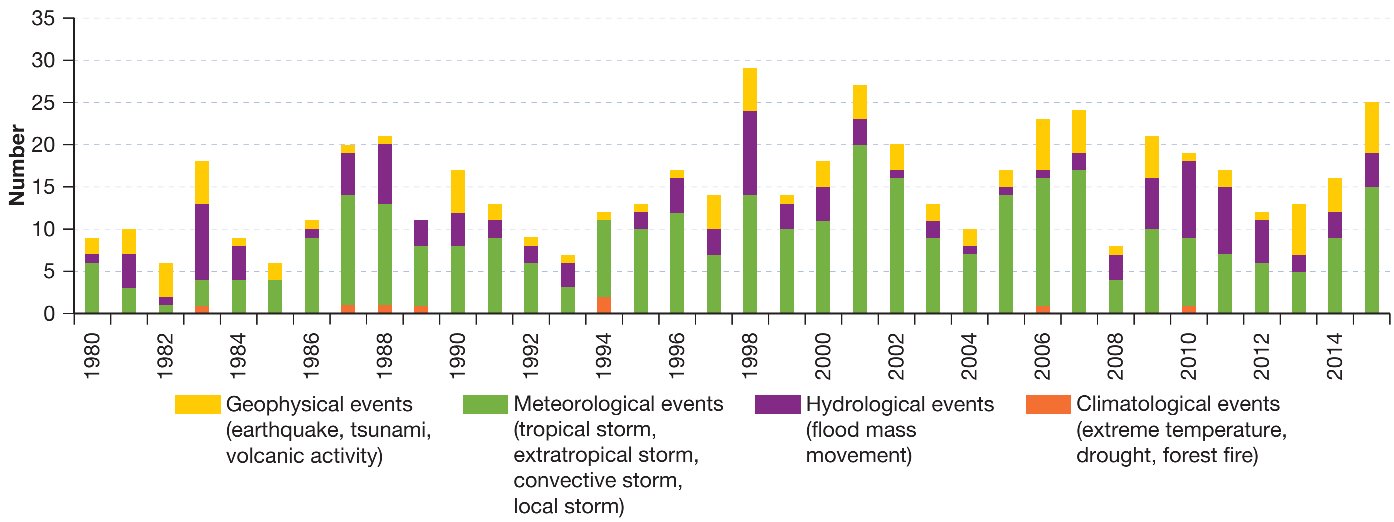
11.1.3 Australia's most common natural hazards are storms, floods, droughts and bushfires.

Impacts of natural hazards

Natural hazards have a range of environmental, economic and social impacts:

- ***environmental impacts***—destruction of natural and human environments; the death of wildlife either directly or indirectly (for example due to starvation)
- ***economic impacts***—the destruction of property, crops and livestock, infrastructure, and plant and equipment; the loss of income for those affected
- ***social impacts***—loss of life and the stress placed on people, as well as the disruption to community life and the destruction of community-based infrastructure such as roads, bridges, schools, shops and power lines.

11.1.4 The incidence of natural disasters in Australia, 1980–2015



Source: Geo Risks Research, Munich RE

SkillsBuilder

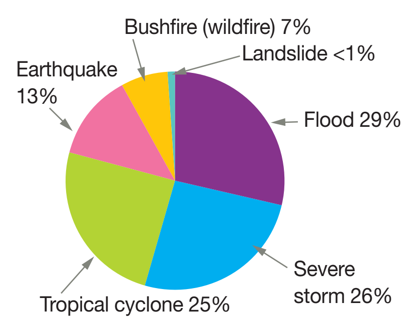
Pie graphs

Pie graphs (see, for example, Figure 11.1.5) are circles divided into segments radiating out from the centre. The size of each segment of the graph is proportional to the value it represents.

A complete pie graph (360°) represents 100 per cent. Therefore, each percentage point is represented by 3.6°. Knowing this statistic will help you to construct and interpret pie graphs.

To construct a pie graph, follow these steps.

1. Draw a circle and then extend a line from its centre to the 12 o'clock position.
2. Convert the percentage value of each value or variable to degrees by multiplying it by 3.6.
3. List your converted values from the largest to the smallest. Place categories such as 'others' at the end of your list.
4. Starting at 12 o'clock, mark each segment on the graph using a protractor. Work in a clockwise direction, starting with the largest segment.
5. Shade and label each segment. It may be useful to provide a legend or key. If a legend is included it is not necessary to label the segments.
6. Add an appropriate title.



11.1.5 Average proportional cost of natural disasters in Australia, by type

Nature's deadly toll

Natural disasters killed 7823 people worldwide in 2014 and caused damage totalling US$99.2 billion. This makes 2014 the least costly in recent years. In total there were 324 identified disasters (down from an average of 384 events).

The number of people killed was the lowest in the last decade and well below the 2004–2013 annual average of 99 820 deaths. The period 2004–2013 includes three years in which more than 200 000 people were reported killed. The most deadly events in the period were the Indian Ocean tsunami in 2004 (226 408 deaths), Cyclone Nargis in Myanmar in 2008 (138 366 deaths) and the earthquake in Haiti in 2010 (225 570 deaths).

In March 2011, a magnitude 9.0 earthquake, now known as the Great East Japan Earthquake, struck off the coast of Japan's largest island, Honshu. The accompanying tsunami killed more than 25 000 people. The economic cost of this disaster is expected to exceed $300 billion, making it the most expensive natural disaster in history.

Recent natural disasters in Australia include widespread flooding in Queensland, New South Wales and Victoria in 2011 and Tropical Cyclone Yasi.

In New Zealand, the city of Christchurch was devastated in February 2011 by a magnitude 6.3 earthquake. More than 180 people were killed.

SPOTLIGHT

Impacts of climate change

Scientists predict that climate change will increase the frequency and severity of some natural disasters. The number of bushfires, such as the one shown in Figure 11.1.6, for example, is likely to increase in many parts of the world as temperatures rise and rainfall becomes less reliable (see Figure 11.1.4). The frequency of severe storms and coastal flooding will increase and low-lying coastal communities will be at greater risk because of rising sea levels. Droughts will be more common and last longer.

11.1.6 A bushfire in Bunyip State Park in February 2009 threatened towns just east of Melbourne.

ACTIVITIES

Knowledge and understanding

1 Explain the difference between a natural hazard and a natural disaster.

2 Identify the main natural hazards affecting Australia.

3 Outline the impacts of natural hazards and disasters.

Applying and analysing

4 Study Figure 11.1.3.
  - a Identify the natural hazards that have the potential to affect where you live.
  - b Discuss ways to reduce the impact of the hazards identified.

Geographical skills

5 Using Figure 11.1.3 and an atlas, describe the areas of Australia most seriously affected by the following natural hazards.
  - a tropical cyclones
  - b floods
  - c bushfires
  - d earthquakes

6 Study Figure 11.1.4. What trend is evident in the number of natural disasters in Australia? Think about the reasons for this trend. What are the most common types of natural disasters? Which are the least common?

7 Using the instructions in the Skills builder box 'Pie graphs', create two pie graphs to display the following data.

Natural disasters

Location	2012	2013
Africa	123	114
Asia	210	229
Europe	91	69
Americas	115	105
Australia and Oceania	14	12

11.2

Severe storms

Effects of severe storms

Severe storms are the most common natural hazard. They are a local disturbance in the atmosphere and are accompanied by thunder, lightning, rain, hail and, in some cases, snow. They can occur anywhere and are responsible for more damage than any other natural hazard.

Environmental

Storms usually only affect a small area compared with tropical cyclones and floods. Environmental damage caused by severe storms includes fallen trees and branches, and damage from hailstones and rain.

Social

In Australia severe storms on average kill between five and ten people a year, mostly due to lightning strikes (see Figure 11.2.1). More deaths occur when strong winds cause power lines and tree limbs to fall, and debris (such as roofing iron) to become airborne. People may be left homeless after a severe storm.

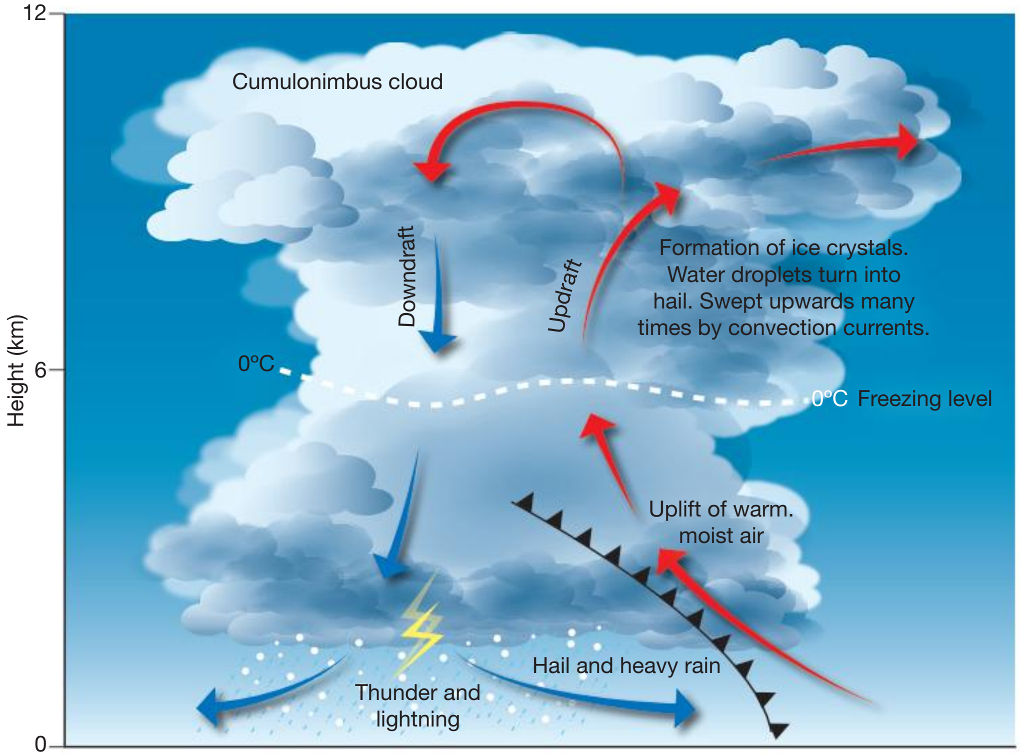
Economic

Severe storms can be very expensive. Infrastructure that is damaged or destroyed needs to be repaired or rebuilt. This can include power lines, homes and businesses. A major economic cost is the damage caused to cars by large hailstones smashing windows and denting panels.

How storms develop

Storms develop when warm, moist air rises rapidly in an unstable atmosphere. Sometimes this upward movement is caused by the passage of a cold front. On other occasions (often in summer), the heating of the earth's surface is enough to bring about the rapid upward movement of moist air (see Figure 11.2.2). Most of these storms do not reach the level of intensity needed to produce widespread damage, but they all produce lightning, which can cause death, injury and damage. Sometimes they are accompanied by hail, wind gusts and flash floods.

11.2.1 Storms are among nature's most spectacular and most dangerous natural hazards.



11.2.2 The development of a thunderstorm associated with the passage of a cold front

SkillsBuilder

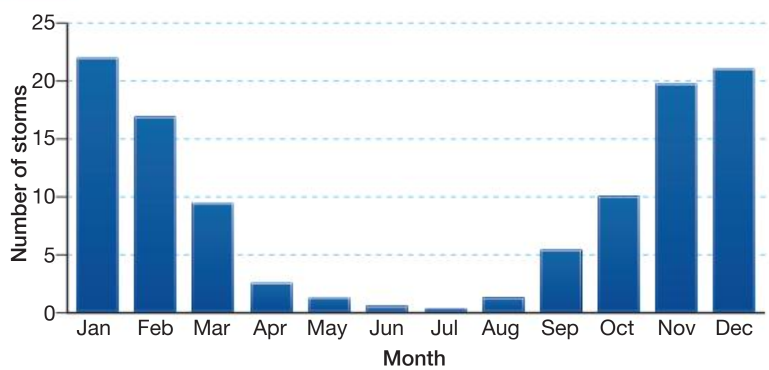
Reading a column graph

A column graph (see Figures 11.2.3 and 11.2.4) uses vertical columns to present information. The height of the column indicates the value of the data. The values on the horizontal axis represent different times or places at which the data was collected. This information can be compared. Note that bar graphs are similar to column graphs, but use horizontal bars.

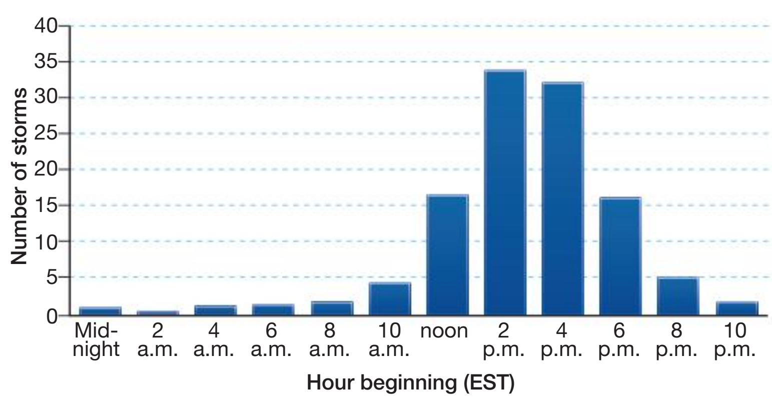
To interpret a column graph, follow steps 1–5.

1. Study the graph's title to see what the graph represents.
2. Read the vertical and horizontal axes.
3. Read the legend to see what extra information it contains.
4. Look at the data. Can you observe a pattern in the data? If so, describe the pattern and suggest reasons for it.
5. Discuss the implications of the trends or patterns identified in the graphed data.

11.2.3 Monthly distribution of severe thunderstorms in NSW and the ACT



11.2.4 Hourly distribution of severe thunderstorms in NSW and the ACT



Lightning and thunder

Lightning is caused by the discharge of electricity during thunderstorms. It is accompanied by thunder. The cause of lightning is not fully understood but ice inside a cumulonimbus cloud is thought to be a key element in lightning development.

The distance of lightning from an observer can be calculated using the time interval from when the lightning is seen to when the sound of thunder is heard. Lightning is approximately 1 kilometre distant for every 2.9 seconds that elapse between the visible flash and the first sound of thunder.

The 2007 Newcastle storm

On 8 June 2007, severe thunderstorms with very heavy rain (164.6 millimetres in six hours from 3.00 p.m. to 9.00 p.m.) and gale-force winds lashed the Newcastle area, resulting in severe flooding in the city's central business district and nearby suburbs. Hundreds of cars were stranded or swept away. Many shops and businesses were flooded. Winds averaged up to 105 kilometres per hour with gusts to 124 kilometres per hour. The 76 000-tonne bulk ore carrier *Pasha Bulker* was blown onto Nobbys Beach (see Figure 11.2.5) and was not refloated until 2 July. There were 20 000 calls for assistance to the State Emergency Service.

11.2.5 The bulk carrier *Pasha Bulker* stranded on Nobbys Beach after running aground during a severe storm

SPOTLIGHT

Storm survival guide

There are many precautions you can take to make sure you don't become a victim of a severe storm. Some of them are listed in Table 11.2.6.

11.2.6 Guide to surviving a storm

Indoors
1 Keep clear of windows, electrical appliances, pipes and other metal fixtures.
2 Avoid using telephones. If an emergency call is required, make it brief!
3 Disconnect external aerial and power leads to radio and television sets.
4 Disconnect computers at their power sources.
Outdoors
1 Seek shelter in a building or 'hard top' vehicle.
2 Avoid taking shelter under an isolated tree or small stand of trees.
3 If out in the open, crouch down, preferably in a hollow, with feet together, and remove metal objects from head and body. Do not lie down.
4 If your hair stands on end or you hear buzzing from nearby rocks, fences etc., move away to a new position immediately.
5 Don't fly kites or model aircraft with control wires.
6 Don't handle long or metallic objects such as umbrellas, golf clubs or fishing rods in the open.
7 Avoid standing close to, or touching, metal structures, wire fences or metal clothes lines.
8 Don't ride horses or bicycles or drive in open vehicles.
9 If driving, park your car away from trees, power lines, etc. Stay inside but avoid touching or leaning on metal body parts.
10 Leave the water immediately and seek shelter if you are swimming or surfing.
11 If boating, go ashore as soon as possible or seek protection beneath a high structure such as a bridge or jetty.
12 Ensure that the mast and stays of sailing boats are adequately 'grounded' to the water.

DID YOU KNOW?

Thunderstorms have killed 1635 people and injured 2021 in Australia since 1824.

ACTIVITIES

Knowledge and understanding

1 Explain what is meant by the term 'severe storms' and identify what often accompanies them.
2 Outline the conditions under which severe storms develop.
3 Retell how people are killed during severe storms in Australia.

Applying and analysing

4 Study Figure 11.2.2. Write an explanation of how thunderstorms develop and explain why they are often associated with gusty winds, hail, lightning, thunder and flash flooding.

Geographical skills

5 Study Figures 11.2.4 and 11.2.5 and answer the following questions.
   a In which months of the year are severe storms most likely to occur in New South Wales and the Australian Capital Territory?
   b At what time of the day does severe storm activity peak in New South Wales and the Australian Capital Territory?
   c You have been asked to plan an outdoor activity in New South Wales or the Australian Capital Territory that requires fine weather. In which month would you plan the event and at what time of the day? Explain your response.

Investigating

6 Using the Bureau of Meteorology severe storm website and the media (newspapers, magazines, television etc.) investigate storms in Australia during the previous 12 months.
   a Include a definition of a severe storm and the causes of a severe storm.
   b On a blank outline map of Australia, locate and mark each storm. Annotate the map and include the following information.
      - the date the storm occurred
      - the impacts of the storm
      - the agencies involved in meeting the needs of the people affected
      - the types of assistance available to the victims of the disaster
      - precautions to take during a severe storm

11.3

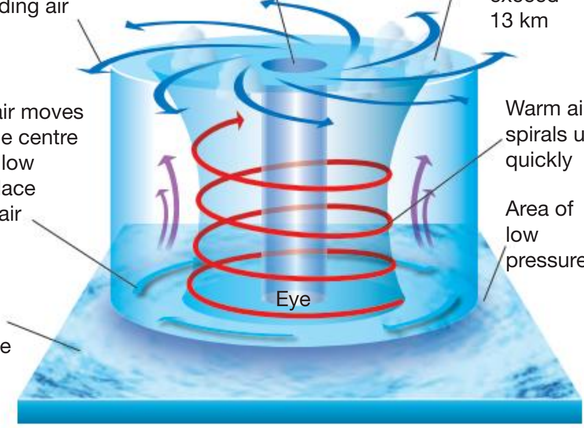
Tropical cyclones

Cyclones explained

Tropical cyclones (known as hurricanes and typhoons in other parts of the world) are intense low-pressure systems that form over warm tropical waters. They are usually accompanied by gale-force winds and torrential rainfall.

Tropical cyclones begin as tropical depressions (strong low-pressure systems that form in the low latitudes near the Equator). They become cyclones when the systems intensify and wind speeds increase, especially towards the centre (or vortex) of the storm. In severe cyclones, wind speeds can exceed 200 kilometres per hour. In the Southern Hemisphere, winds circulate clockwise around the calm eye of the storm. Tropical cyclones can vary in diameter from about 150 kilometres to over 1000 kilometres.

Cyclones move at speeds of up to 25 kilometres per hour along a fairly unpredictable path. The life of an average cyclone is about seven days, but some last longer.



11.3.1 Structure of a tropical cyclone

The life cycle of a cyclone

For tropical cyclones to develop, certain conditions need to be present. These include:

- a warm ocean surface (above 26°C) and very humid air—this means that they usually only occur between 5 degrees and 30 degrees latitude on both sides of the Equator
- low-pressure systems.

The process of cyclone formation is shown in Figure 11.3.1. It begins when an area of low pressure coincides with the vigorous upward movement of air and the formation of cumulonimbus cloud. This is the type of cloud normally associated with thunderstorms. Three phases follow.

Pre-maturity

As the rate of uplift (or convection) increases, winds begin to spiral in towards the system's centre. This is because air moves away from areas of high pressure towards areas of low pressure, which are formed when air is drawn upwards by convection currents. Eventually, the surface winds reach gale force and the distinctive spiral pattern of cloud begins to develop.

Maturity

If the warm ocean surface and low atmospheric pressure remain, the cyclone will continue to increase in strength and power. As it does, the cloud system becomes more circular in shape and develops a distinct eye. This is the severe cyclone stage, at which the cyclone is most destructive. Of all the cyclones that form, about half progress to this stage.

Decay

Tropical cyclones normally decay, or lose their intensity, when they move over land or over the cooler oceans in higher latitudes away from the Equator. A cyclone moving over land normally weakens rapidly due to loss of its energy source—namely, the warm ocean surface. In northern Australia, however, when cyclones move inland they often continue as rain depressions for a number of days, bringing widespread flooding rain, and may even redevelop if they move over the ocean once more.

SPOTLIGHT

Cyclone Winston devastates Fiji

Late on the evening of Saturday 20 February 2016, one of the most powerful storms ever recorded in the Southern Hemisphere tore through the Pacific Island nation of Fiji, killing forty-four people, flattening whole villages and cutting communications (see Figure 11.3.4).

Infrared satellite data shows that sea surface temperatures in the region were close to 31°C, warm enough to keep fuelling and strengthening the storm. Tropical cyclones need sea surface temperatures of at least 26.6°C to maintain intensity. Temperatures at the top of the cyclone's cloud mass dropped to –62°C.

Cyclone Winston was the first Category 5 storm to make landfall in Fiji. Wind gusts of up to 325 kilometres per hour unroofed homes, uprooted trees, damaged infrastructure and destroyed crops. More than 1000 homes were destroyed in Rakiraki, a major town on the north coast of Fiji's main island Viti Levu, and 500 were partially damaged. Residents described the town as looking as though a bomb had gone off, with barely a building left unscathed. The majority of the fatalities were along the western coast and were caused mainly by flying debris and drowning in storm surges. Seven fishermen were lost at sea.

Relief agencies struggled to reinstate communications, distribute supplies and respond to a widespread health crisis, particularly in low-lying areas where thousands of Fiji's 900 000 people live in tin shacks, after water supplies were contaminated.

The challenge of responding to the disaster was made more difficult due to the country's geography. Authorities had to assess the needs of people living in the more remote parts of the archipelago of about 300 islands.

It is not unusual for Fiji to experience severe cyclones. In the past 30 years or so, several severe tropical cyclones have affected Fiji. Planning helped minimise the number of lives lost. In advance of the storm's arrival, storm shelters were opened, and a nationwide curfew was announced.

11.3.2 Cyclone Winston hit Fiji in February 2016

Cyclone categories

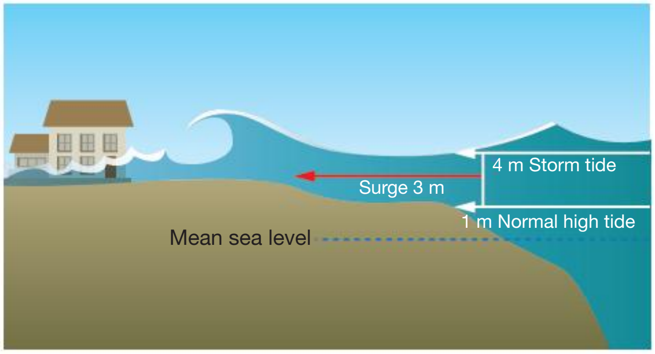
Cyclones are categorised according to their strength. There are five categories: Category 1 is the weakest and Category 5 is the strongest (see Table 11.3.3).

11.3.3 Cyclone categories

Rating	Wind speed	Wave height	Damage
1	Up to 125 km/h Gales	1.2–1.6 m	Slight damage. Damage to some crops, trees and caravans. Craft may drag moorings.
2	126–169 km/h Destructive	1.7–2.5 m	Significant damage. Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Small craft may break moorings.
3	170–224 km/h Very destructive	2.6–3.7 m	Structural damage. Some caravans destroyed. Power failures likely.
4	225–279 km/h Very destructive	3.8–5.4 m	Significant roofing loss and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failures.
5	Above 280 km/h Very destructive	More than 5.5 m	Almost total destruction and extreme danger. Houses flattened, cars overturned.

Storm surges

A **storm surge** is a large mound of seawater that accompanies a tropical cyclone as it comes ashore, as shown in Figure 11.3.4. The intense winds of the cyclone cause a dome of water to form in the ocean and to be pushed onshore as the cyclone strikes the coast. The low **air pressure** of the cyclone adds to the height of the mound of water, though this is a secondary effect.



11.3.4 Storm surges can cause widespread damage in low-lying coastal areas.

Cyclone warning systems

The Bureau of Meteorology identifies cyclones when they develop, and tracks their course. Each cyclone is given a name from an alphabetical list.

The Bureau also has a cyclone warning system. As soon as gales are expected within 24 hours, it issues a cyclone warning to areas that are in danger, predicting wind speeds and other weather conditions. The warnings are issued from three tropical cyclone warning centres (TCWCs) in Brisbane, Darwin and Perth. Information about a cyclone is sent to the TCWCs by computer-controlled instruments located at weather stations around the coast. Automatic weather stations on remote islands, as well as radio links with ships and aircraft, also provide information. Satellite images can be received every hour from a Japanese weather satellite.

Tropical Cyclone Yasi, 2011

Tropical Cyclone Yasi originated from a tropical low near Fiji in late January. It then increased in strength and moved towards Australia, as outlined below and shown in Figures 11.3.5a–c:

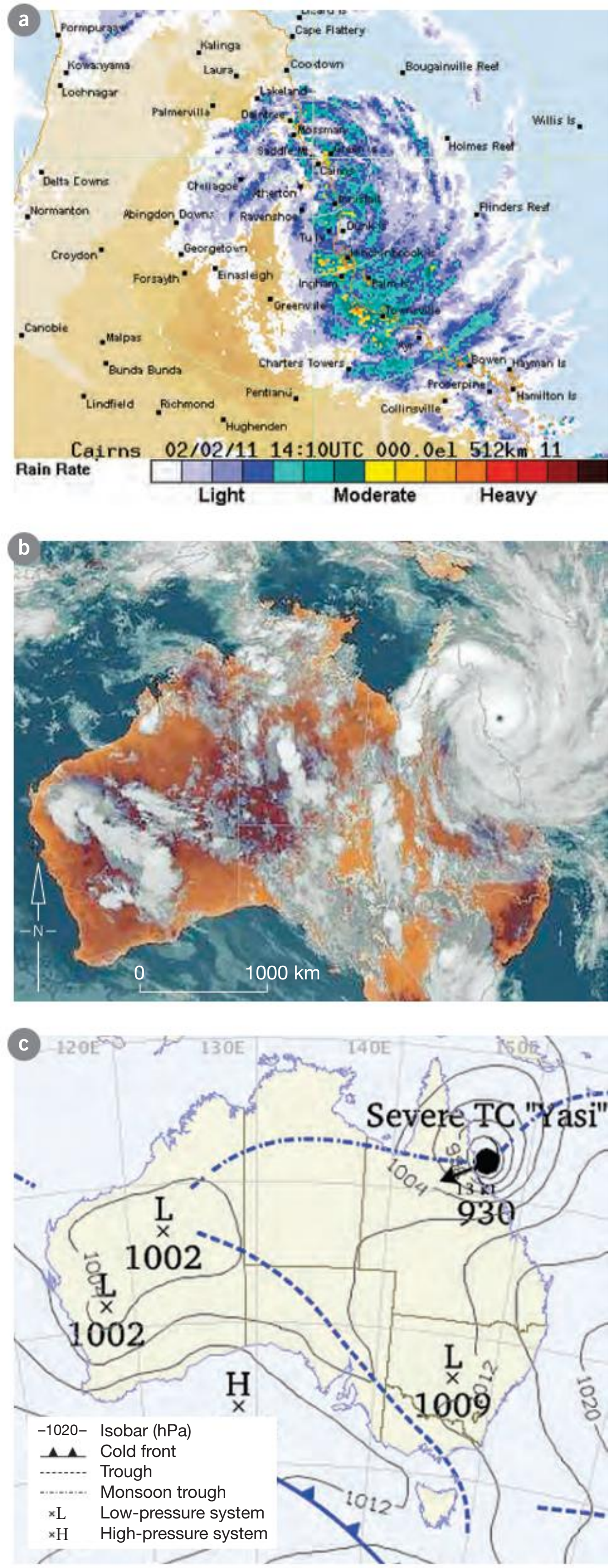
- ***31 January***—intensifies to a Category 3 cyclone late in the afternoon
- ***1 February***—intensifies to a Category 4 cyclone
- ***2 February***—intensifies to a Category 5 cyclone
- ***3 February***—makes landfall in Queensland early in the morning.

The destructive core of the cyclone crossed the Queensland coast between Cardwell and Innisfail. The maximum sustained wind speed reached 205 kilometres per hour, with wind gusts exceeding 285 kilometres per hour.

A storm surge estimated at 7 metres high **inundated** low-lying coastal areas, pushing as far as 300 metres inland in some places. The cyclone's destructive winds were accompanied by heavy rainfall and flooding. The highest 24-hour rainfall total recorded was 471 millimetres at South Mission Beach (see Figure 11.3.5a).

The worst affected communities were Tully, Innisfail, Ingham, Cardwell, Mission Beach, El Arish, Silkwood and Silky Oak. Dozens of homes, businesses and other property (such as the boats in Figure 11.3.6) were destroyed or severely damaged, vegetation was stripped of its leaves and crops were destroyed. The cost of the disaster exceeded $800 million.

11.3.5 (a) Radar image showing rainfall intensity as Yasi crossed the Queensland coast; (b) satellite image of Yasi's swirling cloud mass; (c) weather map showing Severe Tropical Cyclone Yasi



11.3.6 Damaged boats at Port Hinchinbrook, Queensland, after Cyclone Yasi

ACTIVITIES

Knowledge and understanding

1 Define what a tropical cyclone is. Explain how cyclones form. Outline the type of weather associated with cyclones.

2 Describe how storm surges contribute to the damage caused by cyclones.

3 Identify the parts of Australia that are affected by cyclones.

4 Explain how the Bureau of Meteorology monitors the development of cyclones.

Geographical skills

5 Use Figure 11.3.5c to answer the following questions.
   - a What is the air pressure (in hectopascals) of Severe Tropical Cyclone Yasi?
   - b Describe the pattern of the isobars around Tropical Cyclone Yasi. What type of winds does this indicate?
   - c In what direction is the cyclone heading?
   - d How do the low-pressure systems in Western Australia and New South Wales differ from Tropical Cyclone Yasi? What type of weather would these areas be experiencing?

Investigating

6 Create a timeline of what occurs and what to do before, during and after a tropical cyclone. Your timeline should mention all the following stages.
   - the build-up (including preparing your home)
   - during the cyclone (including the eye)
   - immediately after the cyclone
   - after the cyclone (including the damage caused by the cyclone)

   Note: Photographs, diagrams and or videos can be included with your timeline.

7 Access the BoM cyclone website. Using information found on this site and elsewhere, prepare an appropriate multimedia presentation. The following questions will help you to structure your presentation.
   - a What are cyclones?
   - b Where and how do they develop?
   - c In what ways do cyclones pose a threat to life and property?
   - d What precautions can be taken to protect life and property?

11.4

Tornadoes

What is a tornado?

A **tornado** (or 'twister,' as it is sometimes called) is a violently rotating column of air extending from the base of a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction.

Tornadoes come in many shapes and sizes, but are typically in the form of a visible funnel whose narrow end touches the earth and is often encircled by a cloud of swirling debris and dust. The funnel of the tornado is called the vortex.

What causes tornadoes

For a tornado to form, two main factors are needed. The first of these is an unstable atmosphere with rapidly rising air. As warm, moist air rises, it cools and condenses, forming the cumulus and cumulonimbus clouds typically associated with thunderstorms.

The second important factor is wind shear. This is the difference between wind speed on the ground and wind speed higher up in the atmosphere. A thunderstorm cell can develop if there is a speed difference of 30–40 kilometres per hour between winds found at the surface and those found at about 3000 metres.

11.4.1 Tornadoes are violently rotating columns of air extending from the base of a thunderstorm to the ground.

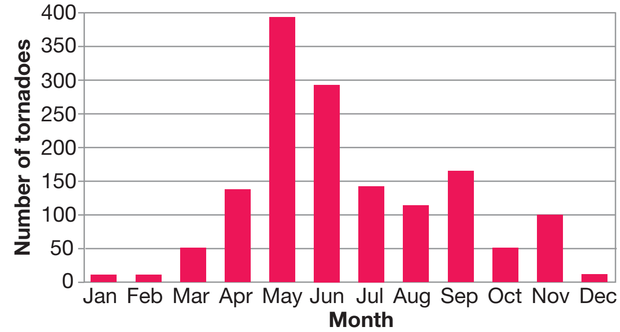
This wind shear causes air to spin in a tube-like fashion along a horizontal axis. The updraft of the thunderstorm then sucks this rolling air upwards so that the axis of its spin is vertical. This gives the tornado its funnel-like appearance (see Figure 11.4.1).

Where tornadoes occur

Although tornadoes can occur in many parts of the world, they occur most frequently in the United States of America, east of the Rocky Mountains, in a region known as 'Tornado Alley' (see Figure 11.4.2). During the spring and summer months, thunderstorms develop throughout the region as warm, moist air is forced to rise rapidly by eastward-moving cold fronts. As the updraft increases in velocity, a spinning vortex can develop. The low air pressure created at the centre of the funnel sucks in surrounding air. If the vortex touches the ground the updraft and difference in pressure can cause great damage.

The most deadly tornado on record occurred in 1925, and up to 747 people perished as twisters swept across Missouri, Illinois and Indiana. Since records began in 1875, more than 19 000 people have been killed by tornadoes in the USA. In an average year, more than 1200 tornadoes are reported across the USA (see Figure 11.4.3).

11.4.3 The number of tornadoes in the USA in one year

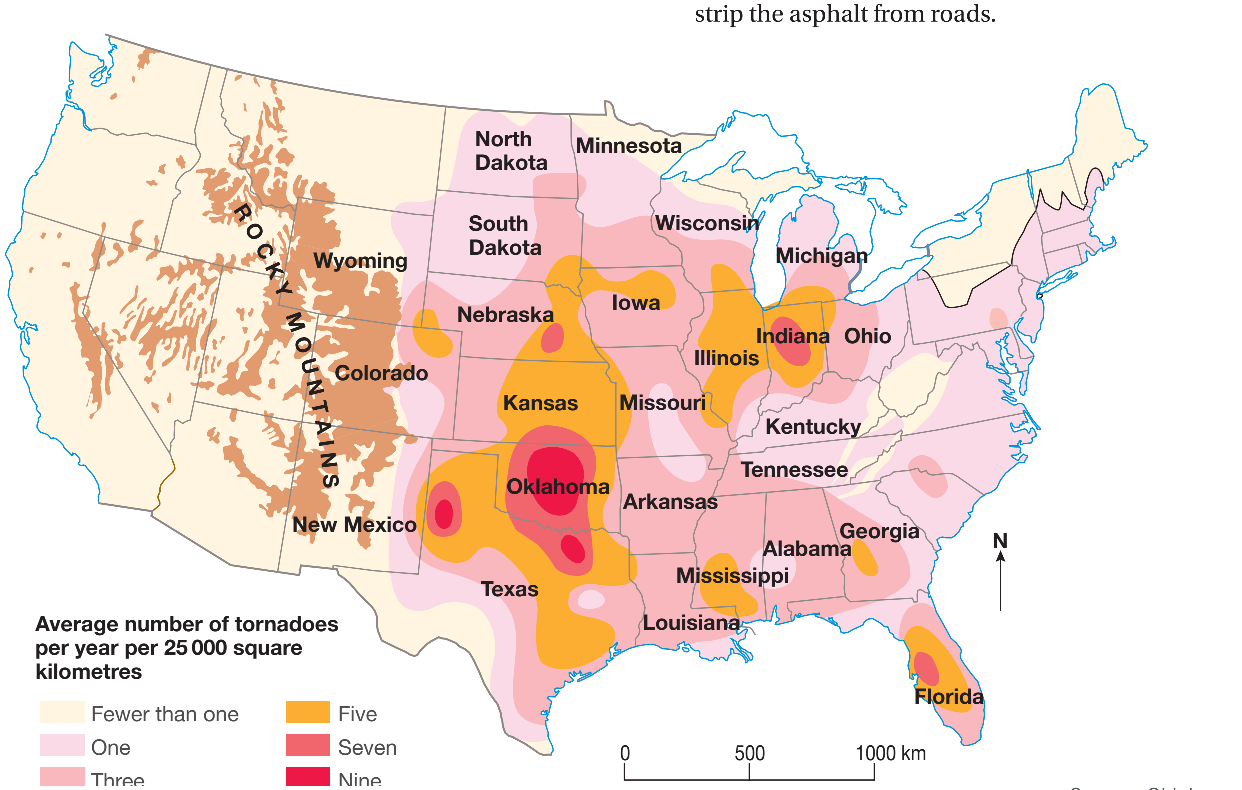


The power of a tornado

Most tornadoes have wind speeds of less than 180 kilometres per hour, measure about 80 metres across and travel several kilometres before subsiding. The most destructive tornadoes can have wind speeds of more than 480 kilometres per hour, develop a width of up to 3 kilometres, and stay in contact with the ground for more than 100 kilometres.

Some tornadoes are so powerful and destructive that they can tear buildings off their foundations and smash them into small pieces; they can flip large trucks and farm machinery and reduce them to mangled pieces of metal; they can pick up and dump cars kilometres away from where they were parked, snap trees off at their base and strip the asphalt from roads.

11.4.2 Tornado risk in the USA

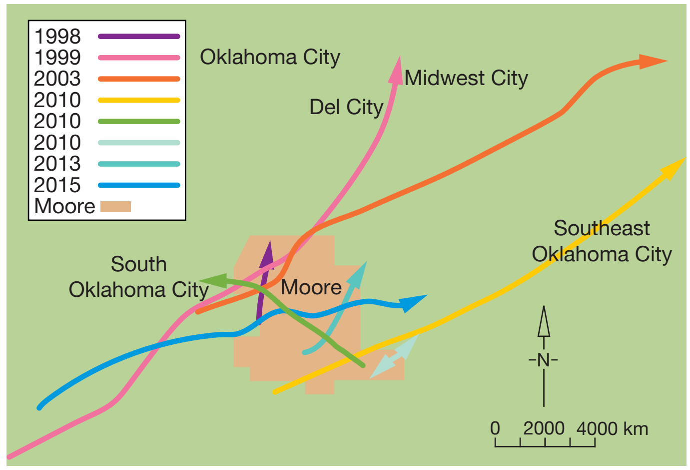


Source: Oklahoma Climatological Survey

Tornado target: Moore, Oklahoma, USA

The City of Moore, part of the Oklahoma City metropolitan area, has been hit by eight devastating tornadoes since 1998. The most recent occurred in late March 2015. Two of these tornadoes, those of 3 May 1999 and 20 May 2013, are considered by meteorologists to be among the most intense ever recorded. The first of these super cells carved a path of destruction 61 kilometres long and 1.6 kilometres wide. It killed 36 people and injured a further 295. The 2013 tornado killed 24 people and injured 212. The damage bill exceeded US$1.4 billion.

Figure 11.4.4 shows the paths of the eight tornadoes that have hit Moore since 1998. Figure 11.4.5 illustrates the destructive force of the 2013 tornado.



11.4.4 Tornadoes in Moore, Oklahoma, USA, 1998–2015

11.4.5 Aerial view of tornado damage in Moore, Oklahoma

SPOTLIGHT

December 2015 Kurnell tornado

On 16 December 2015, a tornado swept along a section of the NSW coast, with high rainfall, hail and unusually strong winds. A wind gust of 213 kilometres per hour was recorded at Kurnell at 10.33 a.m. This was the fastest wind speed ever recorded in NSW. Suburban Kurnell was especially hard hit. Homes and businesses were unroofed, sewerage and electricity were cut, and trucks were tipped on their sides. Fortunately, injuries were only minor.

11.4.6 Damage caused by the Kurnell tornado

11.4.7 A waterspout off Batemans Bay, New South Wales, in November 2012

Australian tornadoes

Australia has about sixteen tornadoes a year. They most commonly occur on the south-western coast of Western Australia; in south-eastern South Australia and the nearby border region of Victoria; in the area around south-eastern Queensland; and on the far north coast of New South Wales.

Waterspouts

Waterspouts develop when a rapidly rotating column of air links the base of a thunderstorm to a water body such as a lake or an ocean (see Figure 11.4.7). Waterspouts do not suck up water; the water seen in the main funnel cloud is actually water droplets formed when water vapour condenses.

ACTIVITIES

Knowledge and understanding

1 State the name given to the funnel of a tornado.
2 Outline the two factors necessary for the formation of tornadoes.
3 Explain why the USA experiences so many destructive tornadoes.
4 Explain what a waterspout is.

Applying and analysing

5 Using Figure 11.4.2, describe the location of the US states that experience the greatest number of tornadoes per year.
6 Use Figure 11.4.3 to answer the following questions.
   a Which months have the highest number of tornadoes?
   b Explain why these months might have the highest number of tornadoes. (Hint: the seasons are opposite in the Northern Hemisphere.)
7 Describe the damage observed in Figure 11.4.5.
8 Write a newspaper report outlining the impacts of a tornado on Moore, Oklahoma.

Investigating

9 The Enhanced Fujita (EF) scale is used to rate tornado intensity. The EF scale is based on the damage tornadoes inflict on human-built structures and vegetation. Use the scale to classify the intensity of the tornado responsible for the damage shown in Figure 11.4.5.
10 Investigate the safety procedures people can put in place to minimise the impact of tornadoes. Structure your finding using the following headings: Before, During and After.

11.5

Flooding

The costs of floods

Environmental costs

Floods can have both positive and negative effects on the environment. The movement of water can remove trees and vegetation and kill wildlife. Floodwater can also deposit rich sediment, ideal for growing crops.

Economic costs

Floods are among Australia's most costly natural disasters (see Figure 11.5.1). Each year, flooding costs the nation, on average, $300–400 million. Since 1790 there have been more than 2360 flood-related deaths. Today, the majority of deaths from flooding are as a result of people trying to drive, walk or swim through floodwaters. Some people are killed by flash flooding while camping on dry riverbeds.

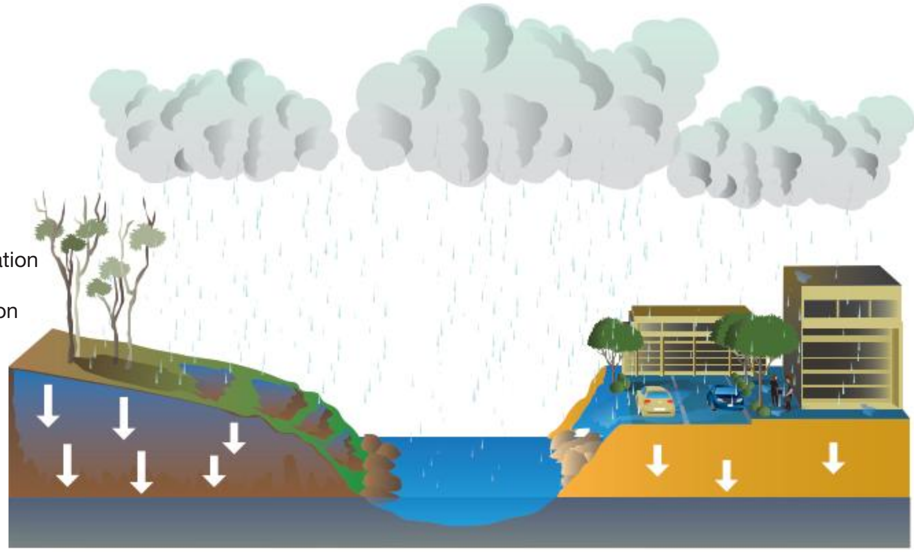
Social costs

Long-term social costs include people losing their homes and businesses and having to rebuild.

Types of floods

Flooding occurs when a waterway overflows its natural banks onto normally dry land. Floods can result from prolonged heavy rain, rapid winter snowmelt or sudden, heavy downpours.

11.5.1 Householders struggle to stop floodwaters inundating their home, Brisbane, 2011.



11.5.2 Human impacts on flooding

There are three types of floods: slow-onset floods, rapid-onset floods and flash floods.

Slow-onset floods build up over time and may last for a week or more—even months. They are often the result of a long period of above-average rainfall. Slow-onset floods can lead to loss of stock, damage to crops and extensive damage to road and rail links. Rivers in central and western New South Wales and Queensland, as well as parts of Western Australia, can flood in this way.

Rapid-onset floods occur more quickly, and are more common in mountain areas of larger rivers and in rivers draining to the coast. These floods may last only one or two days. They are potentially more damaging, since there is often less time to move livestock and farm machinery and to prepare homes and properties.

Flash floods occur when intense storms drop large amounts of rain within a brief period of time. They can occur with little or no warning and can reach their peak within only a few minutes. Flash floods can be extremely dangerous. Sometimes they are caused by heavy rainfall many kilometres away. The resulting floodwaters surge down rivers or creeks, sweeping away all in their path: they can move boulders, tear out trees and destroy buildings and bridges.

Almost all parts of Australia can experience flash floods. These floods pose the greatest threat to life and result in significant damage to property. They are a serious problem in those urban areas where drainage systems are unable to cope.

Factors influencing floods

The main factors that influence whether flooding will occur are:

- the amount and distribution of rainfall
- the capacity of the watercourse or stream network to transport run-off
- water catchment and weather conditions leading up to a rainfall event
- the type of ground cover
- topography (the shape of the land)
- tidal influences.

Human impacts

Human activities in water catchment areas have contributed to the frequency and severity of flooding. People increase the likelihood of flooding by removing water-absorbing vegetation, especially on hillsides. Not only does this increase **run-off**, it also exposes the soil to erosion, especially by running water. Valuable soil is washed into rivers, where it clogs the channels. The rivers are then less able to cope with the increased volumes of water.

Urban areas, with their hard surfaces, such as roads and buildings, do not absorb water. These areas often experience flash flooding. Heavy downpours can overwhelm stormwater drains and cause water to spill across roadways and footpaths. Figure 11.5.2 shows these human impacts.

DID YOU KNOW?

Just 15 centimetres of rapidly moving floodwater can knock a person down. A mere 60 centimetres of water can float a vehicle as large as a bus.

SPOTLIGHT

Victorian floods, 2011

Record-breaking rainfall between 12 and 14 January 2011 caused major flooding across much of the western and central parts of Victoria. The river systems affected by the floods included the Wimmera, Loddon, Campaspe and Avoca. The floodwaters inundated the city of Horsham and the towns of Charlton (see Figure 11.5.3), Rochester and Carisbrook. Other settlements seriously affected were the city of Shepparton and the towns of Beaufort, Bridgewater on Loddon, Clunes, Creswick, Echuca, Kerang, Skipton and Warracknabeal.

The floods devastated farms, with 51 700 hectares of pasture and 41 200 hectares of crops flooded and 6106 sheep killed. Victoria's Department of Primary Industries later calculated a damage bill of up to $2 billion.

11.5.3 A boat makes its way down a flooded street in Charlton, Victoria.

Flood warnings

With the exception of flash floods, there is usually a warning period before floods occur. Some river systems have quite sophisticated warning systems. They may, for example, have an electronic data collection system that automatically and continuously transmits rainfall and river heights from selected locations within the catchment. In Australia, warnings are issued through the Bureau of Meteorology.

Flood management

The construction of expensive levee banks provides some protection from flooding. The best way to protect property and reduce the risk of loss of life is to restrict the types of activities allowed on flood plains. Too many people still choose to live in flood-prone areas.

The risk of flooding increases as more clearing of vegetation takes place in upper catchment areas. Some ways of managing floods are shown in Table 11.5.4. These may help to reduce the impact of flooding.

11.5.4 Reducing the impact of floods

Flood control
• Dams and reservoirs • Levees • River diversion • Barrages and locks • Whole catchment management
Reducing the risk of flood damage
• Flood plain landuse zoning • Relocation of flood-prone property • Flood-proofing of buildings • Flood forecasting • Being prepared
Minimising the effect of losses
• Flood insurance • Evacuation • Post-disaster relief • Public information and education

ACTIVITIES

Knowledge and understanding

1 Construct your own definition of the term ‘flood’.
2 Outline the causes of flooding.
3 Describe the differences between slow-onset floods, rapid-onset floods and flash floods.
4 Identify the flood type that is potentially the most dangerous for human life. Give reasons for your answer.
5 Outline how the activities of people can increase the frequency and intensity of flooding.

Applying and analysing

6 Do the following tasks.
   a Study the list of factors that influence whether a flood will occur.
   b List how each of the factors alters the likelihood of flooding.
   c Discuss ways of managing or preventing the factors that increase the likelihood of flooding.
7 Study Table 11.5.4. Present the information in the table as a concept map.
   a Describe what you see, and the possible damage caused.
   b Identify ways in which flood damage could be reduced in the future.

Investigating

8 Investigate a flood that has occurred in your region, or a region of your choice, in recent years.
   a Identify the type of flood.
   b Outline the reasons for the flooding.
   c Describe how the flood developed over time.
   d Describe the damage the flood caused and how people responded.
9 You are a television reporter who has been assigned the task of reporting on the flooding shown in either Figure 11.5.1 or Figure 11.5.3. You are required to present a five-minute report for the evening news bulletin. In your report you should outline the possible causes of the flood, describe its impact on the community and outline how the community is coping with the disaster.

11.6

Heatwaves

Causes of heatwaves

Heatwaves occur during summer in warm climates. They develop in one of two ways. Firstly, in areas dominated by high pressure with little or no rain or clouds, the air and ground can heat up to excess. A stationary, or very slow-moving, high-pressure system can result in a persistent heatwave. Secondly, winds can direct hot, dry air from arid regions towards areas that are normally cooler.

Heatwaves in Australia

Recent heatwaves in Australia have included the following:

- ***March 2008***—Adelaide experiences fifteen days in a row above 35°C (previous record: seven days)
- ***January 2009***—Adelaide experiences seven days in a row above 40°C
- ***March 2011***—Perth experiences twenty-six days in a row above 30°C
- ***January 2013***—Perth experiences seven days in a row above 39°C
- ***March 2013***—Melbourne experiences nine days in a row above 30°C.

Impacts of heatwaves

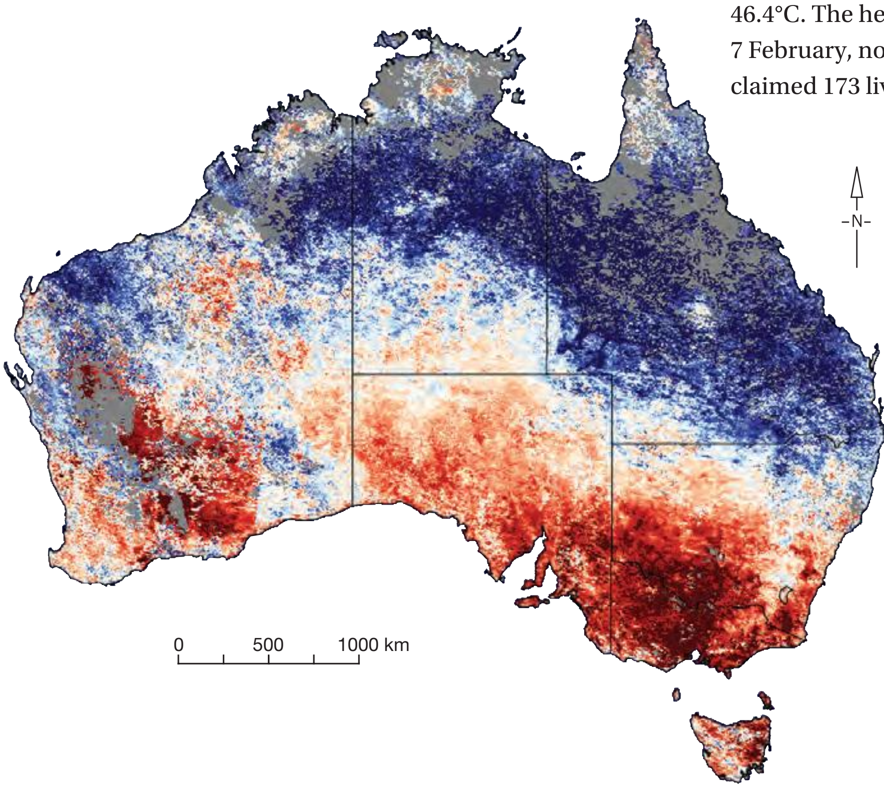
Health and wellbeing

Hyperthermia becomes an important health issue in times of sustained high temperatures, especially when heat is combined with high humidity. Perspiration (the means by which the body seeks to regulate its temperature) is absent in 84 to 100 per cent of those affected. The people most affected by heat-related illness are older adults, very young children, and those who are sick or overweight.

During the 2003 European heatwave, up to 35 000 people died from heat-related illnesses. Much of the heat was concentrated in France, where nearly 15 000 people died. In Portugal, the temperature reached 48°C. In addition to physical impacts, excessive heat can cause psychological stress.

Bushfires

Heatwaves, combined with drought, can increase the likelihood of bushfires. In 2009, for example, the south-eastern Australian heatwave that commenced in late January led to record-breaking prolonged high temperatures across Victoria (see Figure 4.36). During the heatwave Melbourne recorded its highest ever temperature, 46.4°C. The heatwave produced extreme fire conditions. On 7 February, now known as Black Saturday, raging bushfires claimed 173 lives and destroyed 2500 homes.



11.6.1 NASA satellite image of Australia showing the land surface temperature from 25 January to 1 February 2009, compared with average mid-summer temperatures. Places where temperatures were warmer than average are red, places experiencing near-normal temperatures are white, and places with cooler than average temperatures are blue.

SPOTLIGHT

Cold waves

A cold wave occurs when there is a rapid and sustained drop in temperatures to very low levels within a 24-hour period. Such cold snaps can have a devastating effect on crops and livestock. They can also damage infrastructure and disrupt economic activity and social activities.

The European Cold Wave of 2009–10 brought record low temperatures and heavy snowfalls across Europe (see Figure 11.6.2). Ninety people died. Temperatures as low as –47°C were recorded in the Italian Alps.

11.6.2 A child plays in front of an ice-covered car in Versoix, Switzerland, after a cold snap in February 2012.

Infrastructure failures

Heatwaves can be very disruptive to the economy and the day-to-day activities of people. Increased use of air-conditioning can lead to power outages. Rail lines can buckle, disrupting public transport, and breakdowns can cause traffic chaos.

Wildlife

A long heatwave can have a serious impact on wildlife. For example, in 2008, after a long heatwave, more than 2 tonnes of dead fish were discovered in the Agly River, in France (see Figure 11.6.3).

11.6.3 Fish killed by a heatwave

ACTIVITIES

Knowledge and understanding

1 State where and when heatwaves develop.
2 Outline the causes of heatwaves.
3 State what a cold wave is.
4 Copy and complete the following table.

	Impact upon people's health and wellbeing	Other impacts
Heatwave		
Cold wave		

Applying and analysing

5 Study Figure 11.6.1 and locate the regions in Australia that experienced higher than average midsummer temperatures in 2009.
6 Working in groups, discuss and list the ways in which heatwaves can increase the risk of bushfires. Share your findings with the rest of the class.

Investigating

7 Investigate the effects of heat stress on:
 a people
 b plants
 c animals.
 Prepare a digital presentation of your findings and present it to the class.
8 Explore the ways in which people can avoid heat stress during heatwaves. Present your findings as a mind map.
9 Investigate a recent example of a cold wave, and prepare a short report. Include where the cold wave occurred, the temperatures that were experienced and the damage and destruction it caused.

11.7

Drought

Defining drought

Drought occurs when there is a prolonged period of below-average rainfall in an area. It can also be said to exist when the supply of water is insufficient to meet the needs of people.

Meteorological drought

A meteorological drought occurs following an extended period of below-average precipitation (rainfall, snow, hail, sleet). Official declarations of drought vary between regions. For example, in the United Kingdom, where rainfall is higher and more regular than in Australia, a drought is a period of fifteen days without rain.

In Australia, there are two definitions of drought.

- A serious rainfall deficiency occurs when for three or more months, rainfall in an area is between the lowest 5 and 10 per cent recorded in that area over the long term.
- A severe rainfall deficiency occurs when for three or more months the rainfall is less than the lowest 5 per cent of recorded rainfall in that area over the long term.

In arid regions, a drought might be said to occur when there is a succession of unusually dry years.

Hydrological drought

Hydrological drought occurs when water storages such as reservoirs, rivers and groundwater reach critically low levels.

Agricultural drought

Agricultural drought occurs when there is not enough soil moisture for crop production—plant growth is affected.

Socio-economic drought

Socio-economic drought occurs when the supply of a good declines because of a shortage of water. The supply of hydro-electric power and water-demanding crops such as cotton depend on the availability of water.

Impacts of drought

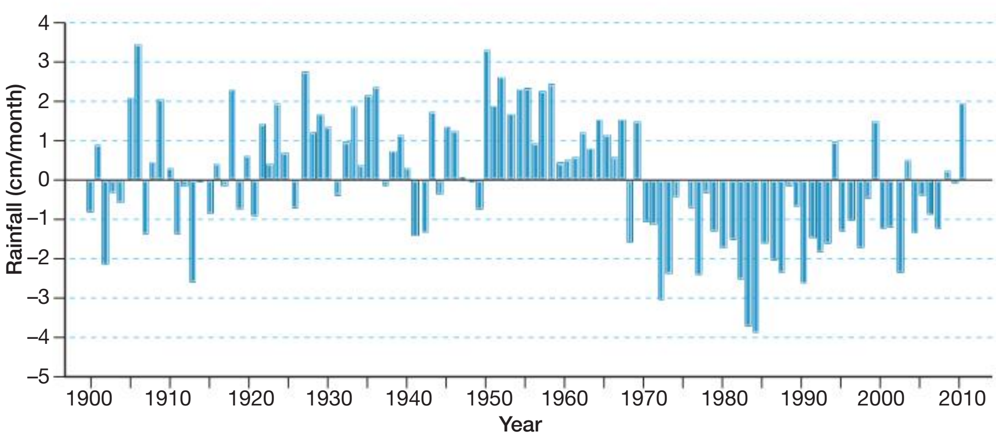
During a drought, rivers and dams dry up, plants wither and die, and the soil is dry and dusty. Droughts are a normal part of weather in most parts of the world.

SPOTLIGHT

Drought and famine in the Sahel

In 2010, Africa's Sahel region suffered one of its worst famines in recent times. The famine was caused by a heatwave that followed nearly four decades of below-average rainfall. The extreme temperatures devastated the region's crops. More than 350 000 people faced starvation and 1.2 million were at risk of famine.

For a long time it was thought that drought in the Sahel was caused by humans' overuse of the region's natural resources, overgrazing, deforestation and poor land management. In the late 1990s, climate studies suggested that large-scale climate changes were also triggering drought. Figure 11.7.1 shows rainfall anomalies (departure from normal rainfall) for the Sahel since 1900. Population growth and the loss of land to the production of cash crops such as cotton are also adding to the shortage of food in the region. These crops are produced for export to developed countries.



11.7.1 Rainfall anomalies in the Sahel, 1900–2010

The problem for farmers, and other water users, is not knowing when droughts will occur and for how long they will last.

Environmental impacts

During drought, native grasses die off, leaving topsoil bare and vulnerable to wind erosion. The topsoil is blown away in dust storms and the land may become infertile. This process is called **desertification**. Drought and people's overuse of land contribute to **land degradation**.

Water quality in river systems is also affected. As flows decrease, rivers become stagnant and may suffer outbreaks of toxic algae. Floods, by contrast, reduce pollutants by flushing out river systems.

Other environmental impacts include the loss of biodiversity, increased risk of extinction for endangered plants and animals, increased chance of weed invasion and increased frequency and intensity of bushfires.

Economic impacts

The worst effects of drought are crop failures and the death of livestock due to lack of water and feed. Farmers are sometimes forced to sell their livestock at reduced prices. They suffer loss of earnings and may face crippling debt. In extreme cases, they are forced to sell their farms. The rural economy (especially those businesses selling goods and services to farmers) and export earnings are also affected. This can, in turn, affect a country's rate of economic growth.

Social impacts

Droughts can have a terrible social impact on rural communities. The loss of a farmer's crops and livestock can be the cause of anxiety and stress. Financial stress can contribute to difficulties in marriages and an increase in the suicide rate. Inequalities between rural and urban sectors of society are often increased by prolonged droughts. Droughts can also increase the farmer's workload. Livestock, for example, may need to be handfed.

Long-lasting droughts have contributed to the decline of the rural population and small rural towns. Dam-based recreational activities are often banned as water levels fall. People in urban centres suffer indirectly through increased food prices and (sometimes) a reduction in quality.

FAMINE

When crops fail and livestock die, food availability is severely reduced. This can lead to famine, and the effects can be catastrophic. People suffer malnutrition as their dietary intake is reduced, and the outcome for many, especially the old and the young, is death.

Responses to drought

Preventing droughts is not possible, but people can reduce their impact. Responses to drought are outlined in Table 11.7.2.

11.7.2 Responses to drought

Farmers
• Develop a drought management plan
• Stock/crop the property at a sustainable rate
• Install water-saving forms of irrigation
• Store grain and/or feed for use in times of drought
• Move stock to areas with feed (this is called agistment)
• Sell all non-breeding stock
• Increase water storage capacity (bores, tanks and dams)
Urban dwellers
• Reduce the amount of water used in the home and business
• Mulch gardens
• Install rainwater tanks
• Obey any restrictions imposed by state government

ACTIVITIES

Knowledge and understanding

1 Define the term 'drought'.
2 Explain why official declarations of drought vary between the United Kingdom and Australia.
3 Outline the differences between meteorological, hydrological, agricultural and socio-economic droughts.

Applying and analysing

4 Is the drought in the Sahel a meteorological, hydrological, agricultural or socio-economic drought, or a combination of two or more? Explain.
5 a Study Table 11.7.2 and rank the responses according to which would be the most effective in reducing water demand in both the short and long terms.
b Explain your ranking and identify those responses you think would reduce water demand.

Geographical skills

6 Study Figure 11.7.1 and describe the trends in Sahel rainfall since 1950.

Investigating

7 Investigate a recent drought outside Australia. Find out about the drought's duration, the type of drought it was (meteorological, hydrological, agricultural or socio-economic), the areas over which it extended and the impact it had on the communities affected. Present this report as an annotated visual display and include a map of the area.

11.8

CASE STUDY: Drought in Australia

Drought

Drought has been a part of life in Australia since the Dreaming. While Indigenous Australians developed sophisticated ways of coping with Australia's irregular rainfall, early European settlers struggled. European-based systems of agriculture relied on rainfall and fertile soils; Australia had neither.

Causes of drought

Australia has one of the most variable rainfall climates in the world. As a result, it tends to experience severe droughts every 10–15 years on average. Droughts may last for extended periods—in some cases, a decade or more.

Droughts over eastern and northern Australia are usually associated with the weather phenomenon known as El Niño. El Niño is a reversal of the weather phenomenon known as La Niña. La Niña brings rainfall to eastern and northern Australia.

Figure 11.8.2a outlines an El Niño period. The main changes that occur in an El Niño period and result in low rainfall for Australia are:

- weaker easterly trade winds from South America
- cool water off the east coast of Australia
- higher air pressure over eastern and northern Australia.

Figure 11.8.2b outlines a La Niña period. The main changes that occur in a La Niña period and result in high rainfall for Australia are:

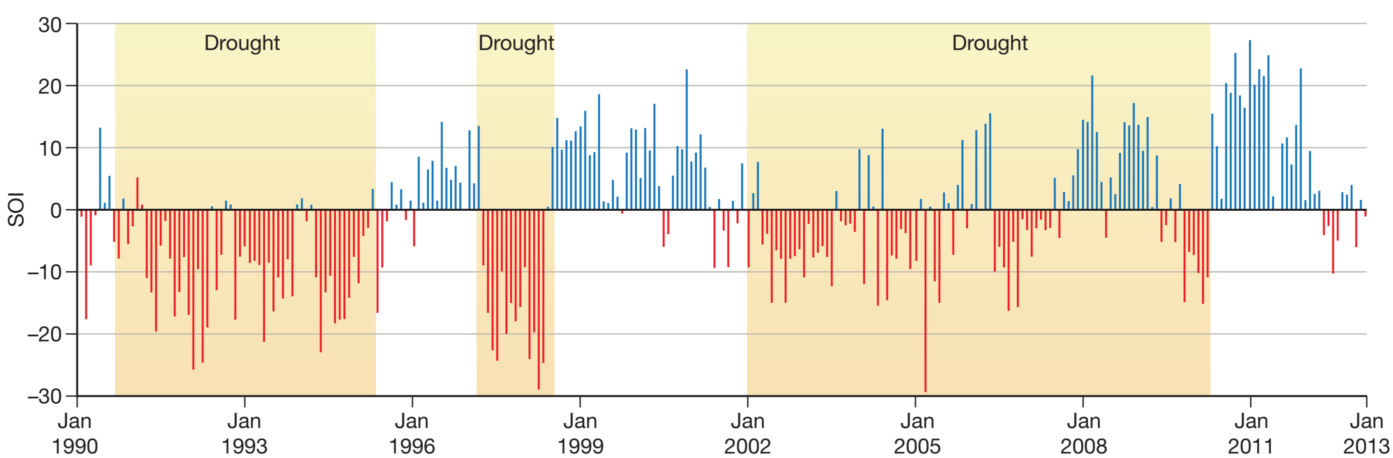
- stronger easterly trade winds from South America
- warm water off the east coast of Australia
- low air pressure over eastern and northern Australia.

