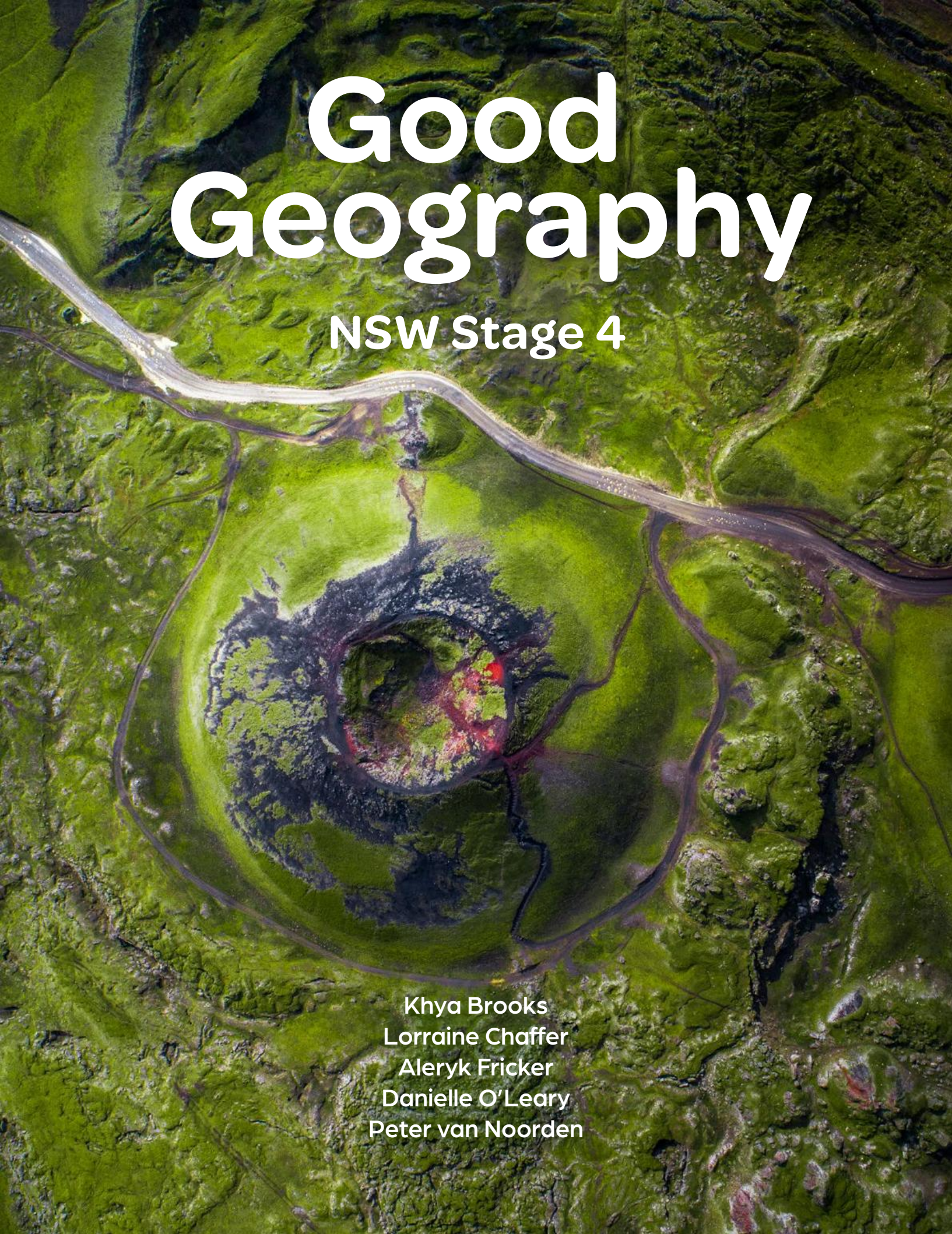

Good Geography

NSW Stage 4

Khya Brooks
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Danielle O'Leary
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Good Geography

NSW Stage 4

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Matilda Education Australia acknowledges the Aboriginal and Torres Strait Islander Peoples of this nation. We acknowledge the traditional custodians on whose unceded lands we conduct the business of our company. We pay our respects to ancestors and Elders past, present and emerging. Matilda Education Australia is committed to honouring Aboriginal and Torres Strait Islander Peoples' unique cultural and spiritual relationships to the land, waters and seas; and their rich contribution to society.

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Good Geography
NSW Stage 4

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Acknowledgement of Country

We acknowledge the Aboriginal and Torres Strait Islander Peoples of this nation. We acknowledge the Traditional Custodians on whose unceded lands we have created this resource. We pay our respects to ancestors and Elders past and present.

Note about language

Please note that we use the terms 'Aboriginal and Torres Strait Islander' and 'First Nations' interchangeably. We acknowledge that there is no one term that is universally accepted and we use these terms with respect.

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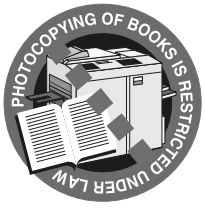


Contents

Landscapes and landforms

Liveability of places

Water in the world

Landscapes and landforms

1 Processes that shape the land

How can I understand landscapes and landforms?

Mountains, glaciers, valleys, plateaus and many other natural features that we see on the surface of the Earth are called landforms. Landforms are produced by natural processes. Similar landforms are grouped together as landscapes.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

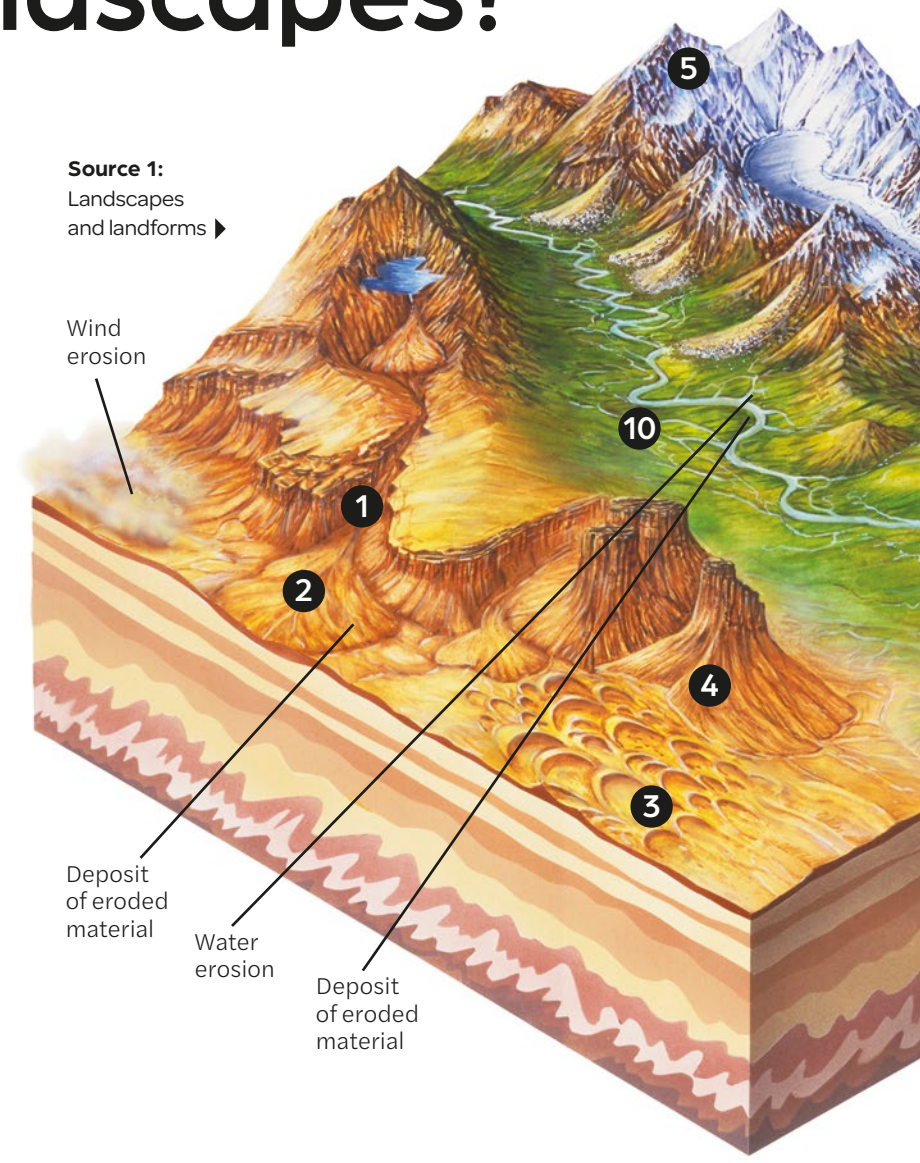
Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information
	Outcomes					Geographical tools and inquiry

Source 1: Horse Head Rock near Bermagui in New South Wales is a natural arch landform caused through wave erosion.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

What are landforms and landscapes?

Earth contains many different types of natural landscapes. Each landscape features unique landforms created by natural forces, such as the movement of tectonic plates.



Source 1: Landscapes and landforms

Landforms and landscapes

A **landscape** is comprised of the visible features of an area. Landscapes can be natural such as deserts or human such as cities. Natural landscapes are made up of different **landforms**. Landforms are shaped over time by **weathering** and **erosion**. Weathering wears them down and breaks them apart and erosion removes the weathered material. The growth of human settlement and activities such as farming, mining, logging and tourism can change and sometimes degrade landscapes.

Desert landscapes

Deserts are dry environments. They can be hot or cold and can be rocky, sandy or even covered in ice. Rocky deserts can be weathered and then eroded by water and wind into amazing shapes. Use the numbers for each landform below to locate them in Source 1.

Desert landforms

1. **Wadi:** Dry watercourse in a deep, narrow **valley** that divides a **plateau**.
2. **Alluvial fan:** Semicircular build-up of eroded material deposited by water and wind at the end of a **wadi**.
3. **Barchan dune:** A crescent-shaped **dune** formed by the wind blowing from one direction. They are a common landform in sandy deserts.
4. **Butte:** Isolated, steep, flat-topped hill of resistant rock (rock that does not erode easily).

Mountain landscapes

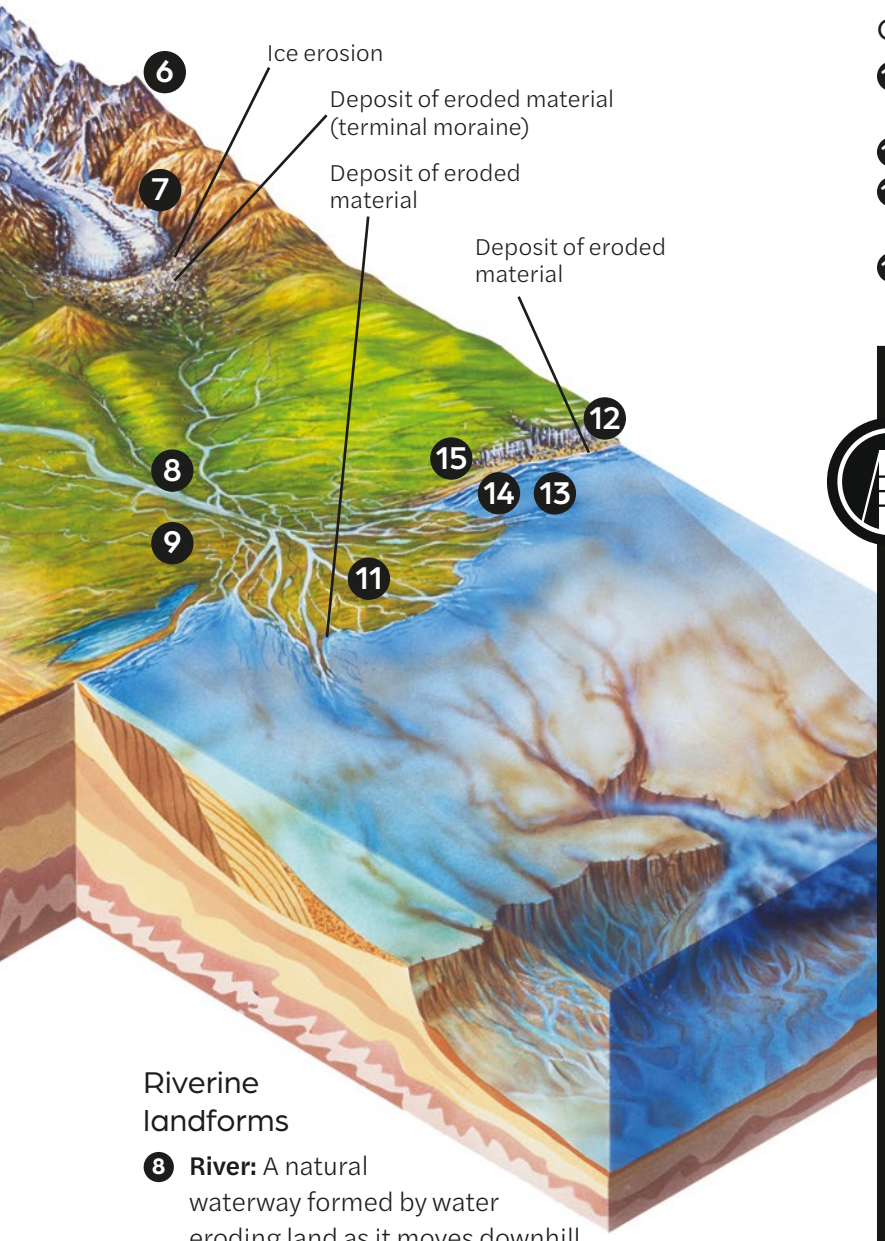
Mountain landscapes sit high above the surrounding land. They are formed by movements in Earth's crust, which also cause earthquakes and volcanoes. Use the numbers for each landform below to locate them in Source 1.

Mountain landforms

5. **Mountain:** Steep-sided, lone peak rising above the surrounding land.
6. **Fold mountains:** Formed when two tectonic plates collide and the crust folds and is pushed upwards.
7. **Glacial valley:** A valley being eroded by a river of ice.

Riverine landscapes

Riverine landscapes are formed by the natural movement of a network of rivers in a **drainage basin**. These landscapes attract farming because they contain fresh water and fertile land from deposited silt. Use the numbers for each landform below to locate them in Source 1.



Riverine landforms

8. **River:** A natural waterway formed by water eroding land as it moves downhill.
9. **Floodplain:** Flat land that water spills onto in flood conditions.
10. **Meander:** Loops in a river when it slows on flatter land. The river erodes the outside and deposits on the inside of the meander.
11. **Delta:** Deposited sediment at a river's mouth, which causes the river to block its own exit. The river splits into a number of finer channels that erode a path to the sea.

Coastal landscapes

The coast is where the land meets the sea. Coastal landscapes are shaped by wind and **waves** that erode and deposit materials to create landforms that are constantly changing (see 1.13 How do waves shape landforms?). Use the numbers for each landform below to locate them in Source 1.

Coastal landforms

12. **Headland:** Narrow, high land jutting out into the sea, formed of harder rock that resists erosion.
13. **Bay:** Curved indentation in the coastline.
14. **Beach:** Deposited rock particles, such as sand or gravel, along the coastline.
15. **Coastal dune:** Mound or ridge of wind-blown sand at the back of the beach.

Learning ladder 1.1

Characteristics of places and environments

1. Source 1: Name a landform that fits each of the following descriptions:
   - **a** eroded by glaciers
   - **b** deposited by water
   - **c** caused by movement of the Earth's crust.
2. Source 1: Which desert landforms are shaped by wind and which are formed by water?
3. Source 1: Describe how meanders change the path of a river.
4. Source 1: Explain how erosion and deposition are key processes in the formation of a delta.

Environment

1. Source 1: Where do glaciers occur and why?
2. Source 1: Describe coastal landforms that are mainly shaped by wind and those formed by waves.
3. Source 1: Explain the key process that drive the formation of desert landscapes.
4. Source 1: Explain how processes form valleys in three different landscapes.
5. Source 1: Select one landscape or landform that will change the most dramatically due to global warming. Suggest what action could be taken to reduce its impact.

HOW TO

Block diagrams, page 418; Environment, page 396

What are geomorphic processes?

The landscapes and landforms on Earth are shaped by geomorphic processes, such as plate tectonics and weathering.

Processes shaping the Earth

The transformation of the Earth's surface into distinctive and constantly changing features is the result of physical and chemical **geomorphic processes**.

These geomorphic processes include:

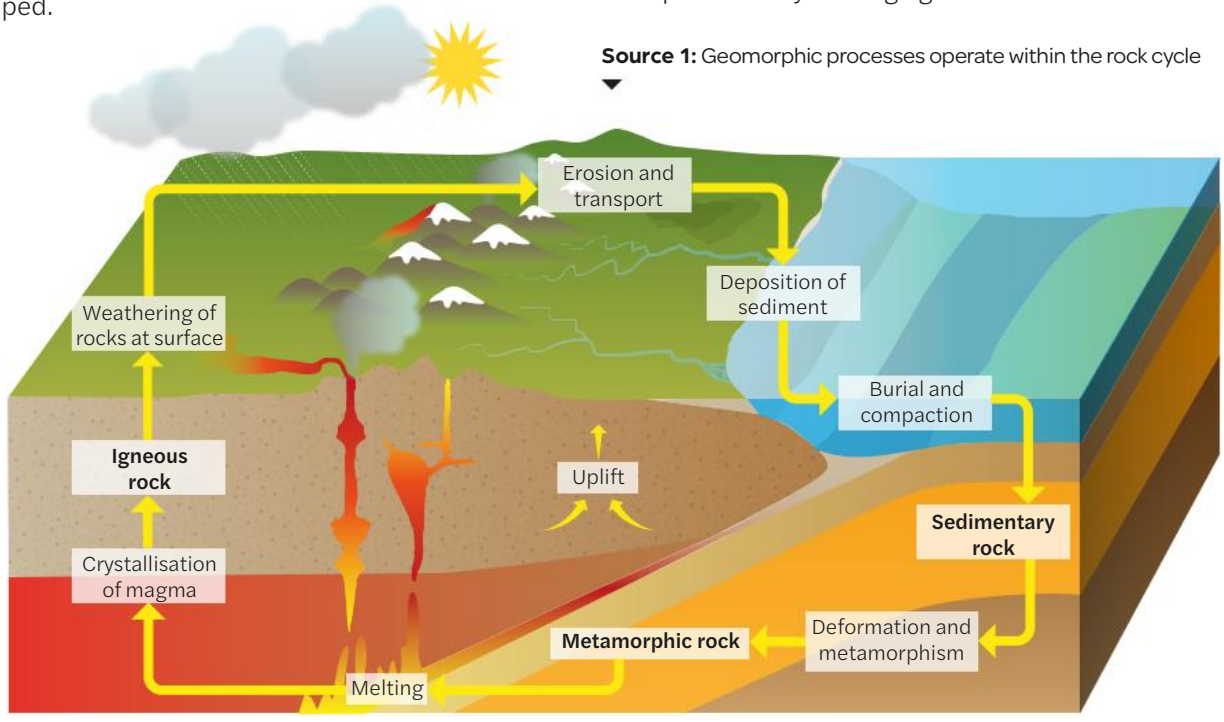
- **plate tectonics:** the physical movement of the Earth's crustal plates that creates mountains and valleys on the surface of the land and beneath the sea through processes such as **folding**, faulting, uplift and subduction. Volcanic landscapes such as mountains result from tectonic processes.
- **weathering:** the chemical and physical breakdown of rock into smaller particles. Weathered rock is easily eroded and deposited to shape new landforms such as sand spits.
- **erosion, transportation and deposition:** the physical movement and transfer of weathered rock by agents, including moving water, ice and wind, to another location. When these forces slow down or stop moving, the sediment they are carrying is dropped.
- **mass movement:** the movement of soil and/or rocks downslope under gravity.
- **the rock cycle:** the continuous process of rock formation that involves weathering, erosion and deposition at different stages as rock is broken down and then transformed into new rock.

The movement of the Earth's crustal plates and their collisions are responsible for the formation of landforms such as mountains, ridges and ocean trenches.

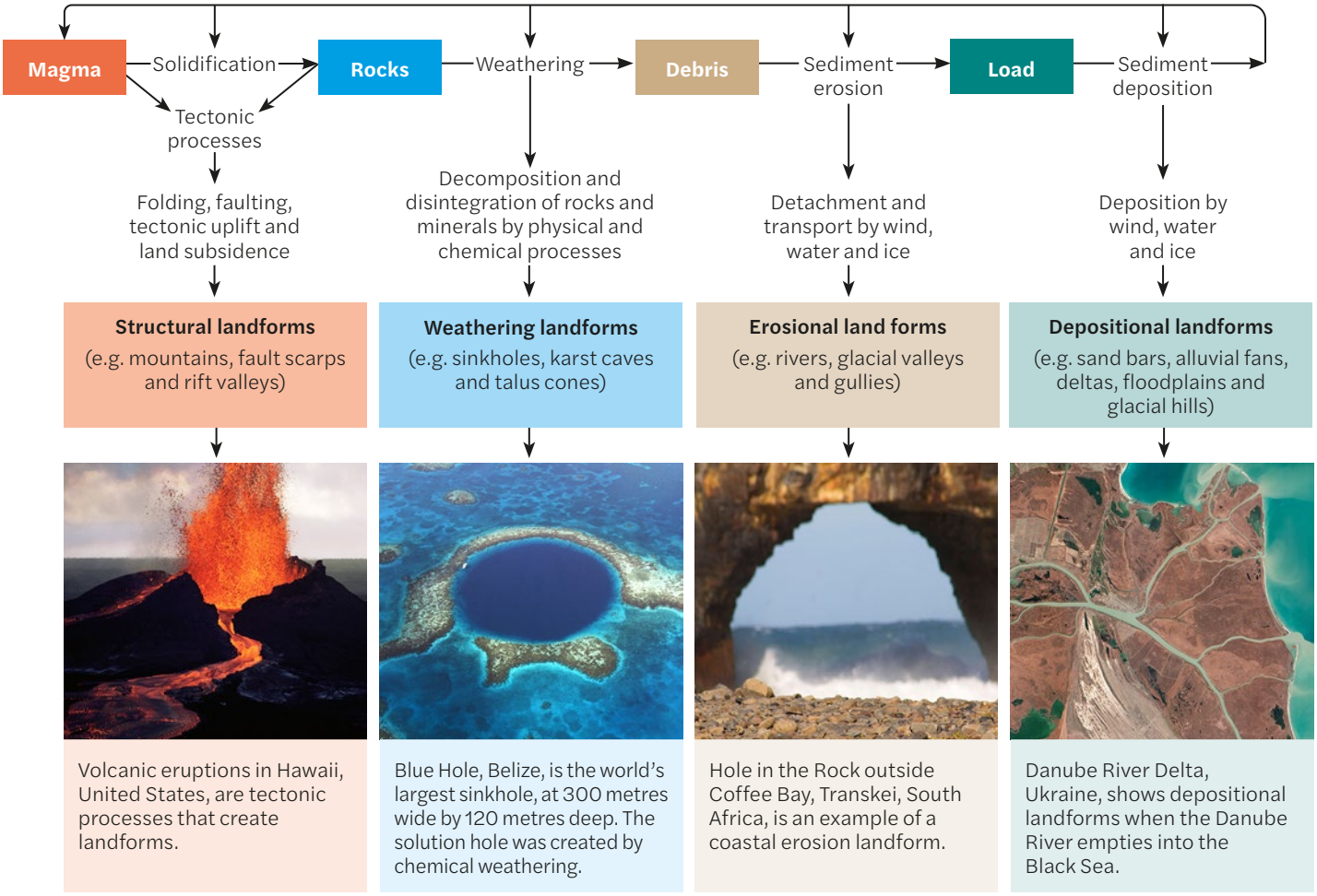
Types of landforms

Landforms can be classified by the main processes that cause their formation. *Structural landforms* such as rift valleys are formed when tectonic plates move. *Weathering landforms* such as limestone caves are caused by **physical weathering** or **chemical weathering**. *Erosional landforms* such as coastal cliffs comprise the crust left behind after rock is eroded and transported away. Depositional landforms such as beaches are created from deposited sediment that has been transported to by moving agents such as waves.

Source 1: Geomorphic processes operate within the rock cycle



Landscapes and landforms change and evolve over millions of years. Examples include Uluru in Central Australia, an erosional landform known as an **inselberg**, created by the exposure of a layer of folded rock as the softer rock layers around it eroded away, the Grand Canyon in the United States formed by tectonic uplift of the land and erosion by the Colorado River, and K'gari, a depositional sand island in Queensland.



▲ **Source 2:** The relationship between geomorphic processes and landforms

Learning ladder 1.2

Processes that transform people, places and environments

1. Identify the main geomorphic processes.
2. Source 1: Describe how rocks can be transformed by geomorphic processes in the rock cycle, beginning with weathering on the land.
3. Source 2: Explain how erosional landforms are shaped.
4. Source 2: Compare the features of erosional landforms with landforms created through deposition.
5. Assess the role of moving agents such as wind, ice and water in the formation of Earth's landforms and landscapes.

Change

1. Over what time frame did Uluru, the Grand Canyon and K'gari form?
2. Source 2: How does weathering change landforms?
3. Source 2: Explain how the Danube River Delta formed over time.
4. Source 1: Explain how an igneous rock can change into a metamorphic rock through the rock cycle.

Block diagrams, page 418; Change, page 394

HOW TO

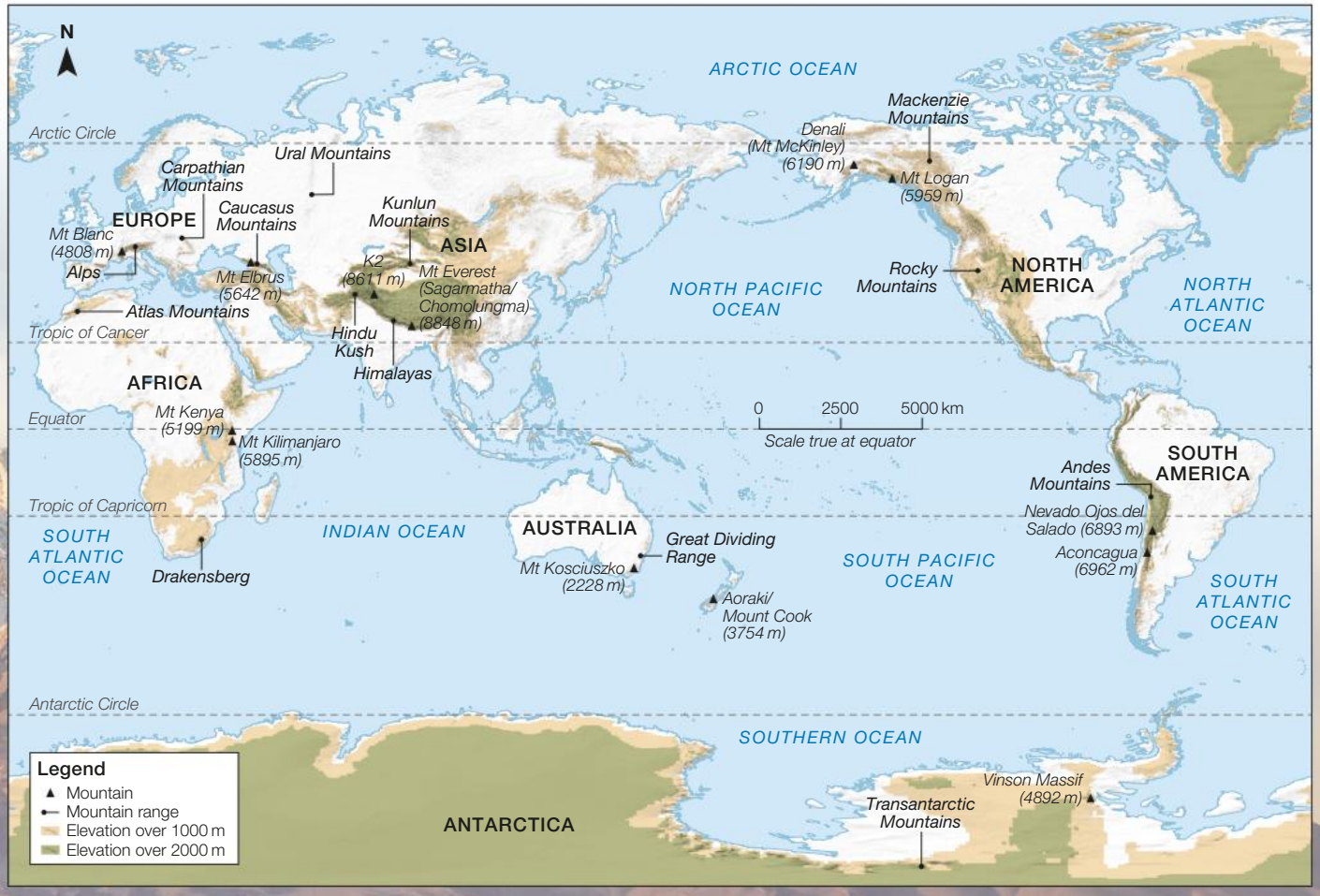
1.3

How are mountains formed?

Mountains are landforms that rise high above the surrounding land. They are formed when tectonic plates in the Earth's crust collide. The land crumples and folds until the rocks are pushed upwards to form a mountain range. Mountains become taller as the tectonic plates continue to collide.

Source 1: At 5895 metres above sea level, Mount Kilimanjaro is Africa's highest mountain and the tallest freestanding mountain in the world. It is a volcanic mountain formed over a hot spot in the Earth's crust. The top is covered in ice and snow even though the mountain is located near the **equator**.

World mountain landscapes



Source: Matilda Education Australia, Natural Earth, European Environment Agency

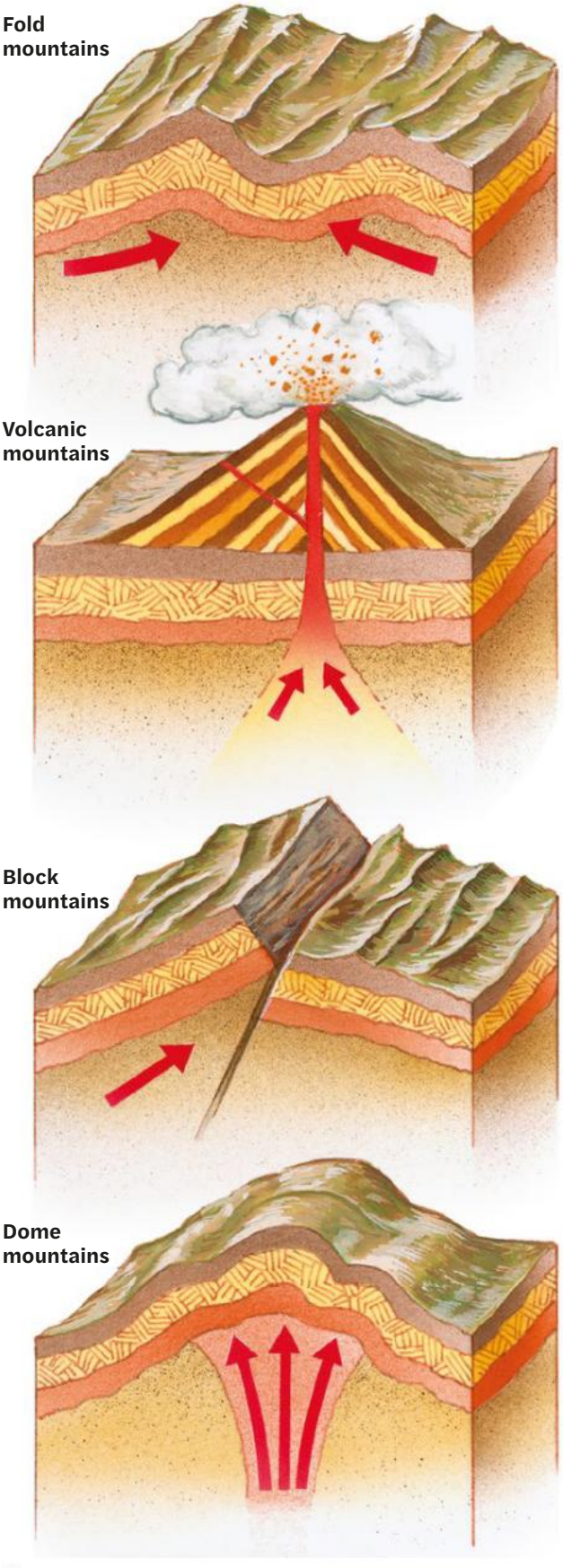
▲ **Source 2:** World mountain landscapes

What are mountains?

A mountain is a large landform that sits above the surrounding land, usually in the form of a peak. A mountain is steeper and higher than a hill. One measurement given to mountains is land higher than 600 metres above sea level.

A few mountains, such as Mount Kilimanjaro in Africa, are isolated, but most are part of a series of mountains called a **mountain range**. The Earth's highest mountain is Mount Everest in Asia's Himalayan mountain range. Its summit is 8848 metres above sea level. Australia's highest mountain, Mount Kosciuszko, is just 2228 metres tall.

The world's longest above-water mountain range is found in South America. Known as the Andes, this mountain range is 7000 kilometres long and travels through seven countries. Australia's longest mountain range is the Great Dividing Range, stretching more than 3500 kilometres through Victoria, New South Wales, the Australian Capital Territory and Queensland.



Source 3: Different mountain formations: fold, volcanic, block and dome

Source 4: The eastern edge of the Sierra Nevada range in the western United States consists of block mountains. They formed along the Sierra Nevada Fault, where tectonic forces have pushed up sections of rock.

How do mountains form?

Mountains are formed through earth movements or volcanic action. Strong forces inside the Earth can push up the surface into long mountain chains or punch through the surface at **hot spots** to create **volcanoes** such as Kīlauea in Hawaii (see page 22) and Mount Kilimanjaro in Tanzania (see Source 1 on page 8).

Fold mountains

Fold mountains are pushed upwards where two continental **tectonic plates** (see pages 16–17) collide. Layers of rock are bent and pushed upwards to create the fold mountains. The world's largest fold mountains are found in the Himalayan mountain range (see pages 18–19), with over 50 peaks more than 7200 metres high.

Volcanic and dome mountains

Volcanic mountains form when **magma** from below the Earth's surface is pushed through an opening in the Earth's crust. This material can build up to form a cone-shaped mountain known as a volcano (see pages 20–1). **Dome mountains** form when magma is injected beneath layers of **sedimentary rock**, causing the top layer to bulge upwards forming the dome shape.

Block mountains

Block mountains form when blocks of rocks are forced upwards or downwards along faults or cracks in the Earth's crust. The uplifted blocks are block mountains or **horsts**. Dropped blocks are called **graben**, which can form **rift valleys**.

Learning ladder 1.3

Processes that transform people, places and environments

1. Source 2: Look at the map of world mountain landscapes. Name two of the highest mountain ranges using the legend and annotations.
2. Source 4: Describe the features of block mountains.
3. Explain the difference in how block and dome mountains are formed.
4. Simulate tectonic plates by placing two sheets of paper end to end on a flat surface (about 2 centimetres apart). Place four fingers on both sheets of paper and move the left sheet slowly towards the right.
   - **a** Sketch what happens when the paper meets.
   - **b** What type of mountains form like this?

Environment

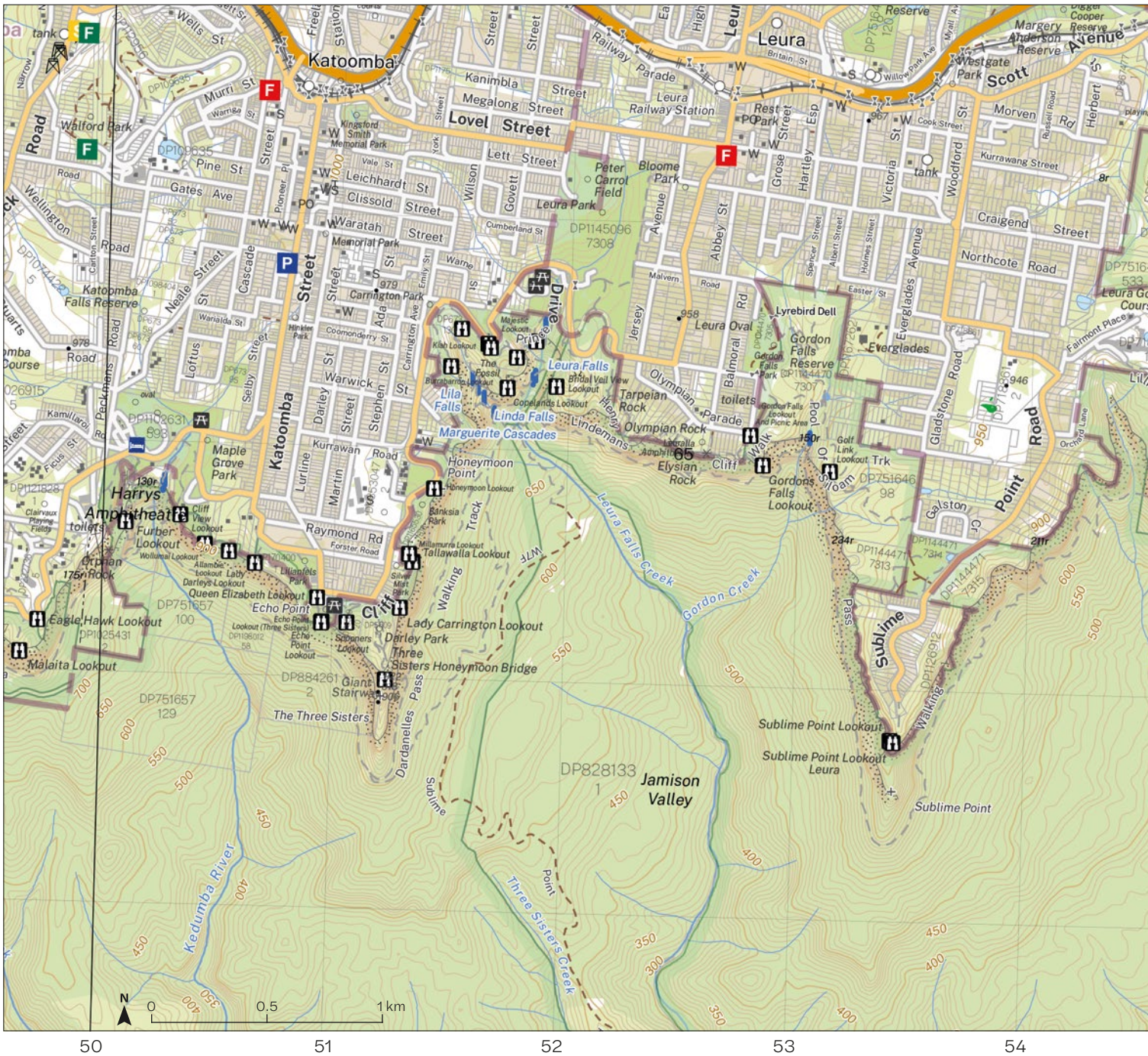
1. How do mountains differ from other environments?
2. Source 3: What is the difference between volcanic mountains, dome mountains and hot spot volcanoes? Present your answer as a table.
3. Source 1: Explain how Mount Kilimanjaro formed.
4. Draw a labelled block diagram to explain how and where fold mountains form.
5. Analyse why a dome mountain has its characteristic dome shape. Provide a three-stage diagram to show how a dome mountain forms. Research an example of a dome mountain and explain how it formed.

HOW TO

Block diagrams, page 418; Environment, page 396

What are the characteristics of the Blue Mountains?

When real **fieldwork** is not possible, a virtual site visit can be used to gather quantitative (statistical) data and qualitative (descriptive) information to answer inquiry questions.



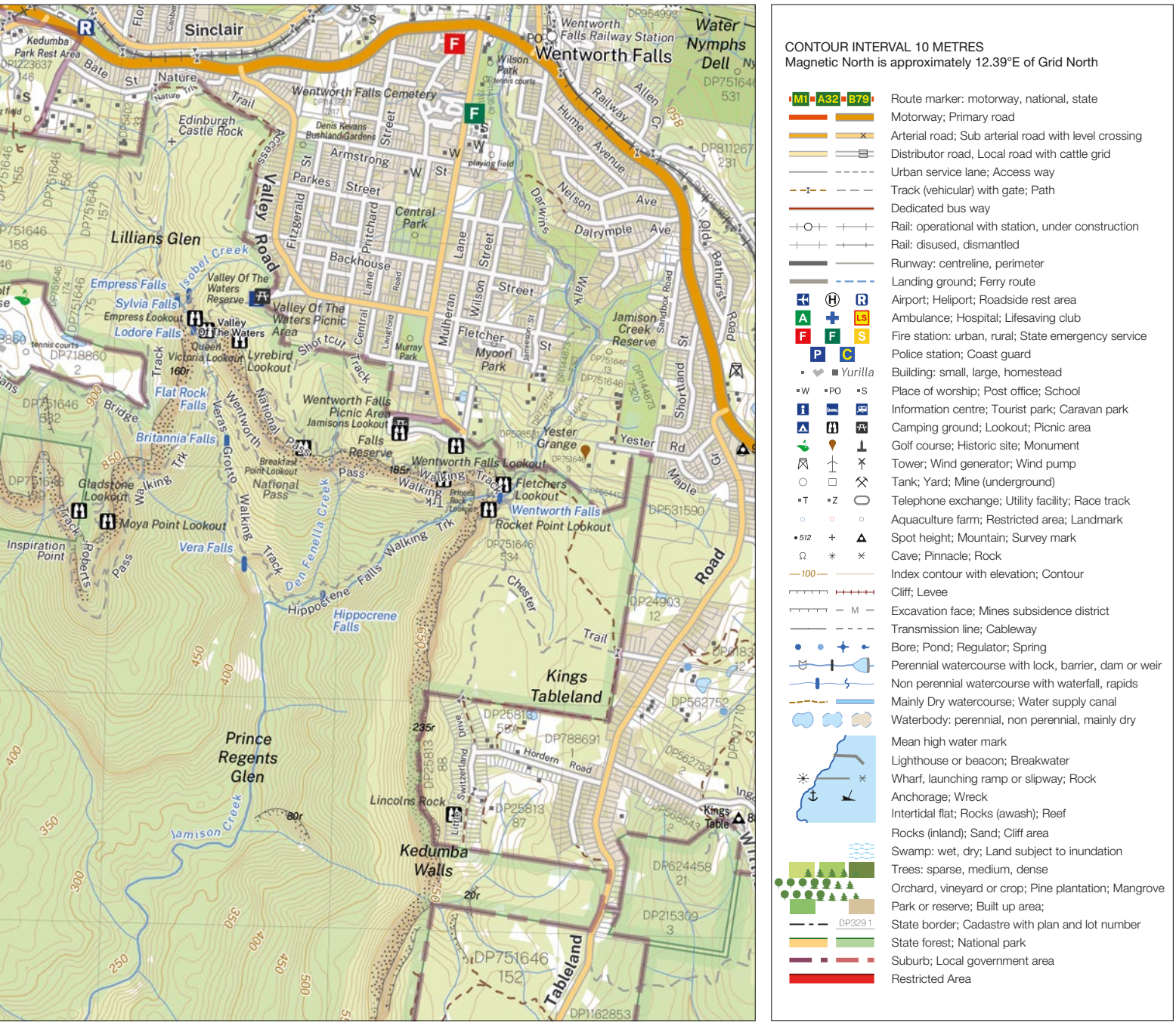
▲ **Source 1:** Katoomba topographic map

Inquiry questions

In a study of landscapes and landforms, you can do a virtual site visit to the Blue Mountains to help explore inquiry questions:

- What are the characteristics of the Blue Mountains landscape and its landforms?
- Which landforms can be identified in the Blue Mountains?
- Which geomorphic processes created the landscape and landforms of the Blue Mountains?
- How does the National Parks and Wildlife Service sustainably manage and protect the Blue Mountains landscape?

Katoomba topographic map



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Source: © State of New South Wales (Spatial Services, a business unit of the Department of Customer Service NSW)

Using secondary sources

Before an actual or virtual visit to the Blue Mountains, gather information from secondary sources (the work of other people). The following questions can guide the collection of information prior to fieldwork.

- Can I find key locations in the Blue Mountains such as Katoomba, the Three Sisters and Wentworth Falls on a topographic map? (See Source 1 on pages 12–13.)
- When and how did the Blue Mountains form? (See Source 2.)
- How does the climate at Katoomba differ from Sydney? (See Source 3.)

The structure of the Blue Mountains

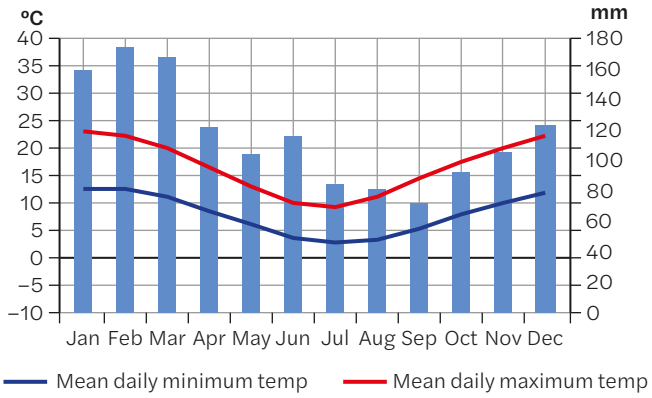
The Blue Mountains are not actually mountains – the area is, in fact, an uplifted plateau that has been dissected by rivers over time. The Blue Mountains are part of the greater Sydney Basin, which is made up of layers of sedimentary rocks laid down over 300 million years. The Blue Mountains, and the Great Dividing Range more generally, were formed about 50 million years ago, when activity under the Earth's crust caused the area to lift. Some of the higher outcrops are covered in **basalt** rock from volcanic eruptions. The lava flows originally covered more of the area, but most of it has worn away.

The Blue Mountains National Park is on the eastern side of the Great Dividing Range. The area descends west to east from a height of around 1100 metres above sea level near Mount Victoria to less than 200 metres above sea level around Glenbrook. The highest point is Mount Werong, which is 1215 metres above sea level, and the lowest point is on the Nepean River, only 20 metres above sea level.

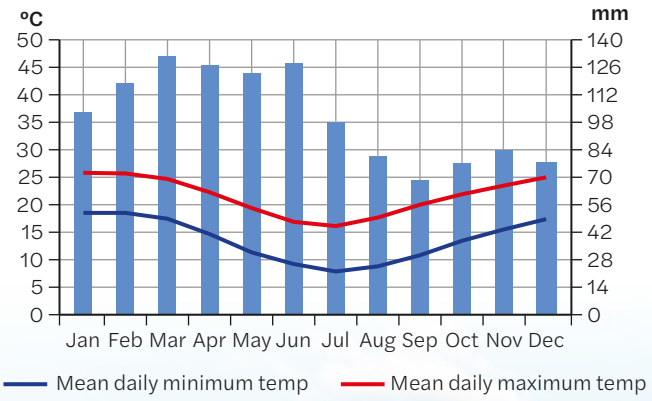
Four major rivers lie inside the national park: the Wollangambe River to the north, the Grose River in the centre, and the Coxs and Wollondilly rivers to the south. The blue haze seen on top of the mountains is created when oil droplets from eucalyptus trees, dust particles and water vapour mix together in the air, and this mixture is reflected in the sunlight.

Source 2: Structure of the Blue Mountains

Climate graph of Katoomba

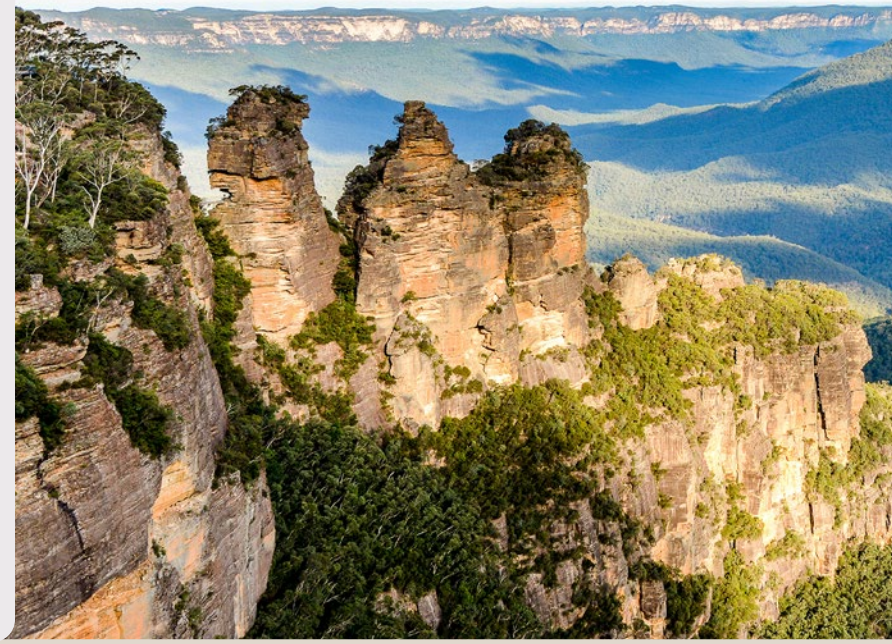


Climate graph of Sydney



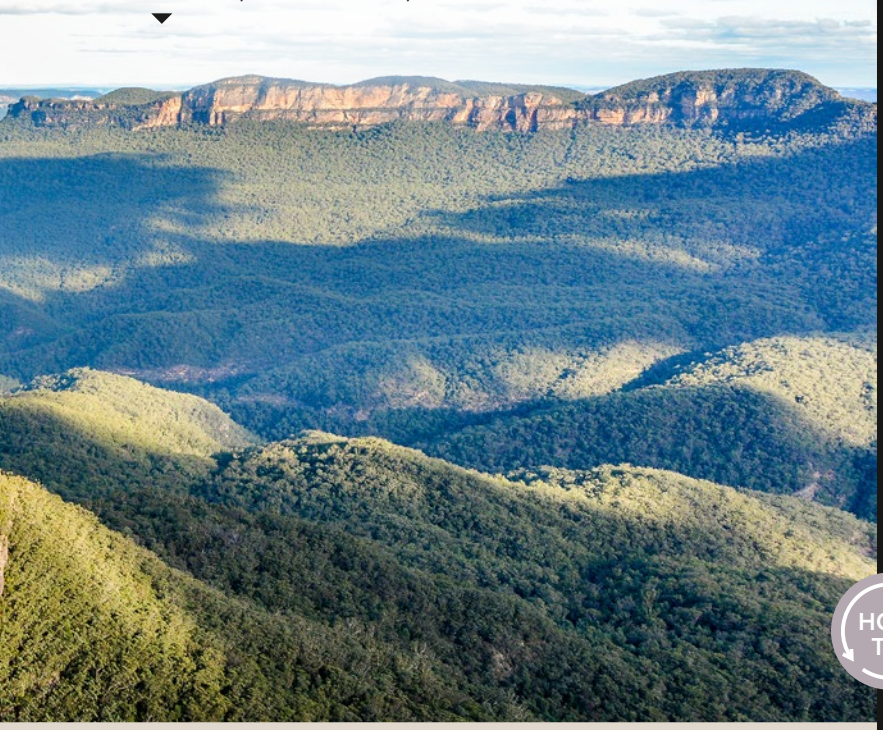
Source: Matilda Education Australia

Source 3: Climate graphs of Katoomba (1017 metres above sea level) and Sydney (35 metres above sea level)



Source 4: Wentworth Falls has a total height of 187 metres. It plunges over the sandstone escarpment (steep slope on the edge of a plateau). It is a three-tiered waterfall fed by the Jamison Creek, near the town of Wentworth Falls.

Jamison Creek travels over Wentworth Falls and into a pool in the valley below. It continues through the valley until its confluence with Kedumba River at the southern end of Sublime Point Ridge.



Source 5: The Three Sisters are located on the north escarpment of the Jamison Valley. This sandstone landform was formed around 200 million years ago. The sandstone has vertical joints and over time weathering and erosion have widened these joints to leave the three pillars of sandstone that form the Three Sisters. Continued widening of these joints will make the pillars thinner, until they eventually fall into the valley below.

Learning ladder 1.4

Representing and communicating information

1. **a** Source 1: Use these four-figure area references (page 408) to identify key sites on the topographic map: AR5464 and AR5064.
   b Source 1: Use four-figure area references (page 408) to identify these key sites on the topographic map: Three Sisters, Kedumba Walls.
2. Source 1: What feature(s) on the topographic map show:
   a that the plateau that Katoomba sits on is surrounded by steep cliffs?
   b the bottom of the valley?
3. Source 2: Are the Blue Mountains really mountains?
4. Source 3: What impact does elevation have on temperature and rainfall when you compare Sydney and Katoomba?
5. Sources 4 and 5: Prepare accurate photo sketches (page 416) of Jamison Valley and Wentworth Falls with annotations, using the captions and Sources 1 and 2 to provide as much detail as possible. A photo sketch is similar to a field sketch.

HOW TO

Topographic maps, page 408;
Field sketches, page 416

What is the theory of plate tectonics?

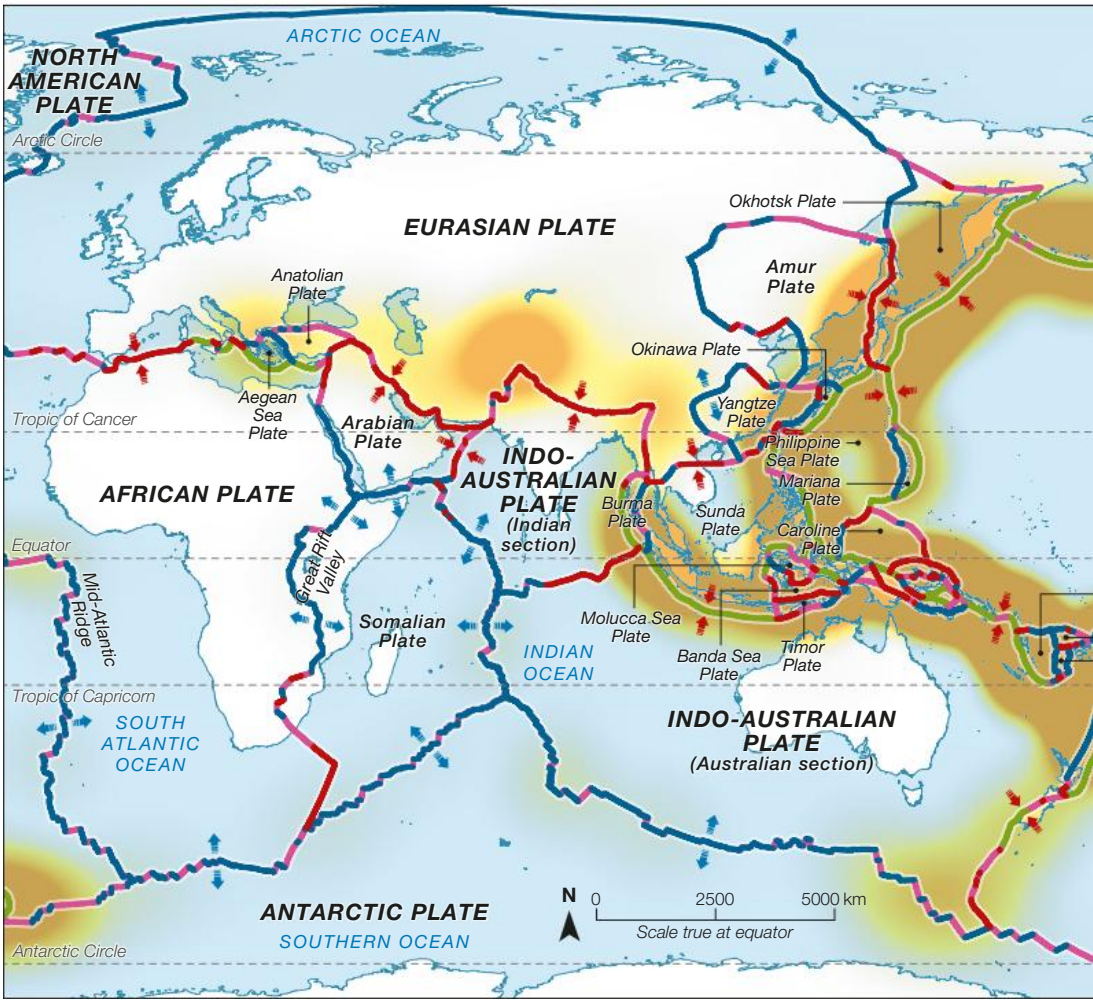
The Earth's surface is made up of huge tectonic plates, much like a big jigsaw puzzle. These rigid plates move on top of a molten layer of the crust's mantle. Tectonic plates are always moving, but usually by only a few centimetres per year. At the boundaries of the plates, they collide, move away or move laterally with other tectonic plates Where they collide, mountains and trenches form and volcanoes and earthquakes are generated. When plates move apart, ocean ridges can form.

How do mountains form?

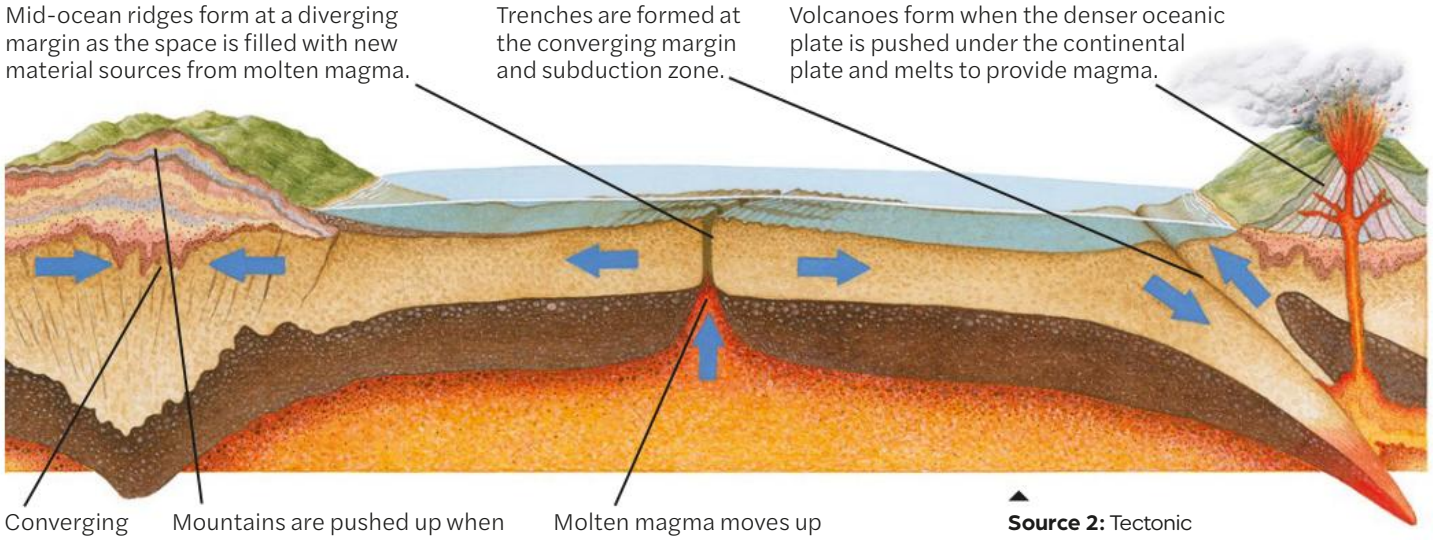
Earth's crust is made up of seven major tectonic plates that move on the semi-molten rocks in the **mantle**. As the plates move apart (**diverging margins**) or collide (**converging margins**), landforms such as mountains, ridges and ocean trenches are created.

Most of the world's volcanoes are located along converging margins or subduction zones. **Subduction** occurs when a continental plate, such as the North American Plate, converges with an oceanic plate, such as the Caribbean Plate. The heavier oceanic crust bends and moves down towards the upper mantle (Source 2). The edge of the plate melts into magma that feeds volcanoes along the converging margin, such as Mount Pinatubo in the Philippines.

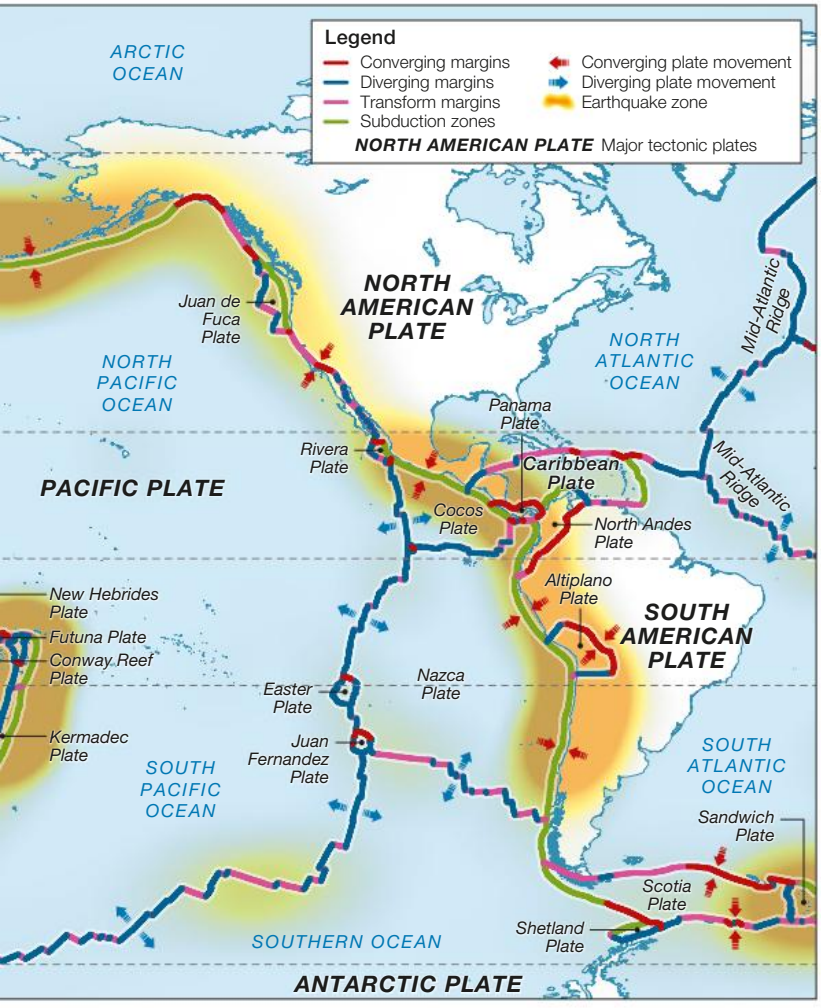
World tectonic plates



Most earthquakes occur near the edges of converging plates or along **transform margins**, which is where the plates slide past one another. Here the plates can become stuck and then break free with a sudden movement that triggers an earthquake. California's San Andreas Fault is a transform margin between the North American and Pacific plates that suffers many earthquakes.



Source 2: Tectonic plate movement



Source: Matilda Education Australia

Source 1: The world's tectonic plates: the seven major plates and some of the minor plates

Learning ladder 1.5

Processes that transform people, places and environments

1. Which process causes earthquakes?
2. Source 2: Describe how volcanoes occur.
3. Source 2: Explain how mountains form.
4. Source 1: Using examples from the map, analyse how tectonic plates influence where earthquakes and volcanoes occur.
5. Source 2: Why do converging margins sometimes produce mountains and other times create volcanoes? Explain using a labelled diagram.

Interconnection

1. Source 2: How are mountains and converging margins interconnected?
2. Source 2: Describe how mid-ocean ridges form at diverging margins.
3. Source 2. Explain how volcanoes form where oceanic plates meet continental plates.
4. Source 1: The Mid-Atlantic Ridge is the longest mountain range in the world. It runs under the Atlantic Ocean between South America and Africa. Explain why it is located here and how it formed.
5. Source 1: Africa's Great Rift Valley is an area of low land that forms where tectonic plates rift, or move apart. Describe its location, length, how it formed and how it can impact communities who live there.

HOW TO Interconnection, page 392

Case study

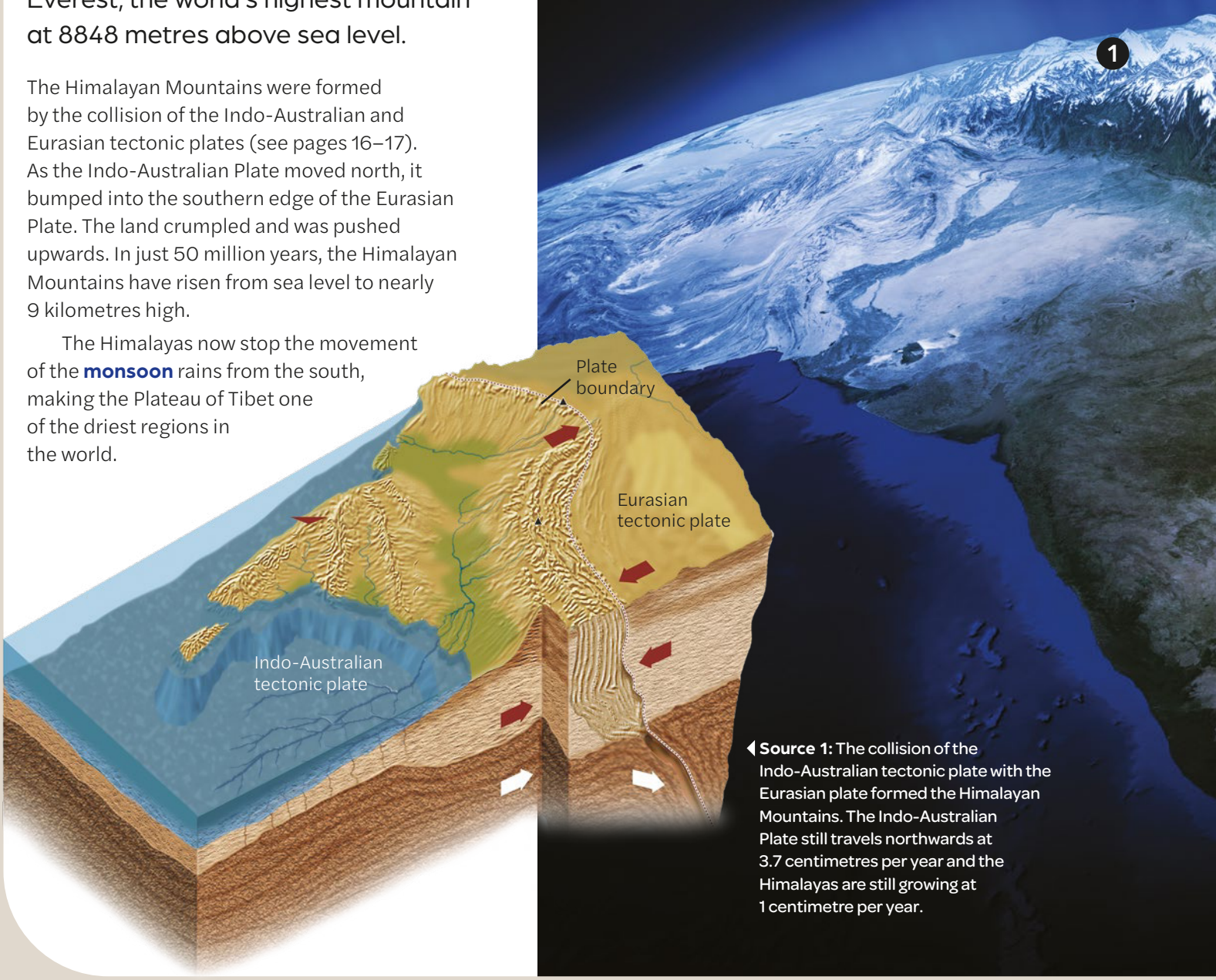
How did the Himalayas form?

Central Asia is dominated by the highest land on Earth: the Plateau of Tibet and the Himalayan mountains. This area is home to 90 of the world's 100 highest peaks, including Mount Everest, the world's highest mountain at 8848 metres above sea level.

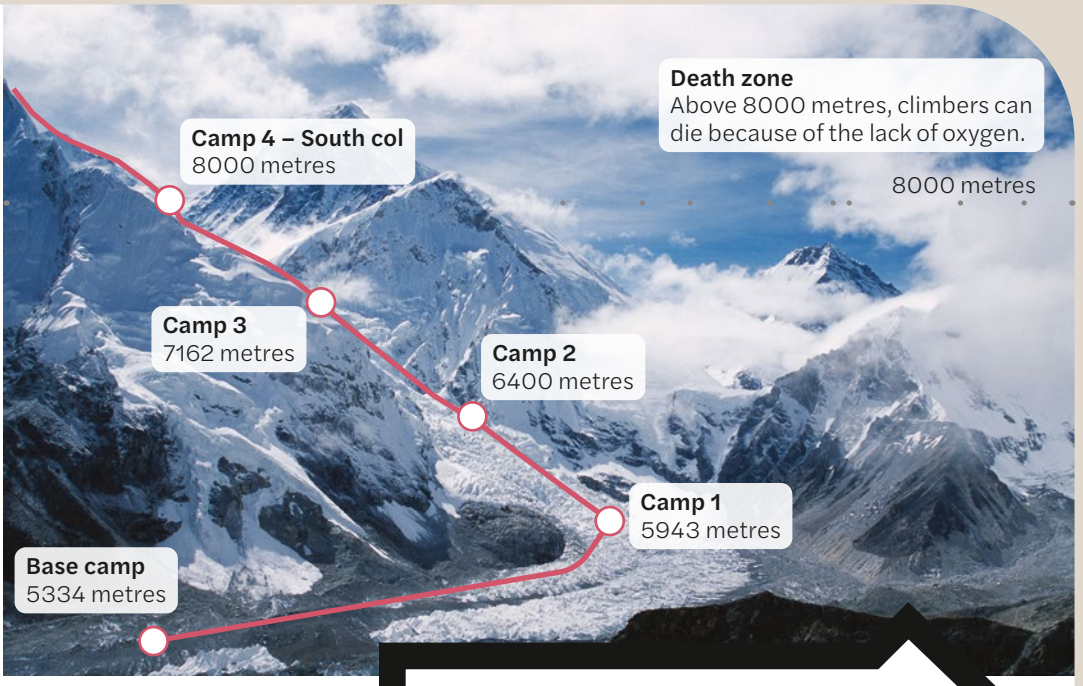
The Himalayan Mountains were formed by the collision of the Indo-Australian and Eurasian tectonic plates (see pages 16–17). As the Indo-Australian Plate moved north, it bumped into the southern edge of the Eurasian Plate. The land crumpled and was pushed upwards. In just 50 million years, the Himalayan Mountains have risen from sea level to nearly 9 kilometres high.

The Himalayas now stop the movement of the **monsoon** rains from the south, making the Plateau of Tibet one of the driest regions in the world.

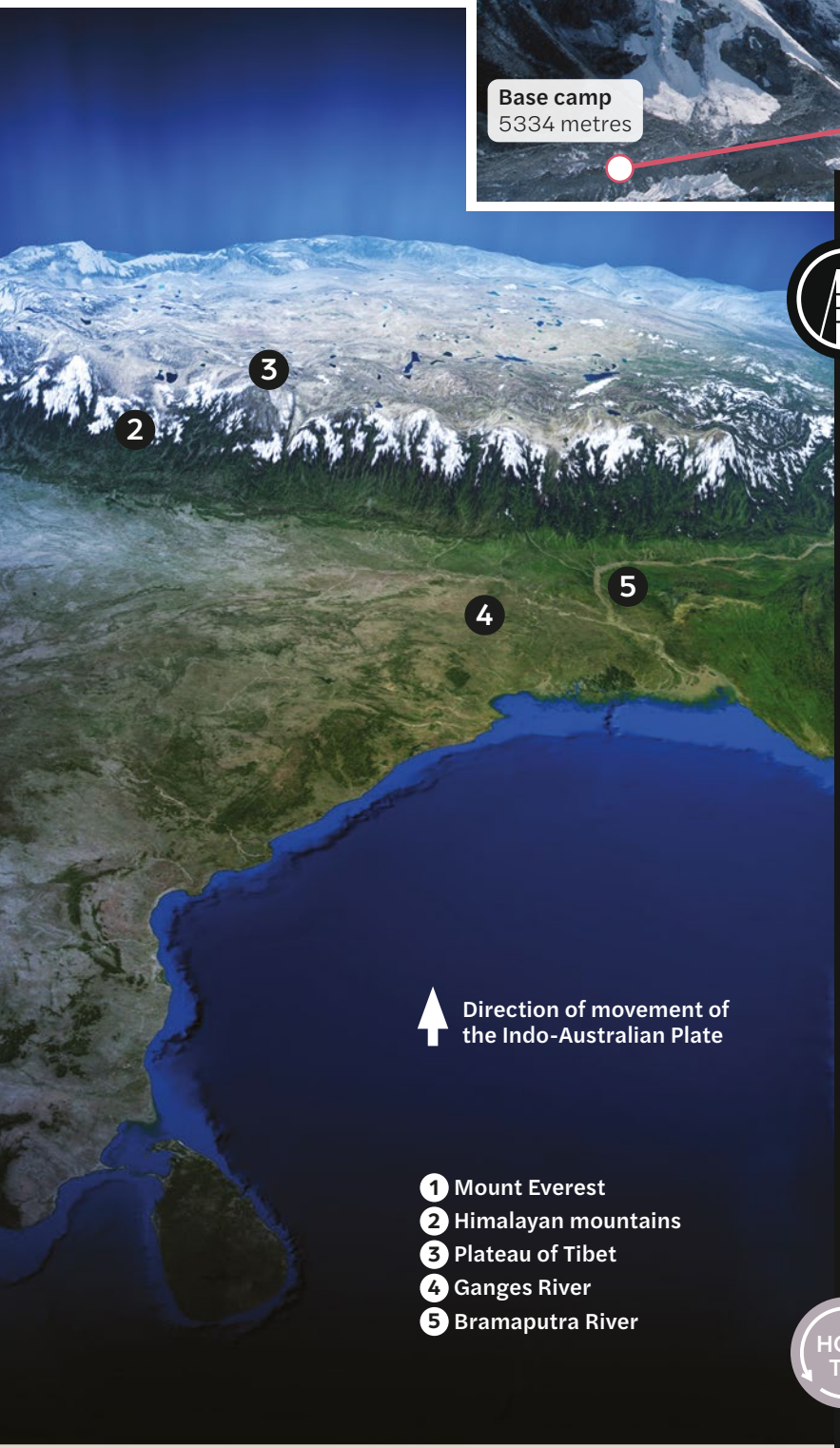
Source 2: The southern edge of the Eurasian tectonic plate was crumpled and buckled up above the Indo-Australian Plate. Neither of these continental plates was heavy enough to be subducted. This caused the crust to thicken because of folding and faulting. The Earth's crust here is about 75 kilometres thick – twice its average thickness. This process marked the end of volcanic activity in the region.



Source 1: The collision of the Indo-Australian tectonic plate with the Eurasian plate formed the Himalayan Mountains. The Indo-Australian Plate still travels northwards at 3.7 centimetres per year and the Himalayas are still growing at 1 centimetre per year.



Source 3: This is the route of climbing the south face of Mount Everest. The mountain was first climbed in 1953 by Sir Edmund Hillary and Tenzing Norgay.



Learning ladder 1.6

Characteristics of places and environments

1. Sources 1 and 2: Which tectonic plate is the Ganges River located on?
2. Source 2: Describe the different environments seen on these tectonic plates.
3. Source 3: Describe the environment a hiker would see as they move from base camp to camp 4.
4. Sources 1 and 2: Explain how the movement of the Indo-Australian Plate has affected the Himalayan Mountains.
5. Sources 1 and 2: Create a series of diagrams with labels to explain the formation of the Himalayan Mountain range. Incorporate the following geographic terms: tectonic plate, faulting, folding, mountain range.

Space

1. Source 1: In which region of the world are the Himalayas and Plateau of Tibet found?
2. Source 2: Describe the features of the landscape shown in this digital terrain model.
3. Source 3: Explain the reasons behind the location of the Himalayan mountain range.
4. Source 3: Where is the 'death zone' and what characteristics does it have?
5. What impact has the uplifting of the Himalayan mountain range had on the climate of the region?

HOW TO

Block diagrams, page 418; Space, page 388

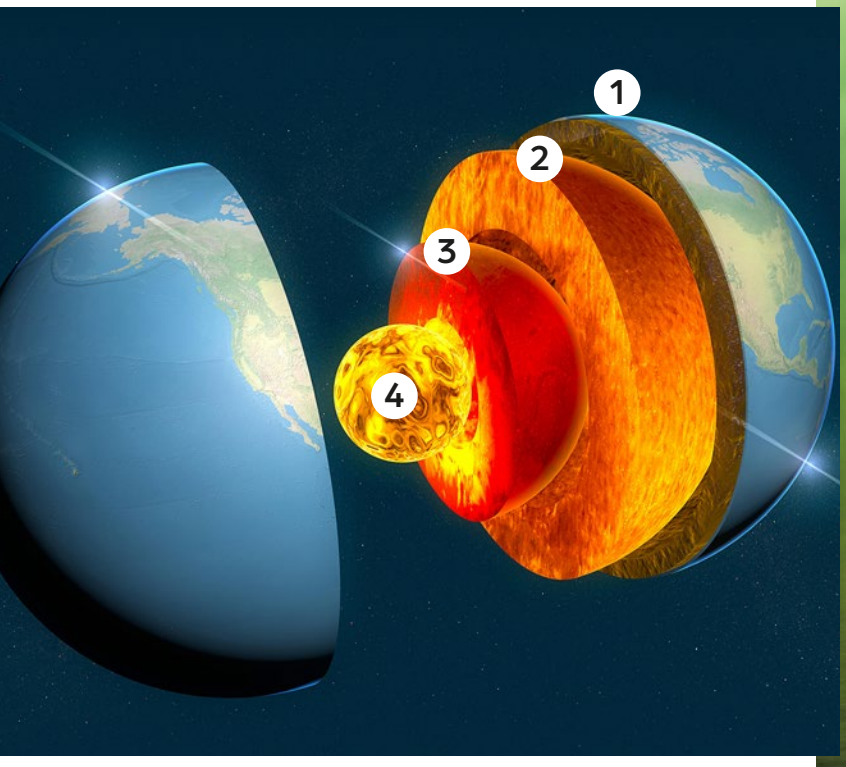
How do volcanoes form?

Volcanoes form when magma from beneath the Earth's surface pushes through the crust along tectonic boundaries and at hot spots in the mantle.

Volcanoes

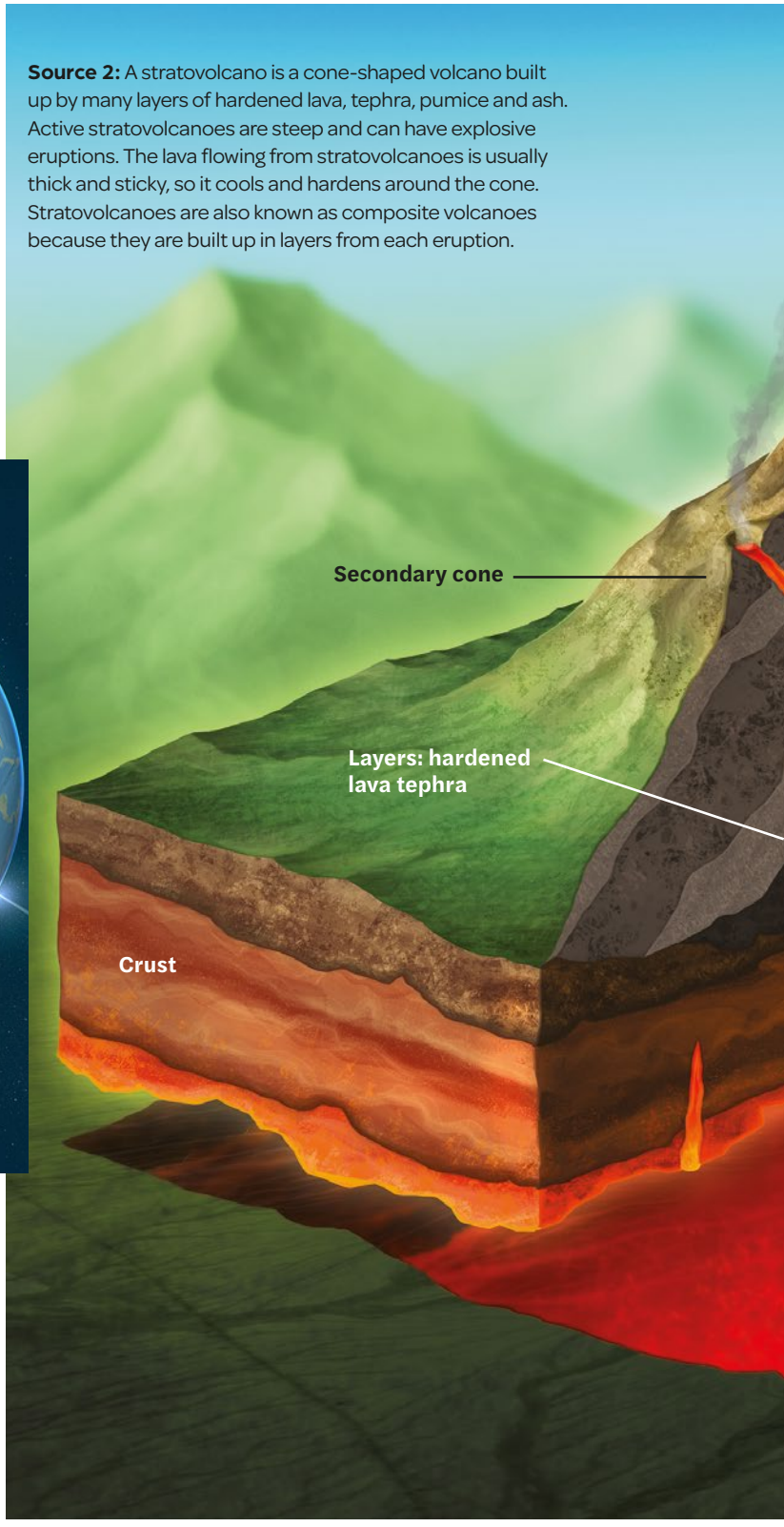
Volcanic mountains form when magma – melted rock from below the Earth's surface – is pushed through an opening in the Earth's crust. This material can build up to form a cone-shaped mountain known as a volcano.

Volcanoes are mainly found along tectonic plate boundaries where plates collide and one plate is forced downwards into the Earth's mantle in a process called subduction (page 16). The edge of the sinking plate melts into magma to feed the volcanoes along the plate boundary.



1. The crust is broken into tectonic plates that form mountains and cause earthquakes.
2. Parts of the solid mantle can melt into magma and move to the surface through volcanoes.
3. With temperatures up to 6000°C, the outer core is the only completely liquid layer.
4. Earth's inner core is solid iron and nickel with temperatures up to 10 000°C.

Source 1: Structure of the Earth

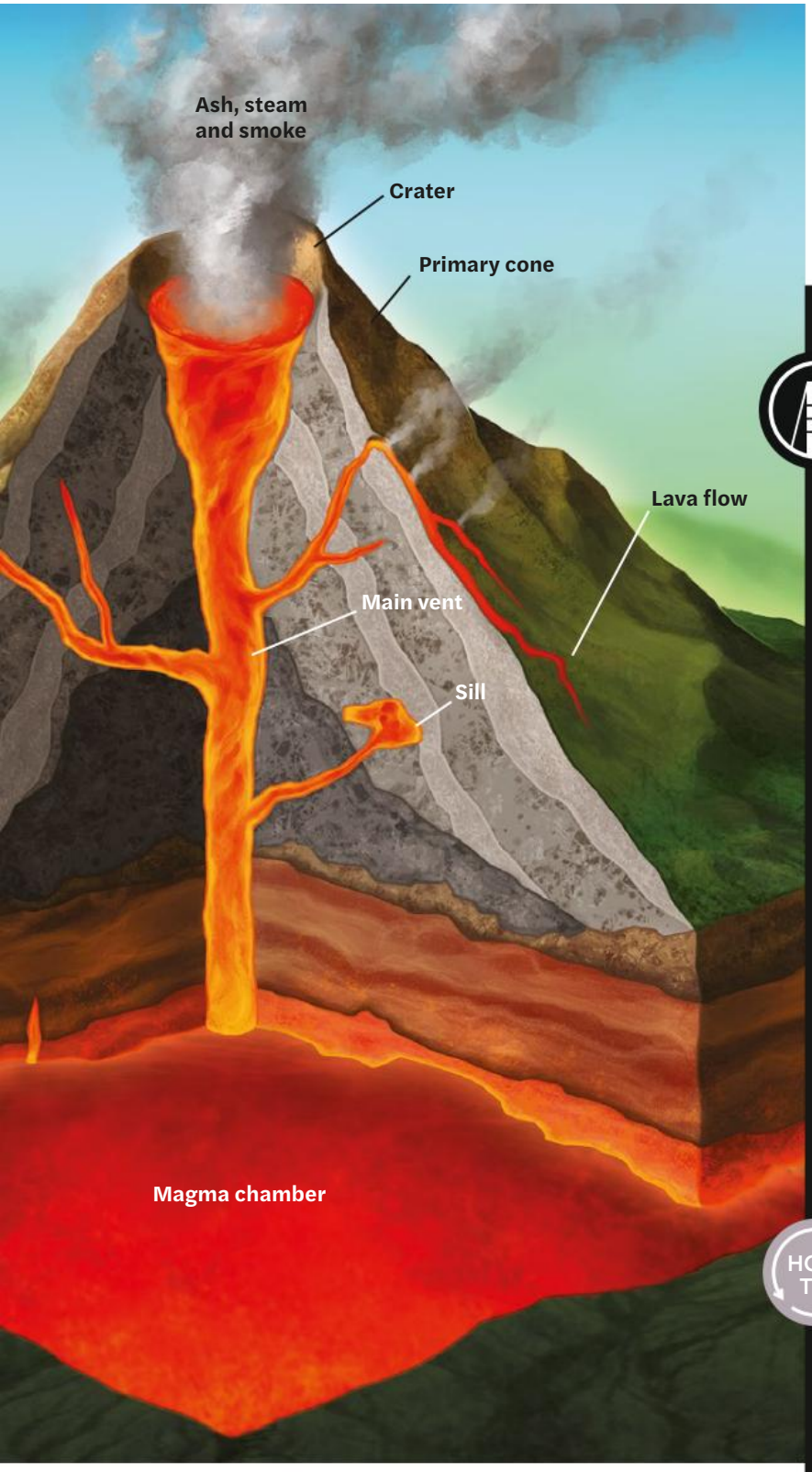


Source 2: A stratovolcano is a cone-shaped volcano built up by many layers of hardened lava, tephra, pumice and ash. Active stratovolcanoes are steep and can have explosive eruptions. The lava flowing from stratovolcanoes is usually thick and sticky, so it cools and hardens around the cone. Stratovolcanoes are also known as composite volcanoes because they are built up in layers from each eruption.

Hot spot volcanoes are found far from plate boundaries. They occur when particularly hot areas of the mantle burn through the Earth's crust, such as Mount Elephant in Victoria.

The material that spews from a volcano builds up the Earth's surface, creating new landforms. Each volcanic eruption brings new material to the surface as **tephra** (rocks and ash) or **lava** (magma that reaches the Earth's surface). Across the Earth's surface, lava flows cover material from previous eruptions to build the height of the land in layers.

Volcanoes are classified as **active** (erupting or likely to erupt), **dormant** (inactive but may erupt in the future) or **extinct** (unlikely to erupt again).



Learning ladder 1.7

Processes that transform people, places and environments

1. Source 1: Where does magma that feeds volcanoes come from?
2. How do volcanic mountains form?
3. Source 2: Explain how stratovolcanoes obtain their layered cones.
4. What is lava and how does it change the landscape in volcanic areas?

Environment

1. Explain why volcanoes can only be present in certain places on Earth.
2. Source 2: What is distinctive about volcanic environments compared to mountainous environments?
3. Source 2: Explain how the magma reaches the surface of the Earth through a stratovolcano.
4. Create a photo essay of different volcanoes around the world. For each photo, state the location and type of the volcano in that place, as well as whether it is active, dormant or extinct.

HOW TO

Photo essays, page 419; Environment, page 396

Geographical tools

How can I use contour maps to study volcanoes?

Kīlauea volcano erupts

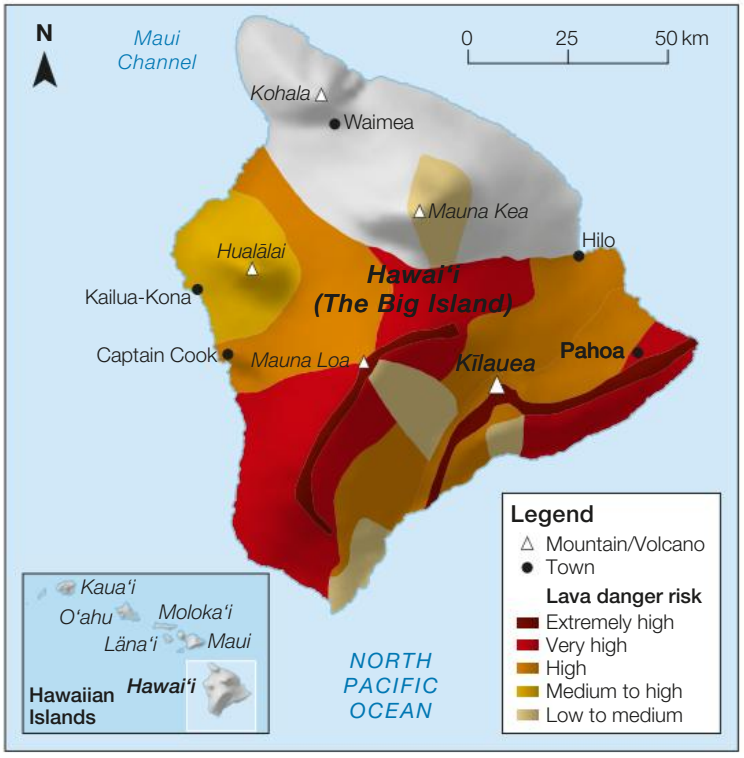
Kīlauea volcano caused a state of emergency on Hawaii Island in 2018. The lava flowed downhill to destroy homes in Pahoa and force 1700 people to evacuate. The 1247-metre Kīlauea volcano is one of five active volcanoes on Hawaii Island.