The Southern Oscillation

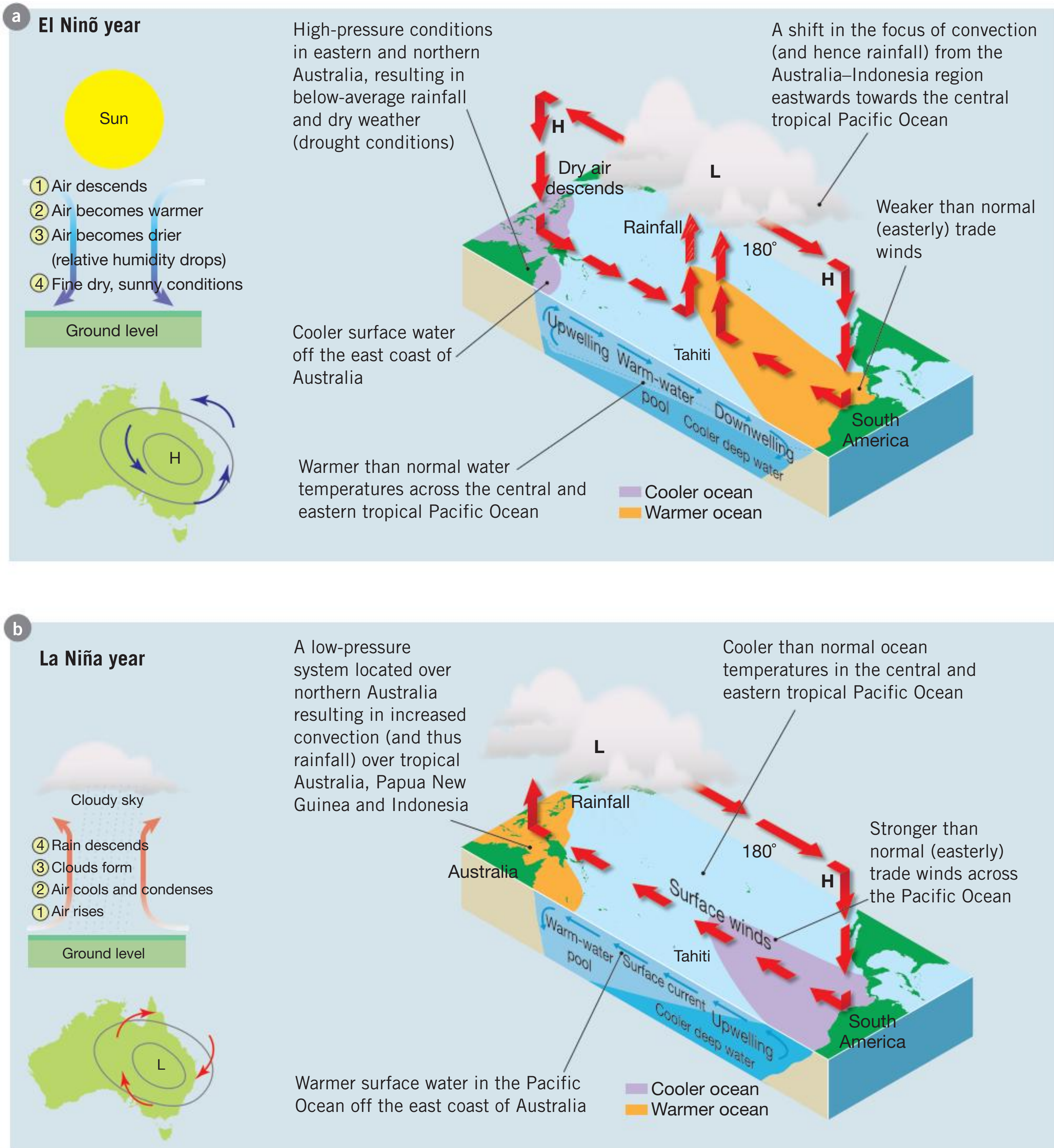
The Southern Oscillation Index (SOI) is a measure of the monthly or seasonal variations in the air pressure difference between Tahiti and Darwin (see Figure 11.8.1). Long-term measurements show that:

- negative SOI values are linked to El Niño periods and droughts
- positive SOI values are linked to La Niña periods and high rainfall.

11.8.1 The Southern Oscillation Index, 1990–2013



11.8.2 Impact of (a) El Niño and (b) La Niña



Predicting droughts

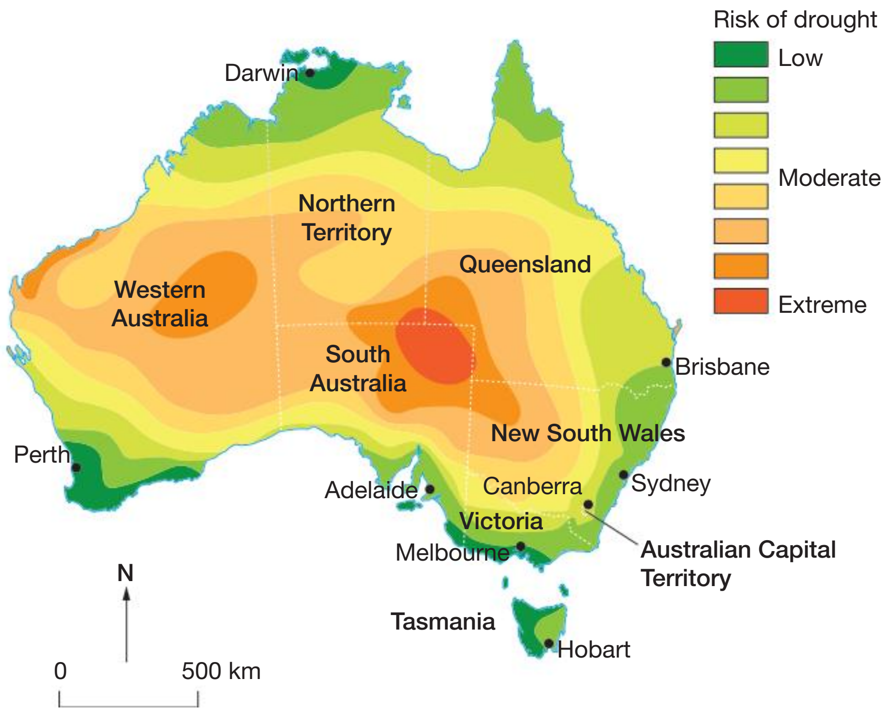
Figure 11.8.3 identifies those areas that are at risk of drought in Australia. Because of the widespread risk of drought, scientists monitor changes in the surface temperature of the Pacific Ocean. Changes in ocean surface temperature can provide advance warning of an El Niño or a La Niña period. With advance warning, farmers can reduce their stock numbers to conserve feed. They may also be able to adjust their crop-planting program to avoid crop losses and soil erosion.

History of droughts

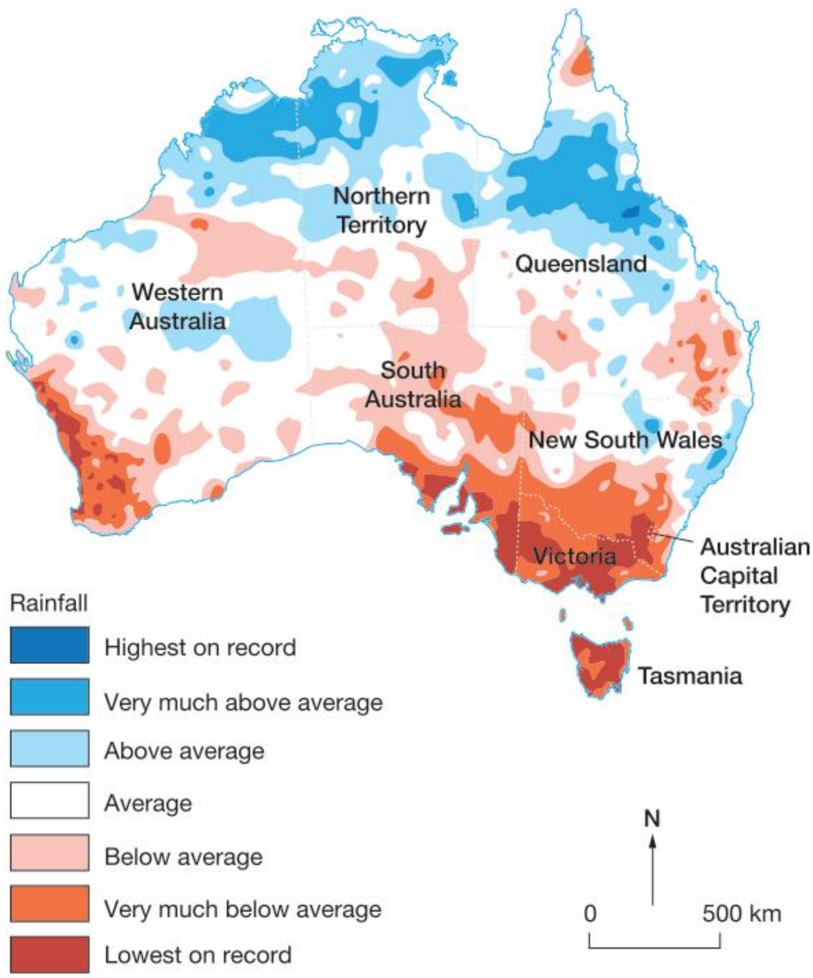
Major Australian droughts have included the 'Federation Drought' (1895–1902); the 1914–15 drought; the Second World War droughts (1937–45); the 1965–68 drought; the drought of 1982–83; and the long El Niño drought of 1991–95.

Recent Australian droughts

Between 2002 and 2003, and again in 2006–09, Australia experienced some of the worst drought conditions on record. Figure 11.8.4 shows the extent and severity of the 2006–09 drought. Much of southern Australia experienced either a serious or a severe water deficiency, and parts of Western Australia, South Australia, New South Wales, the Australian Capital Territory, Victoria and Tasmania received the lowest rainfall on record. Australia's farmers experienced great economic hardship as crops failed and livestock either were sold or died. People living in major urban centres (including Sydney, Melbourne and Canberra) were forced to reduce their use of water.



11.8.3 Areas at risk of drought in Australia



11.8.4 Areas of rainfall deficiency show up clearly in this map of rainfall distribution in 2006–09.

11.8.5 During drought, millions of tonnes of topsoil are blown in blinding dust storms such as this one in Sydney, 2010.

Dust storms

The drought conditions contributed to huge dust storms, such as the one shown in Figure 11.8.5, and some of the worst bushfires ever experienced in eastern and southern Australia. These included the Black Saturday bushfires of 7 February 2009 in Victoria. The drought broke when La Niña rains drenched the region in late 2010.

ACTIVITIES

Knowledge and understanding

1 Outline the effects of drought.

2 Copy and complete the following table.

	El Niño	La Niña
Type of air pressure on the east coast of Australia		
Water temperature off the east coast of Australia		
Influence on Australia's weather		

Applying and analysing

3 Identify the data used to predict droughts. Explain the ways in which farmers can respond to these predictions.

Geographical skills

4 Study Figures 11.8.3 and 11.8.4. Were all areas that experienced rainfall deficiency between 2006 and 2009 located in areas of high drought risk? Explain.

Investigating

5 Investigate a recent drought in Australia. Present your findings as an annotated visual display. Include in your response the following information.

a a map of the area investigated with information about natural features, climate type, average temperatures and annual rainfall

b the drought's duration, the areas over which it extended and the impact it had on the communities affected

c suggestions for droughtproofing the region and/or reducing the impacts of drought in Australia

11.9

Responding to hazards

Early warning systems

Developments in the science of meteorology have greatly increased the accuracy of weather forecasting. Meteorologists are now better able to predict extreme weather events. Warnings can be issued via a range of technologies, such as television, radio and mobile phones. Having warning about such events enables people to undertake necessary preparations to minimise loss of life and damage to property. They can secure their homes and businesses and take shelter in a secure, safe place.

Cyclones and tornadoes

Early cyclone or tornado warning systems allow people to secure their property and act to reduce the threat to their physical wellbeing.

Floods

Early flood warning systems enable people to sandbag premises and build temporary levee banks. Early warning systems also provide people with time to remove valuables from their homes and businesses and move themselves and their livestock and vehicles to higher and safer ground.

Drought

The onset of drought occurs more slowly. In urban areas, water use can be reduced through water restrictions and education campaigns. Farmers can adapt to the drier conditions by reducing stock levels and by using feed grown and stored in better times.

Building laws

Local governments can regulate the activities and the types of buildings that are permitted on flood plains and in areas affected by storm surges. For example, by banning the construction of new homes and commercial buildings in such areas, authorities can minimise property damage and the disruption that flooding and storm surges cause to people's lives.

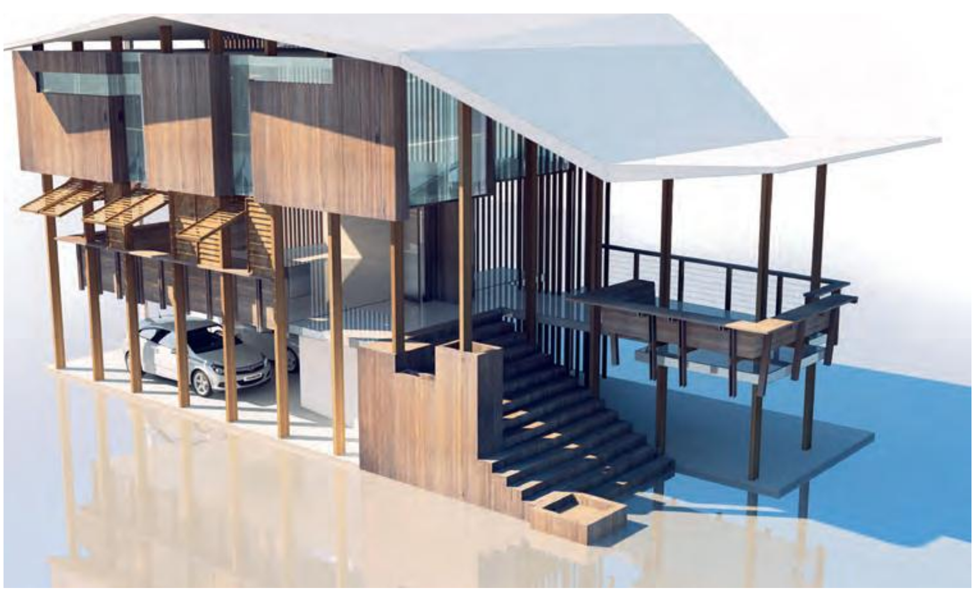
Where communities are already well established on a flood plain, engineering measures can be used to minimise the impacts of flooding and storm surges. Homes can also be designed in ways that reduce the effects of flooding (see Figure 11.9.1).

In built-up areas, authorities can take a range of measures to minimise flash flooding. These include:

- using porous paving, or replacing sealed surfaces with grass and gardens to allow more water to soak into the ground
- keeping street drains clear of blockages
- constructing on-site stormwater retention systems
- controlling erosion from building sites.

Building codes and standards can also minimise damage to property. In Australia's cyclone-prone areas, new buildings must be built to a standard that:

- enables them to remain stable and not collapse
- prevents progressive collapse
- minimises local damage and loss of amenity
- avoids causing damage to other properties.



11.9.1 Following the 2011 Brisbane floods, architect Michael Rayner designed a home that can withstand floods. Rayner based his design on the original Queenslander-style home.

Engineering responses

In the case of flooding, responses that involve engineering can reduce peak flood levels and potential damage. Such responses include:

- using dams and water retention basins to capture floodwaters
- building pipelines to move captured water from place to place
- building levee banks and floodgates to divert water (see Figure 11.9.2)
- erecting barriers such as sea walls to deflect storm surges from coastal communities
- widening and deepening channels of rivers and creeks.

Emergency responses

It is the role of governments to help people in emergencies. Assistance can be supplied through various government departments and agencies. Governments also provide emergency funding to help communities recover from disasters.

Volunteer-based emergency services are quick to respond when disasters occur, as are organisations such as the Red Cross. Community-based groups also play an important role in emergencies.

11.9.2 Do-it-yourself flood mitigation in Mississippi, USA

ACTIVITIES

Knowledge and understanding

1. Explain how developments in meteorological science have helped people manage and adapt to extreme weather events.
2. Give one example of how planning measures implemented by local government can help reduce the impact of floods and storm surges.
3. Outline how engineering responses have been used to manage the impacts of extreme weather events.
4. How can governments and volunteer organisations provide help and support in the period following an extreme weather event?
5. Construct a mind map summarising the ways in which communities manage and adapt to extreme weather events.

Investigating

6. Using the internet, investigate the early warning systems of the Australian Bureau of Meteorology. Write a short report summarising your findings.
7. Research one of the volunteer-based organisations that assist in response to an extreme weather event. Find out:
   a. what the organisation's role is
   b. who its members are
   c. what the source of its funds is
   d. what types of assistance it provides.
8. As a class, discuss how you might assist in response to a weather-related natural disaster affecting:
   a. a local community
   b. a community in another part of the world.

11.10

Investigating an atmospheric or hydrological hazard

Investigation principles

Throughout this chapter there has been the opportunity to explore a range of atmospheric and hydrological hazards that cause change to landscapes across a range of scales. In this unit there is the opportunity to apply the inquiry process to investigate a hazard that has recently occurred or is currently occurring in a particular place.

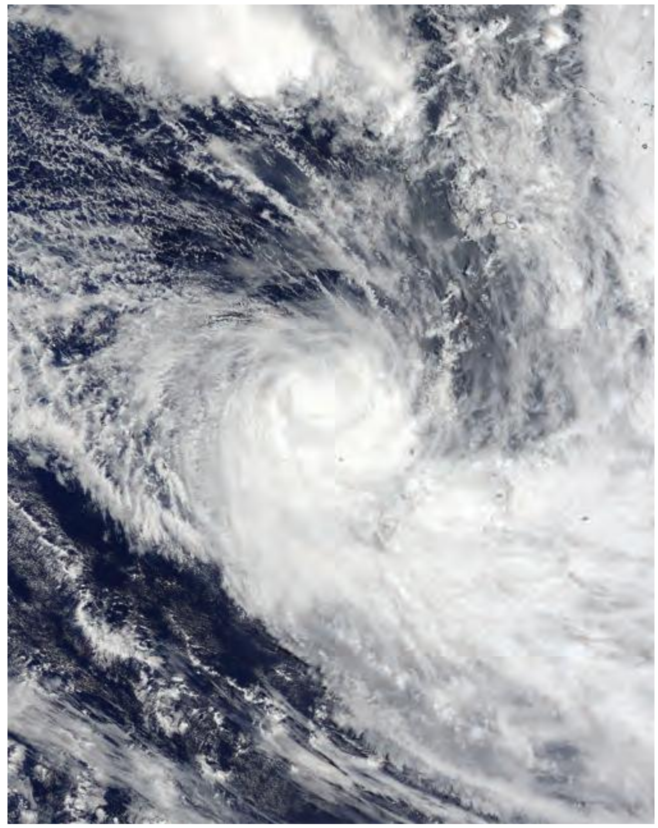
The inquiry process involves acquiring, processing and communicating geographical information using a range of geographical tools (such as maps, fieldwork and visual representations) where appropriate.

INQUIRY QUESTIONS

- What are the causes and impacts of an atmospheric or a hydrological hazard in a chosen place?
- Are there responses to minimise the impacts of this hazard occurring in the future?

Scaffolding an investigation

Tables 11.10.1a–d provide a scaffold for an inquiry process that will help you geographically investigate one atmospheric or hydrological hazard.



11.10.2 Satellite image of Tropical Cyclone Yalo in the South Pacific Ocean on 25 February 2016

Table 11.10.1a

Part 1: Gathering raw data	
Highlight the chosen category of hazard to investigate	Atmospheric Hydrological Name the hazard:
Describe the spatial distribution of this type of this hazard throughout the world	
Identify the specific type of hazard chosen to investigate (e.g. cyclone)	
Identify the place of the chosen hazard using absolute and relative location	
Identify the date, time and duration of the chosen hazard	
Represent all of the above information on a map, using spatial technologies where appropriate	

Table 11.10.1b

Part 2: Acquiring geographical information	
Develop at least one **geographical question** to investigate the chosen geomorphic hazard in a specific place	*The inquiry questions at the beginning of this unit can be adapted to complete this section of the scaffold if required*
Develop a **justified hypothesis** in response to this geographical question	
Identify at least two **primary research** methodologies appropriate to the geographical question	*This may not be appropriate for all inquiries due to the nature and location of the chosen atmospheric or hydrological hazard* **Quantitative (data)** / **Qualitative (information)**
Identify at least two **secondary research** methodologies appropriate to the geographical question	**Quantitative (data)** / **Qualitative (information)**
Collect, select and record the data and information gained from your research methodologies	

Table 11.10.1c

Part 3: Processing geographical information	Cause(s)	Impact(s)	Response(s)
Select data and information for its usefulness			
Analyse data and information to propose a response	**Judgement**: e.g. sudden and unexpected, or unforeseeable, or predictable etc.	**Judgement**: e.g. extensive, or minimal, or life-threatening, or permanent or temporary etc.	**Judgement**: e.g. effective, or ineffective, or good/bad for the short term/long term, or organised etc.
Decide how to represent data and information	e.g. annotated diagram	e.g. photographs and column graphs	e.g. flow charts and pie graphs
Apply two of the concepts in the next column to the conclusions drawn from your research findings	place, change, interconnection, scale, sustainability *There is no order in which to apply the concepts; some concepts may be applied more than once depending on the nature of the investigation*		
Identify and outline whether your research findings support the justified hypothesis	[ ] Yes, all of it ……………………………………………………… [ ] No, none of it …………………………………………………….. [ ] Partially or with qualification ……………………………………		

Table 11.10.1d

Part 4: Communicating geographical information	
Circle the preferred presentation option	as a prezi or Powerpoint a speech in a folder a video a newsflash other……………
Reflect on learning to propose suitable action	

ACTIVITIES

Investigating

Go to the websites of the Bureau of Meteorology, Geoscience Australia (GA) or the United States Geological Survey (USGS) and search for a recent atmospheric or hydrological hazard to begin your investigation.

Personal connections

CHAPTER 12

We are all products of our surroundings. The place in which we live, together with all the things that make up the local environment, helps to shape us as individuals. We are also part of a social network of people that links us to other places.

The environment around us therefore shapes our 'personal geography'—the way in which we view and make sense of the world around us.

In this chapter we focus on the perceptions people have of place, and how this influences their connections to different places. We pay particular attention to the process of cultural diffusion and adaptation and the impact of travel on both the person undertaking the journey and those living in the places visited.

INQUIRY QUESTIONS

- What are the factors that shape our perception and use of places?
- How does place help shape our identity?
- How do people create and modify places?
- What are the influences on, and effects of, people's travel and recreational, cultural or leisure connections with different places?

GLOSSARY

cultural diffusion	the spread of cultural characteristics from one place to another
cultural group	a group made up of people of similar heritage who identify with others in the group through sharing the same language, ancestry and often religion
culture	a complex mixture of people's origins and heritage, language, religion, customs and ways of life
perception	the identification and interpretation of sensory information in order to represent and understand the environment
places	specific areas of the earth's surface that have been given meanings, or which have been shaped by people
place making	the social and physical construction of places
place marketing	the process of reinterpreting, designing, packaging and selling places
place perception	people's awareness of places and the particular opinions they have about them
sense of place	the characteristics that make a place special or unique, as well as those that contribute a sense of human attachment and belonging
space	the three-dimensional realm or expanse in which all material objects are located and all events occur
territoriality	the attachment of individuals or groups to a specific location
tourism	travel for recreational, leisure or business purposes

12.0 The Castellers de la Vila de Gracia demount a human tower, Barcelona, Spain, 2013.

12.1

Perception and use of places

Place perception

Place perception refers to our awareness of **places** and the particular opinions we have about them. Our feelings and interpretations about the characteristics of a place help develop place perception. Place perception influences the decisions we make about a location.

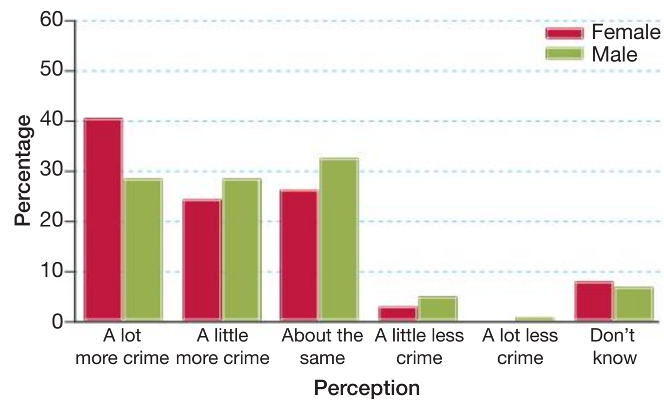
However, our feelings are not always well reasoned; sometimes they are irrational and result in **perceptions** that are not based on reality. One example of this is the decisions we make about living in areas affected by natural hazards such as earthquakes, volcanic activity and tropical cyclones. Our perception of a place as attractive or desirable is very separate from our understanding of its hazard potential.

The perception of place is a very individual thing. People can perceive the same place very differently. For some, ordinary places can have a special meaning. The family vacation destination visited each year will be seen as very special to that family, even years after they have stopped going there. Your local neighbourhood will be viewed very differently by outsiders than by you. This is because the neighbourhood is a place with signs and symbols that provide personal meaning and significance.

Gender difference

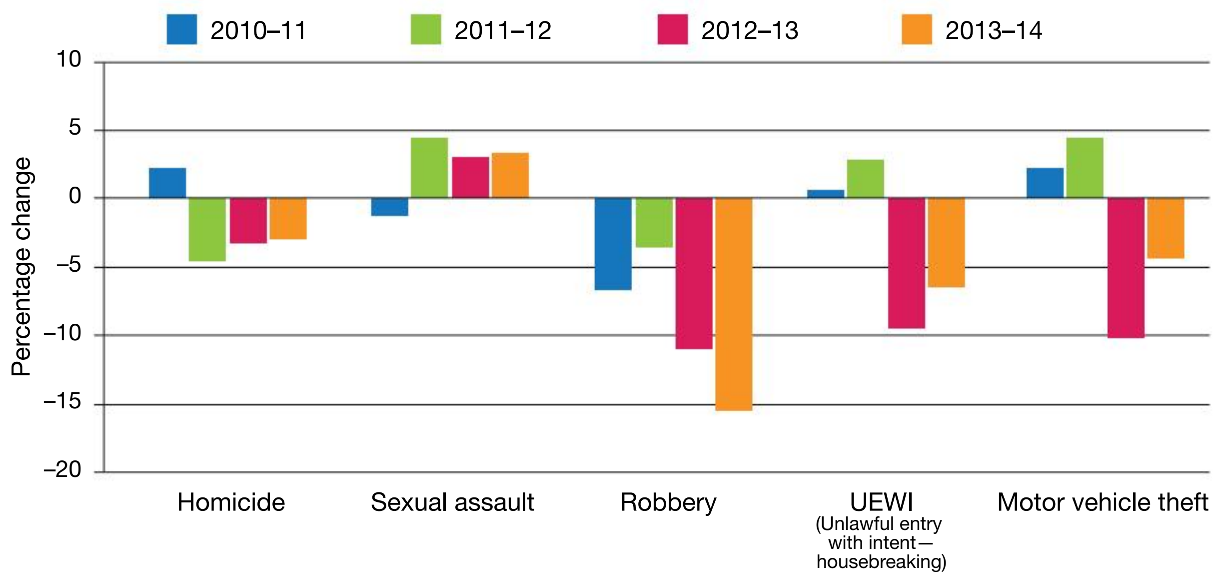
There are differences in the way women and men perceive danger. Even though men are more likely to experience actual violence, many studies have shown that women's fear of violence is likely to be far greater. This is shown in Figure 12.1.1, in which women perceive a greater increase in crime compared to the actual statistics, as shown in Figure 12.1.2. The reasons for this difference in perception have been linked to the nature of urban public spaces.

12.1.1 Australians' perceptions of crime trends



Source: Australian Institute of Criminology

12.1.2 Annual change in incidence of violent crimes, Australia, 2010–14



Source: Australian Bureau of Statistics, 2015

12.1.3 Parks are perceived differently by different groups of people.

Urban places tend to reflect a male-dominated social structure. This results in perceptions of familiarity and comfort for men, but much less so for women.

A recent study about tourists in London found that the perception of danger was greater among females than males. One reason that such studies are important for geographers is that the perception of danger influences behaviour and the use of leisure spaces. In countries where the roles of men and women are very distinct, women are less mobile than men. In these cases, women perceive the accessibility from place to place to be very important.

Developing a perception

The perception of place is developed by direct and indirect experiences. In these experiences, people develop an understanding of their surroundings through 'filters'. These filters include personal or group characteristics such as race, gender, age, religious beliefs, and the time in which they live. For example, the perception and use of a park, similar to one shown in Figure 12.1.3, will most likely be different for a 5-year-old boy and a 68-year-old woman.

When people think about a place they perceive, they organise various parts of it into elements. These elements include paths, edges, districts, nodes and landmarks, as shown in Figure 12.1.4. These elements help people orient and navigate within a place. They may also segregate or alienate people.

Familiarity of places

Places that are well understood and easily read are places in which it is easier to get oriented and to navigate. The more familiar people are with a location, the more they will use it. This familiarity contributes to shaping particular aspects of people's behaviour. For example, the elements of a shopping centre can influence which one we choose to visit. Research about where people travel to shop reveals that their perception of the shopping district influences their choice. The chosen shopping centre may not necessarily be the closest, but it may be the one with the best parking or pedestrian circulation.

12.1.4 The elements of the city

12.1.5 Erik Weihenmayer (in the middle) climbing Mt Everest

Perception and use of place

Mobility disability

People with a mobility-related disability are those who have very limited use of their legs. They may use walking aids or wheelchairs to move within places. Their perception of place will partly be influenced by how well these places accommodate their particular needs. For example, is there wheelchair-accessible parking? Are there wheelchair access ramps? Does the place have steep or unpaved terrain?

The perceptions held by people with a mobility disability are influenced by three factors. For many, the perceptions are affected by their own internal barriers, such as despair or feelings of been overwhelmed by their disability. This is particularly the case for people who have suddenly become disabled. The second factor relates to other people's attitudes towards the disability and how receptive they are to the presence of the person in a wheelchair. Finally, the physical inaccessibility of the environment affects the perceptions about places held by those with a mobility disability.

The desire of people with a mobility disability to experience wilderness areas and pristine places is similar to that of able-bodied people. Unfortunately, there are barriers to them experiencing these places. In New Zealand, some groups have suggested constructing cable cars and gondolas to provide access to pristine wilderness places such as Milford Sound. In Australia, some walks that enable wheelchair access have been built in national parks, such as the Bungoona path in the Royal National Park, south of Sydney.

Vision impairment

People who have a vision impairment can perceive varying degrees of light. Perception, however, is more than just visual. People with a vision impairment are able to use other senses, such as touch, sound and smell, to get a sense of their surroundings. So confident are many vision-impaired people with the perception of their surroundings that they are able to play sport, skateboard and climb mountains, as shown in Figure 12.1.5. In 2001, Erik Weihenmayer became the first blind person to reach the summit of Mount Everest.

Descriptions from others, sounds and touch allow vision-impaired people to build a mental picture. Although colour is often limited in this mental picture, the experiences do differ from one person to the next. People with a vision impairment tend to have a heightened sense of taste, touch and smell. This may allow them to construct detailed mental

12.1.6 Tree roots have lifted the concrete path in this suburban street.

images. The aspects of place that relate to touch, sound and smell are more powerful in influencing the use of place.

Figure 12.1.6 shows that place conditions are not always ideal for people with a vision impairment to navigate safely.

Public transport poses particular difficulties. People with a vision impairment may not know when to get off the bus or whether or not their bus has arrived at the bus stop. Fears and difficulties in moving about places limit independent travel. This makes people with a vision impairment more likely to be housebound and isolated.

PUBLIC TRANSPORT CHANGES

There are 357 000 vision-impaired people in Australia. To enable people with a vision impairment to access public transport, governments are upgrading train stations and light rail stops. This is a very expensive undertaking. The cost of those completed so far has ranged from $500 000 to $1 million. The works involve laying tactile tracks. For those with disabilities that impede mobility, lifts are being installed and platforms raised.

12.1.7 Tactile and braille street signs for vision-impaired people have been introduced in Sydney.

ACTIVITIES

Knowledge and understanding

1. State what is meant by the term 'place perception'.
2. Outline how men and women differ in their perception of places.
3. Outline how we arrive at our perceptions of place.
4. Explain how people with a vision impairment develop their perceptions of places.
5. Outline the factors that shape the perception of place held of people with limited mobility.

Geographical skills

6. Study Figures 12.1.1 and 12.1.2. Outline the apparent contradiction in the data shown in the two line graphs.
7. Study Figure 12.1.4. Explain the concepts of path, edge, district, landmark and node. What role do they fulfill?

Applying and analysing

8. Study Figure 12.1.3 and contrast the differing perceptions of the area of a 10-year-old girl and a 65-year-old woman.
9. Identify a location near your school that could be considered to be a:
   a. path
   b. edge
   c. district
   d. landmark
   e. node.
10. Study Figures 12.1.6 and 12.1.7.
    a. Why is it important to consider how people with a vision impairment use public places?
    b. Describe the difficulties faced by people with a vision impairment when using public transport.
    c. How might the use of public transport be affected by the perception of public transport by people with disabilities?
11. To what extent should wilderness places be modified to cater for people with a mobility disability?
12. With a partner, walk around your school blindfolded for 20 minutes. Take turns and then describe what you felt, observed and thought. How different might it be when moving through a place you have not been to before?

12.2

Place making

Place making and perception

Not only do people perceive and use places, they also create and modify them. People create places in response to the opportunities and constraints of their environment. In some cases this can be almost unconscious and incidental, while at other times it may conscious and purposeful. The social and physical construction of places is known as **place making**.

How we perceive a place affects how we modify it. The modification of the place supports and reinforces our perceptions. A simple example could be how people arrange elements in their garden. The design and placement of objects such as outdoor furniture reflects ownership of **space** and personal preference. Some communities modify places to reflect preferences.

Place making may also imply or result in the exclusion of other people, as shown in Figure 12.2.1, a gated community in California. This is because one aspect of place making is to reinforce who we are in contrast to other people. Consequently, place making often expresses **territoriality**.

Territoriality

Territoriality refers to the persistent attachment of individuals or groups to a specific location. The location provides security and a physical expression of identity. For example, the school playground has zones where certain groups go during break times. There is a sense of ownership of these small places. The ownership is often recognised, not because there are signs or because anyone in the group has purchased the space, as you would a house. The recognition comes about because of regular use.

Sometimes the ownership of place is challenged. The activity of defending and claiming this space further reinforces the need for place making. One extreme example of this is the use of graffiti as markers of the territory, as in Figure 12.2.2. Although most graffiti is not the result of gangs, gangs do use it to mark their territory. Graffiti provides information to those who know how to read it. The information can include the name of the gang and its members, the names of other gangs that have an alliance, as well as warnings to other gangs.

12.2.1 A gated residential community, California

Other organisations legally assert territoriality through place making in other ways. Businesses signal their territory using nicely manicured gardens, large sculpture-like signs and impressive buildings. The combination of these is a signal of territory and at the same time a reflection of perception about the company. In the same way, golf clubs and golf courses often appear as very distinct spaces. The way the places are regulated and used, and the provision of membership, reinforce perceptions about what a golf course should be like.

Place and outsiders

Territoriality as a way of making places leads to exclusion. There is a distinction between the inhabitants and the outsiders. The inhabitants, known as the insiders, are identifiable by common vocabulary, dress, gestures and humour. The outsiders are people who visit on rare occasions or not at all. As the insiders shape the place to reflect what they perceive the place should be like, they also increase the feelings of separation between them and outsiders.

Place marketing

Many places are taking advantage of an increasingly connected world to improve the way that they are perceived. This is known as **place marketing**. Place marketing involves regularly reinterpreting, designing, packaging and selling places. The targets are people who normally live somewhere else and might normally be outsiders.

12.2.2 Contested space: conflict over territory in Northern Ireland

Many places are marketed through the deliberate manipulation of culture and features in order to appeal to potential visitors. These visitors might include wealthy tourists and organisers of business conferences. They are lured by a manipulation of tradition, lifestyles and cultures. Some examples of places that are marketed in this way are Darling Harbour, in Sydney, and South Bank, in Brisbane.

Extreme place marketing can result in a process of Disneyfication; that is, local identity and historical character is replaced with a fabricated landscape of inauthentic settings. Examples are the Wild West in the fake cowboy town of Old Tucson, Arizona, and a Bavarian village created in California, shown in Figure 12.2.3.

12.2.3 Leavenworth, USA—a Bavarian theme town

ACTIVITIES

Knowledge and understanding

1. Explain how place making can result in territoriality.
2. List expressions of territoriality in your neighbourhood. What groups are involved?
3. Describe your experience of feeling like an 'outsider'.
4. List places in which you consider yourself to be an 'insider'.
5. Define 'place marketing'.

Applying and analysing

6. Study Figure 12.2.1. Identify the aspects of this place that reveal territoriality.
7. Draw a map of your school, marking areas of different groups' perceived territory. Indicate how you know this is their territory.
8. Discuss the various perceptions of the place shown in Figure 12.2.2.
9. How is graffiti an illustration of place making and a challenge to ownership?
10. Study Figure 12.2.3. Analyse the deliberate changes made in order to create a place that is attractive to outsiders.
11. Do you think it is appropriate to create places that are not authentic, such as a fake cowboy town?

12.3

Place and identity

Special places

Aspects of identity are often linked to place. This is referred to as 'place identity'. Place identity includes those landscape-related factors that help determine an individual's personal identity and **sense of place**. It comes about through a complex process involving conscious and unconscious ideas, feelings, values, goals, preferences, skills and behavioural tendencies relevant to a specific environment.

All of us have places that are special and have helped shape the person we are. The following questions will help you to clarify your thinking about your relationship to place and identity:

- Where is your favourite place?
- What draws you to that place?
- Are there particular memories about the place?
- How would you spend a perfect day there?

Identifying with place

Local

One way in which identity is connected to a particular place is by a feeling of belonging to that place, or having a sense of place. In this place you feel comfortable, or at home. How you define yourself is influenced by certain qualities of that place. This sense of belonging can occur at a range of scales. It may, for example, occur at a local scale. Sport is one activity that promotes a sense of belonging. Many Australian Rules football fans develop an almost tribal loyalty to their local footy team, as can be seen in Figure 12.3.1.

Regional

It is also possible to identify a sense of belonging at a regional scale. In Rugby League, for example, the annual State of Origin series divides supporters into Blues (New South Wales) and Maroons (Queensland). Such state-based rivalries have been common throughout Australian history across a range of political, social and economic issues. The Australian Commonwealth, a federation of states, only came about after our political leaders were able to put aside their parochial, state-based interests.

National

On a national scale, Australians will unite against the foreign competitor whether it is in netball, cricket, tennis, swimming or soccer.

NATIONAL IDENTITY

National identity is shaped by the way in which people view themselves and the way others see them. The national identity of a country is largely defined by legends and landscapes—by stories of the past, heroic deeds and enduring traditions. It might also be defined by homelands, with their sacred sites, landforms and unique scenery more generally.

Identifying against place

People not only live in places and identify with them, they are sometimes alienated by them. Sometimes people establish an identity by contrasting the place that is 'home' with a place that is 'away'. For example, knowledge of the unique characteristics of Asian landscapes and cultures acts as a point of difference against which the uniqueness of Australia can be judged and appreciated.

Not identifying

Often we first become aware of our own sense of place and identity when we travel to unfamiliar places and begin to realise that our surroundings are different and that we do not feel 'at home' there. The landscape is different; the weather may be different; houses and towns are different; people are not the same; even things such as sounds and smells are not those that we are familiar with. In some instances, the strength of identity associated with one place, for example 'home', might be so strong that it is difficult for people to feel concerned for another place and its people.

12.3.1 Sport is one of those activities that promote a sense of belonging and place identity.

ACTIVITIES

Knowledge and understanding

1 Explain what is meant by the term ‘place identity’.
2 Define the term ‘national identity’.
3 Explain how other places can contribute to the development of ‘place identity’.

Applying and analysing

4 Think of a place that is special to you.
  a Where is your favourite place?
  b What draws you to that place?
  c Are there particular memories about the place?
  d How would you spend a perfect day there?
5 a Write a description of the place with which you identify most strongly.
  b Share your description with others in your class.
6 Outline an example of ‘place identity’ that has local, regional and national scales.
7 Construct a mental map of Australia, including the features that you think give Australia its distinctive identity. You might include landscape features, buildings, particular colours, names or people.

12.4

Impact of people on places

Shaping place

The way that people's cultures contribute to the development of a sense of place and the processes that produce the differences between places are at the heart of human geography. Other related factors, such as economics and wealth, history, technology, population and population movements, also play a role in shaping place.

Geographic features of places

If you think about the features of a place that make it distinctive, you might come up with a list that includes:

- its physical landscape
- its location in relation to the coast, mountains and rivers
- the impacts of industry or agriculture (see Figure 12.4.1a)
- the types of buildings and settlements (see Figure 12.4.1b)
- the appearance of the houses, streetscapes, transport and services (see Figure 12.4.1c)
- invisible features, such as language, religion, culture and wealth.

People influencing places

Aspects of human behaviour that influence places are:

- culture
- economics and wealth
- history
- technology
- population density
- population movements.

Culture

Culture is a complex mixture of people's origins and heritage, their language, religion, customs and ways of life. It has an important influence on the appearance of a place through styles of housing, ways of using outdoor space, community buildings, and the different values placed on parts of the physical landscape. Places that have been strongly influenced by one culture over a long period often have very distinctive and recognisable landscapes.

It is important to recognise that no culture is static. Ideas, technologies, commodities and products, and people move from one place to another. When a culture comes into contact with another through migration, trade or the latest telecommunications devices, they influence each other. In some cases a culture can be overwhelmed by another. In most instances, people adopt, adapt or reject the cultural influences they come in contact with.

Cultures have evolved in response to contact for thousands of years. But the pace of change has accelerated. In the past, the influences of distant cultures came slowly, delayed by long journeys. Today, because of the reach and speed of communication technologies, the expansion of world trade and the affordability of long-distance travel, cultural influences can spread across the planet as fast as the click of a mouse.

Economics and wealth

The level of wealth in a community is an important indicator of the extent to which people can transform places. In affluent societies there is more of a materialistic culture; large homes, sophisticated transport options and large-scale commercial, recreational and entertainment facilities dominate the landscape. Poor communities can afford to build only basic housing, use traditional farming techniques and undertake small-scale manufacturing.

History

The history of any place has an important impact on its sense of place. Some places are still dominated by structures and street patterns built centuries ago. Towns dominated by castles or by narrow medieval streets develop part of their character from this history. Some places are well known for particular historic events such as battles or revolutions. This affects the ways that both the current inhabitants and visitors/tourists perceive the place.

Other places have their character dominated by their newness. Many places in Australia experience similar cultural and economic influences as places in Britain, but look very different because of the recency of settlement.

Technology

Technology as a factor is closely related to levels of wealth, but it should be looked at separately because there is not a perfect correlation between these two as influences on places. The use of technology might not even be obvious as a visual characteristic of a place, but it might still be present in the structure of buildings, the communication network, the power sources, the use of water and the connections with the rest of the world.

12.4.1 a Siem Reap ricefields b Dubai city c French village

For example, Munich in Germany has its sophisticated fibre-optic telecommunications network buried out of sight below its cobbled streets.

Population density

Population density has a major impact on places. There are clearly visible contrasts between rural and urban landscapes, multistorey and single-storey housing, and areas with parks and those without parks. Population densities range from 100 000 people in 1 square kilometre in some parts of some Indian cities to zero in large areas of the world.

Population movements

Movements by people from place to place can be either long-term or short-term. The long-term movements include migrations to new places. Such migrations have had major influences on the place receiving them, through the addition of different cultures, different languages, different skills and different age groups of people. Short-term population movements include daily commuting to work, and the movements of tourists to visit and see places. Each of these has influences on a place.

ACTIVITIES

Knowledge and understanding

1. List the features of places that contribute to their distinctiveness.
2. Identify the characteristics of people that influence places.
3. Explain how culture, history, economics and wealth and technology can have quite different influences on places.

Applying and analysing

4. Name some places that have been changed by specific impacts of people, and describe the particular impacts on each place.
5. Reorder the list of factors that influence places into the order of importance you think these factors have.
6. Study Figure 12.4.1 and do the following tasks.
   a. Identify as many differences between the places shown as you can.
   b. List the human behaviours that have influenced each of these places.

12.5

Cultural diffusion and adaptation

Culture

Culture can be defined as the sum total of ways of living built up by a group of human beings and transmitted from one generation to another. A **cultural group** is made up of people of similar heritage who identify with others in the group through sharing the same language, the same ancestry and often the same religion. People often celebrate their cultural group through their food, music and dance.

Elements of culture

Our culture is made up of the following elements:

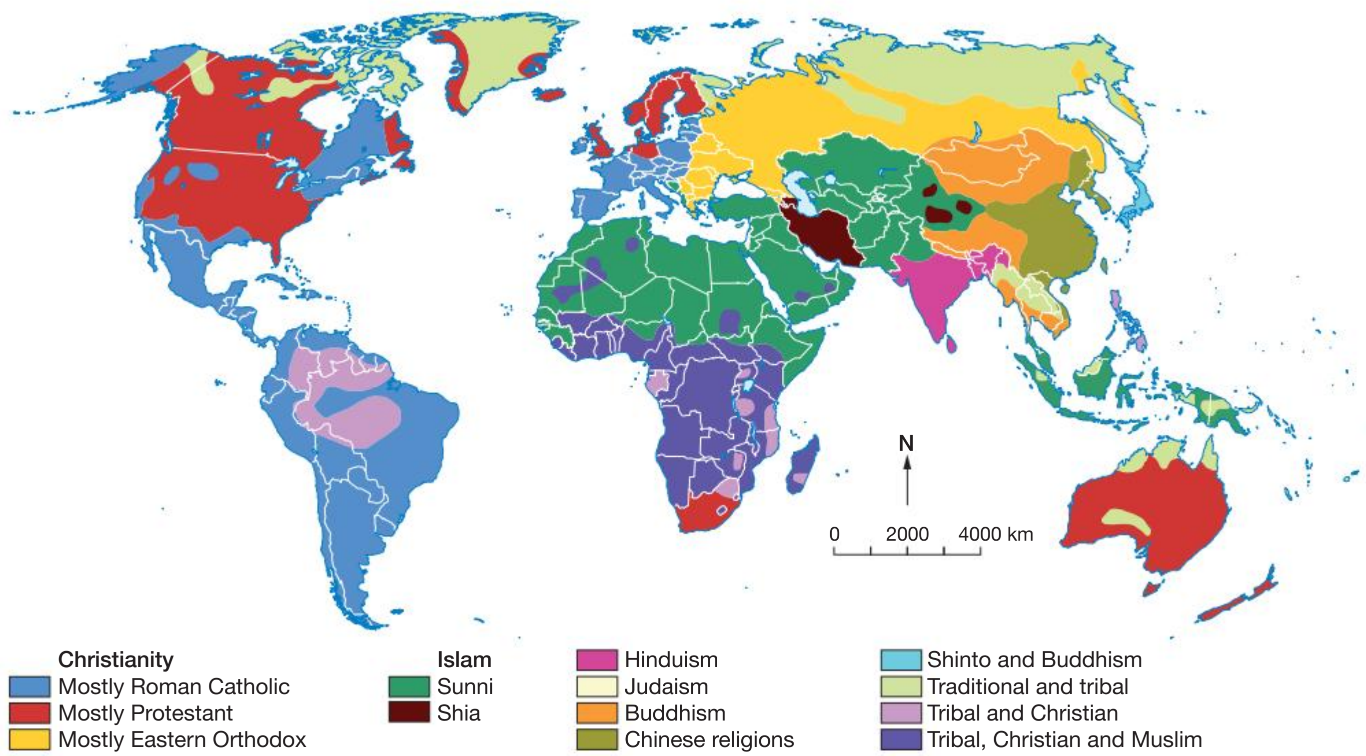
- language
- religion, or religious background
- political system and ideas
- ethnic background
- forms of social organisation
- customs and traditions
- arts and literature
- economic systems.

Together these elements spell out the main features of our culture. However, every person in our society will have a slightly different mix of these characteristics, even though they share the same general culture.

Human geographers are interested in how these aspects of culture differ across the world and how they contribute to a place's uniqueness, its sense of place. They investigate why places are similar, and where they are different. They want to know where particular elements of culture originated and where they have spread. Above all, geographers are interested in the ways people adopt, adapt or resist the cultural forces or cultural groups with which they come in contact.

Cultural spread

The spread of cultural characteristics is called **cultural diffusion**. This cultural diffusion can be fast or slow.



12.5.1 Distribution of world religions

12.5.2 Where to find unique cuisines in Sydney

Suburb	Cuisine
Fairfield	Laotian
Strathfield	Burmese
Marrickville	Peruvian
Glebe	Polish
Enmore	African
Bankstown	Egyptian
Kingsford	Russian
Brighton-Le-Sands	Greek
Newtown	Balkan
Balmain	Turkish

12.5.3 Greek restaurant in Manly, Sydney. The streetscapes of Australian cities illustrate the cultural diffusion of foods from different cultures.

Religion and political geography

Religion is closely linked to other aspects of culture, such as language and ethnic groups. In many countries it is also closely linked to government. For example, the Queen (or King) of England is still the head of the Church of England (Anglican Church). Throughout history the Pope (head of the Roman Catholic Church) has been a very powerful political figure. In present-day politics it is common to talk about the 'Islamic world,' meaning the area of Asia and Africa where most of the population practise the Islamic (or Muslim) religion (see Figure 12.5.1).

Food

Each cultural and ethnic group has particular foods that they have traditionally eaten. In Europe and North America, wheat and corn are the major grains. In Asia, the main grain is rice. In Africa, corn, millet and sorghum are major grains in different cultural areas.

Roast beef, tofu, falafels, curries, pasta, biltong and hummus are all foods that have originated in particular cultures, often related to particular ethnic groups. As the ethnic groups have spread across the world, they have taken their foods with them. Initially, they consumed those foods only in their own houses, but soon they set up restaurants and the foods became known and liked by others (see Table 12.5.2 and Figure 12.5.3). Over time, many of these foods have become staple foods of other cultures.

Sport

Sport is now a global phenomenon. Yet there are still local sports played only in one region, and other sports confined to particular groups of countries. Many sports, however, have spread from their country of origin and are now played and watched by millions of people. Soccer, football, tennis, golf and basketball are played in many countries. The matches played by the top players are televised across the world and followed closely by millions of interested fans.

Like all aspects of culture, sports spread initially with colonisation and migration; as a result, some sports have a global spread, while others are still localised. People moving to new continents and countries take their sports with them. Television and other media have popularised many sports. Sponsorship by large companies has increased prize money and earnings, and this has meant that many sports have developed from mostly an amateur pastime into a full-time professional occupation.

Australian sporting culture

For many Australians, cultural identity is strongly connected to sport. Playing or following sport is a way of sharing an interest, connecting with a group of like-minded people, and giving people a sense of belonging.

Cricket

Cricket is the best example of a sport spread via colonisation. It is very popular in countries that were once British colonies, but is hardly played at all in most other countries.

SPOTLIGHT

The global effects of the slave trade

In the seventeenth, eighteenth and nineteenth centuries there was a highly organised system of buying slaves in Africa and taking them to North, South and Central America. There they were traded and used by landowners, particularly on large plantations. The result of this movement of so many people against their wills was that between 9 and 12 million Africans arrived in the Americas, and their descendants now make up a large proportion of the US population.

The African–American culture is very strong today in the USA. It is evident in religion, foods, speech patterns, music, particular sports and many other aspects of culture.

Even though slavery was abolished in the middle of the nineteenth century, prejudice against black Americans remained strong for over a hundred years, and profoundly influenced politics and work.

12.5.4 The African–American culture is very strong today in New Orleans, USA.

Movies, television and the internet

Movies and television can sometimes have the effect of teaching people more about their culture and allowing them to identify with it. At other times they can have the direct opposite effect—that of overwhelming a local culture by showing only US films and shows, and so promoting US language, beliefs, and ideas—because so many of them originate in the USA. In Australia, US movies have been the most commercially successful, as is shown in Table 12.5.5.

The cultural influence exerted by the internet is different from that exerted by movies or television. This is because the internet operates throughout the world in a large number of languages. It also allows individuals anywhere to communicate with each other through social networks. It has been said that the internet makes knowledge available to more people, and it has even been held responsible for allowing democratic protests to be more successfully organised.

12.5.5 Top 10 grossing films in Australia

Rank	Title	Release date	Box office ($)	Country of origin
1	*Avatar*	2009	115 600 481	USA
2	*Titanic*	1997	57 650 984	USA
3	*The Avengers*	2012	53 250 000	USA
4	*Harry Potter and the Deathly Hallows: Part 2*	2011	52 611 276	UK
5	*Shrek 2*	2004	50 388 327	USA
6	*The Lord of the Rings: The Return of the King*	2003	49 370 354	USA/New Zealand
7	*Skyfall*	2012	49 009 485	UK
8	*Crocodile Dundee*	1986	47 707 045	Australia
9	*The Lord of the Rings: The Fellowship of the Ring*	2001	47 429 619	USA/New Zealand
10	*The Dark Knight*	2008	46 089 622	USA

Source: Screen Australia

ACTIVITIES

Knowledge and understanding

1 Define the terms 'culture' and 'cultural group'. In what ways do people celebrate their culture?

2 Outline why human geographers are interested in culture.

3 State what the term 'cultural diffusion' means.

Applying and analysing

4 Construct a mind map featuring the elements of culture listed.

5 Name some sports you think of as closely related to Australian culture. Answer the same question about US, Chinese and Brazilian culture.

6 List the country of origin of the television programs you have watched in the last 24 hours. What proportion of these came from the United States of America?

7 Make a list of the foods that you have eaten in the last week. How many of them have originated in other countries?

Investigating

8 Investigate the number and diversity of restaurants in your local area.

9 List the main countries playing these sports: cricket, rugby, ice hockey, skiing, baseball, golf and ice hockey. Investigate the origins of each of these sports.

10 Identify the national cultures most strongly related to the following kinds of music: tango, country and western, grand opera, hip hop, jazz, gospel.

12.6

Travel: Expanding personal geographies

Tourism industry

While **tourism** as an industry is a relatively recent development, it is one of the main sources of income for many countries and regions. Mass tourism relies on many people having a combination of leisure time and money to spend on non-basic items. Millions of people in wealthy countries have now travelled widely to other parts of the world. They have visited places that their ancestors could only dream of.

Personal geographies

A personal geography is:

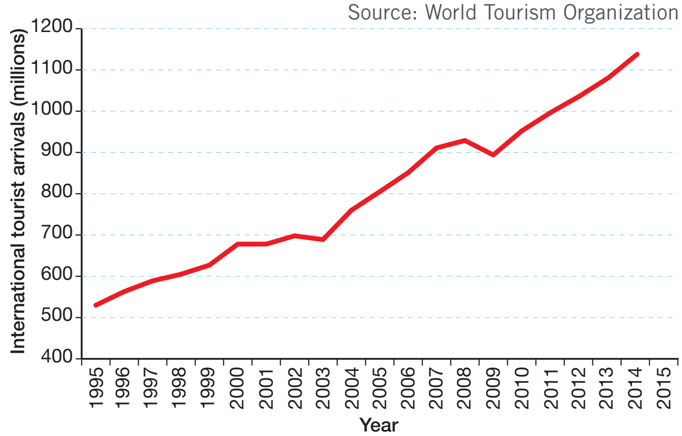
- the idea that the environment (biophysical and constructed) shapes the individual
- the relationship between a person and their environment
- how a person views and sees the world.

This personal geography can be expanded by travel to other countries, cultures and environments. These experiences of travel to different places can changes people's views, opinions or interests.

World tourism

Tourism is one of the world's largest service-based industries. In 2012, for the first time in history, more than a billion people (almost one in seven of the world's population) travelled internationally, as is shown in Figure 12.6.1.

Source: World Tourism Organization



12.6.1 International inbound tourism 1995–2015

This is a massive increase on the 25 million international tourists in the years immediately after World War II. Tourism also has a major impact on the character of places. In some popular tourist destinations, tourism is the dominant form of economic activity and is central to their sense of place or character.

Most visited places

Table 12.6.2 shows the ten countries that attracted the largest numbers of tourists in 2014. Table 12.6.3 shows the ten countries whose inhabitants spent the most on international tourist visits.

12.6.2 The world's top tourist destinations, 2014

Rank	Country	International tourist arrivals (million)
1	France	83.7
2	USA	74.8
3	Spain	65
4	China	55.6
5	Italy	48.6
6	Turkey	39.8
7	Germany	33.3
8	UK	32.6
9	Russia	29.8
10	Mexico	29.1
-	Australia	7.1

Source: World Tourism Organization

DID YOU KNOW?

According to the City of Niagara Falls, over 6 million cubic feet of water (approximately 170 000 cubic metres) flows over the top of Canada's Horseshoe Falls every minute—enough to fill a million bathtubs to the brim in 60 seconds.

12.6.3 Ten biggest spenders on international tourism, 2014

Rank	Country	Amount spent on international tourism (US$ billion)
1	China	164.9
2	USA	110.8
3	Germany	92.2
4	UK	57.6
5	Russia	50.4
6	France	47.8
7	Canada	33.8
8	Italy	28.8
9	Australia	26.3
10	Brazil	11.7

Source: World Tourism Organization

Most visited attractions

Tourism statistics do not differentiate between local and international visitors so it is difficult to know where tourists go within the countries they visit. Table 12.6.4 shows the world's most visited attractions, according to the magazine *Travel and Leisure*.

a

b

12.6.4 The world's most visited attractions, 2014

Rank	Attraction	No. of visitors (millions)
1	Grand Bazaar, Istanbul	91.3
2	The Zócalo, Mexico City	85.0
3	Times Square, New York City (see Figure 12.6.5a)	50.0
4 (tie)	Central Park, New York City Union Station, Washington, D.C.	40.0
6	Las Vegas Strip	30.5
7 (tie)	Sensoji Temple, Tokyo Meiji Jingu Shrine, Tokyo	30.0
9	Niagara Falls, New York and Ontario (see Figure 12.6.5c)	22.0
10	Grand Central Terminal, New York City	21.6
11	Basilica of Our Lady of Guadalupe, Mexico City	20.0
12	Disney World's Magic Kingdom, Orlando, Florida	18.6
13	Faneuil Hall Marketplace, Boston	18.0
14	Tokyo Disneyland	17.2
15	Disneyland Park, Anaheim, California (see Figure 12.6.5b)	16.2
16	Forbidden City, Beijing	15.3
17	Golden Gate National Recreation Area, San Francisco	14.3
18	Tokyo DisneySea	14.1
19	Notre Dame Cathedral, Paris	14.0
20	Golden Gate Park, San Francisco	13.0

Travel and Leisure magazine, 2014

c

12.6.5 **a** Times Square; **b** Disneyland, Anaheim, California; **c** Niagara Falls

12.6.6 Cruising is a form of package tour.

Modes of travel

The early tourists (before the twentieth century) were similar to explorers. They had to organise their own transport, and were subject to the hazards of poor roads, slow horse-drawn vehicles and uncomfortable seagoing vessels. Tourists today can choose from a wide range of transport alternatives, and can expect that all will be relatively fast and comfortable.

The most common forms of transport for tourists are cars (for local and national tourism), air (for longer distances and international tourism), cruise ships (for ocean and river journeys) and trains (for 'special experience' journeys and travel within Europe).

For the majority of tourists travelling by air, the experience is like being 'teleported' by a magic carpet. It is unlikely that this method of transport helps tourists to expand their personal geographies. On a trip from Australia to Europe they may pass over India, Afghanistan, Russia, Pakistan and a dozen other countries, but at an altitude of 12 000 metres they may as well be in outer space. Nor would tourists aboard cruise ships expand their personal geographies. Tourists may see glimpses of other places on one-day excursions at ports, but for much of the time they are in a luxurious version of their own home environment.

Package tours

Cruise ship travel, depicted in Figure 12.6.6, is an example of what the tourist industry calls a 'package tour'. Package tours are planned well before they take place. The costs of travel, accommodation, meals and entertainment are all paid for before departure. Travel companies rather than individual travellers put these packages together. This makes them cheaper, but it means that travellers do not have to do much thinking about their itinerary, the places they visit, or the people who live there.

Issues of tourism

The growth of tourism raises environmental, economic and social issues. The 'honeypot effect', whereby a few popular destinations attract the bulk of the tourism revenues while other places miss out, can also concentrate the negative impacts of tourism.

Environmental issues

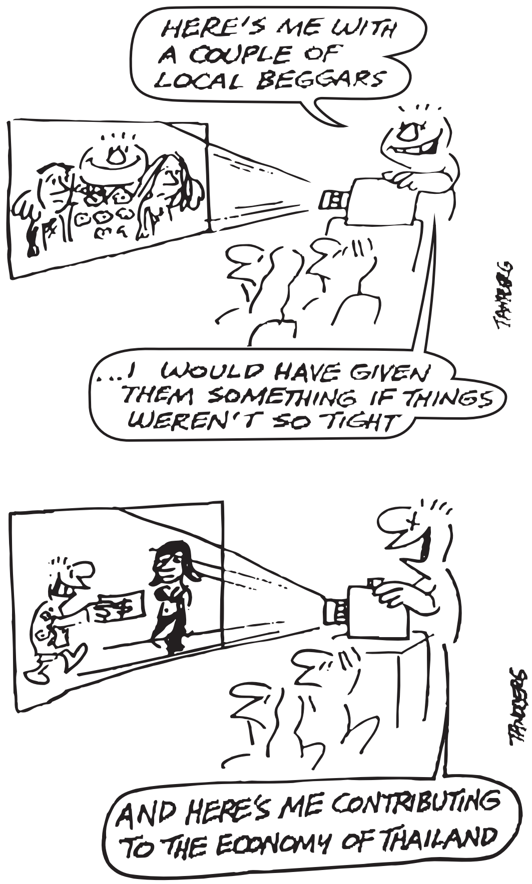
Heavy transport on popular routes can damage roads and produce high levels of pollution. Wasteful tourists can overuse water supplies, and food for tourist consumption may take priority over food for locals.

Economic issues

Tourism brings money into the places tourists visit. Often, however, only a small amount of what is spent goes to locals. Much of it goes to airlines and hotel companies based in other countries.

Social issues

The effects of large numbers of tourists can have negative impacts on the culture and way of life of a people, as is illustrated by the cartoon in Figure 12.6.7. Longstanding customs can be altered to suit tourists and locals can become dependent on the tips and the spending of tourists. Scarce resources may also be used to finance tourist infrastructure and developments instead of education and health care.



12.6.7 Impacts of tourism

ACTIVITIES

Knowledge and understanding

1 Define the term 'personal geography' in your own words.
2 Outline the scale and impacts of the global tourism industry.
3 Explain what is meant by a 'package tour'.
4 Explain in your own words what is meant by the 'honeypot effect' and give examples of tourist destinations that would fit this description.
5 Outline some of the tourism-related issues that might be of interest to geographers.

Applying and analysing

6 List the main modes of travel. Which are more likely to expand a person's personal geography?
7 Study Table 12.6.4. For each place, suggest one or more reasons why it is visited by so many tourists.
8 Study Figure 12.6.7. Working in pairs, discuss the tourism-related issues addressed in each cartoon. List the issues you discussed.
9 Use some of the facts, statistics and suggestions in this unit to write a few paragraphs with the title *How much do modern tourists expand their personal geographies?*

Geographical skills

10 Study Table 12.6.2. With the aid of an atlas describe the location of the top 10 tourist destinations.
11 Study Table 12.6.3.
  a Find out the population of each country and divide the expenditure by the number of people.
  b Rank the countries from the highest to lowest amount of money spent per person.
  c Has the ranking changed? Explain.

12.7

Australia's tourism industry

Tourism

The Australian Tourist Commission defines tourism as 'travel away from your normal place of work and residence, including travel undertaken for business and pleasure'. The World Tourism Organization defines it as 'the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business or other purposes'. Domestic tourism is travel within person's own country.

Economic importance

Australia's domestic and international tourists consume more than $113.3 billion in goods and services each year and the industry accounts for 2.5 per cent of Australia's gross domestic product (GDP); that is, the total value of goods and services produced in the economy in a year. A further 4 per cent of our GDP is indirect revenue from tourism—the flow of benefits, including increased output and employment, that result from tourists consuming goods and services. Tourism is one of Australia's largest service export industries. Tourism is also an important source of employment in Australia. Approximately half a million people are directly employed in tourism-related industries. This represents 4.7 per cent of the workforce.

Inbound tourism

Australia receives approximately 7.4 million visitors a year. It is predicted that by 2020 there will be 8.4 million visitors per year. The reasons for visiting Australia are varied. Approximately 46 per cent of all visitors in 2015 came here on holidays, 28 per cent were visiting friends and relatives, 11 per cent were on business trips and 6 per cent visited for educational purposes. There has also been an increase in the number of backpackers visiting Australia. This market has become an important source of revenue for the Australian tourism industry.

Traditionally, New Zealand, Europe and North America have been the main sources of inbound tourists in Australia, although there now is a growing number of visitors from South-East Asia. The top source countries for visitor arrivals in 2015 were, in descending order, New Zealand, China, the United Kingdom, the United States of America and Singapore, as shown in Table 12.7.1.

12.7.1 Inbound travel to Australia, top 10 markets, 2015

Country	Total inbound economic value 2015 ($ billion)	Arrivals 2015 ('000)
China	8.3	1023.6
United Kingdom	3.8	688.4
United States of America	3.4	609.9
New Zealand	2.6	1309.9
Singapore	1.4	395.8
Japan	1.3	335.5
South Korea	1.3	230.1
Hong Kong	1.2	219.7
India	1.1	233.1
Malaysia	1.1	338.8
Total inbound	25.5	5384.8

Source: ABS

DID YOU KNOW?

The 'Come and say g'day' or 'Throw another shrimp on the barbie' 1984 TV advertising campaign featuring Paul Hogan and created by the Australian Tourism Commission was so successful that Australia moved up from number 78 to number 1–2 on the 'Dream vacation list' for Americans in just over three months.

Tourist destinations

Australia's five largest tourism regions are Sydney (see Figure 12.7.2), Melbourne, Brisbane, Gold Coast and Perth. Together these regions make up about 47 per cent of total tourism expenditure. Some regions in Australia are highly dependent on the income generated by tourism. These regions are Central Northern Territory (Alice Springs/Uluru), Phillip Island, the Whitsundays, the Snowy Mountains and the west coast of Tasmania. These tourist regions receive only about 3 per cent of Australia's total tourism expenditure.

12.7.2 Taronga Zoo, Sydney. The Sydney region accounts for about 15 per cent of total visitor expenditure in Australia.

Outbound tourism

More Australians travel overseas today than ever before. Rising standards of living, changing lifestyle expectations and reductions in the real cost of travel have made this possible. The top destinations for Australian residents departing for short-term travel in 2014–15 were New Zealand, Indonesia (including Bali), the United States of America, the United Kingdom and Thailand, as shown in Table 12.7.3.

12.7.3 Outbound tourists' top 10 destinations, 2014–15

Country	Departures ('000)	Proportion of total (%)
New Zealand	1237.5	13.4
Indonesia (incl. Bali)	1118.7	12.1
United States of America	980.8	10.6
United Kingdom	552.6	6.0
Thailand	549.5	6.0
China	413.2	4.5
Singapore	361.7	3.9
Fiji	335.5	3.6
India	280.7	3.0
Japan	268.3	2.9
Total	9221.5	

Source: ABS

SPOTLIGHT

Backpackers

One of the fastest-growing components of Australia's tourism industry is the backpacker market. Australia is consistently ranked by backpackers as one of the world's top destinations. Each year, Australia is visited by more than 500 000 backpackers, who spend a significant amount of money in the local economy—on average, more than twice as much as other tourists. In the year to 30 June 2013, for example, each backpacker spent an average of $5759 on food, drink and accommodation, and education fees during their stay in Australia. Their average expenditure per night was $69.