Using contour lines

Maps with **contour lines** show the height and shape of the land. We see the shape of volcanoes and can predict where lava will flow.

- Contour lines are numbered lines that join places of equal height.
- Close contour lines indicate a steep slope and widely spaced contours mean a gentle slope.
- Contour interval is the difference in height between the contour lines on a map.
- Local relief is the difference in altitude between the highest and lowest elevations in an area.
- Gradient is the slope between two points. To calculate gradient, divide vertical rise (the change in height between two points) by horizontal run (the horizontal distance between two points).

Lava danger zones on Hawaii



▲ **Source 1:** Lava danger zones on the Island of Hawaii

Source: Matilda Education Australia; ESRI, USGS, Hawaii State GIS Program

Learning ladder 1.8

Representing and communicating information

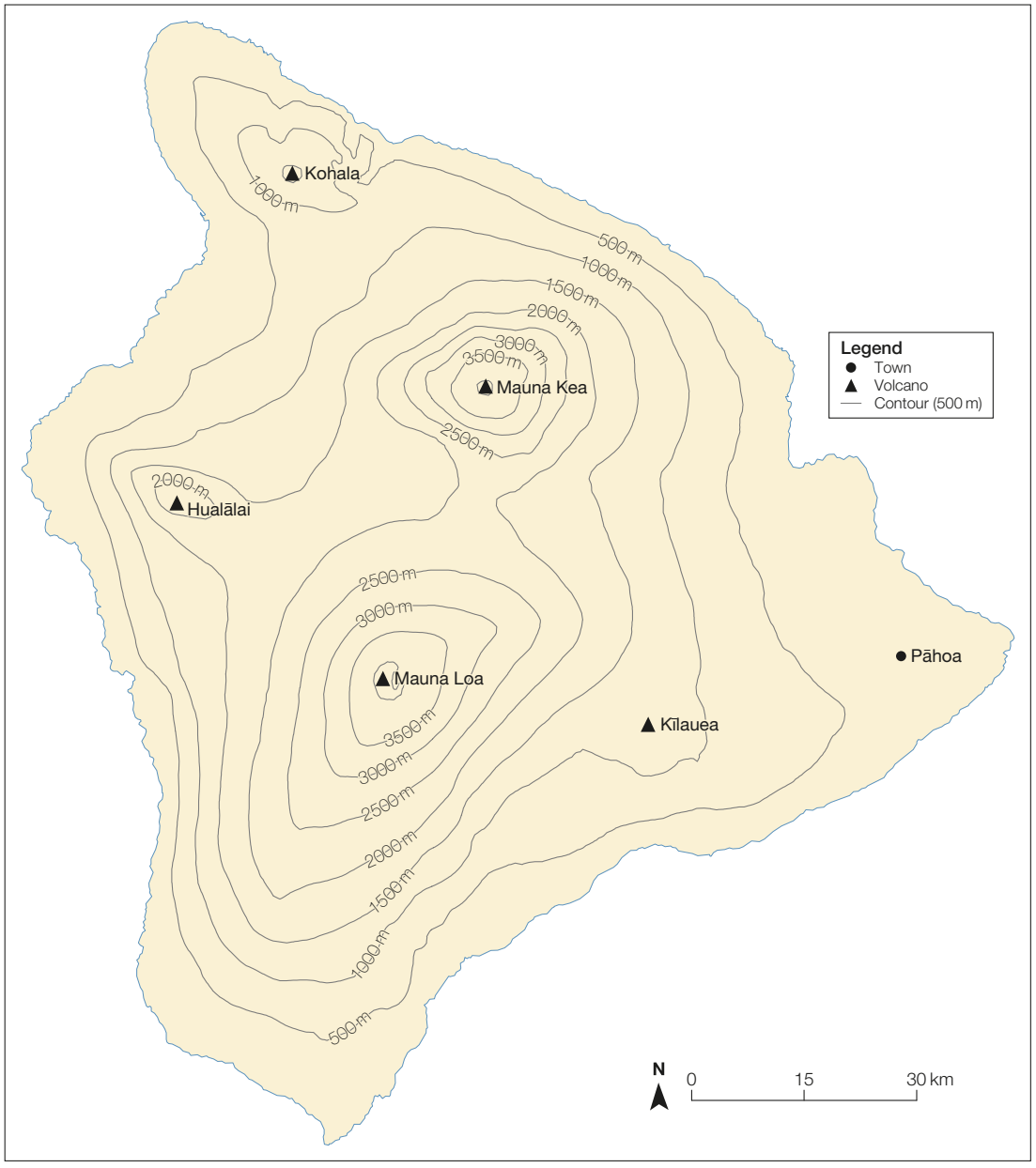
1. Source 2: What contour interval has been used on this map?
2. **a** Source 2: How high above sea level is Kīlauea?
   b Source 2: Why might lava from Kīlauea flow more slowly than lava from Mauna Kea?
   c Source 2: How high is Mauna Kea above sea level? How high is it above the land surrounding it?
3. Source 2: Calculate the local relief of Hawaii Island.
4. Sources 1 and 2: Why is there an extremely high lava danger risk in the areas shown?
5. Source 2: What is the difference in elevation between Kīlauea and Pahoa? Why was this significant in the 2018 eruption?

Contours and cross-sections, pages 408–411

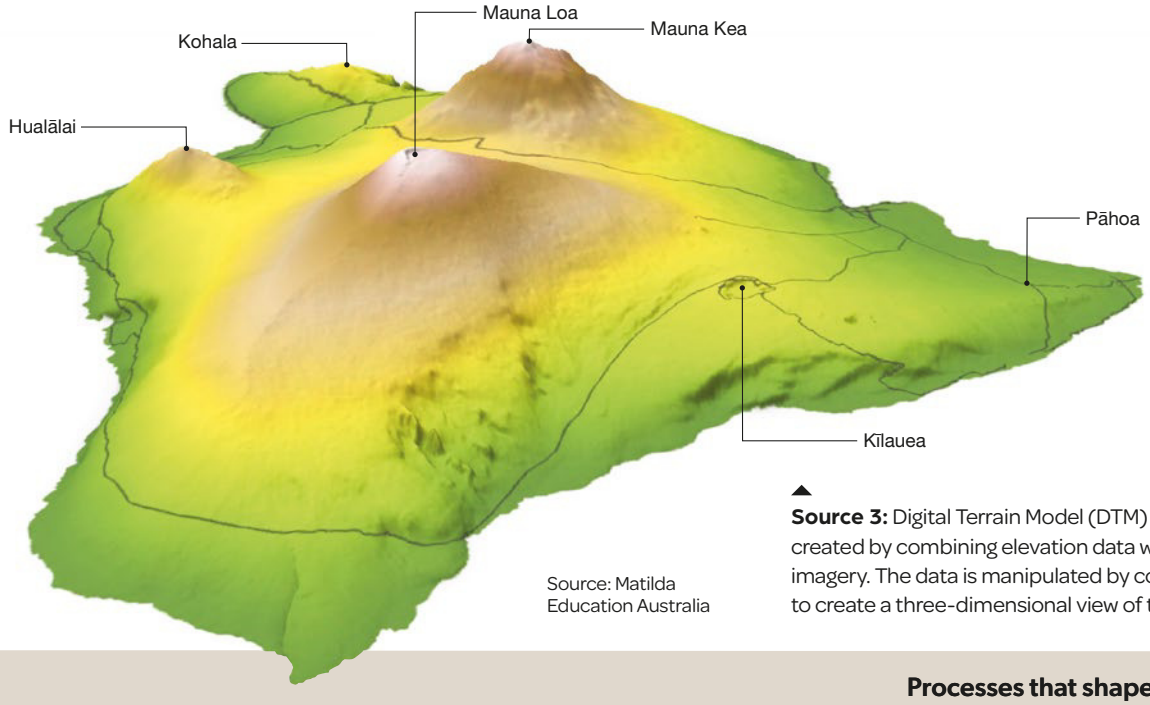
HOW TO

Hawaii Island volcanoes contour map

Source: Matilda Education Australia



Source 2: Contour map of Hawaii Island



Source: Matilda Education Australia

Source 3: Digital Terrain Model (DTM) of Hawaii Island created by combining elevation data with satellite imagery. The data is manipulated by computer programs to create a three-dimensional view of the island.

How does weathering affect landforms?

When rock is exposed on the Earth's surface it can be broken down by water, temperature and the roots of plants. Moving ice, water and wind can further wear down rock and carry it away.

Weathering and erosion

Landforms change because of weathering and erosion. Weathering is the first stage of the process where rock is worn away, broken down or dissolved into smaller and smaller pieces by water, heat and cold. Erosion is the second stage where the weathered material is transported away by agents of erosion such as water, ice, wind and waves.

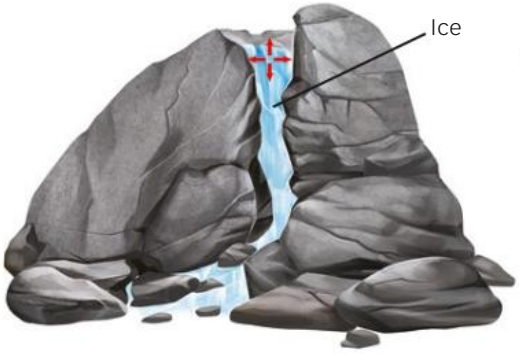
Weathering involves two processes that work to break down rocks on the surface of the Earth. Chemical weathering is a chemical change in a rock, while **mechanical weathering** involves rocks being broken into pieces.

A weathered rock particle is loosened but stays in its place. When the particle begins moving, we name this erosion, or **mass wasting**. Mass wasting is simply the movement of rocks downhill due to gravity, such as rock falls and landslides. Erosion is where rock particles are moved by flowing air (wind), water (rivers, sea and rain) or ice (glaciers). Erosion acts more quickly on softer rocks. Harder rocks remain as landforms such as mountains or **headlands**.

Mechanical weathering

Mechanical (or physical) weathering is where large rocks on the Earth's surface are broken down into smaller ones. Causes of mechanical weathering are:

- **Temperature:** Cold nights and hot days cause rocks to expand and contract, which makes them crack and break apart.
- **Ice:** Water seeps into cracks in rocks. When the water freezes it expands by 9 per cent, splitting the rocks.
- **Roots and plants:** Vegetation pushes into rocks and acts as a wedge to push the rocks apart. This is sometimes categorised as biological weathering.



Source 1: Frost wedging is a form of mechanical weathering that occurs when water freezes and expands in a crack in a rock.

Source 3: The process of erosion

Ice erosion

Ice erosion comes mainly from giant bodies of moving ice known as glaciers. They pick up loose rock and erode the valleys into u-shapes as they move downhill.

Wave erosion

Waves erode the coast by breaking down rock and moving sand and other sediment. Large waves hit rocks with lots of force, breaking them apart. Waves also pick up small rocks and throw them against the land. Waves crashing against the shore can create amazing coastal landforms such as arches, caves, stacks, cliffs and headlands.

Source 2: Mechanical weathering is the key agent that shapes the amazing rock features of Monument Valley in the United States. The hot days and cold nights enable the rocks to expand and contract, which causes cracks that eventually split sections of rock. Wind erosion picks up the small dry weathered rock particles and blasts them against larger rocks, which further shapes them.

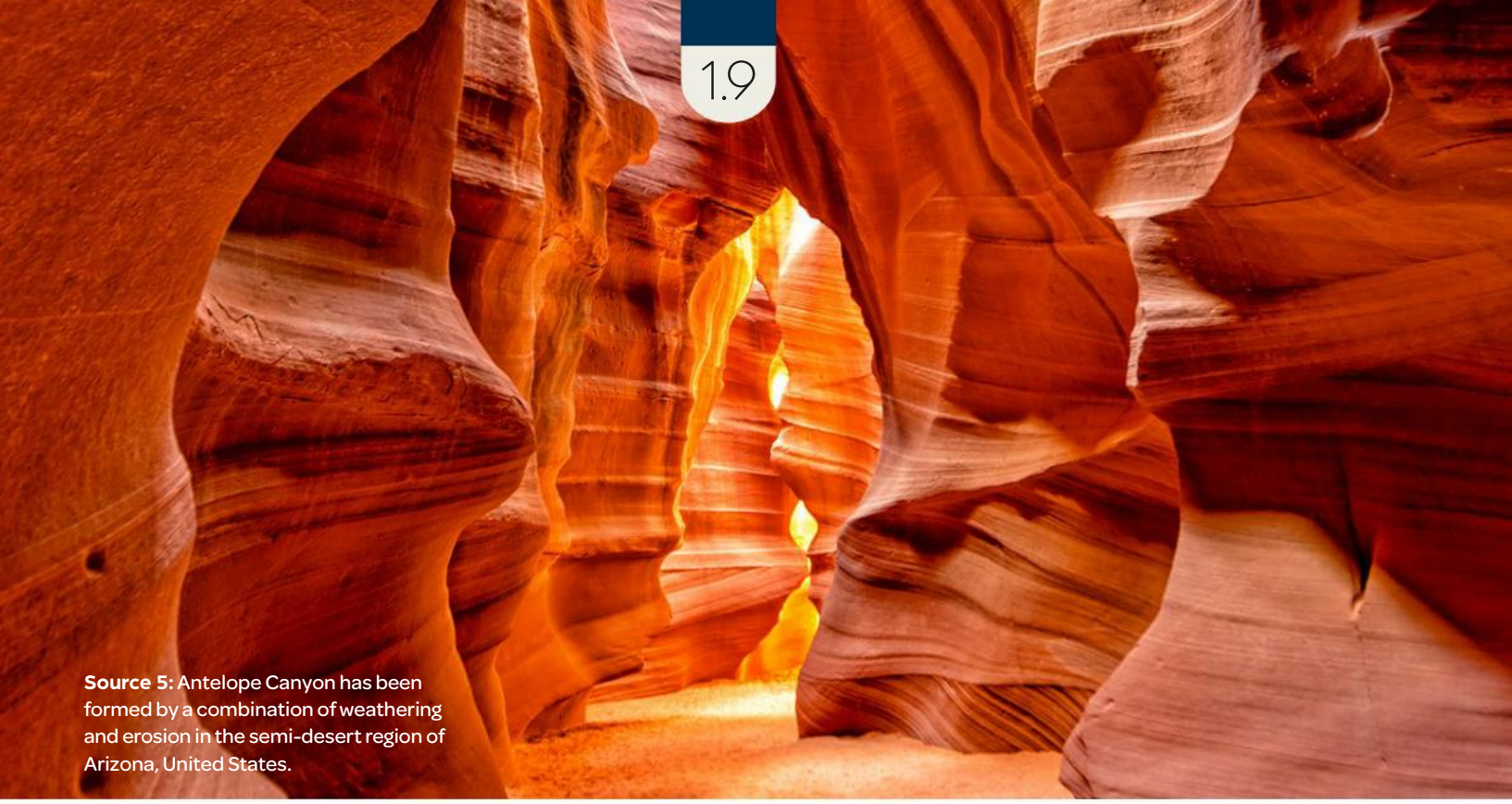
Water erosion

Water erosion occurs from the force of the flow of water and the eroded rock and other material carried in the water. Rocks or debris carried by a river erode its banks and bed as they crash into it.

Wind erosion

Wind erosion is particularly active in dry desert areas. Light objects such as sand and pebbles are swept up and carried by the wind. The small rock particles are thrown against landforms, eroding materials off them. The newly eroded material is also swept away by the wind to sandblast the desert landscape into amazing shapes.

Source 4: The pressure of expanding plant roots causes rocks to crack and break away.



Source 5: Antelope Canyon has been formed by a combination of weathering and erosion in the semi-desert region of Arizona, United States.

Antelope Canyon

Mechanical weathering is very effective in deserts where there is a large temperature range. Mechanical weathering processes such as temperature change and frost wedging opened wide cracks in the soft sandstone rock of Antelope Canyon in the desert region of Arizona in the United States. Flash floods carrying sand, rocks, logs and other debris eroded large amounts of rock to further widen the cracks. Over time, weathering and erosion has cut and smoothed a skinny deep slot canyon. The amazing shapes of Antelope Canyon are very popular with tourists.

Chemical weathering

Chemical weathering decomposes rocks and minerals. Chemicals in water or the reaction of water with minerals in rocks either form or destroy minerals in the rock, breaking down the bonds holding rocks together. This weathering is common in locations where there is a lot of water to help the chemical reactions take place.

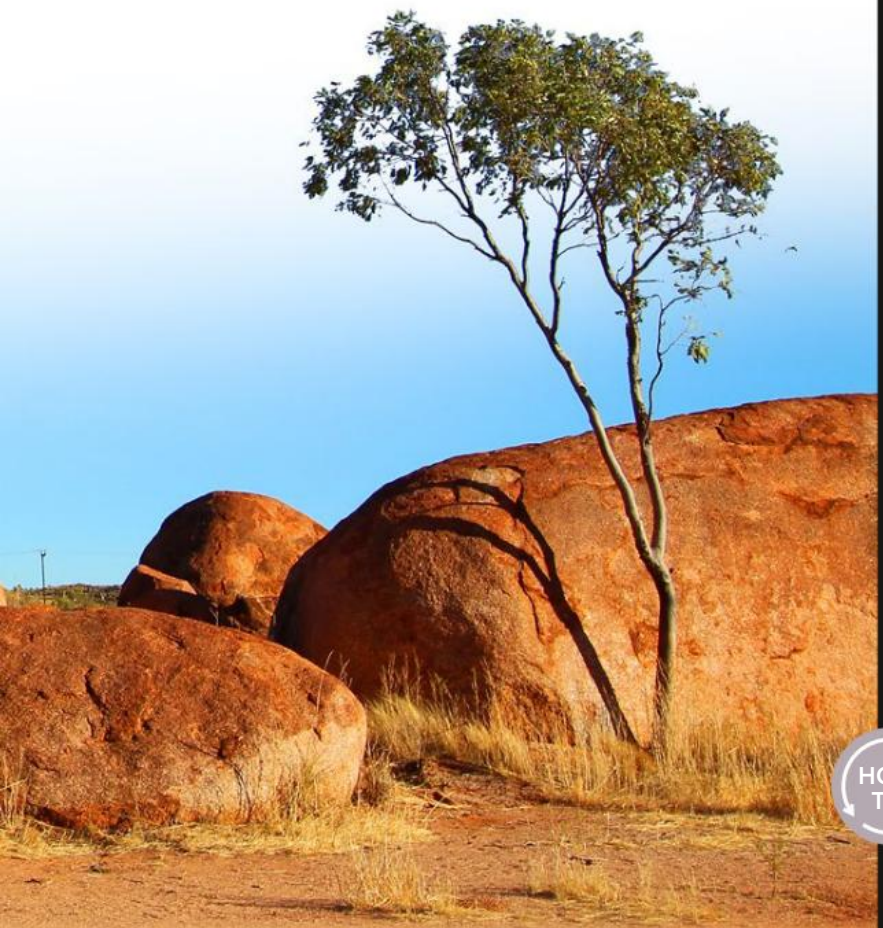
Source 6: Karlu Karlu (the Devil's Marbles) has been shaped by a chemical weathering process known as spheroidal weathering, leaving these amazing balancing boulders behind.

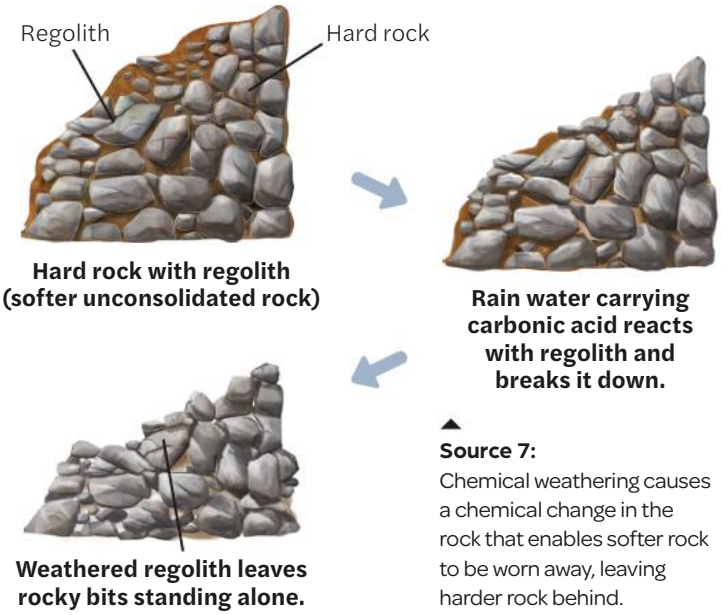
The most common types of chemical weathering are:

- **Hydrolysis:** Hydrogen in water reacts with minerals in the rocks to form new minerals; for example, hard granite rock changes to softer clay through hydrolysis. Clay is more prone to mechanical weathering and erosion than granite.
- **Carbonation:** Rainwater contains carbonic acid because carbon dioxide in the atmosphere dissolves in it. This carbonic acid reacts with minerals in some rocks, causing the rocks to weather.
- **Oxidation:** When oxygen combines with other elements in rocks, new types of rock are formed. As with hydrolysis, these new rocks are generally softer and easier for mechanical weathering to break apart.

Karlu Karlu

Karlu Karlu (the Devil's Marbles) in the Northern Territory is a local example of chemical weathering. The granite rock has been shaped into round boulders by a chemical weathering process known as **spheroidal weathering**. Water seeps into cracks, and chemical reactions cause the rocks to disintegrate along the edges. The cracks are opened wider, allowing even more water to reach the surfaces. Corners are attacked by water from more than one direction and wear away more rapidly. The sharp corners are rounded, forming spherical rocks.





Source 7: Chemical weathering causes a chemical change in the rock that enables softer rock to be worn away, leaving harder rock behind.

Learning ladder 1.9

Processes that transform people, places and environments

1. What change does weathering cause?
2. Describe how weathering and erosion are interconnected.
3. Source 6: Explain how Karlu Karlu formed.
4. Source 3: Analyse what the four agents of erosion shown have in common and how and why they differ.
5. Source 2: Why is mechanical weathering more prevalent in desert regions and what form of erosion is particularly active?

Change

1. What change does chemical weathering cause?
2. Source 4: Draw a two-stage flow diagram to show how plants can cause mechanical weathering.
3. Source 5: Explain the change over time in this location and describe the processes that have caused the changes.
4. Analyse how chemical and mechanical weathering influence environments differently.
5. Weathering is due to a range of interconnecting factors, which ultimately leads to a change in landforms over time. Discuss.

HOW TO Change, page 394

What are deserts?

Deserts are the world's driest environments, receiving less than 250 millimetres of annual precipitation. These dramatic landscapes cover nearly one-third of land on Earth. Deserts can be hot or cold and be rocky, sandy or even covered in ice.

Different desert landscapes

Most deserts are hot deserts that lie between the latitudes of 15 and 30 degrees north and south of the equator. Cold deserts are found in temperate areas or high plateaus, while polar deserts are localised at the North and South poles. The lack of precipitation can be explained by an inland location that is a large distance from water, the dominance of high air pressure cells with sinking air, mountain ranges that block moist air and cause a rainshadow effect, and cold ocean currents that limit evaporation and keep the air dry.

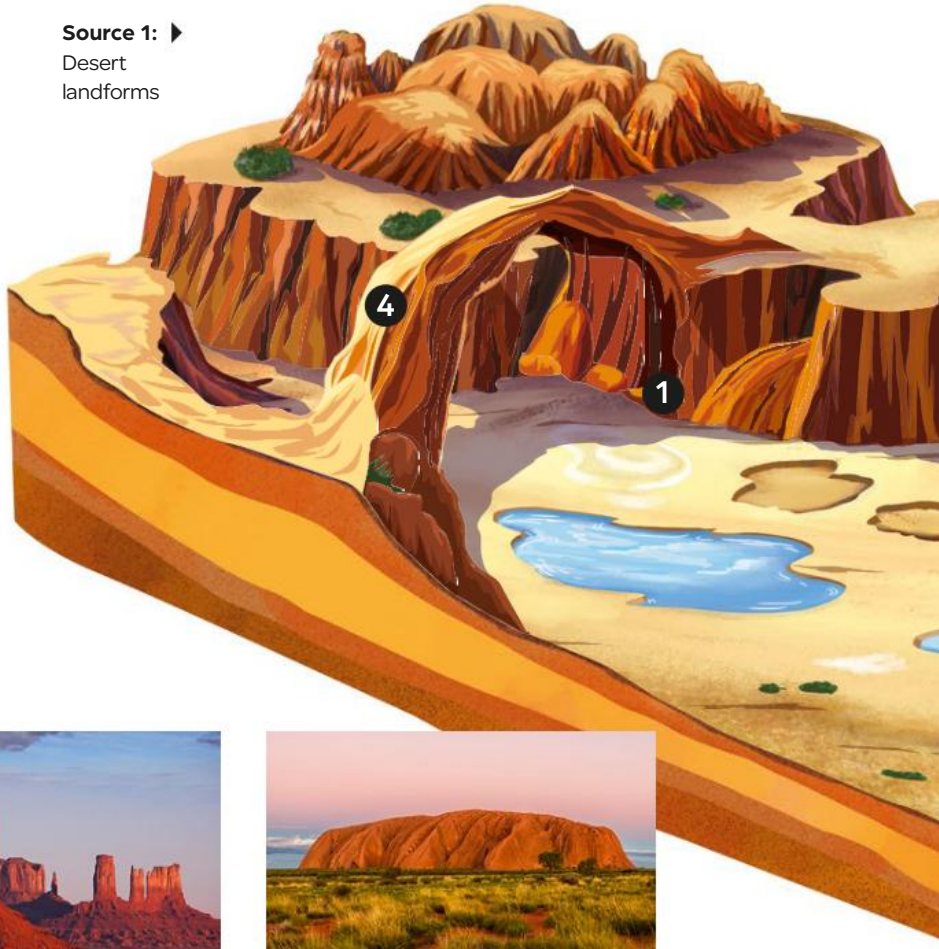
Diverse and spectacular

Some deserts are seas of sand; others are vast, stony plains; others have spectacular rock formations shaped by weathering and erosion. Plateaus of rock weather and erode into isolated **mesas**, **buttes** and chimney rocks. Natural arches form from weathering along joints that leave narrow walls of rock. When the lower wall erodes, an arch results. Inselbergs such as Uluru (see pages 30–1) are islands of rock that remain after a long period of erosion of the surrounding soft rock.

The world's deserts are expanding through a process known as **desertification**. This occurs when land along the edge of a desert becomes damaged by drought and overuse by humans.

4 Arch: A natural bridge weathered and eroded through a solid rock cliff over time

Source 1: Desert landforms

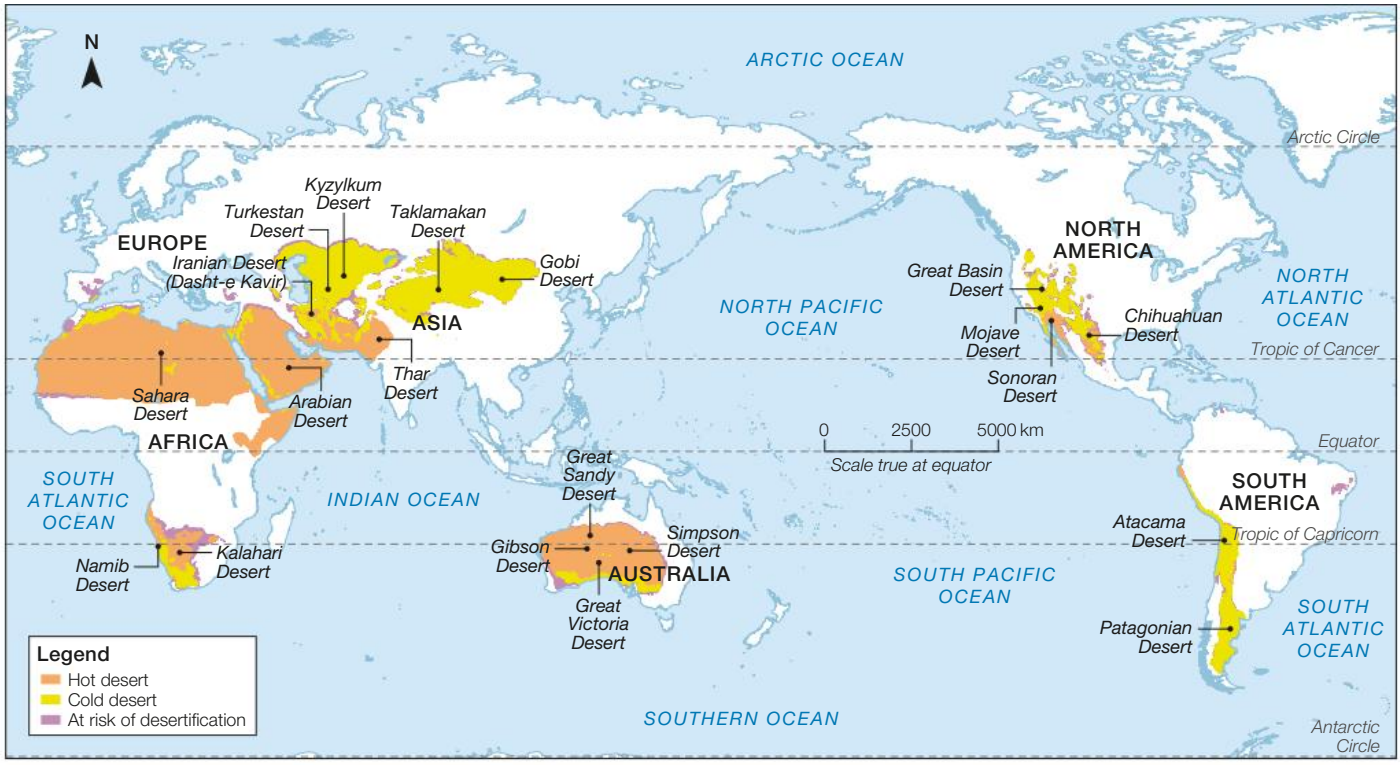


1 Alluvial fan: Semicircular build-up of eroded material deposited by water and wind at the end of wadis (desert valleys)

2 Butte: An isolated hill with vertical sides and a small flat top. Buttes are smaller than mesas

3 Inselberg: An isolated steep-sided mountain, uncovered as the softer land around it is eroded away

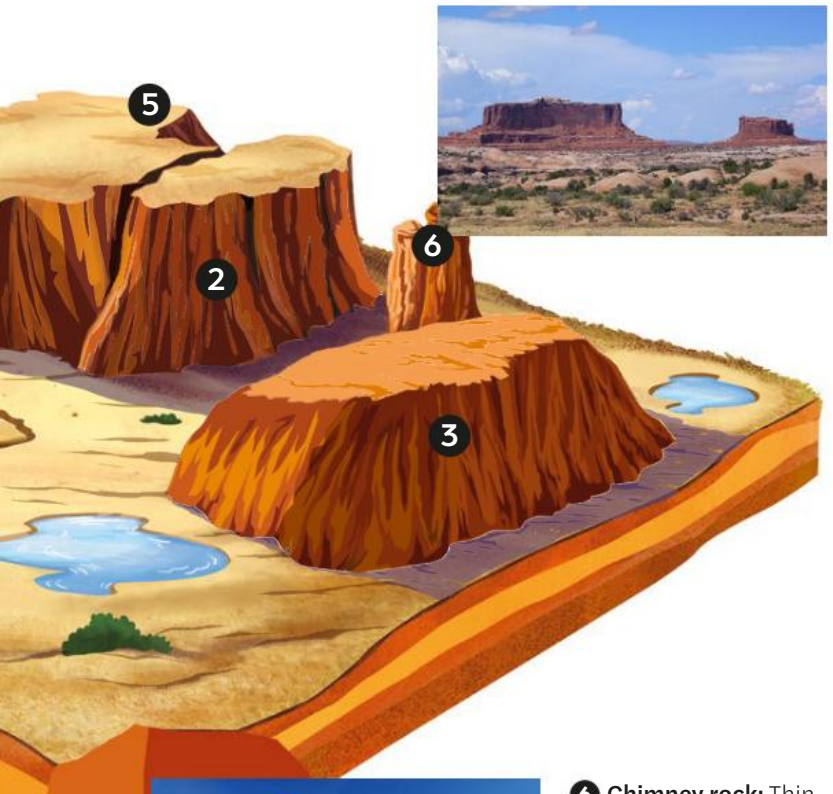
World deserts

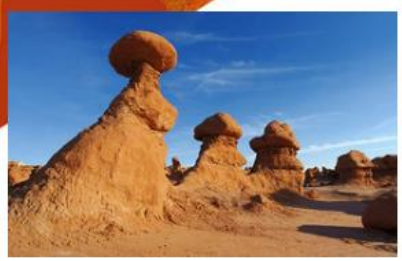


Source: Matilda Education Australia; Beck, Zimmerman, McVicar, Vergopolan, Berg, Wood

▲ **Source 2:** World deserts

5 **Mesa:** A broad, isolated flat-topped landform found in desert areas that are the eroded remains of a wide plateau





6 **Chimney rock:** Thin pillars of rock that are the remains of buttes; evaporating water creates a hard crust on top, protecting it from chemical weathering as the column wears away

Learning ladder 1.10

Processes that transform people, places and environments

1. How did Uluru form?
2. Source 1: Describe how the mesa in the diagram formed.
3. Source 1: Which landform shown here is formed by deposition rather than weathering?
4. Source 1: Draw a two-stage diagram with labels to show how a chimney rock is formed.
5. Source 1: Predict what will happen to the pictured arch landform with further weathering.

Environment

1. What is a desert?
2. Source 1: Describe the geographical characteristics of this desert.
3. Source 2: Explain, using PQE, the distribution of deserts on a global scale.
4. Source 1: Look at the photographs of the mesa, butte and chimney rocks. Analyse the relationship between these landforms.

HOW TO

PQE, page 412; Environment, page 396

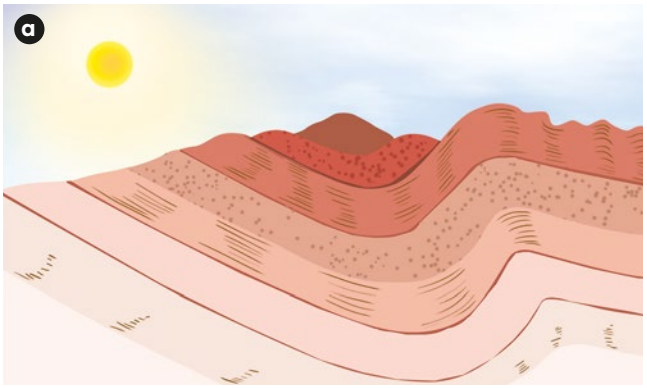
Case study

How did Uluru form?

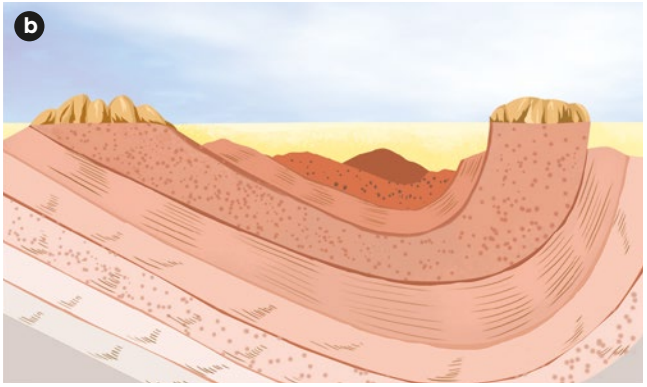
Uluru and nearby Kata Tjuta are inselbergs that were uncovered as the land around them eroded away.

The region was once covered by sea and over time it was covered with marine sediment. About 500 million years ago, pressure from beneath the crust caused the land in Central Australia to fold and be pushed upwards (Source 1a). The layers of sedimentary rock were gradually worn away by weathering and erosion (Source 1b), leaving only the hardest rocks showing as the inselbergs (isolated hills) of Uluru and Kata Tjuta on the surface. Uluru is the largest surface rock in the world. It rises 348 metres above the surrounding land and covers an area of 3.3 square kilometres.

Uluru and Kata Tjuta are sacred to the Pitjantjatjara Anangu. Their understanding of how the rocks formed has been passed down over thousands of years through stories, songs, ceremonies, dances and art. For the Anangu people, Uluru isn't just a rock, it's a living place – with the marks of the creation beings shown everywhere.



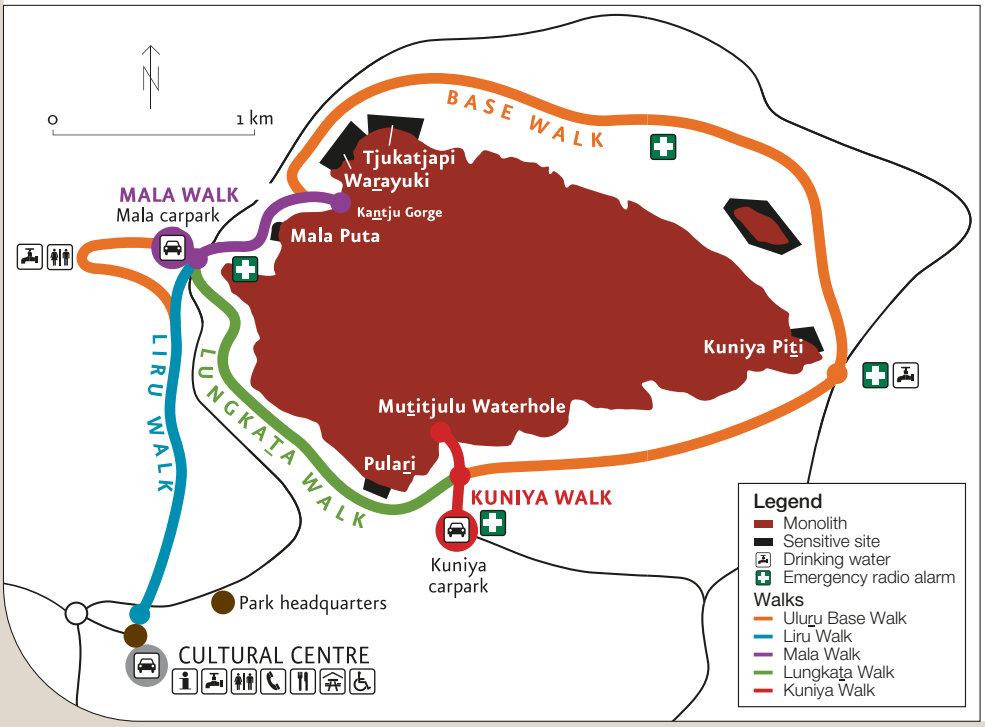
Fold mountains are pushed upwards due to pressure in the Earth's crust. Layers of sedimentary rock are bent and pushed upwards to create fold mountains.



Over time, the processes of weathering and erosion wear away the softer rock, leaving only the harder rocks showing on the surface of the land.

Source 1: The formation of Uluru and Kata Tjuta

Uluru walking tracks and facilities



Source 2: This is a *plan* view of Uluru as seen from directly above. Maps are drawn from the plan view because the scale is constant over the area shown. There is no foreground or background in plan-view images and maps.

Source: Matilda Education Australia; Parks Australia

Source 3: This is an *oblique aerial* view of Uluru. These angled views are good at showing the shape of landforms, as they show the foreground and the background. Uluru is featured in the foreground. Kata Tjuta appears much smaller because it is in the background.

Learning ladder 1.11

Processes that transform people, places and environments

1. Source 1: What role did folding play in the formation of Uluru and Kata Tjuta?
2. Source 1: Describe the role of weathering and erosion in the formation of Uluru and Kata Tjuta.
3. Source 3: Outline the advantages and disadvantages of using oblique aerial views to study landforms.
4. Source 1: Create a further diagram and caption that shows what the region looked like before the sedimentary rock was was pushed up through the process of folding.
5. Source 1: Using the diagram as a source, sketch what the region could look like if further weathering takes place over millions of years.

Change

1. Source 3: What did this region originally look like?
2. How long ago were fold mountains pushed up in this region?
3. Source 3: What has changed in this environment to leave Uluru and Kata Tjuta as inselbergs rising above a flat plain?
4. Sources 15 and 16 (page 410): Calculate the gradient of the slope between X and the nearest 800-metre contour line to the east of X. How might weathering and erosion change this gradient over time?
5. What are the implications of change to Uluru, such as climbing on the rock and graffiti, for the Pitjantjatjara Anangu people?

Cross-sections, page 410; Change, page 394

HOW TO

1.12

How are karst landscapes formed?

Karst refers to an area of land composed of soft rock that dissolves in water. As water seeps through the rock it slowly erodes the landscape to form underground caves and streams, and sinkholes on the surface.

Features of karst landscapes

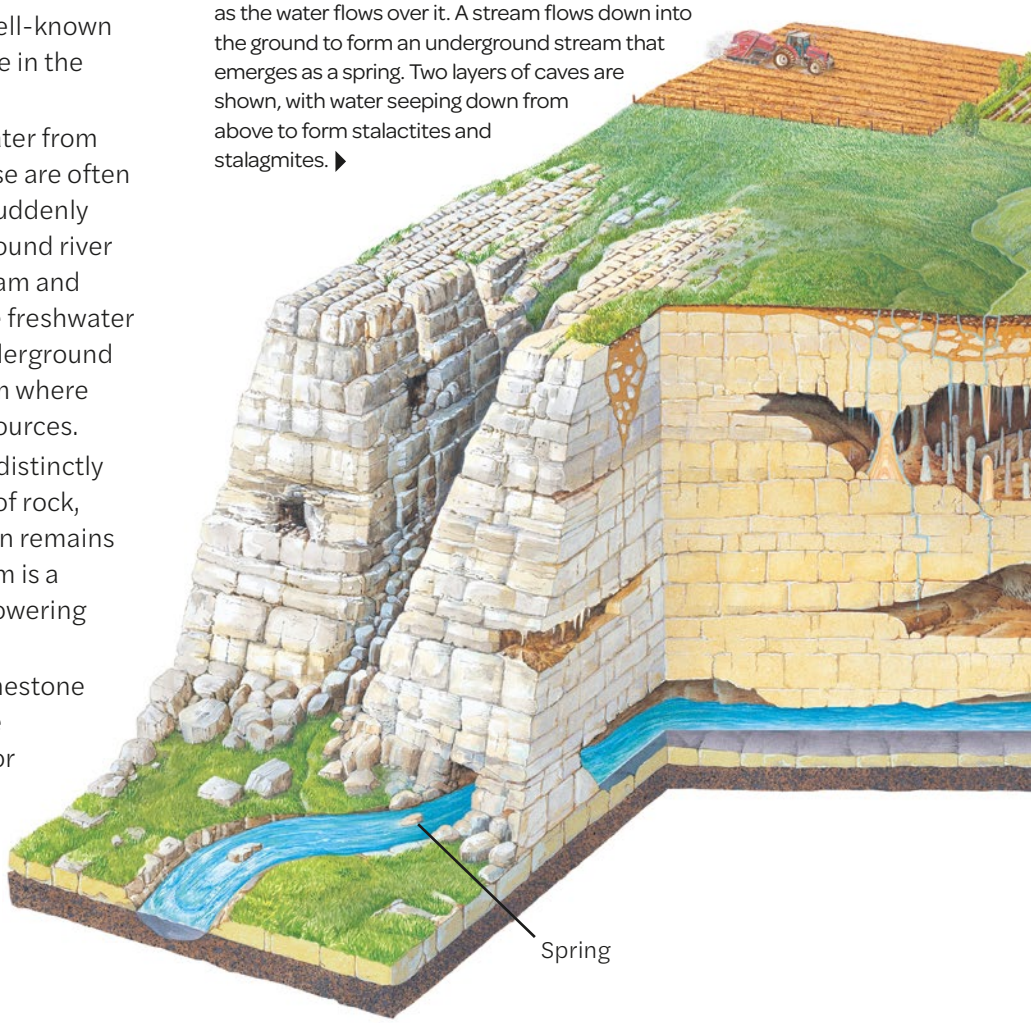
Karst landscapes are found in areas where soluble carbonate rocks such as limestone and dolomite are dissolved by water to form distinct landforms. Typical features of karst landscapes include:

- **caves** and underground networks of tunnels, such as those found along Australia's Nullarbor Plain. These are popular for 'caving' expeditions. Within these caves, stalactites and stalagmites are formed by the deposition of calcium.
- **sinkholes and depressions** in the land surface, often known as cenotes, form when caves collapse. When filled with water, cenotes such as those in the Yucatán peninsula in Mexico become well-known tourist destinations. The largest sinkhole in the world in China is 660 metres deep.
- **underground rivers**, which transport water from the surface through the landscape. These are often the continuation of surface rivers that suddenly disappear. The world's longest underground river travels for 20 kilometres beneath Vietnam and Laos. There can be a shortage of surface freshwater in karst landscapes. In these places, underground rivers, aquifers and the springs that form where water resurfaces, are important water sources.
- **cone and tower karst**, which are steep, distinctly shaped hills isolated by the dissolution of rock, where more rock has been removed than remains in the landscape. Ha Long Bay in Vietnam is a well-known karst landscape featuring towering islands within the bay.
- **limestone pavements**, which are flat limestone surfaces. These may be dissected by the action of water draining through faults or joints in the rock.