The Australian Government provides a 'working holiday visa' for young people aged between 18 and 30 from selected places, including the United Kingdom, Canada, Republic of Ireland, most western and northern European countries, Japan and South Korea. New Zealand citizens do not require a visa to work in Australia.

Backpacking is a unique form of travel that focuses on freedom and exploration. Most backpackers do not make specific plans before they reach Australia. They generally prefer to start with very general travel ideas and make more detailed arrangements when they arrive in the country. These travellers use word of mouth and the internet as sources of information. Of all backpackers visiting Australia in 2013, 76 per cent visited New South Wales, 57 per cent visited Queensland and 45 per cent visited Victoria.

12.7.4 Backpacker visitors by country of residence (year ended 30 June 2013)

Country of residence	Visitors ('000)
United Kingdom	101
Germany	62
USA	40
France	37
Korea	30
New Zealand	30
Japan	29
Scandinavia	28
Taiwan	22
Canada	19
Italy	16
China	15
Malaysia	15
Hong Kong	15
Netherlands	14
Switzerland	14
Singapore	13
Other	79
Total	579

Source: Department of Resources, Energy and Tourism, International Visitor Survey, June 2013

12.7.5 Backpacking is popular among young people wanting to engage in the adventure of international travel on a limited budget.

More than 70 per cent of backpackers visiting Australia are under the age of 30. These backpackers tend to spend more time in Australia than those aged over 30. The average length of stay for a backpacker is 70 nights. This is more than twice as long as the average length of stay for all visitors.

12.7.6 International backpackers, average duration of stay and expenditure by country (year ended 30 June 2013)

Country of residence	Average duration of stay (days)	Average expenditure all items ($)
New Zealand	24	2288
Japan	102	6155
Hong Kong	82	5424
Singapore	24	3313
Malaysia	26	3417
Indonesia	39	2315
Taiwan	176	8571
Thailand	90	6555
South Korea	141	8331
China	75	8328
India	118	11148
Other Asia	92	10487
USA	54	4769
Canada	69	5439
United Kingdom	85	5837
Germany	83	4809
Scandinavia	65	4783
France	103	6174
Italy	129	7098
Netherlands	65	5009
Switzerland	53	6073
Other Europe	100	7523
Other countries	68	5507

Source: Department of Resources, Energy and Tourism, International Visitor Survey, June 2013

ACTIVITIES

Knowledge and understanding

1 Define the term 'tourism'.
2 Outline the importance of tourism to the Australian economy.
3 Identify the main reasons why tourists visit Australia.
4 Explain the meaning of the term 'outbound tourism'. Where do Australians visit when they travel abroad?
5 Outline the importance of the backpacker market to the Australian tourism industry. Provide statistics to support your answer.

Applying and analysing

6 Working in small groups, develop an advertising campaign to promote Australian tourism in our key source markets. Your campaign could include a jingle, a video, a dramatisation or a poster. Present your advertising campaign to the class.

Geographical skills

7 Select the most effective way to graph the information in Table 12.7.3. Construct the graph. Using the information in your graph, write a report describing the destinations of outbound travellers.
8 Study Table 12.7.1. Locate these countries on a map of the world. Develop a key to indicate the contribution of each country to inbound tourism in Australia.
9 Study Table 12.7.4. Name the continent from which the majority of backpackers came.
10 Study Table 12.7.6. Calculate the average expenditure per day for the following countries: New Zealand, Indonesia, China, India, United States of America, the United Kingdom and Germany.
11 Study Tables 12.7.4 and 12.7.6. Write a report outlining the nature of the backpacker component of the Australian tourism sector.

Investigating

12 Update the statistical information provided in this unit by accessing the following websites:
- Australia Bureau of Statistics
- Tourism Australia
- Department of Resources, Energy and Tourism
- Australian Tourism Export Council
- Department of Foreign Affairs and Trade (see the 'Australia in Brief' section).

Present your research as a series of graphs.

12.8

Impacts of tourism on Bali, Indonesia

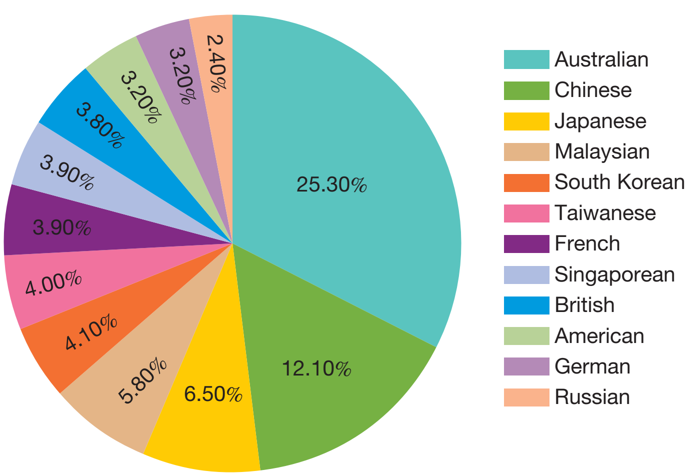
History of tourism in Bali

The Dutch built the first hotel in Bali in 1928 and anthropologists, writers, artists and musicians were drawn to the rich cultural heritage of the island. However, it was only in the 1970s that mass tourism started to develop. It has grown rapidly since, especially with the opening of the airport in Denpasar. Initially, young people on a budget, eager to surf and see the island, were drawn to Bali by images of white beaches, a warm tropical climate, terraced hillsides, Hindu temples and local people who were tolerant and friendly.

When foreign airlines were first allowed to fly directly to Bali in the 1980s, tourist numbers soared from 30 000 in 1969 to 700 000 in 1989. The tourism industry in Bali evolved to cater for high-spending package tour groups in large luxury resorts owned by big multinational companies from both Indonesia and abroad. Today the majority of tourists come from Australia, with new money in China and Russia in recent years boosting their numbers (see Figure 12.8.1).

Bali's tourism development was very rapid and it occurred without proper planning. It has been accompanied by a great wave of change on the island.

12.8.1 Visitors to Bali by nationality, 2013



Economic impacts

Bali lacks natural resources, so tourism is vital to its economy. Investors have flocked to Bali to build hotels, luxurious resorts, shopping complexes and entertainment venues. The presence of all this accommodation and their associated services has provided many jobs and opportunities for the Balinese people to earn money (see Figure 12.8.2). As a result, Bali has the lowest rates of poverty and unemployment of all the provinces in Indonesia. The overall contribution of tourism to Bali's economy is estimated to be over 70 per cent.

12.8.2 Tourists provide a lucrative market for the local Balinese people.

Social impacts

With tourism has come the commercialisation of the Balinese culture. Probably the most negative impact is that the Balinese people are becoming increasingly materialistic, keen to exploit any opportunity that will earn them money. For some, this has become a priority at the expense of their social responsibilities and the observance of rituals that once were central to their daily lives.

The growing tourism industry has also led to an increase in crime, drug trafficking and prostitution. Bribery and corruption only compound the problems.

Environmental impacts

The rapid and unplanned tourism development of Bali has had a substantial impact on the island's natural environment.

- Hotels have been built along the coast without any consideration of the capacity of local water supplies or waste disposal needs.
- Prime agricultural land has been converted to resorts and golf courses, and water redirected away from the rice fields in the region to meet the needs of tourists.
- Hundreds of hotels take a large part of fresh water supplies, with each four-star room using, on average, 300 litres every day. The southern part of Bali is facing a water shortage due to excessive groundwater extraction.
- Generation of waste has increased and 75 per cent of garbage is uncollected or left along the sides of roads.
- Water quality in creeks, rivers and bays has deteriorated because of heavy pollution.
- Coral reefs have been destroyed so that the pulverised coral can be mixed with sand to obtain a mortar used to join construction blocks.
- Mangrove forests have been lost as land is reclaimed for new tourism developments.

SPOTLIGHT

Bali has emerged as one of the world's premier tourist destinations. The Provincial Tourism Office of Bali revealed that 3.76 million tourists visited the island in 2014, an increase of 14.94 per cent on the previous year. In response to increase tourist numbers, a large reclamation project is being considered for Benoa Bay, near Denpasar. It involves luxury tourist facilities, including a Disney-like theme park, apartments, hotels, villas and entertainment centres (see Figure 12.8.3). Critics of the project argue that the area of mangroves should be protected and a conservation zone created.

12.8.3 A protest against the proposed Benoa Bay Reclamation project

ACTIVITIES

Knowledge and understanding

1. Explain why Bali is such a popular tourist destination.
2. Outline the history of tourism in Bali.
3. Describe how tourism has helped the Balinese people.
4. Assess the costs of the tourism development that has occurred

Applying and analysing

5. Create a PMI chart on the impacts of the rapid rate of tourism development in Bali.

12.9

Sport

Sport in Australia

Sport is an important part of the Australian culture and lifestyle. According to the legendary cricketer Sir Donald Bradman: 'Sport is embedded in the fabric of Australian life.' Data collected through the Australian census indicates that one in three Australians aged 15 years and over participates in sports and recreational activities two or more times a week. Australia has a long history of involvement in sport on an international scale. Our passion for sport connects us with the rest of the world in a number of important ways.

Colonial links and international migration

The types of sports played in Australia have changed as our links with other countries have changed. Colonisation and international migration have influenced the types of sports played in Australia. Many popular Australian sports (such as cricket, rugby league, rugby union and tennis) originated in the United Kingdom and spread to the colonies, including Australia, as a result of migration. Events such as the Olympics have also introduced new sports to Australia.

12.9.1 The Matildas, Australia's national women's soccer team

Hosting international events

Australia has world-class sporting facilities and an excellent reputation for the successful hosting of international sporting events. The largest event was the 2000 Sydney Olympic Games. Other important sporting competitions hosted by Australia were the Commonwealth Games, Rugby World Cup, Australian Open (golf and tennis), Australian Grand Prix, Cricket World Cup, World Short Course Swimming Titles and Rip Curl Pro Surfing Titles at Bells Beach.

Sydney Olympics

In September 2000, athletes from 200 countries converged upon Sydney to compete in over 300 events. The Games also served as a magnet for domestic and international tourism, attracting more than 110 000 international visitors over the seventeen days of competition. In total, more than 5.5 million people attended Sydney Olympic Park across the Olympic and Paralympic Games. The Sydney Olympics exposed Australians to a diversity of global cultures as well as giving many people from overseas the opportunity to experience Australian culture.

By the end of the Games, Australia had won a record fifty-eight medals (including sixteen gold), as well as 149 medals (including sixty-three gold) at the Paralympic Games. Our athletes won gold in archery, athletics, beach volleyball, cycling, equestrian, hockey, sailing, shooting, swimming, taekwondo and water polo.

International participation

Australia actively promotes sporting cooperation and knowledge/resource sharing between countries. The International Section of the Australian Sports Commission operates a number of community sports development programs in the Pacific, southern Africa and the Caribbean. These programs provide foreign athletes and sporting organisations with access to Australian sporting services, facilities and expertise.

Despite Australia's relatively small population, it consistently produces world champion teams and elite athletes in a number of sports (see Figure 12.9.1). Our athletes and teams travel widely to compete in international sporting competitions, such as the Davis Cup, the Tour de France, the US PGA Golf Tour and the Association of Surfing Professionals tour.

TNCs and international branding

The growth of transnational corporations (TNCs) and international branding and marketing of sport has had a significant impact on the types of sports played in Australia. American sports, such as baseball and basketball, have become increasingly popular in Australia as a result of the marketing efforts of the global media corporations and TNCs in the textiles, clothing and sportswear industries.

The branded stars of the US NBA (National Basketball Association) are everywhere. Their faces are found in television and magazine advertisements for sportswear companies (such as Nike and Reebok), on billboards, on breakfast cereal packaging and in Hollywood movies. Australian teenagers are not only playing these sports but collecting branded clothing and accessories in the colours and logos of their favourite American baseball, basketball and football teams.

SPOTLIGHT

Extreme sports

A recent trend on the Australian sporting scene has been the increase in popularity of extreme sports. 'Extreme sports' is a term used to describe a broad range of non-traditional adrenaline-based activities. Examples of these sports are wakeboarding, kite surfing, aerial freestyle BMX, snowboarding, downhill skateboard racing, whitewater rafting, mountain biking, motocross, waterskiing and mountain boarding. Some extreme sport events are the X Games in the United States of America and the Planet X summer and winter games in Australia. The growing popularity of these sports is reflected in the International Olympic Committee's decision to include BMX racing in the Olympics.

12.9.2 Freestyle Moto X final at the X Games XII

ACTIVITIES

Knowledge and understanding

1. Explain how colonisation and international migration have influenced the types of sports played in Australia. Provide examples to support your response.
2. Outline how the Australian Sports Commission promotes increased cooperation and resource sharing between countries.
3. Explain how the 2000 Sydney Olympic Games demonstrated Australia's sporting links with the rest of the world.

Applying and analysing

4. Explain how the growth of transnational corporations and international sports marketing has influenced the range of sports played in Australia.
5. In small groups, discuss the importance of sport to Australia's culture. Record your responses and share your group's findings with the rest of the class.

Investigating

6. Undertake research to find out which international sporting events Australia has hosted, as well as those Australia has participated in overseas, in the past 12 months. Present this information in a table. Undertake research to find out about the origins of each of these competitions.
7. Select an Australian sport that is of interest to you. Undertake research to find out more about the origins of this sport. Include the following information in your response.
   - When and where was this sport first played?
   - When and how was the sport introduced to Australia?
   - How have the rules been adapted to suit an Australian context?

12.10

Sporting events and places

Host cities

The hosting of major sporting events is sought after by cities and countries because of the international attention such events attract. Authorities hope that the international coverage of the event and the increase in the number of visitors will have a range of economic benefits. Authorities hope that these benefits will enhance the prestige of the city or country.

Car races

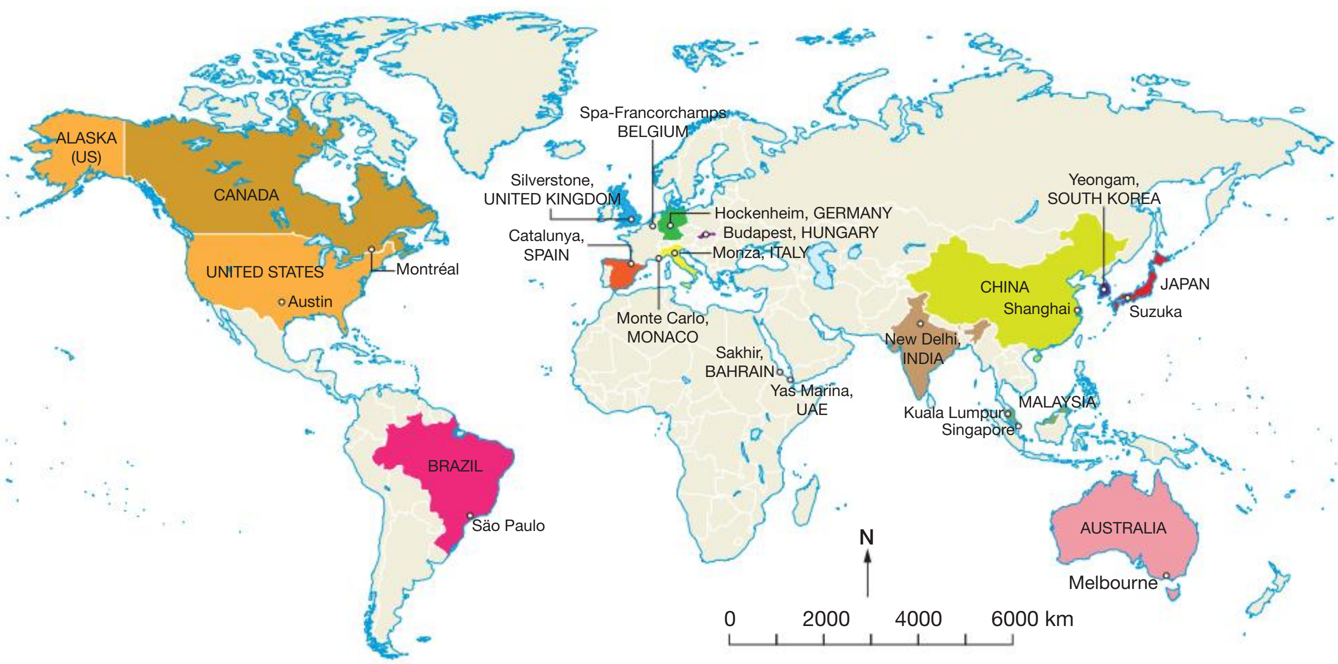
On a world scale, the Formula One Grand Prix races are the biggest of the many types of car races. It is estimated that each F1 race attracts 200 000 spectators, with a combined annual total exceeding three million. Many millions more watch on television.

There is always competition among countries and cities to host these events, even though they can be costly to stage, disrupt the routines of citizens and cause congestion, especially if they are street circuits. The host cities hope to gain from the money spent by the fans, the race teams and their support crews. Figure 12.10.1 shows the host cities that made up the 2013 Formula One Grand Prix circuit.

Other car races, although they do not involve as much money, can still have major impact on cities, which compete to host them. Bathurst, for example, attracts thousands of people every October for its saloon car racing at the Bathurst 1000. Adelaide, after it lost the Australian Grand Prix to Melbourne, was successful in a bid to host a weekend of saloon car racing every March. Community response to the race has been divided, because it is held on city streets and creates congestion. The Gold Coast 600 is also divisive because it is held on the streets of Surfers Paradise.

Cycle races

The most prestigious cycle race is the Tour de France—a series of twenty-one race stages held over three weeks in many different regions of France. It has a huge following. Large support teams, tens of thousands of spectators and a large media contingent follow the race as it progresses through France. Millions watch on television. The finish of the Tour de France on the Avenue des Champs-Elysées, Paris, is shown in Figure 12.10.2. The Giro d'Italia and the Tour of Britain are similar but less prestigious events.



12.10.1 Locations of Formula One races, 2013

12.10.2 The Tour de France

Australia has copied the European cycling race format with the Tour Down Under, run every January since 1999 in the area around Adelaide. For this event, country towns and suburbs of Adelaide seek to host starts, finishes or special events, hoping to attract visitors, money and prestige to their area.

Olympics

The best-known sporting event on a world scale is the summer Olympic Games, held every four years. This is awarded to the city that has submitted the best bid. The city then has seven years to prepare for the Games. Because the Olympics feature so many sporting events, a range of venues needs to be built (see Figure 12.10.3). Other major aspects of the undertaking include the coordination of sporting organisations and the building of the infrastructure needed to support large numbers of spectators.

12.10.3 Tokyo's planned National Olympic Stadium, designed by Kengo Kuma, will be the main venue for the 2020 Olympic Games.

Until the 1980s, the Olympics were often run at a loss because of the huge costs involved in staging them. Since 1996, however, sponsorship deals have reduced the financial risk to the host city. The number of cities bidding to host the Olympics has risen in recent years.

Cities in recent years have used the Olympics to revive rundown urban areas. The site of the Olympics in 2012 was a rundown area of London's East End. The games revitalised the area. New train stations, huge shopping centres and new housing estates were built, in addition to the stadium, swimming centre and other sporting facilities.

The cities and nations hosting the Olympics hope to gain short- and long-term benefits from them. Both Beijing (2008) and Rio de Janeiro (2016) wanted to show that they were world cities. All cities hope to gain increased numbers of tourists in both the short term and long term. Yet for three years after the Sydney Olympic Games (2000) tourist numbers actually fell. Fewer tourists visited Beijing over the whole of 2008 than in non-Olympic years, and Athens had 10 per cent fewer tourists when it hosted the Olympics in 2004, possibly due to fears of overcrowding.

12.10.4 Key economic benefits and costs of the Olympic Games

	Benefits	Costs
Pre-Games phase	Tourism Construction activity	Investment expenditure Preparatory operational costs (including bid costs) Lost benefits from displaced projects
Games phase	Tourism Stadiums and infrastructure Olympics jobs Revenues from Games (tickets, TV rights, sponsorship, etc.)	Operational expenditure associated with Games Congestion Lost benefits from displaced projects
Post-Games phase	Tourism Stadiums and infrastructure Human capital Urban regeneration (renewal) Enhanced international reputation	Maintenance of stadiums and infrastructure Lost benefits from displaced projects

Source: PricewaterhouseCoopers, European Economic Outlook, June 2004

The overall economic effects of hosting the Olympics are difficult to determine. Cities hosting recent Games have aimed to break even on basic costs, and make profits from visitors spending money on non-Olympic related purchases. The Sydney Olympics in 2000 added 1 per cent to Australia's GDP, a fairly modest boost. Sydney clothing shops, cafes and restaurants did well, but retail sales declined sharply in the months after the Olympics. There have been long-term benefits in terms of urban renewal and better environmental quality. Sydney had a policy of 'greening' the Games, which led to better waste disposal and lower energy use. Both Athens and Beijing tried to improve the quality of their air, and London tried to make its Olympics carbon neutral by offsetting the production of carbon dioxide. The costs and benefits of hosting the Olympic Games are summarised in Table 12.10.4.

SPOTLIGHT

Golf in Japan

The game of golf in Japan is an example of how one sport can influence a whole country and the wider world. Golf is one of the most popular sports in Japan, but because of the facilities needed to play the game, it is very expensive. The number of golf courses has risen from 72 in 1956 to over 2500 today. Golf courses occupy a lot of land, and Japan is a small country with only a quarter of the land flat enough for settlement and industry. As a result, golf courses have had to be built in mountain areas.

Building golf courses in the mountains has led to environmental problems. Forests containing valuable timber have been cut down. Rainfall then runs off fairways and greens into rivers, causing flooding. Tonnes of pesticides and herbicides are used on the golf courses, and these are washed into waterways. The scarcity of land and problems associated with constructing golf courses have led to Japanese companies building courses in other Asian countries. As a result, golf-related tourism has become an important feature of Japanese leisure time.

12.10.5 Due to land shortages, many Japanese golf courses are constructed in mountainous areas.

12.10.6 Riots and demonstrations in Rio de Janeiro against the cost of staging the 2014 Soccer World Cup and the 2016 Summer Olympic Games

World championships and cups

There are world and regional championships in almost every sport, hosted by different cities in rotation. Some of these are relatively small, but others have a large economic and social impact. The largest of these is the soccer World Cup. This is held every four years, and is hosted by a different country each time. The matches are spread over a number of cities in the country, but this means that they each need a world-class stadium. The cost of preparing for this event is huge.

Brazil

Brazil spent US$14 billion on the World Cup in 2014, and recovered only an estimated one-tenth of this.

Brazil did, however, gain a set of high-quality stadiums, upgraded airports and better transport systems, and was the focus of the world's attention.

In the lead-up to the World Cup there were riots in the streets, as shown in Figure 12.10.6. Many people were angry about the money the government was spending on sports stadiums and facilities while infrastructure and services deteriorated. The catalyst for the riots was increases in public transport fares.

ACTIVITIES

Knowledge and understanding

1. Explain why major sporting events are so keenly sought after by cities.
2. Outline why playing golf in Japan is very expensive.

Applying and analysing

3. Prepare a case for or against the following proposition: *Hosting the Olympic Games is worth more to a city than monetary profit or loss.*
4. Think about the effects that an important sporting event would have on your town or city.
   a. Suggest some events that would fit the size of your town or city, and then suggest preparations that would have to be made.
   b. Which people would be affected the most?
   c. What benefits would you consider to be most valuable to your town or city?

Investigating

5. Research how a city or country is preparing for the next Olympic Games (summer or winter), or the next World Cup in soccer, cricket or rugby. Find out about:
   - building preparations
   - transport and accommodation
   - special features they are promoting
   - opposition and criticism to the sporting event.

Technology connecting people and places

CHAPTER 13

Advances in transport and communications technology have transformed the way humans live, work and travel.

Today, information flows almost instantaneously around the globe. For most of human history, however, the exchange of ideas between people in one place and those in another was limited by the speed at which people could travel. In the sixteenth century, the ability to spread information improved dramatically with the invention of the printing press, and by the seventeenth century the first modern newspapers were beginning to appear in Europe.

In the nineteenth and twentieth centuries, the invention of the telegraph, followed by the telephone, radio, television, computer and most recently the internet, transformed the ways people communicate, making individual connections more immediate and access to news and other information more efficient than ever before. Recent decades have seen a trend toward developing increasingly compact electronic devices that are affordable and convenient for an increasing share of the world's population.

Transport technologies have also developed rapidly. Large, fuel-efficient jet aircraft; high-speed trains; and ever-larger cruise ships have greatly reduced the real cost of travel. This has made travel available to a larger proportion of the world's population. People's personal geographies have expanded greatly.

INQUIRY QUESTIONS

- How have developments in transportation and information and communication technologies enhanced people's connection with goods, services, information and people in other places?
- What are the impacts of increasing global connectivity on people and places?

GLOSSARY

e-commerce	the buying or selling of products or services using the internet
hinterland	an area surrounding a place that is linked to that place through lines of exchange or interaction
social media	communication technologies through which users create online communities to share information, ideas, personal messages and other forms of content (e.g. videos)
virtual community	a community of people sharing common interests, ideas and feelings over the internet or using other collaborative technologies
virtual space	a computer environment that can simulate a physical presence in places in the real world or imagined worlds

13.0 Young Kyrgyz men using a mobile phone

13.1

Staying connected via transport

Scientific and technological advances

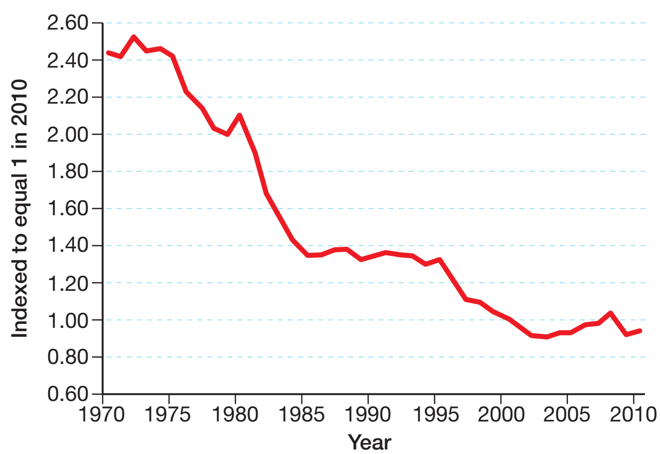
Technological and scientific advances have produced numerous improvements in transport systems. These improvements have enhanced the connections between people and places and led to an explosive growth in service-based industries such as international tourism and education. Transport improvements have also enabled the rapid expansion of world trade.

Transport innovations

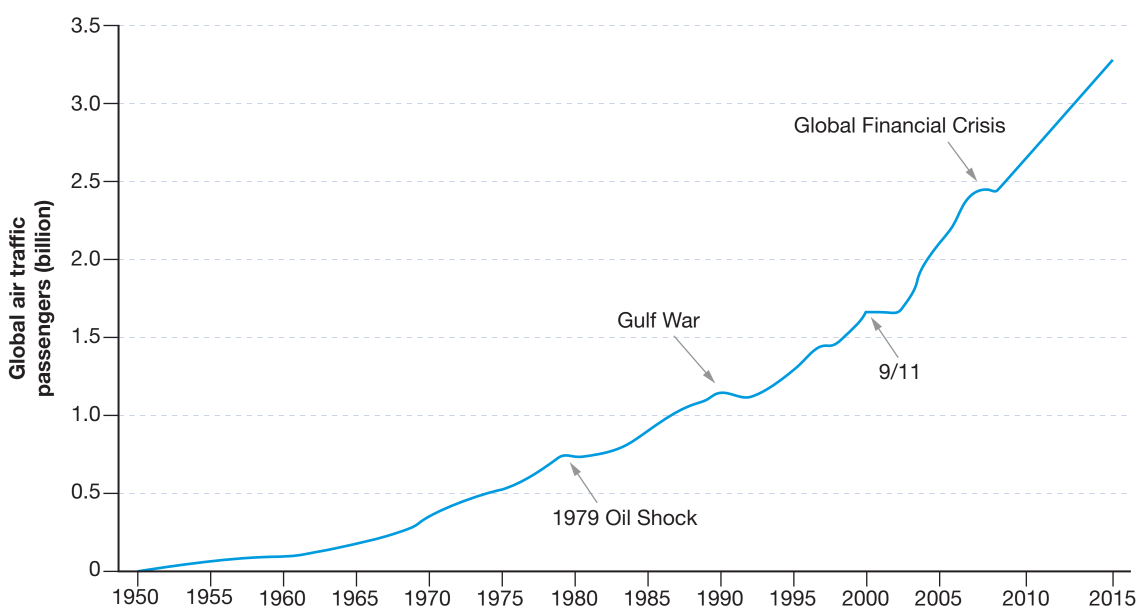
The most significant transport innovations have been:

- the development of high-capacity aircraft such as the Boeing 747 and the Airbus A380. The A380s, each of which costs US$390 million, are capable of carrying up to 853 people a distance of 15 400 kilometres at 900 kilometres per hour without refuelling. High-capacity aircraft have played an important role in reducing the cost of air travel. Figure 13.1.1 shows how the real price of air travel has decreased over the last 40 years. As a result, more people can afford to travel. Figure 13.1.2 shows the increase in global air passenger traffic from 1950 to 2014.
- the advances in railway technology, especially the introduction of high-speed trains. These trains use specialised rolling stock and dedicated tracks to achieve speed well in excess of the speed of traditional trains. Japan, China, France, Germany, Italy, Turkey, South Korea and Spain all have high-speed trains capable of speeds of up to 400 kilometres per hour. The Shanghai Maglev Train is a high-speed magnetic levitation train that runs 30 kilometres from Shanghai to the Pudong International Airport. The train reaches a speed of 431 kilometres per hour.

13.1.1 Real price of air travel, 1970–2012



13.1.2 Global air passenger traffic, 1950–2014



Source: IATA

SPOTLIGHT

Allure of the Seas

The world's largest cruise ship is Royal Caribbean's *Allure of the Seas*. The ship weighs in at 225 282 gross tonnes and has a displacement of 100 000 tonnes. It is the length of three and a half football fields (360 metres) and is capable of accommodating 5400 passengers and 2400 crew members.

13.1.3 *Allure of the Seas* is bigger than the largest aircraft carriers operated by the US Navy.

- the development of megaships—vast ocean-going vessels capable of transporting people, raw materials and manufactured goods at relatively high speeds over long distances and for a low per unit cost. Large bulk carriers, oil tankers and container ships travel the seas, linking sites of production and consumption.
  Cruise ships are an important part of the rapidly growing global tourism industry. In 2014, the world's fleet of 296 cruise ships carried over 30 million passengers, generating revenues of US$33.8 billion.

As a result of the innovations in transport, people have been able to take advantage of:

- decreased (real) travel costs
- increased capacity (passenger loads)
- improvements in safety and reliability
- increased travel and transport speeds
- greater comfort and convenience
- increased fuel efficiency
- declining environmental impacts, especially in the form of air pollution and noise emissions
- low-cost, same-day, next-day and just-in-time deliveries.

The future

Continuing research and development in materials and processes, and in computers and telecommunications, will result in ever greater efficiencies in the movement of people, goods and information. At the same time, technological changes may alter travel patterns, travel behaviour and travel choices in ways that are not completely understood at present. These developments might include:

- intelligent transportation systems (ITS) that result in smarter vehicles, highways and traffic monitoring
- new alternative fuels and vehicles for ground transportation
- new aircraft technologies, high-speed railways and megaships
- further developments in mobile phones and the internet, especially in terms of their potential to transform the travel experience.

ACTIVITIES

Knowledge and understanding

1 Outline the results of improvements in transport technologies.
2 Outline the technological developments in aircraft, railway technology and shipping.
3 Identify likely future technological advances in transport technology.

Geographical skills

4 Study Figure 13.1.1. Describe the trend in the real cost of travel.
5 Study Figure 13.1.2. Describe what impact world events had on the volume of air passengers.

Investigating

6 Select one of the forms of travel examined in this unit. Using the internet, investigate recent developments and likely future developments, and the impact of these advances on interconnectivity.

13.2

Staying connected via ICTs

Changing communication

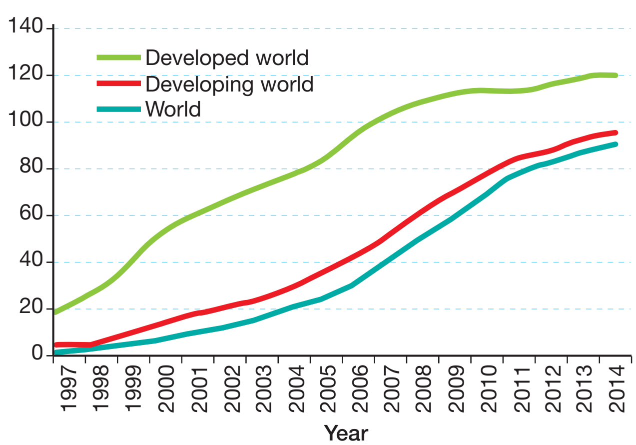
Advances in information and communication technologies (ICTs) have transformed the ways in which people interact. The technologies that many of us now take for granted have created new ways of connecting with our family and friends, and transformed the ways in which we work and shop. New online communities have emerged, defying the limitations once imposed by distance.

We once communicated with our family and friends using handwritten letters. In some cases it took weeks, even months, for the letters to reach their destination. From the mid-1850s until recently, urgent correspondence was transmitted electronically and then hand-delivered as a telegram—quite an expensive option. These messages could be sent long distance, initially using cables and, from the late 1880s, by wireless telegraphy. Australia Post shut down Australia's telegram service in March 2011.

Mobile phones

The first mobile phone call in public was made on 3 April 1973 in New York. The first mobile call in Australia was made less than 10 years later in August 1981. In 2014, there were 84 mobile phone subscriptions per 100 people in the developing world. In the developed world there were 120 subscriptions per 100 people, meaning every fifth person has two phones, as shown in Figure 13.2.1. By mid-2015 there were 21 million mobile phone subscribers in Australia.

13.2.1 Mobile phone subscribers per 100 inhabitants, 1997–2014



The internet

The internet began life in a US Government Defence research lab in California in the late 1960s. The first connections were made between universities in 1969. In Australia, Melbourne and Wollongong universities exchanged files using computers via dial-up. The emergence of the internet as we know it today began in the 1990s. Since then, internet growth has risen dramatically around the world (see Figures 13.2.2 to 13.2.5).

Social media

Today, people keep in touch using a range of fixed and mobile devices. The latter include smartphones, laptops and tablets. These devices, and their associated software, make possible the use of email, text messaging, blogs, Wikis, Skype, YouTube, Facebook, Twitter and photo sharing on sites such a Flickr and Instagram. These form what is often referred to as **social media**. Broadly speaking, social media is any means by which people create and exchange information and ideas.

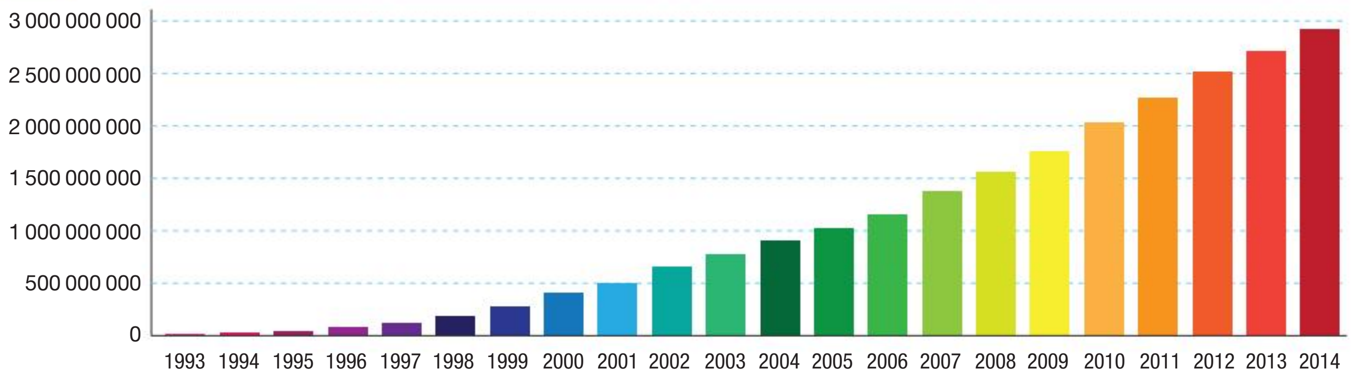
The use of social media has encouraged the emergence of **virtual communities** and networks. A virtual community is any group of individuals who interact through social media. It might, for example, be a group of friends who use technology to keep up to date with what everyone is doing. It might also be a group of individuals with a common professional interest who use email distribution lists to communicate and share information. Alternatively, it might be a network of environmental activists pursuing interests or goals that cross geographical and political boundaries.

People's use of social media is growing rapidly. In Australia, 80.1 per cent of the population have access to the internet and by late 2012 there were 11 680 640 Facebook subscribers (53.1 per cent of the total population).

DID YOU KNOW?

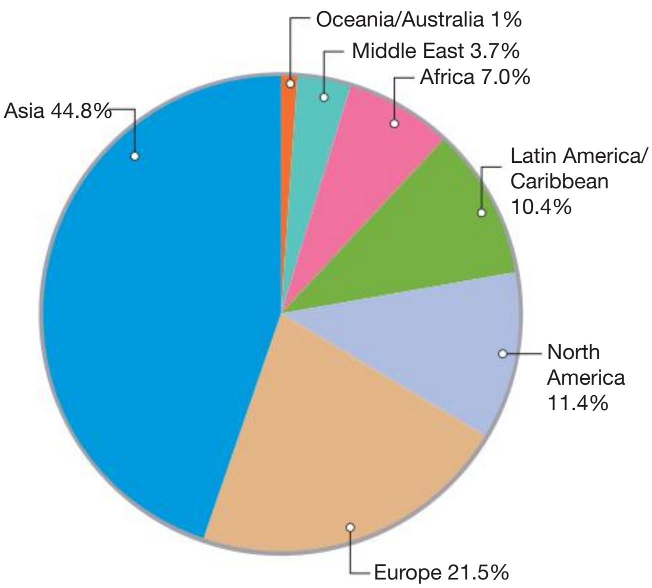
In 2015, advertisers spent over US$23.68 billion on paid media on social network sites. In 2017, that figure is expected to be US$35.98 billion.

13.2.2 Number of internet users in the world, 1993–2014

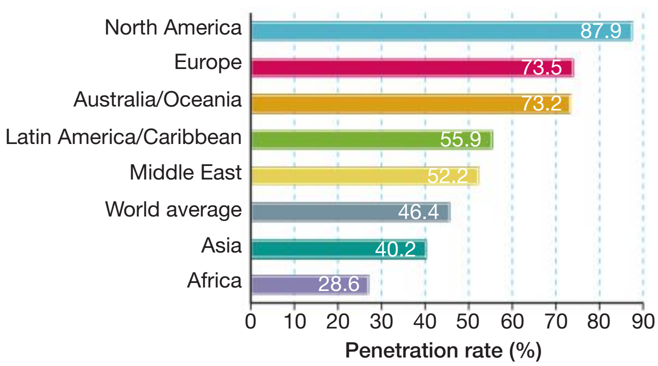


Source: Internet live stats

13.2.3 Distribution of the world's internet users by region, 2015



13.2.4 Percentage of population accessing the internet by region, 2015



Facebook facts (2014)

- Monthly active Facebook users now total nearly 1393 million.
- Fifty-seven per cent of Facebook users are female.
- An average Facebook user has 130 'friends'.
- Twenty-three per cent of Facebook's users check their account five or more times daily.
- Over 350 million photos are uploaded to Facebook every day.

Twitter facts (2014)

- Since the introduction of Twitter, there's been a total of 300 billion tweets.
- There is an average of 500 million tweets posted per day.
- Twenty-three per cent of all internet users are using Twitter.
- Fifty per cent of Twitter users are using the social network via mobile.

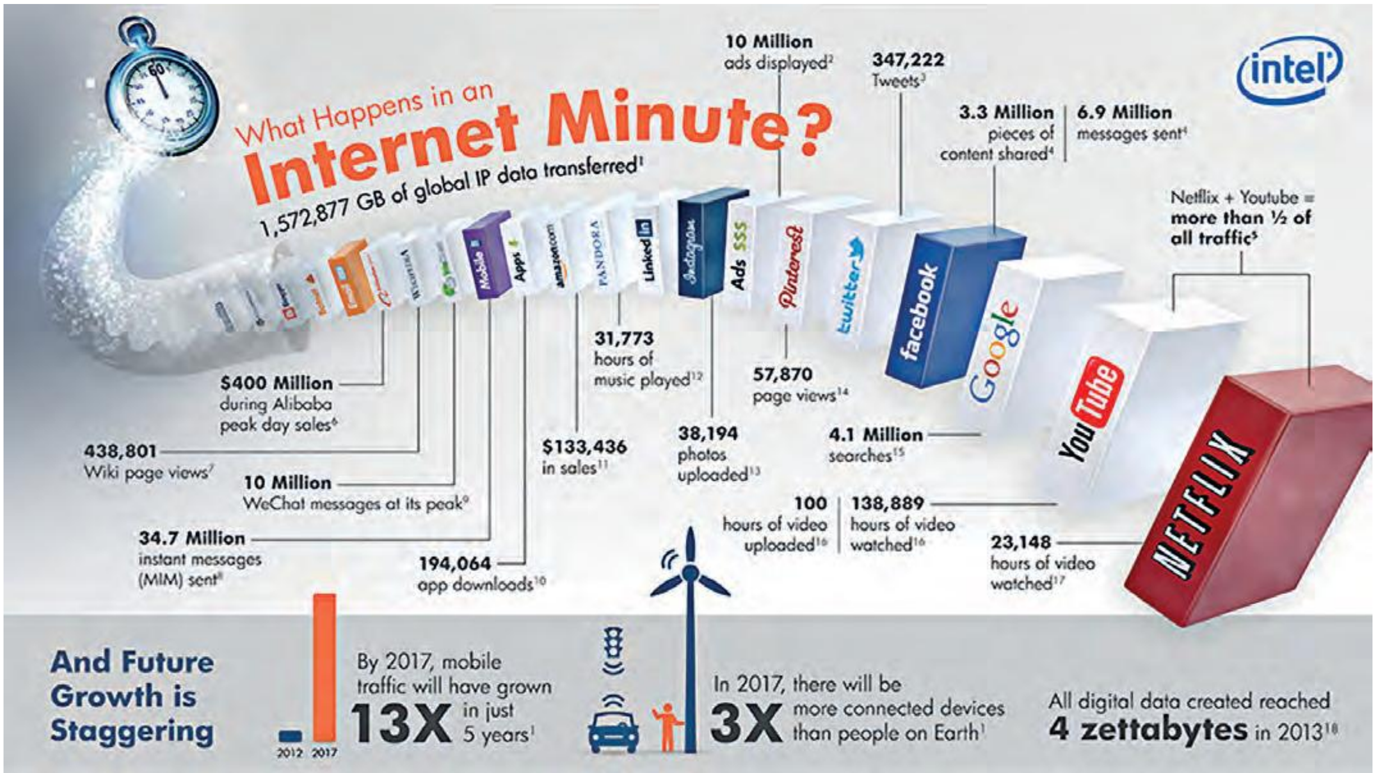
Instagram facts (2014)

- By March 2014, Instagram had 200 million users.
- Nearly 20 billion photos have been shared on Instagram since its beginning.
- More than 60 million photos are uploaded to Instagram every day.

Effects of social media

People spend more time on social networks than on any other category of sites—roughly 20 per cent of their total time online via personal computer, and 30 per cent of their total time online via mobile devices. Facebook is the most-visited social network site.

Most people regard social media as a positive addition to their lives. Unfortunately, however, there appears to be a link between social media use and cyber-bullying. Online sexual predatory behaviours are also a problem, as is the decline in face-to-face social interaction.



13.2.5 Today, the number of networked devices is equal to the global population.

New technologies, new industries, new jobs

ICTs are transforming the ways that people work and interact in workplaces. At one level they are changing the ways in which existing jobs are done. At another, they are creating whole new industries and new forms of employment. More flexible workplace arrangements are replacing the 9 a.m. to 5 p.m. office day. Work can now be performed in multiple locations (including the home and on public transport) and is no longer restricted to set hours.

New forms of economic activity have developed to take advantage of the potential of the internet and social media. The information media industry is a rapidly growing area of employment. Web-based publishing and broadcasting are now challenging the 'old' media—newspapers, magazines and television—and becoming the main means by which people access information. They also provide forums in which people can comment on the events and issues being reported and discussed.

Such developments are not limited to the world's developed economies. In Africa, mobile phones are the continent's fastest-growing technology. There are now an estimated 650 million mobile phone subscribers in Sub-Saharan Africa alone. The World Bank credits the mobile phone industry with creating more than five million jobs in 2014.

New ways of buying

Online retailing is a form of **e-commerce**. It allows consumers to directly buy goods or services from sellers using the internet. In Australia, online purchases reached $10.76 billion in 2015, or 4.5 per cent of traditional retail spending. At the end of 2015, online retailing was growing at an annual rate of 14.4 per cent per annum, compared with traditional retail sales growth of just 3.1 per cent. Travel products were the most popular category of goods bought online, as shown in Figure 13.2.6. In the United States of America, online retailing now accounts for about 8 per cent of all retail sales. In the case of clothing, online sales now account for 13 per cent of all transactions.

The key attraction of online retailing is convenience. Online stores are available 24 hours a day, and many consumers have internet access at home, at work and while mobile. In contrast, visiting a conventional retail outlet takes time, involves travel and must take place during trading hours.

DID YOU KNOW?

The typical smartphone user spends an average of 12 minutes a day on phone calls. They spend more time playing games (14 minutes), listening to music (16 minutes), using social media (17 minutes) and browsing online (25 minutes). The most common use of all mobiles is to check the time.

Comparing prices is also easier online and, because online retailers do not have the expenses of traditional 'bricks and mortar' retailers (for example the cost of maintaining multiple outlets in high-rent shopping malls), they can often sell goods and services at very competitive prices. Consumers are also able to access goods and services internationally. As a result, one-third of the top retail sites accessed by Australians are based outside the country.

The growth of online retailing has led to a rapid expansion in the international logistics industry. Transporting people's purchases to their homes is a massive undertaking and has created thousands of new jobs.

SPOTLIGHT

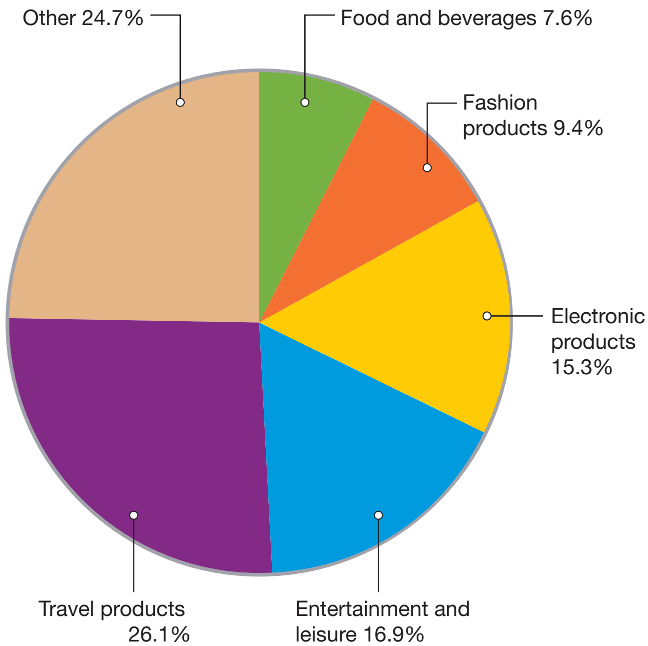
Young abandoning driving and car ownership

There has been a significant drop in the number of young people who own and drive cars. In the United States of America, the percentage of 18-year-olds with a driver's licence plunged from 80 per cent in 1983 to 61 per cent in 2010. In addition, the distance driven per person is below the historic peak by almost 9 per cent.

In Australia, there has also been a marked decrease in the proportion of under-35-year-olds holding a driver's licence. In 1998, 84 per cent of 25-year-olds held a licence. That figure has dropped from 77 per cent in 2000–01 to 66 per cent in 2015.

The decline in car use appears to be part of a structural shift that is largely a result of changing demographics, especially the rise of so-called 'millennials'—today's teenagers and twenty-somethings. Millennials are not driving cars in anything like the numbers that previous generations did. The reasons for this trend are complex but are thought to include the preference of the young for inner-city living, which is less car-dependent. Young people are also more likely to use public transport. The preference for the latter can be explained, at least in part, by the opportunity that public transport travel provides for engagement with social media—something that driving does not accommodate. Catch a train or bus these days and you will see people cruising the internet on their smart phones and tablets, working on their laptops or reading on their e-readers, all the while listening to music.

13.2.6 Online shopping expenditure by category, Australia



ACTIVITIES

Knowledge and understanding

1 Outline how personal communication has changed since the mid-1980s.
2 Define the terms 'social media' and 'virtual community'.
3 Outline the impact of the new technologies on the nature of work.
4 The way people access information is changing. Explain how.
5 Explain why young people in Australia and the USA are driving less.

Geographical skills

6 Study Figure 13.2.1. Using data from the graph, describe the growth in mobile phone use since 1997.
7 Study Figure 13.2.2. Using data from the graph, describe the growth in the number of internet users since 1993.
8 Study Figure 13.2.5.
   a Write down what you do in an internet minute.
   b Compare an internet minute in Figure 13.2.5 to your internet minute. Describe any similarities or differences.
9 Study Figure 13.2.6. Identify the three largest categories of online expenditure.

13.3

Real space versus virtual space

Personal and social places

Think about the reasons why you, your family and your friends move around your personal and social space. Possible reasons are going to school or work, shopping, visiting friends, visiting cinemas or sportsgrounds, going to play sport, taking the dog for a walk or going to the doctor.

Virtual space

Increasingly, a number of our day-to-day activities can be done in **virtual space**. For example, shopping can be done online; friends can be contacted by phone, email or text messaging; and even aspects of work and school can be done at home online. This is a twenty-first century development and it is changing some of the habits and patterns of people's movements and use of space. Virtual space is now taken for granted by people in countries such as Australia. It means that people have much wider access to others with similar interests, and much greater access to a variety of goods, information and activities. Virtual space is changing the way many people live their lives.

Shopping and entertainment online

Before the internet, shopping and most entertainment required travel to shops, cinemas and entertainment centres. Now, much of this is available in different ways through a home computer and a large screen. The percentage of shopping online is increasing, because of the greater range of goods, the ease of ordering at a computer, and the convenience of home delivery.

Working at home online

An increasing number of people are using online connections to work completely or partly from home. Occupations such as writing, editing and design are now possible to do at home while still retaining contact with other people.

Education online

Education at tertiary level is already well developed online. Many tertiary students study courses based at universities in other states, or even countries. Their notes are available online and they can submit assignments and contact their teachers online. Online learning will expand in the future. You will soon be able to watch, listen to and interact with lectures in 'real time'.

Medical applications

Medical diagnosis is already being developed online, so that people in remote areas have access to doctors at their fingertips. As the National Broadband Network expands, more people will have access to fast downloading and communications, and more business will be done using the internet.

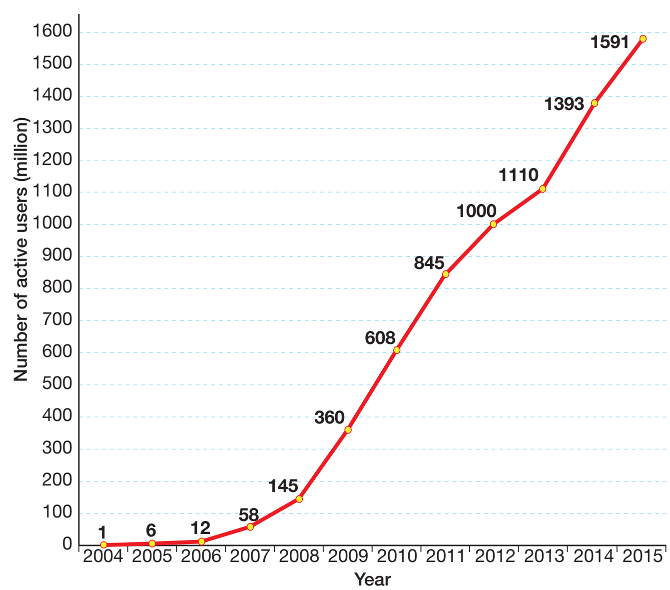
Virtual space inequality

For people who have low income and few assets, the new technologies are still of limited advantage. It is often difficult to pay the phone bills and broadband access accounts, after the rent has been paid and food has been purchased. There is also the isolation experienced by the aged, who sometimes find the technology difficult to master.

Facebook

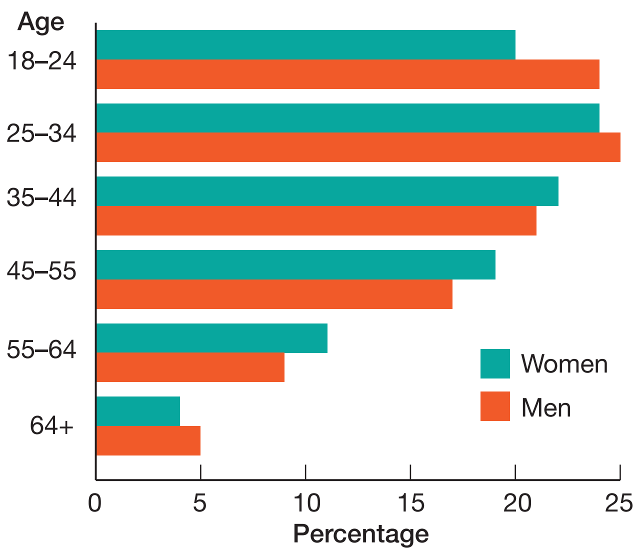
Facebook was introduced in 2004. It was originally just a network for students attending Boston's universities. However, it quickly expanded to include other students and then the general public. The growth to over 1.5 billion users is shown in Figure 13.3.1.

13.3.1 The number of Facebook users, 2004–15



13.3.3 World distribution of Facebook users. Paul Butler from Facebook created this map in 2010. Using the data from approximately 10 million Facebook users, he tabulated the number of friend connections between each city, and the latitude and longitude of each friend. With the data he created a colour code: the more connections between two places, the lighter the line is; the fewer, the darker.

13.3.2 Facebook users by age group and gender, 2015



Facebook is one of the many social media sites on the worldwide web, but it is the largest and probably the most successful. Figure 13.3.2 compares the usage of Facebook in 2014 by age group and gender. The significance of Facebook is that it creates a new and much wider virtual space.

Facebook is part of a much larger social change, linked to the use of mobile phones and emails to exchange social information instantly and often. People have quickly become used to posting photographs of themselves and their activities in virtual space where they can be seen by their friends. They can issue invitations, arrange events, send greetings and keep up to date socially.

Facebook in some ways makes the world seem smaller, with its instant access to friends, wherever they are (see Figure 13.3.3). However, the map of Facebook links shows that the people throughout the world are not evenly engaged in Facebook activities. The main links are clearly in the wealthier countries.

ACTIVITIES

Knowledge and understanding

1 Distinguish between 'real' and 'virtual space'.

2 Identify the activities that can take place in 'virtual space'.

Applying and analysing

3 a Make a list of the ways that new technology has changed how you and your family and friends do things.

b Has it led to you moving around less, or has it just changed the spaces in which you move? Explain.

c Which places do you think will remain as favourite visiting places in real space, and not be replaced by virtual space?

4 Create a PMI chart about the advantages and risks of the increasing reliance on virtual space.

Geographical skills

5 Study Figure 13.3.3. During which period did Facebook use grow most rapidly?

6 Study Figure 13.3.2.

a Name the age group most likely to use Facebook in 2015.

b In 2015, were more females or males most likely to use Facebook? Explain.

7 Study Figure 13.3.3. Describe the patterns of Facebook connections shown in the map of the world.

13.4

Accessing goods and services

Old patterns of access

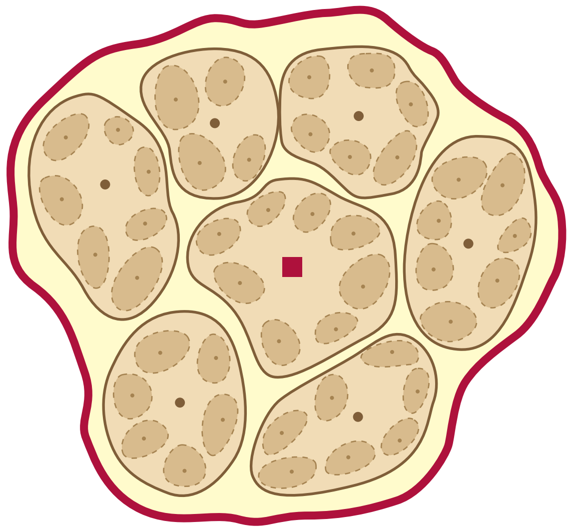
When walking was the only means of transport for the majority of the population, the goods and services that people needed had to be available locally. People would walk to where they worked, to shops and markets for goods, as shown in Figure 13.4.1, and to places such as barbers, doctors and repairers. The population relied upon the local markets, stores and workshops. Goods and services that were needed less often were supplied by travelling salespeople who travelled from settlement to settlement.

New patterns of access

Trains, buses and, more recently, privately owned cars made travel more widespread and longer in distance. People could now travel much further than a walking journey. As a result, people could visit distant places to purchase goods and services. Some places developed a more complex range of functions. This created a pattern of a few large towns with large trade areas overlapping the smaller trade areas of small towns and villages.

Patterns of travel and the consumption of goods and services can be mapped by geographers, as shown in Figure 13.4.2. Geographers can distinguish between larger towns, which supply many goods and services, and small towns and villages. They can also distinguish between places that supply high-order goods and services (needed only occasionally, usually fairly expensive, and people were willing to travel long distances to obtain them) and those that supply low-order goods and services (needed often, usually relatively inexpensive, and people did not want to travel far to obtain them). The area throughout which a good or service is consumed is referred to as the **hinterland** of a place (village, town or city).

13.4.1 A local village shop



City and its trade area (high-order goods and services)

Town and its trade area (middle-order goods and services)

Small town/village and its trade area (low-order goods and services)

13.4.2 Map of trade areas

13.4.3 Westfield redevelopment in Sydney's CBD

Emerging patterns of access

Since the introduction and spread of the internet, the provision of goods and services has changed greatly. Although many people still visit shops and offices for goods and services, the trend towards online purchasing of goods and services has grown very quickly. This is particularly true of some types of goods. Music and movies that were once purchased on CDs and DVDs are now more often than not downloaded, a process which does not involve any travel by the purchaser. Books, clothes and many specialist goods are also increasingly purchased online. These have to be physically delivered to the purchaser, but the courier, not the consumer, undertakes the travel. The trend towards ordering groceries online for a home delivery is growing, especially among people who are time-poor but relatively wealthy.

The next big area of expansion of online use is that of services. Medical advice and diagnosis, legal and financial advice, and education courses of all kinds are increasingly accessed online.

All these changes in accessing goods and services have consequences for shops and town centres. Already many shops have closed or changed greatly because of the increase in online purchasing. This trend will continue, but perhaps in ways so far unimagined. Even the giant shopping malls need to adapt. Most are now much more than just a shopping destination. In recent years, companies such as Westfields have spent billions transforming malls, such as the one shown in Figure 13.4.3, into entertainment destinations featuring cinema complexes and restaurants.

Differences in access to goods and services

Not everybody has access to these new ways of obtaining goods and services brought about by the internet. Within wealthy countries, which typically have high levels of internet use, there are still many people with limited access or no access at all. For them, the consequences of the changes, such as shops closing, still have to be borne without the advantages that others are enjoying.

ACTIVITIES

Knowledge and understanding

1 Explain what is meant by a 'low-order' and 'high-order' good or service.
2 Describe the changes in patterns of travel for goods and services.

Applying and analysing

3 Make a list of goods and services which fit into the categories of low-order and high-order.
4 Make your own list of goods and services that you know are readily available for purchase on the internet. What goods and services do you think it would be difficult to sell using the internet?
5 Which groups of people do not benefit from the increased availability of online goods and services?

CASE STUDY: Using ICT in developing countries

Santarem, Amazon River

Santarem, one of the most remote places in the world, is surrounded by forests and mudflats, which has made communications difficult. Phone lines using wires have been impossible to maintain. In 2012, two high masts carrying mobile phone aerials were built, and now an area stretching 45 kilometres along the river is connected. The masts have wind-powered and solar-powered generators to provide some of their power.

The broadcast signals are not only for mobile phones but also for a computer network in schools. A Swedish firm has connected school computers to a 'cloud server', which can be maintained far away, and set up the school with suitable apps. This means that the children have learning aids similar to those enjoyed by children in much less remote areas.

This new communications development serves 170 separate communities. In addition to the educational uses, there are many advantages for businesses. A breadmaker is able to take orders electronically, and can bake the right quantities of each of the breads to be sold.

13.5.1 Distance learning in the Amazon forest project

Medical facilities have also been improved by the new network. Emergencies can be reported faster, and a boat that travels the rivers with doctors has links to better diagnostic help. Many locals believe that the new methods of communication, and the advantages to education, health and business, make the remote areas of the Amazon a better place for them to live.

Distance learning in the Amazon forest

Distance learning using the internet has been introduced into Amazonas, the largest state in Brazil. Amazonas has a population of 3.3 million inhabitants, half of whom live in the capital, Manaus. The rest of the state's population is spread out across small towns and villages, mostly accessible after a 21-day riverboat trip. Ninety-two per cent of its area is covered by the Amazon forest and the rivers of the Amazon Basin.

The initiative involves teachers transmitting live classes from three studios located in Manaus via a two-way video-conference link to 35 000 students in 300 secondary schools and 700 classrooms, throughout the 62 county districts. A teacher is also located at each classroom to support local activities. Figure 13.5.1 shows students engaged in distance learning.

Bringing the internet to Bangladesh's remote villages

Amina Begum had never seen a computer until a few years ago, but now she's on Skype regularly with her husband. A woman on a bicycle brings the internet to her. Dozens of 'info ladies' ride their bikes from one remote Bangladeshi village to another with laptops and internet connections, helping tens of thousands of people—especially women—get everything from government services to chats with distant loved ones (see Figure 13.5.2). It is a vital service in a country where only 5 million of 152 million people have internet access.

13.5.2 'Info lady' bringing interconnectivity to Bangladesh's remote communities

Digital technology, Kenya

Kenya is not a country where people have surplus spending money for consumer electronics. However, there have been ingenious ways of using digital technology for the benefit of local people. Instead of using connections to the internet from fixed broadband cables or telephone wires, 99 per cent of the connections to the broadband internet are through mobile phones, which are much cheaper than personal computers. Most of the mobile phones in use are relatively cheap, but they connect to the internet. In 2011, there was an 843 per cent growth in mobile internet use. In the five years before that, the coverage of Kenya by broadband increased from 19 per cent of the country to 87 per cent of the country.

13.5.3 Nairobi iHub

Kenya's iHub

Figure 13.5.3 shows iHub, a workspace and business incubator in Nairobi, Kenya. The iHub was founded by Erik Hersman, a blogger and entrepreneur. The facility provides a space where young entrepreneurs, mobile phone programmers, designers and researchers can receive mentoring, internet connectivity and access to capital.

ACTIVITIES

Knowledge and understanding

1 List the issues associated with accessing communication technology in Brazil and Kenya.

2 Describe how internet use is spreading around Bangladesh.

Applying and analysing

3 The examples from Brazil, Kenya and Bangladesh tell us about the nature of economic activity in these countries.

   a How does it differ from that in developed countries?

   b How is technology enhancing the wellbeing of people in developing countries?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Production, consumption and trade

CHAPTER 14

An important aspect of Geography is the study of spatial organisation of the economic, transportation and communication systems that support networks of trade in raw materials, manufactured goods, capital (both human and financial), ideas and services.

Resources are unevenly distributed on earth. No countries have all of the resources they need, nor can they produce all the goods and services their people want. People must therefore trade with others in increasingly complex global networks, which, in turn, promote global economic interdependence.

The spatial pattern of economic activity is increasingly complex. Raw materials may be shipped to locations thousands of kilometres away, where they are processed and transformed into consumer goods and then transported, again over long distances, to where they are sold to consumers.

In this chapter we study the ways that places and people are interconnected with other places through trade in goods and services at a range of scales. We also examine the effects of production and consumption on people, places and environments throughout the world.

INQUIRY QUESTIONS

- How has the geography of production changed over time?
- How has the global pattern of production and consumption changed? Why have these changes taken place?
- What are the effects of the production and consumption of goods on people, places and environments throughout the world?
- How are places and people interconnected through trade in goods and services?

14.0 Container terminals at the port in Shanghai, China

GLOSSARY

brand loyalty	the tendency for people to purchase a particular brand repeatedly rather than other brands
built-in obsolescence	policy to produce goods that have a limited functional life or that become outdated quickly
consumer good	a commodity that is produced and subsequently consumed to satisfy people's current wants or needs
digitisation	the process of transcribing data into a digital form so that it can be directly processed by a computer
fast fashion	low-cost clothing that mimics current luxury trends
goods	items that are tangible (able to be touched), such as coal and iron ore, motor vehicles and bottles of wine
globalisation	a process in which goods and services become similar throughout the world
services	intangibles, provided by people, such as providers of tourism experiences, education providers, accountants, dentists and medical practitioners
sweatshop	a factory or workshop in which poorly paid workers work for long hours and under poor conditions
trade barrier	any government policy or regulation that restricts the international trade of goods and services
trade liberalisation	reductions in the direct and indirect forms of industry protection
transnational corporations	large companies that operate in a number of countries but generally have their headquarters in one of the countries of the developed world
venture capital	money made available for investment in innovative enterprises or research, especially high technology, in which both the risk of loss and the potential for profit may be substantial

14.1

The changing geography of production

History of production

One hundred years ago, the main areas where manufacturing took place were the midlands of the United Kingdom, the Ruhr Valley of Germany and the north-east of the United States of America. The global pattern of manufacturing is now quite different. Today, much of the world's labour-intensive manufacturing takes place in the low labour-cost countries of East and South-East Asia and Central and South America.

Changing distribution of production

The global distribution of the production of goods and services has changed over time. The reasons for this are often complex but include factors such as:

- technological change
- rising living standards and lifestyle aspirations
- the emergence of the transnational corporation
- the movement of labour-intensive manufacturing to low-wage countries of the developing world—an example of this is the Bangladeshi garment factory shown in Figure 14.1.1
- new ways of organising firms.

Transport and technology developments

Developments in technology and transport have enabled large international businesses to locate each of their functions in different parts of the world. The businesses are able to locate specific production tasks in one part of the world and their marketing, decision-making and product development divisions in another.