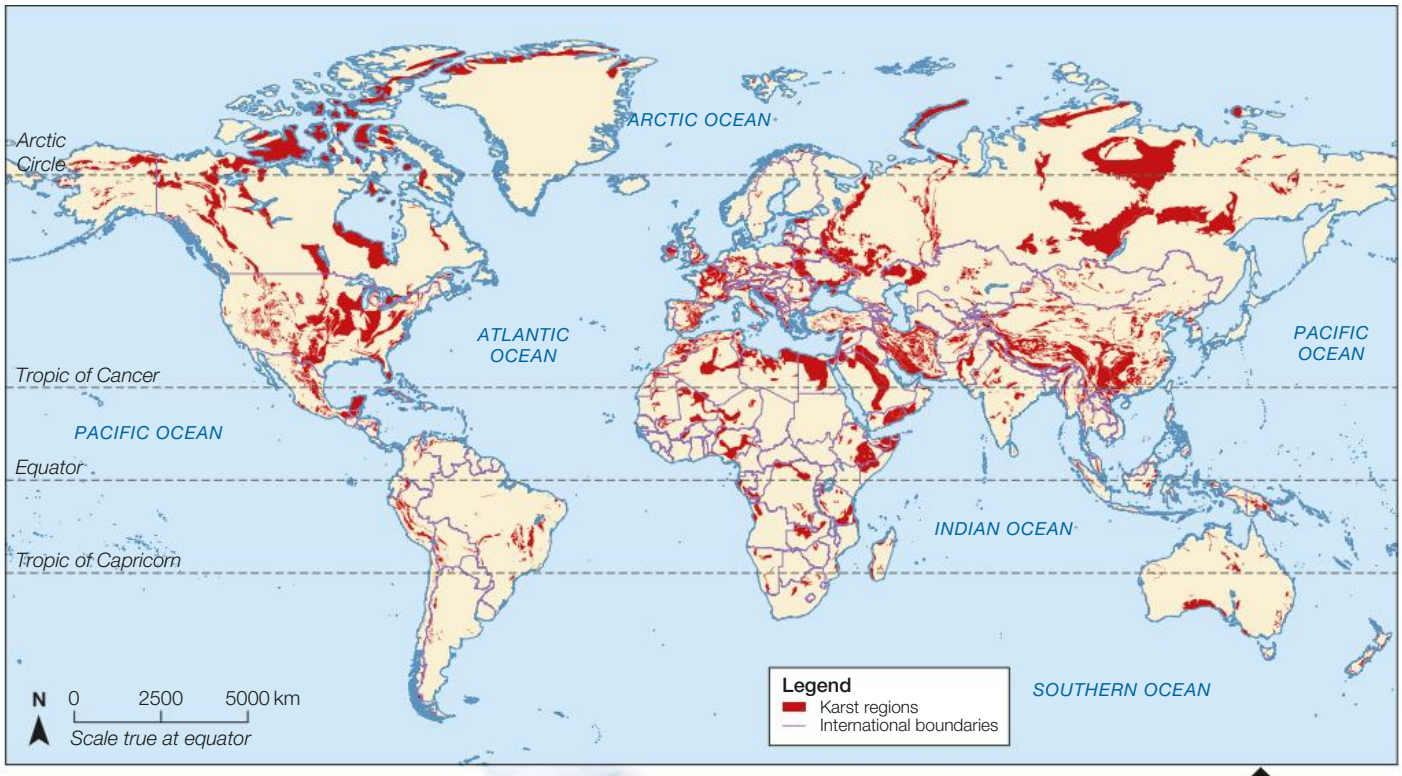
Global distribution

Scientists have calculated that 15 per cent of the Earth's surface is occupied by karst landscapes. The largest areas covering hundreds of square kilometres include the 550 000 km² UNESCO World Heritage South China Karst and Australia's Nullarbor Plain, considered the world's largest continuous karst landscape at approximately 200 000 km². Significant areas of karst are also found in Europe and the United States.

Source 1: These features of a karst limestone landscape have been formed by erosion. The limestone rock has been shaped by natural chemical erosion. Carbon dioxide in the air dissolves in rainwater to form carbonic acid. This acid erodes the limestone rock as the water flows over it. A stream flows down into the ground to form an underground stream that emerges as a spring. Two layers of caves are shown, with water seeping down from above to form stalactites and stalagmites. ▶

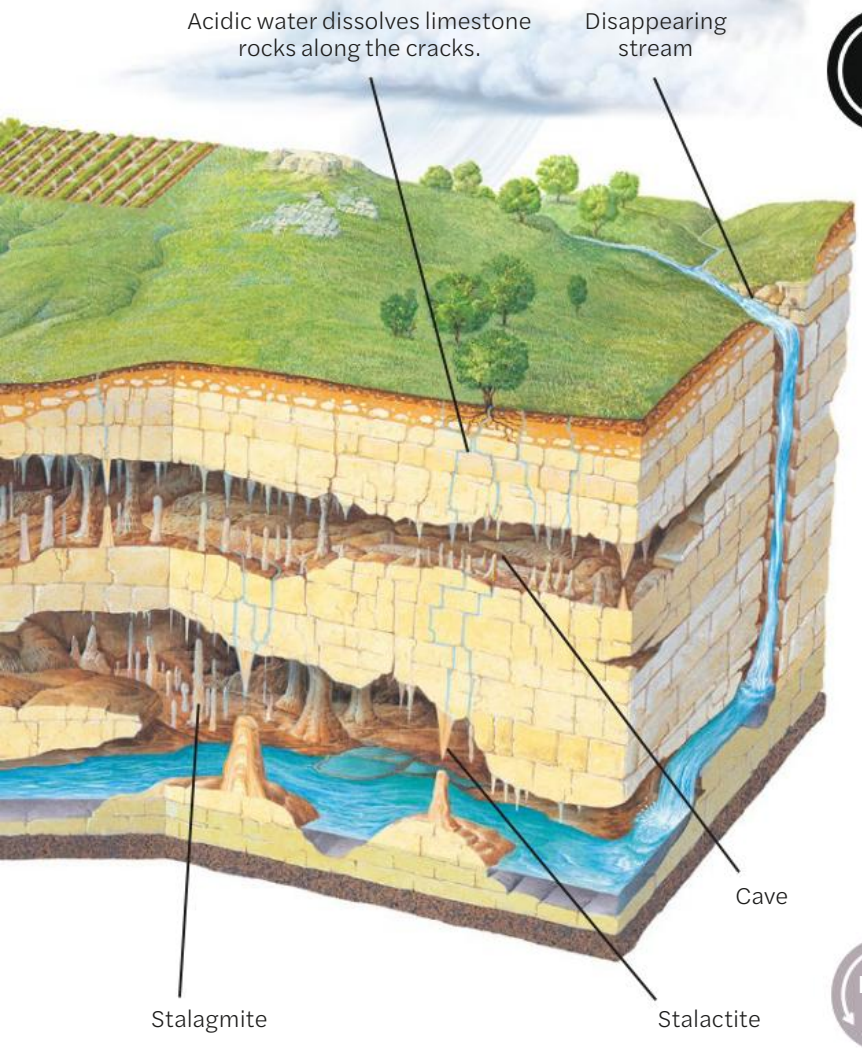


World karst regions



Source: Matilda Education Australia

▲ **Source 2:** World karst regions



Learning ladder 1.12

Processes that transform people, places and environments

1. How are karst landscapes shaped?
2. Source 1: Describe the role of carbon dioxide in the formation of karst.
3. Source 1: Explain how acidic water moves through the limestone rock to form underground caves.
4. Why do karst landscapes have limited surface water?
5. Source 1: Research and explain how stalagmites and stalactites form and how long the process takes.

Environment

1. What is a karst landscape?
2. What karst features can be seen above the ground?
3. Source 1: Explain the different stages of the stream shown in this karst environment.
4. Source 1: Explain in detail how the caves shown here were formed.
5. Source 1: Sketch a block diagram to show what might happen to this karst landscape with further weathering over millions of years.

HOW TO

Block diagrams, page 418; Environment, page 396

How do waves shape landforms?

Waves are one of the strongest forces shaping coastal landforms. Waves can be generated by wind or movements on the Earth's surface. They can travel for thousands of kilometres through water, before breaking in shallower water near coasts, building or scouring away the coastline in the process.

How do waves begin?

Waves travel through water. The water moves up and down but does not actually travel with the wave. It is the energy that travels with the wave. The energy required to create waves most commonly comes from wind, but may also come from earthquakes or volcanic eruptions. The size of a wave depends on wind speed, the distance travelled by wind over the ocean and the amount of time the wind blows.

When wind blows across water it creates ripples on the surface. The wind forces the water to rise and gravity pulls it back down again. Water rising and falling creates a circular movement of water particles beneath the surface. On the surface, we see the top of this orbit, known as the **crest**, and the zone where it falls, called the **trough**.

The orbiting waves can travel for long distances as **swells** through the ocean. A swell is a collection of waves formed by winds. The size of the swell is measured from the crest to the trough. The largest swell ever measured in the **southern hemisphere** was a 23.8-metre swell off New Zealand's Campbell Island in May 2018.

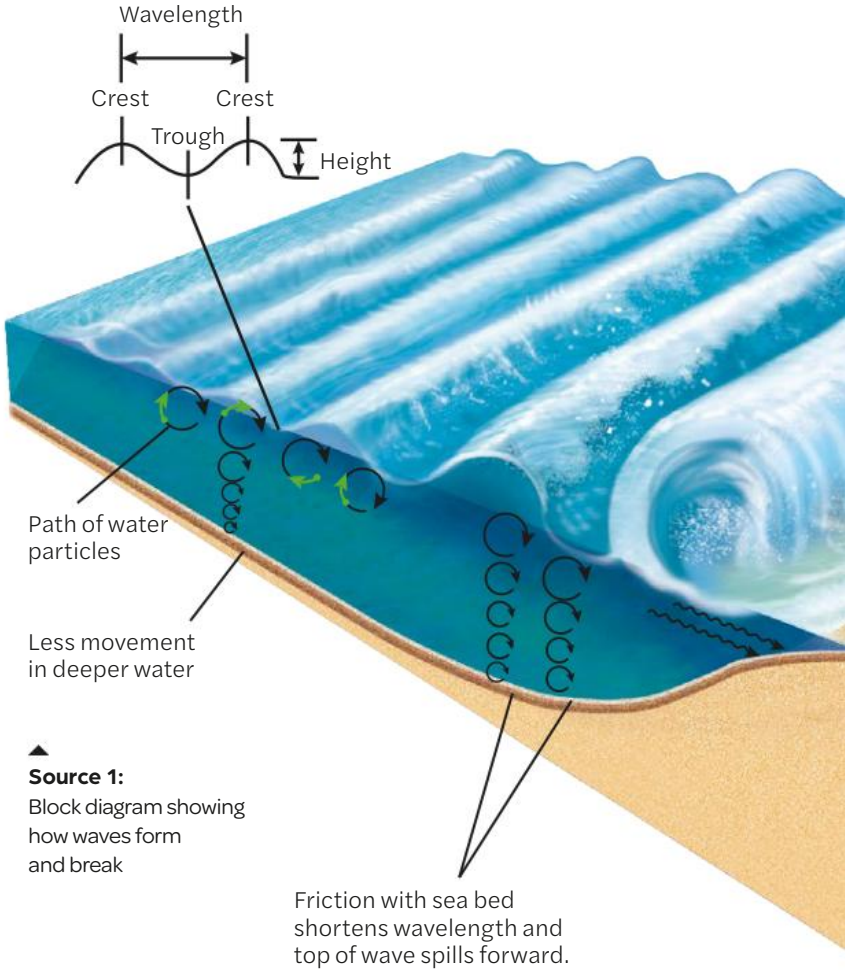
Why do waves break?

As waves move into increasingly shallow water near the coastline or offshore **reefs**, the bottom of the wave orbit comes into contact with the sea floor and slows down. The wavelength is shortened and the crest of the wave overtakes the bottom of the wave. It spills forward as a **breaking wave**. Waves will generally start to break when they reach a water depth of 1.3 times the wave height.

What conditions do surfers look for?

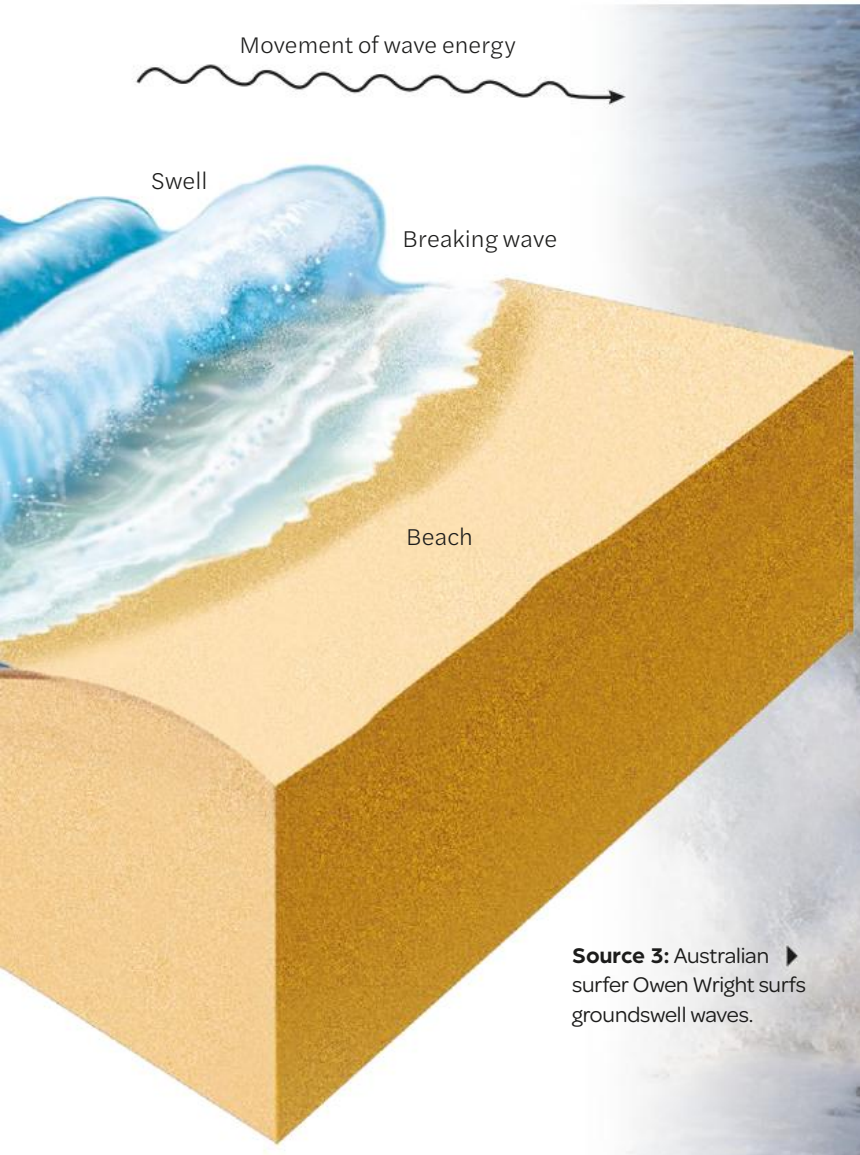
Groundswell waves are steeper and faster. They are the result of strong wind storms in the open ocean that create longer wavelength waves that move quickly into shallow water before breaking. Wind swell waves are the smaller, less powerful waves formed by local winds.

Offshore winds create the best waves as wind blows against the top of the wave to delay it from breaking. Onshore winds push the top of the wave forward, causing the wave to break before the usual breaking depth is reached.



Source 1: Block diagram showing how waves form and break

Source 2: A surfer uses the energy of the breaking wave to be propelled down the face of the wave and into the shallow water near the beach.



Source 3: Australian surfer Owen Wright surfs groundswell waves.

How do different waves shape landforms?

Coastal landforms are both created and worn away by wave action. **Destructive waves** destroy and erode the coastline. Destructive waves are large and powerful; they constantly crash onto the coastline, wearing away cliffs and digging out areas of beach.

Destructive waves travel across open ocean and build a significant amount of energy that hits coastal cliffs and beaches with great force. Cliffs can be carved into amazing erosional landforms such as headlands, caves, arches and **stacks**.

Constructive waves are smaller and less frequent. They deposit sand on the beach rather than scouring it away. Constructive waves are responsible for creating depositional landforms such as beaches, **sand dunes**, **sand bars**, **spits** and **tombolos**.

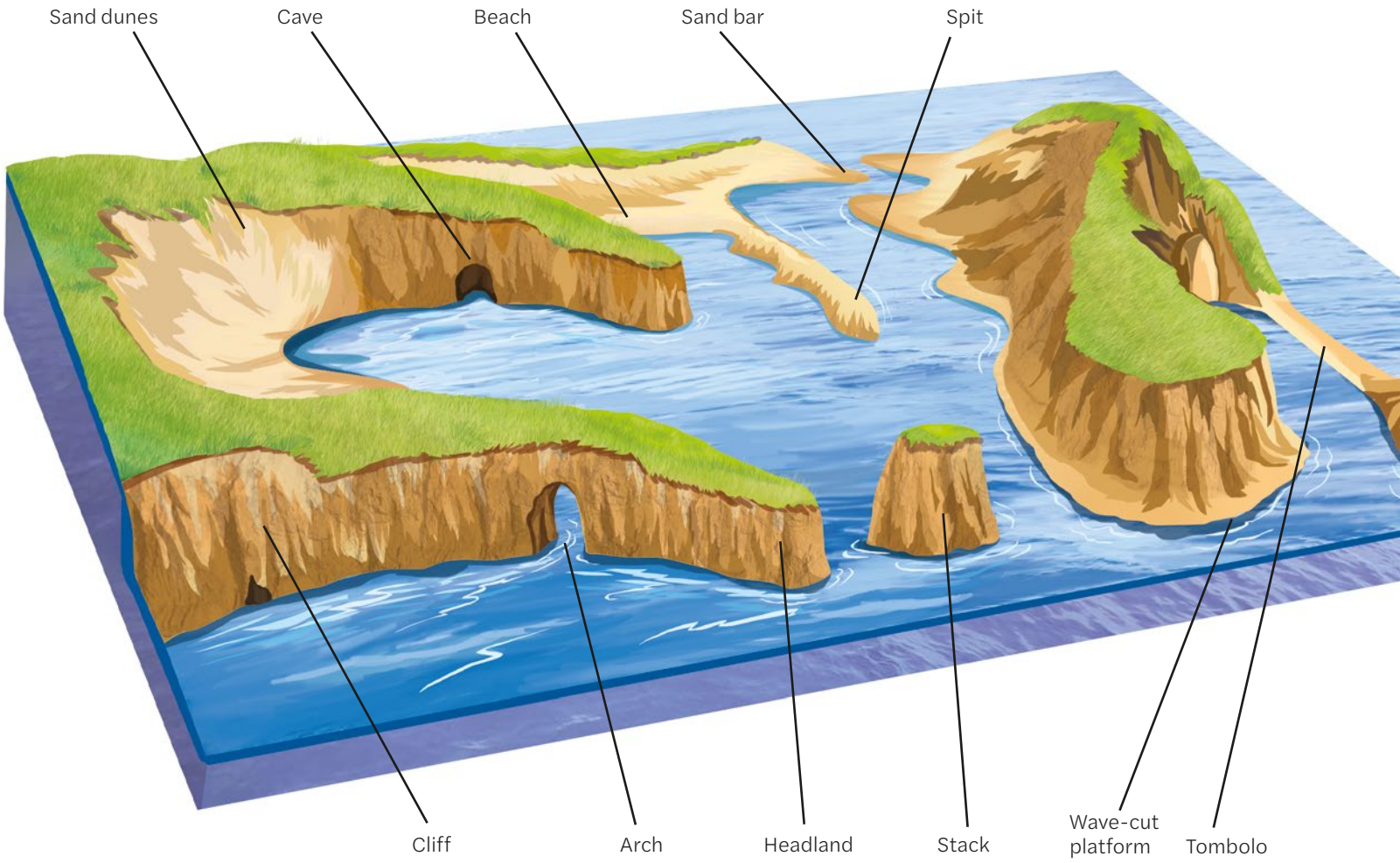
The amount of eroded material taken away or deposited on the coastline depends on the water flowing onto the beach (**swash**) and returning to the sea (**backwash**). Destructive waves have weak swash, but strong backwash that removes material. Constructive waves have strong swash and weak backwash, helping it to build up sand.

Erosional landforms

Destructive waves create erosional landforms, including:

- **cliffs:** the almost-vertical rock face along many coastlines
- **headlands:** narrow, high land jutting out into the sea, formed of harder rock that resists erosion
- **caves:** formed as waves bend around headlands and attack softer rock
- **arches:** formed when caves on either side of a headland join, leaving a gap
- **stacks:** pillars of rock separated from cliffs or a collapsed arch
- **wave-cut platforms:** flat eroded areas of rock at the base of coastal cliffs.

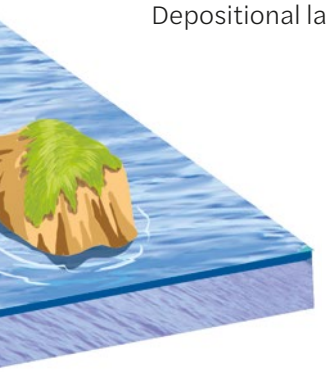
Source 4: Coastal landscape featuring a number of different landforms



Source 5: The action of waves and other erosional forces such as wind, ice and rain are continually shaping and reshaping our coastlines. The famous Elephant Rock sits on the Tongaporutu coastline in New Zealand. It was a double arch in the shape of an elephant until continued erosion and an earthquake removed the elephant's trunk in 2016. Elephant Rock sits alongside the Three Sisters stacks in the same location. One of the Three Sisters disappeared following a storm in 2003, but it was replaced with another sister that became separated from the Tongaporutu cliff face in 2013.

Depositional landforms

Constructive waves, tides and **longshore drift** (page 42) transport sediment to form sand bars, and wind moves sediment to form sand dunes. Depositional landforms in coastal areas include:



- **beaches:** made up of loose particles such as sand and pebbles deposited by waves
- **sand dunes:** hills of sand that form at the back of beaches from wind-blown sand
- **sand bars:** ridges of deposited sand in the ocean that are exposed at low tide
- **spits:** narrow bars of deposited sand linked to the coast
- **tombolos:** form when waves deposit a bar of sand to link an island to the coast.

Learning ladder 1.13

Processes that transform people, places and environments

1. How do waves form?
2. Source 4: Describe how a spit forms.
3. Source 5: What type of landform is this and how was it created?
4. What is the difference between destructive and constructive waves, and the landforms they help create and shape?
5. Source 4: Draw a three-stage diagram to show how a cave can form an arch, and an arch can form a stack.

Environment

1. Source 4: What are some unique features of a coastal environment?
2. Is a coastal environment a physical or built environment? Why?
3. Source 4: Which landforms in this coastal environment were formed by destructive waves?
4. Source 1: Explain how and why waves break.
5. Source 4: How is the formation of sand dunes different from all other coastal landforms shown in this scene?

HOW TO

Environment, page 396

1.14

How do bays form?

Headlands and bays form along coastlines that have alternating bands of hard and soft rock. The hard rock is more resistant to erosion and wears away more slowly, leaving a headland that extends out into the sea. Softer rock is less resistant to erosion and bays are carved out between headlands.

Different rates of erosion

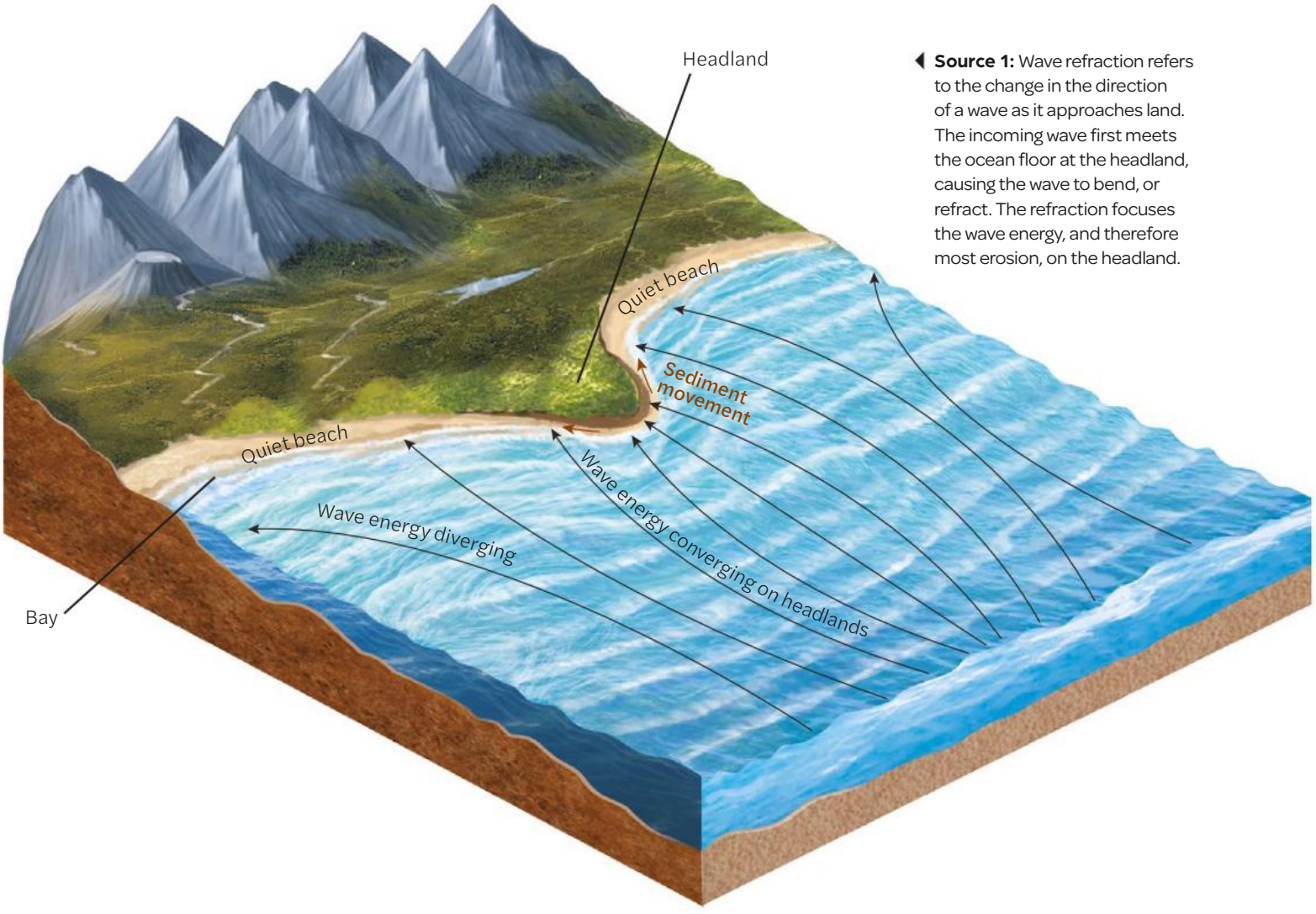
Headlands take the full force of waves, because they jut out from the coastline. As waves approach land they bend to the shape of the coast in a process known as **refraction**. Wave energy is concentrated on the headlands, which erodes into landforms such as caves, arches and stacks.

Waves in bays are more spread out and the wave energy is reduced, allowing for sand to be deposited. Beaches are usually found in shallow bays where waves have less energy.

How bays and headlands form over time

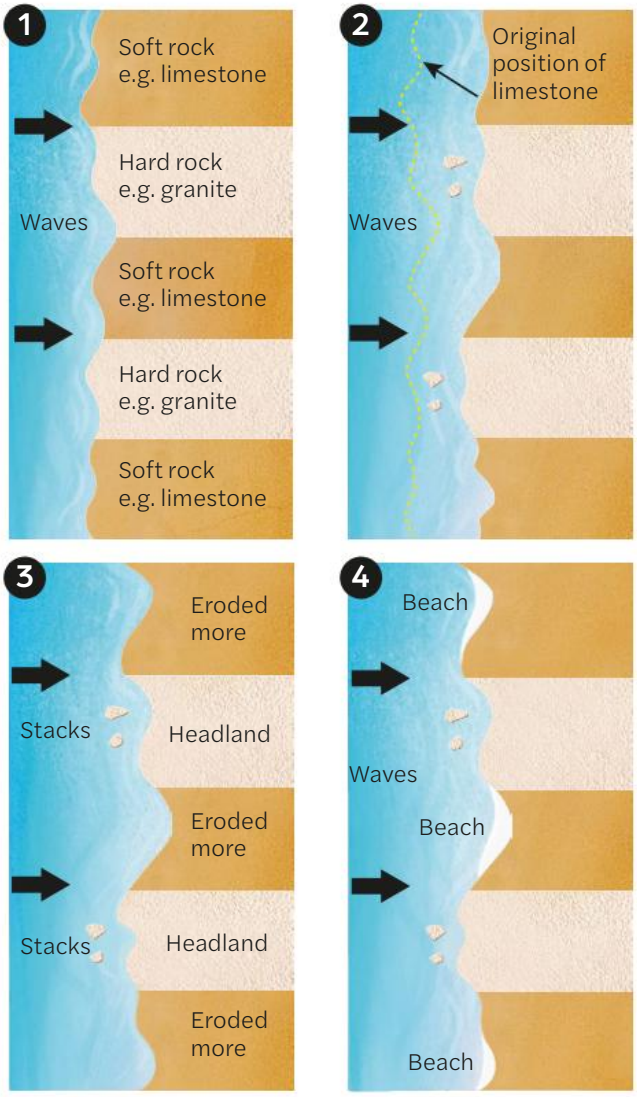
Refer to Source 3.

1. Waves attack the alternating bands of hard and soft rock along a coastline.
2. Destructive waves erode the cliff causing the cliff to retreat.
3. Softer rock erodes more quickly to create bays. The resistant hard rock sticks out to sea as headlands.
4. The protected bays allow deposition of sand to form beaches.



Source 1: Wave refraction refers to the change in the direction of a wave as it approaches land. The incoming wave first meets the ocean floor at the headland, causing the wave to bend, or refract. The refraction focuses the wave energy, and therefore most erosion, on the headland.

Source 2: Wineglass Bay on the east coast of Tasmania is a calm body of water protected by two granite headlands. Granite is a very hard rock that is resistant to erosion. The white quartz sand is eroded material from the granite rocks, which are rich in quartz.



Source 3: The formation of bays and headlands over time

Learning ladder 1.14

Processes that transform people, places and environments

1. Source 2: Why have the headlands at Wineglass Bay been slow to erode?
2. Source 3: Describe where beaches form and where the sand comes from.
3. Source 3: What is meant by the terms 'hard rock' and 'soft rock'? What impact does rock type have on a coastline?
4. Source 1: Using plasticine or clay, construct a headland, cave, arch and stack. Using these models, discuss the 'story' of coastal erosion with a partner. See also Source 4, page 36.

Interconnection

1. Source 1: Refraction is caused by the interconnection of waves and which coastal feature?
2. Source 2: Describe how the interconnection of waves and rock created Wineglass Bay.
3. Source 3: How does the interconnection of waves and soft rock lead to the formation of bays?
4. Sources 2 and 3: Construct a flow diagram identifying how wave interaction with coastal landforms may have shaped Wineglass Bay. Use the following key terms when constructing your diagram:
   - hard rock
   - soft rock
   - erosion
   - headland
   - bay
   - wave.

HOW TO

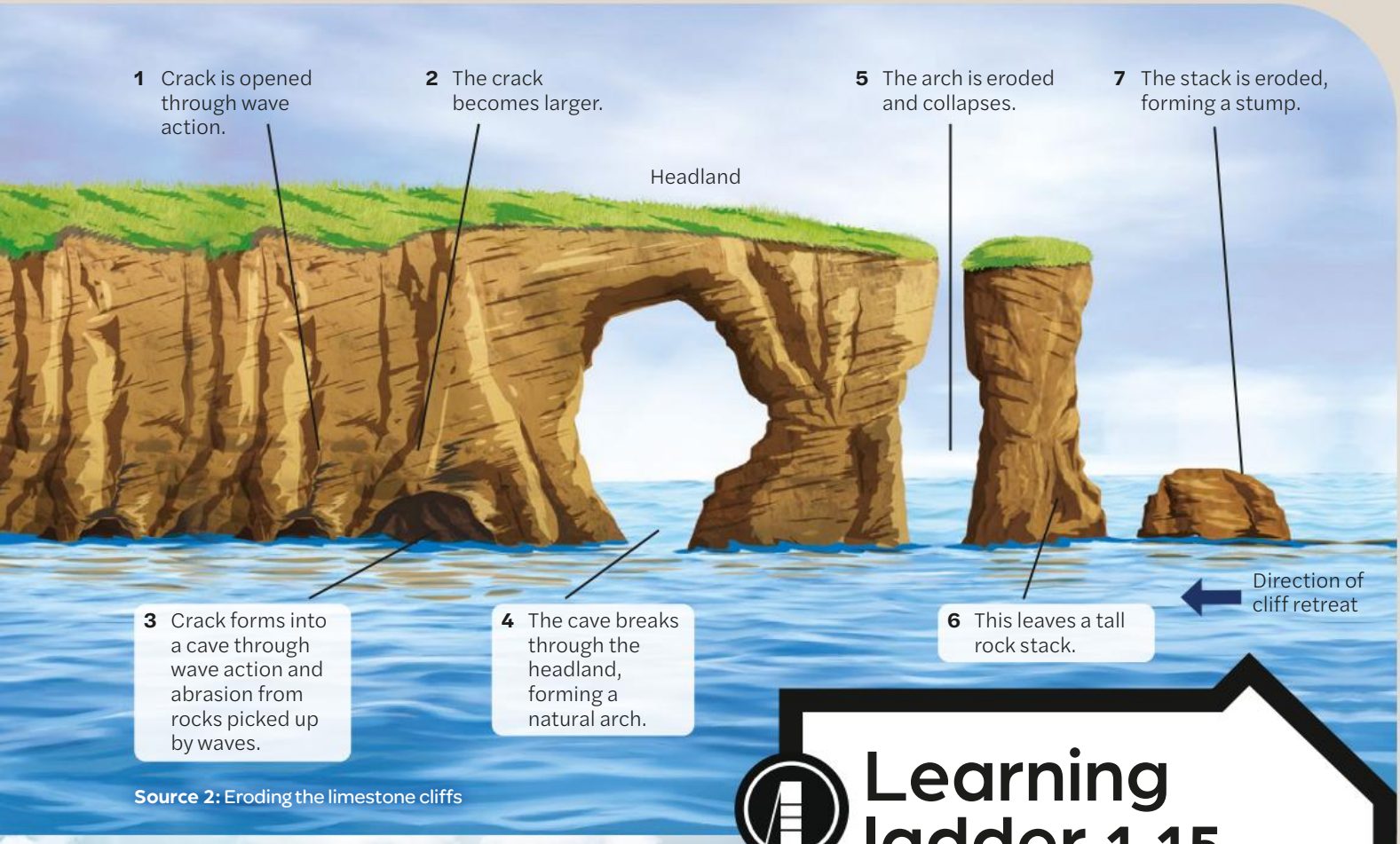
Flow diagrams, page 419;
Interconnection, page 392

Case study

How are waves eroding Loch Ard Gorge?

Loch Ard Gorge at Port Campbell, Victoria, is affected by powerful destructive waves that travel long distances over the ocean. The soft limestone cliffs are eroded into erosional landforms such as gorges, headlands, caves, arches, stacks and blowholes. Salt spray and strong winds weaken the rock and contribute to the weathering and erosion of the steep, exposed cliffs along this coast.

Source 1: Oblique aerial view of Loch Ard Gorge



Source 2: Eroding the limestone cliffs

Learning ladder 1.15

Processes that transform people, places and environments

1. Why is Loch Ard Gorge so prone to erosion?
2. Source 1: Describe the features of the landscape at Loch Ard Gorge.
3. Sources 1 and 2: Make a sketch of the arch at Loch Ard Gorge and use labels and a caption to explain how it formed.
4. Source 2: How are caves, arches and stacks interconnected?

Change

1. Source 1: Give three examples of change at Loch Ard Gorge.
2. In June 2009 an arch collapsed leaving two stacks. Describe the processes that led to this arch collapsing.
3. Source 2: In which direction is the cliff retreating? Why do you think this is the case?
4. Using Sources 1 and 2, explain how destructive wave action has changed the headland marked 'A' on the oblique aerial photograph.
5. Predict how the headland marked 'A' may change in the future.

HOW TO Change, page 394

How does sand move?

As waves hit beaches, the waves move sand along the coast. Constructive waves deposit sand to form other beaches, as the sand builds up against obstacles such as headlands or groynes. Dry sand on the beach can be blown by onshore winds to the back of the beach where it forms sand dunes.

What is a beach?

A **beach** is an accumulation of sand deposited by waves. Beaches constantly change due to the processes of erosion, transportation and deposition. Sand moves along coastlines through waves moving sand to form sand bars and wind moves sediment to the rear of the beach to form sand dunes.

How is sand moved by waves?

Most constructive waves hit the coast at an angle because of the direction of the wind and the shape of the land. Strong swash from the waves picks up grains of sand and moves them along the beach. Gravity takes the weak backwash and some sand directly back into the ocean ready for the next wave to move the sand further along the beach.

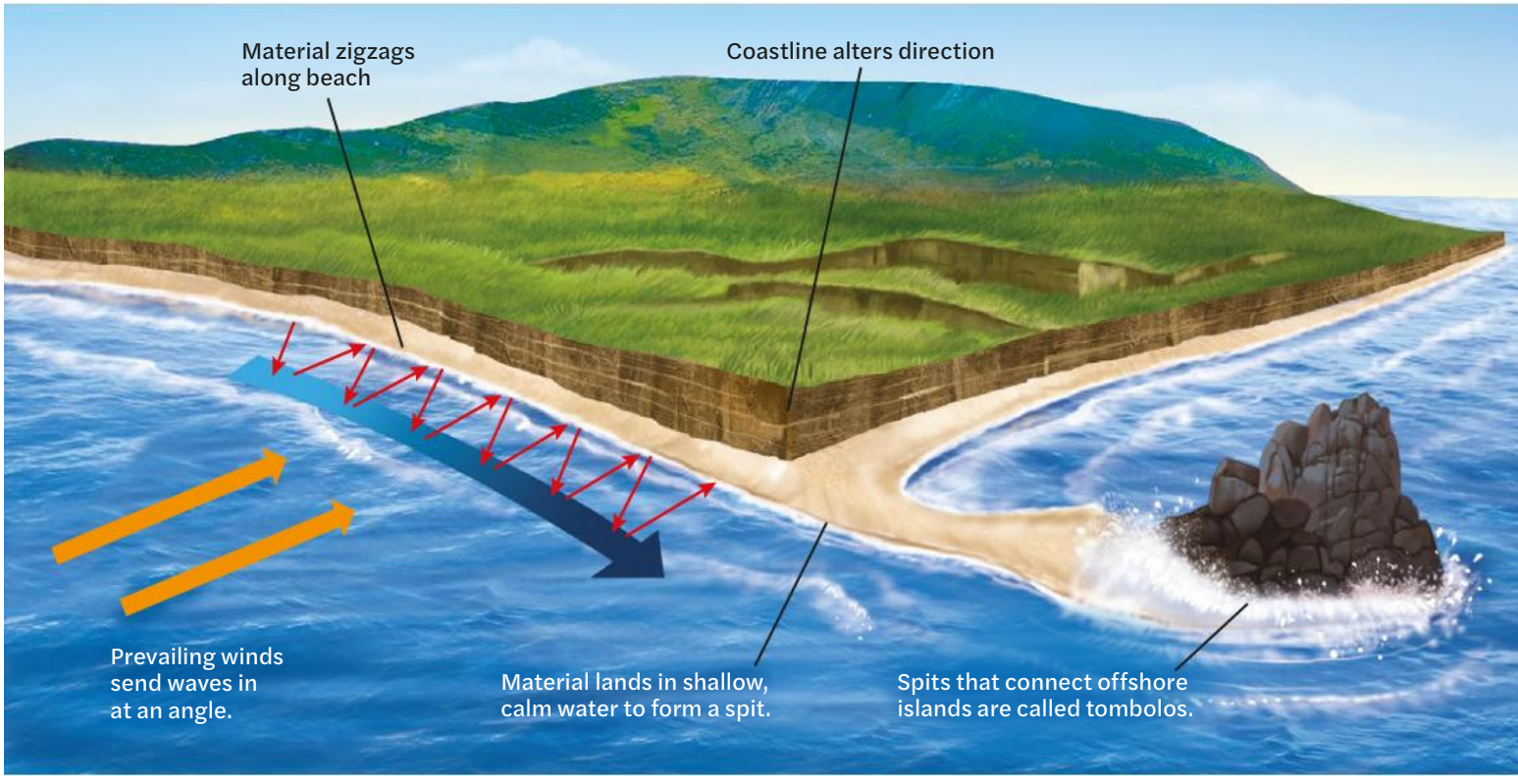
Along the beach, the sand moves in this zigzag fashion, known as longshore drift, until it meets an obstacle such as a headland, rocks or human constructions such as **groynes**. The sand builds up against the obstruction, widening the beach.

Longshore drift is also responsible for forming narrow bars of sand, called spits, that jut out into the ocean. Spits occur when the coastline changes direction or the beach meets the mouth of a river. The sand is deposited and builds up on itself to form a spit. Sometimes the spits join an island to form a tombolo.

How does wind move sand?

At low tide, sand particles on the beach dry out and can be picked up by onshore winds and moved further inland. The moving sand grains may be trapped by obstructions such as plants and mounds at the rear of the beach to form a **primary dune**.

Source 1: Longshore drift

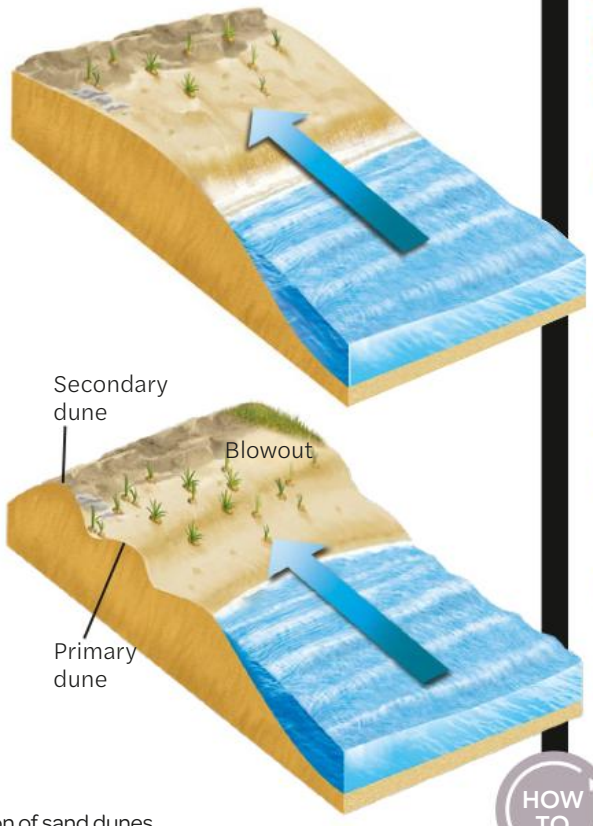


▲ **Source 2:** How waves move sand

There is little soil in a primary dune, so plants find it difficult to take root. Some grasses with shallow roots, such as marram grass, can grow in this very salty environment. Plants hold the sand dunes together and allow the dune to grow larger.

Onshore winds pick up dry sand from the beach and move it inland. The sand starts to mound.

A primary dune builds up, stabilised by plants. Wind scours sand to form a blowout.



▲ **Source 3:** Formation of sand dunes

Learning ladder 1.16

Processes that transform people, places and environments

1. Which two key processes move sand on beaches?
2. Source 3: Describe how a sand dune forms.
3. Source 2: Explain how the processes of swash and backwash operate to enable the longshore drift of sand.
4. Investigate how humans build structures to control longshore drift. Provide a diagram to show how it works.

Interconnection

1. Is longshore drift the only natural process that influences sand movement?
2. How is wind connected with the direction of longshore drift?
3. Source 2: Use a diagram with labels to describe how sand is moved along a beach through the process of longshore drift.
4. Source 1: Explain how a connection beween wave action and shallow water can form spits and tombolos.
5. Evaluate the implications of the connection between plants and wind on sand dunes. Why is it not wise to trample or remove vegetation from sand dunes?

HOW TO
Interconnection, page 392

How were landscapes and landforms created?