There are now two types of forces shaping the geography of production on a global scale: forces of concentration made possible by specialisation of business functions, and forces promoting dispersal (spreading) of a company's operations on a global scale. The geography of production today is one of highly clustered industries using technology to communicate over long distances.

Concentration

Science- and technology-based firms tend to cluster in particular regions and cities, such as Silicon Valley, Austin and southern California in the United States of America. By locating close together, these firms can share the latest technology and form networks with related businesses. Other service-based industries, including retailing, also tend to cluster. The concentrating of stores into shopping districts and large planned shopping centres enables customers to save both time and money.

Related manufacturing industries cluster in different locations across the world so they can be close to their suppliers of raw materials. The auto industry is clustered in southern China (Guangdong), southern Japan, Detroit and Toronto. In Australia, during the period of post-World War II industrialisation, whitegoods and automobile industries clustered in Melbourne and Adelaide, textiles and garment manufacturing in Melbourne and chemicals manufacturing in Sydney and Melbourne. Many of these manufacturing industries have now been outsourced overseas to countries where production costs are lower. Other industry clusters that emerged and continue to grow are the wine industries in locations such as the Barossa Valley in South Australia and Margaret River in Western Australia. More recently, new biotechnology clusters have emerged, often located near major universities.

While the manufacturing firms tend to cluster, suppliers providing intellectual inputs such as banking and legal services can be located some distance from the factories where production takes place, often in world cities on the other side of the globe.

DID YOU KNOW?

Japan has the world's largest concentration of electronics companies. They include Canon, Casio, Citizen, Fujifilm, Fujitsu, Hitachi, JVC Kenwood, Mitsubishi Electric, NEC, Nikon, Nintendo, Olympus, Panasonic, Pioneer, Ricoh, Seiko Group, Sharp, Sony, TDK and Toshiba. Other major concentrations are in Taiwan, South Korea and southern China (mostly manufacturing).

14.1.1 Asia now dominates the global geography of manufacturing.

14.1.2 Key events in the changing geography of production

Date	Key developments affecting production	Impact on the geography of production
Early 1700s	The manufacturing of goods (e.g. textiles) was performed on a limited scale by individual workers (artisans). Packhorses were used to transport raw materials to production locations in homes and workshops.	Small-scale production with raw materials transported to individual houses.
Late 1700s	The development of the steam engine together with improvements in road, canal, rail and shipping infrastructure made it possible for industry to be centralised.	Yarn and cloth began to be produced in large centralised factories. The use of production lines (specialisation of labour) enabled factories to operate extended hours.
1900s	Specialised businesses developed to provide accounting, legal, financial, design and marketing services for manufacturers.	Specialised services did not need to locate close to the businesses they served. They clustered in cities such as Detroit, New York and Chicago so they could be close to the source of 'ideas' and maintain regular face-to-face contact with others in the industry. Intellectual services (e.g. lawyers) and specialised technical services (e.g. IT development firms) now cluster in world cities such as London, New York and Tokyo.
1951	Development of the first purpose-built container ship. Containers, together with specialised bulk carriers, greatly reduced the cost of handling and transporting raw materials and manufactured products.	Lowering the cost of transport and increasing the volume of goods that could be carried promoted trade and the globalisation of production.
1969	Boeing developed the first 747 aircraft designed to take either freight or passengers. Its introduction greatly reduced the real cost of travel.	Rapid expansion in international tourism and the trade in services such as education and healthcare.
1980s–90s	The growth of transnational corporations and the beginning of large-scale economic restructuring—the movement of labour-intensive manufacturing to low labour-cost countries of Asia and South and Central America.	The emergence of Asia and parts of South and Central America as major centres of manufacturing.
1990s–2000s	Technological revolution, especially the internet, enabled service-based activities to move to low-cost countries.	Advanced producer services—the services used by large firms to help them manage their global operations (e.g. accountancy, advertising, banking/finance services and lawyers)—can now be outsourced to low-cost countries in the developing world. China and India re-emerge as global economic powers.

HISTORY OF PRODUCTION

Table 14.1.2 outlines some of the developments in the changing global geography of production.

Forces of concentration vs. forces of dispersal

Clusters are geographic concentrations of competing, complementary or interdependent firms and industries that do business with each other and/or have common needs for talent, technology and infrastructure.

Factors promoting concentration

Factors promoting concentration are:

- the importance of face-to-face contact
- the need to be close to the source of ideas
- the opportunity to pool resources and gain a mutual competitive advantage
- favourable biophysical conditions
- access to low-cost labour
- geographical proximity to clients
- high costs of travel
- the advantages of informal networks created by close proximity to related businesses.

14.1.3 The financial district of London, UK

Examples of clusters are:

- historic know-how-based clusters, such as finance (London, shown in Figure 14.1.3)
- biophysically driven clusters, such as viticulture (southern France), Hunter Valley (Australia), Napa Valley (California)
- high-tech clusters such as Silicon Valley (California)
- low-cost manufacturing centres, such as automotive production, electronics, or textiles (Cordoba, Argentina), electronics (Guangdong Province, southern China)
- low-cost service centres, such as knowledge-based services (Bangalore and Manila).

Factors promoting dispersal/globalisation

Factors promoting dispersal/globalisation are:

- global differences in labour and resource costs
- location of specialist functions in areas of the world where they are most efficient and profitable
- differences in government support for industry and regulation on an international scale
- access to new markets, knowledge and experience overseas.

DID YOU KNOW?

In the 1980s, 200 000 men and women were employed in the Australian garment industry. Today there are just 49 000. Most of these work in the high-end fashion industry, which can absorb the relatively high cost of labour in Australia.

ACTIVITIES

Knowledge and understanding

1 Describe the geography of production in the early 1700s. Explain how raw materials were transported to businesses at this time.
2 Explain how the development of the steam engine altered the geography of production during the Industrial Revolution.
3 Describe changes in infrastructure required to support the growth of large centralised factories.
4 Define the term ‘specialisation of labour’.
5 Outline the types of specialised services used by large manufacturing firms. Describe the location of these specialised services.
6 Explain how developments in technology have made it possible for companies to separate their production and decision-making functions on a global scale.

Applying and analysing

7 Use the information in Table 14.1.2 to construct a wall poster showing changes in the geography of production over time.
8 Working in pairs, brainstorm the advantages and disadvantages of:
   a separating production and decision-making locations on a global scale.
   b clustering similar types of businesses in the same location.
9 Demonstrate how businesses can cluster and globalise at the same time.

14.2

Global production and consumption

Innovations and development

The global geography of product design, marketing and production has been made possible by developments in transportation, communication and the growth of **transnational corporations** (TNCs). Developments in transport and communications have enabled businesses to specialise on a global scale. This means that manufacturing can take place in those parts of the world where it is most profitable.

Innovations in transportation

Air transport

Developments in aviation technology, especially the introduction of the Boeing 747 and the A380, have helped to lower transport costs and increase the volume of international tourism and trade between countries. Although lower volumes of freight are carried by air than by sea, the types of goods transported by air (mainly electronics products and perishable goods such as flowers) are more valuable. Airports are also located closer to areas where high-tech products are manufactured, making air freight more attractive than other transport options.

Land transport

Increased levels of investment in rail and road infrastructure have made land transport faster and more competitive over longer distances. The introduction of high-speed rail systems and new cargo-handling equipment has, for example, cut delivery times and increased efficiency. Land transport plays an important role in the delivery of cargo to and from ports and airports.

Sea transport

Technological developments in shipping and cargo handling have been central to the expansion of international trade. As ships have increased in size, the cost of transporting goods has declined. The use of specialised bulk carriers, oil tankers and container ships lowers costs and reduces the amount of time that ships spend in port being loaded and unloaded. Containerisation has revolutionised the way cargo is handled. Containers are capable of being carried by road, rail or ship. This eliminates the need for the multiple handling of goods.

Impact of transport innovations

Developments in transport technology have made it easier for individuals to migrate from one country to another in search of employment. These migrations are of two main types: the movement of highly skilled, highly paid professionals (often employees of TNCs); and the movement of poorly paid, low-skilled workers.

Developments in communications technology

Developments in communications technology such as telephones, satellite communications and fibre optics have made it easier for people to communicate with each other over large distances, as illustrated in Figure 14.2.1.

The following developments have significantly improved communications on a global scale.

14.2.1 Communications facts

14.2.2 The world's largest container ship, MV CSCL *Globe*

TRANSPORT FACTS

- The world's largest container ship, MV CSCL *Globe*, shown in Figure 14.2.2, is 400 metres long and 59 metres wide, weighs 181 741 gross tonnes, and carries more than 19 100 containers. The ship's top speed is 41 kilometres per hour.
- The largest bulk carrier cargo ship in the world is the iron ore carrier BMS *Ore Brasil*, weighing a massive 198 980 gross tonnes.
- The world's largest oil tankers are the TI class supertankers, which include the TI *Africa*, TI *Asia*, TI *Europe* and TI *Oceania*. Each of the four sister ships has a capacity of over 441 500 dead weight tonnes, a length of 380 metres and a cargo capacity of 3 166 353 barrels of oil.
- The largest ship ever built was the *Mont* (previously known as the *Knock Nevis*, *Jahre Viking*, *Happy Giant* and *Seawise Giant*). The supertanker (launched in 1979) weighed in at 564 763 deadweight tonnes and was 458.5 metres long. The vessel was sold to Indian ship breakers in 2009 and intentionally beached at Alang, Gujarat, India, then dismantled for scrap.

Increasing access to the internet

Networked computers make it possible for individuals and businesses to transfer large amounts of information around the world 24 hours a day, at high speed and low cost. The number of internet users worldwide currently exceeds 2.4 billion, or 34.3 per cent of the world's population. The internet is an important tool in the promotion of the globalisation of trade, investment and culture. This technology has, for example, enabled large companies to locate their design and production functions in different cities. The internet has also enabled small businesses to market their products to a global audience 24 hours a day.

It is important to note that while the development of advanced communications and transport technologies has brought great benefits, especially to the cities of the developed world, many isolated and/or poor regions of the globe have little access to this technology. These countries have effectively been shut out of the growing global networks in trade, transport, finance and communications. Africa, for example, with a population of more than 800 million people, accounts for less than 4 per cent of the world's internet users. In countries such as Uganda, Zimbabwe and Tunisia, less than 2 per cent of the population have access to the internet. Even in cities, internet access is often dial-up and very slow.

INCREASED AVAILABILITY OF BROADBAND

In Australia, the development of the National Broadband Network will significantly improve access to the internet for many individuals and businesses. Costing $37.4 billion, the network will be the single largest nation-building infrastructure project in Australian history. The network will connect 90 per cent of all Australian homes, schools and workplaces to broadband services with speeds of up to 100 megabits per second—100 times faster than those currently experienced by many households and businesses. The other 10 per cent of premises will be linked by next-generation wireless and satellite technologies that will deliver broadband speeds of 12 megabits per second.

Growth of satellite and microwave technologies

Satellite and microwave technologies include mobile phones, pagers, geographical positioning systems (GPS) and satellite television broadcasts. These communications systems have the advantage of being wireless and, therefore, are more flexible than traditional cable-based technologies.

Use of fibre-optic cable technology

Australians currently have communications access to Asia, North America and Europe via an extensive network of cables and satellites. Fibre-optic technology enables the transmission of greater volumes of information at high speed. This has made global communications faster, more efficient and less costly.

Growth of hybrid technologies

Television and internet technologies are beginning to merge as a result of **digitisation**. Many media experts claim that digital television has the potential to revolutionise the way people live by enabling them to use their televisions to undertake many of the functions currently available on the internet. The technology enables consumers to shop, send emails and do their banking in the comfort of their lounge rooms via their digital television sets.

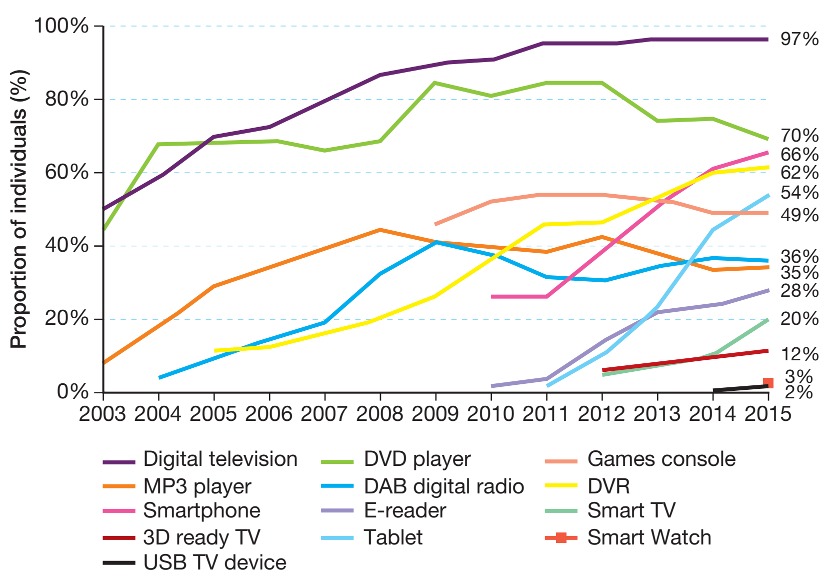
Figure 14.2.3 shows the percentage of households with access to specific communications technologies over time. The graph shows the speed with which new technologies have been adopted. Each technology experiences a period of rapid growth followed by a slower phase as the market becomes saturated (most people have already purchased the product). In some cases, existing technologies have been completely replaced by new ones (e.g. DVD replacing VHS videos).

Growth of TNCs

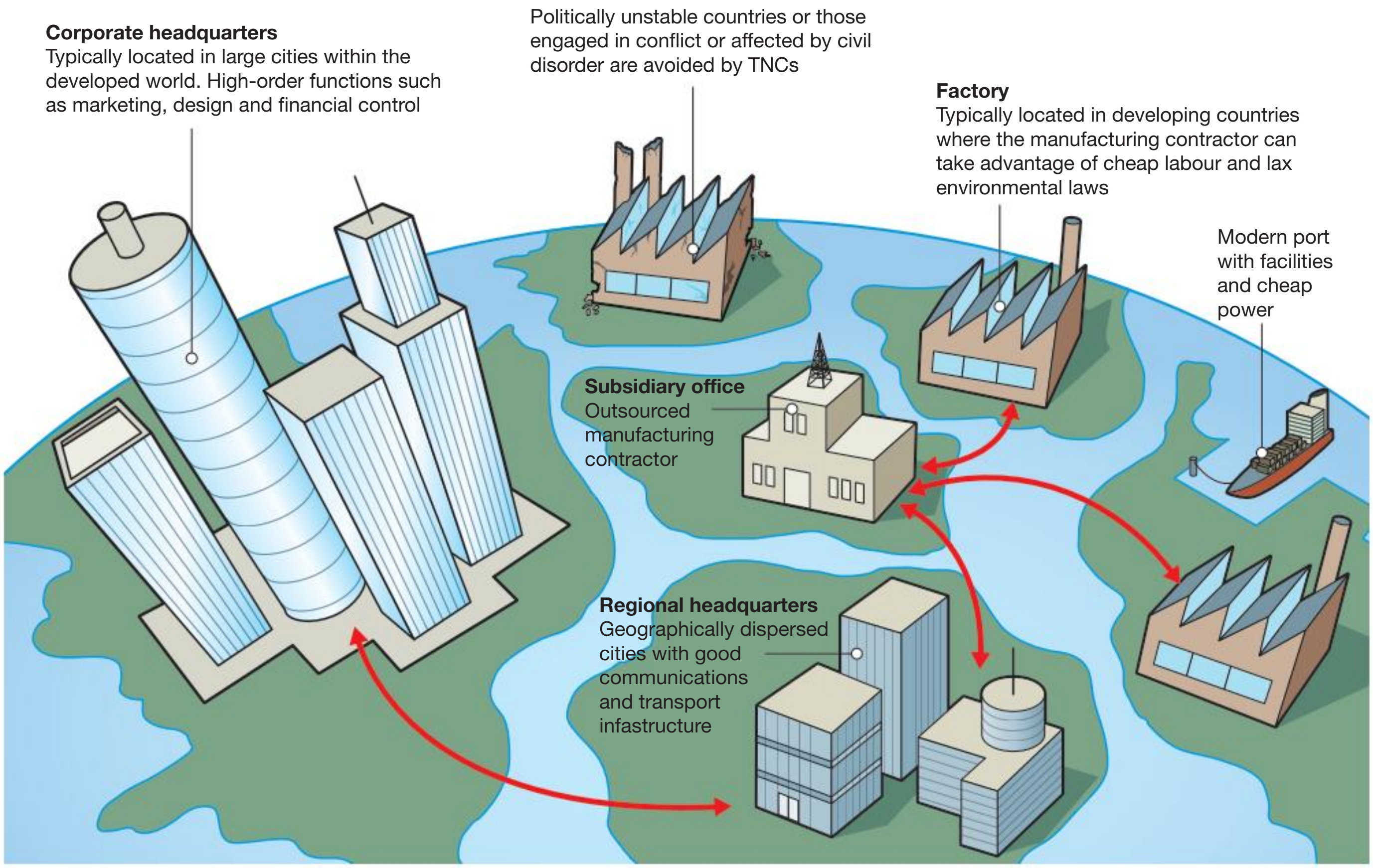
Another factor shaping the global geography of production is the rise of TNCs. TNCs are large companies that operate across a number of countries but have their headquarters in developed nations. Apple Inc., Kraft and Nestlé are all TNCs.

Within these companies, capital (funds) can be moved from one country to another with ease. These businesses can also locate their operations to take advantage of differences in resource costs and government regulations. The business links of TNCs create a more integrated world economy in which decisions made in one country can affect people in other parts of the world.

TNCs can be classified according to the nature of their operations. Some TNCs operate enterprises in different countries to produce the same or similar products, for example McDonald's, KFC and Starbucks. Other TNCs operate facilities in various countries to make products that serve as inputs to their production lines in other countries, for example the large automobile manufacturers. The organisation of a TNC is illustrated in Figure 14.2.4.



14.2.3 Take-up of innovations in communications in the UK, 2003–15. New technologies are adopted at a rapid rate initially. Eventually the market becomes saturated (flooded) with products, and sales drop off.



14.2.4 Global organisation of a TNC

ACTIVITIES

Knowledge and understanding

1 Explain how the development of transport has changed the way goods are manufactured and sold.

2 Explain the original reasons for the development of the internet. How has its use changed over time?

3 a List the four key developments in communications technology that have revolutionised the geography of production and consumption on a global scale.

b What are the advantages of these new technologies?

4 What is a TNC? How do TNCs decide where to locate production?

Applying and analysing

5 Discuss the theme that developments in communications have not benefited all individuals equally.

6 In small groups, use a ‘think, pair, share’ strategy to brainstorm ways to reduce information inequality.

7 a What do you think international transport and communications will be like in 2050?

b What impact is this likely to have on your lifestyle (especially the types of products you consume and where you purchase them from)?

Geographical skills

8 Study Figure 14.2.3 and do the following tasks.

a Identify the major innovations in communications in the United Kingdom since 2003.

b Estimate the percentage of households with digital televisions in the United Kingdom in 2007.

c Estimate the percentage of households with digital televisions in the United Kingdom in 2013.

d Which technologies have been adopted most rapidly? Why do you think this is the case?

9 Study Figure 14.2.4. Write a description of the ways that TNCs operate.

Investigating

10 Interview some older people to find out what you can about changes in communications technology over time.

a Prepare a series of questions (minimum of ten).

b Consider how you will conduct the interview (video, audio recording, writing).

c Present your findings to the class.

14.3

Patterns of production and consumption

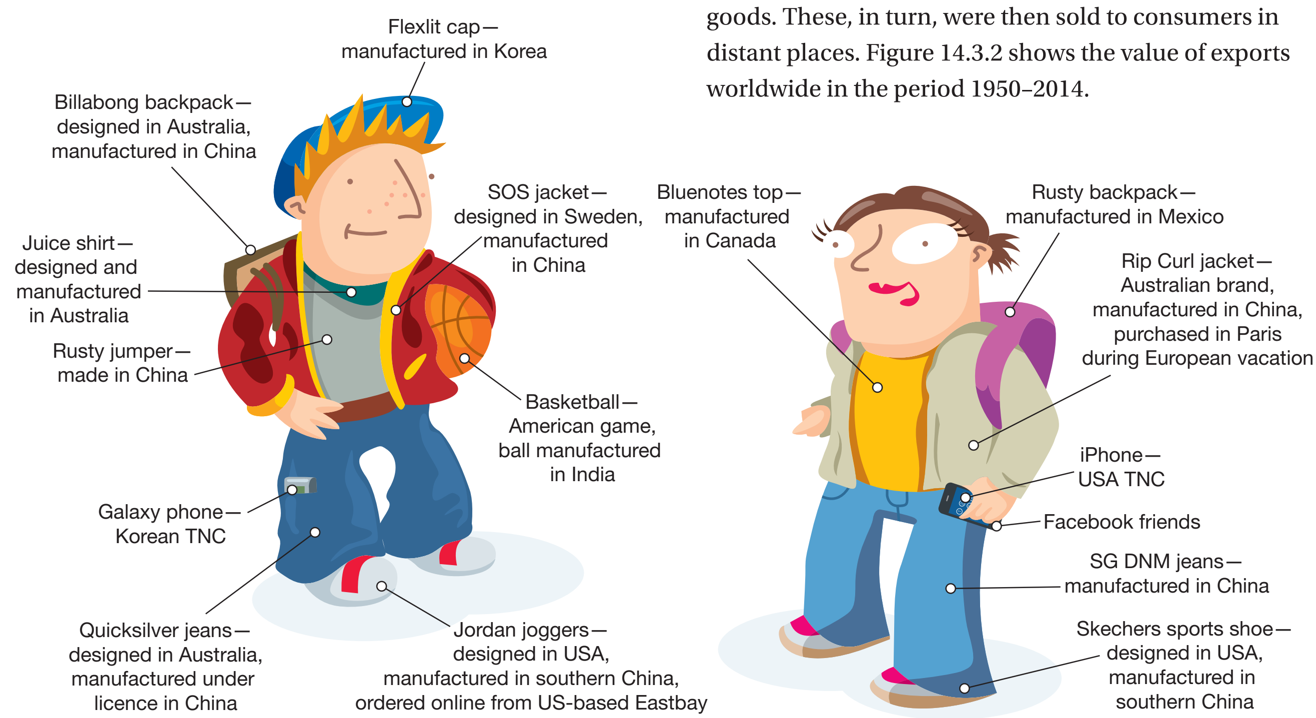
Australia

Australians enjoy one of the highest standards of living on earth. Our homes are, for the most part, full of **consumer goods**. These include the latest electronic gadgets and high-definition, flat-screen televisions. Our wardrobes are likely to hold clothes that reflect the latest fashion trends and the chances are that the cars parked in the driveway have been imported.

Technology changing behaviour

The internet has enabled Australians to buy a rapidly increasing range of goods and services online. People can buy the latest fashions from online retailers in North America and Europe and download movies and music. Australians can Skype their friends on the other side of the planet and they can network with friends via Facebook and Twitter (see Figure 14.3.1). Developments in transport technologies (especially in the aviation and shipping industries) have greatly reduced the cost of transporting goods over long distances. The global pattern of production and consumption of these consumer goods and services demonstrates the increasingly complex pattern of global interconnections.

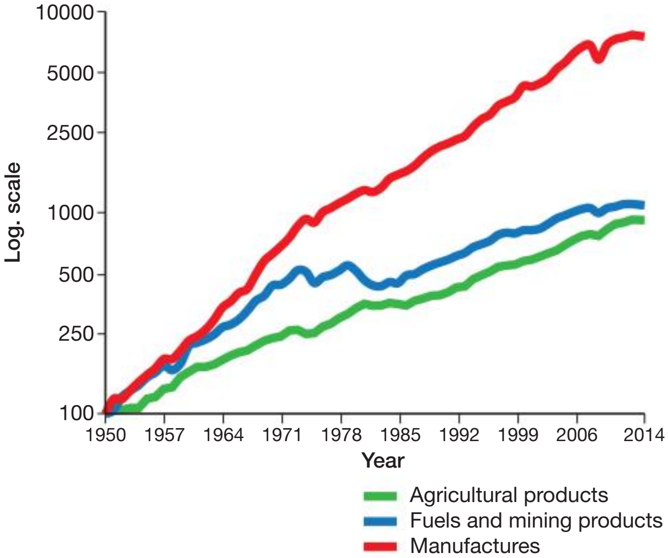
14.3.1 Globalisation of consumer choices



Origins of world trade

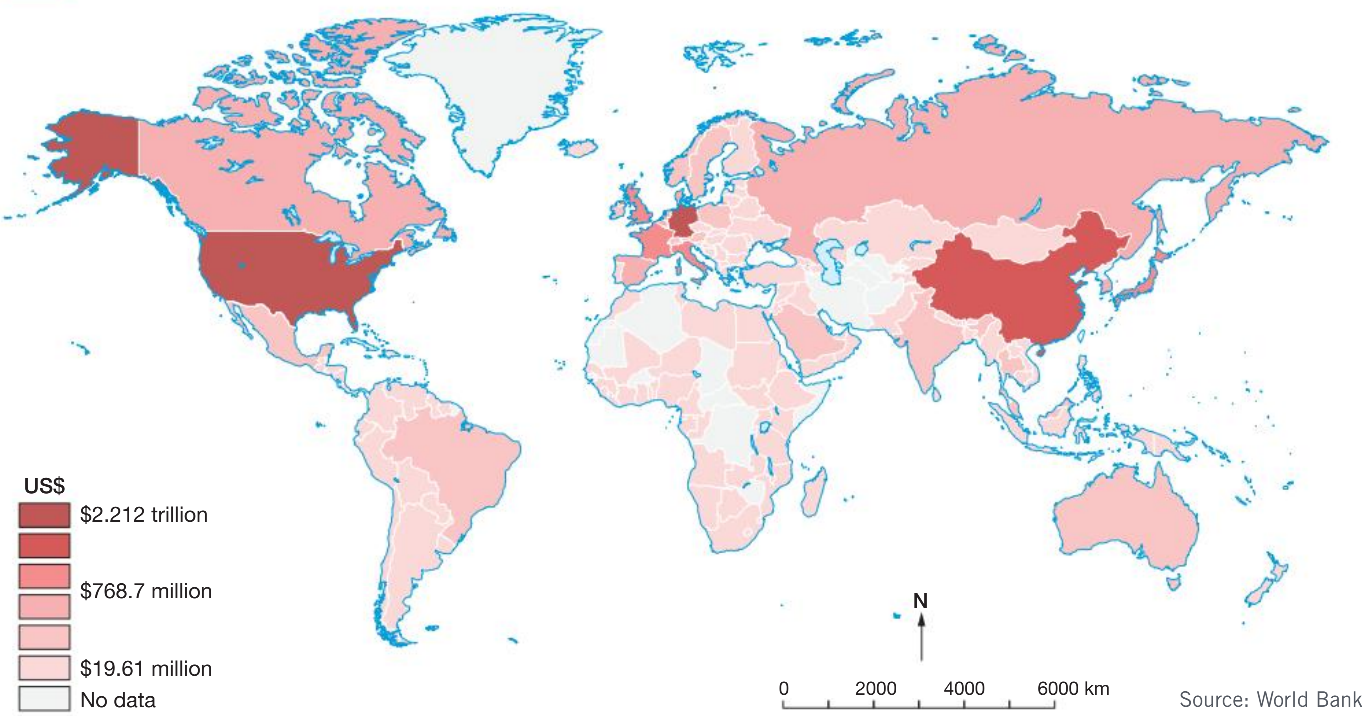
The distribution of raw materials over the surface of the earth is very uneven. Some places have large supplies of coal, while others might have supplies of gold, water or good soil. Similarly, the distribution of population and the ability to buy consumer goods is also uneven. Because of the uneven patterns of supply and demand, a system of trade has developed. Trade is now very important and very complex on a world scale.

The earliest societies bartered (exchanged) goods, but soon developed money as the medium of trade. The earliest trading involved the exchange of materials. For example, if one place had salt and another place had crops, they found that exchanging some of each was beneficial to both places. From this grew a more complex system of trade, in which some places supplied raw materials, while others processed them and then sold them to consumers. In some cases, this involved the manufacture of more complex goods. These, in turn, were then sold to consumers in distant places. Figure 14.3.2 shows the value of exports worldwide in the period 1950–2014.



14.3.2 Volume of world trade by major product group, 1950–2014

14.3.3 Exports of goods and services, 2012



Global patterns of trade

The trading of goods, ideas, services, currencies and shares in companies is now a fully global and complex system.

There are a number of key points about the present pattern of world trade.

- World trade is dominated by the United States of America and the European Union, but Asia is becoming increasingly important (see Figure 14.3.3).
- More than 80 per cent of world trade involves the wealthier economies.
- There is little trade between countries with less developed economies.
- Less developed economies have high levels of specialisation in trading mainly one or two goods.
- About half of the world's trade by value is of manufactured goods.
- There have been important increases in the trade of high-tech goods.
- World trade is increasingly dominated by large global companies.

ACTIVITIES

Knowledge and understanding

1 Identify the technologies that have increased the complexity of the global pattern of production and consumption.

2 Outline the key features of the current pattern of world trade.

Analysing and applying

3 Study Figure 14.3.1. A typical teenager in Australia, USA or Europe might have clothes made in Asia but designed in the USA or Europe, electronic gadgets made in China and designed in the USA, DVDs of American or European films, and computer games from Japan. Brainstorm a list of other consumer goods and experiences that Australian households purchase.

14.4

Trade: Connecting people and places

Places of trade

Think about all the places in the world that you have links with. You might start with family or friends, places visited or that you would like to visit, and places that particularly interest you. When you have done this, think about some of possible connections from the list below:

- places where your clothes are made
- places where your electronic gadgets are designed and made
- places from where you have ordered online goods or services
- places that provide services that your family uses (banks, airlines, internet provider)
- places that make films and television shows that you watch.

These connections are all part of **globalisation**, a process in which goods and services become similar throughout the world.

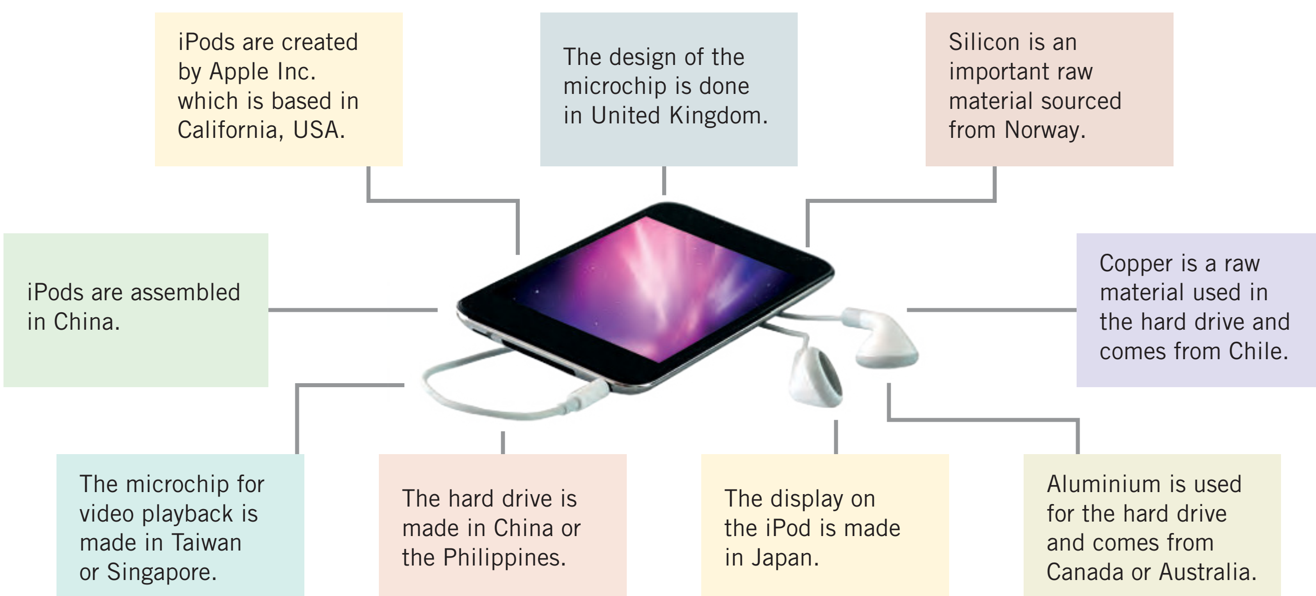
Origins of clothing

The chances are that your clothes were designed in the United States of America, Europe or Australia, but were made in an Asian country. This is now a very common pattern. Clothing companies might have their head offices and administration in one country, their design offices in another, and the actual manufacturers of the clothing in a number of other countries. They need to have their designers near the latest trends, but they want to use cheap labour and processing to produce the clothing.

Origins of digital devices

Many people own a digital device such as an iPod. Look at the list of components and processes involved in the making of an iPod in Figure 14.4.1. This information is current at the time of publication, but the source of raw materials and the sites of manufacturing keep changing as costs and profitability change. Global companies are constantly assessing their costs and profits, and are prepared to shift their contracts to different suppliers in different countries if that improves their costs.

14.4.1 The design and production of an iPod is a worldwide collaboration.

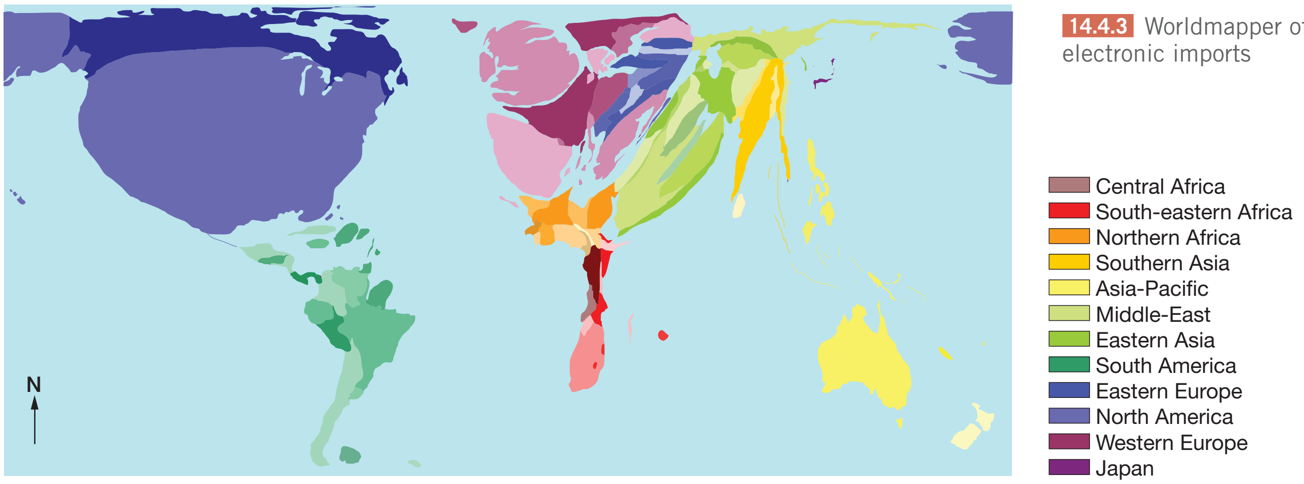


Global electronics trade

The patterns of trade suggested in the iPod example are further illustrated Figures 14.4.2 and 14.4.3, which show the regions with the greatest exports and the greatest imports of electronic goods.

> **DID YOU KNOW?**
>
> A cartogram is a special type of map in which countries are resized according to the variable being mapped. In Figures 14.4.2 and 14.4.3, the variables are electronics exports and imports.

14.4.2 Worldmapper of electronic exports



14.4.3 Worldmapper of electronic imports

ACTIVITIES

Knowledge and understanding

1 List the metals that are used in the production of an iPod.

2 Name the countries that are involved in the production of an iPod.

3 Outline the clothing production process.

Applying and analysing

4 Demonstrate the influences globalisation has on your life.

5 List the places that you are connected with through the origins of your:
- clothing
- goods, such as smart phone, tablet etc.
- favourite music or shows.

6 Look through the list of the countries and places throughout the world that you have any connection with. Which connections have come about recently through globalisation?

7 Do you think that globalisation is good or bad, and inevitable or changeable? Give reasons for your opinion.

Geographical skills

8 Study Figures 14.4.2 and 14.4.3.

a Name the regions with the largest levels of exports.

b Name the regions with the largest levels of imports.

c Describe the pattern that this shows.

14.5

Australia's trading connections

International trade

International trade (the export and import of goods and services) creates connections between countries. Australia has a complex pattern of trade that has changed over time as our export base has broadened and diversified. Two of Australia's most important exports now are services—education and tourism.

Goods are items that are tangible (able to be touched), such as coal and iron ore, motor vehicles and bottles of wine. **Services** are intangibles. They are provided by people, such as providers of tourism experiences, education providers, accountants, dentists and medical practitioners.

Australia's exports

For many years, minerals (such as iron ore, coal, gold and alumina) have accounted for a significant proportion of Australia's exports. More recently, the demand for these commodities has come from a rapidly developing China. Exports of services such as education and tourism have increased in importance and now make a major contribution to the Australian economy.

Exports of manufactured goods have been slower to develop. As a country we have relied on exporting minerals and primary products such as wheat, wool and beef to finance the purchase of manufactured goods from overseas. This is starting to change. Manufactured goods, especially elaborately transformed goods such as pharmaceuticals, scientific instruments and wine, now account for a growing share of Australia's exports. Australia's top ten exports are shown in Table 14.5.1. China is Australia's largest single export market, followed by Japan and South Korea.

14.5.1 Australia's top 10 exports, 2014 (A$ million)

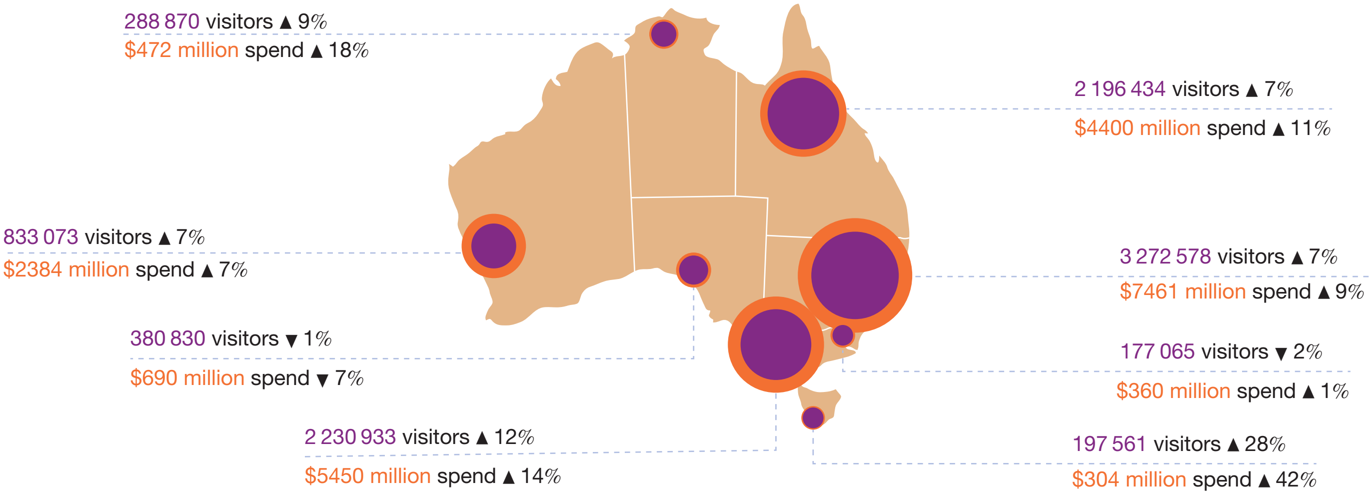
Rank	Commodity	Value	% share
1	Iron ore	66 008	20.2
2	Coal	37 999	11.6
3	Natural gas	17 743	5.4
4	Education	17 037	5.2
5	Tourism	14 227	4.4
6	Gold	13 460	4.1
7	Crude petroleum	10 564	3.2
8	Beef	7 751	2.4
9	Aluminium ore	6 336	1.9
10	Wheat	5 920	1.8
Total		**362 862**	

Tourism

Tourism makes an important contribution to the Australian economy. In 2015, the tourism industry represented 2.5 per cent of the Australia's GDP—a total contribution valued at A$107 billion. International tourism accounts for approximately 27 per cent of this economic activity (A$33.4 billion). Tourism employs more than half a million people.

In 2015, there were 7.4 million visitor arrivals and tourism contributed 4.4 per cent of Australia's total export earnings. Visitor numbers and their expenditure per state are outlined in Figure 15.5.3.

14.5.2 Australia's largest single export by value is iron ore. The collapse in world prices for iron ore in 2015–16—brought about by a slowing of economic growth in China and an expansion in supply—caused considerable economic hardship in Australia. Unemployment in the industry increased, government revenues declined and the profits of mining companies collapsed.



14.5.3 Visitor numbers and expenditure, year ending March 2015

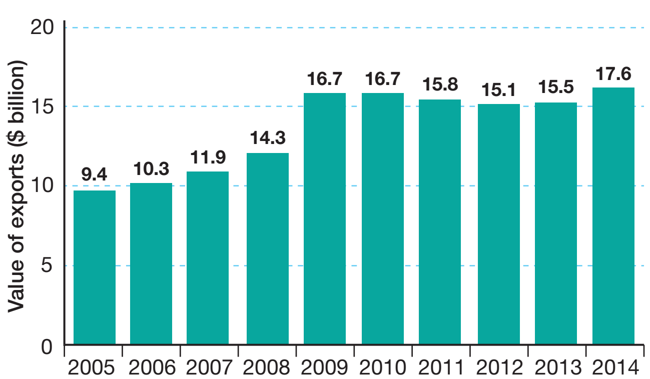
Education

International demand for Australia education has grown rapidly since the 1990s. This growth was reflected in the export value of the sector, which increased by $2.1 billion in 2014 to a total of $17.6 billion, as shown in Figure 14.5.4. Demand is strong across the higher education, vocational education and training, schools and English language sectors.

Australia's imports

The money earned from exporting goods and services offsets the cost of imports. Australia's major imports include petroleum-based products, motor vehicles, transport equipment, telecommunications equipment, medical goods including pharmaceuticals, clothing and footwear and electronic goods. Many of the imports in the last two categories come from the developing countries of South and East Asia, especially China. Australia's top ten imports are shown in Table 14.5.5. China is Australia's principal source of imports, followed by the USA and Japan.

14.5.4 Value of Australia's education exports, 2005–14



Source: Austrade

14.5.5 Australia's top 10 imports, 2014 (A$ million)

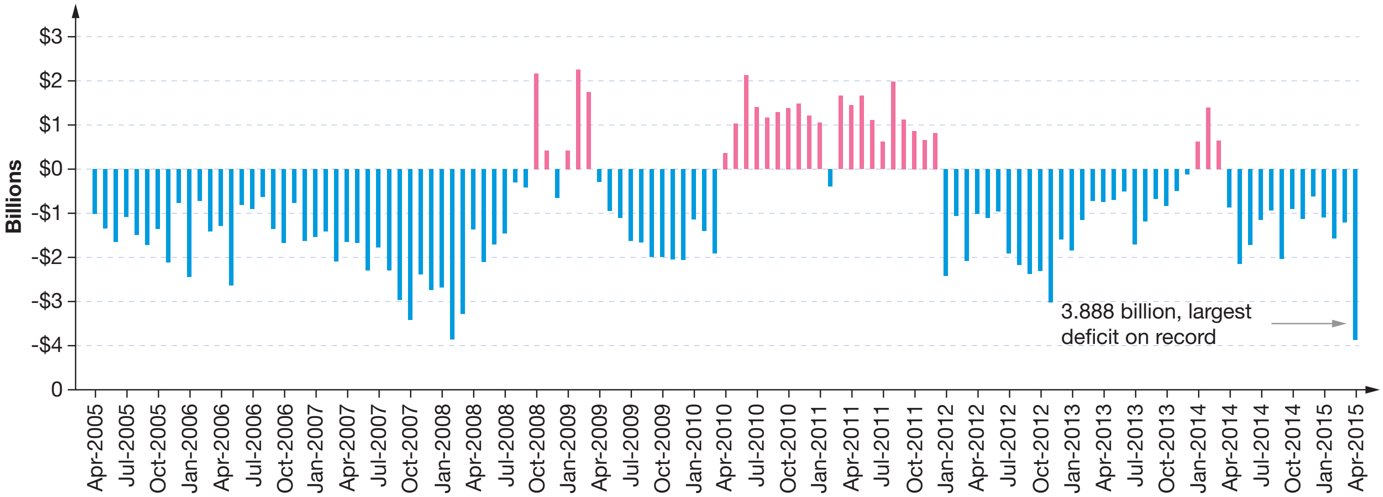
Rank	Commodity	Value	% share
1	Personal travel	24 597	7.3
2	Crude petroleum	20 050	6.0
3	Refined petroleum	18 579	5.5
4	Passenger motor vehicles	17 566	5.2
5	Telecom equipment	9845	2.9
6	Freight transport services	9686	2.9
7	Medical supplies	7497	2.2
8	Computers	7316	2.2
9	Passenger transport services	6141	1.8
10	Goods vehicles	6008	1.8
Total		**336 957**	

SPOTLIGHT

Asia–Pacific Economic Cooperation

The Asia–Pacific Economic Cooperation (APEC) group was established in 1989 as a response to the European Union's introduction of aggressive trade barriers. There are twenty-one member countries of APEC, representing a region of over two billion people (one-third of the world's population) and accounting for more than half the world's trade. Members of this forum include Japan, the United States and the rapidly developing countries of Asia (including China, Hong Kong, Taiwan and South Korea). The Latin American nations of Chile, Peru and Mexico are also members of this trade forum.

14.5.6 Australia's goods and services trade balance, 2005–15



Balance of trade

Australia's balance of trade (the difference between the value of the nation's imports and the value of its exports) is an important economic measure. Generally, Australia runs a negative balance of trade, as shown in Figure 14.5.6. This is only important if imports do not contribute to the future generation of wealth. Aircraft, for example, while expensive to purchase, generate considerable economic wealth over their lifespan.

Australia's major trading partners

Australia's trading connections have changed over time. Over the past 100 years, the country's trade focus has shifted away from Europe to Asia and North America. The decision by the United Kingdom to increase its trading links with other European nations in the 1960s forced Australian exporters to develop new trading relationships. These links were found in the rapidly expanding economies of North-East and South-East Asia. By 2000, Australia's focus was firmly on the members of the Asia–Pacific Economic Group (APEC). Eight of Australia's ten major trading partners in 2014 were members of APEC. Australia's top ten trading partners are shown in Table 14.5.7.

14.5.7 Australia's major trading partners, 2014 (A$ million)

Rank	Country	Exports	Imports	Total trade
1	China	98 210	54 258	152 468
2	Japan	50 247	19 971	70 218
3	USA	18 510	41 932	60 442
4	South Korea	22 017	12 609	34 626
5	Singapore	12 085	18 102	30 187
6	New Zealand	12 125	11 343	23 467
7	United Kingdom	8 319	12 469	20 788
8	Malaysia	7 923	12 659	20 582
9	Thailand	6 105	12 873	18 978
10	Germany	2 867	13 858	16 725

Barriers to stronger trade connections

A **trade barrier** is any government policy or regulation that restricts the international trade of goods and services. Trade barriers can take many forms, such as tariffs, subsidies, and various import duties, licences and quotas. Non-trade barriers include import bans, packaging and labelling requirements, product standards and occupational safety and health regulations.

Most trade barriers impose some sort of cost on trade, which raises the price of the traded products. Economists generally agree that such barriers are detrimental and decrease overall economic efficiency. Free trade involves the removal of all such barriers, except perhaps those considered necessary for health or national security. In practice, however, even those countries promoting free trade often subsidise certain industries, such as agriculture and steel.

The commercial interests of agriculture-based corporations and the political demands of sectional interest groups (for example US and European farmers) often result in protectionist policies.

Trade liberalisation

Trade liberalisation involves reductions in the direct and indirect forms of industry protection. Over time, these forms of protection have been reduced as a result of trade liberalisation policies. The average level of tariffs applied to manufactured goods entering Australia is, for example, now less than 4 per cent. The Australian Government is working to eliminate these non-tariff forms of protection in an attempt to boost the productivity and international competitiveness of the Australian economy. Some countries, however, are less willing to agree to reductions in the level of protection provided for their industries.

Free trade agreements

Free trade agreements (FTAs) are international treaties that reduce barriers to trade and investment. Australia has FTAs with both individual countries and groups of countries. They provide:

- better Australian access to important markets
- an improved competitive position for Australian exports
- more prospects for increased two-way investment
- reduced import costs for Australian businesses and consumers alike.

Australia's recently concluded FTAs include agreements with China, Japan, Korea and the Trans-Pacific Partnership countries.

ACTIVITIES

Knowledge and understanding

1. Distinguish between a 'good' and a 'service'.
2. Outline the changing nature of Australia's principal exports.
3. Identify Australia's principal export markets.
4. Explain what is meant by the term 'balance of payments'.
5. Identify Australia's principal imports. Where do Australia's principal imports come from?
6. Explain the circumstances under which a negative balance of trade can be seen as acceptable.
7. Outline how Australia's major trading connections have changed over time.
8. Explain how trade liberalisation can be achieved.
9. State what free trade agreements are and outline their benefits to Australia.

Geographical skills

10. Study Figure 14.5.1. Construct a proportional pie graph showing Australia's top 10 exports. Include an 'others' category.
11. Study Figure 14.5.3. Identify the three most popular destinations for international visitors to Australia.
12. Study Figure 14.5.4. By how much has the economic value of Australia's education exports increased between 2005 and 2014?
13. Study Figure 14.5.6. During which periods has Australia experienced a positive balance of trade?
14. Study Table 14.5.7. Rank Australia's principal trading partners from the largest to the smallest in terms of the total value of trade.

Investigating

15. Access Austrade's website. Locate the most recent export and import data. Identify any changes in the nature and direction of Australia's international trade. Present your findings as an oral report.

14.6

Electronic consumer goods

Electronics at home

It is now normal for many Australian homes to have flat-screen or digital televisions, personal computers, laptops or tablets, sound systems, wi-fi, digital cameras and mobile phones. This is very different from the 1950s, when the typical household had only one radio and a telephone. Since that time there have been waves of new products hitting the market.

Declining costs of electronics

The main factor influencing the astounding growth of electronic products is the steady fall in the relative price of these products. This has been possible because of the development of mass production methods. Mass production is carried out in highly automated factories located in places with low labour costs.

Purchasing electronic goods

The countries with the highest average incomes have generally been those that have seen consumer electronics goods purchased in the largest quantities and spread most quickly.

However, there are differences between countries with similar levels of wealth. The graphs in Figure 14.6.1 show the differences in usage of ten electronic products in six of the wealthiest countries of the world.

The raw materials for electronics

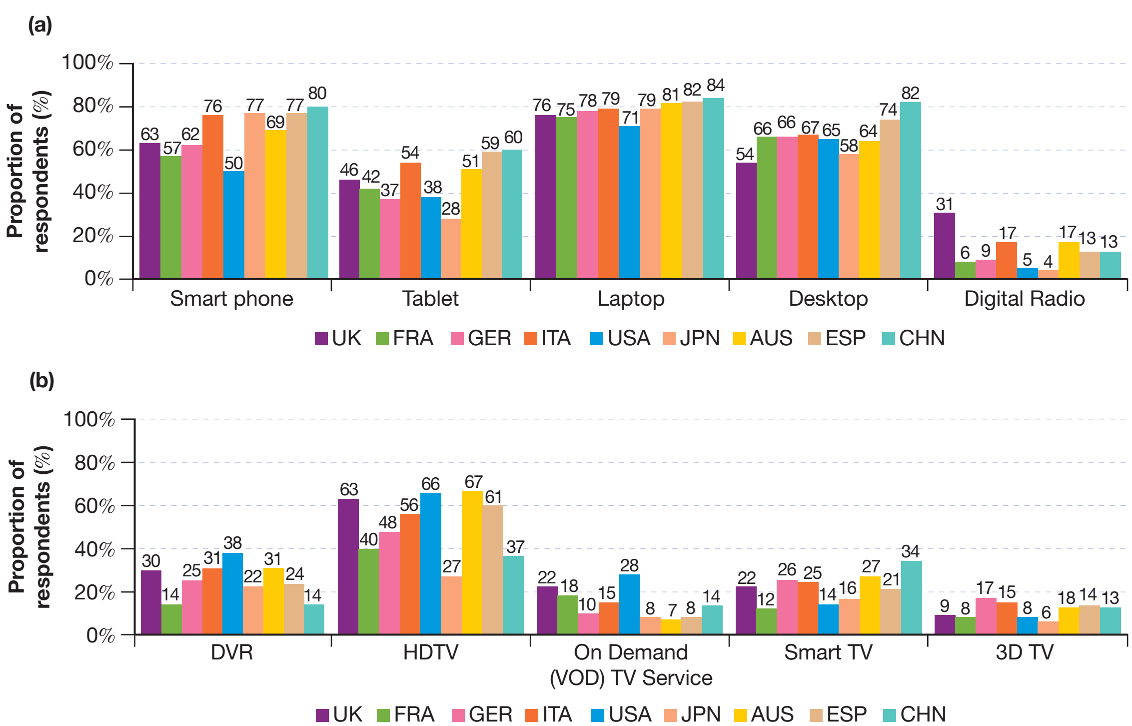
Metals

There is a range of metals used in the production of electronic devices. Copper has always been important because it conducts electricity well. Tin, silver, lead, aluminium, nickel and chromium are also found in many everyday electronic products.

Petrochemicals

Two of the other key raw materials in electronics are plastics, which are derived from petrochemicals, and silicon. Silicon is a commonly occurring mineral found in quartz, amethyst, flint and jasper. Petrochemicals are the chemical materials obtained from oil. Most of the electronic devices we use contain microprocessors, integrated circuits and printed circuits. These are all made from petrochemical-based products. The bodies of the electronic devices are also made mostly of plastics derived from petrochemicals.

14.6.1 Ownership and use of electronic devices, 2014



Environmental effects of electronics

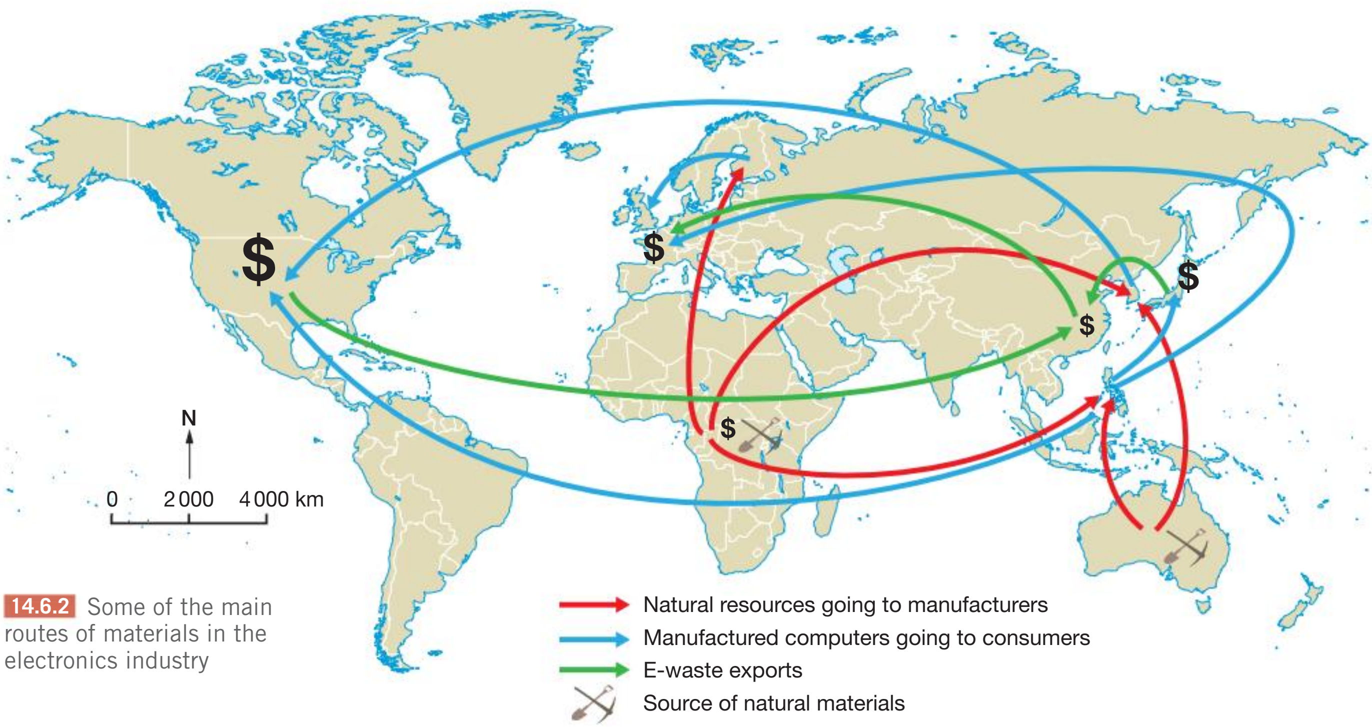
The standby power used by electronic devices in the home when they are not turned off accounts for 5 to 10 per cent of the electricity consumed in the average household.

Some electronic devices now carry 'energy stars' in a similar way to household appliances. Solid state drives use less power and are being used in an increasing range of devices.

Some electronic gadgets are now being promoted for their 'green-ness'. However, if you buy one of these and throw out an older item, you are in fact using more of the earth's resources, because of the amount of energy and raw materials used in making and transporting the new purchase.

World cycle of the electronics industry

Figure 14.6.2 shows some of the main routes of materials in the electronics industry. It is drawn to show generalised patterns, not the particular routes of every material. The raw materials are shown travelling from Australia and Africa, but these locations only account for metals and silicon materials. Petrochemicals come from many other countries which export oil. The manufactured computers are shown being transported from eastern Asia to Europe, Japan and the United States of America, but there are obviously many other buyers. The waste is then shown being taken back to China, as a representative country used for disposal of outdated electronic equipment. India is another major destination of electronic waste.



14.6.2 Some of the main routes of materials in the electronics industry

ACTIVITIES

Knowledge and understanding

1 Explain why the number of electronic goods in households in wealthy countries is growing so fast.

2 Outline the environmental effects of the electronics industry.

Geographical skills

3 Study Figure 14.6.1 and do the following tasks.
   - a Identify the four devices with the highest take-up.
   - b Name the countries that have the highest overall ownership of these four devices in general.
   - c HDTV shows the greatest difference in take-up between countries—Australia at 67 per cent and Japan at 27 per cent. Can you suggest reasons for this?
   - d Name the device with the next greatest difference in take-up.

Investigating

4
   - a Make a list of the electronic devices in your home.
   - b Which of them do you have more than one of?
   - c Ask your parents how many electronic devices they had in their homes when they were your age.

14.7

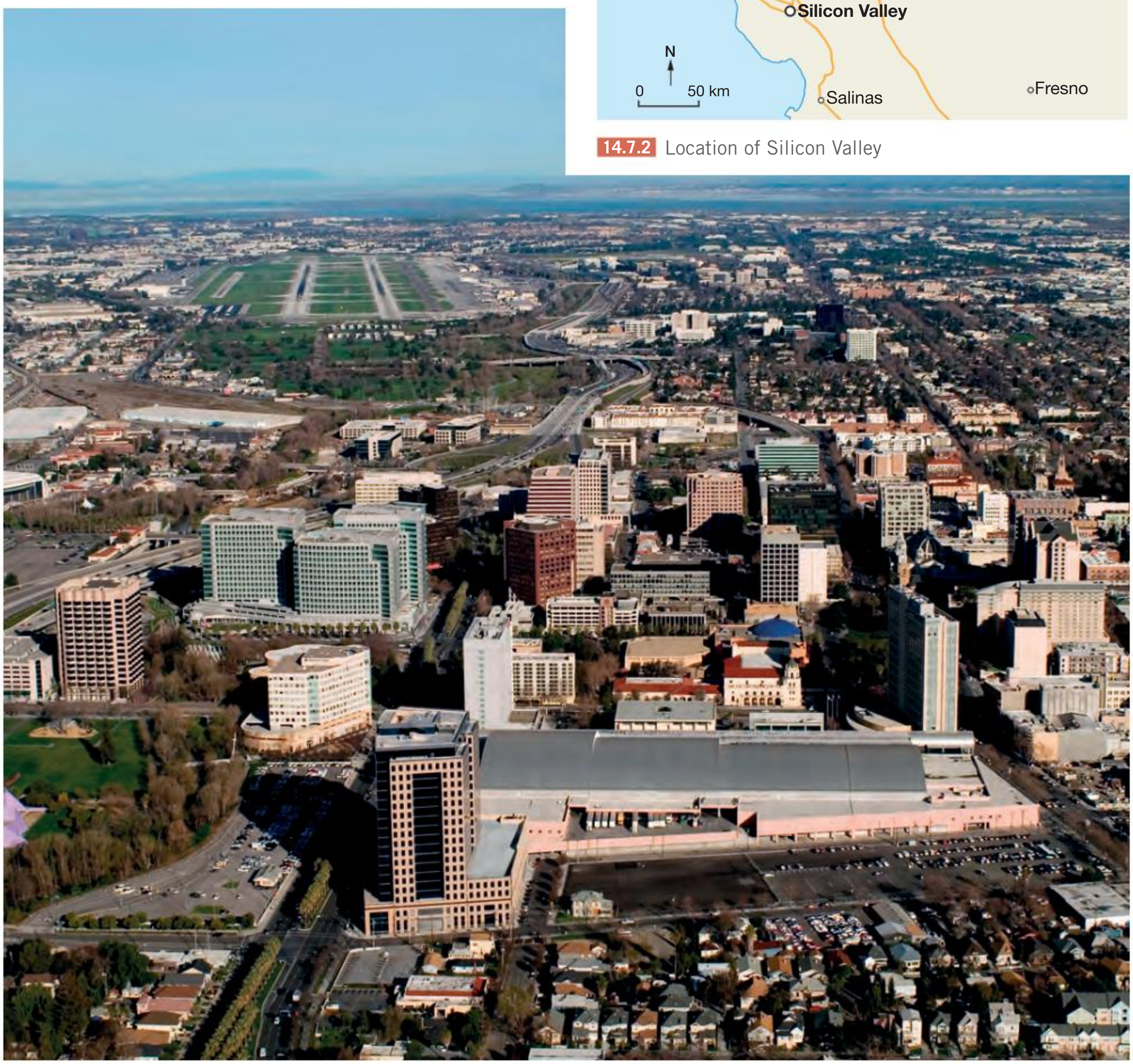
Silicon Valley

Location

Silicon Valley, shown in Figure 14.7.1, is located in the Santa Clara Valley at the southern end of San Francisco Bay in California, United States of America (see Figure 14.7.2). The area is located around Stanford University, one of the world's leading institutions in electronics and engineering.

14.7.2 Location of Silicon Valley

14.7.1 Downtown San Jose, the principal urban centre in California's Silicon Valley



Reasons for growth

A number of factors have contributed to the rapid growth of the Santa Clara Valley as a centre for innovation and high-tech industry.

The growth of Silicon Valley as an IT hub began in the 1950s, when Stanford University leased half of its land to establish a high-technology industrial park. Within three years a number of large businesses had moved into the area, including General Electric, Hewlett-Packard and Lockheed. Stanford also established a research institute to promote collaboration with these firms. The aim was to create a community of 'technical scholars' by encouraging the business and the academic community to work together.

In the 60 years that followed, the area continued to grow and attract firms from a range of industries, including aeronautics, aerospace, computer programming, and software and internet development. A large number of **venture capital** firms (providing funds for start-up businesses) and semi-conductor manufacturers also located in the region.

Today, Silicon Valley employs more than 250 000 information technology workers and hosts the head offices of thousands of high-technology businesses, including IBM, Facebook, Adobe Systems, Apple Inc., eBay, Google, Hewlett-Packard, Intel, Xerox and Yahoo. The mix of businesses in the area is always growing and changing. Of the top fifteen companies in Silicon Valley, 80 per cent were formed in the past 20 years. These businesses account for more than US$600 billion in revenue, and employ approximately three-quarters of the people in the region.

Why firms cluster in this area

A range of factors have made Silicon Valley an attractive place for high-technology firms to locate. Proximity to other similar businesses is one of the key attractions. Being close together promotes a cross-fertilisation or sharing of ideas. By clustering, or grouping together, executives can keep up to date with the latest developments in the industry and conduct important business meetings face-to-face. These social networks give Silicon Valley its innovative edge and enable businesses to respond flexibly to changes in technology and economic conditions. Silicon Valley also provides businesses with access to a large pool of highly skilled employees, including graduates of the neighbouring Stanford University and the University of California.

Another important advantage of this location is the large number of venture capital firms in the region. These firms provide start-up funds for new companies in return for a share of the future business profits. Many highly successful technology companies in Silicon Valley have used venture capital to establish themselves.

SPOTLIGHT

Timeline of industry development in the Santa Clara Valley

1891 Stanford University founded.

1900 Santa Clara Valley dominated by fruit orchards.

1909 First radio station in the United States of America established in San Jose. Over the next 10 years the world's first global radio communications system developed here for the US Navy.

1930s San Francisco Bay area attracts aeronautics and aerospace research firms.

1951 Stanford Industrial Park established, enabling high-tech businesses to work in close partnership with Stanford University.

1956 Nobel Prize in Physics awarded jointly to William Bradford Shockley, John Bardeen and Walter Houser Brattain for their research on semi-conductors and their discovery of the transistor effect.

1968 Robert Noyce and Gordon Moore form Intel (Integrated Electronics Corporation) and locate their offices in Santa Clara Valley.

1971 Intel creates the world's first microprocessor/semi-conductor. The Santa Clara Valley becomes a magnet for a broad range of high-tech companies.

1990s At the height of the dot.com boom Silicon Valley hosts more than 500 000 high-tech businesses. One-fifth of the world's 100 largest high-tech companies have a presence in the valley.

2000 While the dot.com crash of the late 1990s results in a slowing of the Valley's economic and population growth rate, it retains its status as one of the top research and development centres in the world.

Challenges

The Valley's emergence as a high-tech centre brought with it a range of challenges.

Housing and environment

The emergence of the high-technology sector has promoted rapid population and urban growth in Silicon Valley. Today, 1.8 million people live in the Valley's cities and towns. Much of the Valley's population growth has been fuelled by interstate and international migration.

While this growth has been good for local businesses it has also pushed up property prices, making housing less affordable. The increased population and housing density of the Silicon Valley has also created environmental problems. Traffic congestion has increased and employees are spending longer periods of time travelling to and from work. One response to this problem has been the development of housing to accommodate multiple families. The government has also developed an urban plan to ensure that new homes are built close to sources of employment.