Dreaming stories of First Nations Peoples help inform a deeper understanding of the creation of landscapes and landforms and the peoples' spiritual link to a place.

Creation stories

Landscapes contain many landforms that are sites of spiritual importance, particularly for Indigenous peoples. In the Hawaiian religion, the ancient fire goddess Pele, who lives in the crater at the top of the Kīlauea volcano, created Hawaii's landscape. When Kīlauea erupts, lava is the physical embodiment of Pele. She is known to be unpredictable, so Hawaiians traditionally provide gifts and offerings to keep her happy. During the eruption of Kīlauea in 2018 (see page 22), Hawaiians left leaves in front of their homes and flowers in cracks caused by the volcano for good luck.

For Australia's First Nations Peoples, landscapes and landforms were formed by the Ancestors who continue to live in the land, water and sky. Aboriginal spirituality draws on the stories of the Dreaming, while Torres Strait Islander spirituality is based upon the stories of the Tagai.

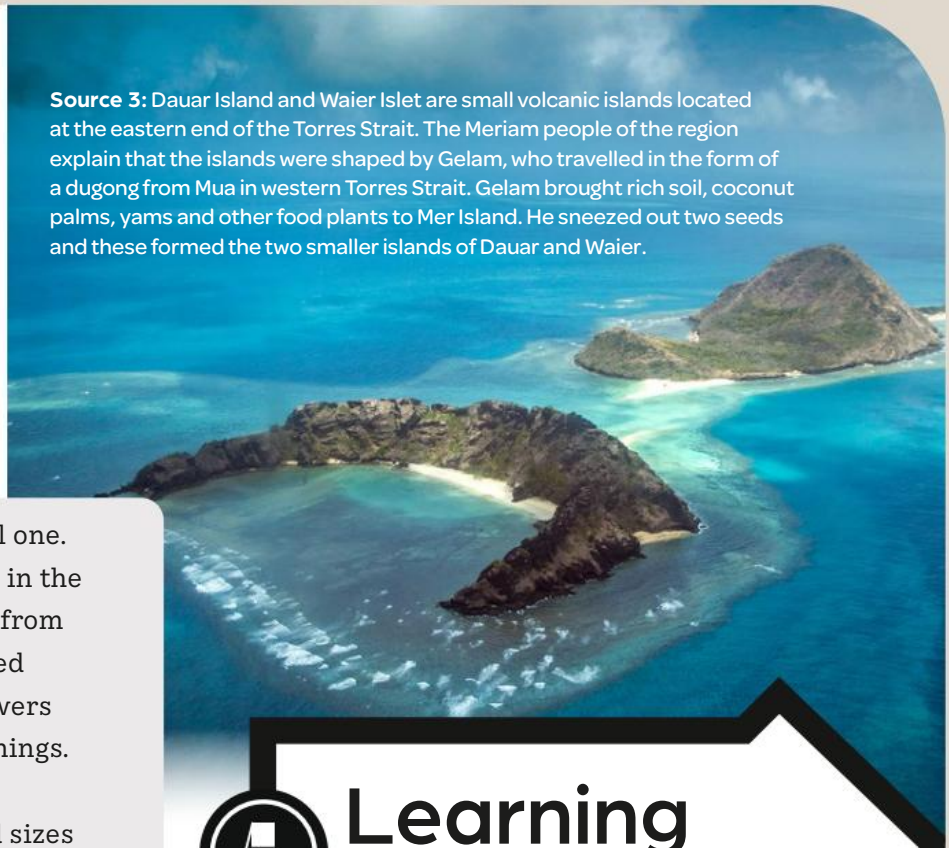
The Dreaming gives meaning to everything and establishes the rules for relationships between people, the land and all living things for Aboriginal people. The Dreaming tells about the creation of the world by Ancestor spirits who came from the earth and sky to create and shape landforms and all life.

Torres Strait Islands creation

The islands and waters of the Torres Strait are important to its peoples, who identify themselves by their home islands. Each island has its own creation story.

Torres Strait Islander peoples are sea travellers, traders, fishers and gardeners. Their culture is unique and includes elements from Australia, Papua New Guinea and the surrounding region. The spirituality of Torres Strait Islander peoples is linked to their life on their home islands and surrounding waterways.

They believe that all natural features and living things were created by ancestral beings. A key creator being in Torres Strait Islander culture is Tagai, a great sea hero. Tagai is represented in the sky by several constellations of stars. These constellations are used as a guide for the seasonal cultivation of crops and gardens.



Source 3: Dauar Island and Waier Islet are small volcanic islands located at the eastern end of the Torres Strait. The Meriam people of the region explain that the islands were shaped by Gelam, who travelled in the form of a dugong from Mua in western Torres Strait. Gelam brought rich soil, coconut palms, yams and other food plants to Mer Island. He sneezed out two seeds and these formed the two smaller islands of Dauar and Waier.

The story of Biami is a special one. Biami is a God to my people, in the beginning he stepped down from the sky and created the land, formed the mountains and valleys, filled rivers with water, and created all living things. Everything Biami creator [sic] was wonderful! Plants of all shapes and sizes were placed on the land. He also placed men and women on special place he had created.

Biami stayed and made sure all things that he created lived together in harmony. When he was satisfied he stepped back into the sky from which he came, where he remains now watching over his people and the wonderful place he created.

Source 2: Biami was the creator being in the Dreaming of First Nations peoples of south-eastern Australia, such as the Wonnarua, Kamilaroi, Guringay, Eora, Darkinjung and Wiradjuri peoples. Leslie Saxby Jupurula, Aboriginal teacher and painter, *Aboriginal spirituality changes and adapts*, Creative Spirits.

Source 1: The Three Sisters in the Blue Mountains is significant to the Gundangurra, Wiradjuri, Tharawal and Darug peoples and was recognised as an Aboriginal place by the New South Wales Government in 2014.

One creation story tells the tale of three sisters from the Katoomba tribe who fell in love with three brothers from a neighbouring Aboriginal nation. The law forbade the girls from marrying outside their own people. When the brothers decided to capture the girls, a major battle erupted. A clever man from the Katoomba nation cast a spell to turn the sisters to stone to keep them safe. During the battle, the clever man was killed and unable to reverse his spell, so the sisters remain trapped in stone to this very day.

Learning ladder 1.17

Perspectives of people and organisations

1. Source 2: What landforms did Biami create?
2. What role does the Dreaming play in explaining the formation of landscapes and landforms?
3. According to Indigenous Hawaiians, why did the Kīlauea volcano erupt in 2018? What action did local people take?
4. Source 3: Which parts of the creation story are linked to how Torres Strait Islander people live?

Interconnection

1. How do Indigenous Australians show their connection to the land?
2. Source 1: Describe the interconnection between this landform and the creation story. How were the Three Sisters formed?
3. Source 3: Explain the interconnection between this landform and the creation story. How were Dauar Island and Waier Islet formed?
4. Source 2: How did Biami set an example for First Nations Peoples to care for Country?
5. Source 1: If changes were to be made to allow tourists to get closer to the Three Sisters site, what might be the implications for the Gundangurra, Wiradjuri, Tharawal and Darug peoples?

HOW TO Interconnection, page 392

1.18

How do humans modify beaches?

Only 15 per cent of the world's coasts remain unchanged natural landscapes. Beaches and beach dunes are the coastal landforms most modified by human activities. The majority of change is intentional and often without thought for the consequences.

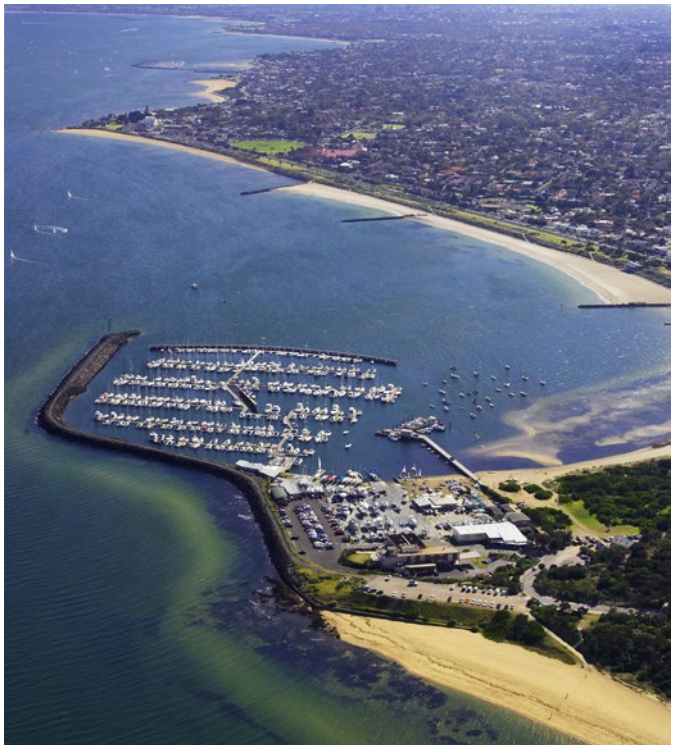
Dynamic landforms

Beaches are dynamic environments that continuously adapt to changing environmental conditions such as wind, waves, currents and tides. They change quickly because sediment is loose and moves easily. With 75 per cent of the world's population living within 50 kilometres of the coast, and the world's largest cities located on the coast, the human pressure on beaches is growing.

People modify beaches to create the environment they want to live in. Management is needed to address the unintentional consequences of these modifications.

Dune development

Building houses, tourist resorts and infrastructure such as roads, car parks and public buildings on sand dunes has been a common practice in Australia and overseas. Sand dunes are nature's reservoir, part of a natural cycle of deposition and erosion that occurs on beaches. Dune development interferes with that process and as a result, properties are threatened by erosion. Further change is then needed to protect those properties. Media reports of beach erosion threatening homes appear after large storm events, and people call for protective measures such as seawalls to be built.



▲ **Source 1:** Hampton Beach, Port Phillip, Victoria

Marine developments

People dredge sand bars or build walls at the mouths of rivers to deepen the water channels for boats and ships to navigate. They build boat harbours and marinas by closing off part of a bay or inlet with hard structures, such as concrete blocks, to provide a safe refuge.

Hampton Beach seasonal longshore drift

Source: Matilda Education Australia

▲ **Source 2:** Longshore drift at Hampton Beach, Victoria

▲ **Source 3:** Training walls built at the Tweed River had consequences for Gold Coast beaches.

These developments interrupt currents that carry sand. When the current stops, so does the sand supply to beaches.

Hampton Beach on Port Phillip Bay illustrates how people intentionally modify beaches and later make additional changes to solve problems they create. A large breakwater was built at the southern end of the Hampton Beach in 1948 to protect Sandringham Harbour from storms. The harbour filled with sand from the longshore drift stopped by the wall and sand was not returned to the beach during the next season. Successive storms eroded the beach further until a series of groynes and renourishment projects were used to replenish the beach with sand and keep it there. A seawall was built at the back of the beach to protect properties. The groynes hold the sand in place and natural currents move sand between groynes.

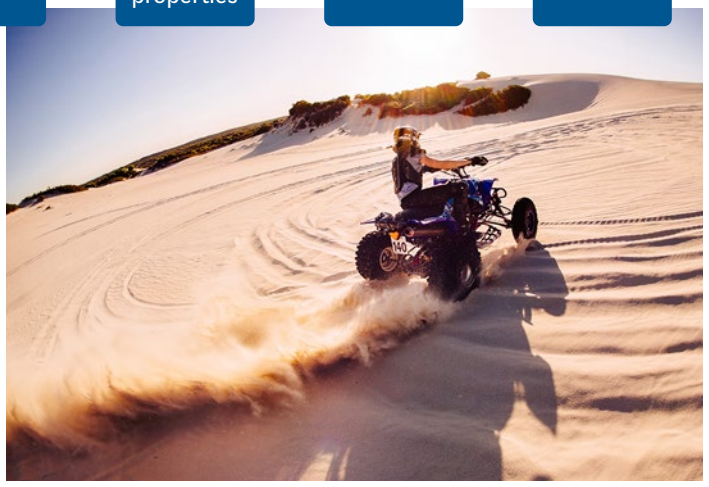
On the Tweed River in northern NSW, rock training walls were built to improve navigation. Gold Coast beaches were robbed of sand trapped by the walls. In both cases human actions had interrupted natural processes and then additional modifications such as Tweed Sand Bypassing and groynes on Hampton Beach were needed.

Beach adjustment

Many beaches are graded in summer to create wide, flat places for people to enjoy. Sand is moved around and redistributed, often taking away the natural deposits that would be blown inland to form dunes, or sand is moved to replace eroded sections. Sand mining removes sand and valuable minerals, while dredging sand from off the coast nourishes beaches that have been eroded. These actions can change waves and currents and impact coastal ecosystems used by beach fishermen and recreational divers.

Beach and dune enjoyment

Recreational use can cause unintended modifications to beaches and dunes. Walking tracks, tobogganing and off-road vehicles lead to the loss of the plants that hold sand dunes together, creating wind channels that blow sand inland and destabilise dune systems. As well as losing sand from beaches, property inland from beaches can be smothered by unstable, moving sand dunes. Dune stabilisation structures and controls on where people can legally do these activities are then needed.



▲ **Source 4:** People modify beach dunes when they use them for recreation.

Learning ladder 1.18

Processes that transform people, places and environments

1. Identify six ways people modify beaches.
2. Source 4: Describe the impact of this activity on beaches.
3. Use a Venn diagram to record similarities and differences between the modifications made to Hampton Beach and Gold Coast beaches north of the Tweed River.
4. Source 1: In what season was the photo taken?
5. Source 2: Explain how longshore drift moves sand between groynes and how this process saves beaches.

Change

1. How does nature change beaches?
2. How do people change beaches for their own enjoyment?
3. Create a flow diagram like Source 3 to show how building houses on dunes modifies beaches and the further modifications required.
4. Explain the following statement using examples: 'Every action has a reaction.'
5. Analyse the dual benefits of groynes for beach users and boat owners.

HOW TO

Change, page 394

1.19

How does mining modify landscapes?

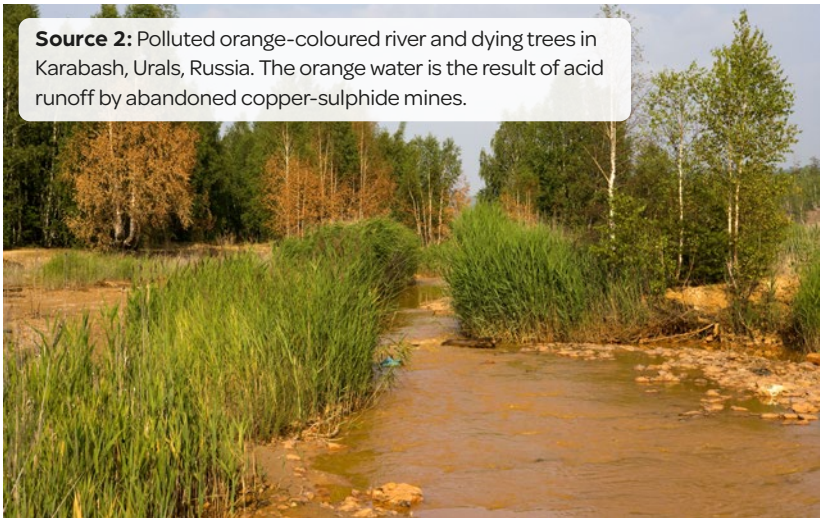
Mining is the process of extracting valuable minerals or materials from the Earth's crust to produce metals, building materials and energy resources. As new products and technologies develop, mining activities have increased around the world. A single lithium electric-vehicle battery-pack requires the mining of 16 kilograms of lithium and over 43 kilograms each of nickel, cobalt and manganese. Mining can significantly alter landscapes through processes such as excavation, deforestation and waste disposal, causing changes to the natural environment.

Changing landscapes

There are different types of mining activities, all of which have an impact on landscapes. Surface mining involves creating large open pits and quarries to extract minerals from the ground. Subsurface mining requires the development of deep underground tunnels to extract minerals from deep under the Earth's surface. There is also mountaintop removal mining, which involves removing the tops of mountains to access coal seams, and placer mining, which involves extracting minerals from surface deposits such as riverbeds and beaches. These processes alter the topography of the land, creating landscape features and landforms such as:

- **plane mountaintops:** flat or levelled mountaintops as a result of removing large quantities of soil and rock from the surface
- **sculpted mountainsides:** sculpted and reshaped mountains, to enable access to mineral deposits by miners
- **canals and ponds:** created by surface mining operations as part of water management systems for collecting and managing runoff and wastewater generated during mining activities
- **alluvial fans and terraces:** created when surface mining activities disturb natural drainage patterns and alter the transportation of sediments in the surrounding environment
- **debris aprons:** loose rock and soil materials deposited at the base of slopes or excavation sites from surface mining
- **conical mounds and towering piles:** created when excavated materials are piled or stockpiled on the surface

Source 1: The open-pit gold mine in Sonora, Mexico. Mining has altered the topography of this landscape by removing vegetation and creating depressions, pits and tunnels in the landscape.



Source 2: Polluted orange-coloured river and dying trees in Karabash, Urals, Russia. The orange water is the result of acid runoff by abandoned copper-sulphide mines.

- **deep pits:** created by surface mining, altering the topography of the land and increasing erosion, as there are generally more steep hills in a mining pit
- **wide, shallow depressions:** where soil and rock materials have been removed
- **settling ponds, levees or dams:** created by some mining companies to deposit excess waste and materials into, further transforming the land.

Impact of these changes

These modifications to landscapes have many environmental impacts:

- Biodiversity is reduced, as vegetation and habitats are removed.
- Topsoils often become degraded, increasing vulnerability to desertification.
- Air is polluted with sulphur dioxide and nitrogen oxides, reducing local air quality.
- Surface water and groundwater sources are polluted with heavy metals, acids and sediments, impacting water quality for neighbouring ecosystems and downstream communities.

Mining generates waste rock, called overburden and tailings, which are rock and chemical byproducts that are often disposed of in tailing dams and dumps. In addition to the mining activities themselves, other land use changes are made to accommodate the large mining workforce, including building roads, infrastructure and buildings.

Some non-government organisations are looking to rehabilitate old mining sites and reduce their environmental impact. Australia has over 80 000 old mining sites that are no longer in operation. Current environmental projects are using spatial technologies to monitor the growth of new vegetation in these sites and putting in strategies to support more biodiversity.

Source 3: An oblique aerial view of China's 'Emerald Lake' in Qinghai Province. The Emerald Lake is an abandoned mining zone, where salts and minerals left behind created giant emerald-coloured lakes covering 6 square kilometres.

Learning ladder 1.19

Processes that transform people, places and environments

1. Identify one impact of mining on environments.
2. Why do humans mine the environment?
3. Source 3: Explain how mining activities impacted the environment in Qinghai.
4. Analyse how technological development can lead to positive and negative impacts on the environment.
5. Assess the positive and negative impacts of mining.

Change

1. Source 1: Identify the type of landform mining created in Sonora, Mexico.
2. Describe how surface mining and sub-surface mining change the landscape differently.
3. Explain how mining can impact neighbouring environments.
4. Explain the environmental impacts of mining on biodiversity and soil quality.
5. Evaluate the statement: Mining activities have a significant impact on landscapes and ecosystems, but advancements in environmental rehabilitation offer hope for mitigating these effects.

HOW TO

Change, page 394

How can I use block diagrams to show degradation?

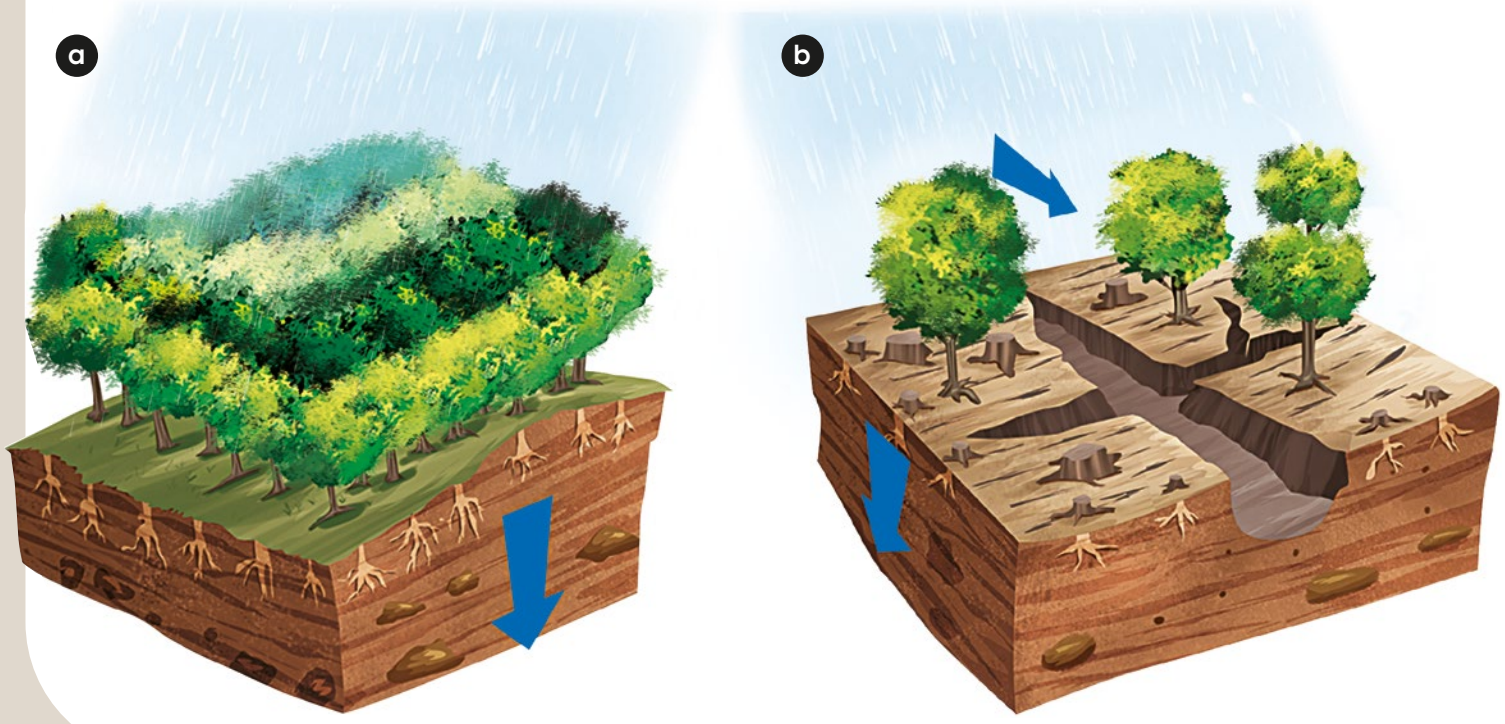
As humans change landscapes, the land can be degraded through processes such as deforestation and desertification. Block diagrams help us to visualise these changes, above and below the surface of the land.

Soil erosion

Deforestation and overgrazing account for two-thirds of Australia's land degradation. Vegetation binds the soil together with its roots, so when trees are cut or plants are trampled by cattle, the soil is opened to erosion.

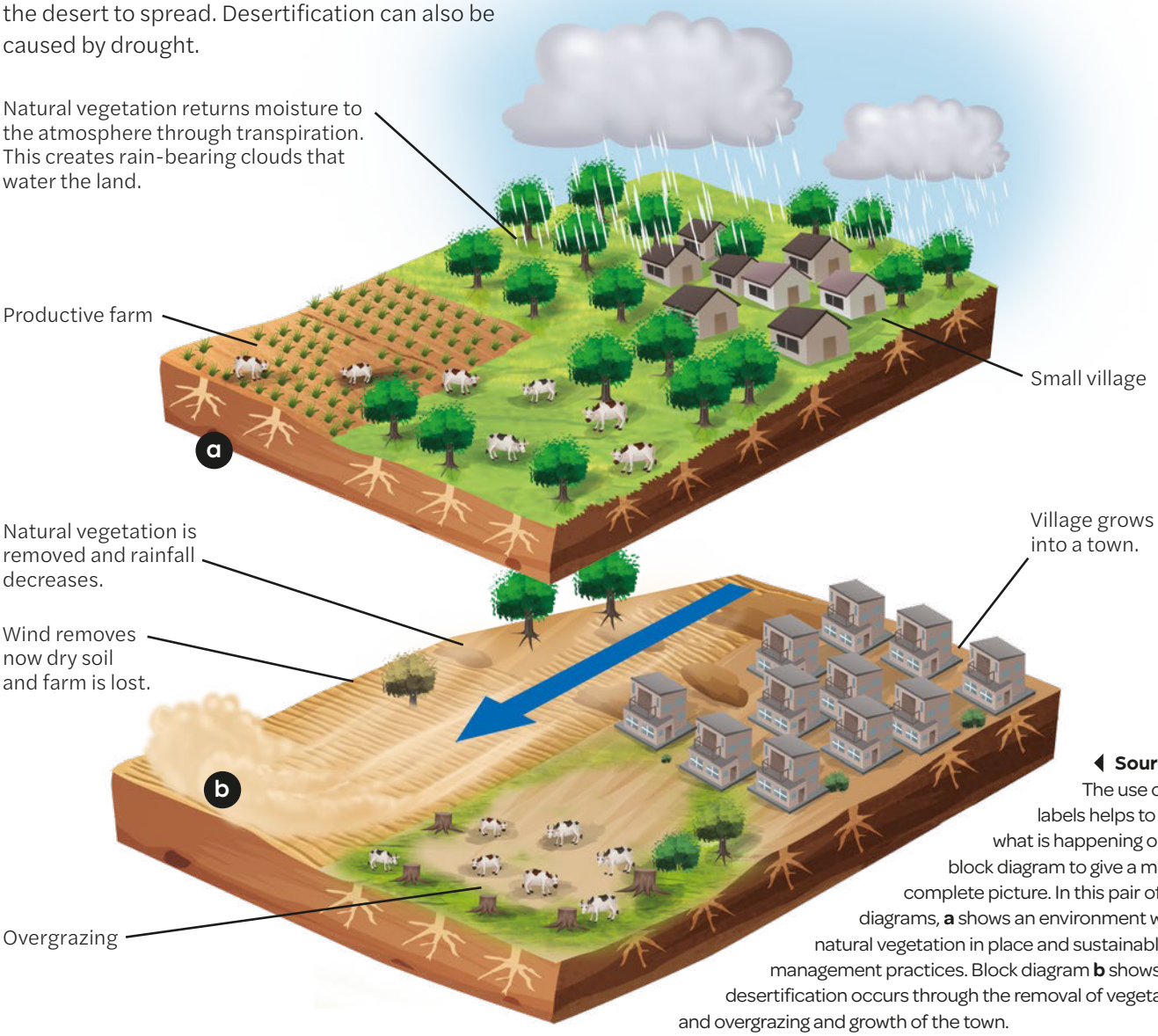
Water can remove unprotected soil in sheets or cut gullies into the earth. Wind can pick up dry soil and deposit it great distances away. The eroded soil can clog rivers and the deforested land can no longer hold onto water, causing more erosion and flooding. Worldwide, half of Earth's topsoil has been lost in the last 150 years.

Source 1: Block diagrams give a three-dimensional view of the environment, both above and below the ground. A pair of block diagrams can show how an environment changes over time. Block diagram **a** shows how a forested hillside binds the soil together and takes up water through its roots. Block diagram **b** shows a deforested hillside. The soil is left unprotected and easily eroded by water and wind because the roots no longer bind the soil together or take up the water.



Desertification

Desertification occurs on the edges of deserts, when fragile land is over-farmed and overgrazed, causing the desert to spread. Desertification can also be caused by drought.



Source 2: The use of labels helps to explain what is happening on the block diagram to give a more complete picture. In this pair of block diagrams, **a** shows an environment with natural vegetation in place and sustainable land management practices. Block diagram **b** shows how desertification occurs through the removal of vegetation and overgrazing and growth of the town.

Learning ladder 1.20

Representing and communicating information

1. Source 1: What information is shown underground on these block diagrams?
2. **a** Source 1b: Describe what has happened to this landscape.
   b Source 2: What are the key processes of change with desertification and what change do they bring?
3. Sources 1 and 2: How is movement shown on block diagrams?
4. Source 1: Trace or sketch the block diagrams shown here and add labels to provide a more complete explanation.
5. Sources 1 and 2: Prepare your own 'stage 3' diagram for either source, showing the action taken to repair the landscape.

Block diagrams, page 418

HOW TO

Landscapes and landforms

Valuing and protecting the land

2

HOW CAN WE MANAGE LANDSCAPES? 64

How can I study valuing and protecting the land?

Landforms and landscapes are valued for their environmental, economic, recreational and cultural value and need to be managed and protected in a sustainable way, including community-led initiatives and national and global strategies.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information
	Outcomes					Geographical tools and inquiry

Source 1: First Nations Peoples have a deep connection with the land and responsibility to care for Country.

I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Place	**Space**	**Environment**	**Inter-connection**	**Scale**	**Sustainability**	**Change**	Steps in skill progression
Geographical concepts							

2.1

How are we connected to landscapes?

Landscapes and landforms around the world are valued in different ways. Some people may have a cultural, spiritual or aesthetic connection to a particular landscape, while others are more interested in the economic value of the place.

Aesthetic values

The **aesthetic value** of a landscape is linked to its uniqueness and its perceived beauty. People are drawn to a place for many reasons, including how it looks, how it makes them feel or through a personal connection with the place.

Mountains are among the most aesthetic landscapes (see pages 8–11). The beauty of mountains goes beyond an appreciation of the landscape and the landforms within it. It also includes concepts such as wilderness and adventure, and emotions such as excitement, anticipation and even fear.

Source 1: Photograph of tourists visiting an African safari to benefit from the recreational value of savanna landscapes

In Nepal, exploration and appreciation of the Mount Everest region is something that began when the peak was first climbed in 1953. Since then more than 5000 climbers have climbed to the peak of the world's tallest mountain (see pages 18–19). Recently, mountaineers have complained that the crowds climbing Mount Everest are taking away from its aesthetic appeal.

Environmental values

Landscapes provide many important and valuable environmental services. They provide habitats for a wide variety of plant and animal species. Maintaining these habitats is crucial for preserving **biodiversity**, which is essential for environments to function and overcome changes. Many landscapes, such as wetlands and forests, also play critical roles in regulating and filtering water. They help maintain water quality by filtering pollutants and storing water during wet periods, which can reduce the impact of floods and droughts. Landscapes, such as forests and grasslands, can influence local and global climates. They regulate atmospheric temperatures, store carbon and help **offset** carbon emissions,

Source 2: The aesthetic value of Mount Everest goes beyond the beauty of this mountain region. It includes its uniqueness and majesty as the world's highest mountain, along with the achievement of climbing it.

which is vital in managing climate change. Landforms found in landscapes, such as hills and mountains, also help form and preserve soils for vegetation to grow. Vegetation cover helps prevent soil erosion by wind and water, which is crucial for agriculture and maintaining land fertility. Protecting landscapes and landforms ensures their environmental values are maintained.

Recreational values

Landscapes provide recreational opportunities that attract people for activities such as hiking, skiing, fishing and camping. These activities offer health benefits and help people develop a deeper appreciation of and connection to the natural world. Many people travel to places around the world to enjoy the recreational benefits of landscapes – 1.5 million people travel to Kenya each year to take a safari tour across the savanna landscapes. Many people around the world travel to the Swiss Alps to ski across the mountains. Tourists help boost local economies by creating jobs in hospitality, transportation and retail, and by increasing the demand for locally produced goods and services.

As people come to value landscapes for their beauty and recreational opportunities, they often become more invested in conserving them. This stewardship can lead to community involvement and efforts to maintain or restore natural environments.

Source 3: An oblique aerial image of the Florida Everglades. This landscape provides many environmental services, including purifying water and providing a habitat for thousands of species.

Learning ladder 2.1

Perspectives of people and organisations

1. What is the aesthetic value of a landscape?
2. Source 1: What are the cultural, aesthetic and economic values of this landscape?
3. Source 2: Explain the values of Mount Everest.
4. What is your favourite landform or landscape? Create and deliver a short presentation on this place. Consider the following:
   - **a** the location of the landform or landscape
   - **b** how it was formed
   - **c** why you have a connection to that place.
5. Create and conduct a survey of your class or a large group of students asking them their favourite type of landscape and how they are connected to it. Create graphs or maps to show your findings and discuss the results.

Interconnection

1. Why do you think tourists are attracted to particular landscapes and landforms?
2. How do the environmental values of landscapes connect places?
3. How do environmental and recreational values of landscapes connect human activities and natural ecosystems?
4. Source 2: Explain why there is a strong inter-connection between climbers and Mount Everest.

HOW TO Interconnection, page 392

2.2

Who benefits from the economic value of landscapes?

The physical features of landscapes provide economic opportunities that include income earned from the use of natural resources, such as minerals, forests and farmland, the creation of jobs and the growth of tourism. People, communities and even nations rely on the **economic value** of their landscapes for prosperity and survival; however, this often conflicts with cultural and environmental values.

Mining and agriculture

Mining is one of the highest income-generating industries for countries that are rich in mineral resources. The rocky landscapes of mountains and deserts are a source of large mineral reserves. In 2023 the mining industry made up two-thirds (66 per cent) of Australia's income from exports to other countries and annually it contributes around 10 per cent to its GDP (national income). Australia takes advantage of the economic value of resources such as gold and iron ore, having more reserves of these resources than any other country in the world. Many of these resources are found in the Hamersley Ranges in Western Australia's Pilbara region, known for its large mining industry.

In some parts of the world, minerals are located on land that is culturally important to First Nations Peoples.

▲ **Source 1:** Mount Tom Price mine, an iron ore mine located in the Pilbara region of Western Australia

▲ **Source 2:** Sheep and yaks grazing on the meadow on Pamir Plateau, Xinjiang, China

In 2020, when large Australian mining company Rio Tinto detonated explosives at a Pilbara mine, two historic Aboriginal shelters were destroyed. The failure to protect cultural heritage in the pursuit of economic gain was widely condemned. While the economic value of iron ore is easy to calculate and the benefits are large, including to the Aboriginal people employed by mining companies, it is considered by many as inappropriate to compare economic values with cultural values, and prioritise money over cultural connection that spans thousands of years.

Commercial agriculture takes place in landscapes. In Australia, flat inland plains are used for wheat and sheep production and the northern grasslands of the Barkley tableland support beef cattle grazing. Across Asia, the fertile soils of volcanoes and river floodplains are used to grow rice, a major export crop, and hilly

▲ **Source 3:** Wildlife safari on tha savanna plains of the Serengeti in Tanzania

land supports plantation crops such as tea, coffee and palm oil. Producing food in these landscapes often involves clearing native forests, thereby contributing to deforestation and loss of habitat and wildlife. The clearing of land for crops and the use of irrigation and agricultural chemicals has historically caused the degradation of landscapes through water pollution in riverine and coastal landscapes, or erosion in mountainous regions. There is pressure for agriculture to use more sustainable practices to minimise the environmental impact on landscapes and landforms.

Tourism

The recreational and aesthetic values of natural landscapes and landforms attract tourists who inject millions of dollars into local economies through their purchases of food, accommodation, transport and souvenirs. Tourism also generates employment by creating jobs in local businesses, and in the tourism industry, such as local guides and rangers. In Iceland, spectacular glacial landscapes, waterfalls and volcanoes attract more than 2 million visitors a year and generate around 10 per cent of Iceland's income. Volcano tourism has become an attraction in recent years with visitors fascinated by slow-moving lava flows across already spectacular, often frozen landscapes. Coastal and underwater landscapes such as coral reefs attract millions of tourists to Australia, while the native wildlife of Africa's grasslands (Source 3) and South America's rainforests are significant tourism drawcards that benefit the economies of nations such as Kenya and Brazil.

▲ **Source 4:** Tourists on a whale-watching boat observing a humpback whale off Mooloolaba, Queensland

In contrast to the economic value of tourism is the impact of overtourism, where increasing numbers of tourists destroy landscapes, degrade their quality and interfere with the lives of local people. To these people, the social disturbance caused by tourism has to be balanced against the economic benefits.

Learning ladder 2.2

Perspectives of people and organisations

1. Write a definition of economic value.
2. Outline how landscapes have economic value.
3. Source 2: Describe the perspective of a livestock farmer on the value of grasslands on the Pamir Plateau in China.
4. Source 1: Explain two perspectives on the economic value of mineral resources in the Pilbara.
5. Analyse how the perspective of a mining company might influence the use of mountain landscapes.

Interconnection

1. Identify two economic benefits of using landscapes for agriculture.
2. Sources 3 and 4: What problems might arise from tourism becoming too popular in these landscapes?
3. Explain the connection between land degradation and the use of landscapes for economic gain.
4. How do the values attached to landscapes influence how they are used?
5. Sources 1–4: Suggest strategies for the use of one of the landscapes shown, which recognises conflicting values and focus on achieving economic, environmental, social or cultural sustainability.

HOW TO

Interconnection, page 392

2.3

How do tourists value coastal landscapes?

Australia's coastline is the number-one attraction for international visitors. Each year, it attracts millions of overseas visitors and Australian tourists, and earns billions of dollars in local and international tourism.

Tourism

Tourism is a very important part of the Australian **economy**. It contributes 3.2 per cent of Australia's total wealth, also known as the country's **gross domestic product (GDP)**. Tourism also employs nearly 5 per cent of all Australians. Australia welcomed 9.1 million international visitors in 2018 and they spent $42.5 billion.

Tourism Australia is the government agency responsible for attracting international visitors to Australia. To continue to increase tourism, Tourism Australia undertakes research to understand what draws tourists to Australia. This research underpins the planning and **marketing** activities of Tourism Australia.

Source 1: The 'There's nothing like Australia' marketing campaign puts the focus on exploring Australia's natural offerings, especially on the coast.

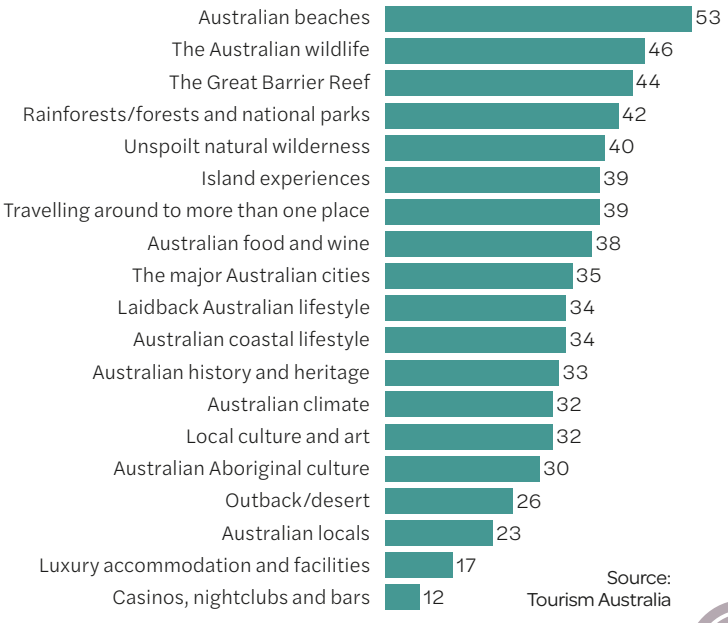
Source: Tourism Australia

Source 2: Tourism Australia's research shows that the Australian coastline is very popular with international visitors.

The economic value of the coast

Tourism Australia's research shows that 70 per cent of our international visitors enjoy aquatic and coastal experiences as part of their trip to Australia. The tourists rank Australia as the best place in the world to enjoy marine wildlife and coastal beaches. Approximately 7 million international visitors enjoy Australia's coastline each year and they contribute $35 billion to the Australian economy.

What attracts international visitors to Australia



▲ **Source 3:** What attracts international visitors to Australia (percentage) – Tourism Australia 2020 report

Learning ladder 2.3

Perspectives of people and organisations

1. Source 1: Identify three landscapes shown on the map that are used to attract international tourists.
2. Using quantitative data, describe how tourism contributes to the Australian economy.
3. Source 3: Which Australian landscapes are most highly valued by international tourists?
4. How could we make tourism more sustainable to ensure our coastlines do not suffer for economic gain?

Place

1. Source 1: What attractions are advertised on Fraser Island (now called K'gari)?
2. Source 3: Which actual coastal location is listed separately on this list?
3. Source 2: Describe the physical characteristics of this place and suggest why it is used to advertise Australia.
4. Explain how different places across Australia can be enjoyed by tourists in various ways.

HOW TO
Place, page 390

How are First Nations Peoples connected to Country?

Connection to place has always been an important part of First Nations identity and cultural belonging. For many First Nations people, the relationship with Country is different from non-Indigenous people and goes beyond thinking about land as something to be exploited. Rather, First Nations people are in a relationship with Country.

What Country is not

For many First Nations people, **Country** is not a commodity; that is, something to be bought, sold, developed or mined, or take resources from. Country is also not something that can be owned, or something used to divide people with and without wealth. It is also not something to be exploited. These are all ways that the land has been used by non-Indigenous people since colonisation and the declaration of Australia as **terra nullius**.

What Country is

For many First Nations people, Country is an important part of everyday life. For many, Country is food, medicine, building materials and other everyday items. Country goes beyond the immediate need to thrive in Australia, and Country for many First Nations people also represents lore, and law, responsibilities, stories and languages, community, songs and songlines, dances, ceremony and culture. Country also represents sacred places, ancestors and spirits, the past, present and future. Finally, Country also represents learning, growth, memory, Dreaming and so much more.

Relationships with Country

For many First Nations people, Country represents so much more than many Western experiences of land. Rather than land or Country being owned by people, as it is in non-Indigenous cultures, for First Nations people, the Country or land also owns the people. As such, it is understood that there is a reciprocal relationship with Country. This means that as people have a responsibility to care for Country, Country also has a responsibility to care for the people.

For some First Nations people, Country is experienced as part of an extended family or kinship network. This also often includes the plants and animals that live on Country, but it also can include the earth, rocks, waterways and other landmarks. The relationships with the more-than-human aspects of Country are shared and celebrated through ceremony, song, dance, story and ritual. Engaging with Country through these methods not only builds relationships with Country, but also supports the ongoing health and wellbeing of First Nations people.

An outcome of **connection to Country** is that many First Nations people have a totem. This is often a plant, animal or insect that lives on Country that individuals and groups have a specific responsibility to care for. First Nations people are often responsible for caring for their totem to ensure that it remains healthy and in turn helps to keep Country healthy.

First Nations agricultural and land management practices have always included sustainable ways of caring for Country. This means that Country is cared for in the present, and in turn Country will care for future generations.

Relationships with Country disrupted

The arrival of the British and declaration of terra nullius (nobody's land), and subsequent colonisation of Australia, meant that many First Nations people were forced from their Country to live in Missions and Reserves and on the outskirts of British colonial centres. Because of this, many First Nations people have been forced to grow up, live and work away from their ancestral Country. Despite this disruption, many First Nations people recognise that it does not matter whose Country you live on, you still have a responsibility to care for it.

Source 1: Manja Shelter at Gariwerd in Victoria contains rock art of hand stencils. It is believed that the stencils record visits to the site and renew a person's ties to Country.

By studying core soil samples, scientists have been able to observe the impact of colonisation through the different colours of the soil. These indicate that removing First Nations people from Country has significantly changed the landscape and has contributed to more frequent bushfires during the hot months, because there have not been people caring for Country to effectively manage the land. This is definitive proof that unlike European myths that the landscape was 'pristine' and 'untouched', which were used to justify colonisation, it had actually been managed by First Nations Peoples for millennia.

For many people in Australia today, there is an expectation that, since the colonisation of Australia, Country is now shared between First Nations people and non-Indigenous people, and we are all responsible for caring for Country to ensure that Country can care for us all.

Learning ladder 2.4

First Nations Peoples' interaction with Country

1. What is Country not?
2. Give three different examples of the relationship with Country for First Nations Peoples.
3. How have core soil samples provided evidence of First Nations Peoples' land management practices?
4. What 'more-than-human' relationships do First Nations Peoples have with Country? How does this encourage caring for Country?

Interconnection

1. Why do First Nations Peoples have a duty to respect and look after their Country?
2. What are totems and how are they interconnected with Country?
3. Source 1: Describe why stencilled handprints are renewed at Manja Shelter.
4. Why is Country much more than a landscape to First Nations Peoples? Why did European colonists find this difficult to understand?

HOW TO Interconnection, page 392

2.5

How can we take action to manage landscapes?

To help improve a landscape or stop its degradation, management strategies are employed at a variety of scales – local, regional, national and global. Often the need to protect and manage an environment is brought to the attention of governments by people protesting or lobbying members of parliament.

Direct action

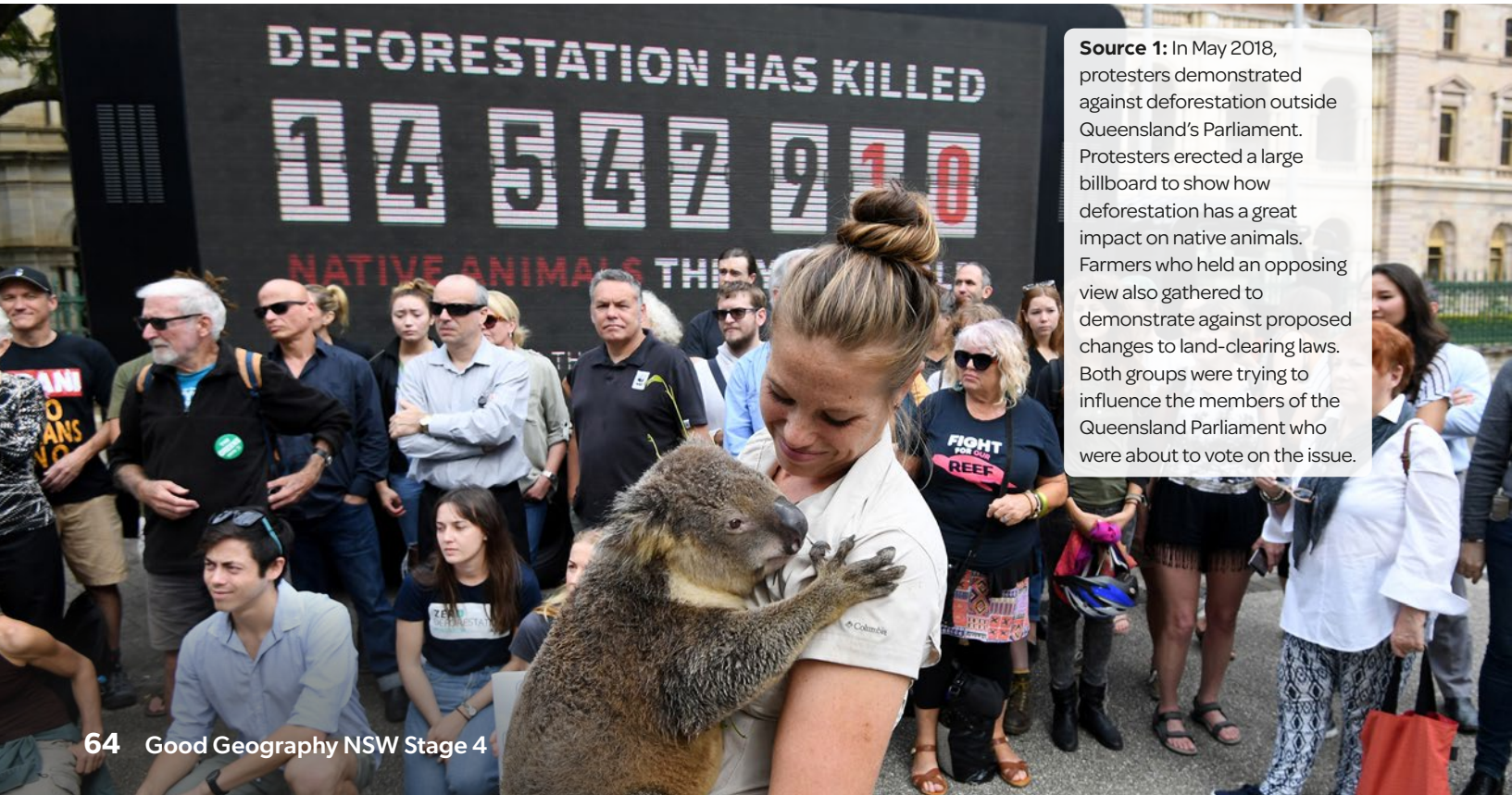
People raise awareness about environmental and other issues through **direct action**. Direct action is an effective way of raising awareness about issues. Today, people use social media to quickly spread messages about direct action events and bring issues to people's attention.

Protests are an effective form of direct action where protesters march or hold a **demonstration** at the site of an issue such as a deforested area or the steps of parliament. Protests can attract large numbers of people with placards, T-shirts and badges showing slogans to get their message across. Protest organisers invite the media to their demonstrations to record speeches and beam the protest to a wider audience in Australia and around the world.

Lobby groups

Lobbying is any attempt by individuals or groups to influence the decisions of government. Lobby groups work on behalf of a particular cause to influence political decisions. In Australia, there are many conservation organisations that work to influence public and government opinions on issues such as deforestation, pollution and the impact of introduced species.

The World Wildlife Fund (WWF) is a lobby group that works around the world to protect endangered species and habitats. It tries to influence political decisions about the environment through media campaigns or speaking directly with federal or state members of parliament. The WWF website gives interested people the chance to email a message to members of parliament on issues such as protecting koalas from **deforestation**.



Source 1: In May 2018, protesters demonstrated against deforestation outside Queensland's Parliament. Protesters erected a large billboard to show how deforestation has a great impact on native animals. Farmers who held an opposing view also gathered to demonstrate against proposed changes to land-clearing laws. Both groups were trying to influence the members of the Queensland Parliament who were about to vote on the issue.

Source 2: Seal Bay Conservation Park on Kangaroo Island in South Australia uses a conservation management strategy approach to allow visitors to witness the Australian sea lion colony, but protect the environment. A fenced boardwalk behind the beach has been built to allow tourists to view the sea lions on the beach, but restrict access to them.

Landscape management strategies

A management strategy is a plan to achieve goals and objectives. Managing landscapes involves approaches with different levels of environmental protection.

Preservation

Preservation is a management strategy that plans to protect an environment in its existing form. The environment is untouched and people are denied access. Management of the Great Barrier Reef Marine Park defines preservation zones as 'no go' areas. No one can enter these zones without written permission.

Conservation

A conservation management strategy involves active management to reduce environmental damage of a landscape. Human activities are allowed, but are strictly controlled, and other uses of resources are limited to reduce impact on ecosystems. Ecotourism at Seal Bay on Kangaroo Island is an example of a conservation management strategy where the natural habitat of a colony of Australian sea lions is protected, while still allowing tourists to learn about the importance of conserving this endangered species and their habitat.

Utilisation

Utilisation is a management strategy that involves alteration of the landscape to allow human activities such as farming to occur. This land management approach usually involves damage to natural environments. For example, mountain graziers took stock into the mountains in Kosciuszko State Park each summer to feed on the lush pastures, causing great damage to the fragile environment. Grazing leases were terminated in the park in 1944 and all grazing had ended by 1970.

Exploitation

Ecosystems are destroyed, degraded or reduced in extent as a result of exploitation, which is when a landscape is used with little regard for the impact.

Learning ladder 2.5

Sustainable management strategies

1. Which landscape strategy has the potential to do the greatest harm to the natural environment?
2. Source 1: What environmental impact is spelled out on the billboard behind the protesters?
3. What issue was caused by cattle graziers utilising mountainous areas such as Mount Kosciuszko and what action was taken?
4. Explain how lobby groups attempt to protect places.
5. Rank the four management strategies from the potential to do the greatest harm to the environment down to the potential to do the least harm to the environment. Which of the four strategies are likely to be used in the management of Australia's national parks and why?

Sustainability

1. How do management strategies improve sustainability?
2. Source 1: Describe the unsustainable practice these protesters are trying to stop.
3. Explain why preservation zones have been established in the Great Barrier Reef Marine Park?
4. Source 2: Explain how the management on Kangaroo Island can lead to long-term sustainability.

HOW TO Sustainability, page 400

2.6

How can we manage landscapes on an international scale?

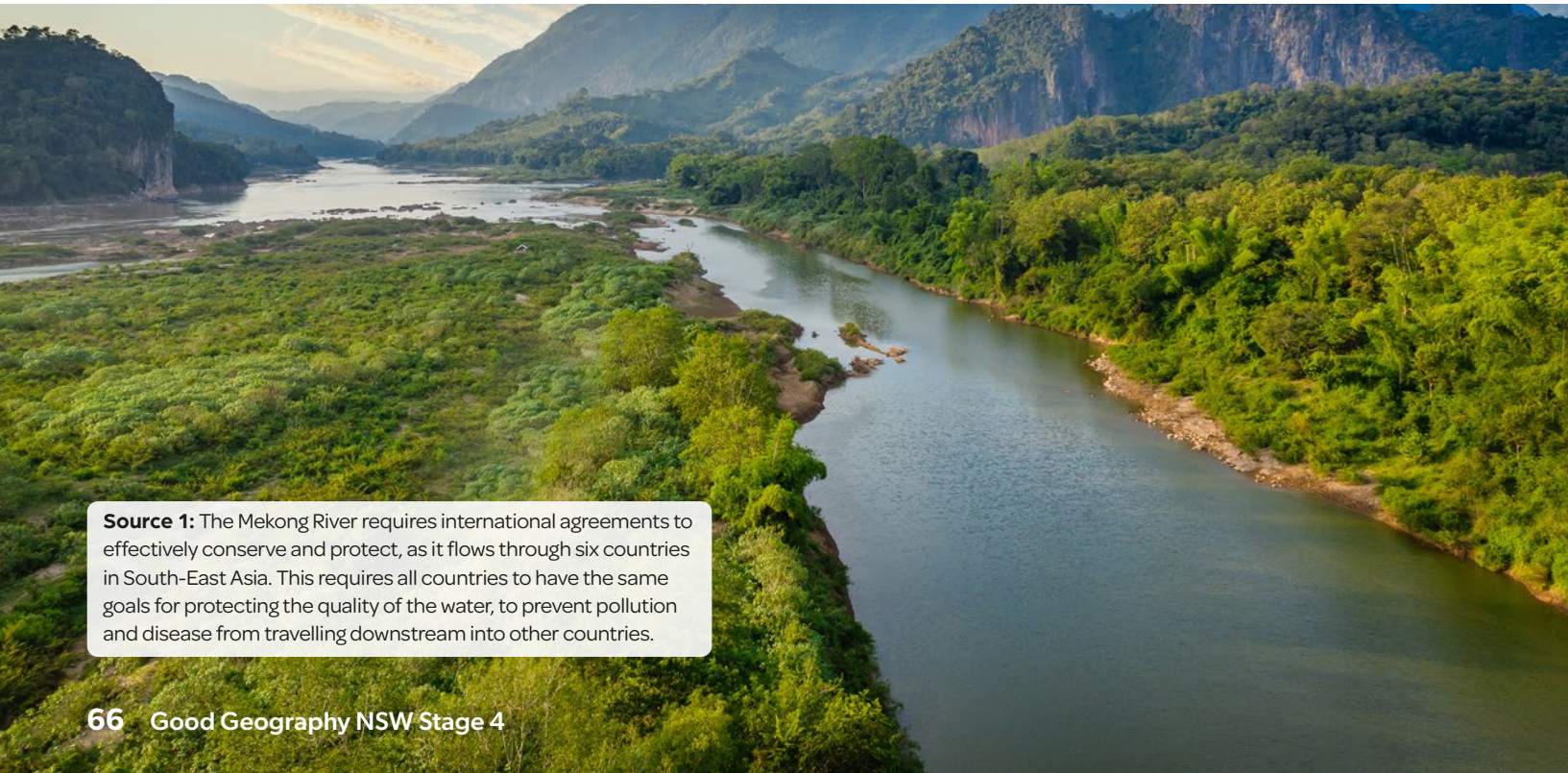
Many landscapes and their processes do not stop at country borders and can be shared between neighbouring countries. As an example, the Mekong River transports eroded sediments and pollution from upstream countries like China and Myanmar to downstream countries such as Laos, Thailand, Cambodia and Vietnam. This can affect river dynamics, sedimentation patterns and ecosystem health across the entire basin. This interconnectivity of landscapes makes it important for countries to work together on an international scale through agreements and cooperation.

International agreements and treaties

International agreements are formal agreements or treaties between two or more countries that cover a wide range of topics, including environmental protection and human rights. By signing an international agreement, countries agree to work together towards common goals to protect landscapes. This can include agreeing to conserve environments, implement laws to prevent their degradation, share knowledge and allocate funding to environmental protection. These international agreements are often facilitated by international organisations, such as the United Nations or the World Bank.

World Heritage Sites

The United Nations Educational, Scientific and Cultural Organization (UNESCO) oversees an international agreement known as the World Heritage Convention. This convention has created criteria that is used to identify places in the world that have outstanding



Source 1: The Mekong River requires international agreements to effectively conserve and protect, as it flows through six countries in South-East Asia. This requires all countries to have the same goals for protecting the quality of the water, to prevent pollution and disease from travelling downstream into other countries.

universal value to humanity, referred to as World Heritage Sites (WHS). These sites encompass natural wonders, cultural landmarks and significant historical locations. Through this agreement, UNESCO collaborates with nations to recognise and protect these sites, ensuring their conservation and sustainable management for future generations.

Serengeti–Mara National Park

The Serengeti-Mara Ecosystem, in Tanzania and Kenya, is protected by many international agreements. Containing the Serengeti National Park WHS, it meets criteria of the convention due to its exceptional biodiversity, including the largest annual wildebeest migration, where over 1 million wildebeests and hundreds of thousands of hoofed mammals engage in a 1000-kilometre circular trek across Kenya and Tanzania. It also meets criteria by containing a wide variety of aquatic and terrestrial habitats with diverse ecosystems, including grasslands, plains and forests. Due to its important World Heritage Site status, international organisations, such as the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), provide funding to the Kenyan and Tanzanian governments to implement conservation projects, regulate human activities and reduce habitat loss in the Serengeti-Mara Ecosystem.

International agreements between Tanzania and Kenya have also been crucial for the sustainable management and conservation of the Serengeti-Mara Ecosystem to ensure both countries can support the movement of wildlife across international borders and are both aware of shared environmental challenges. These agreements also ensure both countries equally implement wildlife conservation strategies, monitoring programs, law enforcement efforts and methods to combat the illegal wildlife trade.

World Heritage status and effective international agreements have resulted in effective laws against hunting in the ecosystem, developing conservation areas, establishing land use planning rules to reduce habitat fragmentation and implementing vegetation planting projects. It has also led to increases in tourism and scientific research in the ecosystem, resulting in increased funding and knowledge about ecosystem processes to improve conservation efforts. Through these efforts, elephant numbers have grown in parts of the ecosystem, and this has also had positive ecological effects, such as shaping vegetation dynamics and creating habitat for other wildlife species.

Source 2: Annual migration of over 1 million white-bearded (or brindled) wildebeest and 200 000 zebras across the Serengeti-Mara Ecosystem. International agreements are important for establishing the conservation efforts of this large ecosystem that goes across two countries.

Learning ladder 2.6

Sustainable management strategies

1. What is an international agreement, and why are they important for managing landscapes?
2. Describe what World Heritage Sites are and how they contribute to landscape conservation.
3. Explain the role of UNESCO in overseeing World Heritage Sites and how countries collaborate to protect them.
4. Explain how the Serengeti-Mara Ecosystem meets criteria (vii) and (x) of the World Heritage Convention. What significance do these criteria hold for landscape conservation?

Sustainability

1. Identify two ways in which international agreements can address environmental challenges in the Mekong River basin.
2. Describe how international agreements have improved the sustainability of the Serengeti-Mara Ecosystem.
3. How does the Mekong River exemplify the need for international cooperation in managing landscapes? Provide specific examples.
4. Analyse the effectiveness of international funding in conserving ecosystems. What are some key successes and limitations of these efforts?

HOW TO Sustainability, page 400

Case study

How is Dorrigo National Park managed?

Dorrigo National Park sits on the Dorrigo Plateau on the mid-north coast of New South Wales. Like other National Parks in Australia, Dorrigo National Park has a management plan that sets out a vision for the park and includes objectives and strategies designed to meet that vision.

The landscape and landforms of Dorrigo National Park have their origins in the tectonic uplift that created Australia's Great Dividing Range. This section of the range is an undulating plateau with a steep scarp that drops to the coast. The orographic effect of the scarp produces the heavy rainfall that creates waterfalls and supports thick rainforests. These forests are among the oldest in Australia and are often referred to as the 'Gondwana' rainforests. The Gumbaynggirr people retain strong connections to this land, its forests and wildlife.

Management focuses on protecting the cultural and environmental values of this special place, while allowing people to experience the natural features and learn about its Indigenous history.

World Heritage Site

The New England group of reserves, including Dorrigo National Park, is one of eight groups of protected areas that comprise the World Heritage Area of the Central Gondwana Rainforest Reserves of Australia. The rainforests of New South Wales are of international significance as:

- outstanding examples of major rainforest types
- sites where rainforest is the main vegetation cover
- sites with outstanding geological or scenic features.

Management of Dorrigo National Park

Objectives for Dorrigo National Park include:

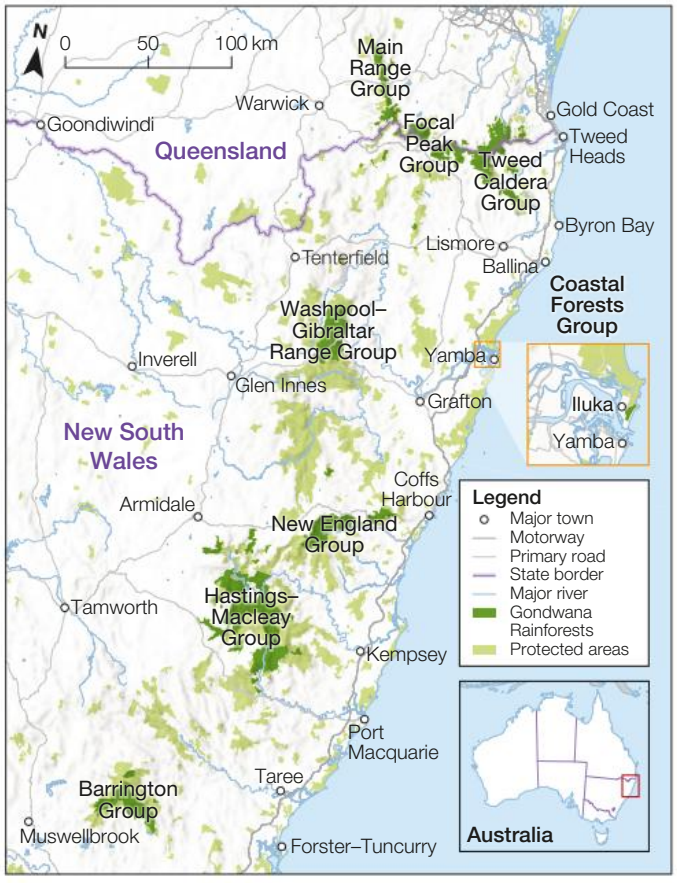
- protection of the physical, biological and scenic features as an interrelated system
- protection of rare, endangered and isolated animal and plant species; locations of these species are mapped and monitored by park staff
- control and eradication of introduced plants and animals using techniques with minimal environmental impact
- maintenance of the water quality of catchments including reduction of pollutant inflows

Source 1: Footbridge and Crystal Falls along the Wonga Walk in the rainforest of Dorrigo National Park, New South Wales

Source 2: Management techniques used for the safety of visitors and protection of the environment: fences, lookouts, walking tracks, seats, information boards, and signs to direct visitors

- conservation of Aboriginal sites in consultation with the Ngiyambandigay Wajaarr Aboriginal Corporation and employment of Gumbaynggirr rangers to share culture and knowledge
- facilitation of visitor access to selected sites of the park
- maintenance of walking tracks and signage indicating grading according to difficulty for walkers.

Gondwana Rainforests of Australia World Heritage-listed areas



Source: Matilda Education Australia/NSW Department of Planning, Industry and Environment

Source 3: Location of the World Heritage-listed Gondwana Rainforests of Australia. This site comprises eight protected areas, including Dorrigo National Park in the New England group of reserves.

Learning ladder 2.7

Sustainable management strategies

1. List three objectives designed to protect Dorrigo National Park from damage.
2. Source 2: What are the defined walking tracks and signs designed to do?
3. Explain the role of the Gumbaynggirr community in the management of the park.
4. Analyse the objectives for the management of Dorrigo National Park. Which objective do you think is most difficult to achieve and why?
5. Source 2: Evaluate the effectiveness of pathways for tourists. How can pathways and tracks best control where visitors to national parks can travel?

Scale

1. Source 1: Is this photo showing a local, state, national or global scale?
2. Source 2: Describe one way Dorrigo National Park is managed on a local scale.
3. Source 3: Explain the location of Dorrigo National Park, referring to where it is on a state and national scale.
4. Dorrigo National Park is part of the Gondwana Rainforests, which are listed as an important world heritage site. Why do you think visitors are allowed to come to such an important site?
5. Is Dorrigo National Park mostly managed on a local, state or national scale? Explain why.

HOW TO

Scale, page 398

How do people manage coasts?

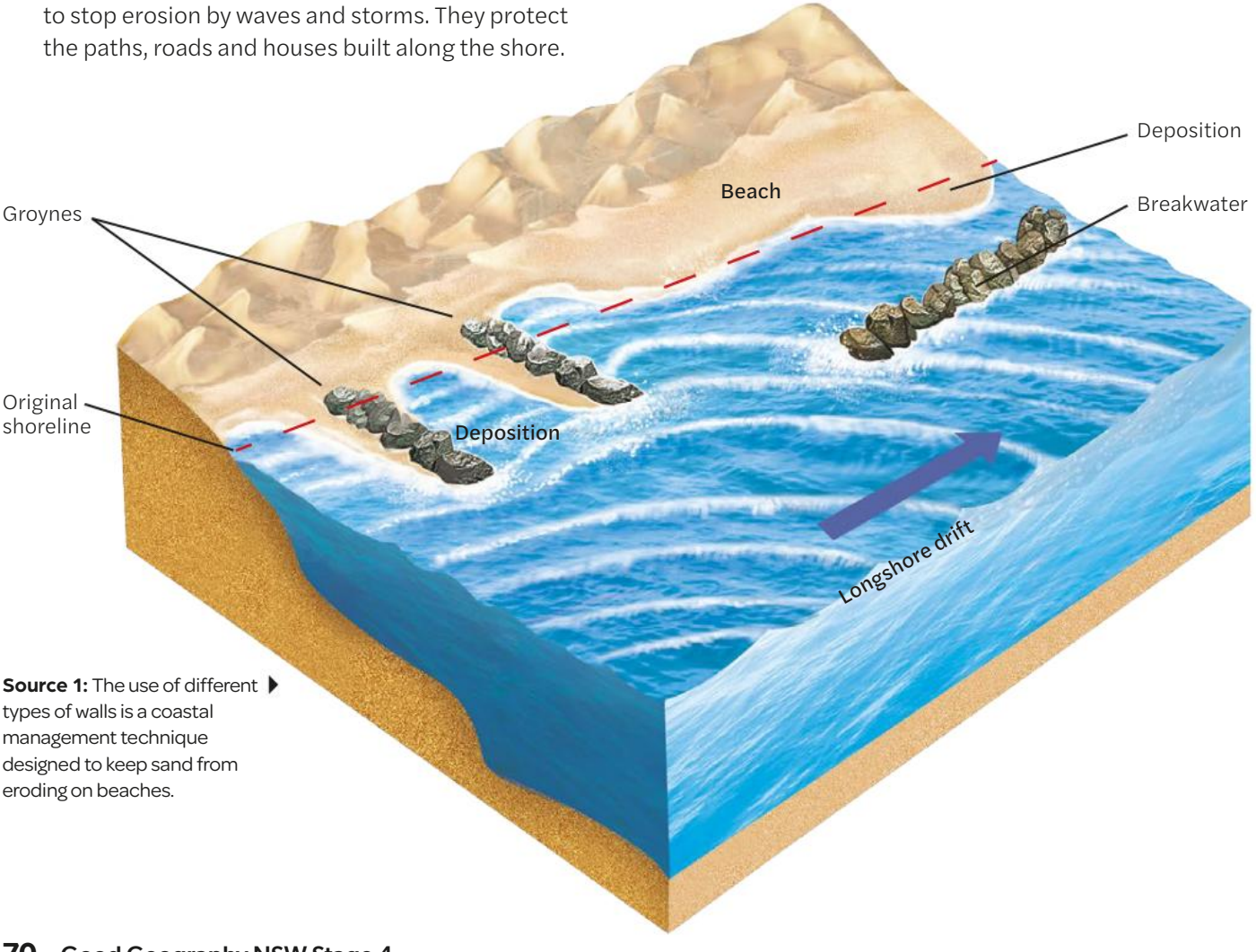
Natural processes such as longshore drift and events such as storms are constantly changing the shape of our coastlines. Settlements built in coastal areas are affected by these changes.

Managing coastlines

Humans have tried to manage coasts to ensure we have beaches to enjoy, that erosion doesn't threaten communities and that sand doesn't clog harbours. To stop or slow the movement of sand, communities construct walls from concrete, rock, timber and sandbags. Solid sea walls deflect wave energy down, scouring sand away and undermining the wall. Loose rock walls help disperse the energy of the wave.

The different types of walls are as follows:

- **Sea walls** run parallel to the shore and are designed to stop erosion by waves and storms. They protect the paths, roads and houses built along the shore.
- **Breakwaters** are rock walls parallel to the beach and located in the water. They are designed to direct the force of the waves at the wall and not at the beach and sand dunes behind it.
- Groynes are walls that extend out from a beach into the sea. They are designed to trap the sand moving along the beach. Groynes also direct waves away from the shore, reducing erosion.
- **Training walls** are built on either side of a river mouth to stop sand from blocking it.



Source 1: The use of different types of walls is a coastal management technique designed to keep sand from eroding on beaches.

Source 2: A huge dredger pumps sand towards the Surfers Paradise coastline to replenish eroded beaches. Sand is dredged from kilometres offshore and pumped back about 50 metres away from the breaking waves to redistribute to the beaches.

Repairing damaged coastlines

Coastal engineers use a number of methods to repair damaged beaches. They can transport sand by truck or **dredge** it from offshore, and then pump it back just offshore to replenish eroded beaches. This process is known as **beach nourishment**. On the Gold Coast, millions of cubic metres of sand have been dredged from the sea floor or transported from other places to restock eroding beaches.

Sand dunes are stabilised and repaired by erecting fences and signs to keep people off the dunes. Replanting sand dunes with vegetation such as coastal grasses and native plants helps bind the sand together and holds it in place. Sand also mounds up against the plants.

Source 3: The North Cronulla sand dune revegetation program involved fencing and replanting.

Source: State of Queensland 2011

Source 4: Plan view of Tweed Heads (NSW) and Coolangatta (Queensland)

Source 5: The Tweed Heads and Coolangatta coastline

Managing the coast at Coolangatta

Coolangatta is a popular tourist resort on Queensland's Gold Coast, just north of Tweed Heads. After many attempts to restore them, the wide beaches along Coolangatta have returned to the way they were 100 years ago.

Changes made along the coastline on the border between Queensland and New South Wales greatly affected the beaches at Coolangatta. In 1962, the training walls on either side of the Tweed River were extended to protect the mouth of the river from a build-up of sand. Unfortunately, **longshore drift** was unable to move sand past the training walls and Greenmount and Kirra beaches quickly disappeared.

In 1972, a groyne was constructed at Kirra Point at the northern end of Coolangatta Beach to help restore sand to Greenmount Beach. The beach expanded as sand accumulated against the groyne. Beach nourishment in 1974, 1989 and 1995 pumped sand onto the beach.

From 2001, sand has been pumped from south of the Tweed River training walls through pipes to Greenmount and Kirra beaches to match the natural longshore drift of sand that was in place before they were built. This project was called Tweed Sand Bypassing. Sand transported by longshore drift is pumped from nearer the shore, along the jetty seen in Sources 4 and 5 and released back into the ocean at the end of the jetty, past the training walls to continue its journey northwards.

▲ **Source 6:** Changes in beaches at Coolangatta from 1935 to 2004

Learning ladder 2.8

Sustainable management strategies

1. List three different techniques used to manage coastlines.
2. Source 1: How are groynes and breakwaters similar and different in managing the coastline?
3. Source 1: Explain what coastal managers are attempting to do using these constructions.
4. Source 2: What is the management strategy shown here? How is this strategy interconnected with the natural process of longshore drift?
5. Create a photo essay illustrating the use of key coastal management strategies in real-life situations. For each photo, describe the management strategy being used and what natural process it is trying to prevent.

Change

1. Source 2: What change is occuring here?
2. How has sand been pumped to Greenmount and Kirra beaches?
3. Sources 4 and 5: Examine the training walls built at the mouth of the Tweed River. Prepare a diagram to explain why the training walls have been built and show where the sand is building up and why.
4. Source 6: How is the Coolangatta coastline now similar to the 1935 profile?
5. Source 6: Examine the two aerial images from 1935 and 2004. Describe the change to Greenmount Beach and explain why it occurred. Outline the management techniques to replenish the beach and explain how they have tried to mirror the natural cycle of sand movement.

HOW TO

Change, page 394; Photo essays, page 419

How do First Nations Peoples care for Country?

First Nations people have been connected to Country and caring for Country for more than 60 000 years. There are many ways that First Nations people continue to care for the diverse landscapes that Australia presents. First Nations people live in all parts of Australia, and each cultural or language group holds knowledge about their unique landscape.

Caring for Country

'Caring for Country' is about knowing and understanding the delicate ecosystems within the environment. Animals, plants, waterways and landforms are all connected through creation stories, as oral traditions and individually as 'being and living as part of Country'. **Elders** and knowledge holders teach particular ways of caring for Country to younger generations. Knowledge holders and cultural obligations still guide communities through deeply understood principles of **sustainability**. Caring for Country also requires an understanding of the bond between people, place and knowledge of Country. The ways that Country is described and cared for is different between First Nations and non-Indigenous people; however, all of us are responsible for Country as is sustains us all.

Where salt water meets freshwater

Many First Nations communities are located on or near coastal and or river regions. These communities benefited from a sustainable landscape that enabled them to feed and nourish their communities and trade with neighbouring communities. Most First Nations people did not travel vast distances as there was a ready-made infrastructure and economic trade system built within Country. D'harawal (Tharawal) and Gandangara peoples still share specialist knowledge in a variety of ways. These urban coastal and river communities are still transmitting and teaching this knowledge to future generations.

Caring for these environments requires an understanding of both Dreaming and the interconnectedness Country has with the living and non-living worlds. Understanding and caring for Country involves cyclical seasonal knowledge, such as breeding cycles and plant life cycles, and associated knowledge such as insects that thrive on native plants, tidal and moon connections to water and seasonal migrations, and the healing and medicinal links to water, animals and plants.

Rivers and mountains

First Nations Peoples have creation stories about rivers and mountains. This relationship with the natural world comes from the belief that all elements of the universe, including humans, plants, animals, landforms and waterways, as well as the Sun, Moon and stars, were created by Ancestral (spirit) beings. These exist as connected entities and form the guiding knowledge that supports First Nations communities to remain sustainable.

The story of Yeperenye the caterpillar and the formation of mountainous landforms located at Mparntwe (Alice Springs) demonstrates the interconnected stories the Arrernte community have transmitted for generations. This story shows why caring and understanding the cycles of the environment, rivers and mountains is so important. Yeperenye is the most important of three caterpillars in this region, and the Dreaming stories are about these caterpillars and a carab beetle creating parts of Tyerretye (MacDonnell Ranges).

D'harawal

Seasons of the year

Compiled by Frances Bodkin
Illustrated by Lorraine Robertson

Time of Ngoonungi – Murrai'yonggory

(cool, getting warmer) The time of the gathering of the flying foxes, when the flying foxes gather in the darkening skies over D'harawal Lands. They come in from the north-east, the north, the north-west and the west, and swirl over the Sydney area in a wonderful, sky-dancing display just after sunset, before setting off for their night-time feeding grounds to the south. But it is also a very important ceremonial time for the D'harawals, which begins with the appearance of the splashes of the bright red Miwa Gawaian (*Telopea speciosissima*) in the bushland.

Time of Parra'dowee – Goray'murrai

(warm and wet) This season begins with the Great Eel Spirit calling his children to him, and the eels that are ready to mate make their way down the rivers and creeks to the ocean. It is the time of the blooming of the Kai'arrewan (*Acacia binervia*) which announces the arrival of fish in the bays and estuaries.

Time of Burran – Gadalung Marool

(hot and dry) The behaviour of the male kangaroos becomes quite aggressive in this season, and it is a sign that the eating of meat is forbidden during this time. This is a health factor; because of the heat of the day, meat does not keep, and the likelihood of food poisoning is high. The blooming of the Weetjellan (*Acacia implexa*) is an important sign that fires must not be lit unless they are on sand only and well away from bushland, and that there will be violent storms and heavy rain, so camping near creeks and rivers is not recommended.

Time of Marrai'gang – Bana'murrai'yung

(wet, becoming cooler) The time when the cries of the Marrai'gang (Quoll) seeking his mate can be heard through the forests and woodlands, and when the lilly pillys ripen on the trees. However, when the lilly pillys start to fall, it is the time to mend the old warm cloaks from last cold season, or make new ones, and begin the yearly trek to the coastal areas.

Time of Burrugin – Tugarah Juli

(cold, frosty, short days) This is the time when the male Burrugin (echidnas) form lines of up to ten as they follow the female through the woodlands in an effort to wear her down and mate with her. It is also when the Burringoa (*Eucalyptus tereticornis*) starts to produce flowers, indicating that it is a time to collect the nectar of certain plants for the ceremonies that will begin to take place during the next season. It is also a warning not to eat shellfish again until the Boo'kerrikin blooms.

Time of Wiritjiribin – Tugarah Gunya'marri

(cold and windy) The lyrebird calls ring out through the bushland as he builds his dancing mounds to attract his potential mates. It is the time of the flowering of the Marrai'uo (*Acacia floribunda*), which is a sign that the fish are running in the rivers. At the end of this time, the Boo'kerrikin (*Acacia decurrens*) flowers, which indicates the end of the cold, windy weather, and the beginning of the gentle spring rains.

Source 1: 'The yearly calendar does not rely upon dates in months and weeks, or even an understanding of the solstices, but on key events that occur in the environment. These events involve specific plant flowerings and fruitings, and noticeable quirks of animal behaviour that occur only at certain times of the year. The calendar is not set rigidly in time, but responds to the triggers of the environment, a response to the Land of the D'harawal Peoples as they moved through the environment, observing the signs of these changes.' Frances Bodkin and Lorraine Robertson, *D'harawal Climate and Natural Resources*.

Included are stories about passes, rock piles, trees and woodlands in the Mparntwe region. There are also places in between like Ellery Creek Big Hole, which cuts through a gorge in Tyerretye, the West MacDonnell Ranges, and these require special care.

Knowing stories is another important feature of caring for Country. Many stories hold information to help understand key features and topographic knowledge of rivers and mountains.

Deserts

An Australian geographical feature that has changed dramatically is the desert region of Lake Mungo in NSW. It is the place where archaeological evidence of human occupation dating from 45 000 to 60 000 years ago is visible to the public. Mungo is part of the Willandra Lakes Region of NSW. The vast area is home to the Paakantji, Ngyiampaa and Mutthi Mutthi, and care for Lake Mungo is not only about maintaining the spiritual significance, but its protection as a World Heritage Site. The site exemplifies major stages in the Earth's evolutionary history, direct links to long-held cultural traditions, archaeological significance and clear evidence of ongoing geological processes.

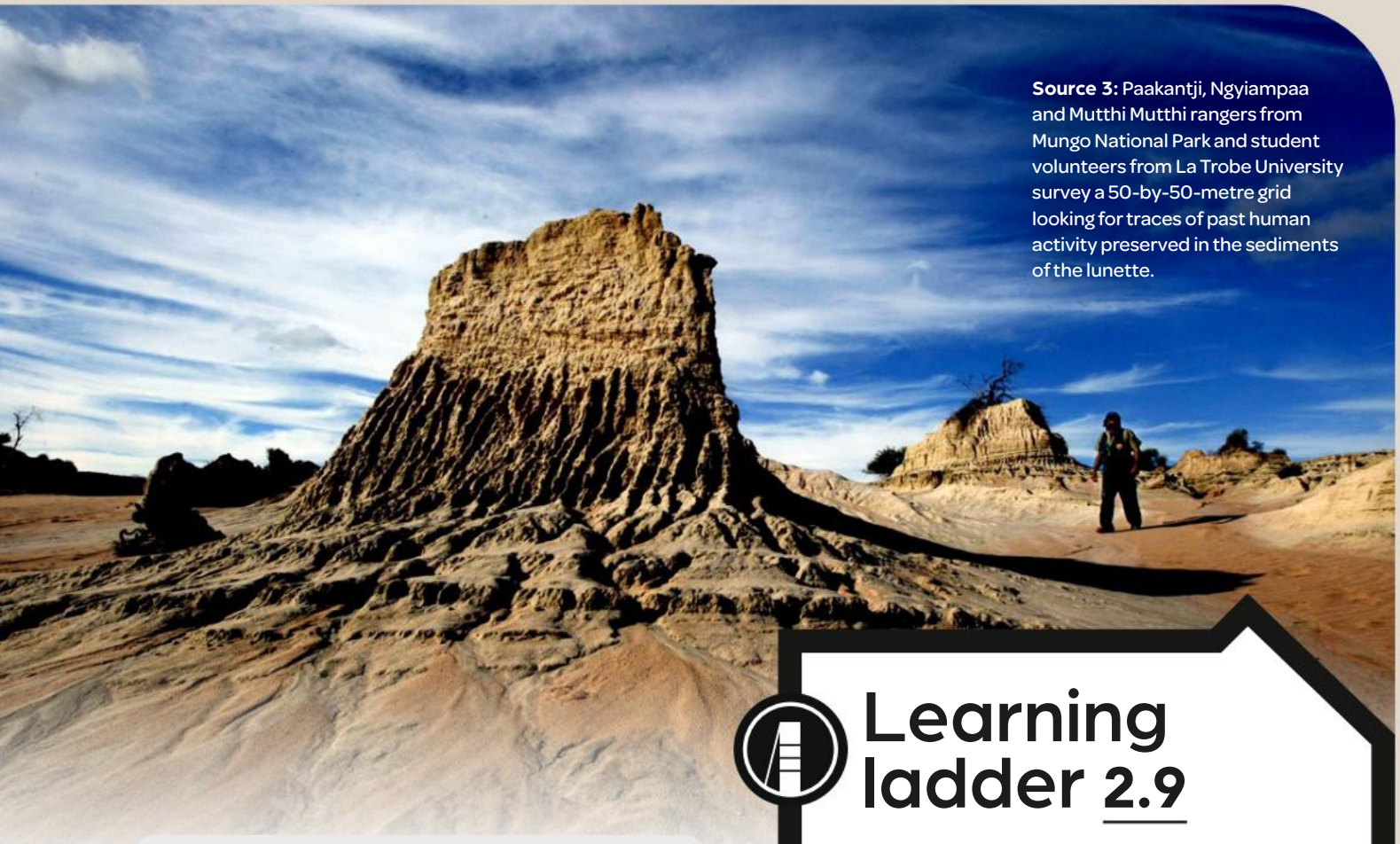
Representatives of the Paakantji, Ngyiampaa and Mutthi Mutthi work as rangers at Lake Mungo to share some of the cultural history and take part in the ongoing research and management of the Mungo National Park and the Willandra Lakes Region World Heritage Area.

Rainforests

There are many types of rainforests (subtropical, littoral, dry, warm and cool) and the First Nations communities that are entrusted to care for them have ongoing connections to the Dreaming stories and cultural knowledge that makes them continue to be part of Australia's unique landscape.

Dorrigo National Park, part of the Gondwana Rainforests of Australia, is a World Heritage Area located on the NSW mid-north coast region (see page 68). Dorrigo National Park includes both temperate rainforest and subtropical rainforest. Traditional Custodians of this area are the Gumbaynggirr community. They care for unique plants, animals and rock formations in the region. Native marsupials, including the swamp wallaby, long-nosed potoroo and spotted-tail quoll, can be found in the area.

Source 2: Ellery Creek Big Hole (Udepata) is a permanent waterhole in the West MacDonnell Ranges in the Northern Territory. It is a special meeting place for the Arrernte people. The main Dreaming story at Udepata is Honey Ant Dreaming, and a Fish Dreaming story is also associated with the waterhole.



Source 3: Paakantji, Ngyiampaa and Mutthi Mutthi rangers from Mungo National Park and student volunteers from La Trobe University survey a 50-by-50-metre grid looking for traces of past human activity preserved in the sediments of the lunette.

Giinagay! My name is Uncle Mark Flanders and I'd like to welcome you to the Gumbaynggirr Aboriginal Country, my Country. We are saltwater–freshwater people. We are land and sea people. We are custodians of our lands and waters and we are caretakers of our lands and waters. This bush you're looking at, this is our calendar. This told us when the foods were available, when to move camp; the seasonal patterns determined what we were doing. At winter time, we travelled from the mountains down into the ocean because there's lots more food available. In the summertime, before the summer, we'd travel back up into the mountains here again. Come up here and visit this beautiful rainforest up here on the escarpment that we have. The foods are still here, our medicines are still here. Our culture is still strong in this area. Come up here and visit. You'll enjoy it.

Source 4: Uncle Mark Flanders shares his Gumbaynggirr Culture at Dorrigo National Park.

Learning ladder 2.9

First Nations Peoples' interaction with Country

1. Source 1: At what time of year do the D'harawal head to the coast?
2. How does the story of Yeperenye link the Arrernte people to the land?
3. Describe one method used by First Nations Peoples to care for Country.
4. Source 4: Explain how Gumbaynggirr use geographical knowledge to manage Country.
5. Source 3: Why were the Paakantji, Ngyiampaa and Mutthi Mutthi Peoples important in establishing the evolution of the Lake Mungo region and its cultural traditions? What role do they continue to play today?

Environment

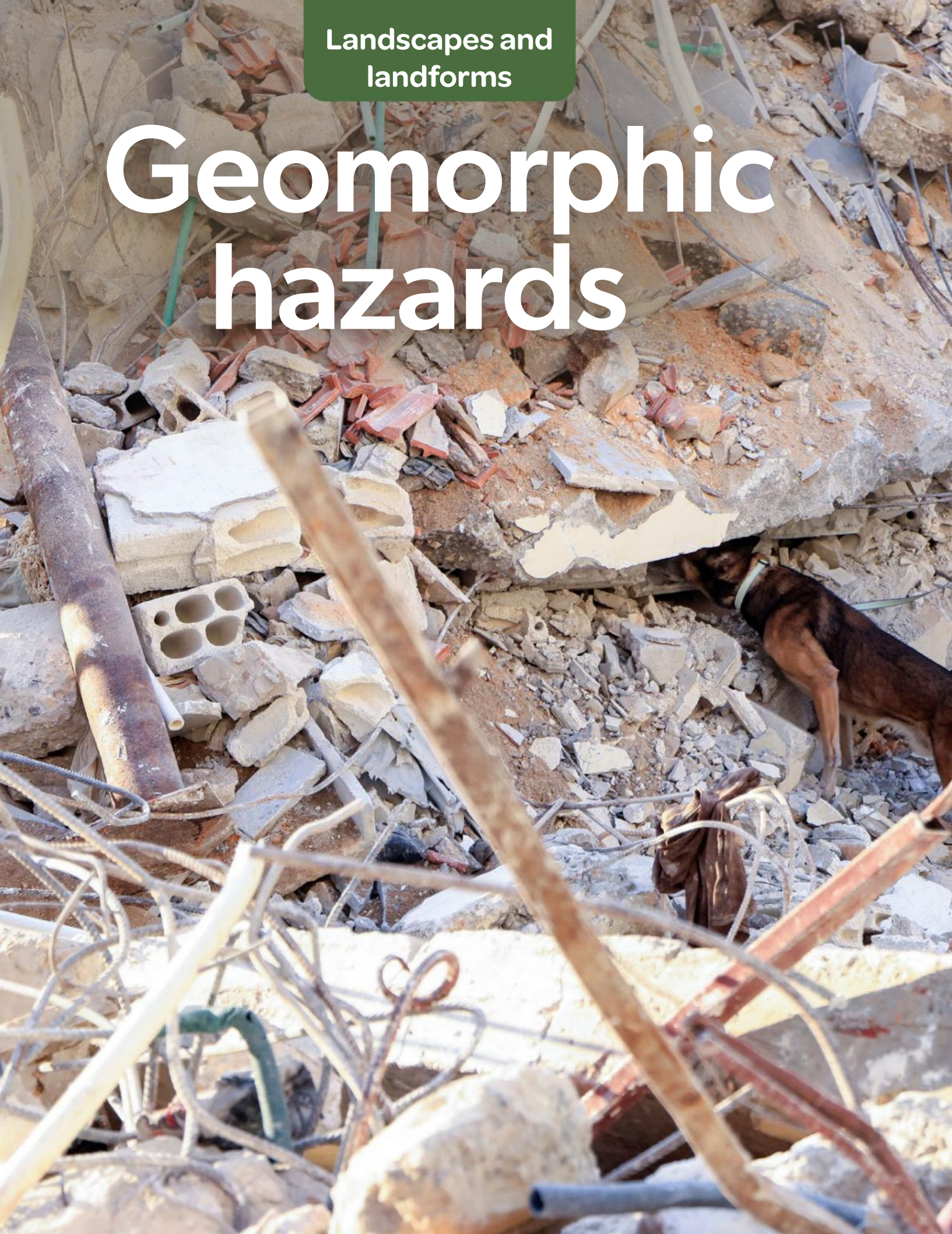
1. Source 2: What environment is shown here?
2. Give three examples of different environments that First Nations Peoples call Country.
3. According to Arrernte Dreaming, how did the MacDonnell Ranges form?
4. How is knowledge of Country essential for understanding the processes of change at Lake Mungo?
5. Source 1: How is the D'harawal calendar reliant on the enviroment as signals for action?