Human wellbeing

Due to the concentration of highly skilled workers in the Valley, the region has one of the highest average incomes in the United States of America. It also has one of the highest costs of living in the country—60 per cent higher than the national average. The high cost of housing is a major contributor to this problem.

Levels of employment and average incomes in Silicon Valley are also highly dependent on the performance of the global high-technology sector. The economy has had to reinvent itself several times in response to a number of downturns in the industry, which are shown in Figure 14.7.3. The dot.com crisis of the late 1990s forced many businesses to close down, resulting in increased levels of unemployment. The number of new start-up businesses also declined from 3500 in the boom to approximately 1000 today.

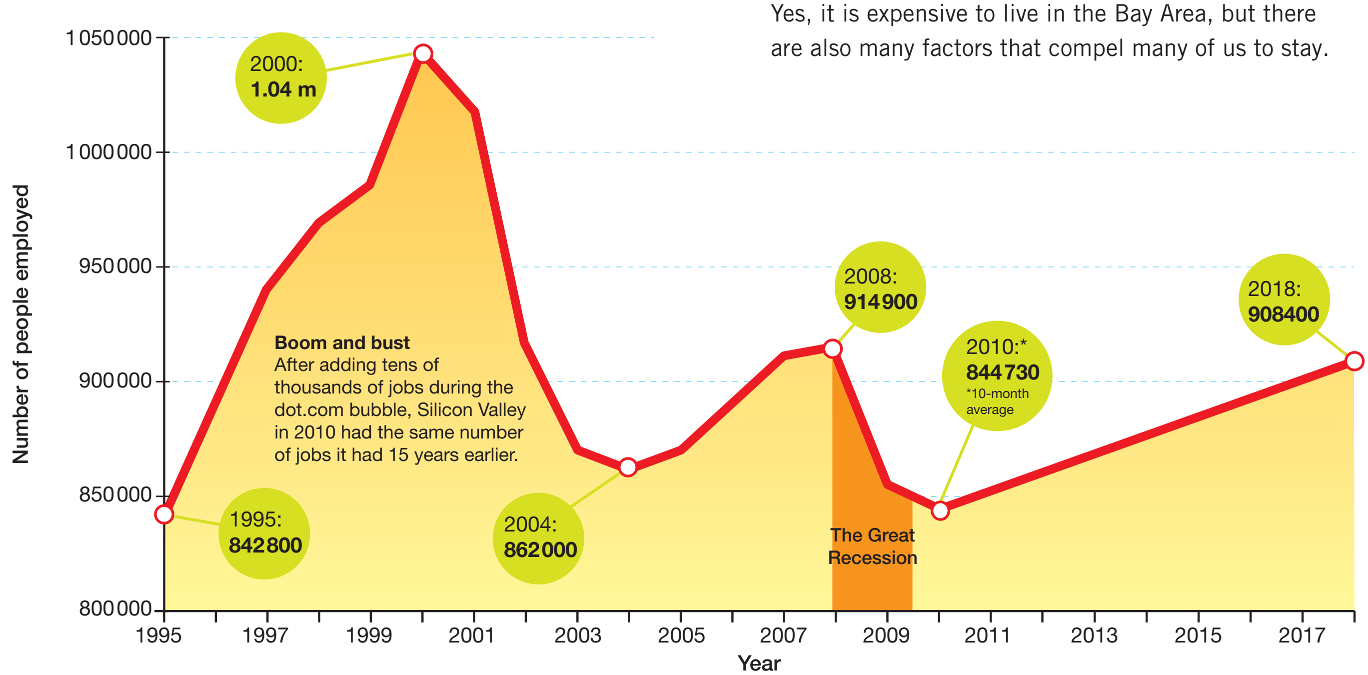
Demographics

Silicon Valley is also struggling to retain its highly qualified workforce. Many young workers leave the area when they decide to start a family. When compared with the total US population, Silicon Valley has a higher proportion of people of working age (25–64 years of age) and a lower proportion of children, as is shown Table 14.7.4.

Despite these disadvantages, people continue to make the choice to live and work in Silicon Valley. One long-term resident and IT employee explained the reasons for this on his blog:

> … the Bay Area is the epicentre of innovation and education … the area has a rich history of offering many entrepreneurs and job seekers plenty of opportunities. (Lots of people have found their fortunes here with start-ups, stock options and, until recently, real estate). We also have incredible access to mountains, beaches, wine country, snow, and major metropolitan cities with numerous cultural venues, restaurants, shopping, waterways and more. You could ski in Lake Tahoe in the morning and make it back to San Francisco for an evening on the town. In addition, we enjoy some of the best weather in the country. Yes, it is expensive to live in the Bay Area, but there are also many factors that compel many of us to stay.

14.7.3 Employment in Silicon Valley, 1995–2010



> **DID YOU KNOW?**
> In 2010, the median house price in San Jose was US$602 000. The average house price in the USA was US$173 000.

14.7.4 Population statistics for Santa Clara County, California and the USA

Population quick facts	Santa Clara County	California	USA
Population change, 2010 –2014	6.3%	10.0%	3.3%
Persons under 5 years, 2014	6.5%	6.5%	6.2%
Persons under 18 years, 2014	23.1%	23.6%	23.1%
Persons 65 years and over, 2014	12.2%	12.9%	14.5%
Female persons, 2014	49.7%	50.3%	50.8%
Persons reporting two or more races, 2014	4.0%	3.7%	2.5%
Foreign-born persons, 2010–2014	37.4%	27%	13.1%
Language other than English spoken at home, aged 5+, 2010–2014	51.6%	43.8%	20.9%
Bachelor's degree or higher, persons aged 25+, 2010–2014	47.3%	31.0%	29.3%
Home ownership rate, 2010–2014	57%	54.8%	64.4%
Median gross rent, 2010–2014	$1637	$1243	$920
Median value of owner-occupied housing units, 2010–2014	$664 100	$371 400	$175 700
Persons per household, 2010–2014	2.94	2.95	2.63
Median household income, 2010–2014	$93 854	$61 489	$53 482
Persons below poverty level, 2014	8.5%	16.4%	14.8%

Source: US Census Database

ACTIVITIES

Knowledge and understanding

1. Describe the location of Silicon Valley.
2. Explain the origins of the name 'Silicon Valley'.
3. Name five high-technology firms located in the Santa Clara Valley.
4. Explain why high-tech firms cluster.

Applying and analysing

5. Describe the impact of rapid population growth on Silicon Valley.
6. Create a PMI chart about working and living in Silicon Valley.

Geographical skills

7. Study Table 14.7.4 and answer the following questions.
   a. How does the rate of population growth in Santa Clara County compare with the national average?
   b. How does the age structure of Santa Clara County differ from the age distribution of the total US population?
   c. What is the percentage difference in the average value of owner-occupied housing in Santa Clara County and the USA as a whole?
   d. What is the percentage difference between average household income in Santa Clara County and in the USA as a whole?
   e. Suggest possible explanations for the above differences.

Investigating

8. Select one high-tech firm located in Silicon Valley. Undertake research to find answers to the following questions.
   a. What does the company produce?
   b. When was it was established?
   c. How is it connected to other businesses in the area?

14.8

CASE STUDY: Designing for the world—Cupertino, USA

Cupertino

Cupertino is a city in California, in the area known as Silicon Valley. It has this name because of the concentration of computer hardware and software firms using the silicon chip as the central invention of their business.

Major businesses

Cupertino is the headquarters of Apple Inc., one of the largest and most influential companies in the world. Oracle and Hewlett-Packard also have a presence there. These companies have played an important role in the technological revolution that has changed the ways in which people work and interact. In total, sixty high-tech firms of different sizes can be found in the city.

Cupertino's growth and development

Until the 1960s, Cupertino was a small town in the centre of a fruit-growing area just to the south of San Francisco Bay. In that decade, some local landowners set up an industrial and technology park to attract firms specialising in the new growth area of electronics. Hewlett-Packard, a small firm making the newly invented electronic calculators, was one of the firms to buy land in the park.

Other firms making or designing computers, calculators or the software to run them were attracted to the area by a number of factors. There was the encouragement of local government and landowners. The area was easily accessible to the large and important cities of Los Angeles, San Francisco and the cities surrounding San Francisco Bay. Within these cities there were a number of world-class universities producing graduates with ideas, enterprise and knowledge.

The area also had a warm and pleasant climate that appealed to many of the graduates, who wanted to live in a place that was at the centre of new ideas, but also offered good living, recreation and opportunity.

From its initial growth, Silicon Valley quickly gained a reputation for being the centre of the world's computer ideas industry, and that reputation then attracted people from all over the world, and from Asia in particular.

Population and employment

The population of Cupertino is now 60 000, having grown from just a few dozen in the 1950s. The city's population is unusual in a number of ways. It has been described as one of the most highly educated small towns in the United States of America because of the university qualifications held by many of its residents. Furthermore, 63 per cent of residents are of Asian origin, attracted there by the opportunities that draw on their knowledge and skills.

The companies in Cupertino mostly work on ideas, development, design, promotion, software production and marketing. Most of the actual building of the computers and other pieces of hardware equipment is done in other countries, where labour is cheaper. Figure 14.8.1 shows Cupertino's largest IT employers and the number of workers they employ. The incomes of people working at the high end of the businesses are correspondingly high, leading to a high spending power for services and retail establishments in the area. The average household income in Cupertino is US$118 000 compared to the average for the whole state of California of US$58 000.

14.8.1 Largest IT employers in Cupertino

Employer	Number of employees (2010)
Apple	34 300
Oracle	8 000
Hewlett-Packard	3 000
ArcSight	512
Chordiant	285
Trend Micro	250

14.8.2 An artist's impression of Apple's new corporate headquarters under construction in Cupertino

Cupertino's constructed environment

Cupertino has no easily identified central business district. Instead, it has a number of shopping malls scattered throughout the city. The city is made up of districts based on housing developments set up at different times. Each of these housing developments has its own character and price range, but generally they are made up of relatively expensive housing for high salary earners. The average value of houses in Cupertino is about US$900 000 compared to the average for California of US$350 000.

Besides a major tertiary college and nearby universities, Cupertino has a number of schools that rank highly in the league tables of American schools.

The significance of Cupertino

Cupertino is an example of a new type of city—one that is based on the building of product ideas rather than manufacturing things. As a result, it does not have to be near a source of coal, or iron or some other raw material. It does not even have to be near a source of labour, because it can attract workers to it. What it needs nearby are universities and other educational institutions, and easy access to the rest of the world through good transport systems and excellent communications.

The development of information and computer technologies, particularly the World Wide Web, have meant that the headquarters of businesses (see Figure 14.8.2) do not need to be near the factories making their products, or in any particular location. They can be where the owners want to live, or where they can attract the best staff, or where they can be in touch with firms that give them business advantages.

ACTIVITIES

Knowledge and understanding

1 Identify the location factors that were most important in the early days of Cupertino's development. Which locational factors do you think are most important now?
2 Outline the ways in which Cupertino differs from the rest of the USA. Explain why.

Applying and analysing

3 Make a list of some of the new inventions in communications and transport that make it possible for the headquarters of a large company to be so far away from the factories manufacturing its products.
4 Make a list of the various reasons given in this unit for the main function of Cupertino as a headquarters for design and development of products, rather than a manufacturer of mass-produced consumer goods.

14.9

CASE STUDY: Apple Inc.

Popularity of Apple Inc.

Products made by Apple Inc. are among the most desired consumer products in the world. Apple's bitten apple has become one of the world's most readily recognised icons (see Figure 14.9.1). Young people queue for days outside Apple stores just to be among the first to buy the latest technology. Apple has achieved a level of **brand loyalty** rarely seen in the commercial world. Many Apple users will update their technology every time a new model is released.

14.9.1 Apple iPods, iPhones, iPads and MacBooks are the must-have electronic goods of the modern age.

History of Apple Inc.

Apple Inc., manufacturer of the iPod, iPhone and iPad, is an example of a highly successful IT company with truly global links and strong brand loyalty. Apple employs more than 76 000 people globally and locates its various functions (design, marketing, manufacturing and assembly) in parts or the world where they are most efficient and profitable. Its worldwide annual revenue in 2012 totalled US$156 billion.

Apple Inc.'s world corporate headquarters are located in Cupertino in the middle of Silicon Valley, California, United States of America. This region of northern California hosts the headquarters of thousands of high-tech businesses. These companies cluster (locate in the same region) so they can benefit from each other's services, conduct business face-to-face and take advantage of the concentration of technically skilled people in the area.

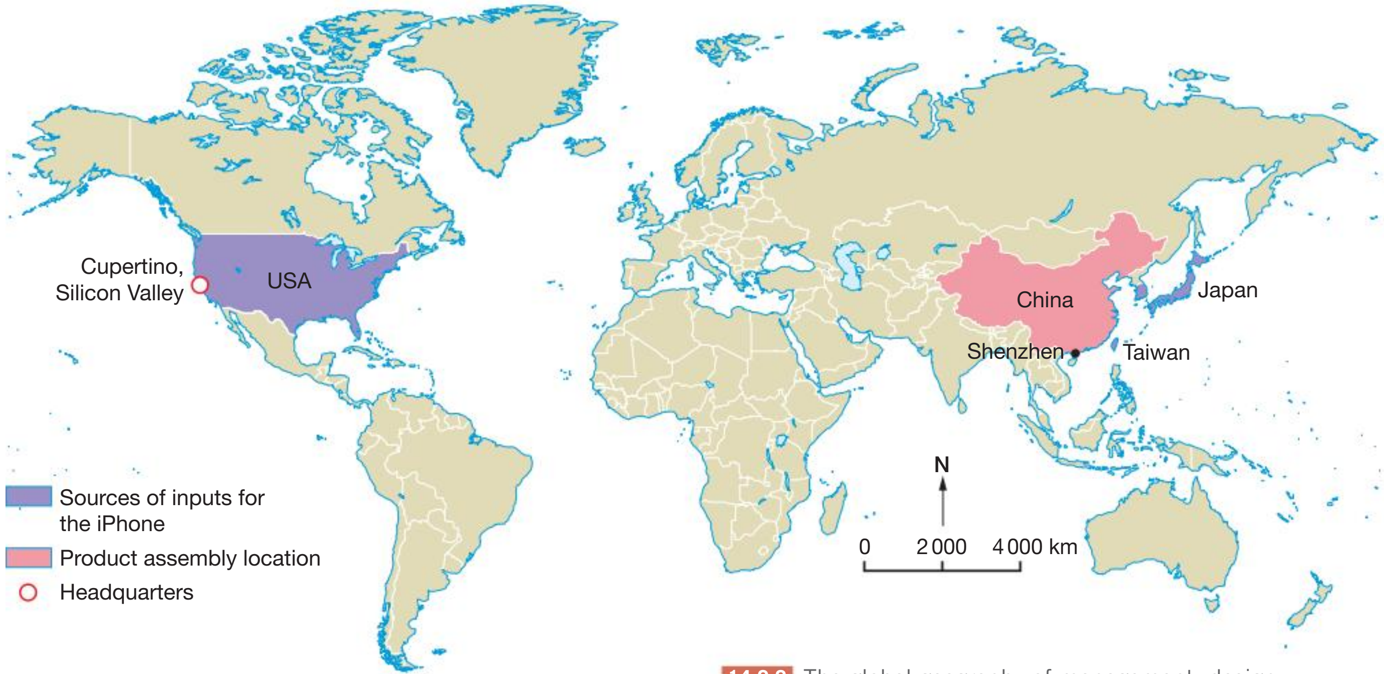
Effective marketing has been a key component of Apple's success. Marketing includes decisions about how products look and feel, what they are made from, where they are manufactured, how they are distributed and what prices they are sold for. Within Apple Inc., these strategic decisions are also made in the company's headquarters in Silicon Valley.

Geography of production

Apple has one of the world's most efficient and globalised production processes, with manufacturing and final assembly taking place in several countries. The iPhone's components are from America, Taiwan, Korea and Japan. The final assembly of these products currently takes place in Shenzhen, China (see Figure 14.9.2). Apple uses numerous suppliers and allocates them specific tasks. This enables Apple to source a range of expertise and remain responsive to the demands of customers.

Apple also goes to significant lengths to protect its ideas. It keeps leaks to a minimum by providing suppliers with information on a 'need to know' basis and by allowing individual employees to see only a small component of the total production process prior to the launch of a new product. They also insist that suppliers produce customised inputs rather than mass-produced components, making it difficult for these firms to supply parts to Apple's competitors.

Secrecy is also maintained using high levels of security. According to some media reports, the Longshua manufacturing plant in China resembles a self-contained 'industrial fortress'. The plant has very high security and employees are checked with fingerprint scanners when they arrive for work. Metal detectors are also used to ensure that employees do not leave the factory with components of Apple products. The factory includes places for employees to sleep, along with food stalls, banking facilities and a post office. Employees have little need to leave the complex and this helps to keep production ideas confidential.



14.9.2 The global geography of management, design and production at Apple

Ethical issues

Over the past decade, Apple has faced a number of environmental and labour-practice challenges.

Environmental

Following a successful campaign by Greenpeace in 2003, Apple became the first laptop manufacturer to eliminate dangerous chemicals (PVC and BFRs) from its products. The company produces an annual report detailing the environmental impacts of its activities and has reduced its carbon footprint by changing the way its products are manufactured, used and recycled.

Labour practices

Apple has faced criticisms about labour practices and **sweatshop** conditions in the contracted companies producing its components. In 2006, a number of newspapers ran reports claiming that some of Apple's suppliers in China required employees to work more than 60 hours a week for salaries of less than $120 a month. The reports also claimed that workers were required to live on site and pay more than 50 per cent of their salaries back to their employer to cover their rent and food expenses. In response to these challenges, Apple established a Supplier Code of Conduct, which states that contractors are required to provide 'safe working conditions, treat workers with dignity and respect, and use environmentally responsible manufacturing processes'. Since 2007, Apple has also conducted yearly audits of the working practices to ensure that suppliers are 'socially responsible' and comply with strict workplace regulations. These audits are made available to the public on Apple's webpage.

ACTIVITIES

Knowledge and understanding

1. Outline the measures Apple has put in place to protect its ideas (intellectual property).
2. Describe the changes Apple has made to reduce its environmental impact.
3. Outline the strategies Apple has put in place to address labour issues and ensure that its operations are socially responsible.

Applying and analysing

4. Explain why Apple uses multiple firms in different places to produce and assemble its products.
5. Describe the location of Apple's headquarters and marketing functions. Suggest two advantages of this location for Apple.
6. Brainstorm the advantages and disadvantages of subcontracting (using external businesses) to manufacture and assemble products. Think about the views of the global companies, employees and local communities.

Investigating

7. Access the Apple website and locate the company's latest environmental report. Draw up a table summarising the issues identified and the company's responses to these issues.

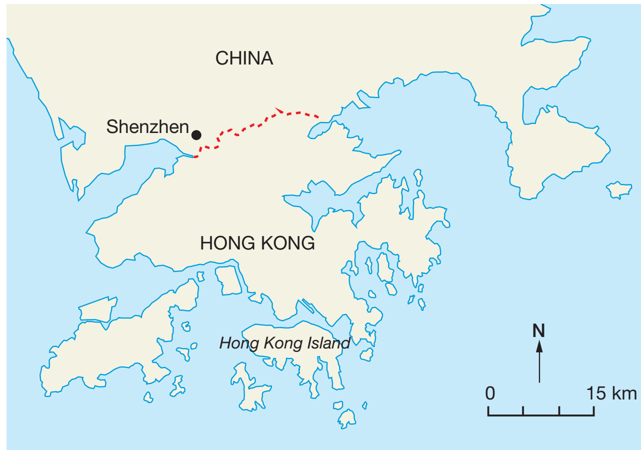
CASE STUDY:
Shenzhen: the world's factory

Shenzhen

Shenzhen is one of China's main industrial cities (see Figure 14.10.1)—only Beijing, Hong Kong and Shanghai are more important. Many of the world's top 500 enterprises and well-known multinational companies have established a presence in Shenzhen, including many of the world's top brands in the high-tech industries. The city is the country's richest urban centre on a per capita basis.

Special Economic Zone

Until 1979, when it was named one of China's first Special Economic Zones (SEZ), Shenzhen was a small and fairly insignificant town. At the time, its population was just 300 000. Today, the population is thirty times that figure and the city has grown to accommodate this increase (see Figure 14.10.2). The present population of 10 million includes 6 million immigrants, who are registered as temporary workers, nannies, service workers and cleaners.



14.10.1 Shenzhen's proximity to Hong Kong has been a key factor in the city's emergence as a major industrial centre.

14.10.2 In just over 30 years, Shenzhen has emerged as one of the world's great industrial and commercial centres.

Shenzhen's growth

The growth of Shenzhen started when it became an SEZ. This designation gave it advantages in exporting goods, obtaining labour, setting up joint ventures with foreign companies, and obtaining tax advantages. The other factor that gave it huge advantages was its proximity to Hong Kong. Before 1997, Hong Kong was not part of China. It was a British colony with booming industries, a major port and a free economy. The new leaders of China saw Hong Kong as a model and partner for the type of industrial city they wanted.

Shenzhen's industries

Shenzhen factories produce a range of consumer goods, with a focus on electronics. These include computer software, telecommunication equipment and medical instruments. Meanwhile, newer industries such as pharmaceuticals, medical equipment, biotechnology and new materials have also grown rapidly. Electronics and telecom equipment manufacturing remains the city's largest industry.

Toys are also a major product of the whole region. According to one estimate, one million workers produce about 50 000 different toy models in Shenzhen. The largest of these factories employ up to 15 000 workers, who work, live and sleep in the factory complex. Many of these workers go back to their homes in other regions of the country only once a year.

One Shenzhen-based company is now the second-largest battery maker in the world. Its factory is half a million square metres in size. Another Shenzhen firm makes 100 000 laptops each month and is aiming to be the world's largest computer maker by 2020.

New industrial parks

Shenzhen, like many other industrial cities, is now trying to locate factories in special industrial parks, away from residential and retail areas. There are advantages for the factories in transport, parking, power supplies and waste disposal. Shenzhen has recently established a high-tech industrial park and, adjoining it, a software park.

Population

The rapid growth of Shenzhen's population has been fuelled by young people migrating from other parts of China. The average age of the population is less than 30. Only one per cent are aged 60 years or above. The population can be generalised as fitting into two main groups. One of these is highly educated people with specialist skills in electronics, computer software, design and management. The other group is the larger group of poorly educated migrant workers who have been attracted by the abundance of unskilled jobs.

Human wellbeing

There are both advantages and problems for the workers in Shenzhen. The enormous growth of industry and exports has provided millions of jobs to people who needed them. China's expanding population would have found it difficult to achieve a reasonable living without this kind of growth.

At the same time, the location of jobs in Shenzhen has meant that people have had to travel and live far from their homes if they are to secure employment.

The jobs in industry pay wages that are higher than those in some other occupations and regions in China, but are low by world standards. Some factories have been accused of paying workers less than a dollar an hour, and making employees work long hours without adequate benefits.

Connections with the rest of the world

Almost all the products made by factories in Shenzhen are for export overseas. This was the purpose of the SEZ, and it has been highly successful in Shenzhen. The exported goods go mainly to the United States of America and Japan. Many of them also are sent to Hong Kong, where they may be repackaged before export. Shenzhen imports oil, foodstuffs, computers and electronic equipment from other countries, mainly the USA and Japan. Because it is an industrial city, Shenzhen does not attract many tourists, but this is slowly changing.

ACTIVITIES

Knowledge and understanding

1 Name the three Chinese cities more important than Shenzhen.

2 Describe the demographic character of Shenzhen and the level of wellbeing experienced by its residents.

3 Outline Shenzhen's connections with the world.

Applying and analysing

4 a Describe the purpose of the SEZs in China.

b Why do you think that China developed these zones?

c What advantages have they created for China?

5 The average age of people in Shenzhen is significantly lower than the average age for China as a whole. Suggest some reasons for this.

14.11

Fast fashion's global reach

Fast fashion

Fast fashion is the name given to the process by which international clothing retailers are able stock the latest fashion trends in their stores within weeks of their appearing on the Fashion Week catwalks of London, Paris, Milan and New York. Fast fashion reflects the extent to which global brands and retailers now dominate the clothing industry.

Fast fashion retailers

Fast fashion retailers include some of the biggest names in the industry. Firms such as Cotton On (Australian-based), Esprit (USA), Forever 21 (USA), Gap (USA), H&M (Sweden), Topshop (UK), Uniqlo (Japan) and Zara (Spain) have recently entered the Australian market, challenging the dominance of established clothing retailers, especially department stores such as David Jones and Myer.

Origins of fast fashion

Fast fashion had its origins in the manufacturing model referred to as 'quick response' developed in the USA in the 1980s. Zara, owned by the Spanish Inditex group (the world's largest multinational clothing company), has been at the forefront of applying this approach to fashion retailing. Zara's collections are based on the most recent fashion trends and their supply chain has been designed to manufacture products quickly and inexpensively. This allows the mainstream consumer to buy current clothing styles at a lower price.

Fast and efficient supply chains are central to the success of fast fashion retailers. Supply chain systems are designed to add value and reduce cost in the process of moving goods from design to the manufacturer, to the retail outlet and finally through to the consumer. Zara, for example, is able to manufacture over 30 000 units of its products every year and distribute them to its 2000 stores in eighty-eight countries. New items are delivered twice a week to the stores. The pace of supply enhances consumer choices and product availability while significantly increasing the number of customer visits.

DID YOU KNOW?

Every year, an estimated 80 billion garments are created. In the developed world, on average, a woman now has four times as many clothes in her wardrobe as she did in the 1980s.

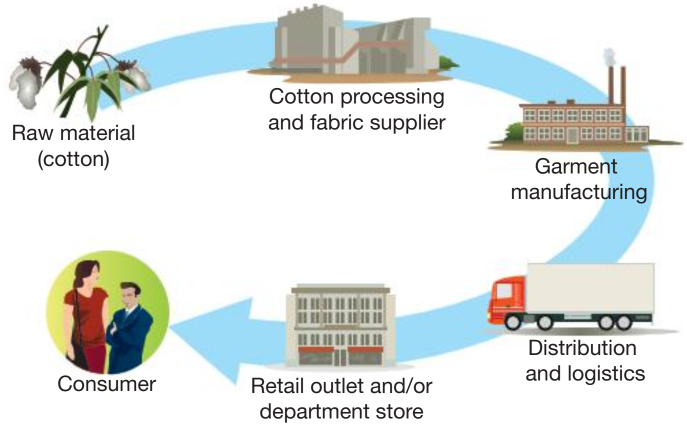
Structure of the fashion industry

There are four key components of the fashion industry:

- the production of raw materials, principally fibres, textiles and leather
- the production process—designers and manufacturers
- advertising and promotion
- retailing.

The clothing manufacturing process is illustrated in Figure 14.11.1.

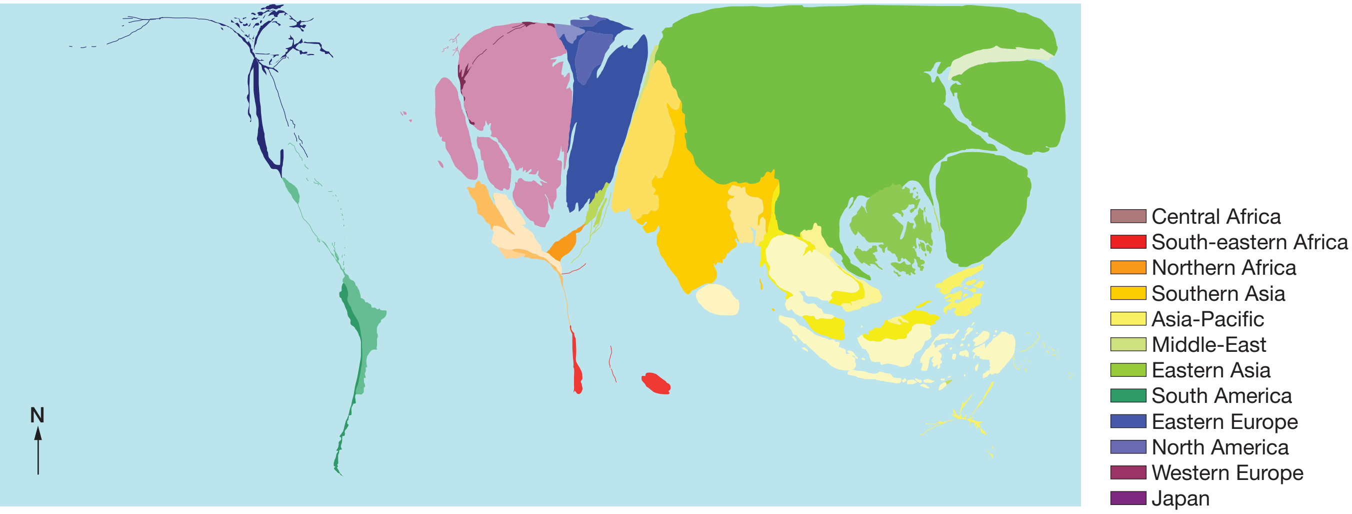
14.11.1 Key components of the fashion industry



The global fashion industry

While the fashion industry originated in Europe and then spread to the United States of America, it is, today, a truly global undertaking, with clothing often designed in one country, manufactured in another, and then sold worldwide. An Australian-owned surfwear company might, for example, buy its cotton fabric from Chinese mills, have the garments sewn and screen-printed in Vietnam and then ship the product to distribution centres in Australia, the USA and Europe to be sold by retailers internationally. High-end fashion houses might weave Australia's finest merino wool into cloth in Italian fabric mills before shipping the cloth to tailors in China, who transform it into expensive business suits using designs generated in the fashion houses of Milan, Italy (see Figures 14.11.2 and 14.11.3).

14.11.2 Worldmapper map showing clothing exports



14.11.3 Worldmapper map showing clothing imports

Marketing fast fashion

Marketing is central to the success of the fast fashion industry. Advertising creates a demand for the latest designs. Within the industry this is achieved by promoting fashion consumption as something fast, low-priced and disposable. The continual release of new products has the effect of making the garments the marketing tool. It drives consumer visits and increases brand awareness. The outcome is higher sales and profit.

The commercial success of this clothing retail sector is based on the consumers' desire for new clothing to wear. In order to meet consumer demand, fast fashion brands provide affordable prices and a wide range of clothing that reflects the latest trends. This ends up persuading consumers to buy more and more. Critics of fast fashion argue that this results in overconsumption. They also criticise the **built-in obsolescence** evident within the fast fashion industry. Last year's fashions are designed to be replaced by this year's, even though the old ones are still wearable.

Impacts of fast fashion

The built-in obsolescence of fast fashion is not only about trends. Most of the clothing is poorly made, using cheap fabric, meaning the clothes will not survive multiple launderings. These clothes often end up in landfill. In Australia, an estimated A$140 million worth of clothes or 1.2 million tonnes ends up in landfill every year. Clothing not worn is also donated to charity shops, and according to the Australian National Association of Charitable Recycling Organisations, of the 50 million kilograms of textile waste collected annually through charity bins and donations, an estimated 12.5 million kilograms is unsuitable for reclamation and is sent to landfill. Additionally, most fast fashion clothing is made from synthetic fibres. These are not easily recyclable and do not biodegrade as quickly as natural fibres.

14.11.4 Liquid and cloth waste from the dyeing factories, Dhaka, Bangladesh. The chemicals used are released directly into the Turag River.

Environmental impacts of fast fashion

The two main types of fibres used in the fashion industry are synthetic (nylon and polyester) and natural (cotton). Synthetic fibres are increasingly used in the fast fashion industry because it is becoming cheaper to produce these fibres. Synthetic fibres are now more popular than cotton and make up nearly 60 per cent of all fibres used worldwide. Synthetic fibres are created from oil and it takes about 70 million barrels of oil just to produce the virgin polyester used in fabrics each year. To grow cotton, large amounts of pesticides are required, as well as water. For every 1 kilogram of cotton to make a pair of jeans, about 11 000 litres of water are required to grow and pick the cotton and then produce, pack and ship the final product.

The textiles industry requires large amounts of water to dye and rinse natural and synthetic cloth, as well as steam for printing and pressing fabric. To make 1 kilogram of cloth requires 120–170 litres of water. In Dhaka, Bangladesh, after implementing water-saving plans and technology, some factories have reduced this amount to 60 litres.

It is estimated that for every 1 tonne of textiles produced, 200 tonnes of water are polluted (see Figure 14.11.4). The not-for profit Institute of Public and Environmental Affairs (IPE) estimates that China's textile industry discharges about 2.5 trillion litres of wastewater into its rivers each year.

Opposing fast fashion

Fast fashion is often associated with 'disposable fashion' because it delivers a designer product to a mass market at relatively low prices. The 'slow fashion' movement has developed in opposition to fast fashion. It blames fast fashion retailers for emphasising short-term fashion trends over classic style. It also accuses the fast fashion sector of contributing to the exploitation of workers in developing countries such as Bangladesh, and causing pollution associated with production processes and the decay of synthetic fabrics.

Worldwide Responsible Accredited Production (WRAP)

WRAP is a not-for-profit organisation established by global fashion and clothing companies to monitor and certify clothing manufacturing facilities' compliance with set standards. In 2016, there were 2153 WRAP-accredited factories worldwide, employing around 1 924 782 people. The companies must comply with set standards in the following areas.

- laws and workplace regulations
- prohibition of forced labour
- prohibition of child labour
- prohibition of harassment or abuse
- compensation and benefits
- hours of work
- prohibition of discrimination
- health and safety
- freedom of association and collective bargaining
- environment
- customs compliance
- security

SPOTLIGHT

Clean Clothes Campaign

The Clean Clothes Campaign is a non-government organisation dedicated to improving working conditions and supporting the empowerment of workers in the global garment and sportswear industries. They do this by educating and mobilising consumers, lobbying companies and governments, and offering direct support to workers as they fight for their rights and demand better working conditions.

The Clean Clothes Campaign supports protests such as those in Figure 14.11.5. The garment workers at an industrial park in Phnom Penh, Cambodia are holding stickers and wearing t-shirts showing 'USD177'. The protesters are demanding an increase of their minimum salary to US$177 per month—the minimum wage. The campaign is also asking international brands which make clothes in Cambodia to support their minimum wage campaign.

14.11.5 US$177 minimum wage campaign by garment workers, Phnom Penh, Cambodia

ACTIVITIES

Knowledge and understanding

1. Explain what is meant by the term 'fast fashion'.
2. Identify the fast fashion retailers that have entered the Australian market in recent years.
3. Outline the origins of fast fashion.
4. Explain how the business model of fast fashion retailers differs from that of other clothing brands.
5. Outline how marketing is used to promote sales in the fast fashion retail sector.
6. State the concerns of those who question the practices of the fast fashion industry.

Applying and analysing

7. Create a PMI chart on WRAP and the Clean Clothes Campaign.
8. Think about your own and your friends' fashion purchases and discuss how you could reduce your impact on the environment.
9. Design a social media campaign urging consumers to boycott fast fashion stores until they can demonstrate that they source their clothing from factories where workers are not exploited.

Geographical skills

10. Study Figures 14.11.2 and 14.11.3. Name the regions with the largest exports and imports of clothing.

Investigating

11. Select a fast fashion retailer and investigate how they are responding to criticisms of fast fashion in regard to:
    - environmental impacts
    - exploitation of workers.

    Your response needs to outline the programs that have begun and analyse whether they are working or not working.

14.12

Exploitation of workers

Labour laws

In Australia, there are laws to prevent the exploitation of workers. There are minimum wage rates, the 40-hour week, overtime payments and penalty rates for weekend work. There are also strict laws and inspections related to the occupational health and safely conditions of workplaces, so that accidents and injuries are minimised. However, such strict laws do not apply in many countries.

Labour exploitation

Labour exploitation is defined by the International Labour Organization (ILO) as work obtained from people under threat (real or perceived) and for which people have not offered themselves voluntarily. There are a number of conditions in a society that contribute to the prevalence of worker exploitation. These are:

- high levels of unemployment, forcing people to take whatever jobs they can find
- the non-payment of the legal minimum wage by some employers
- high levels of poverty
- high levels of crime
- high levels of discrimination against women and other groups
- high levels of corruption in business and government organisations.

When these conditions apply, factory owners can pay their workers low wages and force them to work long hours. Trade unions are suppressed and little attention is paid to occupational health and safety issues. There are many examples of such factories operating in Asia and Africa. Most act as subcontractors to large, well-known global companies with headquarters in the United States of America or Europe and markets throughout the world.

FORCED LABOUR

According to the ILO, over 12 million people in the world are trapped in forced labour. Forced labour is outlawed by the ILO and takes one or more of the following forms:

- threats of or actual physical harm to a worker
- restriction of movement to other workplaces
- withholding of wages because of debts
- retention of passports or personal documents
- making threats to tell authorities that a worker is of illegal status.

Alternative perspectives

Some experts have argued that there need to be large numbers of sweatshops paying low wages at a certain stage in a developing nation's economy. They use the examples of countries such as South Korea and Taiwan, which were paying very low wages in the early stages of their development in the 1950s. In the present decade, more than 50 years later, these countries' wages are much higher, and their factories are producing cars, ships and complex electronic equipment.

Former World Bank economist Martin Wolf wrote:

> It is right to say that transnational companies exploit their Chinese workers in the hope of making profits. It is equally right to say that Chinese workers are exploiting transnationals in the (almost universally fulfilled) hope of obtaining higher pay, better training and more opportunities than would otherwise be available to them.

Anti-sweatshop activist groups such as Clean Clothes Campaign, SweatFree Communities and No Sweat all campaign to improve the conditions and human rights of workers in sweatshops. They argue that the exploitation of workers can never be justified.

Child labour

The ILO estimates there are 220 million children (5–17 years old) working as child labourers around the world. No one would argue that this is a good thing, but it is sometimes the only way in which a large family can support itself.

In India, 25 per cent of the workers in glass-making factories are children, while the chemical industry employs children as young as 3 years old in making matchsticks. Children are even employed in the manufacturing of arms and ammunition, a very dangerous occupation. There are also thousands of children employed as full-time miners in the diamond and gold mines of Africa, Asia and Latin America.

POOR CHILDREN MADE TO STITCH SPORTS BALLS IN SWEATSHOPS

THE footballs Australian children punt, pass and catch in weekend games are stitched by India's poorest children, who work in appalling, dangerous and illegal conditions for as little as seven cents a ball.

Two of Australia's most well-known football brands, Sherrin and Canterbury, have operations in India that use banned child labour.

A 12-month investigation by the *Herald* has discovered that despite significant reforms to India's massive but poorly regulated sports ball industry, children are still working, sometimes forced, in the painstaking and painful hand-stitching of footballs, netballs and soccer balls.

The children who stitch Sherrin and Canterbury balls are employed unofficially, through subcontractors, who pay them for each ball stitched …

Most child-stitchers earn between 50 and 60 rupees, about a dollar a day.

The children the *Herald* discovered stitching, sit, hunched on low stools, for between five and eight hours a day, six or seven days a week.

Stitchers often end up with chronic back injuries from the unnatural sitting position.

They regularly pierce their fingers with the sharp, heavy needles, or slice their hands on the wax-coated string.

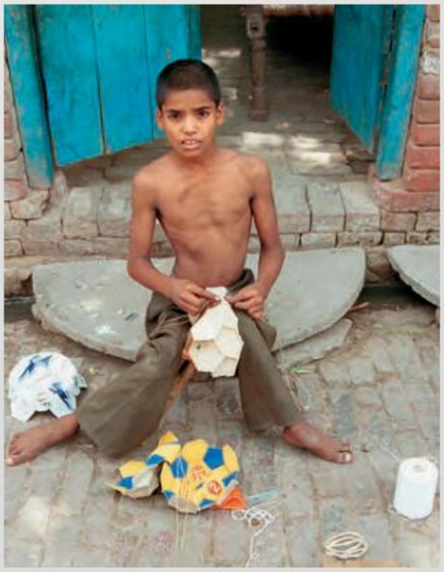
Working inside and in the dark, as most child labourers do to keep them hidden from authorities, strains child-stitchers' eyes and leads to vision disorders.

Keeping children from school to make them work is illegal in India. In 2010, the Right to Education Act made it compulsory for children under 14 to attend school.

Across Punjab's industrial cities, the *Herald* discovered children, almost all of them girls, and as young as seven, who have been pulled out of school to work in secret, stitching sports balls full-time.

Presented with the *Herald*'s findings, both Canterbury and Russell (Sherrin) promised investigations.

Source: Adapted from Ben Doherty, *Sydney Morning Herald*, 22 September 2012



14.12.1 Child stitching sports balls

ACTIVITIES

Knowledge and understanding

1 Compare the treatment of workers in Australia with those in countries without strict enough labour laws.
2 Define the term 'labour exploitation'.
3 Outline the social factors that can contribute to an environment in which workers are exploited.
4 List the various forms of forced labour.
5 State the perspective of organisations campaigning against sweatshops.

Applying and analysing

6 Explain in your own words your understanding of the term 'sweatshop'.
7 Make a list of arguments for and against the following statement.
People are more concerned about cheap consumer goods than labour exploitation.

14.13

The hazards of electronic waste

Hazardous components

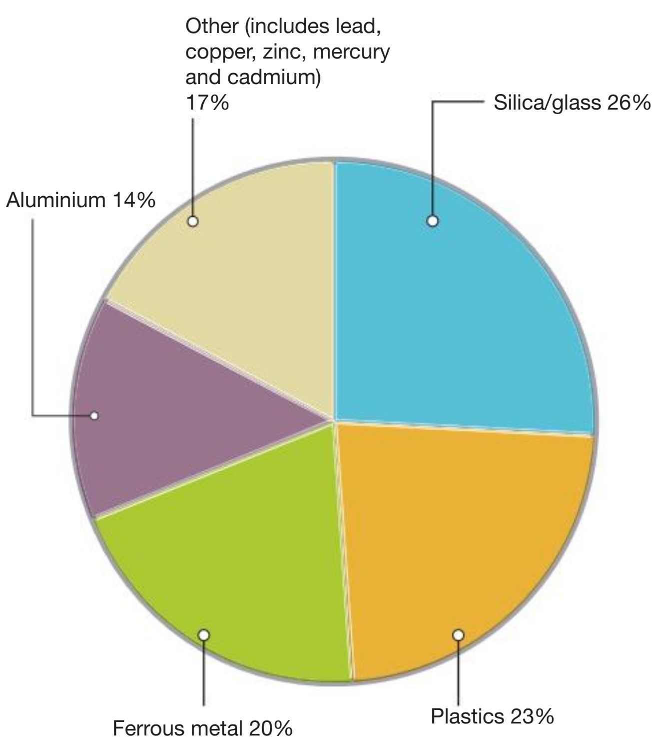
Personal computers contain small quantities of toxic heavy metals, such as cadmium, lead and mercury (see Figure 14.13.1). These are all chemicals that are monitored and regulated by environmental protection agencies in countries such as Australia and United States of America. The uncontrolled disposal of personal computers creates concentrations of these metals far above recommended levels.

Increasing electronic waste

The increase in the amount of electronic waste has been caused by two changes in relation to computers.

- The number of computers purchased for home use has increased at an astounding rate.
- The average lifespan for a computer has dropped from about 5 years in 1999 to less than 2 years today.

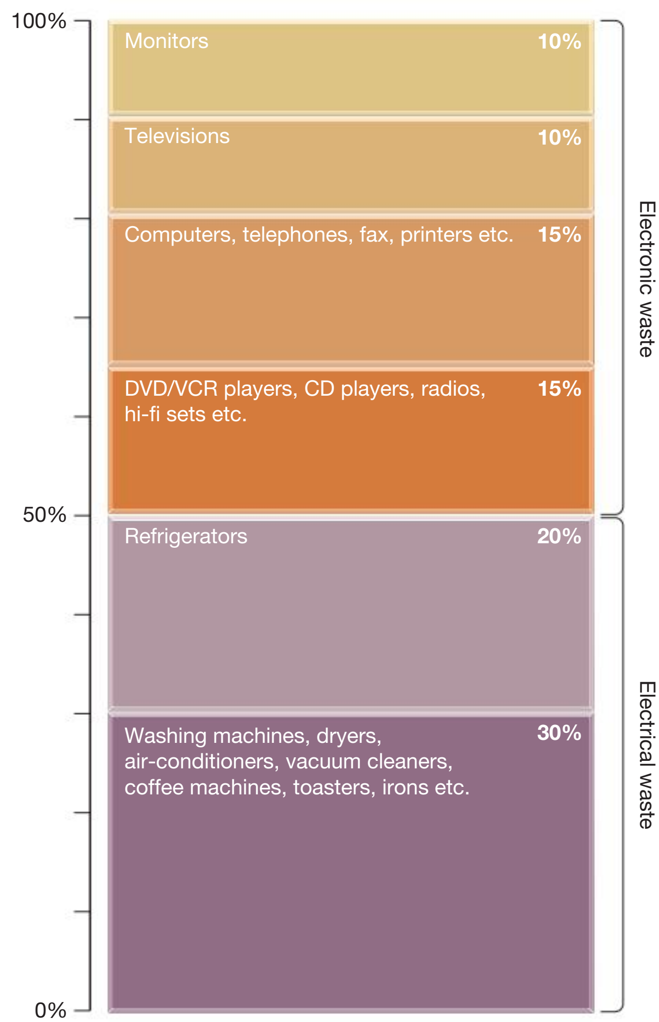
Most computers and other electronic items are thrown away, rather than recycled (only about 10 per cent are recycled). This means that the dangerous heavy metals leach into the subsoil, where they can contaminate groundwater. It is estimated that 50 million tonnes of electronic waste are produced each year.



14.13.1 Computer components

Europe discards 100 million mobile phones per year, and the United States of America discards 30 million computers annually. Some estimates suggest that electronic waste may rise by 500 per cent over the next decade. Figure 14.13.2 illustrates the composition of electronic waste, approximately 25 per cent of which is related to computer waste. Pollutants found in electronic waste include:

- lead in cathode ray tubes and solder
- mercury in switches and housing
- arsenic in cathode ray tubes
- antimony trioxide as flame retardant
- selenium in circuit boards
- cadmium in semiconductors
- cobalt in steel for magnets.



14.13.2 The composition of electronic waste

Recycling computers and electronics

It is possible to recycle computers and consumer electronics. Recycling involves breaking down electronic items for their component parts and processing the materials from which they are made. Complicating the process, however, is the rapid rate of technological development. Electronic goods can be made redundant by new and upgraded technologies.

Take, for example, the iPhone. From the time it was first released in mid-2007 until 2013, six increasingly sophisticated models were released. In many cases, consumers simply discarded the obsolete model in order to have the latest technology available.

DID YOU KNOW?

Seventy-five per cent of the three million computers purchased in Australia every year will end up in landfill.

SPOTLIGHT

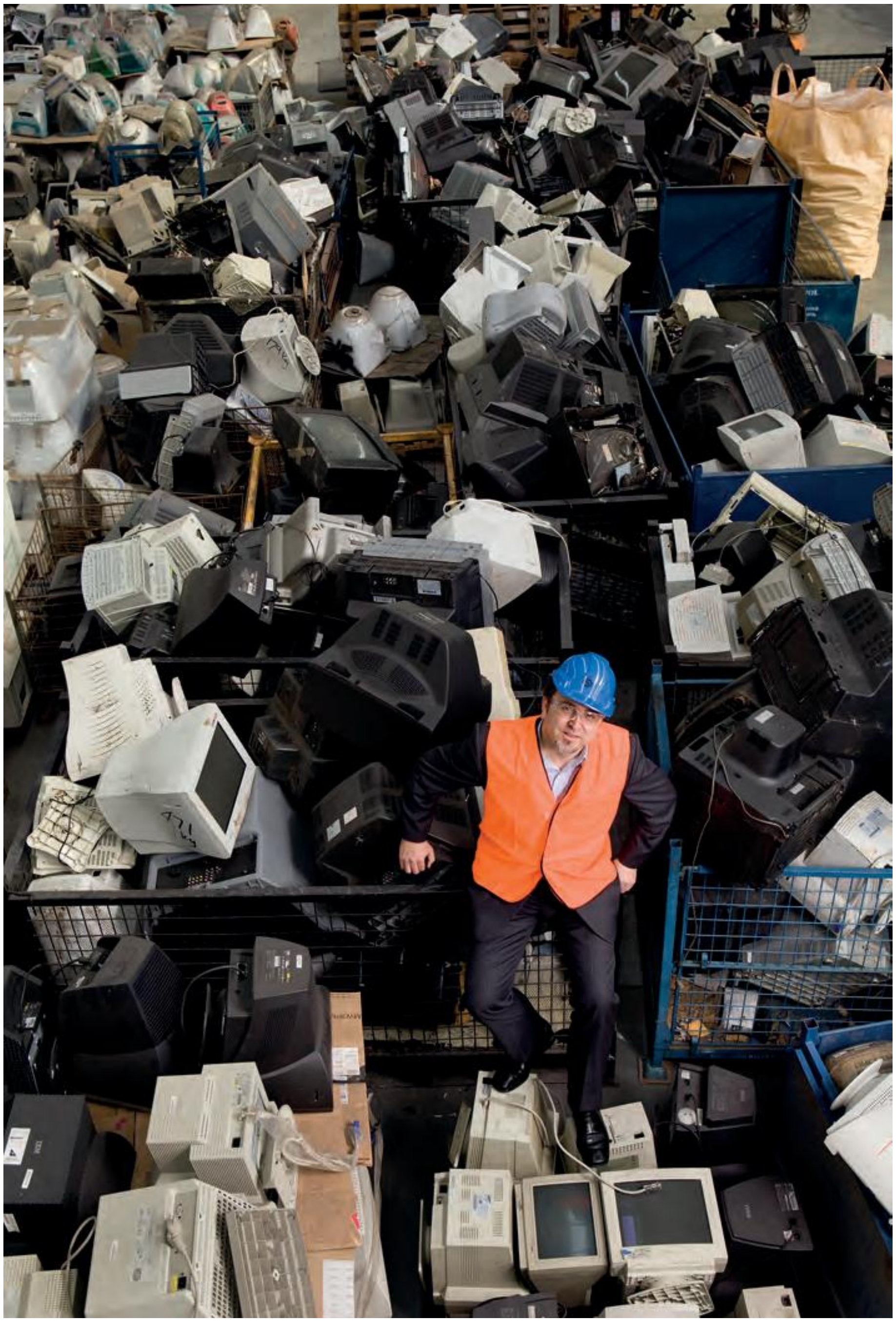
National Television and Computer Recycling Scheme

Electronic waste in Australia is increasing and is usually discarded rather than recycled. Less than 10 per cent of the 15.7 million computers no longer in use have been recycled. It is estimated that if 75 per cent of the 1.5 million televisions thrown out annually were recycled there would be savings of 23 000 tonnes of carbon dioxide equivalents, 520 megalitres of water, 400 000 gigajoules of energy and 160 000 cubic metres of landfill.

The National Television and Computer Recycling Scheme provides Australian householders and small businesses with access to free recycling services for:

- televisions
- computers
- printers
- computer products (such as keyboards, mice and hard drives).

Drop-off points have been established around Australia at recycling depots and retailers.



14.13.3 Electronic waste drop-off point

Processing of electronic waste

Both China and India have places that specialise in disposal of electronic waste. China has a site at Guiyu, and India has sites near Delhi and Bangalore. At these sites thousands of people are engaged in the dangerous recycling process. They separate toners, plastics and metals from wastes. In the process they come into contact with many sources of dangerous substances (see Figure 14.13.4). Furthermore, the uncontrolled burning and disposal of products cause chemicals and metals to discharge into the atmosphere, soil and groundwater. Figure 14.13.5 outlines the electronic waste traffic in Asia.

Spread of electronic waste

Many illegal shipments of electronic waste find their way to countries such as Ghana, bypassing the rules controlling the movement of such materials. Those responsible simply label the electronic waste as television sets for re-use or computers given as donations. When they finally reach the landfills in the country where they are to be dumped, they are scavenged by groups of children looking for microchips or other parts they can sell. The useless parts are smashed, burned and crushed.

Medical workers have found all kinds of health problems in people working on or scavenging from electronic waste tips. Children break open cathode ray tubes and expose themselves to lead poisoning. People who use acid to strip down circuit boards splash their skin with it and breathe the fumes.

14.13.4 Child labourers sorting recyclables from electronic waste. Such workers come into contact with hazardous substances.

14.13.5 Electronic waste movements in South and East Asia

DID YOU KNOW?

One hundred and twenty-six million children are engaged in the worst form of child labour—slavery, armed conflict and hazardous work.

ACTIVITIES

Knowledge and understanding

1 State what electronic waste is.
2 Explain why electronic waste is now such a problem.
3 Outline why electronic waste is such a problem in countries with not as many computers or phones per person.

Geographical skills

4 Study Figure 14.13.5. Outline the movement of electronic waste in South and East Asia.

Investigating

5 Investigate local recycling schemes for batteries, computers and mobile phones.

Alpine landforms

CHAPTER 15

The world's alpine landscapes are not defined by their landforms. Rather, it is the distinctive climate found at high altitudes that determines their location and extent. Many alpine areas are, however, home to landforms shaped by the processes of glaciation, in either the past or the present. These harsh but spectacular places, and the related landforms, plants and animal life, are among the most culturally important of all environments.

INQUIRY QUESTIONS

- What are the principal geomorphic processes responsible for the shaping of alpine landscapes and landforms?
- What are the distinctive landform features associated with glaciation? How are they formed?
- Why are alpine landscapes are worth protecting?
- In what ways can alpine landscapes be managed sustainably?

GLOSSARY

abrasion	the wearing down or wearing away of rock by friction
accumulation zone	an area where snow and ice accumulate at a faster rate than they melt
arête	the sharp-sided ridge separating two cirques
cirque	a small valley that is shaped like an amphitheatre
endemic	unique to a defined geographic location
firn	a compacted layer of new snow that survives the summer melt
fjord	a long, narrow flooded valley with steep sides, carved by glaciation
glacier	a slow-moving river of compacted snow and ice
ground moraine	rock debris deposited across a valley floor as a glacier retreats
hanging valley	a valley formed at the point where a smaller (tributary) glacier once joined a larger, deeper glacier
horn (pyramidal peak)	the pyramid-shaped peak of a mountain formed by three or more cirques
lapse rate	the rate at which the temperature of a body of air declines with elevation
lateral moraine	the rock that accumulates along the edge of a glacier
medial moraine	the rock debris found in the centre of a valley, resulting from the merging of two lateral moraines when two glaciers merge
melting zone	an area where snow and ice melt at a rate faster than they accumulate—the end of a glacier
moraine	the rock material deposited by a glacier
tarn	a lake at the base of a cirque
terminal moraine	the rock material exposed as a glacier melts and retreats
treeline	the edge of the habitat in which trees are able to grow
U-shaped valley	a valley with a flat floor and steep sides, formed by the abrasive power of material embedded in a glacier
V-shaped valley	a valley eroded by a river

15.0 Mt Assiniboine, British Columbia, Canada

15.1

Alpine landscapes

Location of alpine landscapes

The earth's highest mountains and plateaus are home to its alpine landscapes. The extent of such landscapes is determined by the distribution of alpine climates. An alpine climate is defined by the conditions that exist above the **treeline**—the elevation at which it is too cold for trees to grow.

Alpine climates

The climate is the average weather conditions experienced over a long period of time. One of the most important elements of weather is temperature. Alpine temperatures range from –18°C to 10°C. Precipitation is low and often falls as snow. Night temperatures are almost always below 0°C. The growing season of plants in alpine climates is usually less than 180 days per year.

The treeline in an alpine environment appears well-defined from a distance. On closer inspection it is actually a zone of slow change. The growing season of trees becomes shorter with increased altitude and more extreme climate conditions, and eventually there is a point where trees stop growing. In Australia's Snowy Mountains the treeline is approximately 1800 metres above sea level. In the Swiss Alps the treeline is approximately 2200 metres above sea level (see Figure 15.1.1) and in the Canadian Rockies it is 2400 metres.

15.1.1 The treeline in Davos, the Swiss Alps

Temperatures decline with elevation

Due to air expanding as it rises, temperatures drop as elevation increases. It is important to remember that the atmosphere is heated by the earth's surface, not from above. As a dry mass of air rises, it cools at a rate of –10°C per 1000 metres.

Shaping alpine landforms

When mountains are formed, weathering and erosion begin to wear them away. Exposed rock surfaces are broken down by physical and chemical weathering. The material is then removed by wind and water, and deposited (by rivers and glaciers) at lower elevations as sediment.

Work of rivers

Running water is the most powerful form of erosion in alpine landscapes that are not permanently covered with snow and ice, transporting and depositing rock and soil. In mountainous areas, rivers erode downwards, creating narrow, **V-shaped valleys**. Away from the mountains, valleys become wider and some of the river's load of sediment is deposited. Eventually, this material finds its way to the sea, where it is deposited in layers.

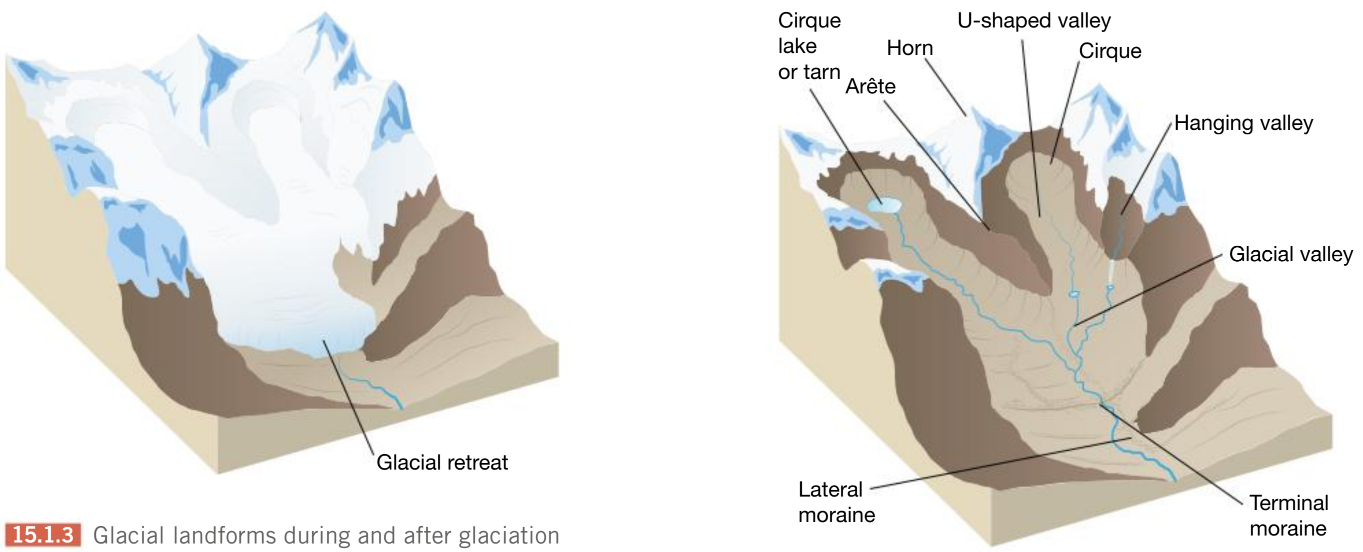
Glaciers: Rivers of ice

At elevations where it is cold enough for snow and ice to accumulate over a long period of time, **glaciers** are the main type of erosion. Glaciers are slow-moving rivers of compacted snow and ice. Figure 15.1.2 shows a river of ice at the Gorner Glacier in Switzerland. Glaciers form when compacted snow, which has accumulated over many years, gradually moves downhill under the force of gravity.

Figure 15.1.3 shows the formation of a glacial valley. As the glacier moves, the surface of the land is scratched and worn down by rock fragments that have been picked up from the ground and frozen into the base of the glacier. This process is known as **abrasion**. The most spectacular landform features of glacial landscapes are **U-shaped valleys**. During periods of glacial activity, glaciers cause the valleys once occupied by rivers to deepen and widen. **Hanging valleys** form where smaller (tributary) glaciers join larger glaciers. Other erosional features include **cirques**, **arêtes** and **horns (pyramidal peaks)**. **Fjords** are formed when rising sea levels flood the valleys once occupied by glaciers.

The rocks that are picked up and transported by the ice can be carried long distances before they are deposited, forming features known as **moraines**.

15.1.2 A U-shaped valley at Gorner Glacier, Switzerland



15.1.3 Glacial landforms during and after glaciation

ACTIVITIES

Knowledge and understanding

1 Explain how the extent of an alpine landscape is defined.
2 State what the term 'treeline' refers to.
3 Explain in your own words why the weather gets colder with altitude.
4 Identify the main types of erosion that shape alpine landscapes.
5 Explain what a glacier is.
6 Outline how glaciers shape the land.
7 List the landform features associated with the movement of glaciers (glaciation).

15.2

Glacial landforms and processes

Glacier formation

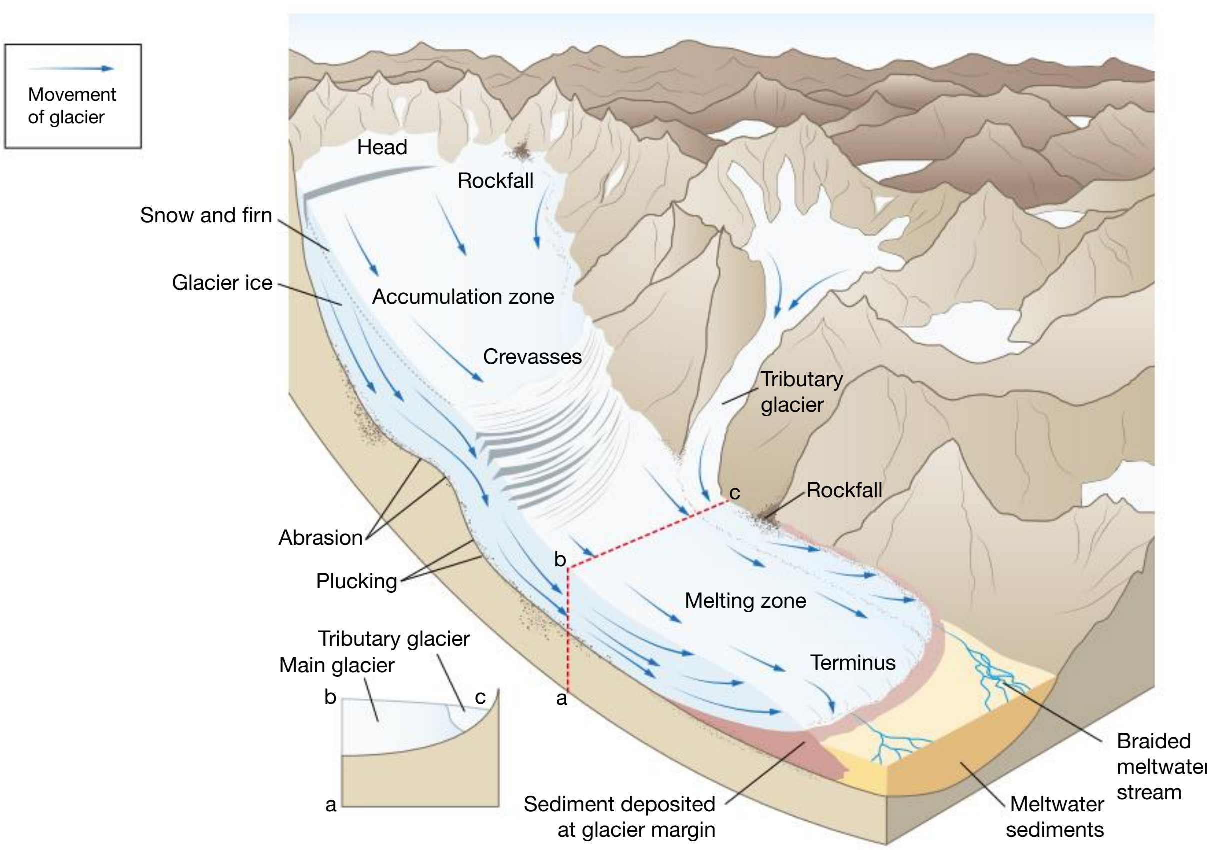
A glacier is a slow-moving river of ice. Glaciers are found in alpine landscapes where temperatures are below zero for most or all of the year. Glaciers create a range of distinctive landform features that give alpine landscapes their spectacular appearance.

When snow falls to the ground it forms a light, feathery layer that traps a lot of air. Where snow collects in a low area of land, or depression, it becomes compressed by more snowfalls and gradually develops into a more compact, thick layer of snow. When this compacted layer of snow experiences one winter's freezing and survives a summer's melting it is called **firn**. Air is progressively squeezed out of the firn and after 20 to 40 years it becomes solid ice. In parts of Antarctica and Greenland where there is no summer melting, the same process can take more than 200 years. Large masses of this ice may begin to 'flow' downhill, under the force of gravity, as a glacier. Figure 15.2.1 shows the main features of a glacier.

Glacier types

Glaciers are classified according to their size and shape. The five main types are:

- ***niche glaciers***—very small accumulations of glacial ice that are found in depressions and gullies
- ***cirque glaciers***—relatively small glaciers found in 'armchair-shaped' depressions in mountains
- ***valley glaciers***—larger masses of ice that move down former river courses and are bounded by steep (almost vertical) valley sides
- ***piedmont glaciers***—glaciers that form when valley glaciers extend onto lowland areas, spread out and merge.
- ***ice caps and ice sheets***—huge areas of ice covering more than 50 000 square kilometres. Ice sheets once covered much of northern Europe and North America, but they are now found only in Antarctica and Greenland.



15.2.1 Main features of a valley glacier

15.2.2 A U-shaped, former glacial valley with hanging valley and associated waterfall, Yosemite National Park, United States of America

Glacial inputs and outputs

Water enters the glacial system mostly as snow and leaves as meltwater. At higher elevations, inputs (snow accumulation) exceed outputs (evaporation and meltwater). This area is called the **accumulation zone**. At lower elevations, outputs exceed inputs. This area is called the **melting zone**. It is shown in Figure 15.2.1.

Glacial erosion

Nearly all the glacial processes of erosion are physical, as the climate is too cold for chemical reactions to occur. Frost shattering is common and produces large amounts of loose rock. This rock material falls from valley walls to form **lateral moraine** along the edges of the glacier. Glacial abrasion, which is the scraping and grinding effect of rock material in the glacier, smooths and widens the U-shaped valley—a distinctive characteristic of areas shaped by glaciation.

At the top of glacial valleys, large steep-walled bowls called cirques are located. When glaciers carve out valleys next to each other, a sharp-sided ridge, or arête, will separate them. If several of these valleys begin near the top of a mountain, a sharp peak, or horn, is formed. A glacial hanging valley forms where a smaller tributary glacier joins a larger valley glacier. After the glacial ice melts, the valley formed by the smaller glacier is left 'hanging' high above the valley floor. Hanging valleys often have spectacular waterfalls, as shown in Figure 15.2.2.

DID YOU KNOW?