HOW TO

Environment, page 396

Landscapes and landforms

Geomorphic hazards



3

HOW DO WE RESPOND TO EARTHQUAKE DISASTERS? 92

How can I understand geomorphic hazards?

Geomorphic hazards such as volcanic eruptions, earthquakes, tsunamis, landslides and avalanches occur across the Earth every day. A hazard becomes a disaster when it causes death, loss of livelihood and damage to property. As disasters are unpredictable, preventative measures from the local to the global scale aim to minimise losses.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information
	Outcomes					Geographical tools and inquiry

Source 1: Following a 6.8-magnitude earthquake that struck Dingri County in Xizang Autonomous Region, south-west China, rescuers transfer the personal belongings of earthquake-affected residents to a safe area on 11 January 2025 in Xigaze City, Xizang, China.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

3.1

What are geomorphic hazards?

Geomorphic hazards, or geohazards, are dangers that originate at or near the Earth's surface, such as volcanic eruptions, earthquakes and landslides. They pose a great threat to people and environments.

Volcanoes

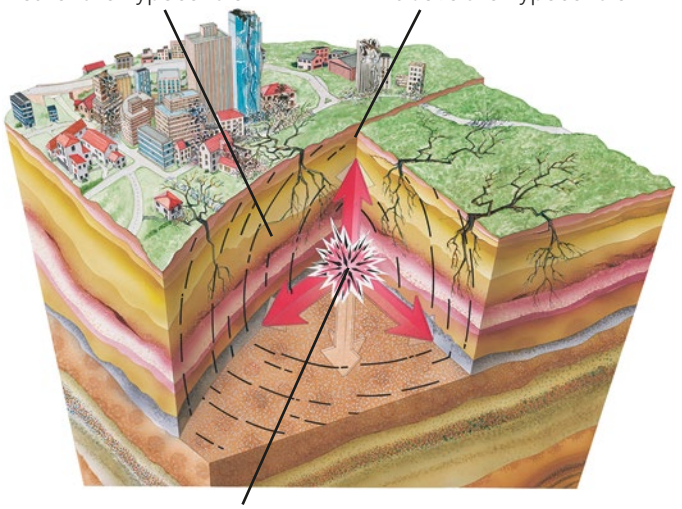
Volcanoes pose a huge threat to nearby communities. Dangerous **pyroclastic flows**, **volcanic bombs**, **lava** flows and volcanic gases are an immediate threat to people. Other **geomorphic hazards** can follow a volcanic eruption, including **lahars** (mudflows), **landslides** and even **tsunamis** caused by ocean-floor volcanic eruptions.

Earthquakes

Earthquakes are one of the deadliest geomorphic hazards. An earthquake occurs when **seismic waves** shake the surface of the Earth. These waves are generated from the sudden release of energy in or beneath the Earth's crust. The shaking can cause massive damage to buildings and large death tolls. Earthquakes can also trigger landslides and tsunamis.

Source 1: Ash-covered Aeta people were forced from their villages on the slopes of Mount Pinatubo (see pages 84–5) following a volcanic eruption in 1991. More than 200 000 Aeta lost their homes and were forced into resettlement camps or moved to urban areas.

Source 2: Rescue workers digging in the rubble of a collapsed house following a 7.8-magnitude earthquake that hit Türkiye and Syria in 2023. More than 1.5 million people were left homeless and nearly 60 000 people died.



Source 3: An earthquake in action

A major earthquake struck Haiti's capital, Port-au-Prince, in January 2010. Up to 85 000 people died and another million were made homeless. Haiti is a less economically developed country (LEDC) and most of its population live in poverty. Those left homeless by the earthquake could not afford to move elsewhere. In the devastated urban areas, displaced Haitians were forced into crowded and unsanitary camps in city parks, and they were living in self-made structures or donated tents.

Humanitarian organisations such as the United Nations and the Red Cross supplied aid. Countries sent doctors, relief workers and supplies in the wake of the disaster in Haiti. Aid agencies struggled to supply the most basic needs, and in October contaminated food and water caused an outbreak of cholera in the camps, claiming hundreds of lives. Two years after the earthquake, more than half a million people were still living in **refugee** camps.

Landslides

A landslide is the mass movement of soil, rock and debris down a slope. In most cases, landslides are caused by extended rainfall or flooding, where the soil becomes saturated and heavy. Landslides can also be triggered by earthquakes, volcanic eruptions or cutting into slopes for buildings and roads. In 1997, a landslide at Thredbo in New South Wales destroyed two buildings and killed 18 people. Miraculously, rescue workers pulled the sole survivor, Stuart Diver, from the rubble after three days in sub-zero temperatures.

Learning ladder 3.1

Sustainable management strategies

1. List the threats from a volcanic eruption.
2. What made the earthquake disaster in Haiti more difficult to deal with? What more could have been done?
3. Compare the response to the Mount Pinatubo and Haiti disasters. What similarities are there?
4. What human factor influences landslides and how can this factor be reduced?
5. Source 2: What rules need to be made for buildings in earthquake-prone areas? Why might this be difficult to enforce in countries like Haiti?

Change

1. List one other geomorphic hazard that earthquakes can trigger.
2. Source 1: Describe how change in this environment has occurred.
3. Source 3: Explain how earthquakes work and why they cause so much damage.
4. Source 2: What are the implications of change in this environment for rescue workers?
5. Source 1: Evaluate the implications of change for the Aeta people and suggest actions that might have been taken to assist them.

HOW TO
Change, page 394

3.2

What happens when a volcano erupts?

Volcanic eruptions are one of the most dangerous **natural hazards** on Earth. Explosive eruptions can completely destroy the surrounding area and ash clouds can travel for thousands of kilometres. Other eruptions may just produce small ash clouds or slow-flowing streams of lava.

The main categories of volcanic eruptions are:

- **effusive eruptions** where magma flows out of the volcano as a lava, also known as Hawaiian eruptions
- **explosive eruptions**, either where magma full of bubbling gas explodes as it reaches the surface, also called a Plinian eruption, or where magma reacts with water to create a steam-blast, also called a **phreatic eruption**.

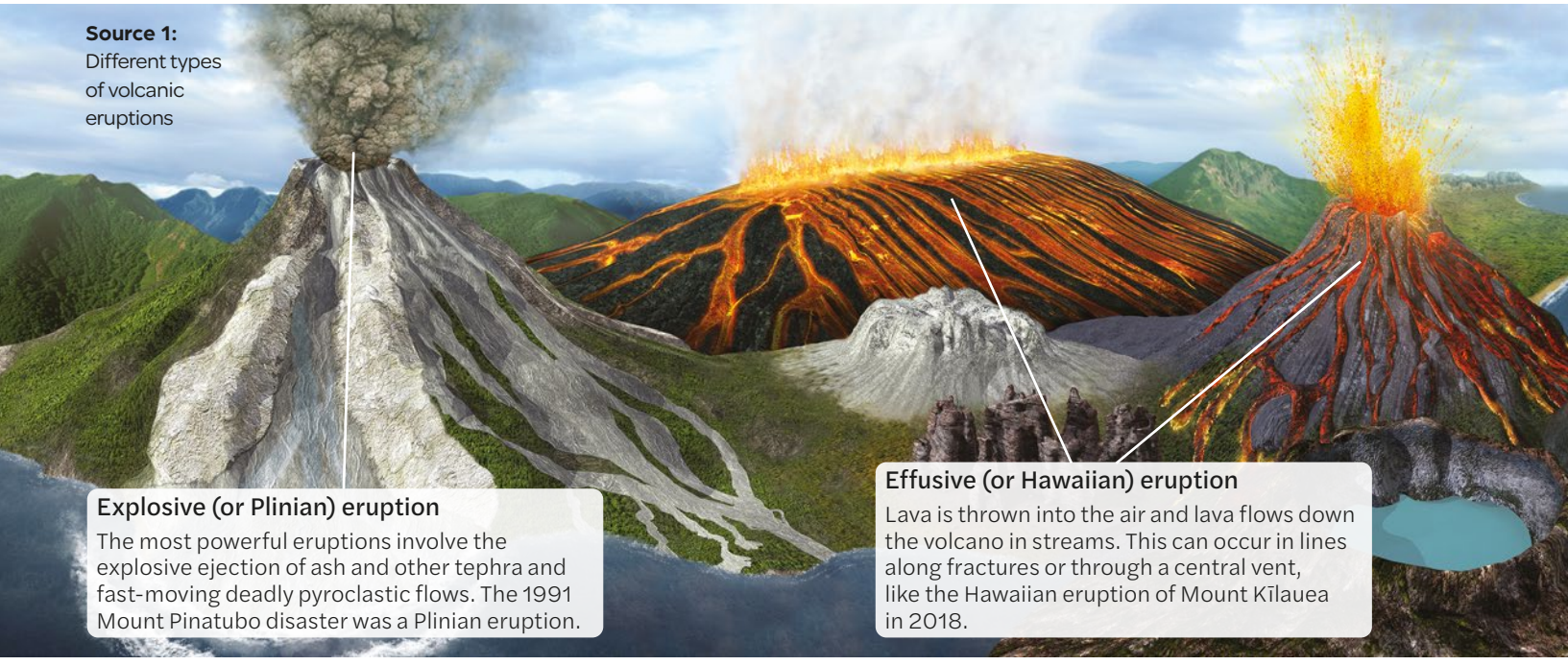
The **magma** that feeds volcanoes along plate boundaries generally contains a lot of gas. If magma moves up through the volcano's vent slowly, the gases are released slowly and escape safely. However, if magma moves to the surface quickly, most gases are retained and will explode if there is enough pressure. Explosive volcanic eruptions push huge amounts of ash and gas high into the air. Powerful eruptions can launch large rocks, known as volcanic bombs, into the air.

Mount Pinatubo erupts

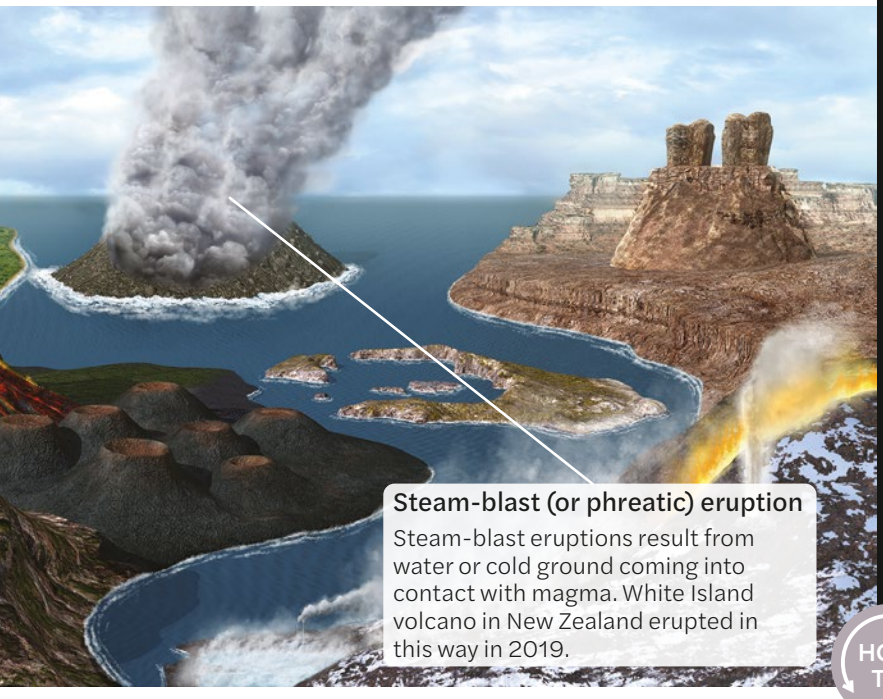
When Mount Pinatubo erupted in the Philippines in 1991, it ejected more than 5 cubic kilometres of material from its vent, and the ash cloud rose 35 kilometres into the air. An ash and sulphur-dioxide gas cloud travelled several times around the globe, blocking the sun and lowering world temperatures by 0.5°C for a year.

A pyroclastic flow raced down Mount Pinatubo, wiping out villages and everything else in its way. A pyroclastic flow is a huge avalanche of hot gas and rock particles, known as **tephra**, that can move at speeds of up to 700 kilometres per hour and heat to temperatures of 1000°C, destroying everything is its path. Near Mount Pinatubo, valleys were filled with ash and rock up to 200 metres thick. Heavy rains washed this material onto lowlands in fast-moving mudflows called lahars, creating even more damage than the eruption. More than 700 lives and 100 000 homes were lost in the Mount Pinatubo eruption.

Source 1: Different types of volcanic eruptions



Source 2: The Mount Pinatubo eruption in 1991 was the second-largest volcanic eruption of the 20th century.



Steam-blast (or phreatic) eruption
Steam-blast eruptions result from water or cold ground coming into contact with magma. White Island volcano in New Zealand erupted in this way in 2019.

Learning ladder 3.2

Processes that transform, people, places and environments

1. Source 2: Was the eruption of Mount Pinatubo in 1991 an effusive or explosive eruption? Explain.
2. What is a pyroclastic flow and why is it so dangerous?
3. How does the speed of moving magma influence volcanic eruptions?
4. What impact did Mount Pinatubo's eruption have:
   - **a** locally
   - **b** globally?
5. More than 700 lives were lost in the Mount Pinatubo eruption in 1991 and no lives were lost in the Mount Kīlauea eruption in 2018. Explain why there is such a difference.

Environment

1. Source 1: What two environmental factors are present in a steam-blast eruption?
2. Describe the common factors in volcanic eruptions.
3. Source 1: Explain the processes behind an effusive eruption.
4. What are lahars and how were they even more deadly than the Mount Pinatubo eruption?

HOW TO
Environment, page 396

Case study

Why do volcanoes erupt in Indonesia?

Indonesia, an **archipelago** comprising thousands of islands to the north of Australia, has more active volcanoes than any other country. Volcanoes bring benefits to 280 million Indonesians, but the high population density of 160 people per square kilometre means large volcanic eruptions become disasters that destroy lives, property and incomes.

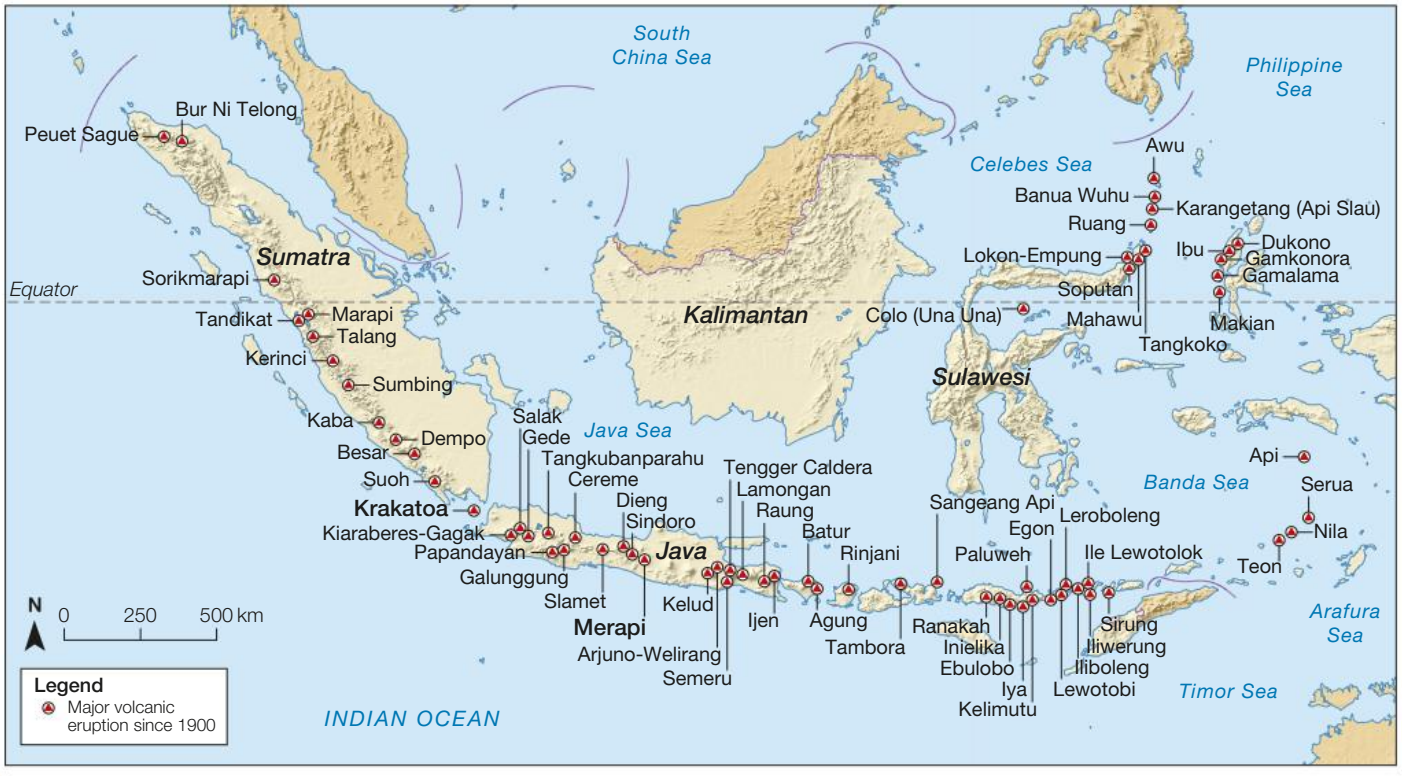
Active, dormant and extinct volcanoes

Indonesia lies on an active tectonic plate boundary, a section of a 40 000 kilometre-long tectonic collision zone (converging plates) circling the Pacific Ocean, known as the '**Ring of Fire**'. The subduction of the Indo-Australian Plate beneath the Pacific Plate results in both explosive (blasts of ash) and effusive (lava flows) eruptions.

There are currently 55 recently active volcanoes in Indonesia, 40 in Japan and 39 in the United States. An active volcano is one that has erupted in the past 10 000 years, or recently (since 1960), or could potentially erupt in the future. Many lie dormant for years. On the Island of Bali, for example, over 65 years separated the disastrous eruption of Mt Agung in 1963–64 and the recent and continuous lava flows and ash plumes between 2017 and 2019.

The most famous and deadly volcanic eruption in Indonesia was Krakatoa in 1815, which blew the island apart and killed over 35 000 people. It now lies dormant, but could erupt again. The most active volcano is Mount Merapi, with a history of eruptions since 1548. It has been on high-level alert status since 2020 following increased activity, and erupted again in 2025.

Volcanic eruptions in Indonesia since 1900



Source: Matilda Education Australia

▲ **Source 1:** The location and pattern of major volcanic eruptions in Indonesia since 1900

Ashfall from Mount Tambora eruption, 1815

Source: Matilda Education Australia

▲ **Source 2:** The calculated thickness of ashfalls following the 1815 eruption of Mount Tambora. Ashfall information is provided by The Indonesian Center for Volcanology and Geological Hazard Mitigation, the Darwin Volcanic Ash Advisory Centre and satellite imagery.

Local and global impacts

Volcanoes create fertile soils that support intensive agriculture and the livelihoods of millions of Indonesian farmers. Sulphur, an economically valuable mineral, is mined from active volcanoes in Indonesia. Many volcanoes are popular tourist attractions with spiritual significance to islanders. Eruptions also have human, economic and environmental impacts.

Ash can suffocate people and wildlife, and toxic fumes cause ongoing health problems or death. Mapping ash falls and monitoring ash clouds allows for health warnings to reduce human impacts. Interruptions to air traffic and tourism are global impacts of large ash plumes. Lava and ash destroy property and lives, force evacuations and interrupt economic activities, often for years following lava flows.

Source 3: Volcanic materials spewed out from Mount Merapi are seen at a nearby village in Yogyakarta, 11 March 2023

Learning ladder 3.3

Characteristics of places and environments

1. Name the four largest islands of Indonesia shown in Source 1.
2. Describe the location of Krakatoa and Merapi volcanoes.
3. Sources 1 and 2: Describe the following spatial patterns:
   - i Volcanic eruptions since 1960. Refer to the Equator and Indonesian islands.
   - ii The spread of ashfalls from Mount Tambora in 1815.
4. Create a table to summarise the benefits and disadvantages of volcanoes to Indonesians. Add a row to include international impacts.
5. Assess the values of volcanoes in Indonesia.

Interconnection

1. How are all of the volcanoes in Sumatra and Java connected?
2. Source 2: Why is the thickness of ash from volcanic eruptions important to know?
3. Explain the connection between international travel to Australia and Indonesia and volcanic interruptions.
4. Create a flow diagram to show how a subducting plate leads to a volcanic eruption which then benefits Indonesian people.

HOW TO

Interconnection, page 392

How can I use contour maps to study volcanoes?

Geographers use **contour lines** and shading to represent three-dimensional shapes on a flat piece of paper. We can locate volcanic mountains and their calderas on topographic maps by interpreting the contour patterns.

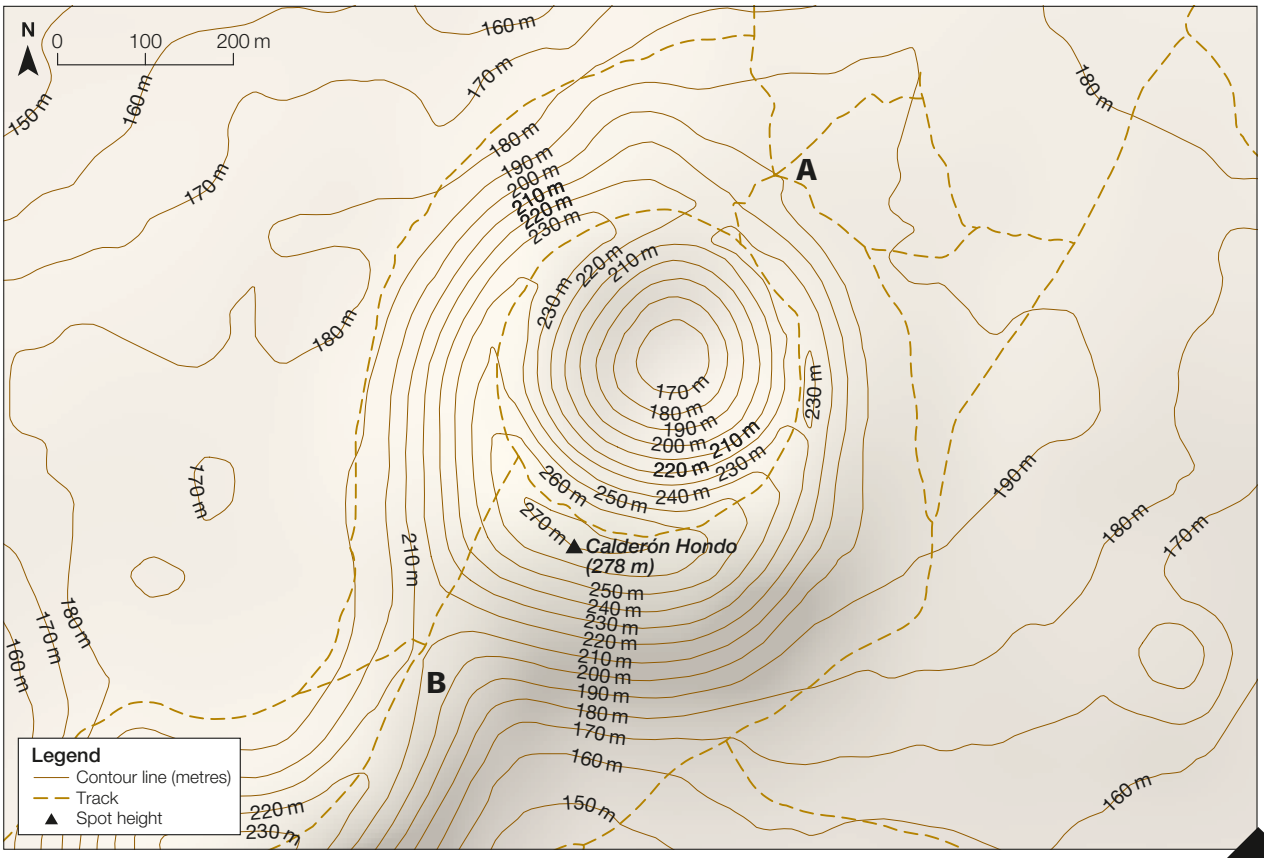
The shape of volcanoes

Volcanoes are shaped like an upside-down ice-cream cone with a bowl-shaped crater on top. During a volcanic eruption, magma and volcanic gases rise from under the ground through vents to the crater, where gases escape into the atmosphere and molten magma escapes as lava. The volcano we typically think of is a **stratovolcano**, with a tall cone shape and a small crater at the top. The cooled lava builds up through many many eruptions to form a cone.

Calderas such as Calderón Hondo (see Source 1) are different. When Calderón Hondo erupted, so much magma came to the surface that the surface sank to form a bowl shape called a caldera.

Source 1: Calderón Hondo is a 278-metre-high volcano with a larger crater known as a caldera on top. The volcanic caldera, and one of eight volcanoes on the island of Fuerteventura, is part of the Canary Islands off the north-west African coast.

Contour map of Calderón Hondo



Source: Matilda Education Australia

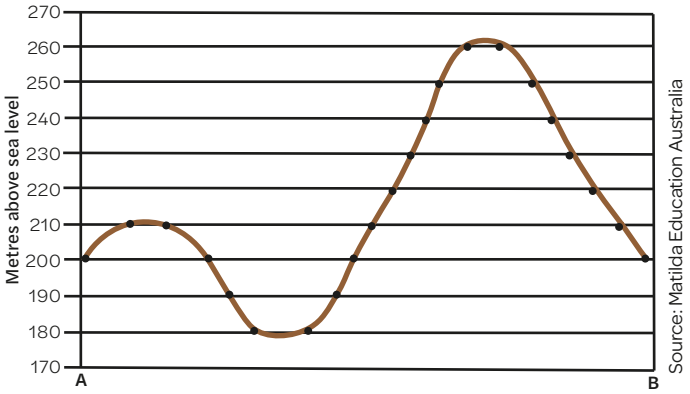
Source 2: Calderón Hondo contour map

Using contour lines to show shape

The distinctive shape of volcanoes is easy to spot on a contour map, where lines join places of the same height above sea level. A pattern of concentric circles in Source 2 indicates a volcano or a round hill or mountain. Instead of building to a peak, Calderón Hondo has a bowl-shaped caldera, indicated where the contour lines decrease rather than increase. The map is also enhanced by shading that clearly shows the depression on top of the volcano.

The cross-section from point A to point B in Source 3 shows the dip in landscape where the caldera has formed.

Cross-section of Calderón Hondo



Source: Matilda Education Australia

▲ **Source 3:** Cross-section of Calderón Hondo from points marked A to B in Source 2

Learning ladder 3.4

Representing and communicating information

1. What are contour lines?
2. Source 2:
   - **a** What is the typical shape of a volcano on a contour map?
   - **b** Which two methods has the cartographer used to show the caldera on the map?
   - **c** What is the lowest point of the caldera?
   - **d** What is the distance between points A and B?
3. Source 3:
   - **a** How deep is the caldera?
   - **b** What is the difference in height between the two rims of the caldera?
4. Sources 1–3:
   - **a** From which direction was the photograph in Source 1 taken?
   - **b** In which direction would you travel from point A to point B?

HOW TO

Cross-sections, page 410

3.5

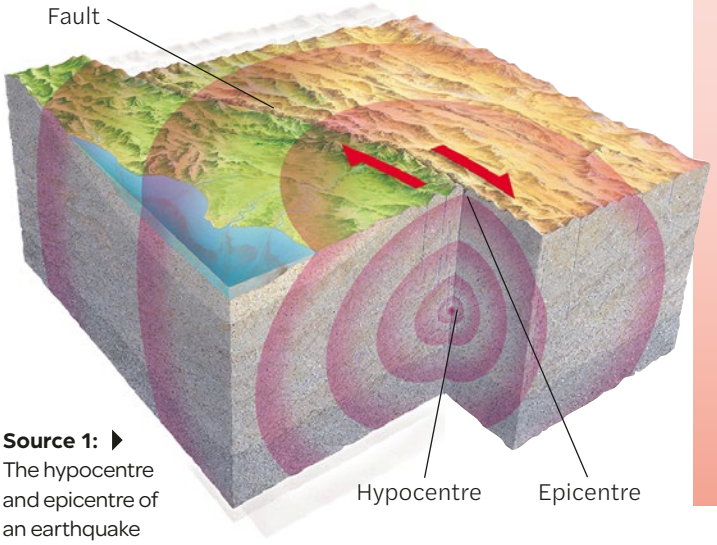
How and where do earthquakes occur?

Earthquakes are one of the deadlist geomorphic hazards, with thousands occurring every day as the Earth moves along fault lines. Large magnitude earthquakes can destroy nearby settlements and trigger tsunamis that can damage areas thousands of kilometres away.

Causes and spatial patterns

The Earth's crust is dynamic, with the tectonic plates continually and slowly moving around on the mantle below. At the boundaries between plates, the fault zones and the crustal rocks interact, colliding and often sliding against each other. In these locations plates can get stuck, causing pressure to build up as they try to move. When plates move again or a plate breaks, the movement is usually sudden and sends shock waves through the crust. A similar process occurs along fault lines within tectonic plates. As it is located at the middle of a tectonic plate, these are the type of earthquakes experienced in Australia.

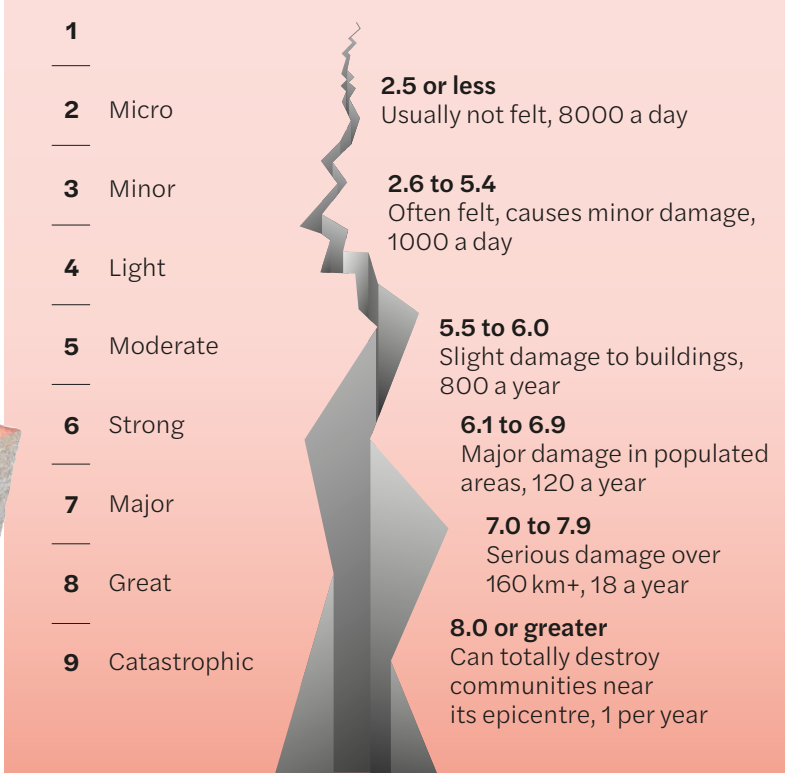
The location within the crust where the earthquake begins is the **hypocentre**, while the location directly above this on the Earth's surface is the **epicentre**. A naturally occurring earthquake, also called a tectonic earthquake, may coincide with the location of volcanic activity, particularly around the Pacific Ocean rim, where 80 per cent of large earthquakes occur. Other large earthquakes occur along the mountainous belt running through the European Alps, the Himalayas and Asia where tectonic plates collide. Random earthquakes are also caused by human activities such as oil drilling, fracking, mine blasting and underwater seismic testing.



Source 1: The hypocentre and epicentre of an earthquake

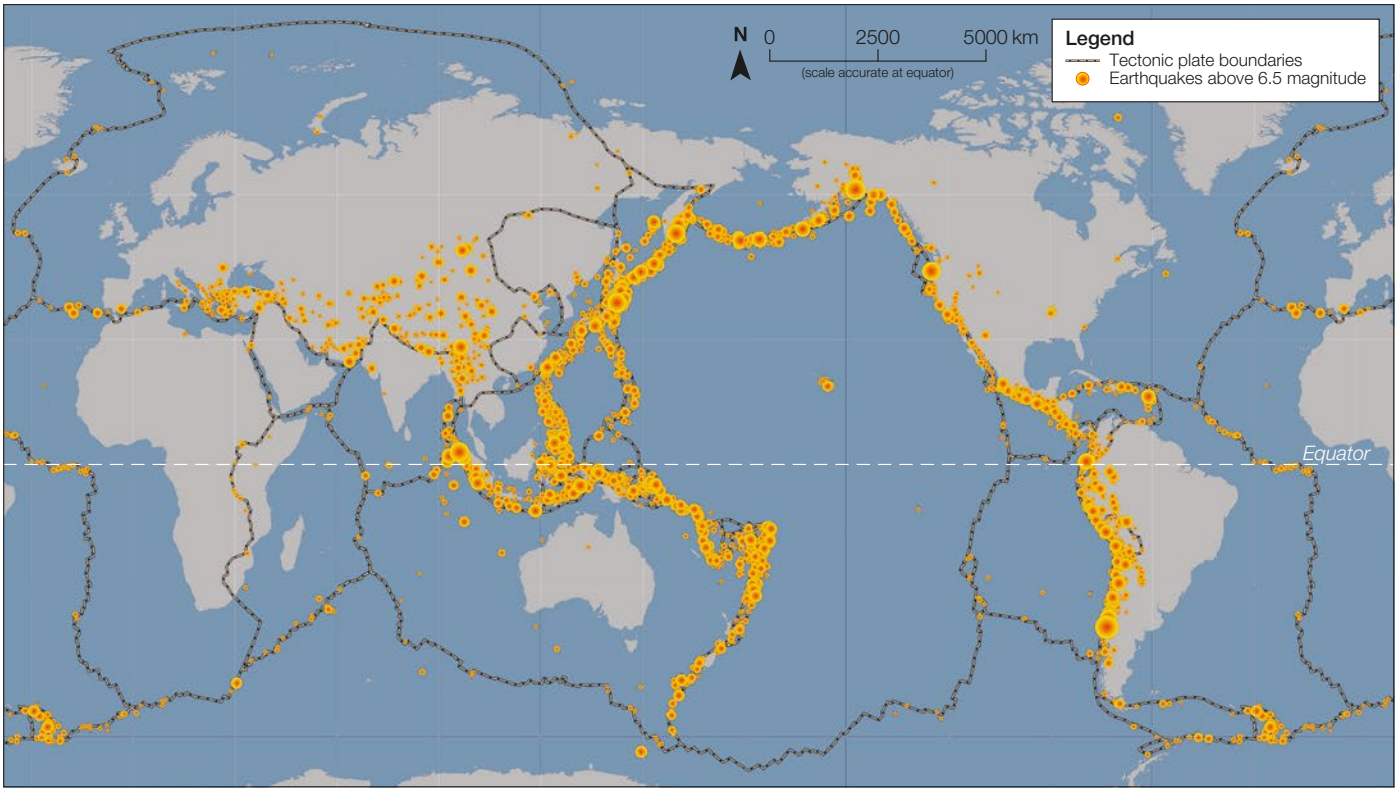
Measuring earthquakes

The energy released by earthquakes radiates outwards in seismic waves. Seismometers record earthquakes as zig-zag lines that increase in size with the magnitude (strength) of the waves. These are reported on the Richter Scale, used to compare different earthquakes. On this scale, the magnitude of earthquakes at each level is ten times greater than the previous one. For example, a magnitude 7 is 10 times stronger than a magnitude 6, and 100 times stronger than a magnitude 5. Scientists also assign a magnitude rating based on the strength and duration of seismic waves. A quake measuring 2.6 to 5.4 is considered minor or light, and 7 to 7.9 a major eruption. A magnitude 9.5 earthquake in Chile in 1960



▲ **Source 2:** Earthquake magnitude, frequency and impacts

Major earthquakes, 1900–2017



Source: Alamy

▲ **Source 3:** Major earthquakes and their magnitude, 1900–2017

was the strongest ever recorded. Aftershocks follow earthquakes, gradually diminishing in power after the main hazard event. Pre-shocks can help with early warning systems.

Impacts and responses

According to the World Health Organization, earthquakes cause over 50 per cent of deaths from natural disasters, with around 750 000 earthquake-related deaths occurring between 1998 and 2017. Deaths are caused by collapsing buildings and infrastructure, as well as related mudslides, fires and tsunamis. The impact is influenced by magnitude, depth below the surface, rock structure, land use and population density. Although earthquakes cannot be prevented, damage and loss of life can be minimised with early warning systems, earthquake-proof buildings and well-planned evacuation procedures.

Learning ladder 3.5

Processes that transform people, places and environments

1. Define fault zone, seismic waves, hypocentre and epicentre.
2. Describe how tectonic plate movements cause earthquakes.
3. Source 2: Explain how earthquakes change places.
4. Source 2: Explain the relationship between the magnitude of earthquakes and the damage caused.
5. Analyse the factors that influence the impact of earthquakes on people, places and environments.

Space

1. Source 1: Describe the pattern of seismic waves around the hypocentre and epicentre of an earthquake.
2. Source 3:
   - **a** Analyse the spatial distribution of major earthquakes at a global scale.
   - **b** Explain why Australia experiences fewer earthquakes than New Zealand.
3. Compare the spatial distribution of earthquakes and volcanoes in Indonesia using Source 3 and Source 1 on page 86.

Space, page 388

HOW TO

Case study

What was the impact of the 2023 earthquake in Türkiye and Syria?

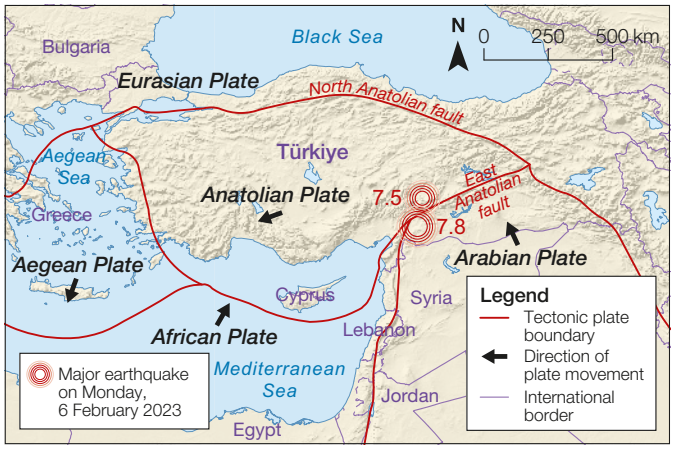
On 6 February 2023, a magnitude 7.8 earthquake hit southern Türkiye and northern Syria leading to widespread damage over 350 000 square kilometres, killing 59 259 people and leaving 1.5 million people homeless in one of the deadliest disasters of the 21st century.

The earthquake

The M7.8 earthquake is the largest in Türkiye since 1939. The epicentre was close to Kahramanmaras in southern Türkiye, near the Syrian border. The earthquake hypocentre was 10 kilometres below the surface. Shallow earthquakes such as this are more damaging than deeper earthquakes because the seismic waves have less distance to lose energy. It was followed by a M7.7 earthquake hours later, 95 kilometres from the first epicentre, and 30 000 aftershocks in the three months that followed.

The sequence of earthquakes was the result of shallow **strike–slip faulting**, where parallel rock masses slipped past one another along the East Anatolian fault. The earthquake opened two enormous cracks, known as **fissures**, on the Earth's surface near the Türkiye–Syria border. The fissures were up to 7 metres wide and 300 kilometres long.

Fault lines and tectonic plates, Türkiye



Source: Matilda Education Australia

▲ **Source 1:** Map of Türkiye's fault lines and tectonic plates

Impacts

The earthquakes caused widespread damage over about 350 000 square kilometres. More than 160 000 buildings collapsed or were severely damaged, leaving 1.5 million people homeless. The death toll was 50 783 in Türkiye and 8476 in Syria – a total of 59 259 people. The damage bill is estimated at US$119 billion.

Roads and communications damaged by the earthquakes and winter storms hampered rescue efforts. Türkiye's Disaster and Emergency Management Presidency's team of rescue and relief workers included a 60 000-strong search-and-rescue team, 5000 health workers and 30 000 volunteers. A further 141 000 people from 94 countries joined the rescue and relief effort.

Some places, such as Japan and California, have warning systems that can warn of an incoming earthquake up to a minute before it starts. These systems turn street lights red and bring trains to a halt. Türkiye did not have these systems in place.

Following a large earthquake in 1999, the Turkish government implemented a series of building codes to improve the rigidity of buildings to better withstand earthquakes. This meant any new buildings had to include at least one of the following designs:

- Structurally tie walls and floors together, using more steel than concrete.
- Design materials and layouts so opposite walls of a building move together during seismic activity, rather than apart as regular buildings do. This prevents buildings splitting and inner floors collapsing on each other.
- Deepen the foundations of a building so they are connected to bedrock.
- Build on flexible pads to isolate the building from ground motion.

However, these design changes can increase building costs by 20 per cent or more. Many builders chose to pay a cheaper 'construction amnesty', where they were given approval to build without these structural designs. Further, many journalists have reported that the building codes were not strictly enforced. This resulted in more collapsed buildings, more damaged infrastructure and increased debris to sift through to find survivors.

▲ **Source 3:** Oblique aerial view of rescue effort from collapsed buildings in Kahramanmaras, the epicentre of the first earthquake in February 2023.

Source 2: This oblique aerial view shows tents set up in the grounds of the Kahramanmaras stadium to temporarily house the people left homeless by the earthquake on 6 February 2023. Snow on the nearby hills gives some idea of the freezing temperatures survivors and rescue workers faced in the aftermath of the earthquakes.

Learning ladder 3.6

Perspectives of people and organisations

1. What are some different opinions on earthquake safety measures in Türkiye and Syria?
2. Describe how people might feel about the building codes designed to prevent earthquake damage in Türkiye.
3. Sources 2 and 3: Using examples from the oblique aerial photographs, explain the different perspectives of impacts of the earthquakes in Kahramanmaras.
4. How did the government's view on building codes influence decisions about construction safety in Türkiye?
5. Is it fair to blame the building regulations for the high number of deaths in Türkiye, or should other factors be considered?

Place

1. What was the epicentre of the 2023 earthquakes?
2. Source 1: Describe the location of Türkiye.
3. Source 2: Describe the physical and human characteristics of Kahramanmaras.
4. Source 2: What are the small white structures in the Kahramanmaras stadium and why are they needed?
5. How can the government better support builders to implement earthquake-resistant designs to protect the city?

HOW TO Place, page 390

How do tsunamis impact coastlines?

Tsunamis are geomorphic hazards that originate at or near the Earth's surface, when water is pushed up by undersea earthquakes and volcanoes. They travel at speeds of up to 800 kilometres per hour and cause extensive damage when they crash onto coastlines.

How tsunamis work

A tsunami is caused when tectonic plates shift or volcanic activity occurs under water. The energy from these movements displaces the water above it, creating waves that move rapidly across the ocean. Initially, tsunami waves appear quite small. However, as they near coastal areas, the decreasing depth forces the wave to slow down and build in height. This process can produce waves towering up to 30 metres high.

Often, the first sign of an approaching tsunami is the sudden withdrawal of water from the shoreline. This is caused by the wave's trough reaching shore before the crest, leaving the seafloor exposed. The retreating sea water is an important warning sign that a tsunami wave is coming. Tsunamis hit the shore as a huge wave or a surging tide of water. They cause incredible damage to coastlines, and in low-lying coastal areas they can flow many kilometres inland.