Ten per cent of the earth's land area is covered with glacial ice, which includes glaciers, ice caps and ice sheets.

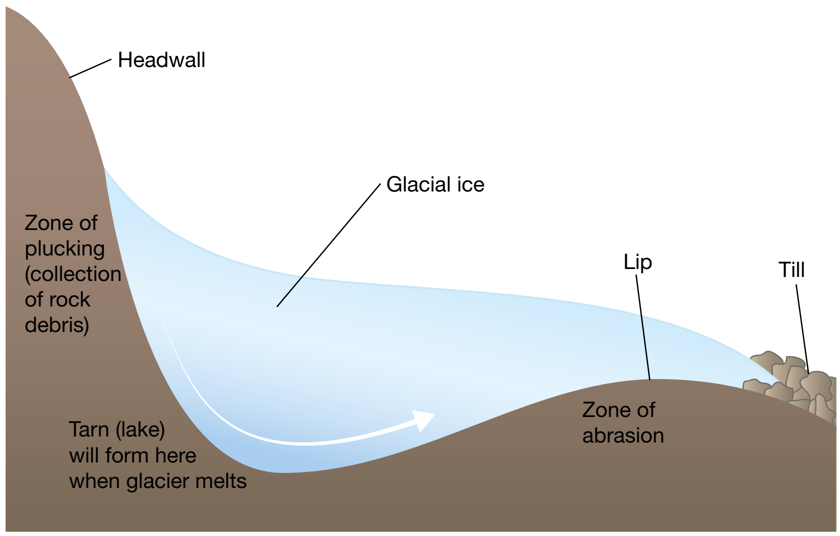
SPOTLIGHT

Formation of cirques

A cirque is a bowl-shaped landform feature often found at the beginning, or head, of a valley glacier. Carved by ice, this distinctive feature is usually surrounded on three sides by steep cliffs. The highest cliff is often called a headwall. The fourth side, known as the lip or sill, is the point at which the glacier flowed away from the cirque. Many glacial cirques are now occupied by **tarns**—lake-like features that form behind the till (rock debris) that collects at the lip (see Figures 15.2.3 and 15.2.4). The ridge between two adjacent cirques is called an arête.

A glacial horn, or pyramidal peak, is formed when three, or sometimes four, cirque headwalls and their arêtes join together to form a single peak that has a distinctive pyramid shape with very steep walls. The number of faces that make up the sides of a pyramidal peak depends on the number of cirques involved in its formation.

15.2.3 Formation of a cirque



15.2.4 Blue Lake in Kosciuszko National Park, an example of a tarn

15.2.5 Aletsch Glacier, the largest glacier in Switzerland. The glacier's terminal, medial and lateral moraines are clearly visible.

1 Terminal moraine 2 Medial moraine 3 Lateral moraine

Glacial transportation

Glaciers are able to move large amounts of rock material, known as moraine. There are three main ways this material is moved downhill: on the surface of the glacier as lateral or **medial moraine**; as debris carried within the body of the glacier; or as material embedded in the base of the glacier, or **ground moraine**.

Glacial deposition

The rock debris carried by glaciers is deposited at the point at which the glacier melts. When glaciers retreat (melt), these materials are deposited across the exposed landscape. A **terminal moraine** consists of a mound of material across the face of the glacier. The terminal moraine can be used to determine the maximum advance of a glacier. Ground moraine is deposited as rock debris across a valley floor as a glacier retreats. Lateral moraine is rock debris deposited as an embankment along the valley sides as the glacier retreats. Medial moraine is found in the centre of a valley and results from the merging of two lateral moraines when two glaciers merge (see Figure 15.2.5).

ACTIVITIES

Knowledge and understanding

1 Explain the process of glacier formation.
2 State the difference between valley and piedmont glaciers.
3 Explain why physical rather than chemical weathering processes dominate in alpine areas.
4 Outline what is meant by the term 'abrasion'.
5 State the conditions under which arêtes and horns develop.

Geographical skills

6 Study Figure 15.2.1. Sketch a glacier and label the main glacial landform features.
7 Study Figure 15.2.2. Write a paragraph explaining the circumstances in which hanging valleys develop.
8 Study Figure 15.2.2. Construct an annotated photo sketch of Yosemite National Park, highlighting the key elements of the U-shaped and hanging valleys.
9 Study Figure 15.2.4. Construct an annotated photo sketch of Blue Lake, highlighting the key elements of the cirque.

Alpine ecosystems

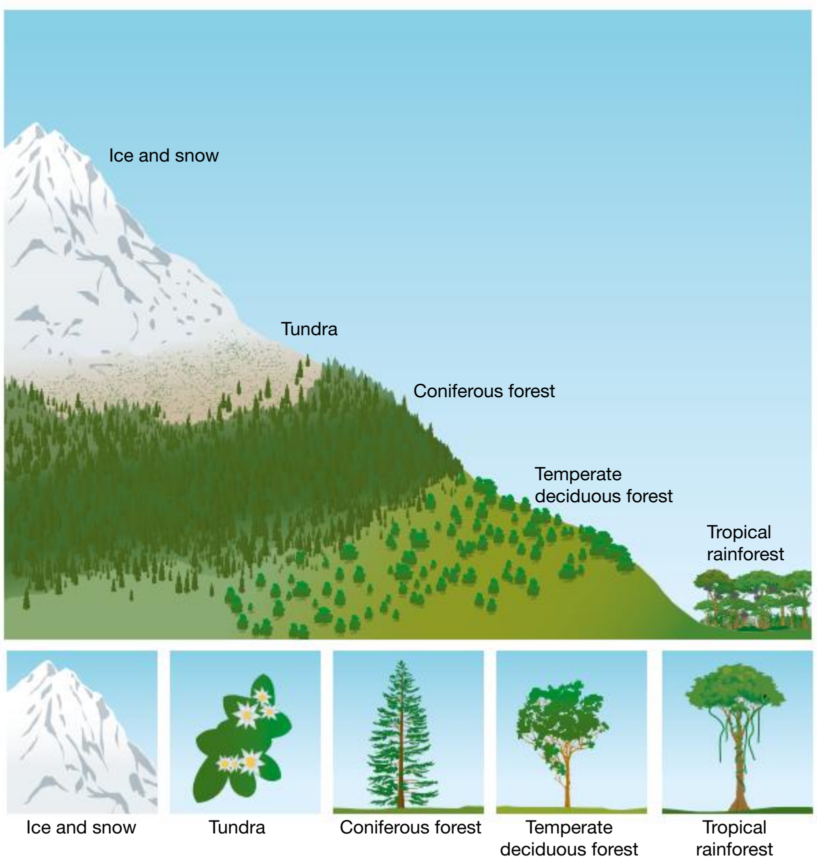
Factors influencing alpine ecosystems

The factors that help to shape the alpine ecosystems are altitude, slope and aspect.

Altitude

With increasing elevation (or altitude), air temperatures decrease and wind speeds increase. These changes have a major impact on plant growth. As you go up a mountain, you can see very distinct zones of vegetation. These zones are shown in Figure 15.3.1. At the highest zone there is no plant life, only ice and snow. Below this zone is the tundra. Figure 15.3.2 shows the flowering plants of the Rocky Mountains that grow in the tundra. Below the tundra is the coniferous forests zone. Figure 15.3.3 shows the forests on the slopes of Canada's Whistler Mountain. Beneath the forest is the temperate or deciduous forests zone.

15.3.2 The tundra above the treeline, Rocky Mountains, United States of America. Flowering plants have a brief and intense life, with a growing season as short as thirty days. During this time, the plants must race through the processes of germination, growth and reproduction.



15.3.1 Ecosystems change with altitude.

15.3.3 Coniferous forest on the slopes of Canada's Whistler Mountain

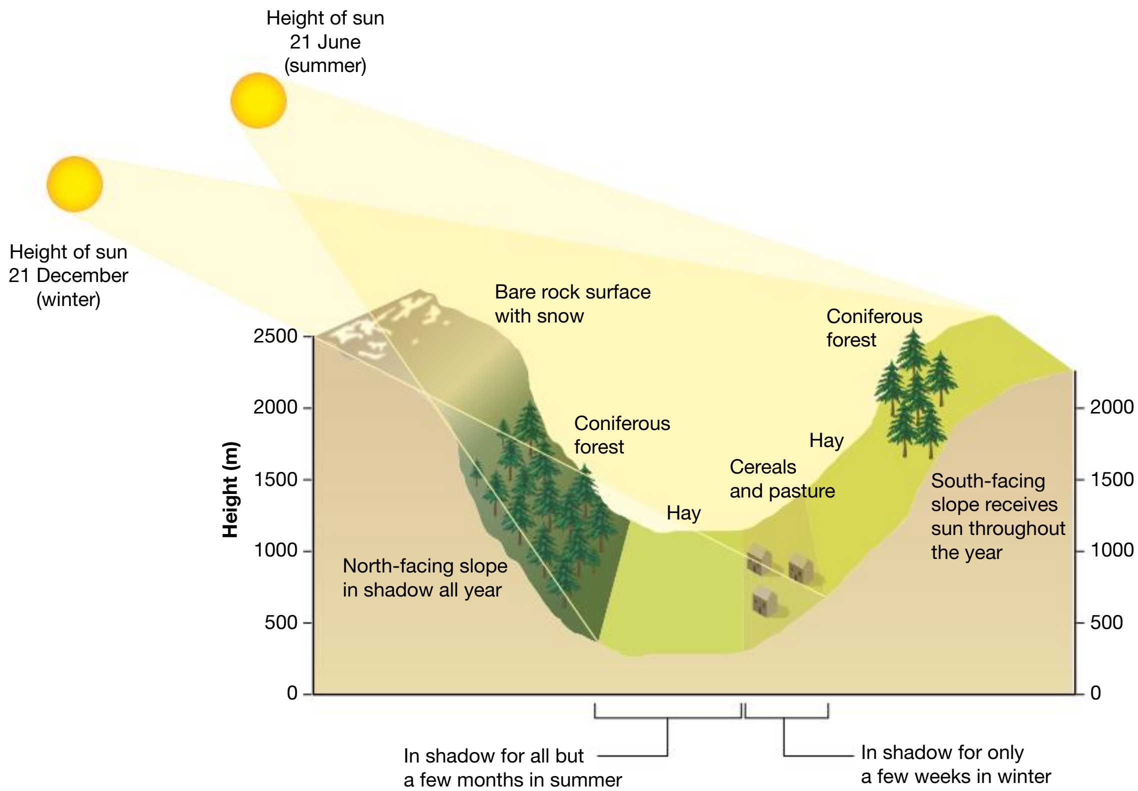
Slope

The degree of slope is important in alpine regions because it influences soil depth and moisture content. Rates of erosion are higher on steep slopes and moisture drains away quickly. This makes it difficult for steep slopes to support plant life.

Aspect

The aspect of a slope affects both light and temperature conditions. South-facing slopes in the Northern Hemisphere are more favourable for plant growth than those facing north (especially in winter). This is because north-facing slopes receive less direct sunlight, as illustrated in Figure 15.3.4. In the Southern Hemisphere, north-facing slopes receive more direct sunlight.

15.3.4 Impact of climate in a Northern Hemisphere valley



Alpine climates

Latitude, altitude and aspect interact to produce alpine climates. In general, the climate becomes colder with elevation—this characteristic is described by the **lapse rate** of air: air tends to get colder as it rises, because it expands. The rate at which dry air cools as it rises is 10°C per kilometre of altitude. Therefore, the temperature at the summit of a 4000-metre high mountain will be up to 40°C cooler than the sea-level temperature. This vertical variation in temperature determines which flora and fauna can survive at different altitudes.

DID YOU KNOW?

Alpine plants and animals are restricted to an area between the treeline and the mountain summit. In Australia, there are more than 250 species of alpine plants that grow only in this restricted habitat.

ACTIVITIES

Knowledge and understanding

1 Explain how altitude affects plant growth.
2 Outline how slope affects the potential for plant life in mountain environments.
3 Outline how aspect affects the pattern of vegetation in mountain environments.

Applying and analysing

4 Study Figures 15.3.2 and 15.3.3. Write down the vegetation differences you observe in the different alpine environments.
5 Study Figure 15.3.4. Explain the impact that aspect has on the valley shown in the diagram. If you were going to build a house, where would you build it? Justify your answer.

15.4

Managing Australia's alpine environments

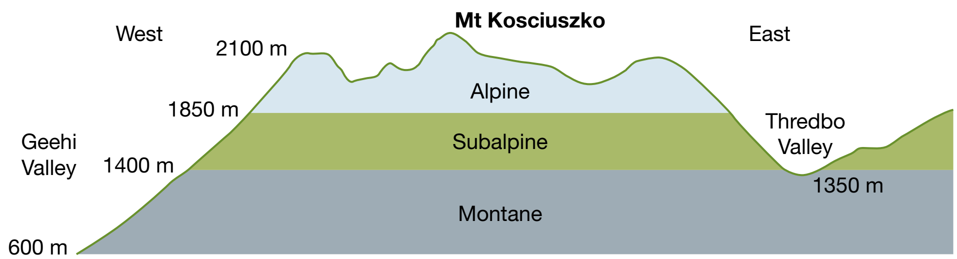
Location of Australia's alpine environments

Australia's alpine areas are found on both sides of the mountains and plateaus of the highest part of the Great Dividing Range. This is the only region on the mainland where snow accumulates on the ground, forming a snowpack that remains throughout winter. Australian alpine environments are unique and vulnerable.

Alpine environments

The word 'alpine' is used to describe all snow-covered areas. In the strictest sense it refers to the higher country where it is too cold for trees to survive, such as the Main Range of Kosciuszko National Park shown in Figure 15.4.1. On mainland Australia this occurs at 1800 metres (shown in the cross-section of Kosciuszko National Park in Figure 15.4.2) and in Tasmania at 1200 metres.

15.4.1 The Main Range of Kosciuszko National Park, where it is too cold for trees to grow at the highest elevations



15.4.2 Cross-section of the Kosciuszko National Park alpine landscape

Environmentally significant features

Australia's alpine regions are an important part of Australia's natural and cultural heritage.

Natural values

Australia's alpine region includes:

- landforms such as cirque lakes (tarns) resulting from glacial activity during the last Ice Age
- unique flora and fauna communities adapted to the harsh conditions of low temperatures, frequent frosts and strong, cold winds. The alpine marsh marigold actually flowers under the snow in icy meltwater, enabling it to have enough time to flower and set seed in the brief summer
- rare cold-climate animal species such as the mountain pygmy possum (see Figure 15.4.3) and the corroboree frog. Many of these species are **endemic**, as they are found naturally only in the alpine region. Several species are restricted in their distribution to within 5 or 6 kilometres of Mount Kosciuszko
- the only mountains in the world with such a substantial covering of soil. The humus soils are globally significant.

15.4.3 The mountain pygmy possum

Cultural values

The following aspects of the alpine region are an important part of Australia's cultural heritage.

- Aboriginal people have a living spiritual connection with the mountains. Researchers believe their summer visitation started 9000 years ago. Tribes travelled long distances to hold celebrations in the mountains and, while there, they feasted on the Bogong moths.
- There is a cultural history associated with European grazing of the alpine area that dates back to the 1830s. Legends of the high-country horsemen and relics such as stockyards and huts are valuable elements of Australia's colonial heritage.
- The mountains are significant water catchments and the Snowy Mountains Hydro-electric Scheme is one of the world's most complex engineering feats. The scheme enables water to be collected and diverted through the mountains to inland New South Wales and Victoria, where it is used for irrigation.
- People have long visited the mountains for recreation, to enjoy the spectacular scenery in the summer, and to ski or snowboard in the winter.

A fragile environment

While the species that survive in the climatic extremes of the alpine area are hardy, their survival is dependent on their environment remaining the same. Historically, considerable damage has resulted from human landuse practices in the mountains. Today, there are still a number of risk factors.

Damage from grazing

Records show that graziers started bringing large numbers of sheep and cattle up into Australia's alpine environments in the early 1820s in the search for pastures and water. The heavy, hard-hoofed animals caused considerable damage to the native alpine vegetation, resulting in severe soil erosion. Grazing continued for over 120 years.

The pressure of tourism

As numbers of tourists grow, increasing pressures are placed on the environment. Vegetation is trampled, rubbish and human waste are left behind, and damage is caused by people camping in the wrong areas. Victoria's five alpine resorts attract up to 900 000 people each winter, and an increasing number visit outside the snow season. The New South Wales ski resorts, including Thredbo (see Figure 15.4.4) and Perisher Blue, attract 1.2 million visitors a year and are important sources of employment for those living in the region.

The threat of climate change

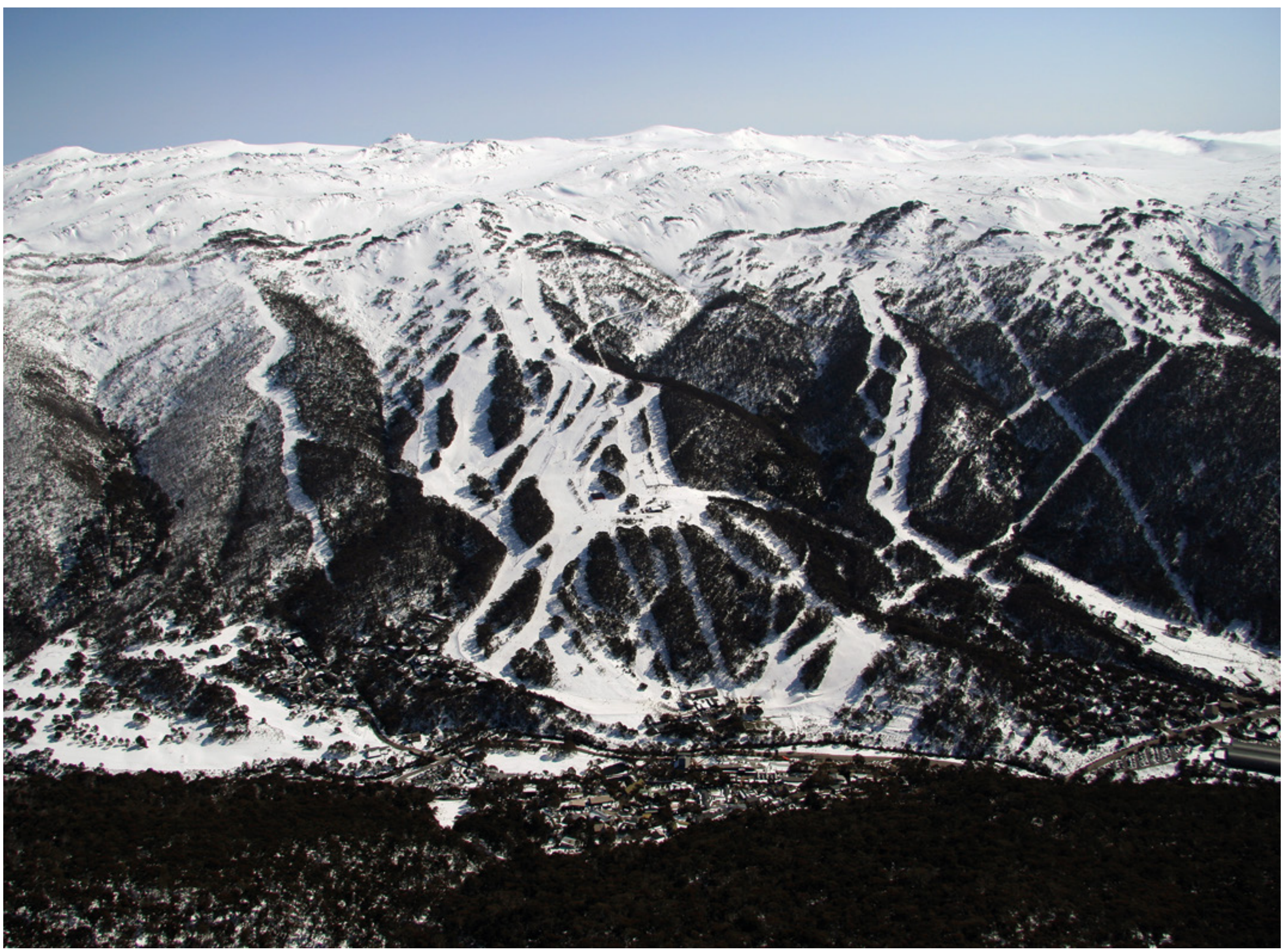
Climate change has the potential to lead to a reduction in snow cover, as milder temperatures will result in fewer snow days and a reduced depth of snow. If the change is too rapid, species will not have a chance to adapt. Australian alpine areas are particularly vulnerable, as they occupy only 0.00001 per cent of the continent; the impact of global warming would significantly reduce the size of this already small area. Figure 15.4.5 shows current snow cover and projected reduction in snow cover up until the year 2050. The two projected scenarios are:

- low scenario: the lowest projected level of global warming combined with the highest levels of precipitation
- high scenario: the highest projected level of global warming combined with the lowest levels of precipitation.

Environmental management

Australia's alpine national parks are featured on the Australian National Heritage List. With this recognition comes the responsibility to manage and protect them for the benefit of future generations.

15.4.4 Thredbo, Kosciuszko National Park. A range of sustainable practices have been implemented to minimise environmental impacts.



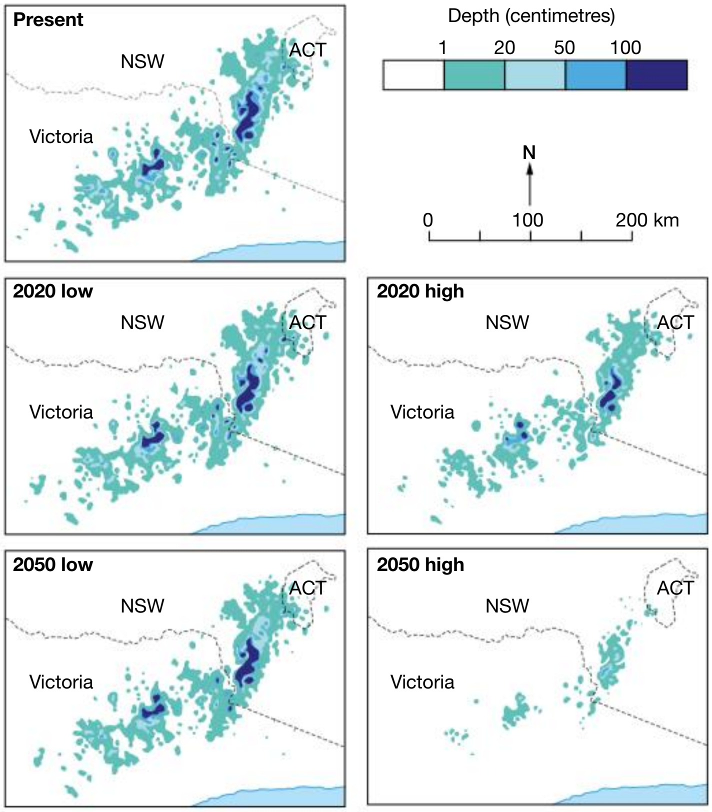
The management plans for the alpine national parks aim to:

- protect the unique mountain landscapes
- protect the region's natural and cultural values
- provide an appropriate range of outdoor recreation and tourism opportunities that encourage the enjoyment, education, understanding and conservation of natural and cultural values, and protect mountain catchments.

Management also includes safeguarding against the impacts of:

- introduced plants and feral animals
- soil erosion
- fragmentation or division of habitats
- pollution of waterways
- incompatible human activities.

Minimal impact is one strategy used to protect the alpine environment. Under this strategy, all users of the parks are asked to reduce their environmental impact. Educational and information brochures on minimal impact are distributed to visitors. People are asked to take all rubbish out of the park, stay on tracks (shown in Figure 15.4.6), camp well away from watercourses and fragile landscapes, use fuel stoves instead of wood fires for cooking, leave all Aboriginal and historic sites undisturbed, and avoid disturbing any plants, rocks, logs or animal nesting sites.



15.4.5 Current and projected decline in Australia's snow cover. The two predictions show the impact of 'high' and 'low' temperature rises due to climate change.

15.4.6 Paths and boardwalks are used to protect fragile landscapes at Mt Kosciuszko.

ACTIVITIES

Knowledge and understanding

1. Justify the protection of Australian alpine environments.
2. Define the term 'endemic species'.
3. Explain how the Australian Alps differ from mountainous areas elsewhere in the world.
4. Outline the threats to Australian alpine environments.

Applying and analysing

5. Use the 'think, pair, share' strategy to consider the following tasks.
   a. Consider why the treeline that marks the beginning of the alpine area is at a lower elevation in Tasmania than on the mainland.
   b. Assess the impact of grazing on soil formation in the alpine environment of Australia.
   c. Develop a poster designed to educate visitors to the Australian alpine parks on how to minimise their environmental impact.

Riverine landforms

CHAPTER 16

Water has travelled across landscapes for millions of years. As it has done so, it has sculpted the surface of the land. It has carved deep valleys and deposited sediments to form the rich alluvial plains that support our most productive agricultural systems.

In this chapter we examine the processes shaping riverine landscapes and landforms. We also look at how the activities of people impact on riverine landscapes. In particular, we look at the catchment of the Bow River in Canada to examine the landforms shaped by rivers and the ways in which people affect such landscapes and landforms.

INQUIRY QUESTIONS

- What are the processes responsible for the formation of riverine landscapes and landforms?
- How do riverine landforms change over the course of a river?
- How do the activities of people affect riverine landscapes and landforms?

GLOSSARY

abrasion	the wearing down or wearing away of rock by friction
attrition	the wearing away of material due to the friction caused by particles rubbing against each other
bed load	material transported along the bed of a river
braided channel	a river channel featuring a network of small channels separated by small and often temporary islands of sediment
catchment	the area drained by a river and its tributaries; an alternative term for 'river basin' or 'drainage basin'
delta	extensive deposit of alluvial material (sediment) at the mouth of a river
deposition	accumulation of sediment by the action of erosional agents, such as water and wind
discharge	the amount of water that flows from a river catchment and into another river system, the sea or a lake
environmental flow	the amount of water that is needed to maintain a healthy river ecosystem
flood plain	a nearly flat plain along the course of a river that is subject to flooding
gradient	a measure of the steepness of a slope
groundwater	water beneath the earth's surface that fills pores or tiny spaces in the earth or rock
infiltration	the movement of water from the land surface into the soil
meander	a bend or curve in the course of a river
natural levee	the build-up of sand along, and sloping away from, either side of a river
point bar	the accumulation of sediment on the inside of a river bend
rapid	a section of a river with a relatively steep gradient that causes the velocity and turbulence of water to increase
sediment	rock-based material that has been broken down by weathering and erosion and then transported by the action of wind, water or ice, and the force of gravity
suspended load	fine particles of silt and clay carried in river water
tributary	a river system flowing into a larger river
turbidity	muddiness; high turbidity occurs when there are high levels of suspended sediment in water
watershed	the boundary between catchments

16.0 Horseshoe Bend, Colorado River, United States of America

16.1

Rivers

Power of rivers

Rivers are responsible for shaping most of the landforms covering the earth's surface. They are powerful agents of erosion and they transport vast amounts of **sediment** that is eventually deposited to form a range of depositional landform features.

River erosion

Rivers erode the land over which they flow through the processes of:

- **abrasion**—sediment in the river grinds against the beds and banks of the river channel. This action dislodges material and carries it away

16.1.1 The Uvac canyon meander, Serbia

- **attrition**—dislodged materials collide with the river sides and bed, and with each another. Over time, they become smaller and are eventually reduced to fine particles called silt
- ***corrosion***—the solvent action of water dissolves soluble materials and carries them away in solution
- ***hydraulic action***—the rocks are broken down, usually along lines of weakness in the rock lining the river channel.

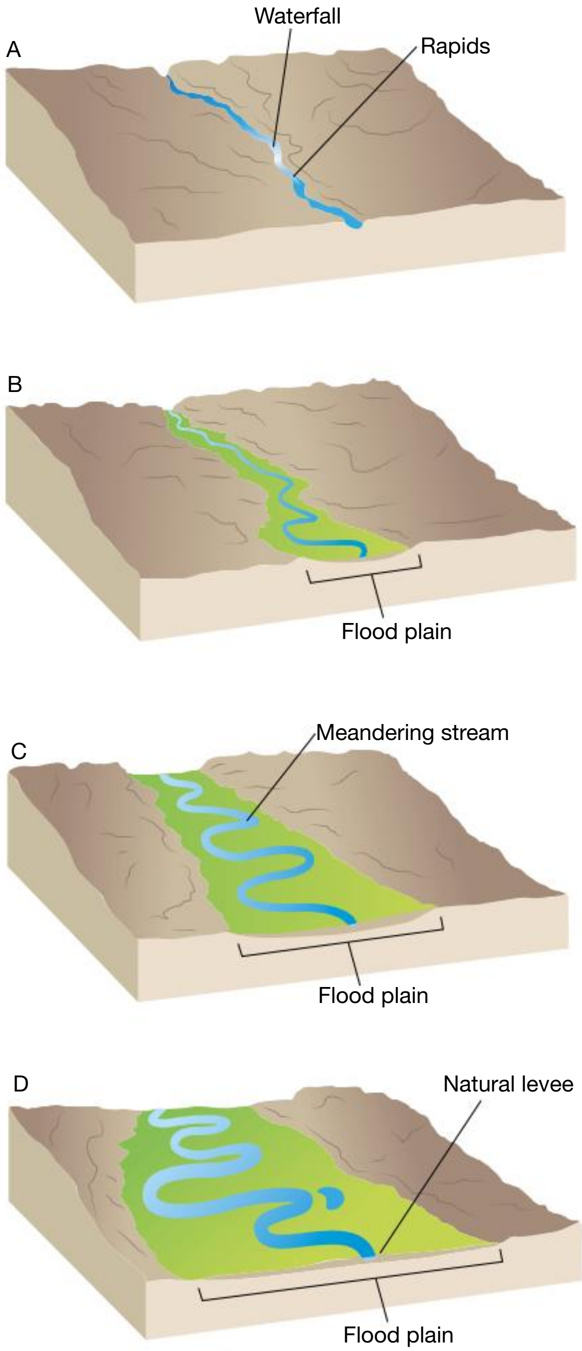
Transporting sediment

The eroded sediment in a river is transported as either **bed load** (the larger fragments that move along the riverbed) or **suspended load** (the finer fragments carried in the water). This process is illustrated in Figure 16.1.2. Transported sediment is then deposited.

Transforming the land

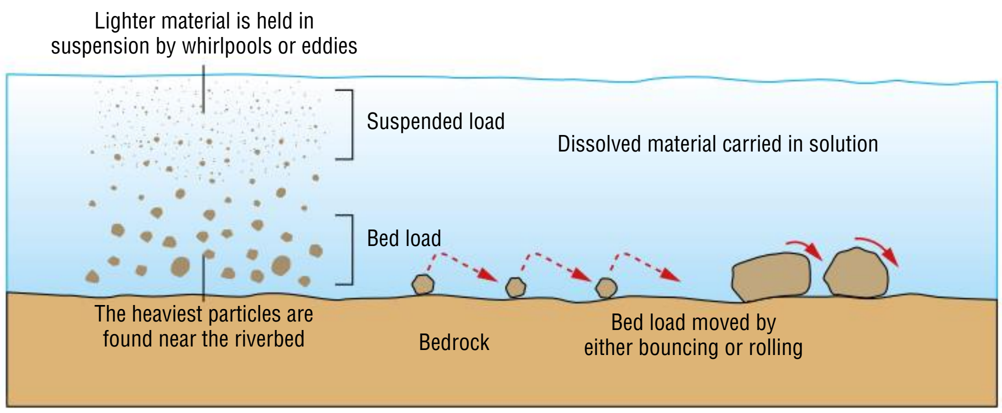
As a river flows from its source towards where it empties into the sea or lake, it changes the land.

Figure 16.1.3 illustrates how the riverine landscape changes from a narrow V-shaped valley in the upper reaches of the river to a broad, meander-dominated river valley in its lower reaches. In the upper reaches (A in Figure 16.1.3) the river is narrower and usually has a rapid, tumbling flow that cuts a narrow channel through rocky hills or mountains. Over time, a small **flood plain** develops and the first signs of river meandering appear (B). In the middle reaches of a river the flood plain develops further and a series of **meanders** form in the sediment deposits that have accumulated on the valley floor (C). In the lower reaches of a river the flood plain is broad and the meandering river channel is well developed (D). The presence of oxbow lakes suggests that the course of the river has changed over time.



16.1.3 Riverine landscapes change over the course of the river.

16.1.2 The process of sediment transport in a river



Catchments

When rain or snow falls, some water soaks into the ground, while the rest runs over the surface of the land. The high point in the landscape that determines which river system the water flows into is called a **watershed**, or divide. The watershed forms the boundary between river **catchments**, or drainage basins, as seen in Figure 16.1.4.

Drainage patterns

Rivers are fed by a network of smaller rivers or streams called **tributaries**. These tributaries form different patterns depending on the nature of the geology and topography. For example, hard rock such as basalt is hard to erode, so rivers or streams flow around this rock, influencing the course of the river.

Rivers as systems

A catchment is an open system, and is part of the water cycle. When a catchment is viewed as a system the terms 'inputs' (precipitation) and 'outputs' (evaporation, transpiration and human use) can be used. Within the system some of the water is stored, at least temporarily, in lakes or the soil.

Impacts on rivers

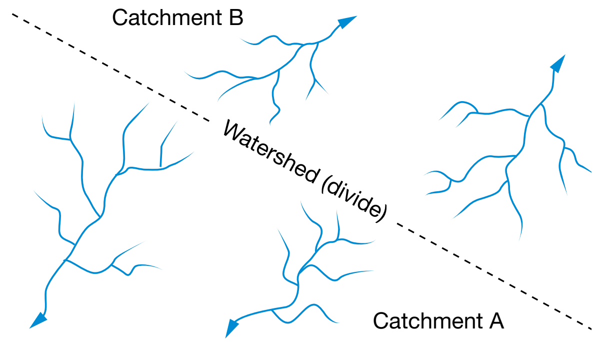
There are many factors that determine the nature of a river and its associated landforms.

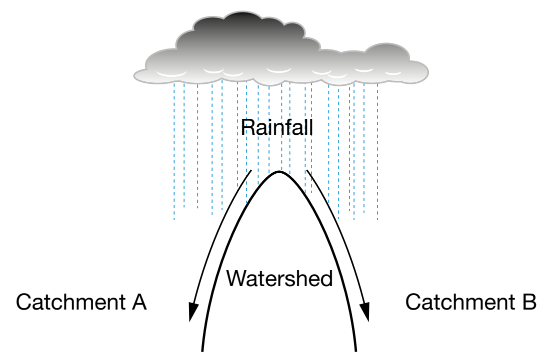
Climate

Precipitation and temperature have a major influence on the amount of water flowing through the river catchment. High temperatures increase the rate of evaporation during and after rainfall, and so reduce water run-off. Under cold conditions, precipitation in the form of snow often accumulates at higher altitudes and does not provide much run-off until it melts in warmer temperatures. Therefore, rivers that have their source in cold alpine regions often have a seasonal flow of water.

Geology

The geology of a catchment affects the nature of the river in at least two important ways. The rate of **infiltration** (the movement of water soaking into the soil) and the type and amount of sediment washing into rivers are affected by the geology of the catchment. Sandstone landscapes produce very porous, sandy soils. Erosion of sandstone creates a sandy river system. The geology also influences the river channel pattern. A river will flow through an area of weaker rock types or along fault lines.





16.1.4 A watershed, or divide

River basin topography

The size, shape and **gradient** (slope) of the catchment basin have a major impact on the **discharge** (the amount of water that flows from the river catchment) rate of the river. Large catchments tend to discharge more water over a longer period than smaller ones. Also, a steeper gradient causes water to drain more quickly.

Soils and vegetation

A catchment's soils and vegetation affect the amount and rate of water run-off. If soils are sandy, much of the water soaks into the soils. Thick groundcover vegetation also increases water absorption. Clay soils are heavy and water is not easily absorbed. When clay soils with little vegetation cover have been saturated from previous rainfall, there is much greater water run-off and sometimes flooding.

River channels

As water passes over land, friction slows down its movement. Figure 16.1.5 shows the cross-section of a river. The fastest flowing water is found in the part of the river least affected by frictional drag.

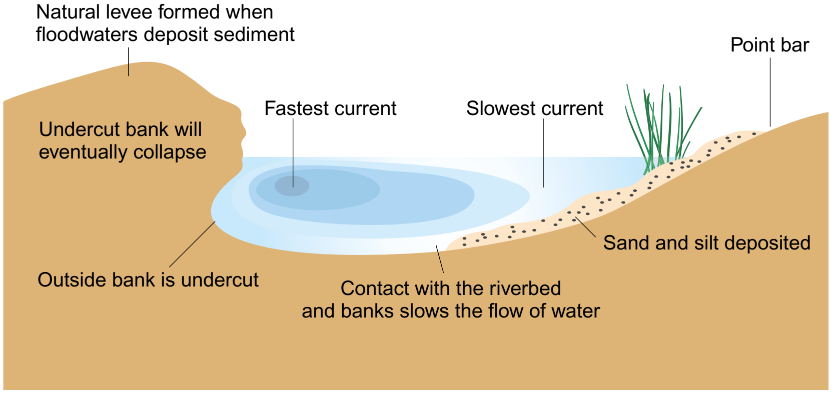
Figure 16.1.6 illustrates why water velocity increases towards the mouth of a river. Frictional drag slows the velocity of water in the upper reaches of a river.

Velocity, capacity and discharge

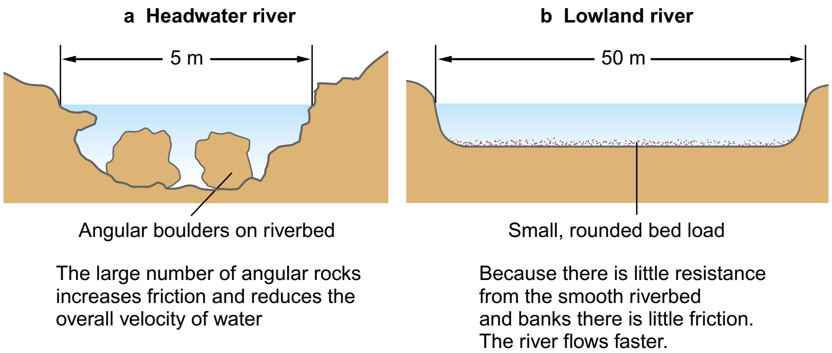
Velocity

The velocity, or speed, of water within river channels is influenced by:

- the shape of the channel—the rate of flow is faster in channels that are as deep as they are wide than it is in channels that are wide but very shallow, or very deep and narrow
- the roughness of the channel bed and banks—water flowing through a channel full of large rocks is more turbulent, but slower, than water flowing through a channel lined with fine silt
- the gradient or slope of the river—as a river approaches the sea its gradient decreases, but because more water is added to the channel, the velocity of the river actually increases.



16.1.5 Water velocity in the cross-section of a river



16.1.6 Why the water velocity of a river increases towards its mouth

Capacity

Stream capacity is the ability of a river to transport its load of sediment. It is expressed as the amount of sediment that can be moved past a particular point over a specified period of time. Stream capacity increases as sediment size within the channel decreases, and as stream discharge increases.

Discharge

The amount of water that flows from the catchment into another river system, the sea or a lake is called discharge. Discharge is expressed in cubic metres per second.

ACTIVITIES

Knowledge and understanding

1 Distinguish between abrasion and attrition.
2 Explain what corrosion and hydraulic action are.
3 Distinguish between bed load and suspended load.
4 State what a catchment is and outline the role of the watershed.
5 Outline the ways in which a river can be thought of as a ‘system’.
6 Outline the factors that influence the velocity of water in a river channel.
7 State what is meant by the term ‘stream capacity’.
8 Define the term ‘discharge’.

Applying and analysing

9 Study Figure 16.1.3. Outline how and why the nature of riverine landscapes and landforms changes along the course of the river, beginning at its headwaters or source.
10 Construct a mind map illustrating the factors that determine the nature of rivers.
11 Study Figure 16.1.5. Explain why water velocity is fastest at the point highlighted in the illustration.
12 Study Figure 16.1.6. Explain why average river velocity is greater in the lowland stretches of a river.

16.2

Types of riverine landforms

Riverine landforms

There is a wide variety of riverine, sometimes referred to as 'fluvial', landform features. This diversity results from the ways the river interacts with the geology and topography of the land. The nature of the vegetation and the activities of people also play a role.

Upstream landforms

In the upper reaches near the river's source, the channel is often narrow and deep, and the gradient steeper than further downstream. This results in the development of a number of distinctive landform features, including V-shaped valleys, rapids and waterfalls.

V-shaped valleys

The turbulent fast-flowing waters of the upper reaches of a river generate a great deal of corrasion as rocks crash against each other and the riverbed. In this part of the river, erosion cuts downwards more than it does sideways. The development of a V-shaped cross-sectional profile is the result (see Figure 16.2.1).

16.2.1 V-shaped valleys develop in sections of the river where erosion cuts downwards more than it does sideways.

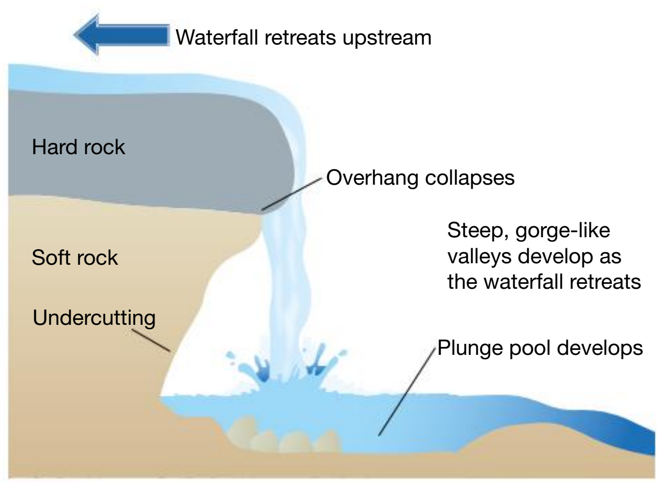
Rapids and waterfalls

A **rapid** is a section of a river with a relatively steep gradient that causes the velocity and turbulence of water to increase. In a rapid, the river becomes shallower and large rocks are exposed above the surface.

Waterfalls occur where water plunges over a vertical drop in the course of a river. They are most commonly found where the river channel is narrow and deep (that is, V-shaped). Figure 16.2.2 illustrates the formation of a waterfall. When a river comes into contact with a harder layer of rock, the rate of erosion slows. As the water plunges over the edge of the harder rock it creates turbulence, which erodes any underlying softer rock.

Tectonic influences

Tectonic forces can also impact on riverine landform features. Figure 16.2.3 shows what can happen when a section of land is uplifted slowly or rapidly. If the rate of uplift is slower than the downward rate of erosion, a canyon will form. If the rate of uplift is faster than the downward rate of erosion, the path of a river can be blocked or a lake formed.



16.2.2 Waterfalls develop when a harder layer of rock slows the downward rate of erosion. Gradually, the waterfall retreats upstream.

Downstream landforms

In the lower reaches of a river that is characterised by depositional landforms, the water speed slows.

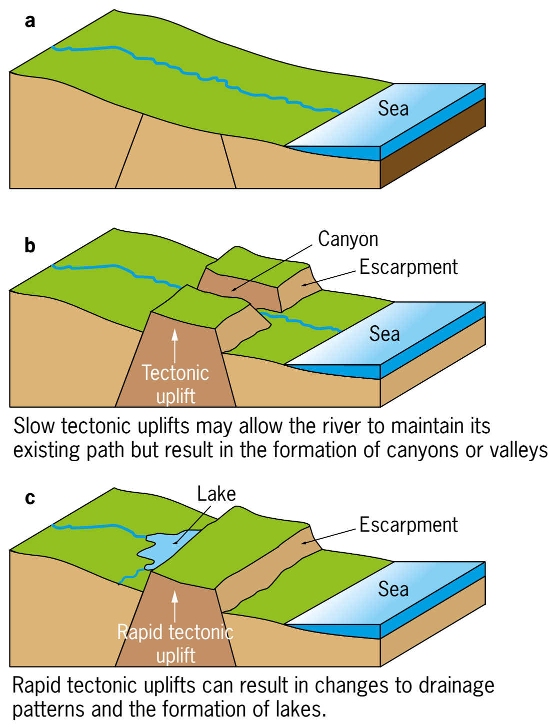
Flood plains

A flood plain is the flat or nearly flat land on either side of a river. It stretches from the banks of the river channel over the area inundated (flooded) when the river is at its peak. The landform features of the flood plain change over time. During floods, the waters of a river are capable of eroding, transporting and depositing vast amounts of sediment. The landform features of the flood plain are shown in Figure 16.2.4.

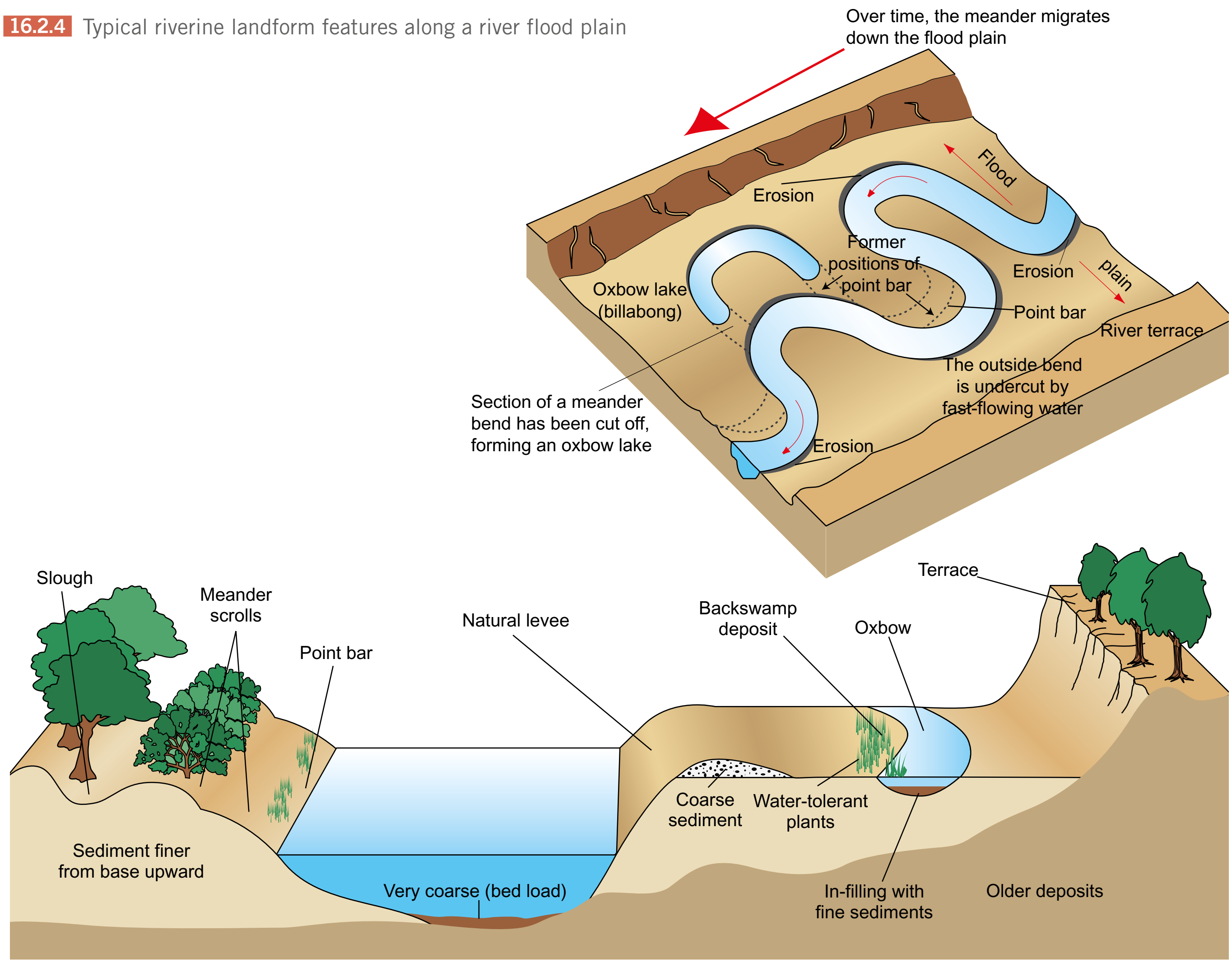
Natural levees

As sediment-full floodwaters spread out across the flood plain, they quickly lose speed. Much of the suspended silt and sand settles on the ground. The greatest amount of **deposition** occurs close to the channel. This causes a **natural levee** of elevated ground to develop on either side of the main channel (see Figure 16.2.4).

16.2.3 The impact of geological processes on river systems



16.2.4 Typical riverine landform features along a river flood plain



Braiding

When a river becomes choked with sediments it divides into a series of **braided channels** (see Figure 16.2.5). The sediment 'islands' are a feature of braided channels. Braided channels are common in regions with seasonally heavy precipitation (for example in alpine and semi-arid areas) and heavy loads of sediment.

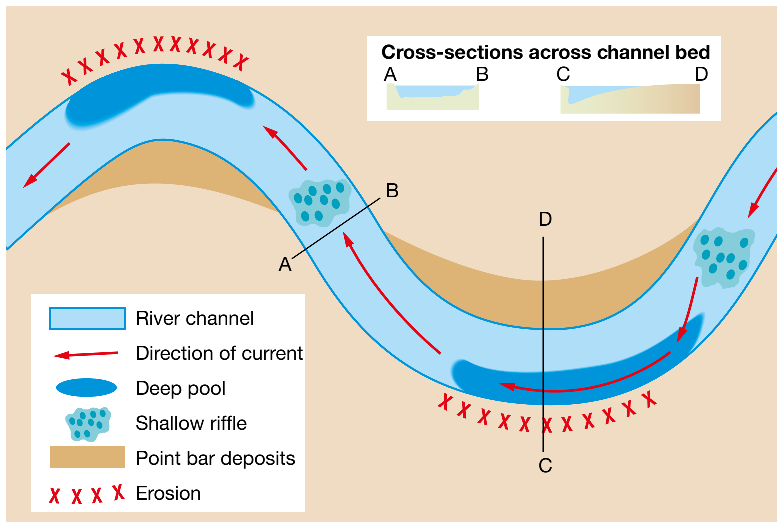
Meanders

Meanders are the repeated curves of the river channel. They are formed when the moving water in a river erodes the outer banks and widens its valley. Meanders are more common in areas where rivers flow through flat land. Meanders are formed from deep pools and shallow riffles (shallow gravel bars) in the river channel. As water travels past a riffle it is deflected towards the outside bank. As the river undercuts the outside bank, the meander migrates outwards. **Point bar** deposits build up on the inside of the loop. This process is illustrated in Figure 16.2.6.

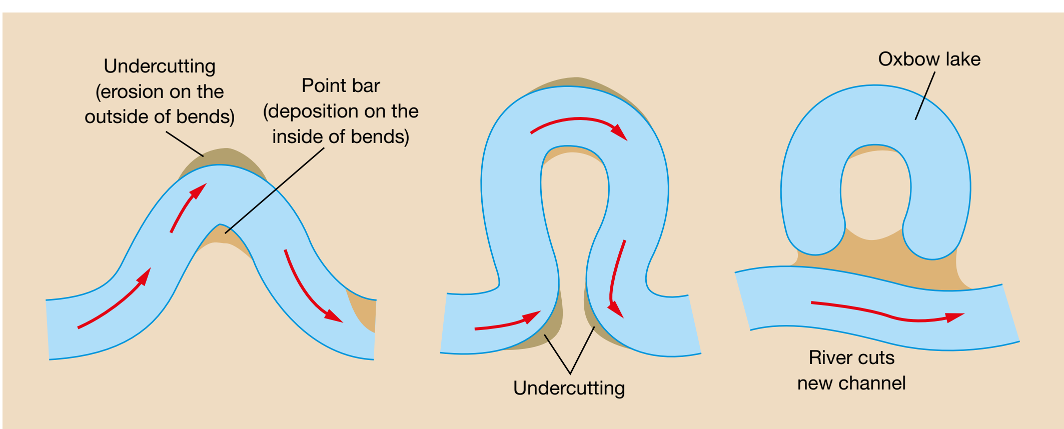
Oxbow lakes

The meander loops grow larger and larger until the channels almost meet. During floods, there is an increase in the amount and speed of water. This may cause the river to cut straight across the narrow neck of land separating two meander loops. The old sections of the former channel are called cut-offs or oxbow lakes. An oxbow lake, in time, fills with sediment, becoming a waterhole or, in Australia, a billabong, an Aboriginal word meaning 'dead river'. Figure 16.2.7 illustrates this process. Meanders and oxbow lakes can be observed in Figure 16.2.8, in which a map extract and an aerial photograph are compared.

16.2.5 Braided river channel, Murray River, Victoria



16.2.6 Features of a meandering river



16.2.7 Formation of an oxbow lake

Deltas

Deltas are the landform features that develop at the mouth of a river. As the waters of a river reach the sea (or lake), there is a drop in the water's speed and the river's ability to support its suspended load declines. As a result, much of the sediment load is deposited near or at the mouth of the river. Over time, a delta develops. Depending on factors such as wave action, currents and tides, different types of deltas develop.

Other rivers, particularly those located on coasts with a significant tidal range, do not form deltas. Rather, they enter the sea through an estuary—a partly enclosed coastal body of water.

16.2.8 Topographic map extract (left) and aerial photograph (right) showing the landform features associated with meandering

ACTIVITIES

Knowledge and understanding

1. a List the landform features associated with the upper and lower reaches of a river.
   b Identify and describe the main process responsible for their formation (that is, whether they are erosional or depositional landform features).

Geographical skills

2. Study Figure 16.2.8. Construct an annotated sketch map to identify the various meander-related landform features of the topographic map extract and the aerial photograph.

16.3

IN THE FIELD: Investigating rivers

Aim

The aim of this fieldwork activity is to investigate a river. A fieldwork investigation of a length of river provides an opportunity to learn more about this important feature 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 16.3.1):

- ruler
- tape measure
- ranging pole
- stopwatch
- clinometer
- 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

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.

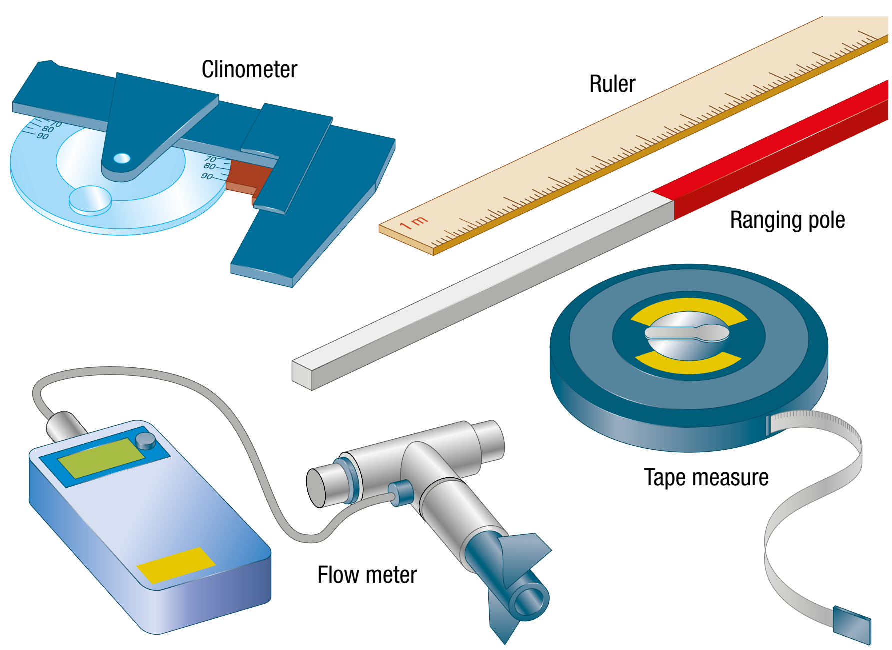
3 Take at least three readings. For greater accuracy take readings on both sides of the river and in the middle. Record your readings on your data record sheet. Average the readings to determine the water velocity.

Calculating 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.



16.3.1 Tools used to collect data in the field

3 Calculate the average depth by adding all the depth readings and dividing by the number of readings. Using the data shown in Table 16.3.2, the average would be (1.2 m + 1.4 m + 1.5 m + 1.3 m + 1.0 m) ÷ 5 = 1.28 m.

4 Multiply the average depth by the average width of the river to give the area. Using the data shown in Table 16.3.2, the area would be 1.28 m × 16 m = 20.48 m^2.

16.3.2 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:		• 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 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:

Discharge = velocity × cross-sectional area

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 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 16.3.3.

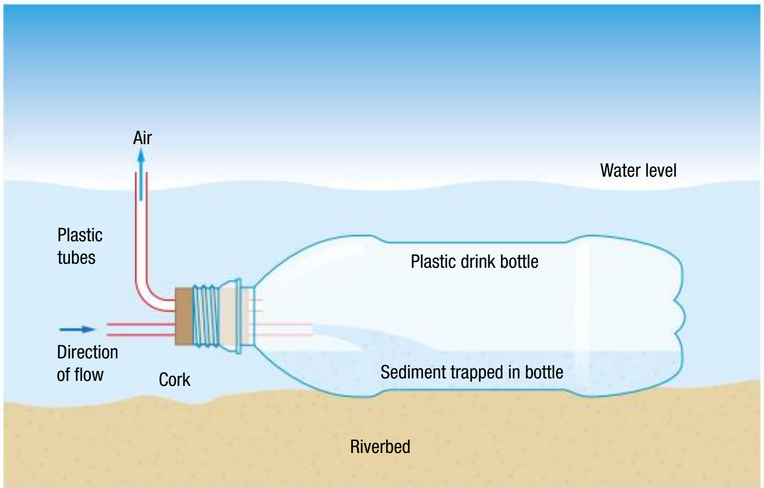
2 Anchor the bottle to the riverbed with two or three stones. When doing so, make sure that you stand downstream, so that you do not stir up too much sand and sediment.

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.



16.3.3 Sediment sampler

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.

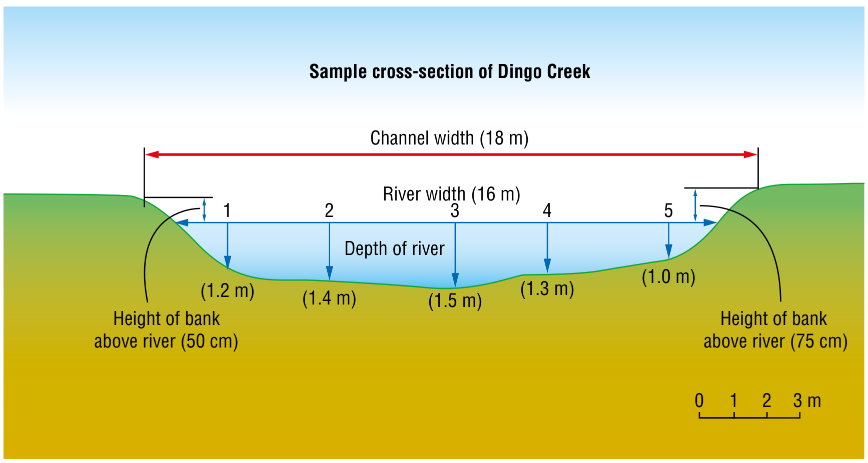
2 Look at the measurements for the height of the bank above the river level on both sides and mark the position of both banks. Measure the width of the channel from bank to bank. Now draw in the banks.

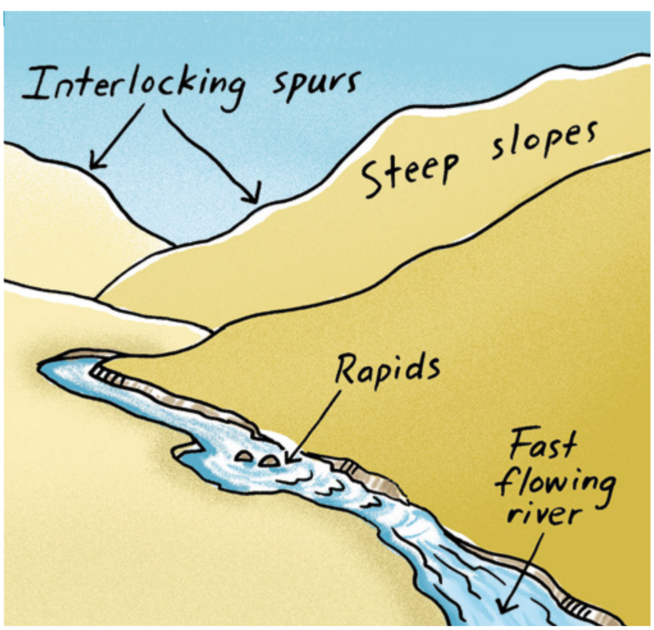
3 Mark in the riverbed by using your measurements of the depth of the river from the surface. Join the points together to show the shape of the riverbed. Add a scale and a heading, as shown in Figure 16.3.4.

Drawing a field sketch

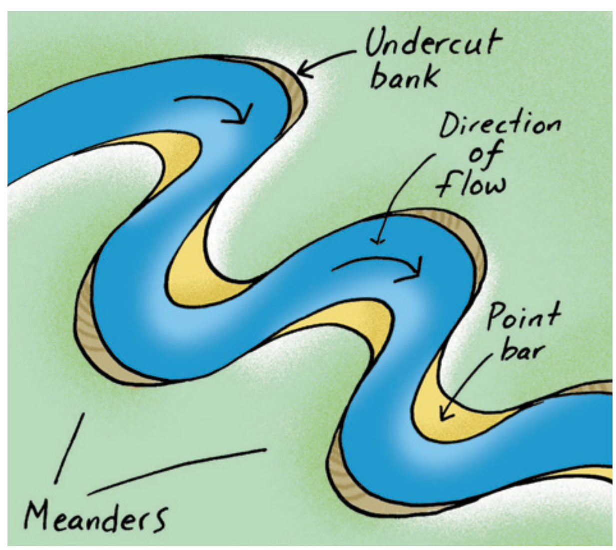
To draw a field sketch of the river being studied, use Figures 16.3.5 and 16.3.6 as a guide.

16.3.4 Sample cross-section of a river





16.3.5 Annotated field sketch of the upper reach of the river being studied



16.3.6 Sketch plan of the mid-reach of the river being studied

ACTIVITIES

Aim

To investigate the physical features of a river

Instructions

1 Select a suitable river to investigate and include a map of the area investigated.

2 Calculate water velocity.

   a Collect data and record it in a data record sheet similar to the sample below.

   b Select data from two different locations, and follow the steps for calculating water velocity on page 386.

River: Sandy Creek	Location: Site 1	Date: 23 May 2016
A. 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)	

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 2016
B. 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 × average depth 15 × 0.29 = 4.35 square metres (ii)		

4 Calculate river discharge.

River: Sandy Creek	Location: Site 1	Date: 23 May 2013
C. Discharge		
Velocity (i) × cross-sectional area (ii) 0.6 metres per second × 4.35 square metres = 2.61 cubic metres per second		

5 Measure turbidity. Collect data and record it in a data record sheet.

6 Measure suspended load.

7 Draw a cross-section of the river.

8 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, downstream and land on either side of the river channel.

   b Explain how each has or might influence the river channel.

   c Include the photos and explanations as annotations 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, recreational, household use, etc.)
- problems associated with the river (pollution, reduced water flow, etc.).

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 section of river that you investigated

   b information about changes in speed of flow along the river

   c information about levels of turbidity and suspended load—was there a correlation between the two?

Conclusion

10 Describe what you have learnt about river profiles.

16.4

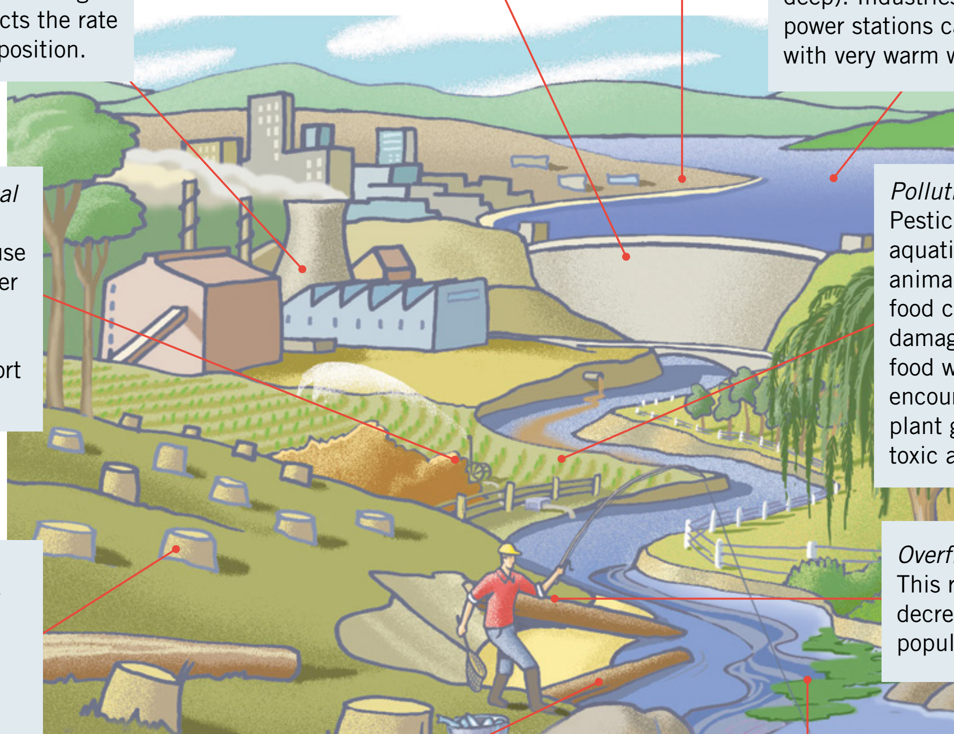
People's impact on rivers

The impacts

There are many ways in which human activity can impact on river-based landforms and ecosystems. Any activity within a river's catchment has the potential to impact on the river.

The impacts of people on riverine landforms and landscapes are outlined in Figure 16.4.1.

16.4.1 The impacts of people on river systems



River modification works

River modification works are designed to change or control the natural course or flow of a river. This is usually done to improve drainage and reduce flooding.

River modification works usually involve rearranging the riverbed or bank material, as has been done along the River Lea in London, shown in Figure 16.4.2. It is commonly thought that straightening the channel, by constructing either a totally new river canal or a flow path across a meander bend, increases river drainage capacity. In some cases, a river channel's capacity can be increased by enlarging and straightening the channel and then lining it with concrete. This usually happens in urban areas.

The construction of levee banks (see Figure 16.4.3), or retarding basins, is designed to control floodwaters.

Rivers can also be modified to reduce erosion. This may involve the removal or relocation of sediment bars and islands within the channel to prevent flows from being diverted to the banks and causing erosion.

Almost all river modification works involve the use of earth-moving machinery in or near the river channel. These machines damage the riverbed and/or banks, and can, at least in the short term, increase the amount of sediment flowing into the river.

16.4.2 London's River Lea is now a heavily modified urban waterway. The modifications date back hundreds of years. The most recent of these modifications occurred as part of the development of the Olympics site.

16.4.3 Large-scale levee construction in the catchment of the Missouri River, United States of America

Protection

The best way to protect riverine landforms and landscapes is to manage the whole catchment. Sources of soil erosion can be identified and addressed. Obstacles to the natural flow of water can be removed. Pollutants such as sewage, industrial pollution, agricultural fertilisers and pesticides, and salty **groundwater** can be identified and treated before they find their way into a catchment's waterways.

There is also a need to control and manage the amount of water taken from rivers for irrigation and urban and industrial uses. Experts now talk of maintaining an adequate **environmental flow**, ensuring that there is enough water in the river to help maintain a river's natural processes and to protect the health of the river and its wetland ecosystems.

Figure 16.4.4 illustrates how farmland next to a river can be managed to control the quality of water entering a river.

Urban areas

People in cities can also protect riverine landforms. Many stormwater drains in cities and built-up areas flow into rivers and creeks before flowing into the sea. Figure 16.4.5 shows how people can reduce the amount of wastes entering stormwater drains.

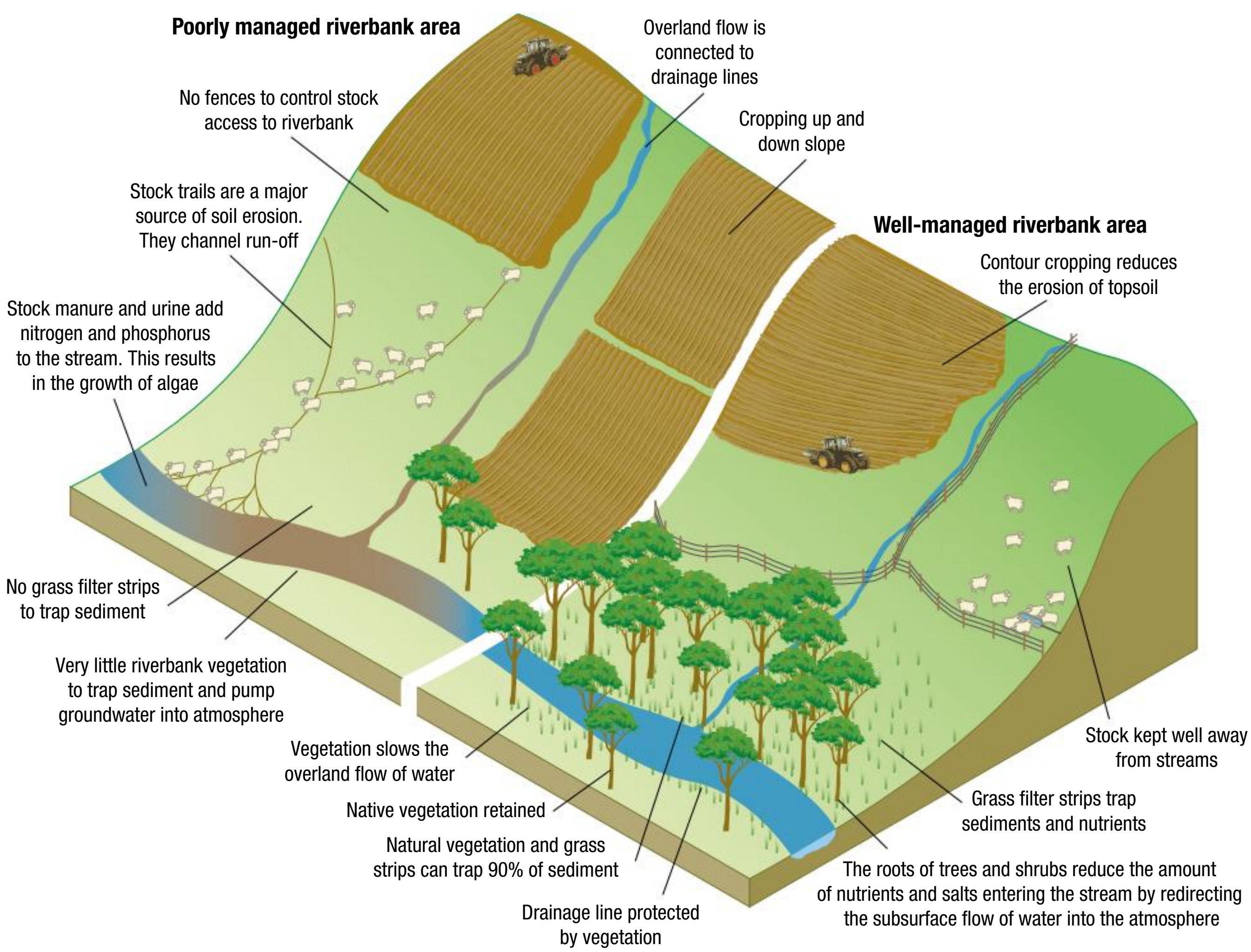
RAINGARDENS

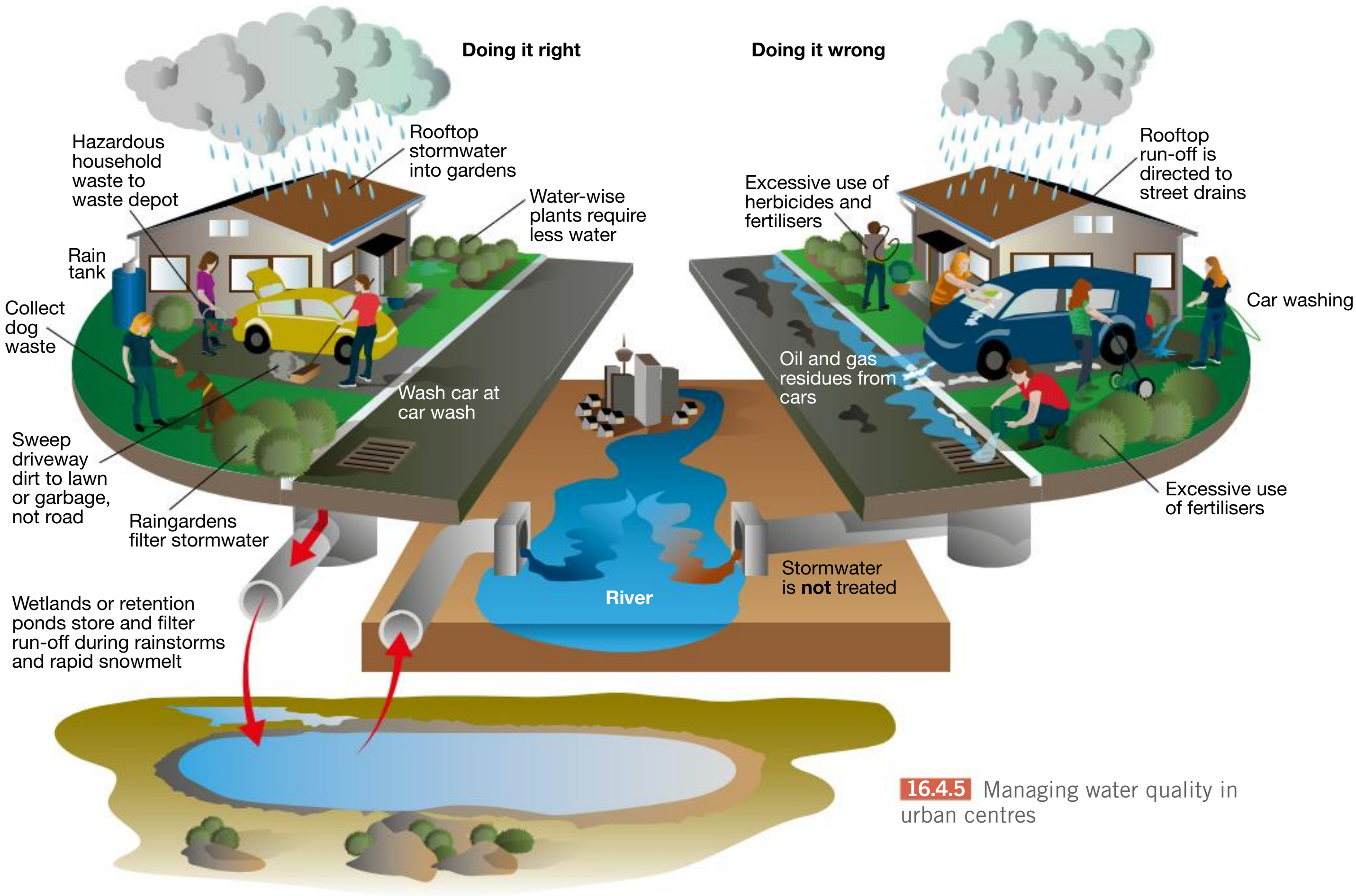
A raingarden looks like a normal garden but is designed to capture stormwater. When water falls on hard surfaces such as roads, footpaths and roofs, the raingarden captures the water and filters it through layers of sandy soil. As the water soaks through the layers, pollutants such as animal droppings are removed. Figure 16.4.6 shows a raingarden in action after rainfall.

FLOOD DETENTION BASINS

Flood detention or retention basins capture a large amount of stormwater and slow the amount of water entering a stream or river after heavy rainfall. A basin can remove pollutants and sediment flowing into a river or stream. Basins like the one shown in Figure 16.4.7 are being constructed throughout Australia.

16.4.4 Careful management of riverbanks can help to protect riverine landforms and water quality.





16.4.5 Managing water quality in urban centres

16.4.6 A suburban raingarden

16.4.7 Karkarook Park—a flood detention basin aimed at removing pollutants

ACTIVITIES

Knowledge and understanding

1 Describe the ways in which river modification works can impact on a river.
2 Explain how riverine landforms and landscapes can be protected.
3 Define the term ‘environmental flow’.

Applying and analysing

4 List the ways your household could manage its wastewater better.
5 In pairs or small groups, prepare a presentation for the School Council and Principal, outlining a plan for a new raingarden for your school. Your presentation should include the following information.
- map of the school showing the location of the raingarden
- benefits of the raingarden
- a sketch or diagram showing what the raingarden will look like

16.5

CASE STUDY: Bow River catchment

An important catchment

The Bow River is located in the Canadian province of Alberta. Over the length of the river can be seen the full range of riverine landforms. The river is an important source of drinking water and water for irrigation and hydro-electric power. It also provides habitat for wildlife and opportunities for recreational activities such as fishing and boating.

Riverine landforms

The Bow River's source is the meltwater of the Bow Glacier high in the Wapta Icefield of the Canadian Rockies. Figure 16.5.1 shows the location of the Bow River. The meltwater first finds it way into Bow Lake, shown in Figure 16.5.2, before it flows to the south through the rocky moraine debris on the floor of a former glacial (U-shaped) valley. It then flows through the village of Lake Louise and the town of Banff to Ghost Lake reservoir. It then flows onto the prairies to the city of Calgary, which has a population of 1.1 million. Downstream from Calgary are a range of depositional river landform features, including meanders, cut-offs and oxbow lakes. Further downstream the Bow River flows into the South Saskatchewan River, which continues to wind its way across the Canadian prairies before flowing into Lake Winnipeg and then into Hudson Bay via the Nelson River.

16.5.2 The Bow River has its source in the meltwater of the Bow Glacier high in the Canadian Rocky Mountains. Bow Lake is in the foreground.

16.5.1 Bow River catchment

16.5.3 The Bow River in its upper reaches

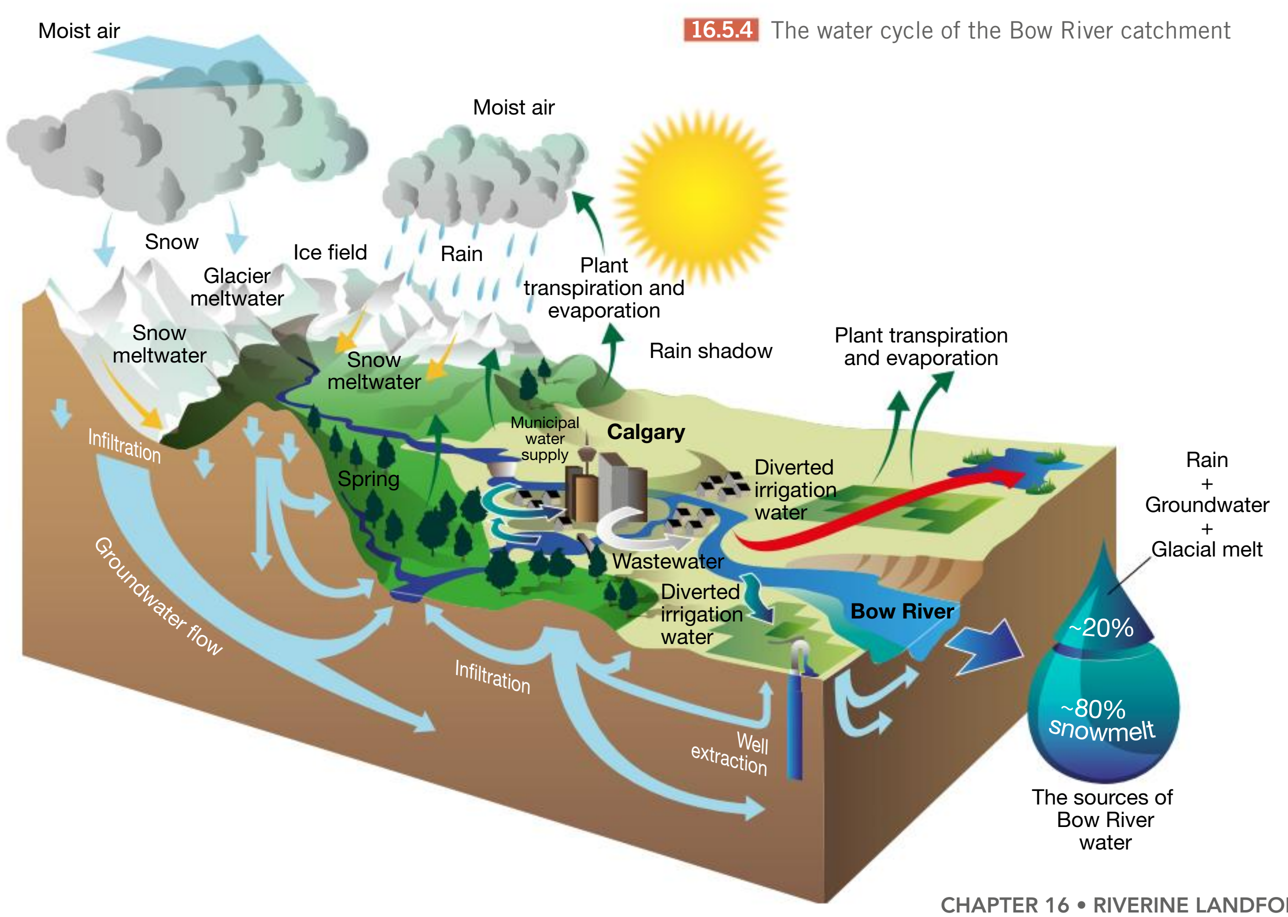
The water cycle

The Rocky Mountains force air to rise and cool, causing moisture to condense and fall as rain or snow. This precipitation, together with the meltwaters from glaciers, feeds the Bow River through its many mountain tributaries. Figure 16.5.3 shows the upper reaches of the river.

The grasslands, or prairies, of Canada's interior have a relatively dry climate. Due to their height, the Rocky Mountains strip moisture from eastward-moving air masses in what is referred to as a 'rain shadow' effect. As a result, little of the moisture from the eastward-moving air masses reaches the prairies of Alberta. The region therefore relies on the Bow River and groundwater for irrigation in agriculture and human use.

The water cycle of the Bow River catchment is illustrated in Figure 16.5.4.

16.5.4 The water cycle of the Bow River catchment



Human modifications

In their efforts to use the water resources of the Bow River for irrigation, people have significantly changed, or modified, the river. Water is used for agriculture (irrigation), urban water supplies, hydro-electric power, industry and recreation.

Irrigation

Early in the last century, European settlers developed irrigation systems to move the waters of the Bow River out onto the prairie. Water was supplied to farmers through a system of canals and storage reservoirs. Over time, communities and industries developed across Alberta's prairies.

Figure 16.5.5 shows the extent of the modifications made to the river. Irrigation is used during the growing season, which begins in May and continues through to October. Improved irrigation techniques have greatly reduced the water required to grow crops. The canals and reservoirs provide important wetland habitat for waterfowl and fish.

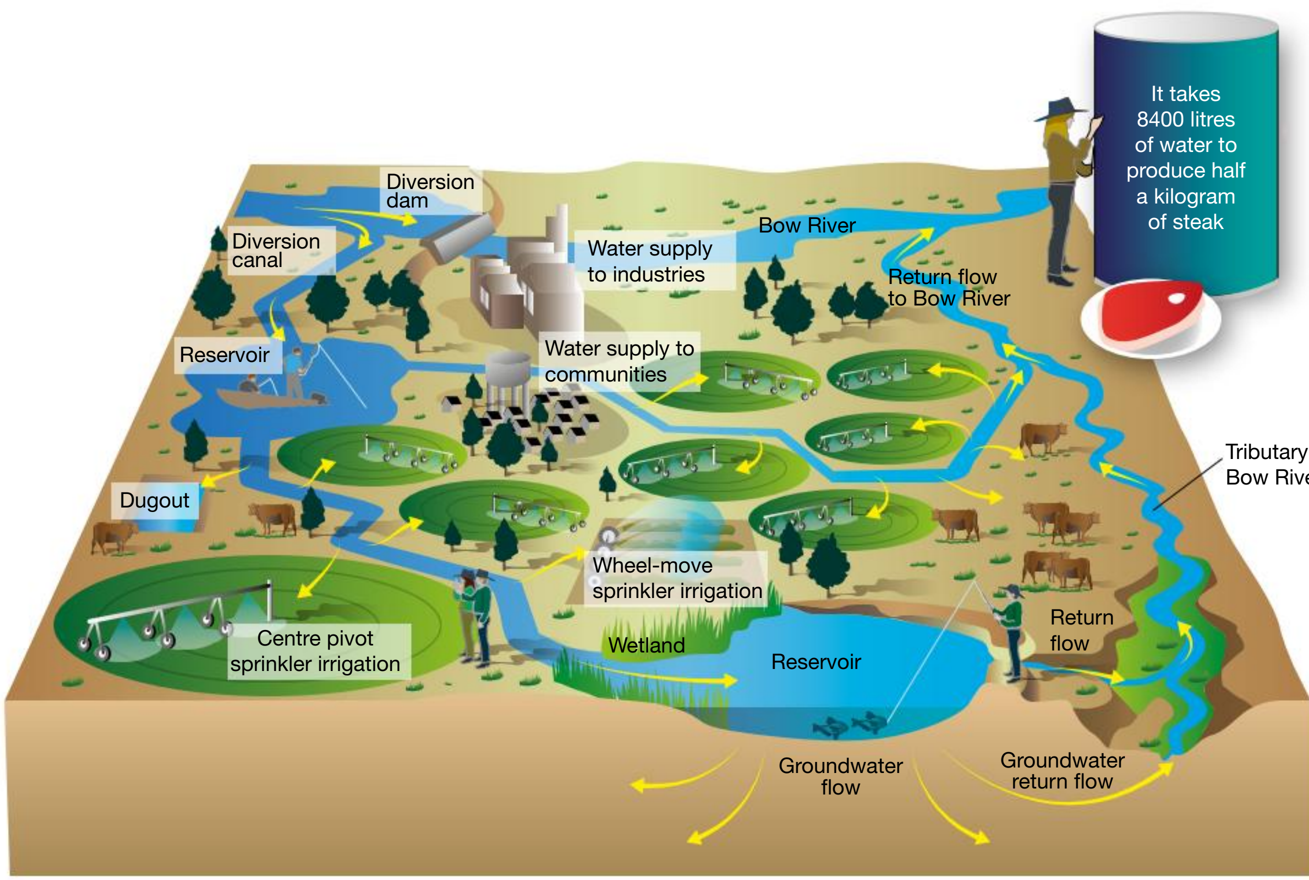
Urban water use

Municipalities (towns and cities) in the area return over 90 per cent of the water they use as treated sewage back to the Bow River. Calgary, a rapidly growing city on a relatively small river, is by far the largest urban centre in the Bow River catchment. As a result, it has limited capacity to absorb wastewater without reducing water quality. Because of this, Calgary's wastewater treatment standards are among the highest in Canada. During summer, Calgary's residential water use rises by 50 per cent, largely due to garden and lawn watering. Calgary's water usage is shown in Table 16.5.6.

Protecting the Bow River

There are a variety of ways in which the riverine landscape of the Bow River can be protected.

Of particular importance is the health of the riparian zone—the area bordering streams and wetlands where moist soils and shallow water tables allow water-loving plant communities to establish. These zones are important ecosystems. They stabilise stream banks and protect water quality. They also provide habitat for wildlife. Cattle grazing in riparian areas must be managed carefully so that river-related landforms are not degraded.



16.5.5 The waters of the Bow River have been diverted, dammed and used for irrigation.

16.5.6 Municipal and residential water use

Calgary's municipal water use	
Residential	52%
Industrial commercial infrastructure	34%
Non-revenue (e.g. leakage)	12%
Other communities	2%
Calgary's residential water use	
Toilet	29%
Clothes washer	20%
Taps	16%
Shower	13%
Leaks	10%
Water softener	9%
Baths	2%
Dishwasher	1%

Impacts of climate change on the Bow River catchment

The potential impacts of climate change on the Bow River catchment include:

- reduced snowfall and shrinking glaciers, causing a decline in the amount of river flow, which in turn will:
  - affect water supply, water quality and both the extent and type of recreational activities that people can do
  - lead to decreased hydro-electric power generation
- warmer, drier summers and earlier springs, resulting in an increase in the frequency and intensity of forest fires
- an increase in the incidence of extreme weather events such as tornadoes, hailstorms, heatwaves, droughts, dust storms, floods and blizzards
- increased demand for irrigation water and a change in crop types due to a longer growing season
- warmer river temperatures, resulting in increased stress for cold-water fish species such as trout
- reduced groundwater recharge, resulting in lower water tables and the drying up of shallow wells.

Many people are concerned about the rate at which the glaciers high in the Rocky Mountains are retreating. While this is a serious problem and one of the major impacts of climate change, the contribution of meltwater to the annual flow of the Bow River is relatively small (less than 1 per cent). However, the portion of Bow River water that comes from glaciers rises during the summer as snowmelt declines. During a drought year, the relative contribution of glacier meltwater to the discharge of the Bow River is higher. Without glaciers in the Bow River basin, water supply during drought years would be less secure. However, as long as it snows and rains every year, we can expect the river to keep moving.

ACTIVITIES

Knowledge and understanding

1. With the aid of Figure 16.5.4, describe the geography of the Bow River catchment.
2. Explain why it is important to protect the catchment's riparian zone.
3. Outline the strategies used to manage landuse in the Bow River catchment.
4. Describe the potential impacts of climate change on the Bow River catchment.

Applying and analysing

5. Study Figure 16.5.5.
   a. Describe the extent to which people have modified the flow of water in the Bow River catchment.
   b. Reflect on how this might impact on the river itself and list the ways in which the riverine landscape can be managed better.

Geographical skills

6. Study Figure 16.5.1.
   a. List the rivers that flow into the Saskatchewan River and the cities on each river.
   b. Name the lake into which the Saskatchewan River flows.
   c. True or false? *All rivers that flow into the Nelson River originate in Canada.* Explain your answer.
7. Study Table 16.5.6. Construct two proportional pie graphs—one showing Calgary's municipal water use and the other showing Calgary's residential water use.

Desert landforms

CHAPTER 17

Deserts are among the world's most spectacular landscapes and feature amazing landforms that have been shaped by wind and water.

Deserts are found where precipitation is low and evaporation is high. Contrary to popular belief, deserts are not necessarily hot. All deserts have a number of features in common, including very low and irregular rainfall, highly specialised plants and animals, and few, if any, people.

INQUIRY QUESTIONS

- Why are deserts dry places and how are their distinctive landform features formed?
- What is the process of desertification?
- In what ways do the activities of humans contribute to the process of desertification?

GLOSSARY

alluvial fan	a low, cone-shaped deposit of sand and rock formed when a stream deposits its load on a low-lying plain as a result of an abrupt change of slope
aquifer	a layer of permeable rock that is capable of storing significant quantities of water
bolson	an inland desert basin surrounded by mountains
butte	a flat-topped landform feature that is taller than it is wide
deflation	the process whereby material is removed from a surface by wind
desert	a very dry environment in which evaporation is greater than precipitation or precipitation is less than 250 millimetres a year
desertification	the process by which productive land in arid areas is changed into desert
erg	a desert surface covered with sand dunes
escarpment	a long, steep slope that defines the edge of a plateau or separates areas of land at different heights
hamada	a desert landscape dominated by exposed bedrock
inselberg	a large erosion-resistant rock feature surrounded by an eroded plain
mesa	a flat-topped landform feature that is wider than it is high
oasis	a fertile or well-watered area within a desert
playa lake	a dried-up salt lake found in arid or semi-arid environments
reg	a stone-covered desert
sand dune	a hill of sand shaped by the wind
succulent	a plant capable of storing water in its tissues
transpiration	the loss of water vapour from the leaves of plants
wadi	a watercourse or gully that is dry except during periods of rainfall
xerophyte	a drought-resistant plant adapted to the dry desert environment

17.0 Mountains and sand dune at Death Valley, California, United States of America

17.1

Deserts

Desert features

Deserts are the driest places on earth. They usually have few plants and hard, wind-blown surfaces covered with rocks and sand. The range of temperatures experienced each day is often very broad, with very high daytime temperatures and very cold night temperatures. There is no cloud cover, so heat is lost into the atmosphere very quickly. The lack of moisture in the air (combined with the lack of vegetation) also allows the surface of the desert to lose heat rapidly after the sun goes down.

Desert location

Deserts occur where evaporation is greater than precipitation or where precipitation is less than 250 millimetres a year. These areas cover about 30 per cent of the earth's surface. Approximately 13 per cent of the world's population live in deserts.

Deserts occur in regions where the climate is dominated by high-pressure systems. High-pressure systems are areas in which there is little rainfall, as outlined in Figure 17.1.1. Evaporation rates in deserts are often twenty times the annual precipitation.

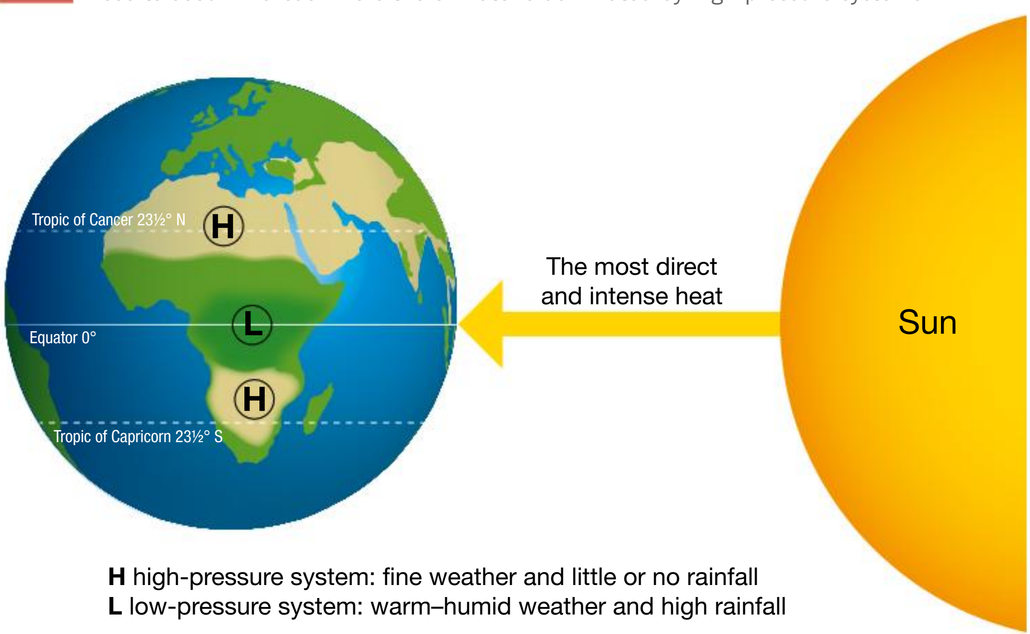
Air near the Equator rises into the atmosphere because it is hot. This air then travels towards either the Tropic of Cancer or the Tropic of Capricorn. As it does so, the temperature of the air decreases and it sinks back towards the earth. This sinking air creates an area of high pressure. There is little chance of precipitation in these areas because air must be rising before condensation, and therefore precipitation, can develop.

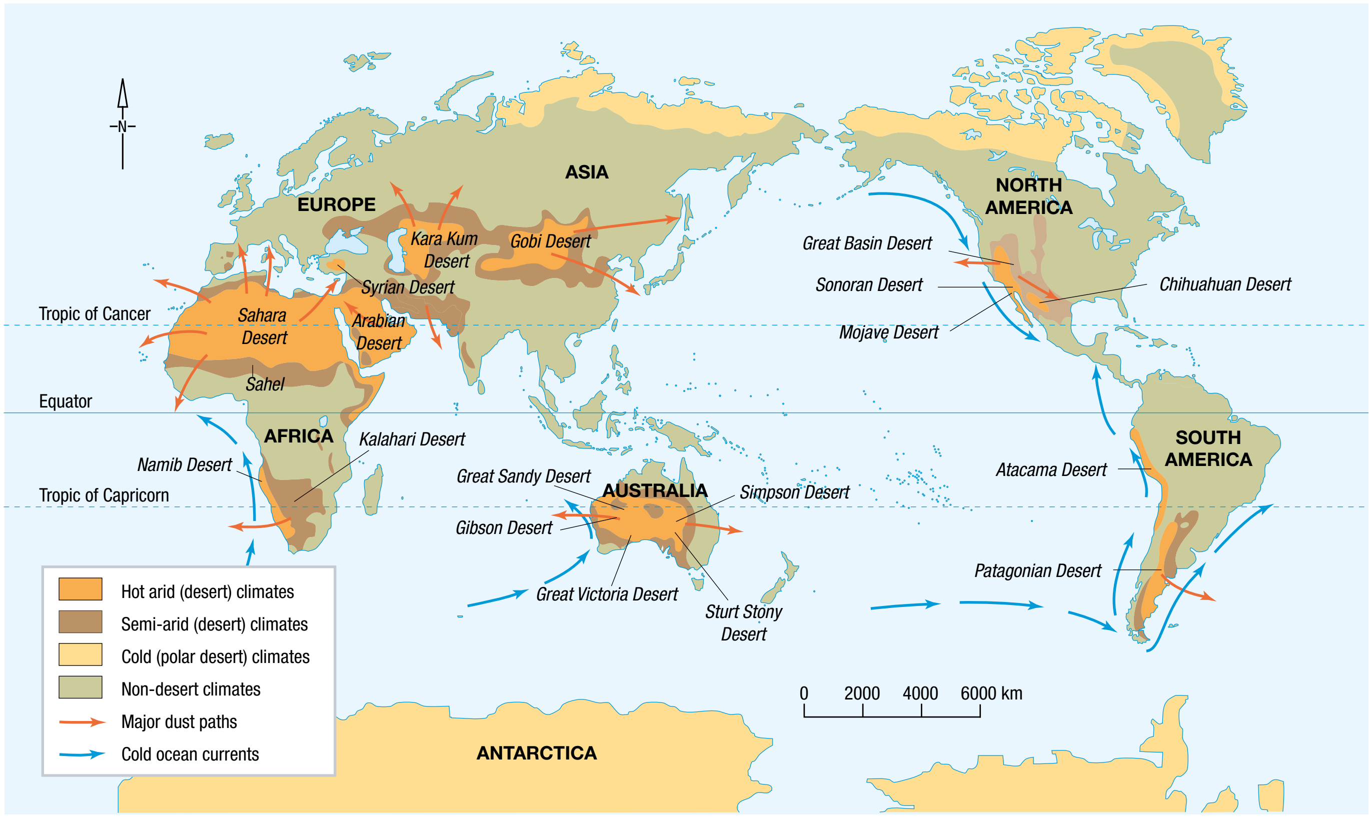
Distribution of deserts

Figure 17.1.2 shows the distribution of deserts. Deserts are located either in the interior of continents or near the coast next to cold ocean currents, excluding the Sahara.
The distribution of deserts is influenced by:

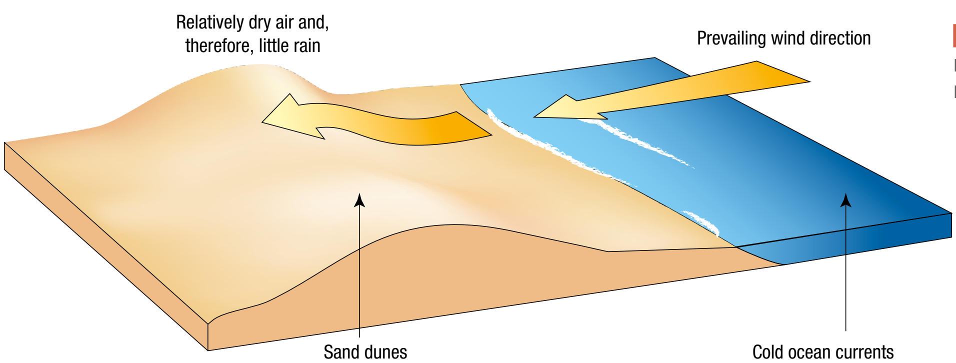
- cold ocean currents—as evaporation rates from cold water are low, the amount of water in the air and therefore the amount of rainfall are reduced, as shown in Figure 17.1.3
- wind direction—in the mid-latitudes, hot dry winds blow mainly across land towards the sea
- mountain rain shadow—mountains can block the inland movement of rainfall. This is shown in Figure 17.1.4.

17.1.1 Deserts occur in areas where the climate is dominated by high-pressure systems.

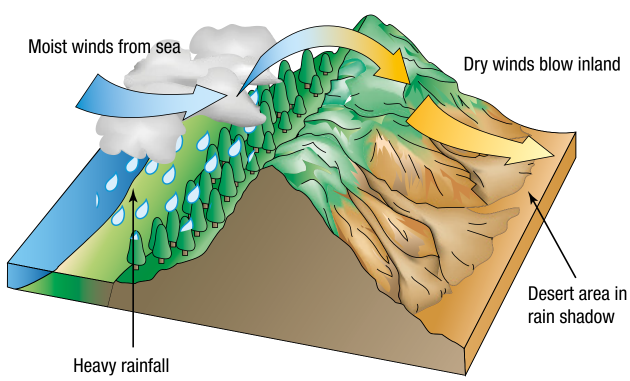




17.1.2 Distribution of the world's desert lands



17.1.3 Large bodies of cold water result in low rates of evaporation. As a result, the air moving onshore is dry.



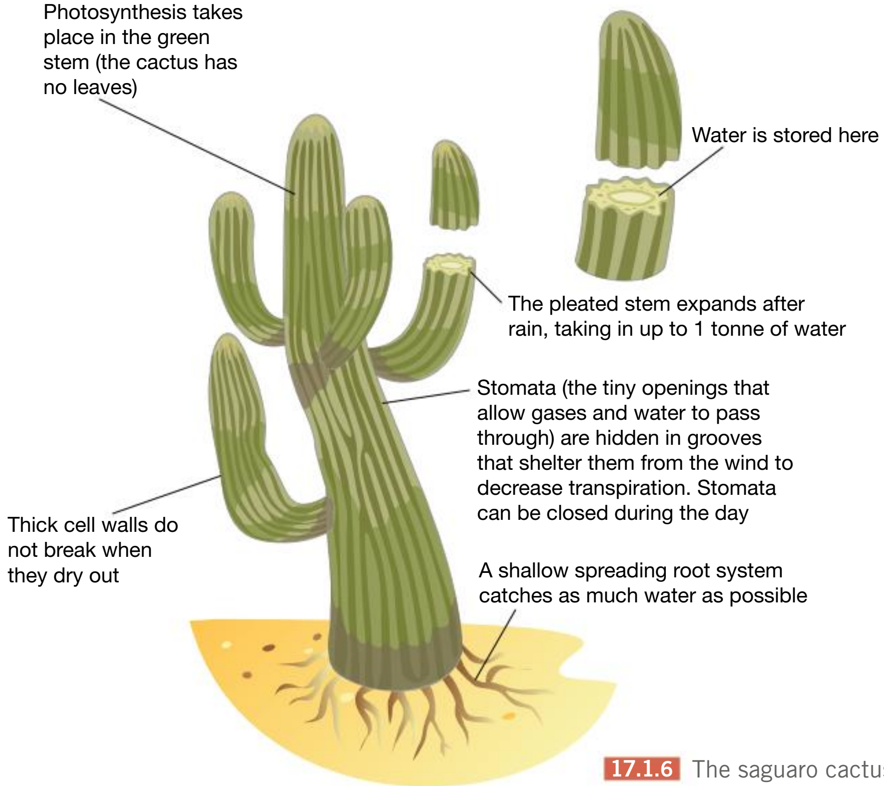
17.1.4 Mountain ranges can block the inland movement of moisture, producing desert environments.

SPOTLIGHT

Surviving aridity: The cactus

Drought-resistant plants are known as **xerophytes**. Many xerophytes are **succulents**. This means that they are able to store water in their tissues. Cacti (Figure 17.1.5), for example, absorb large amounts of water following rainfall. Their fleshy stems swell up, then slowly shrink as moisture is lost through **transpiration** (the loss of water vapour from the leaves of plants). Many succulents further reduce the amount of moisture lost by transpiring only at night.

Most desert plants, including cacti, have small leaves that are spiky or wax-coated. This reduces transpiration. Cacti also spread their shallow roots wide to take advantage of any rain or dew; other adaptations are shown in Figure 17.1.6.



17.1.6 The saguaro cactus

17.1.5 The cactus is a well-known symbol of North American deserts.

Cold deserts

Antarctica and the Arctic regions are also classified as deserts. Although covered with a thick layer of ice, Antarctica is, in fact, a very dry place. The continent's average annual snowfall equals just 50 millimetres of rainfall.

Desert size

The Sahara is the world's largest desert, although the Antarctic Desert (Antarctica), at 13 829 430 square kilometres, is sometimes referred to as the largest. Table 17.1.7 shows the largest deserts in area.

17.1.7 The world's greatest deserts

Desert	Area (km^2)
Sahara (Africa)	8 600 000
Arabian (Middle East)	2 330 000
Gobi (Asia)	1 200 000
Kalahari (Africa)	900 000
Patagonian (South America)	673 000
Great Victoria (Australia)	647 000
Syrian (Middle East)	520 000
Great Basin (North America)	492 000
Chihuahuan (USA)	450 000
Great Sandy (Australia)	407 000

DID YOU KNOW?

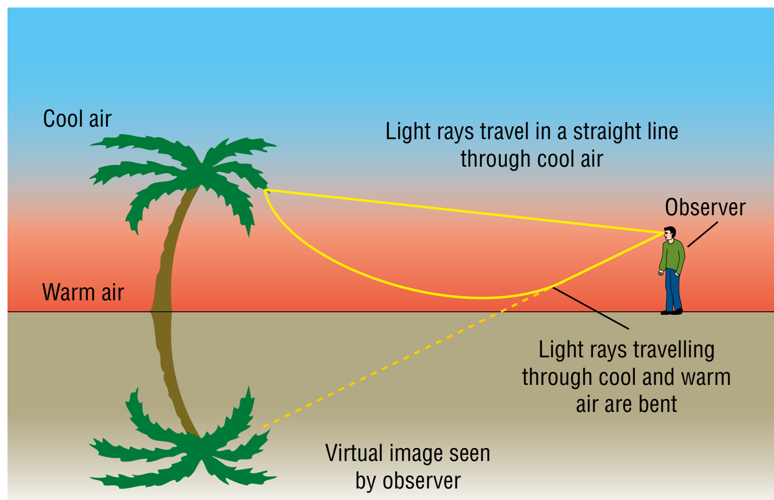
If someone spent a day in the desert with no shade, food, water or clothes, their temperature would be about 46°C by sunset, and they would have lost 2 to 3.5 litres of water. By nightfall they would be dead.

Desert plants

Vegetation in deserts depends on the desert's location. The cactus is a well-known symbol of the desert, but is, in fact, found only in North American deserts. In southern African deserts, aloe plants are widespread, and in northern African and Middle Eastern deserts, date palms are typical plants. In Australia, grasslands cover large parts of the arid zones.

Desert mirages

Mirages are often seen in the world's hot deserts. They occur when a shallow layer of warm air next to the ground is trapped by cooler air above. Light bends towards the horizontal line of vision, and eventually travels upwards: the mirage is an upside-down 'virtual' image (see Figure 17.1.8).



17.1.8 A mirage is an optical illusion.

ACTIVITIES

Knowledge and understanding

1. Define the term 'desert'.
2. State the proportion of the earth's surface that is covered by desert.
3. Explain why deserts are often very cold at night.
4. Identify the conditions under which deserts occur.
5. Identify the types of plants that are common in the deserts in the following locations.
   a. southern Africa
   b. northern Africa and the Middle East
   c. North America

Geography skills

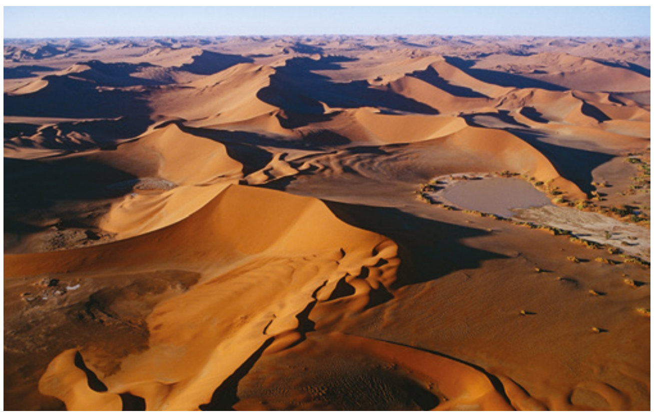
6. Study Figure 17.1.2.
   a. Describe the distribution of the world's hot deserts.
   b. Describe the distribution of the world's cold deserts.
   c. Explain why desert-like conditions are found in these areas.
   d. Are there any deserts along the Equator? Explain.

17.2

Desert landforms

Desert surfaces

Sand dunes cover only about 25 per cent of the world's deserts. The remaining 75 per cent are either exposed rock or stone-covered plains. The rocks of the desert surface are usually quite smooth, having been polished by the wind-blown sand. This process is known as abrasion. The three main types of desert surfaces are shown in Figures 17.2.1 to 17.2.3.



17.2.1 Sandy desert or erg surface, Namibia, Africa

17.2.2 Stony desert or reg surface (known as a gibber plain in Australia) of the Jbel Bani mountain range of Western Sahara, Africa

17.2.3 Rocky desert or hamada surface, Double Arch, Utah, United States of America

Landforms shaped by wind

The erosion of fine surface sand by wind is known as **deflation**. Once airborne, sand can act as an abrasive tool, wearing down and shaping exposed rock. Pedestal rocks, for example, are formed when wind-blown sand cuts away the base of rock structures but leaves their tops intact.

When the wind-blown material is deposited, it accumulates and forms sand dunes. The shape of these dunes varies according to the strength and direction of the wind, the amount of sand available and the type and extent of vegetation cover in the area. Dunes are named according to their shape and direction. Some of the more common types are shown in Figure 17.2.4.

Landforms shaped by water

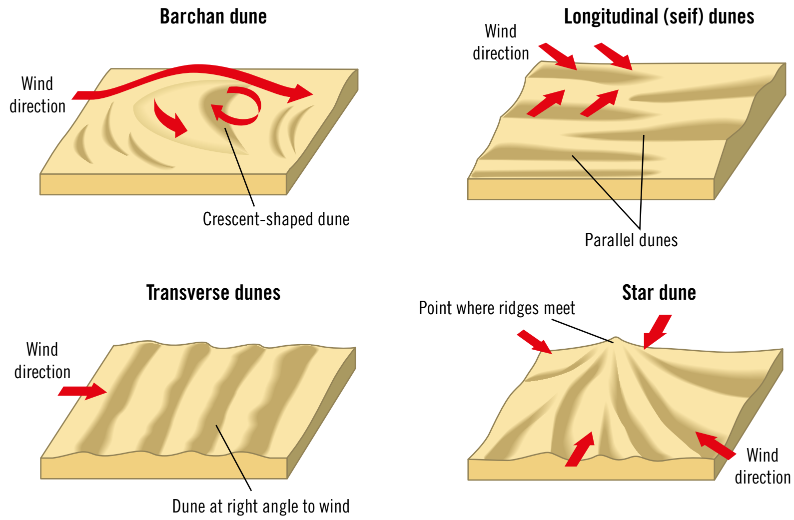
Although it does not rain often in deserts, when it does, the rain is often very heavy and results in flash flooding. Because there is little or no vegetation, run-off is extremely rapid and can erode large amounts of material.

Surface run-off is channelled into dry riverbeds (**wadis**) that cut through plateaus, forming canyons. As plateaus are eroded, **mesas** and **buttes** are left isolated from the retreating **escarpment**, or steep cliff. Mesas are wider than they are high, while buttes are higher than they are wide.

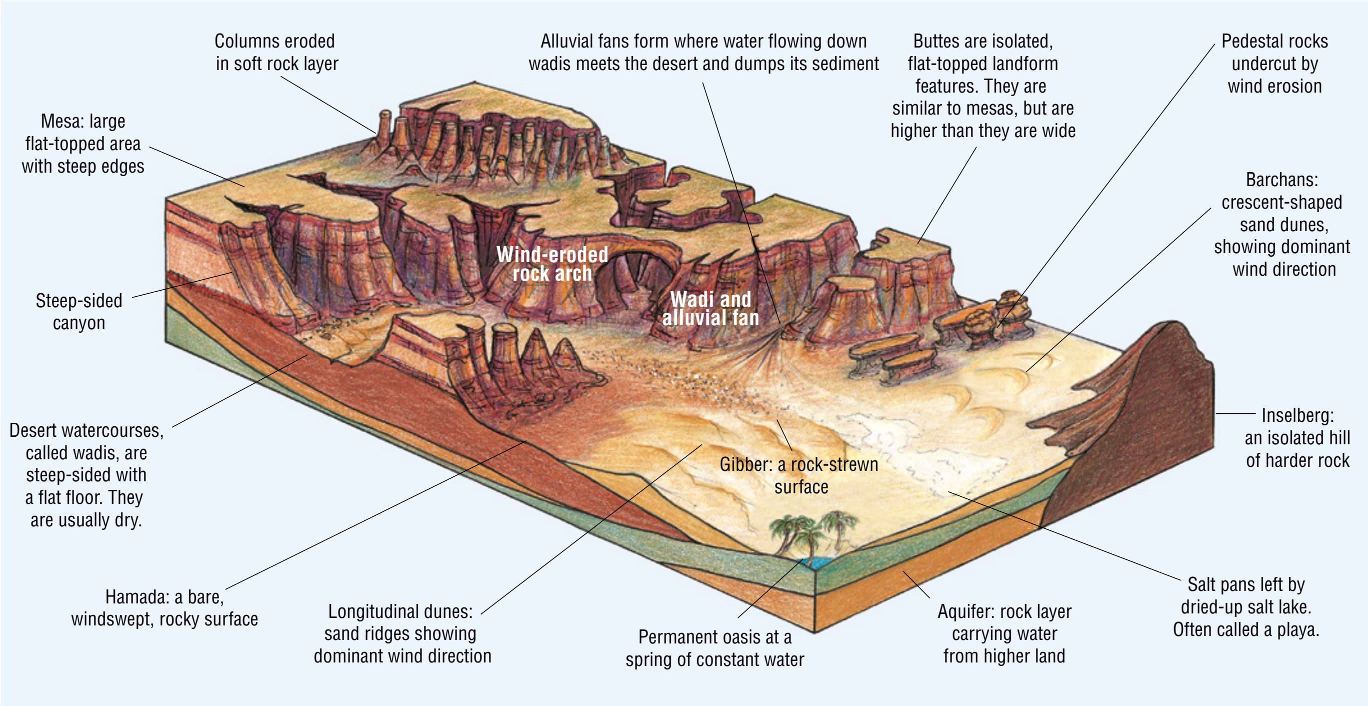
The eroded material is carried by the water through the wadis. It is eventually deposited on the lowlands, forming **alluvial fans**. These spread out across the desert basin, or **bolson**, where the fine particles can be shaped into dunes by the wind.

Where water flows into a desert depression, **playa lakes** form. When the water eventually evaporates, salt pans or clay pans are formed.

Inselbergs are large masses of resistant rock that rise abruptly from the surrounding plain. They are exposed when the softer surrounding rock material is eroded. Uluru/Ayers Rock, in central Australia, is probably the world's best known inselberg. The landforms of the desert are shown in Figure 17.2.5.



17.2.4 Types of sand dunes



17.2.5 Landforms of the desert

ACTIVITIES

Knowledge and understanding

1. Name and describe the three types of desert surfaces.
2. Explain what abrasion is. What impact does it have on rocks?
3. Define the term 'deflation'.
4. Explain why rainfall is such an effective agent of erosion in desert environments.

CASE STUDY: The Sahara

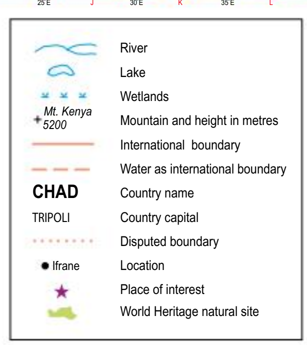
Location

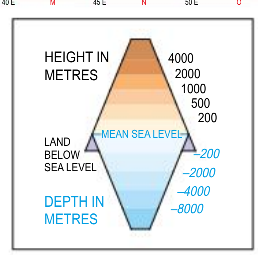
The Sahara covers almost one-third of Africa (see Figure 17.3.1), stretching from the Red Sea to the Atlantic Ocean. Its boundaries are the Atlas Mountains, the Mediterranean Sea, Egypt, Sudan and the valley of the Niger River. It is a very hostile environment in which to live, with extremes of temperature, frequent sandstorms, little vegetation and few surface sources of water.

Landforms of the Sahara

One-quarter of the Sahara consists of sand sheets (flat or gently undulating plots of sand) and dunes. These areas are called **ergs**. Some of the dunes are as high as 190 metres and they are constantly being reshaped by the wind. In other parts of the Sahara, there are large areas of stony plains, called **regs**, and high, rocky plateaus and mountains, called **hamadas**, shown in Figure 17.3.2.

17.3.1 The Sahara occupies most of North Africa.





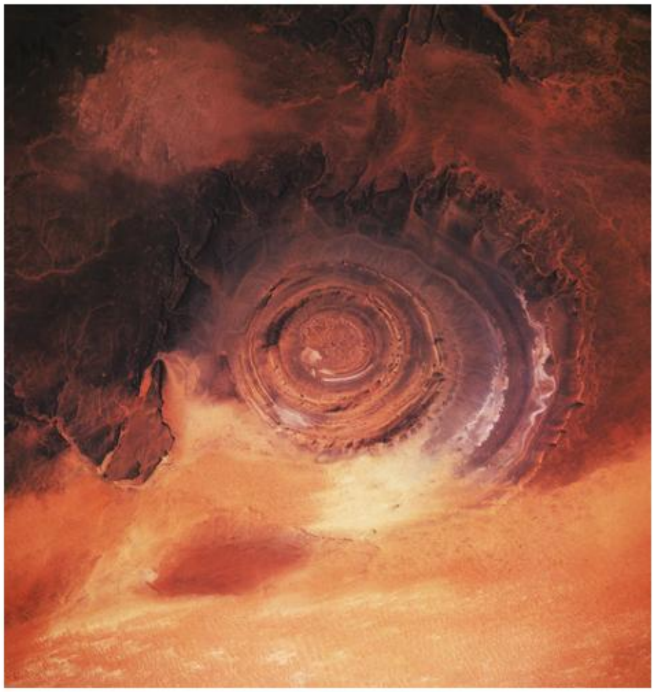
Source: *Heinemann Atlas*, Fifth Edition

17.3.2 Massive sand dunes, some as high as 190 metres, cover a quarter of the Sahara's land surface. In the foreground is a reg surface. A hamada can be seen in the background.

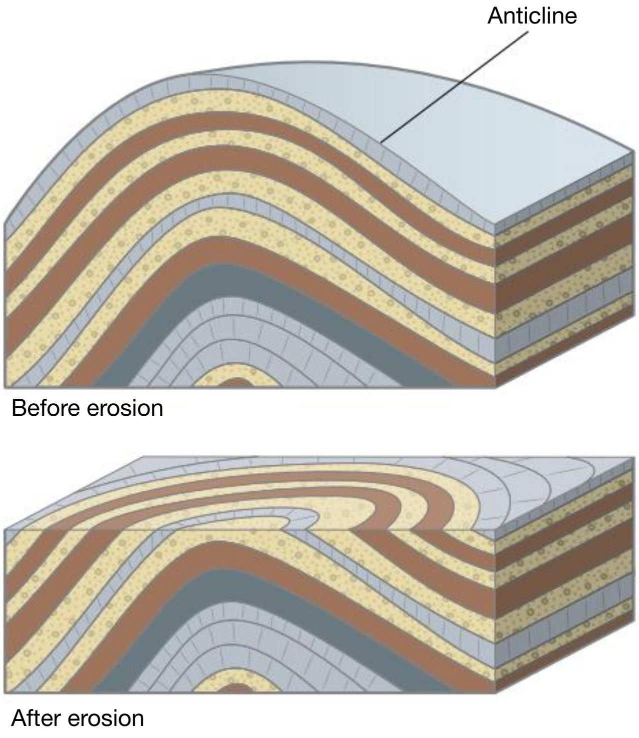
At one point, in the Qattara Depression, the land dips to 133 metres below sea level. Other parts are quite mountainous. Emi Koussi, in the Tibesti Mountains, is the highest peak in the Sahara, with a height of 3415 metres. The Tibesti Mountains, a prominent feature of the central Sahara region, are a range of inactive volcanoes located in northern Chad. The landforms of the Sahara are undergoing constant change. They are shaped by the direction of the wind and the occasional rainfall.

The 'Eye of the Sahara'

The Richat Structure, more commonly known as the Eye of the Sahara, is a circular landform feature in Mauritania (Figure 17.3.3). The landform is a deeply eroded dome, nearly 50 kilometres wide. The Richat Structure formed when an anticline (Figure 17.3.4), a product of the folding of rock strata, eroded.



17.3.3 The Richat Structure, Mauritania

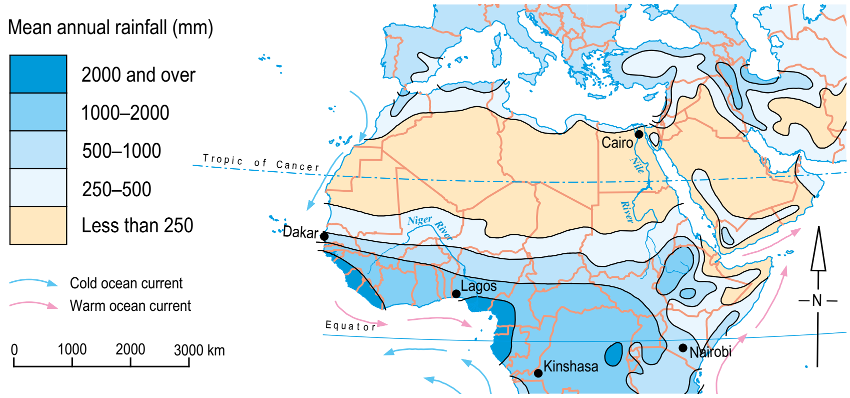


17.3.4 The formation of the Richat Structure

Water in the Sahara

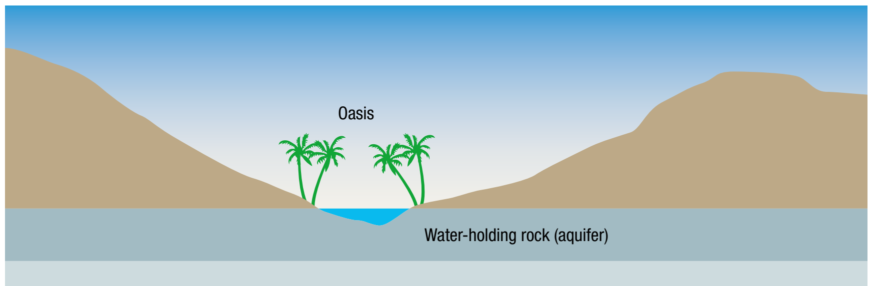
In the Sahara there is very little water, as rainfall is very low (see Figure 17.3.5). Some plants and animals are able to make use of the rainwater that filters through the sand or collects briefly on the rocky surfaces. However, humans can find permanent water supplies only in rivers or underground water-bearing rocks. The major rivers in the Sahara are the Niger and the Nile. The Nile River dominates the north-eastern part of the Sahara.

The most widespread source of water in the Sahara is in underground water-bearing rocks called **aquifers** (see Figure 17.3.6). These lie in layers below the sand and surface rocks. An **oasis** (see Figure 17.3.7) is formed when these water-bearing rocks reach the surface of a depression in the desert. Due to increasing human use of underground water, the supply is declining, causing some springs to dry up.



Source: *Heinemann Atlas*, 5th edition

17.3.5 Vast areas of North Africa receive less than 250 millimetres of rainfall a year.



17.3.6 An oasis develops when an underlying aquifer (a saturated layer of rock) meets a depression in the desert surface.

17.3.7 A palm tree oasis, Sahara, Chad

Peoples of the Sahara

The peoples of the Sahara have adapted to the harsh environment and developed ways of obtaining the food and water required for survival.

The Tuareg

'Tuareg' is a term used to identify the diverse groups of nomadic people living in parts of the Sahara. The Tuareg share a common language and history.

For thousands of years, the livelihood of the Tuareg revolved around trans-Saharan trade. There were five main trade routes that crossed the Sahara from the Mediterranean coast of Africa to the great cities on the southern edge of the Sahara. Tuareg merchants transported goods from these cities to the north. From there they were distributed throughout the world.

Tuareg camel caravans continued to transport goods across the Sahara until the mid-twentieth century, when European trains and trucks took over. Today, many Tuareg live in the cities bordering the Sahara.

17.3.8 Tuareg man dressed in traditional blue robe

SPOTLIGHT

Camels

There are millions of camels living in Africa, most of them in the countries that border the Sahara and the Horn of Africa. The African camels are of the single-humped (dromedary) type. They have a range of adaptations that allow them to cope with the harsh conditions of the desert.

These include:

- a woolly coat on the upper part of the body to provide good insulation from the sun
- a hump that stores fat reserves, which can keep the camel alive when there is no food available
- the production of dry dung, which reduces water loss
- the ability to carry large amounts of water (equal to about 25 per cent of its body weight) in its stomach
- a lack of wool on the underside of the body, which enables heat loss
- a web of tissue between the two toes, which stops the camel from sinking in the sand
- a feathery mouth, which enables the camel to eat thorny desert plants
- nostrils that can be closed during sandstorms.

Camels are used for transport, meat, milk, wool and leather. They have also made it possible to establish trade routes across the Sahara linking West Africa to North Africa (see Figure 17.3.9).

17.3.9 Bedouin camel train among the Sahara's sand dunes

ACTIVITIES

Knowledge and understanding

1. Describe the location and extent of the Sahara.
2. Identify and describe the principal landform types found in the Sahara.
3. Explain why the Sahara is such a difficult environment for humans and animals.

Geographical skills

4. Study Figure 17.3.5. Write a paragraph describing the rainfall pattern of Africa.
5. Construct a photo sketch of Figure 17.3.2. Annotate your sketch to highlight each of the types of desert landform depicted.

Australian deserts

Location and size

Australia's deserts cover approximately 81 per cent (or 1 371 000 square kilometres) of the Australian mainland, and desert is the largest landscape type in the country. Deserts are mainly located on the western plateau and interior lowlands of Australia.

17.4.1 Australia's deserts

Source: *Heinemann Atlas*, Fifth Edition

Tanami Desert (WA/NT), 184 500 square kilometres (2.4 per cent). The Tanami Desert is dominated by a rocky terrain with small hills.

Great Sandy Desert (WA) 267 250 square kilometres (3.5 per cent of the Australian mainland). The desert is located near the Pilbara and southern Kimberley regions. While the region has an average rainfall greater than 250 millimetres, it is very unreliable. Thunderstorms develop on 20 to 30 days a year.

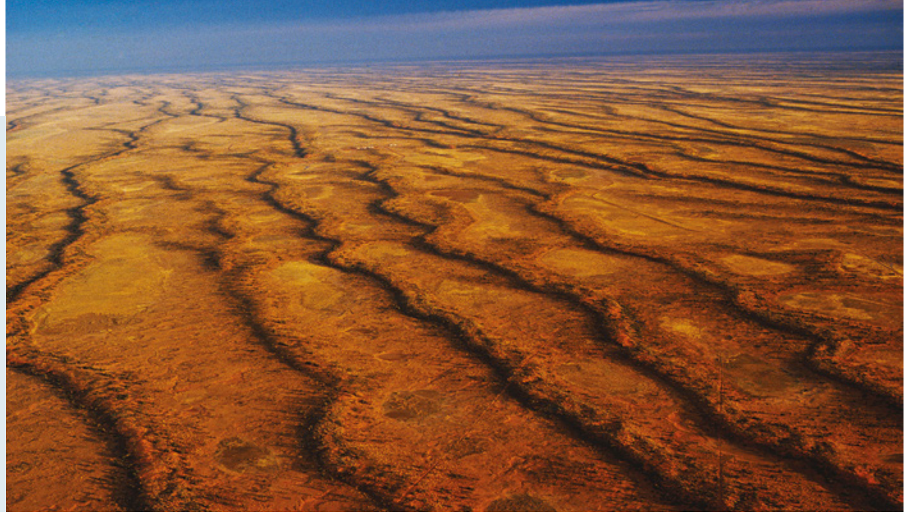
Little Sandy Desert (WA) 111 500 square kilometres (1.5 per cent). The landforms of the region are similar to those of the Great Sandy Desert.

Gibson Desert (WA) 156 000 square kilometres (2.0 per cent). The Gibson is dominated by gravel-covered surface with tussock desert grasses. There are also large areas of red sand plains and dunefields. Several saltwater lakes are to be found in the centre of the region. Large areas of the desert remain in a near-natural state.

Great Victoria Desert (WA/SA) 348 750 square kilometres (4.5 per cent of the Australian mainland). The Great Victoria is dominated by many small sand hills, grassland plains, gibber plains and salt lakes. Average annual rainfall is low, ranging from 200 to 250 millimetres per year. Thunderstorms are relatively common.

Tirari Desert (SA), 15 250 square kilometres (0.2 per cent). The Tirari is dominated by windswept white sand dunes and numerous salt lakes. The climate is characterised by high temperatures and very low rainfall. Average annual rainfall is below 125 millimetres.

Simpson Desert (NT/Qld/SA)
176 500 square kilometres (2.3 per cent). The Simpson is an erg (a sand-dominated desert). It contains the world's longest parallel sand dunes. These north–south oriented dunes vary in height from 3 metres in the west, to around 20 metres in the east. The tallest dune, Nappanerica, is 40 metres high. Under the desert lies the Great Artesian Basin—a vast underground reservoir of groundwater.



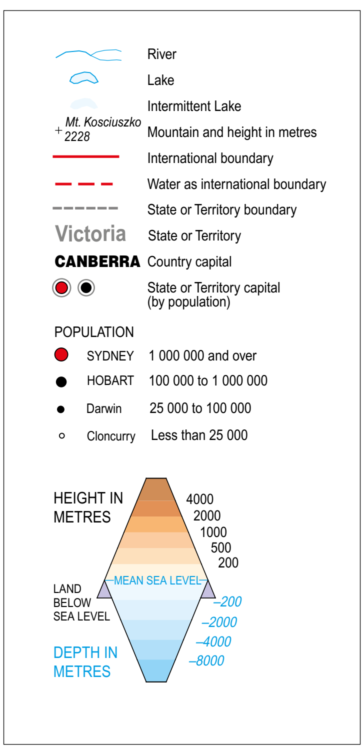
17.4.2 The Simpson Desert contains the world's longest parallel sand dunes.

Strzelecki Desert (SA/Qld/NSW)
80 250 square kilometres (1.0 per cent). The Strzelecki is located to the north-east of the Lake Eyre Basin and to the north of South Australia's Flinders Ranges. The Tirari and Simpson deserts are also in the Lake Eyre Basin.

Pedirka Desert (SA)
1250 square kilometres (0.016 per cent). Pedirka is Australia's smallest desert. The landscape is dominated by a deep red longitudinal (north–south) dunefield. Dense scrub and grasses grow in between the dunes.

Sturt Stony Desert (SA/Qld/NSW) 29 750 square kilometres (0.3 per cent). As the name suggests, the Sturt Stony Desert is a reg desert—a largely flat plain covered with fist-sized rocks.

17.4.3 The Sturt Stony Desert



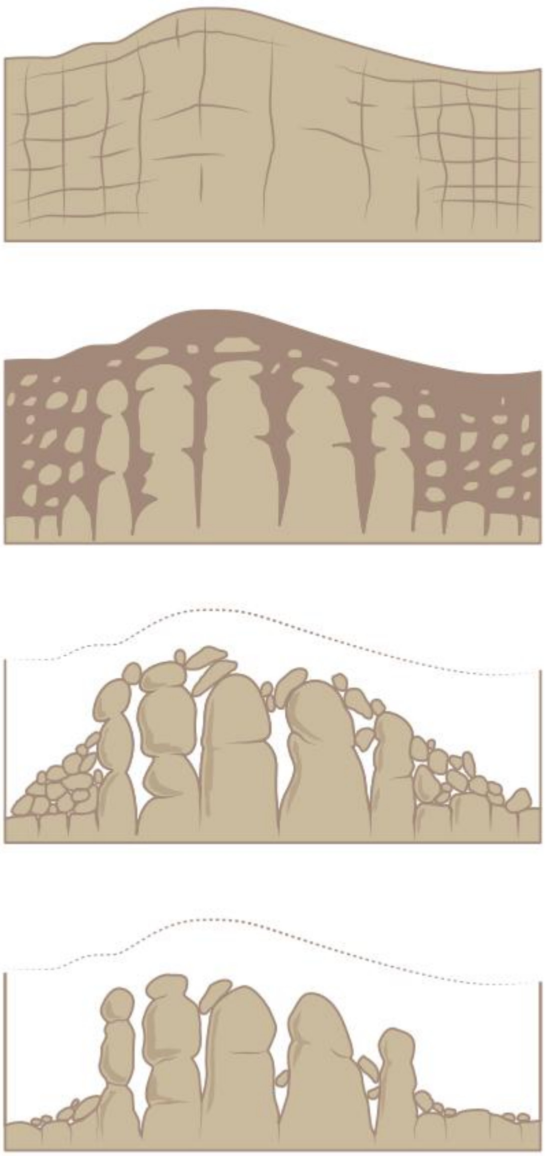
Famous Australian desert landforms

17.4.4 Wave Rock, a 14-metre granite cliff face near Hyden, Western Australia, weathered into a perfect wave formation.

17.4.5 Uluru/Ayers Rock, the world's second largest monolith (only Mt Augustus, WA, is larger), central Australia. Uluru is an inselberg, an isolated residual landform that rises abruptly from, and is surrounded by, extensive and relatively flat erosion lowlands.

17.4.6 Kata Tjuta (the Olgas), a large group of rock domes in central Australia

17.4.7 The Pinnacles, Western Australia—a vast desert of upright sandstone formations, weathered over time into weird shapes



17.4.9 How inselbergs such as Kata Tjuta were formed

17.4.8 Kati Thanda–Lake Eyre, 15 metres below sea level in the South Australian outback

ACTIVITIES

Knowledge and understanding

1 Study Figure 17.4.1. List the Australian states and/or territories that have no desert regions.
2 Study Figures 17.4.4 to 17.4.8. Write a description of the different types of deserts. Comment on the sand, rocks and vegetation.
3 Study Figure 17.4.9. Write a paragraph outlining how inselbergs are formed.

17.5

Desertification

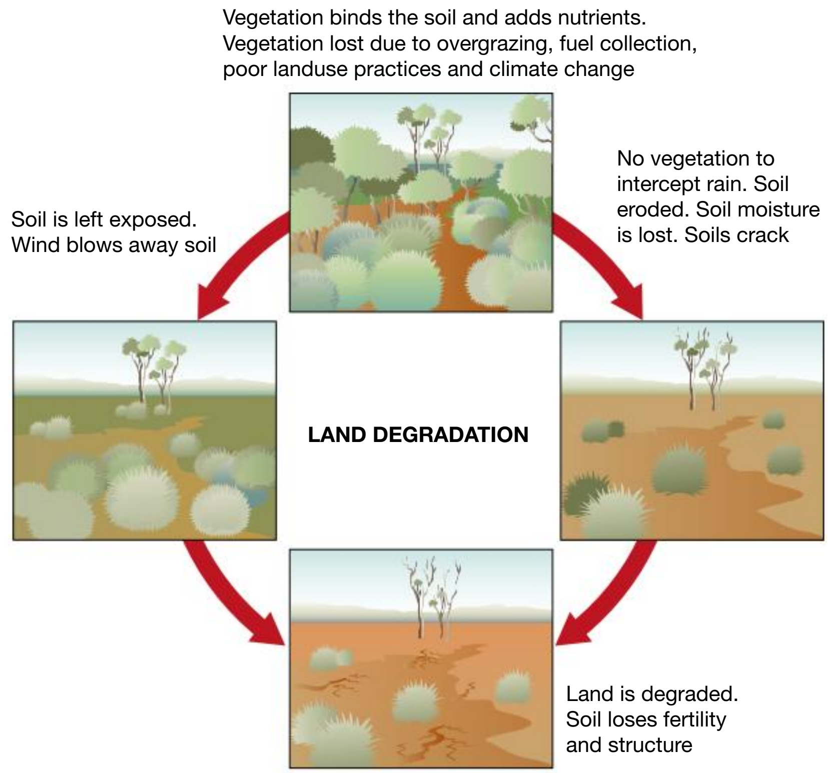
Causes of desertification

Since the early 1970s, deserts have been increasing in size. Semi-arid areas on the edges of deserts are getting drier and becoming deserts. This process is called **desertification**.

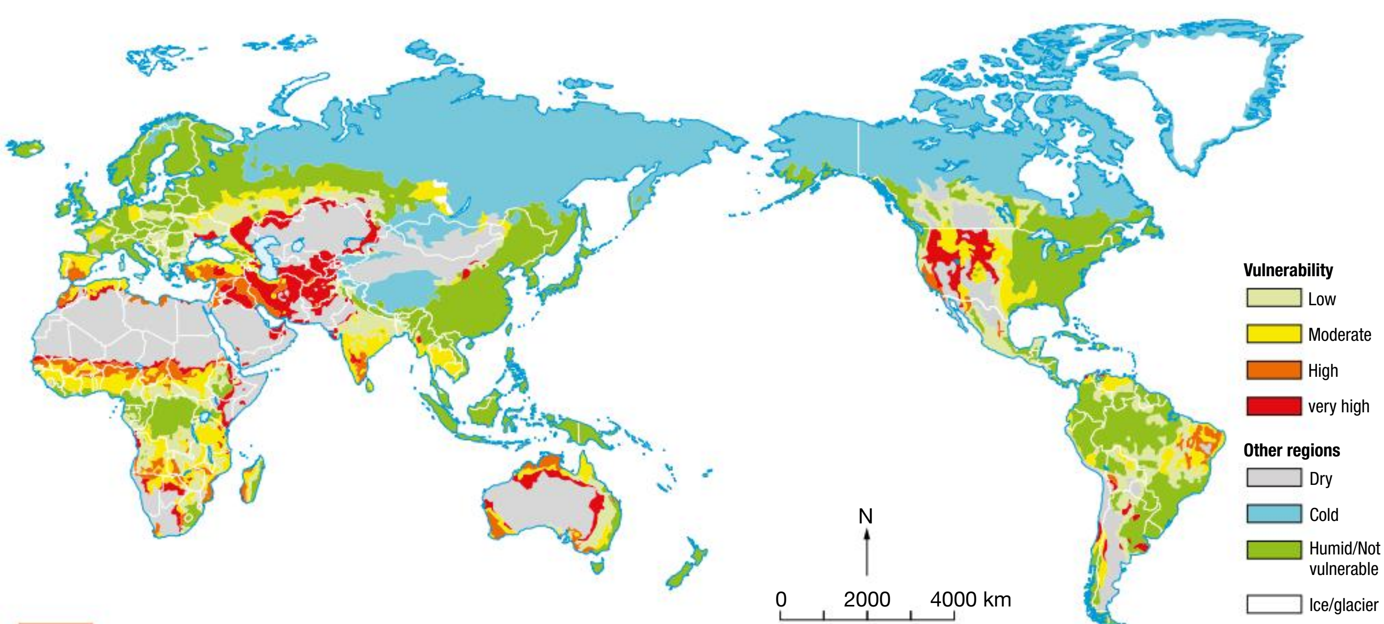
There are two main theories about the causes of desertification: it is due to natural processes or it is a result of human behaviour. Figure 17.5.1 shows the process of human and natural causes of land degradation.

Natural causes

Climate change has reduced the amount of rainfall and shortened the wet season. As a result, vegetation dies, soil is blown away and the land becomes degraded.



17.5.1 The process of land degradation



17.5.2 Global vulnerability to desertification

Human causes

Deserts and semi-desert lands have become degraded because of poorly managed landuse on the edges of deserts. In these areas, too many cattle graze the land, crops are grown on land that is not really suited to agriculture and people cut down trees to use as fuel for cooking and providing warmth.

Some scientists argue that desertification is caused by a combination of both natural and human factors and may also be linked to the process of global warming.

Impacts of desertification

When land becomes degraded, fewer crops are able to be grown and fewer animals can be grazed. An estimated 8.1 million square kilometres worldwide—an area the size of Brazil in South America—have been affected by desertification in the last 50 years (Figure 17.5.2). If this continues, the wellbeing of at least 1.2 billion people could be threatened.

Responding to desertification

The most effective way to slow desertification is to drastically reduce overgrazing, deforestation and excessive cultivation. Reforestation (tree-planting) programs will help to bind the soil and hold water while slowing the process of desertification.

The Green Wall of China

The Green Wall of China is a massive environmental project that involves creating a series of human-planted forests to prevent the expansion of the Gobi Desert (Figure 17.5.3). By 2050, the project will feature a 4500-kilometre forested strip that will increase forest cover in northern China from 5 to 15 per cent.

17.5.3 Desertification in China. The country now has more than 2.62 million square kilometres of land under desertification, twice the amount of the total available farmland in China.

The Chinese have used aerial seeding to promote tree growth over this vast area. They have also offered cash to farmers to plant trees.

The Green Wall of China involves the planting of sand-tolerant vegetation in a chequerboard pattern. The aim is to stabilise the developing sand dunes and reduce sandstorms by planting windbreaks (Figure 17.5.4).

17.5.4 Massive tree-planting programs aim to halt desertification on the edges of the Gobi. Here, workers use hay to create grid patterns that stabilise sand dunes.

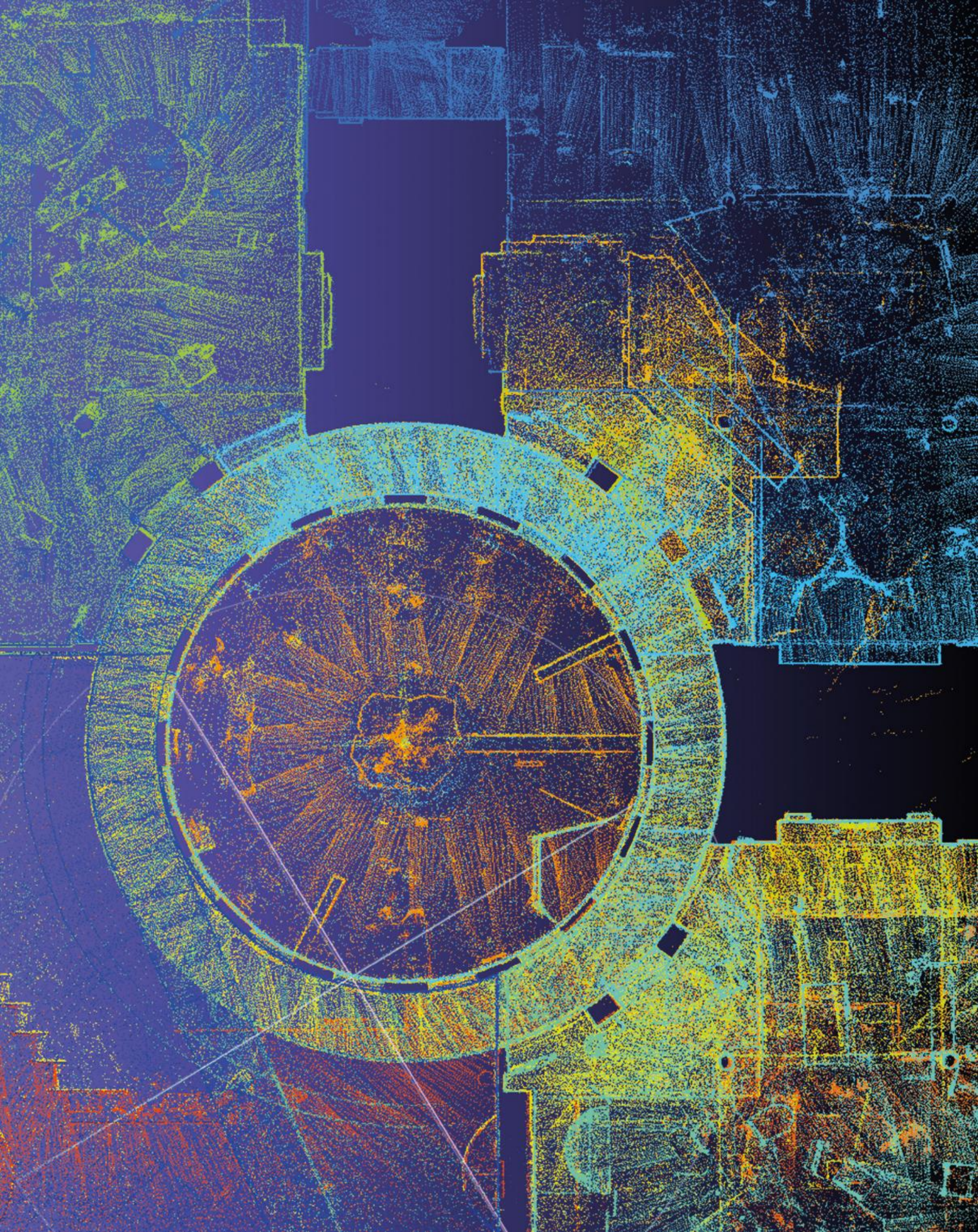
ACTIVITIES

Knowledge and understanding

1. Define the term ‘desertification’ and outline the two theories about why desertification is occurring.
2. State how much land has been affected by desertification worldwide in the last 50 years.
3. Explain how the process of desertification can be slowed.
4. Explain the Green Wall of China.

Geographical skills

5. Study Figure 17.5.2.
   a. With the aid of an atlas, outline the location of places that are under threat of desertification.
   b. Describe the location of the areas that are not under threat of desertification.
   c. Describe the location of the areas in Australia that are under threat of desertification.



Geoskills

CHAPTER 18

Geographers use many different tools and skills to investigate the world in which we live. Maps are among the most important of these tools. Graphs are also an important tool used by geographers and many different types are created and studied.

In this chapter we learn about analysing photographs, satellite images, climate graphs, weather maps and population pyramids.

INQUIRY QUESTIONS

- What types of maps and graphs can be used to investigate weather and climate?
- What key skills are involved in the interpretation of maps and graphs?
- What types of maps, photographs and satellite images do geographers use and what are the conventions used in their construction?
- How can population pyramids be used in investigating population changes over time?

GLOSSARY

emigration	the act of leaving one's country to live permanently in another country	**orbiting**	revolving around a central body
meteorologist	a scientist who investigates weather and climate	**remote sensing**	the scanning of the earth by satellites or high-flying aircraft in order to obtain information about it
oblique photograph	photograph taken from above the ground, where the camera is slanted at an angle towards the ground	**synoptic chart,** or **weather map**	a map of the weather conditions at a specific time

18.0 Image taken using a hand-held 3-D mapping laser, Zebedee

18.1

Photographs

Using photographs

Photographs are very important to geographers. A photo of an area of the earth can give a geographer an idea of what the area looks like without the need to visit it. Photographs record a landscape as it exists at a particular time; they can be used to record fieldwork observations.

Types of photographs

Geographers group photographs in three different categories, as Figures 18.1.1 to 18.1.4 show: ground level, oblique and vertical.

18.1.1 A ground-level photograph of part of Serengeti National Park, Tanzania

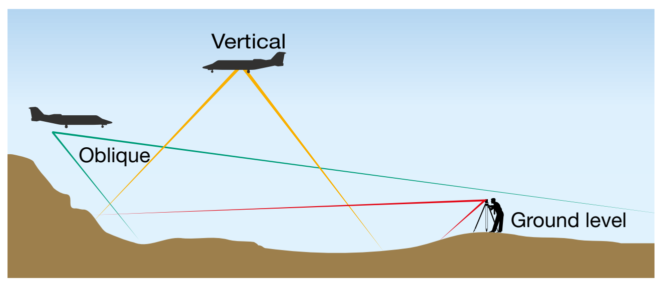
Ground-level photographs are taken from the ground. Features in the foreground will appear larger than those in the background. Large objects in the foreground may block out features in the middle and background.

18.1.2 A vertical photograph of Tokyo, Japan

Vertical photographs are taken from above the ground with the camera lens pointed directly down on the area being photographed. Features across the photograph will not be distorted, although it will be hard to estimate their height.

18.1.3 An oblique photograph of Dubrovnik, Croatia

Oblique photographs are similar to ground-level photographs in that features in the background will appear smaller than those in the foreground. Unlike ground-level photographs, oblique photographs are taken from above the ground. Often a horizon cannot be seen. The camera is pointed at an oblique (slanted) angle to the ground.



18.1.4 Taking ground-level, oblique and vertical photographs

Interpreting photographs

When interpreting photographs, look for:

- the main features being shown
- relevant information given with the photograph, such as a caption or written information
- evidence of location and time
- clues to scale and living conditions
- features that seem out of place, as they may warrant further reading or investigation.

SkillsBuilder

Photo sketching

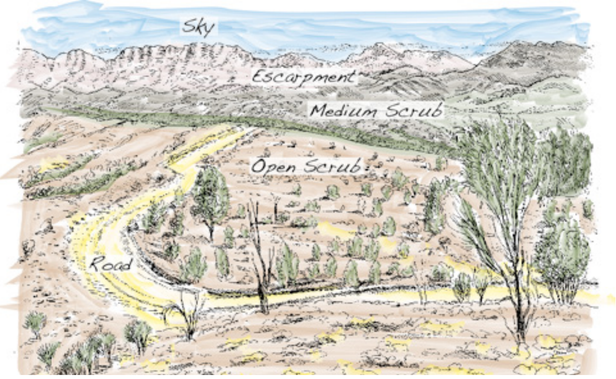
Being able to sketch from photographs allows you to make a quick summary of the information shown in an image, and to highlight and/or annotate the key elements of the feature or place photographed. Photo sketches can be used to illustrate reports and displays.

Use a soft pencil on blank paper. A photo sketch should not reproduce everything in the photograph. Pick out the main features of the photograph, and sketch in their shape. Include the features you want to highlight. Always place your sketch within a frame that is in the same proportions as the original photograph. Annotate your sketch to point out the main features, or to indicate a changing feature or some important link between features.

For ground-level photographs it may be useful to divide your photograph into three areas: foreground, middle ground and background. Before you begin sketching, lightly pencil these three areas into your frame. The features of each area can then be sketched in. Begin with the background, followed by the middle ground and then the foreground.

Ground-level photo sketches can be annotated or coloured to highlight particular features. You can see both of these techniques in Figure 18.1.6, which is a sketch from Figure 18.1.5.

18.1.5 A ground-level photograph of the Flinders Ranges, South Australia



18.1.6 A sketch of Figure 18.1.5

ACTIVITIES

Knowledge and understanding

1 Explain why photographs are important to geographers.

2 State how ground-level photographs differ from oblique photographs.

Applying and analysing

3 Study Figures 18.1.1 to 18.1.3 and answer the following questions.
   a Which type of photograph:
      i shows excellent detail about the foreground
      ii eliminates any distortion to the shape of an area covered by features
      iii best shows the shape of the landscape?
   b Which type of photograph would be most suitable for showing:
      i a plan view of your school
      ii a crowded shopping centre
      iii areas affected by flooding
      iv the height of a new building?

4 Study Figures 18.1.1 and 18.1.3. Compare the two locations by interpreting the photos.

Geographical skills

5 Study Figure 18.1.3 and do the following tasks.
   a Construct a photo sketch of the image. Label Dubrovnik's harbour, marina and fort.
   b Describe the site of Dubrovnik.

18.2

Satellite images

Satellites

Satellites **orbiting** the earth take satellite images. The processes involved are referred to as **remote sensing**. Geographers use remote sensing to study the spatial distribution of natural, managed and constructed environments. Remotely sensed images are especially useful for investigating change over time.

Collecting data

Remotely sensed images are produced from data gathered by satellite-mounted sensors. These sensors are so sensitive that they can record the radiation given off by features on the earth's surface. This data is then converted into images. Often these images are referred to as false-coloured images and the observer needs to know what each colour represents to be able to interpret them (see Table 18.2.1).

As satellites have become more sophisticated they have been able to capture the data necessary to produce true-coloured images. These images feature colours as they appear to human eyes. However, we still need to know what each colour represents (see Table 18.2.2).

18.2.1 Colour guide for false-coloured images

Colour	Feature
Dark blue to black	Deep water in oceans, lakes and dams
Mauve to steely blue	Urban and industrial areas
Blue to light blue	Arid scrubland; very shallow water
Dark green	Deep muddy floodwaters, clear shallow water
Light green	Moist, ploughed, bare soils; light grass cover
Brown	Drier vegetation such as eucalypts and arid woodlands; bare rock
Red	Healthy growing vegetation; rainforest (deep red); growing crops and pastures; mangroves (deep red)
Pink to red	Early growth of crops and grasslands; suburban gardens, lawns and parks
Yellow	Areas with little vegetation cover, heavily grazed areas, deserts and sand dunes
White to cream	Bare ground; dry sand and salt areas, dunes and beaches; clouds

18.2.2 Colour guide for true-coloured images

Colour	Feature
Dark blue to black	Deep clear water in oceans, lakes and dams
Light blue	Shallow water
Mauve to steely blue	Urban and industrial areas
Brown to light brown	Drier vegetation such as eucalypt and arid woodlands; bare rock
Bright light green	Grassland, growing crops and pastures; suburban parks and gardens
Bright green	Healthy growing green vegetation; rainforest and mangroves
Light pink to orange to brown	Cleared farming land; early growth in crops and grasslands
White to cream	Bare ground; dry sand and salt areas; dunes and beaches; clouds

Mt St Helens

In the three decades since the 1980 eruption of Mt St Helens in Washington State, United States of America, geographers have been given a unique opportunity to observe the steps through which a devastated landscape is reclaimed. The series of images in Figures 18.2.3 and 18.2.4 document the scale of the eruption and the beginning of recovery in the Mt St Helens blast zone. They were captured by NASA's Landsat satellites between 1979 and 2011.

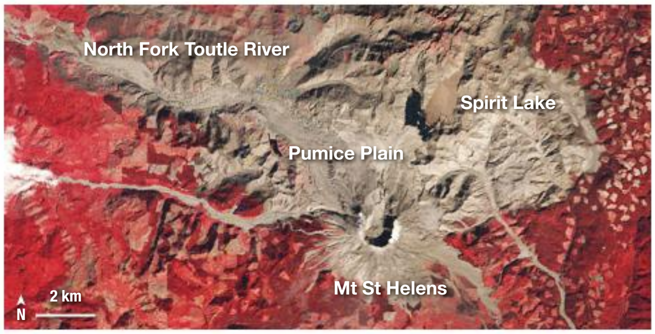
The 1980 eruption began with an earthquake that caused the northern face of the mountain to collapse, producing the largest landslide in recorded history. The avalanche buried 23 kilometres of the North Fork Toutle River valley with an average 46 metres—but in places up to 180 metres—of rocks, dirt and trees. In the years since the eruption, the river has recarved a shallow path through the buried valley.

When the mountain collapsed, hot rocks, ash, gas and steam exploded upward and outward to the north. The outward blast spread volcanic debris (grey in the images) over 600 square kilometres. All around the southern half of the mountain, volcanic mudflows (lahars) poured down rivers and gullies.

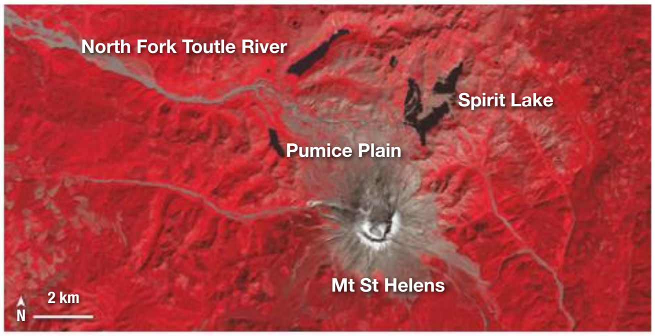
The first plant to grow in the devastated landscape was the prairie lupine. This plant attracted insects and herbivores, and captured leaves and other organic matter. Dead plants and insects, wind-blown organic matter and the droppings of herbivores (plant-eating animals) slowly created pockets of soil on the volcanic deposits. Gradually other plants began to grow.

18.2.3 A sequence of false-coloured satellite images of Mt St Helens before and after the 1980 eruption

29 August 1979



24 September 1980



10 September 2009

18.2.4 True-coloured images of Mt St Helens, 1984 (top) and 2011

ACTIVITIES

Knowledge and understanding

1 Explain what is meant by the term 'remote sensing'.
2 Outline why geographers find remotely sensed images useful.
3 Explain the difference between false-coloured and true-coloured images.

Geographical skills

4 Outline the changes you can observe in the sequence of satellite images.

18.3

Climate graphs

Climate statistics

In Australia, the Bureau of Meteorology collects weather-related data from more than 1000 sites. Once the Bureau has collected data from any site for 10 years, the data is made available to the public. Many sites have records going back more than 100 years.

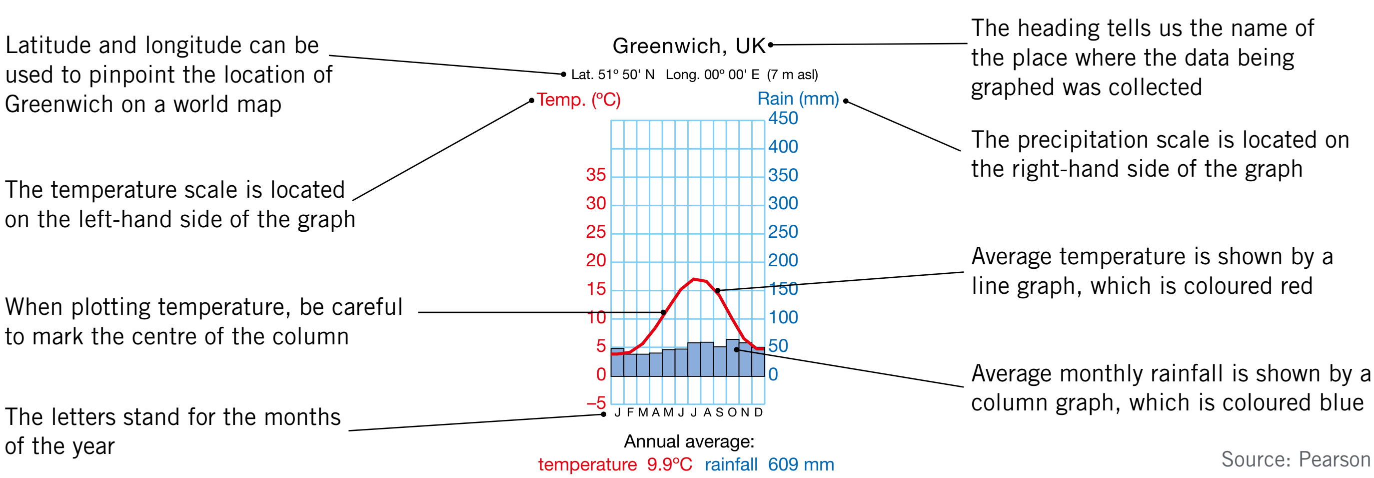
Constructing a climate graph

Climate graphs are constructed using data collected by **meteorologists**. The main features of a climate graph are shown in Figure 18.3.1.

When constructing a climate graph, follow these steps:

1. Transfer the relevant temperature and rainfall data from your data source into the table at the base of the climate graph. The data used to create the climate graph in Figure 18.3.1 is shown in Table 18.3.2.
2. Study the data to identify the wettest month and the highest and lowest temperatures. Use this information to select a suitable scale for both temperature and precipitation.
3. Add a heading that includes the name of the place being graphed and its latitude, longitude and elevation.

18.3.1 Climate graph for Greenwich, United Kingdom



Source: Pearson

18.3.2 Climate statistics for Greenwich, United Kingdom

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Average temperature (°C)	3.9	4.2	5.7	8.5	11.9	15.2	17.0	16.6	14.2	10.3	6.6	4.8	9.9
Rainfall (mm)	49	39	39	41	47	48	59	60	52	65	59	51	609

Describing climate

Climate can be broadly described as very hot, hot, warm, cool, cold or very cold. To give a more detailed description, use Tables 18.3.3 to 18.3.5.

- Table 18.3.3 lists terms that are used to describe the annual temperature range—the difference between the highest monthly average temperature and the lowest.
- Table 18.3.4 shows that a description of annual rainfall is influenced by both the amount of rainfall and the broad type of climate.
- Table 18.3.5 lists terms that are used to describe monthly average precipitation.

For example, Greenwich (see Figure 18.3.2) has a moderate temperature range: the difference between the highest monthly average temperature (17.0°C) and the lowest (3.9°C) is 13.1°C. The annual average temperature (9.9°C) is classified as cool; because of this, Greenwich's annual average precipitation (609 millimetres) is considered to be adequate. Greenwich has seven dry months and five wet months; it does not have any very wet months.

18.3.3 Describing annual temperature range

Temperature range (°C)	Description
less than 5	small
between 5 and 15	moderate
between 15 and 30	large
more than 30	very large

18.3.4 Describing annual precipitation

Amount—cold to warm climates (mm)	Description	Amount—hot to very hot climates (mm)
below 250	slight	below 375
250–500	small	375–625
500–1000	adequate	625–1125
1000–1500	large	1125–1750
above 1500	very large	above 1750

18.3.5 Describing monthly average precipitation

Amount (mm)	Description
below 50	dry month
50–150	wet month
above 150	very wet month

ACTIVITIES

Knowledge and understanding

1 Name the data typically featured in climate graphs.

Geographical skills

2 a Construct climate graphs for New York City and New Delhi from the data in Tables 18.3.6 and 18.3.7.

b Access Bureau of Meteorology data and create a climate graph for your closest city or town.

c On a blank map of the world, mark in New Delhi, Greenwich, New York City and your closest city or town. Next to each city, write a short paragraph describing its climate.

d Does the location of a city have an impact on its climate? Explain.

18.3.6 Climate statistics for New York City, USA

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Average temperature (°C)	–0.4	–0.1	4.1	10.1	16.1	21.3	24.3	23.3	19.5	13.5	7.3	1.5	11.7
Rainfall (mm)	83.6	78.8	98.5	93.4	106.0	84.5	105.0	104.3	91.2	83.5	106.6	92.3	1128.9

18.3.7 Climate statistics for New Delhi, India

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Average temperature (°C)	14	17	22	29	33	34	31	30	29	26	20	15	25
Rainfall (mm)	23	20	15	10	15	68	200	200	123	19	3	10	706

18.4

Weather maps

Reading weather maps

A **weather map**, or **synoptic chart**, is a record of the weather conditions across part of the earth's surface at a particular point in time. It includes information about air pressure, wind speed and direction, and distribution of rainfall.

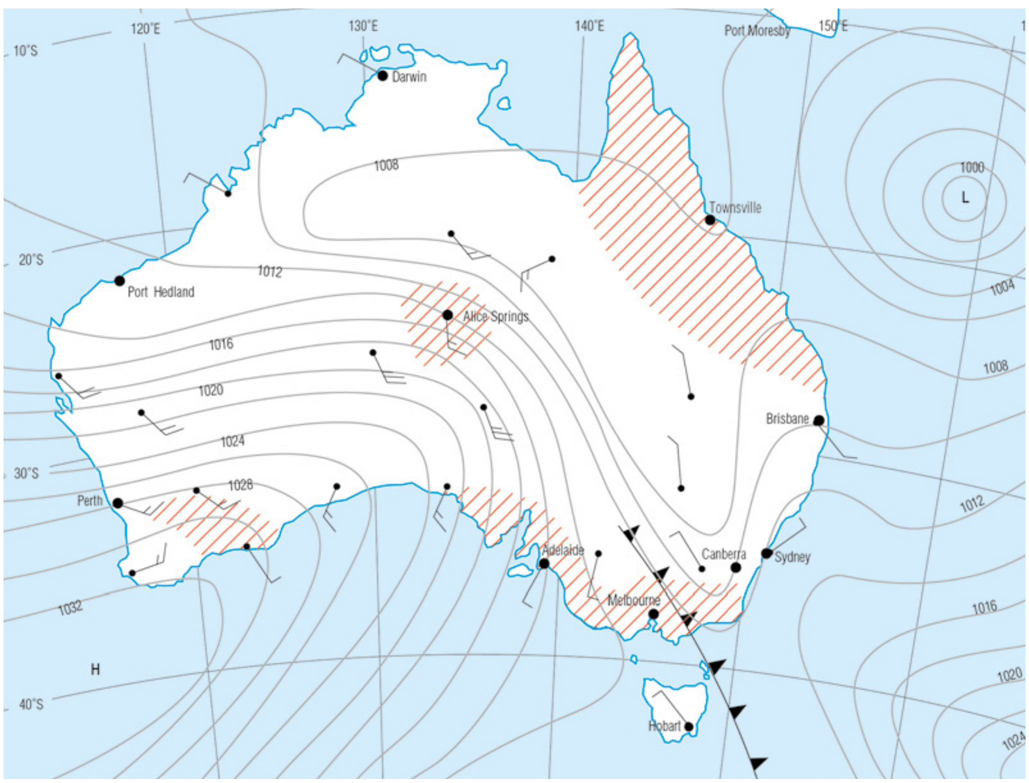
Being able to read weather maps is an important life skill. Australian farmers, for example, use weather maps to help them plan their farming activities. With the aid of weather maps and satellite photographs, meteorologists are able to identify and predict hazardous weather conditions, including storms, temperature extremes and cyclones.

18.4.1 A weather map, or synoptic chart, records the conditions in the atmosphere at a particular time.

Warm fronts occur when a warm parcel of air overtakes a colder, denser air mass, and is forced to rise. As with a cold front, rain often results as air rises. Warm fronts are not common in Australia.

Cold fronts occur when a mass of cold, dense air pushes in under a mass of warm air, forcing it to rise. As the warm air rises, it cools and condensation takes place. Lower temperatures are experienced once the front has passed.

Ⓛ Low-pressure systems form when warm air rises rapidly. They are typically associated with unstable weather conditions: cloudy skies, rain and relatively strong winds.



Ⓗ High-pressure systems are typically characterised by stable atmospheric conditions: gentle winds, clear skies and little chance of rain.

Rainfall areas are shown by shading or cross-hatching.

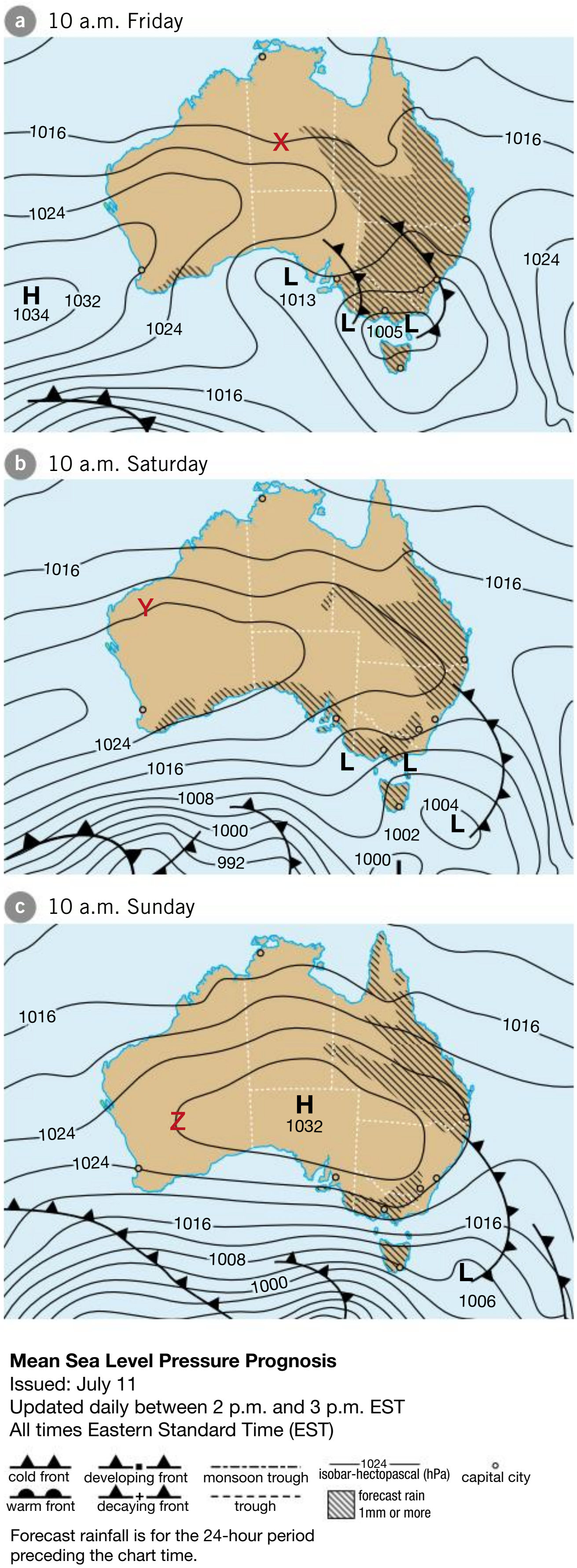
1212

Isobars join places with the same atmospheric pressure. Air pressure is measured in hectopascals (hPa). Isobars are usually drawn at intervals of 2 hPa. Isobars that are well spaced indicate only gentle winds. Isobars close together indicate relatively strong winds.

Winds (km/h)

calm ◉
1–4
5–13
14–23
24–32
33–41
42–51
52–60
61–68

Wind direction and strength are shown for selected locations using lines with small barbs or tails. Winds are named after the direction they blow from; for example, Alice Springs is experiencing a moderate southerly wind.



18.4.2 A three-day weather forecast from the Bureau of Meteorology

ACTIVITIES

Knowledge and understanding

1 Explain why the ability to interpret weather maps is an important 'life skill'.
2 Outline the weather conditions typically associated with high- and low-pressure systems.
3 Describe the wind conditions when isobars are:
   a close together
   b further apart.

Geographical skills

4 Use Figure 18.4.1 to answer the following questions.
   a Which capital cities received rainfall in the previous 24 hours?
   b What were the wind conditions for the following cities?
      i Perth
      ii Brisbane
      iii Adelaide
   c Which capital city had gentle winds?
   d Predict what the weather will be like in Perth in the next 24 hours.
   e Predict what the weather will be like in Melbourne in the next 24 hours.
   f What is the air pressure in the following cities?
      i Sydney
      ii Adelaide
5 Use Figures 18.4.2a, b and c to answer the following questions.
   a At 10 a.m. Friday, which capital cities are predicted to experience rainfall in the next 24 hours?
   b At 10 a.m. Friday, what type of weather system crosses the southern half of Australia?
   c What is the atmospheric pressure in hectopascals at X?
   d What is the pressure in hectopascals at Y?
   e What is the atmospheric pressure in hectopascals at Z?
   f At 10 a.m. Saturday, what is the air pressure at the centre of the low off the south-east coast of Tasmania?
   g At 10 a.m. Sunday, in which states is no rainfall forecast?
   h Predict the weather for your region of Australia at 10 a.m. on Monday.

18.5

Landscape photos

Landscapes

The world's landscapes have been developed by wind, water and plate movements. These landscapes are constantly undergoing change.

World facts

- The world's largest gorge is the Grand Canyon in the United States of America. Carved by the Colorado River, it is 20 kilometres wide at its widest point, 349 kilometres long, and more than 1.5 kilometres deep.
- The world's deepest canyon is El Cañon de Colca, in Peru, South America. It is 3 kilometres deep.
- With a length of 515 kilometres, the Lambert-Fisher Ice Passage in Antarctica is the world's longest glacier.
- The world's fastest-moving glacier is Greenland's Quarayaq Glacier. It moves 20 to 24 metres per day.

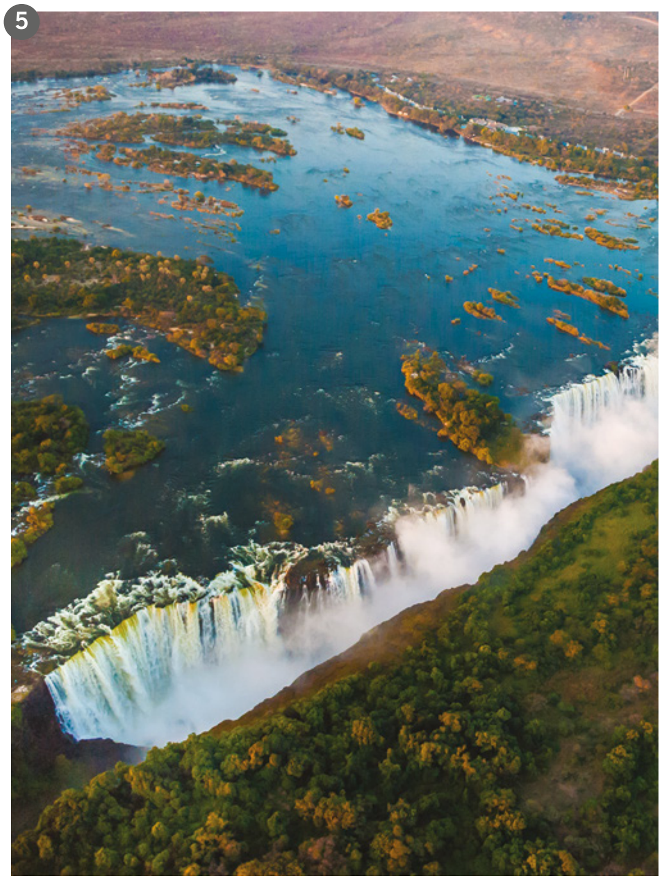
1

2

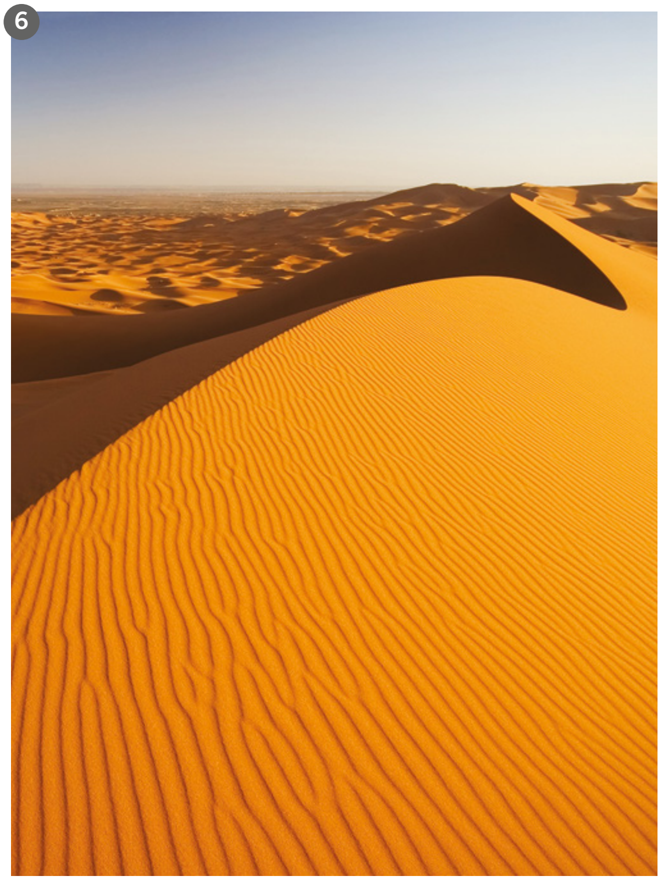
3

4

5



6



7

ACTIVITIES

Applying and analysing

1 Match the following captions with the photographs.
  a Mt Fuji, Japan
  b Californian coast, United States
  c fjord, New Zealand
  d the Sahara, Africa
  e Grand Canyon, United States
  f glacial landscape, Alaska, United States
  g Victoria Falls, Africa
2 Identify the photographs that best match each of the following descriptions.
  a landscape shaped by wind
  b landform shaped by ice
  c landform shaped by wave action
  d landform feature produced by volcanic action
3 Write a sentence describing the type of landform shown in each photograph.
4 Select one of the photographs and write a paragraph explaining the processes responsible for the landscape's landform features.

18.6

Population pyramids

What a population pyramid tells us

A population pyramid is a special type of bar graph used to show the age and sex structure of a population. We can compare it with the population pyramids of other populations, and with those of the same population over time.

A population pyramid shows the age groups of a population and shows either the actual number, or the proportion of the population, in each age group for both males and females. Each population pyramid represents 100 per cent of a particular population.

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

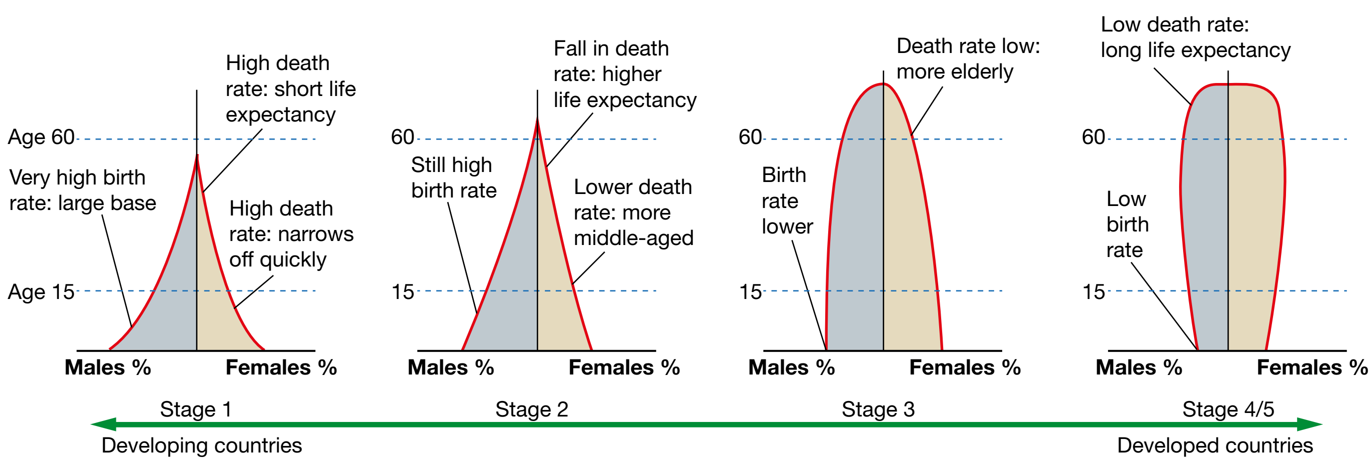
- if the base of the pyramid is wide, then there are more people in the younger age groups and the population is said to be 'young'
- if the upper part is relatively wide, then the population is said to be 'old' or 'ageing'.

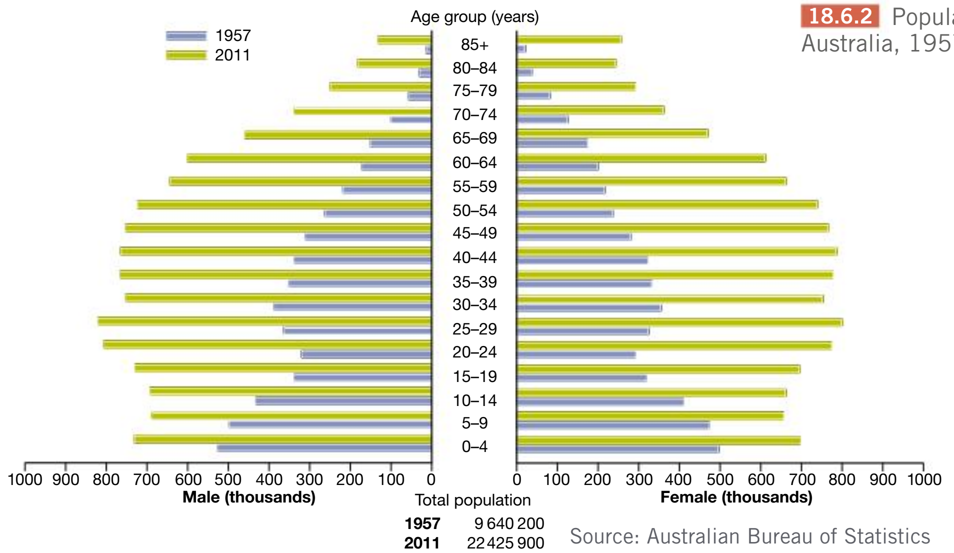
Events such as war, famine, disease or large-scale **emigration** may explain why there are fewer people than you might expect in a particular age group. The impact of a baby boom and/or immigration may explain why there are more people in a particular age group.

Figure 18.6.1 shows a series of pyramid shapes with an explanation of conditions under which such population structures develop.

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

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

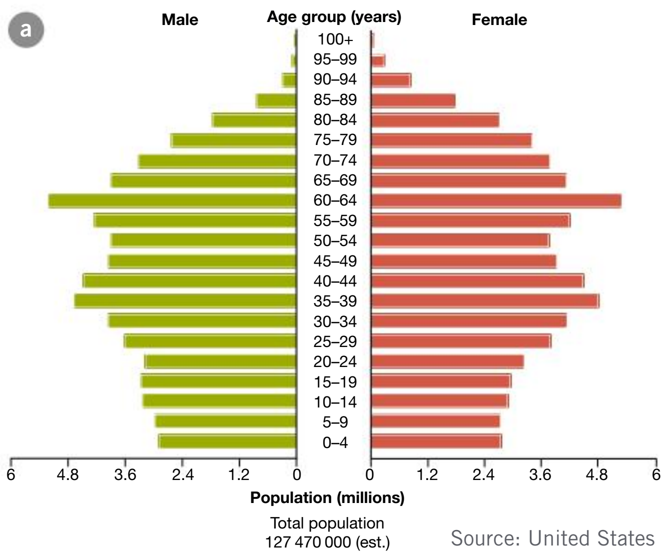




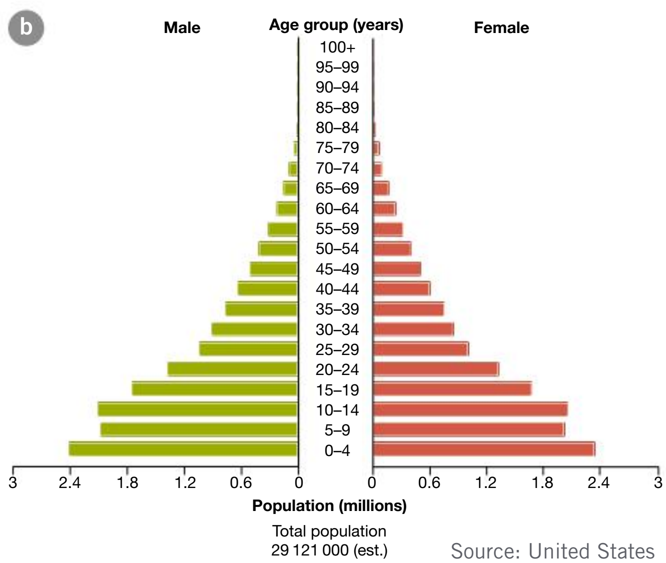
18.6.2 Population pyramid for Australia, 1957 and 2011

Source: Australian Bureau of Statistics

18.6.3 Population pyramids for (a) Japan in 2011 and (b) Afghanistan in 2010



Source: United States Census Bureau



Source: United States Census Bureau

ACTIVITIES

Geographical skills

1 Study Figure 18.6.2 and do the following tasks.
 a Estimate the percentage of the population under the age of 15 years in 1957 and 2011.
 b Estimate the percentage of the population over the age of 65 years in 1957 and 2011.
 c Using the data from Figures 18.6.1 and 18.6.2 and the information in the text, write an explanation of the trends observed.
 d In groups, list and discuss the likely impact of the trends observed in Figure 18.6.2 on the future of childcare, education, the age pension and aged care.

2 a Study Figures 18.6.1 and 18.6.3 and copy and complete the following table in your workbook.

	Japan, 2011	Afghanistan, 2010
Population age (young, old or ageing)		
Stage of development		
Percentage of the population under 15 years of age		
Percentage of the population over 65 years of age		

 b What different issues may Japan and Afghanistan experience in the future?

Stage 4: Extension tasks

Activity 1

Making choices: Which future?

19.1.1 Alternative futures

Study Figure 19.1.1. Which cartoon best fits your view of the relationship between people and their environment? Write a paragraph about each cartoon, stating whether you agree with the view presented. Explain why you agree or disagree. Return to this activity at the end of Year 8 and decide whether your views have changed.

Activity 2

Around-the-world odyssey

1. Select eight destinations in the world that you would like to visit. You must:
   - visit at least five continents
   - visit at least two places in each hemisphere—north, south, east and west
   - visit at least one very hot and one very cold climate
   - not visit the same country more than once.
2. Provide information about each of your destinations. Include information about:
   - the climate (rainfall and temperature)
   - the biophysical and constructed environments
   - population statistics.
3. Present your 'Around-the-world odyssey' as an annotated visual display (print or digital). Be sure to:
   - locate and mark each destination on a map
   - present the information in dot-point form
   - provide images of each destination.

1.0 Thunderstorm, outback NSW—Perry Sand Hills, Wentworth, NSW, Australia.

Activity 3

Developing a natural hazard information brochure

Using internet-based resources and relevant software, develop a multiple-page website promoting community awareness about a selected geomorphic hazard. Include links to relevant government authorities, for example Geoscience Australia.

Your website should include information on:

- the nature of the geomorphic hazard
- the geographical processes involved
- the economic, environmental and social impacts of the geomorphic hazard
- the responsibilities of the various levels of government in respect to the geomorphic hazard
- the community-based groups involved in responding to the geomorphic hazard
- the strategies individuals can use to protect themselves and their property.

Good sources of information are:

- Emergency Management Australia
- Geoscience Australia
- US Geological Survey
- British Geological Survey

Activity 4

Mining, people and landscapes: You be the judge!

The rush to meet the growing global demand for coal and energy sources such as Coal Seam Gas (CSG) has caused conflict, especially in regional Australia, where some farmers and local residents believe their interests are being ignored, their health affected and their way of live destroyed. There is also a concern that mining and gas extraction will transform Australian landscapes and landforms.

There has been considerable hostility in some regions as landholders have realised that while they may own the land, they do not own the mineral rights to that land. Farmers in the United States of America can sell their mineral rights, but in Australia these rights belong to the state. So the state can issue a licence to a mining or energy company wanting to extract resources.

ARGUMENTS FOR COAL MINING AND CSG EXTRACTION

Many landholders and communities in areas affected by coal mining and CSG extraction are supportive of such projects as long as environmental concerns can be satisfactorily resolved. Coal mines generate many jobs and substantial export earnings. Miners are capable of rehabilitating mined land, and gas extraction, if kept some distance from homesteads, does not significantly affect people's wellbeing. The income from access fees over the life of the gas wells can supplement the landholder's income. Coal and gas are important in maintaining our material wellbeing. Without CSG extraction, household energy costs would rise significantly.

State governments rely on the royalties from coal and gas exploitation. The money raised is used to fund the full range of government activities. These include health care, education, law and order, and infrastructure.

ARGUMENTS AGAINST COAL MINING AND CSG EXTRACTION

Those who are against coal mining and CSG extraction are concerned about the environment. They see mining and extraction as a threat to food production and the unique Australian rural landscape.

Issues raised in objection to coal mining and GSC extraction include the following.

- **Impacts on landscapes:** Coal mining and CSG extraction can transform landscapes. Many people feel the loss of the distinctive Australian rural landscape. This has an impact on the aesthetics of the landscape and, in some cases, its spiritual and recreational value.
- **Impacts on high-value agricultural land**: Landholders of fertile cropping country, or specialised farms such as wineries and olive groves, oppose open-cut coal mining and CSG extraction because the necessary infrastructure, noise and traffic would have a significant impact on their operations.
- **Lifestyle impacts**: In many rural communities, where several generations of families have worked the land, people believe that their identity and way of life is at risk.
- **Impacts on global climate**: The burning of fossil fuels produces carbon dioxide gas.
- **Damage to aquifers:** Coal mining can disrupt the movement of water in aquifers, as can CSG extraction. There is a fear that they will alter groundwater levels and the bores that farmers rely on may fail.

- **Contamination of water:** In some coals seams, it is necessary to create fractures that provide pathways through which the gas can flow. The technique used to do this is known as hydraulic fracturing, or fracking. This is done by injecting fluid made up of water, sand and chemicals under high pressure into the well. 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 ground and surface water.

HYPOTHETICAL

A large transnational corporation has been granted a licence to search for CSG in the coal body underlying one of Australia's most productive agricultural regions. A large Australian-owned coal company already operates a large open-cut mine in the area and has lobbied the government to expand its operations.

1. As a class, make a list of statements that are in favour of the proposals to develop a CSG field in the area and expand the existing open-cut coal mine. Make a separate list of statements against the development.
2. In groups of four or five, discuss the statements about the development proposal.
3. Determine which point of view you agree with. Write an exposition outlining the arguments you would use to justify your position.
4. Brainstorm the strategies you could use to influence public opinion and the government's decision-making processes.

Activity 5

Improving your local area

1. Working in pairs or small groups, choose a teenage-friendly facility you would like to develop in your local neighbourhood, and select a location for it. Suitable facilities could include:
   - a skate park
   - a new indoor sports and recreational facility
   - a swimming pool
   - a cinema complex
   - open-air cinemas
   - better public transport, e.g. safer train stations or more buses and extended bus routes
   - more shops and cafes
   - cycle paths
   - green open spaces
   - a free wi-fi network
   - an area for free activities such as music concerts.
2. Prepare a multimedia display of your plans. Include the following in your presentation.
   - a map of the area with the location shown
   - details about what is to be built or developed
   - examples of similar facilities elsewhere
   - the benefits to the local community (you may want to include the 'costs' of the plan)
   - an indication of who is likely to use the facility
3. Outline your social network campaign. Include in your plan:
   - the social networks you are going to use
   - the people or groups your campaign will target; these could include:
     - the local mayor and councillors
     - the local state and/or federal Member of Parliament
     - community groups
   - the message you are going to send to each group or person.

Activity 6

Liveability around the world

Select two or three cities from around the world. Ensure you select cities from different continents.

1. Conduct research into the following aspects of liveability for each of the cities you chose.
   - law and order
   - economics
   - environment
   - culture
   - education
   - health care
   - infrastructure
2. Present your findings in an annotated visual display. Central to your display should be a map of the world with each of the cities you chose marked and labelled on it. Your display can include images, graphs and tables. Write a short response comparing and contrasting the liveability of the cities you chose.

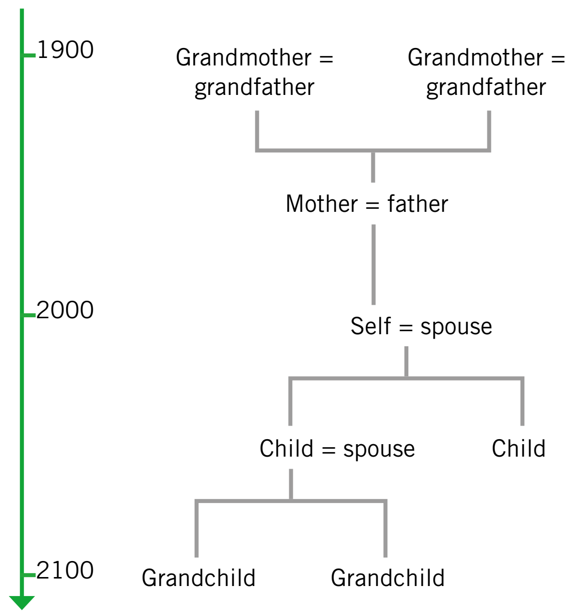
Activity 7

Looking to the future

Geographers are interested in the future, not just the past and the present. They use their geographical knowledge and skills to discover, examine, evaluate and propose possible, probable and preferable futures. We cannot 'study' the future because it does not exist yet. We can, however, make informed predictions about the future. We can do this because of our knowledge of the past and the present.

Figure 19.1.2 shows how generations overlap. Much of our learning about the world we live in is through the interactions we have with others. We can, for example, learn about the past by talking to our grandparents, parents and teachers. We can then use this knowledge to think about what the future might be like.

Figure 19.1.2 also shows how the 'present' can span 200 years of 'lived' experience. Members of a community are linked, through people's life experience, with the events of the past 100 years, and some of those born today may live for another 100 years, thus carrying this knowledge into the future.



19.1.2 The family chain

1. Using Figure 19.1.2 as a guide, list those things that you can think of that have been passed down from one generation to the next.
2. As a class, brainstorm and list other things that may have been passed between generations.
3. Use this information to explore how the local community has changed over the last 100 years, and how it might change over the course of your lifetime. Present this information in a timeline.

Activity 8
Reclaimed water

Reclaiming, or recycling, water consists of removing solids or other impurities from water and using the water for irrigation or putting it back into the water table. In Victoria, reclaimed water has been used on market gardens in Werribee. In Singapore, reclaimed water is added to the water supply; the reclaimed water is safe enough for human use but it is mainly used in industry. Around the world, some cities are planning to use reclaimed water and add it to their water supply so the water can be used for human consumption.

Develop a marketing and advertising campaign to promote water recycling in your city, state or local area. The campaign can include one or more of the following formats.

- a poster
- a short multimedia presentation
- a social media plan
- a short video

Activity 9
Big dam hypothetical

For decades, people have had different ideas about ways to irrigate and droughtproof Australia's arid interior. Many of these schemes have involved diverting rivers of northern Queensland to central and southern areas of the state.

Outlined below are a range of views regarding the proposal to dam and divert the waters of Queensland's rivers.

- The project will be of great economic benefit to the whole country. Thousands of jobs will be created.
- The scheme will be hugely expensive and any economic benefit will be very small. The money could be better spent helping farmers to use existing water supplies more efficiently.
- The project will be a great economic boost to the area. Our towns will grow and there will be work for our young people.
- The diverted water will enable us to irrigate our crops and reduce the risk associated with Australia's unreliable rainfall.
- We don't need the dams. We need to use the land and water more sustainably. We should focus on conserving water and growing crops that can cope with the unreliable rainfall.
- The water currently just flows out to sea. Why not put it to work irrigating Australia's arid interior?
- Pumping vast amounts of additional water into the system will simply create problems with salinity, just as it did in the Murray–Darling Basin.
- The proposed dams will flood some of Queensland's most fragile forest ecosystems. Endangered species will be lost.
- The spirits of the Dreaming inhabit these sacred lands. Cultural heritage must be respected.
- More water in the lake means more tourists to see the region's spectacular birdlife.

- Big dams have a major impact on river systems. They cut off the supply of fertile sediments to the flood plain, resulting in reduced fertility and soil depth. Reductions in the flow of sediment can increase coastal erosion. Cold water released from deep in the reservoir can affect the downstream ecology of the river.
- Big dams are not without their environmental impacts. The focus needs to be on conserving existing supplies of water and making sure that we maintain healthy river systems as close to their natural state as possible.

1 Read each of the statements above and copy and complete the following table by placing each statement in the correct column.

In favour of the dam project	Neutral about the dam project	Against the dam project

2 In groups of four or five students, discuss the different statements about the proposal. Reach agreement on what you think should happen. Prepare to defend your group's viewpoint when you report back to the class.

3 Conduct a class debate on the following topic: *The Australian government should adopt and fund the proposal to dam and divert the waters of Queensland's northern rivers.* At the end of the debate, conduct a secret ballot to determine whether the class will support or reject the proposal.

Activity 10

Desalination investigation

Desalination plants are expensive to build and operate. They are, however, seen by many as a solution to the growing demand for water at a time when rainfall is becoming less reliable due to climate change.

Your task is to investigate the advantages and disadvantages of desalination. Your investigation should consider the following:

- the process of desalination
- the reasons why desalination plants are being built
- the location of desalination plants in Australia and worldwide
- the economic, social and environmental benefits and impacts of desalination
- other relevant information.

After examining the advantages and disadvantages, write an extended response to the following statement: *Desalination is the best response to meeting the water needs of a growing urban population.*

Activity 11

Global futures

In this activity are a number of questions about the future of our global community. Working in groups, consider each question. As you gather your ideas for each question, divide them into those you consider desirable/good and those you consider undesirable/bad. One student should act as recorder.

1 What are your predictions for the future uses of the internet? Expand on each of the following areas with your own ideas.
   - playing games
   - accessing information
   - social networking
   - getting a job
   - buying goods
   - getting medical information

2 What are your predictions for the future of world transport? Expand on each of the following areas with your own ideas.
   - air transport
   - private cars
   - urban transport—buses/trams/light rail

3 What are your predictions for the future changes in consumer goods? Expand on each of these following with your own ideas.
   - mobile phones
   - home theatres
   - television sets
   - mobile personal music players

4 What are your predictions for changes in the lives of workers? Expand on each of the following with your own ideas.
   - migration from home to new places of work
   - increase or decrease in wealth
   - changes in work conditions
   - differences and changes in the work of women and men

5 What are your predictions for future changes in large global companies? Expand on each of the following with your own ideas.
   - companies growing larger and having more power
   - government controls of large companies
   - locations of factories, head offices

6 What are your predictions for the future of large sporting events? Expand on each of the following with your own ideas.
   - Olympic Games—Where? What size? Which sports? What costs?
   - World Cups
   - Championship series, for example Grand Prix

7 What are your predictions for the future of highly connected large world cities? Expand on each of the following with your own ideas.
   - use of energy and conservation
   - changes in lifestyle for people living in the cities
   - changes in the planning of the cities

Compare your responses to Questions 1–7 with those of other groups in the class. What common themes emerge? What differences are there between the groups?

Use the knowledge gained from this activity to debate the following topic: *On balance the future is something to look forward to.*

Activity 12

Places to visit, find out about and investigate

Many people have compiled lists of 'Seven wonders of the world' in response to the original list of Seven Wonders of the World in ancient times. Only one of the original list is still standing—the great pyramid of Giza.

The American Society of Engineers drew up the following list of Seven Wonders of the Modern World.

- Channel Tunnel
- CN Tower, Toronto
- Empire State Building, New York
- Golden Gate Bridge, San Francisco
- Itaipu Dam, Brazil
- Netherlands North Sea protection works
- Panama Canal

CNN compiled a list of Seven Natural Wonders of the World in 1997.

- Grand Canyon
- Great Barrier Reef
- Harbour of Rio de Janeiro
- Mt Everest
- Northern Lights
- Paricutin Volcano
- Victoria Falls

A new list of Seven Wonders of the World was compiled by people voting online in 2007.

- Chichen Itza (a Mayan city) Mexico
- Christ the Redeemer statue in Rio de Janeiro, Brazil
- Great Wall of China
- Machu Picchu, Peru
- Petra, an ancient city in Jordan
- Colosseum, Rome
- Taj Mahal, India

1 *Time* magazine made a list of the 100 most influential places in history. Below is a selection of some of these places. Write one to two sentences about each.
   - Sequoia National Park
   - Grand Canyon
   - Wall Street, New York
   - New York City
   - Cape Canaveral
   - Stonehenge, Britain
   - Waterloo
   - Galápagos Rift
   - Bastille, Paris
   - Athens
   - Calvary Hill, Jerusalem
   - Istanbul
   - Mecca
   - Great Pyramid and Sphinx, Giza
   - Timbuktu
   - Taj Mahal, India
   - Angkor, Cambodia
   - Great Barrier Reef, Australia
   - Sydney Opera House

2 a Use the information in this unit, as well as your increasing knowledge of places in the world to draw up any three of the following lists as they relate to your personal preferences.
   - Places I want to visit sometime in my life
   - Places I want to visit while I am young
   - Places where I would like to spend time working or studying
   - Places which I want to visit before they change too much

   b Think about the places you have already visited close to where you live. Draw up a list of between five and ten of these places and for each place give at least one reason why you think it is worth visiting. What gives it a distinctive character?

   c There are many places mentioned in the lists in this unit of which you do not yet have much knowledge. Choose two or three of those that sound interesting to you and find out more about them.

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