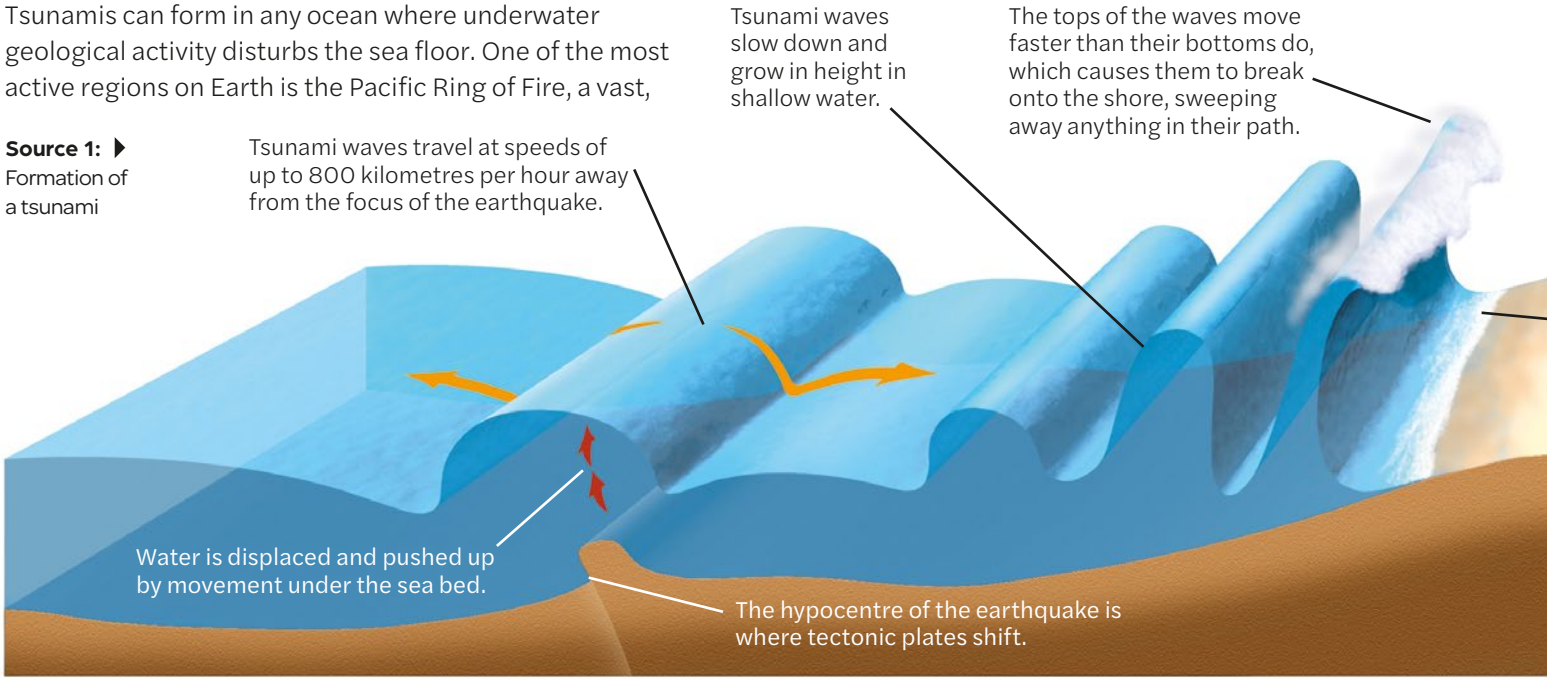
Tsunamis around the world

Tsunamis can form in any ocean where underwater geological activity disturbs the sea floor. One of the most active regions on Earth is the Pacific Ring of Fire, a vast, horseshoe-shaped zone found in the Pacific Ocean. Here, multiple tectonic plates meet and interact, leading to around 90 per cent of the world's earthquakes and 75 per cent of its volcanoes. This concentrated tectonic activity makes the Pacific Ring of Fire the source of approximately 90 per cent of all tsunamis worldwide. As a result, many Pacific countries located closer to the Pacific Ring of Fire are more vulnerable to tsunamis; such as Japan, Indonesia and the Philippines.

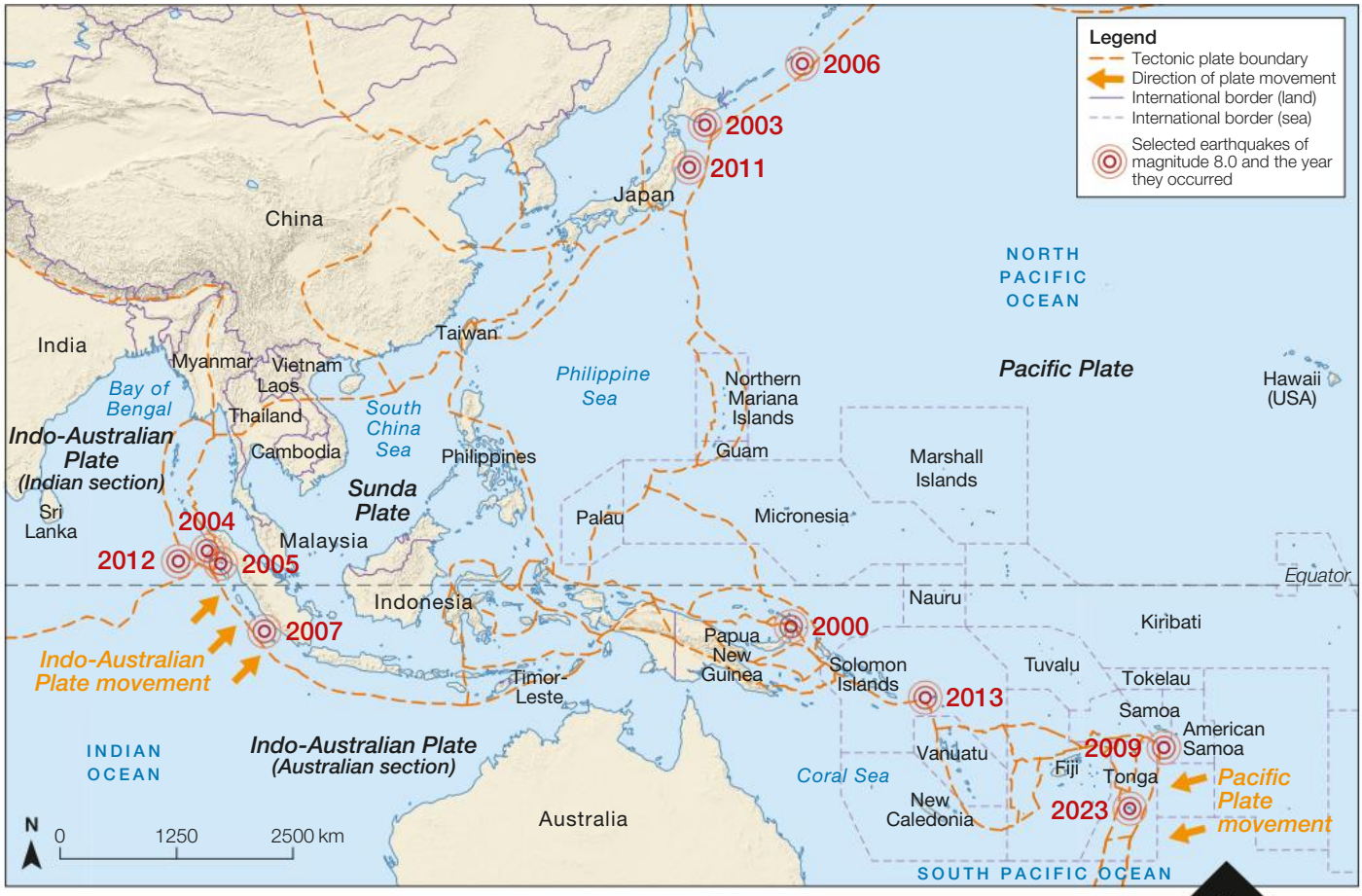
The impact of tsunamis on coastline

Tsunamis dramatically reshape coastlines by eroding coastlines, destroying coral reefs, uprooting vegetation, altering the shape of river mouths and damaging wetlands and estuaries. This can lead to the destruction of natural habitats and built environments. For example, the 2004 Indian Ocean tsunami was triggered by a magnitude 9.1 undersea earthquake off the coast of Sumatra. The waves struck surrounding countries

Source 1: ▶ Formation of a tsunami



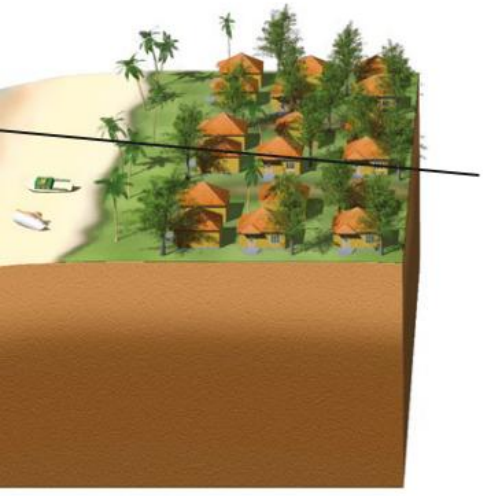
Major earthquakes near Australia, 2000–23



Source: Matilda Education Australia

▲ **Source 2:** Major earthquakes near Australia since 2000

within hours, reaching heights of up to 30 metres in some locations. Coastal areas in Indonesia, Sri Lanka and Thailand were severely impacted. Entire stretches of beach and mangroves were eroded, villages and infrastructure was destroyed and farmland was flooded with saltwater, making the land unusable for years. In many regions, thick layers of sand and debris were also deposited inland, contaminating water sources and transforming the landscapes for years to come.



Water is sucked out to sea as the wave trough hits the shore, exposing the sea bed.

Learning ladder 3.7

Processes that transform people, places and environments

1. Define a tsunami in your own words.
2. Source 1: Describe how tsunamis are formed.
3. Explain how the 2009 Samoa tsunami was formed.
4. Why was the 2004 Indian Ocean tsunami the deadliest in history?

Space

1. Source 2: In which directions are the Indo-Australian and Pacific plates moving?
2. Source 2: Describe the distribution of major earthquakes near Australia since 2000.
3. Source 2: Explain why tsunamis are prevalent in this region.
4. Source 2: Analyse which countries experience more frequent tsunamis and why.

HOW TO

Space, page 388

Case study

How did the 2011 tsunami impact Japan?

On 11 March 2011, one of the strongest earthquakes ever recorded occurred approximately 72 kilometres east of the coast of Tohoku, Japan. The force of the 9.1 magnitude earthquake was so strong that it shifted Japan's main island, Honshu, by approximately 2.4 metres. The force of the earthquake resulted in a destructive tsunami that reached Japan within 30 minutes, with waves as high as 40 metres.

Social and economic impacts

The 2011 tsunami caused a major humanitarian crisis. Nearly 20 000 people lost their lives, and thousands were injured or were missing. More than 450 000 people were forced to leave their homes, many of whom had to live in temporary shelters for months. Schools, hospitals and infrastructure were destroyed, with over 4 million households losing electricity and over 1.5 million losing access to water.

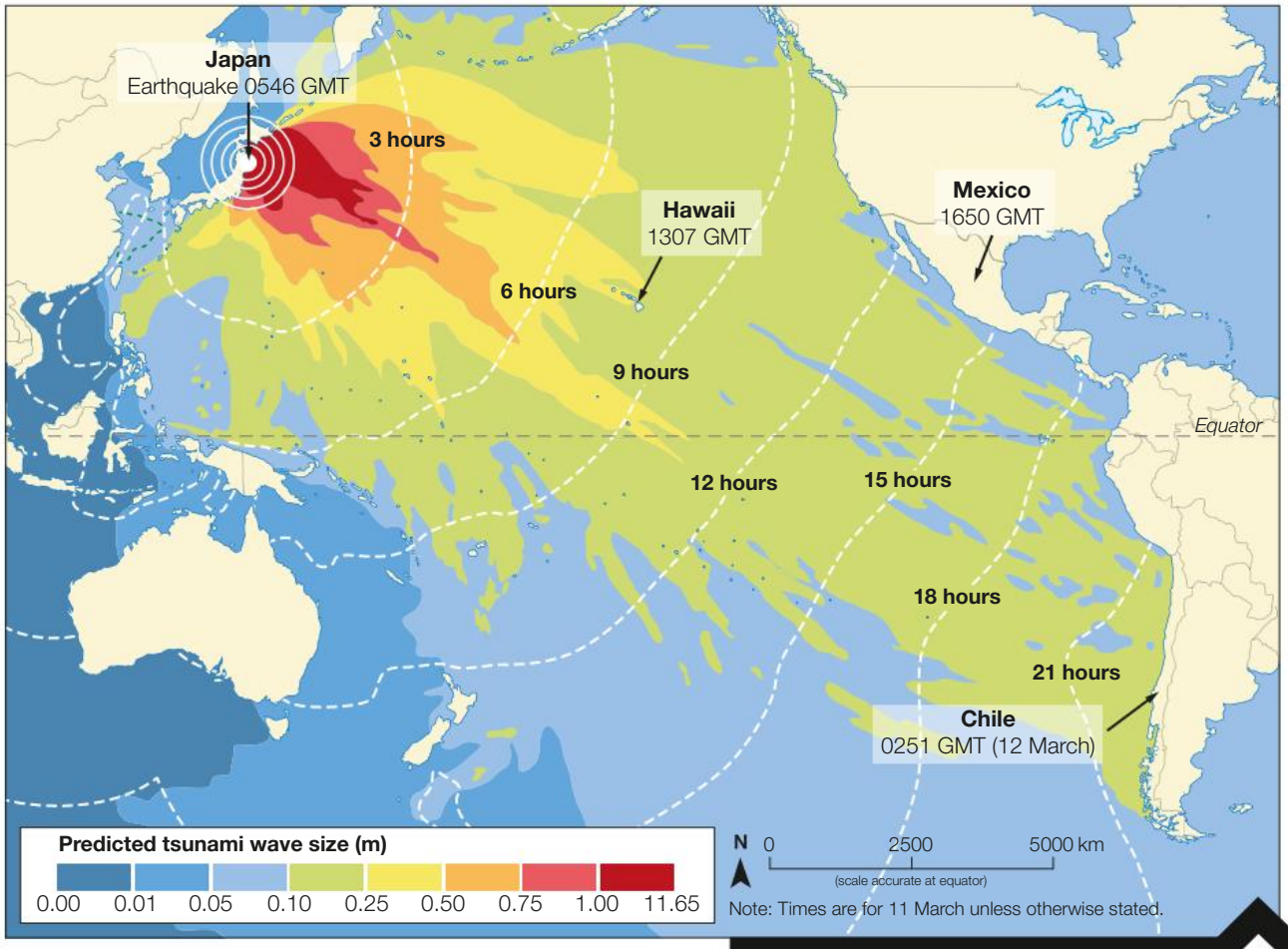
Homes, roads, railways and businesses were destroyed in the disaster. Major factories and transport networks were also forced to shut down, affecting global supply chains and reducing employment. The tsunami was estimated to cost more than US$235 billion, making it the most expensive **natural disaster** in history.

Environmental impacts

At the Fukushima Daiichi nuclear power plant, the tsunami waves flooded the site and damaged the emergency generators that were designed to cool the nuclear plant. As a result, the cooling system stopped working and the plant overheated, leading to explosions and the release of radiation into the environment. This caused serious concerns about safety, health and long-term environmental damage. Nearby farmland was contaminated, making crops unsafe to eat, and radioactive water leaked into the Pacific Ocean,

Source 1: The city of Miyako on the north-east coast of Japan's Honshu island was devastated by the 2011 tsunami. The 13-metre-high tsunami swamped the city's seawall and tsunami shelters. Over 600 people were killed and 6000 buildings were destroyed in that city.

Japan's 2011 tsunami wave data



Source 2: The heights of Japan's tsunami waves and the time it took to travel across the world

affecting marine life. Some fish and seafood caught in the area showed increased levels of radiation for years after the disaster. The tsunami also severely affected Japan's coastlines, eroding beaches, damaging coral reefs, flooding rice paddies with saltwater (making the land unusable for years) and spreading rubbish, chemicals and debris inland for kilometres.

Was Japan prepared?

Japan is located along the Pacific Ring of Fire, a region known for its frequent earthquakes and tsunamis. Because of this, the country has some of the most advanced earthquake and tsunami warning systems in the world. These include early alert systems, sea wall defences, and public education on how to respond during emergencies. In 2011, people living in coastal areas received warnings just minutes after the earthquake struck. Many were able to move to higher ground in time, which saved thousands of lives. However, the size of the tsunami was still much larger than expected, and in some places the waves were so powerful they passed over sea walls and swept inland faster than people could evacuate.

Learning ladder 3.8

Processes that transform people, places and environments

1. What was the cause and magnitude of the 2011 earthquake?
2. Describe the social impacts of the 2011 tsunami.
3. Explain how the tsunami impacted economic activity in Japan.
4. How did the tsunami affect Japan's environment?
5. Assess the success of Japan's preparation for an earthquake and tsunami.

Space

1. Source 2: Describe the path of the tsunami across the Pacific Ocean.
2. Source 2: How long did the tsunami take to reach Chile, and what was the height of the waves?
3. Explain why Japan's location makes it vulnerable to tsunamis.

HOW TO

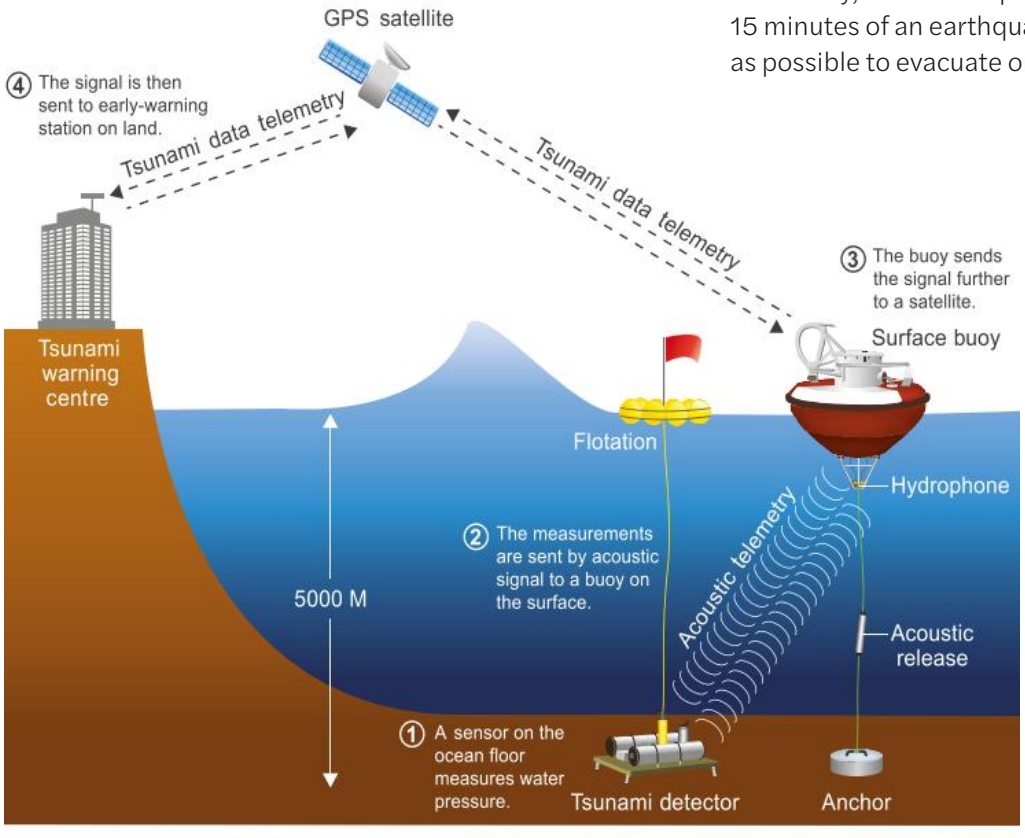
Space, page 388

How do countries respond to and manage tsunamis?

In the last century, more than 58 tsunamis have claimed over 260 000 lives. More of these hazards are expected in the future as climate change leads to rising sea levels. Countries cannot prevent tsunamis, so it is important to be prepared for when they do occur. It is difficult to be entirely prepared, as tsunamis travel as fast as 640–960 kilometres per hour, and their direction and magnitude can be influenced by the shape of the seabed, the water depth and the location of the epicentre. However, new technologies have made this easier.

Warning systems

Technologies can be used to detect tsunamis. Seismologists (scientists who study the Earth's tectonic crust) can use conductivity instruments, seismometers and thermal cameras to detect underwater volcanic activity and tectonic movements. Drones, satellites and buoys placed around the ocean can also detect if water surface levels decrease, a sign that a tsunami is about to occur. These technologies feed live information to international organisations that constantly monitor tsunami activity, such as the Pacific Tsunami Warning Centre. The information is used to determine the tsunami risk and potential severity, and countries likely to be affected are notified. Each national authority is responsible for issuing tsunami warnings to their citizens and implementing evacuation protocols. The news, media and government SMS systems can explain to people how to evacuate and keep safe. If implemented effectively, evacuation procedures can occur within 15 minutes of an earthquake, giving people as much time as possible to evacuate or seek high ground.



Source 1: Tsunami warning systems use a variety of technologies to quickly identify earthquakes and determine the risk of tsunamis. This can help nations issue evacuations quickly to affected communities.

Coastal defence

Tsunami-vulnerable countries can implement coastal defences to mitigate the impact of tsunamis. This includes building structural measures such as seawalls, offshore breakwaters, tsunami walls and flood levees to prevent coastal erosion and reduce the energy of incoming tsunamis before they reach land. A more cost-effective solution for developing countries can be to strengthen natural barriers to reduce the energy of waves, such as coral reefs. This can be done by using nature-based solutions like rock armour or heavy sandbags.

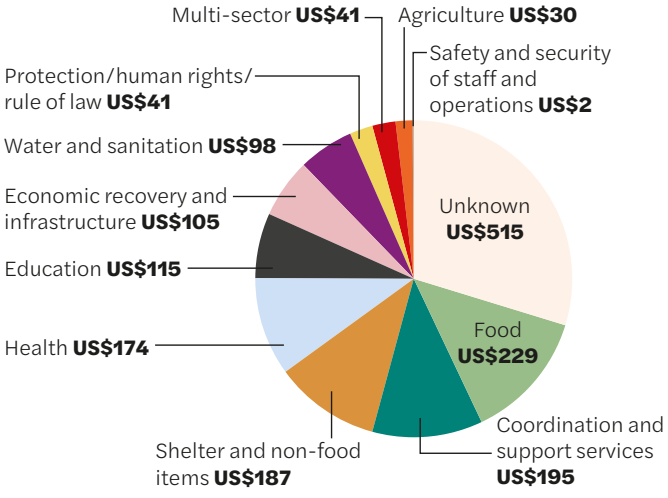
Forests can also be planted between communities and coasts to act as a buffer zone, reducing the impact of tsunami waves on communities.

Governments must also build critical infrastructure, such as power plants and densely populated areas, on higher ground to minimise their risk of damage. After the 2011 Tohoku tsunami in Japan, towns were rebuilt on elevated ground filled with compacted soils. This helps reduce the impact tsunamis will have on infrastructure and people in the future.

Aid responses

Aid is crucial after tsunamis to support affected communities in their recovery and rebuilding efforts. Governments, international organisations, non-governmental organisations (NGOs) and individuals all contribute aid to impacted areas. This aid can take various forms, including financial assistance, medical supplies, food and water, shelter, and rebuilding infrastructure and housing. Governments of affected countries often coordinate relief efforts and distribute aid to affected regions through their national disaster management agencies. International organisations, such as the United Nations (UN) and the Red Cross, provide additional support by mobilising resources, coordinating relief efforts and delivering aid directly to affected communities. Following the 2004 Indian Ocean tsunami, $6.25 billion was raised by the UN relief fund and used to assist 14 countries, including Sri Lanka, Myanmar, Somalia, Indonesia and Thailand. A separate flash fund by the UN raised $1.25 billion. Source 3 shows how the total US$1.7 billion of funds were distributed.

2004 Indian Ocean tsunami funding by sector (US$ millions)



Source: FTS UNOCHA

Source 3: The distribution of over US$1.7 billion of aid following the 2004 Indian Ocean tsunami, including US$1.25 billion raised by the United Nations. This was divided among the 14 affected countries, with Indonesia and Sri Lanka receiving the most funding.

Source 2: An aerial image of a new coastal levee under construction in Japan. This concrete levee will absorb energy from any future tsunami waves, to reduce the intensity of the waves moving inland towards communities.

Learning ladder 3.9

Sustainable management strategies

1. How do tsunami warning systems work?
2. Describe the role of seismologists in detecting tsunamis, including the technologies they use.
3. Explain the role of aid in supporting communities affected by tsunamis, and identify the various sources of aid.
4. Discuss the importance of natural barriers, such as coral reefs and forests, in reducing the energy of tsunami waves and protecting coastal communities.
5. Analyse the significance of aid to help in the response of countries to tsunamis. Refer to the 2004 Indian Ocean tsunami aid as an example.

Scale

1. Identify one international and one national response to tsunamis.
2. Describe how governments coordinate relief efforts and distribute aid to affected regions after a tsunami.
3. How can national governments implement coastal defence to mitigate the impact of tsunamis?
4. Analyse the importance of international organisations in monitoring tsunami activity and issuing warnings to affected countries.
5. Technologies are required to effectively warn people of an incoming tsunami. Why might this disadvantage lower income nations?

HOW TO Scale, page 398

How do landslides occur?

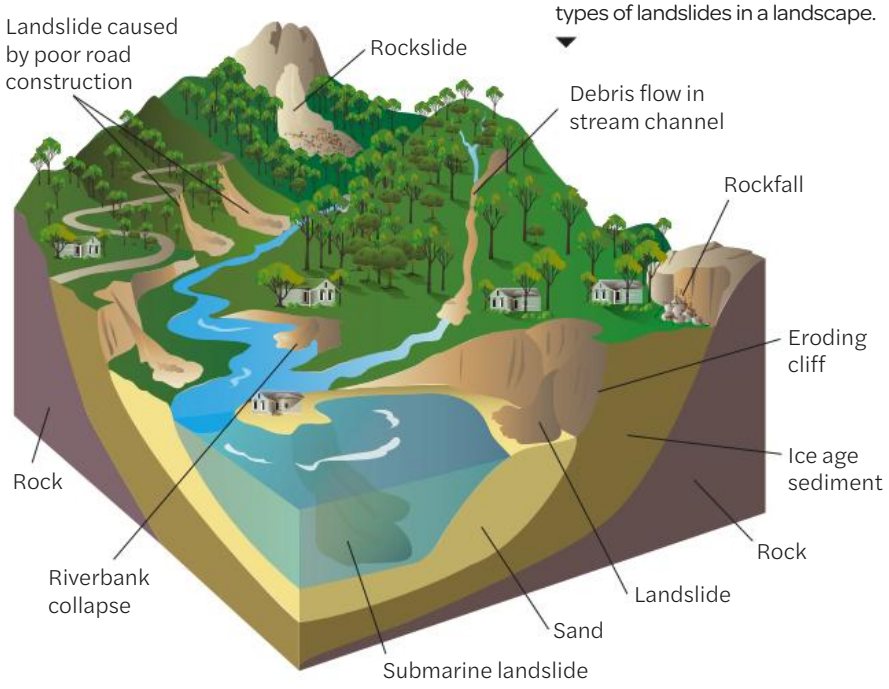
When weathered and loose sediment or rock moves downslope under the force of gravity it is classed as a landslide. Often the movement is very slow and barely noticeable; however, when it is sudden and unexpected the impacts are devastating on people and communities.

Contributing factors

A **landslide** can be triggered by many factors, often in combination.

- **Gradient** of the land. Steeper slopes, particularly in mountainous landscapes, are more vulnerable to large and devastating landslides.
- **Water** lubricates layers of earth and rock, while also adding weight. Large landslides, including mudslides, occur after heavy rain or where drainage is poor.
- **Weathering and erosion** undercut the land below a slope and cause rock falls and landslides in coastal and river landscapes where waves and rivers erode the bases of cliffs and hillsides.
- **Tectonic movements in Earth's crust.** Earthquakes can destabilise rock and soil, causing it to start moving downslope. These landslides occur in mountainous landscapes, including underwater.
- **Human activity.** Clearing slopes of vegetation increases erosion and destabilises land and building infrastructure, such as roads, and housing on steep slopes interferes with natural drainage. Mine-blasting can also trigger rockfalls.

Source 2: Location of different types of landslides in a landscape.

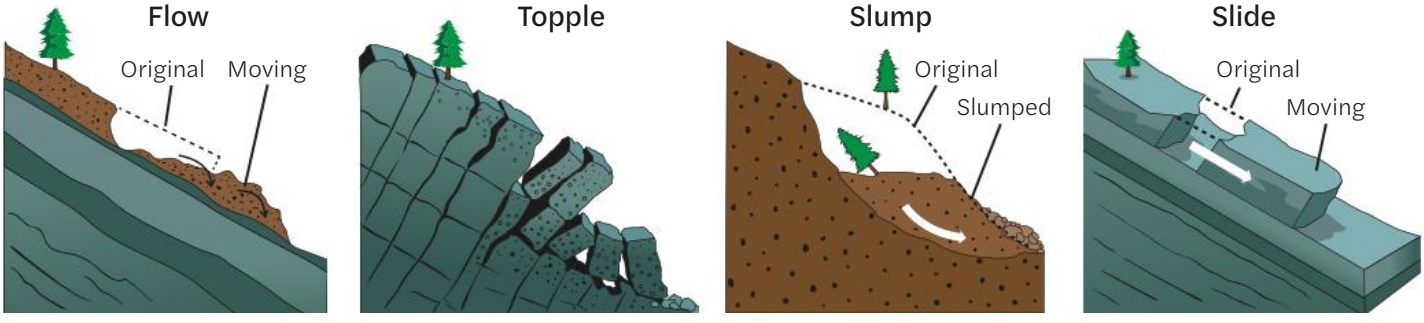


Climate change is predicted to increase the frequency, magnitude and vulnerability of places to landslides through extreme rainfall events, flooding, melting glaciers and wildfires.

Types of landslides

Landslides are categorised by speed of movement, the nature of the material moving and how the movement occurs. Loose sediment can flow, slump or creep downslope. Soil creep is slow, common and

Source 1: Types of landslides

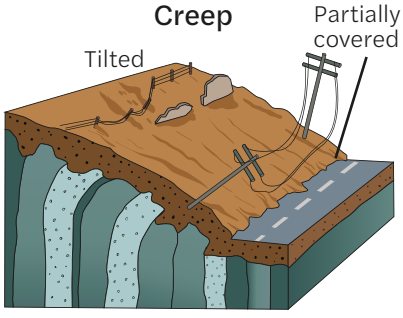


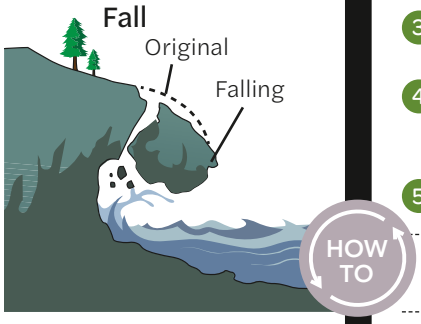
Source 3: A massive landslide buried much of the small city of Alausi in Ecuador's Andes Mountains in 2023. The landslide destroyed 57 buildings and left 1000 people homeless. At least 48 people died in the landslide, caused by months of heavy rainfall.

evidenced by leaning fences or trees. Slumping can be fast or slow. Scars on the land where a section of soil has moved are evidence of slumping. Soil flow is very common and usually occurs after heavy rain. Large amounts of soil and rock can travel large distances, often clogging rivers and valleys and burying settlements downstream. These soil movements are most visible in agricultural landscapes, particularly land used for grazing. Rockfalls are most common in landscapes dominated by structural landforms such as coastal cliffs and mountain valleys. Rocks topple, slide or fall when a combination of factors reduces the cohesion of the layers of rock and resistance against gravity.

Responding to disasters

In 2024, there were over 17000 landslides of different sizes and intensity in Hunan Province, China attributed to typhoon Gaemi. It affected 136 villages with 50 deaths and the displacement of 128500 people. Many villages are now considered uninhabitable after recurrent landslides over years. Even forested slopes are not immune to landslides and climate change is causing increased rainfall and floods. Reinforcing riverbanks, improving drainage and mapping disaster-prone zones has not worked and it is now considered essential to relocate people and communities away from floodplains and mountain slopes. The dilemma for people is leaving land that has been farmed by their families for decades in favour of safety and an uncertain future livelihood.





Learning ladder 3.10

Processes that transform people, places and environments

1. Mindmap the factors that contribute to landslides.
2. Describe the difference between slow and fast landslides using examples.
3. Explain how rainfall and gradient interact to cause landslides.
4. Source 3: Explain why the landslide in Alausi and the landslides in Hunan Province are considered disasters and not just natural hazards.
5. Assess the impact of landslides on people, places and environments.

Environment

1. Identify environments where landslides occur.
2. Source 1: Describe how slump and creep landslides differ from topple and fall landslides.
3. Explain why river and mountain environments are vulnerable to landslides.
4. Source 3: Draw and label a photo sketch to include features of the landslide, contributing factors visible in the landscape and impacts on the town below.
5. Research a recent landslide to create a photo essay.

HOW TO

Environment, page 396; sketches and annotating, page 416; visual communication, page 418

Case study

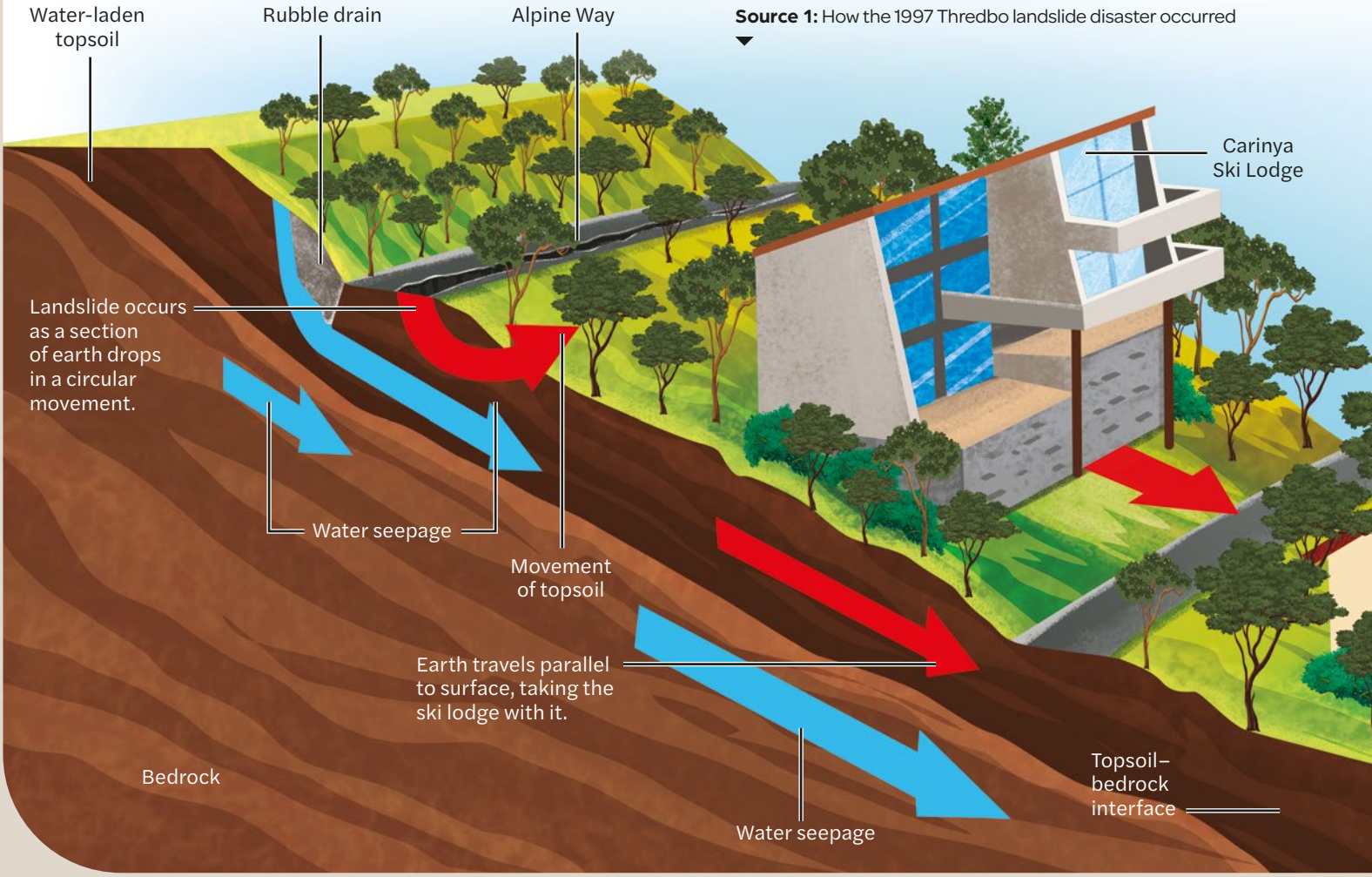
What was Australia's worst landslide disaster?

The 1997 Thredbo landslide, although small by world standards, was Australia's deadliest landslide with the loss of 18 lives.

The landslide and its impacts

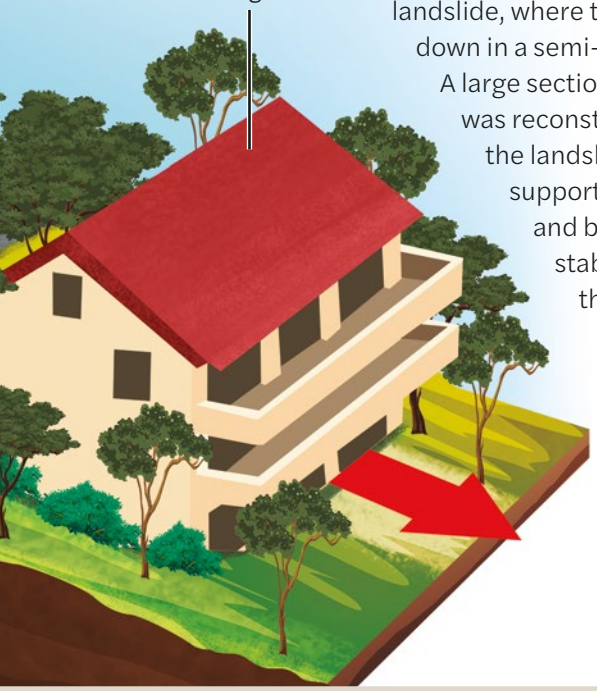
At 11.40 pm on 30 July 1997 a landslide event occurred at Mount Thredbo, causing part of the Alpine Way embankment to slide down a steep slope into the ski resort in New South Wales' Snowy Mountains. The **flow landslide** knocked Carinya Lodge off its foundations and pushed it into Bimbadeen Lodge at high speed, destroying both buildings and burying 19 victims under 2000 cubic metres of rubble.

The steep slope and instability of the land hampered rescue operations. An underground stream that was exposed by the landslide needed to be dammed before the rescue operation could start. Eighteen bodies were recovered from the rubble and only one survivor, Stuart Diver, was rescued after spending more than 60 hours under the debris.



Source 1: How the 1997 Thredbo landslide disaster occurred

Source 2: Damage being surveyed by rescue teams at the site of the 1997 Thredbo landslide



Investigations and analysis of the landslide found a leaking water main had saturated the embankment on the Alpine Way road, causing a flow landslide, where the land slipped down in a semi-liquid state.

A large section of the Alpine Way was reconstructed following the landslide, including support structures above and below the road to stabilise the land on the steep slope.

Learning ladder 3.11

Processes that transform people, places and environments

1. What type of landslide occurred at Thredbo in 1997?
2. Source 1: Describe the cause of the landslide.
3. Explain the impacts of the Thredbo landslide.
4. Source 2: Why was the rescue effort a difficult one?

Sustainability

1. What elements of the Thredbo landslide recovery effort show a focus on sustainability?
2. Describe how the reconstruction of the Alpine Way after the Thredbo landslide aimed to make the area more sustainable.
3. Explain how an unsustainable water management system contributed to the Thredbo landslide.
4. Analyse how the improvements made after the landslide could have long-term benefits.
5. Evaluate the strategies used to improve the stability of the Alpine Way after the Thredbo landslide. Were they effective in ensuring future sustainability?

HOW TO Sustainability, page 400

Where and why do avalanches occur?

An avalanche is a large mass of snow, ice, rock and soil, often weighing millions of tonnes, that travels quickly down a mountainside at speeds of up to 320 kilometres per hour. Each year avalanches kill more than 150 people worldwide. In most fatalities, the victim or someone in their ski party causes the avalanche.

Contributing factors

The gradient of the land and tectonic events, such as earthquakes, extreme weather and climate change, influence the occurrence, magnitude and impact of avalanches in a similar way to landslides. A combination of factors reduces the cohesion of the snow layers until they can no longer resist the force of gravity. The risk of an **avalanche** is greatest on slopes with a gradient over 28 degrees, although wet avalanches occur at lower angles following heavy rain or thawing.

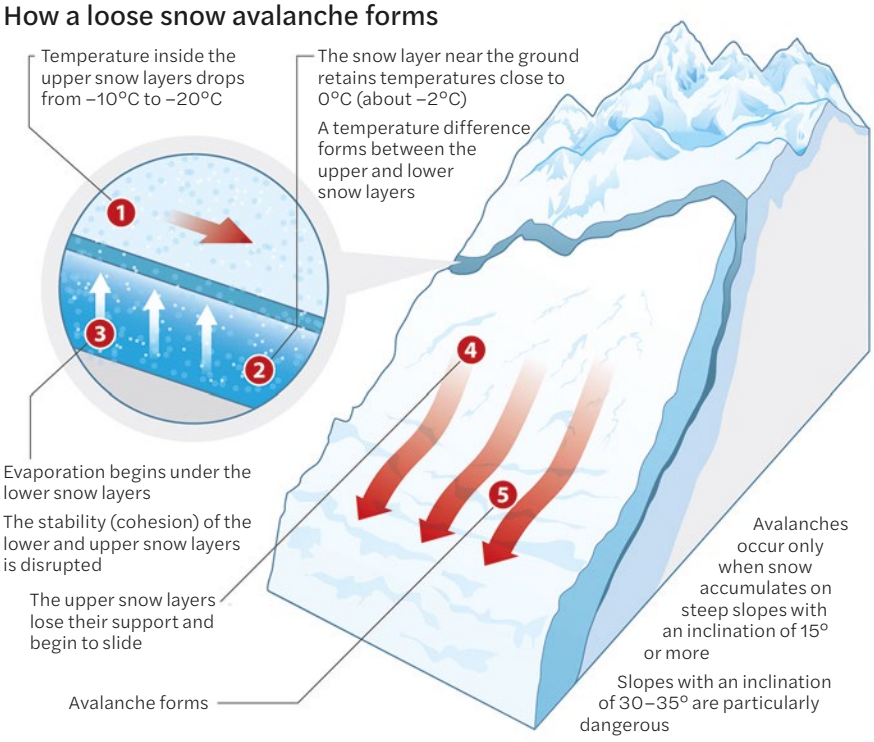
- **Snowpack features.** The build-up of new snow adds mass to an existing snowpack. If the new layer accumulates quickly, it can slide downhill as a surface avalanche or the increasingly deep snow mass can slide downhill as a full-depth avalanche, exposing the rock beneath. Conditions within the snow such as weak or slippery layers and air pockets can also increase instability and cause fresh snow to melt and refreeze.
- **Atmospheric conditions.** Warming temperatures and sun exposure can make layers of snow less cohesive. Strong winds and heavy rainfall caused by storms can quickly change conditions, causing large snow accumulations or 'cornices' (overhangs) on mountain ridges that can collapse quickly.
- **Surface features.** Trees and rock outcrops in the landscape can act as anchors for snow; however, they can also cause temperature differences between snow layers and increase instability.
- **Human activities.** Skiing is a known trigger for avalanches and participants of snow sports make up the greatest number of human victims. Alpine settlements, resorts and infrastructure located in mountain valleys contribute to and are destroyed by avalanches.

Spatial pattern and magnitude of avalanches

Avalanches occur globally in high altitude locations. Avalanche-prone mountain landscapes cover roughly 6 per cent of Earth's land area, mostly in the major ranges such as the Himalayas and European Alps. Climate change and the likelihood of reduced snowfall, rising snow lines and shorter snow seasons are predicted to result in the migration of avalanches to higher altitudes and a reduction in their frequency and size. Avalanche magnitude is assessed using a scale ranging from 1 to 5, based on potential destructive force due to the mass, density, speed and length of the avalanche path.

Source 1: Large avalanche on Shkhara Mountain in Georgia. The top of the avalanche is known as the crown. The end of the avalanche is the deposition zone.

How a loose snow avalanche forms



Speed of avalanches and snow density

As a rule, dry avalanches move at 20–70 metres per second and up to 125 metres per second, with snow density being 0.02–0.3 g/cm^3

Wet avalanches move at 10–20 metres per second and up to 40 metres per second, with snow density being 0.3–0.4 g/cm^3

The speed of avalanches depends on the ground where the snow is lying, on the slope inclination and on the condition and size of the snow mass. The average speed of avalanches is about 20–30 metres per second

Types of avalanches

Loose snow avalanches
They slide down the entire surface of the slope outside specific channels

'Trough' type avalanches move down narrow gullies, ravines and erosion furrows

'Jumping' avalanches
These free-falling avalanches move along ledges

Interesting facts

The first snow avalanche was mentioned in 1129. A historical document records the death of people from the entourage of Bishop Rudolf, who was headed for Rome via the Great St Bernard Pass in the Swiss Alps.

On 10 January 1962, a huge avalanche, called by some experts the largest in the history of recorded observations, wiped out an entire city in Peru. The 1000-metre long avalanche edge rushed along at a speed of 150 kilometres per hour.

▲ **Source 2:** Causes of avalanches

Impact of avalanches

The people who die in an avalanche are generally affected by suffocation, trauma or hypothermia. A size 1 avalanche is small and less likely to bury a person compared to a size 5 event, which can devastate a landscape and bury both people and settlements.

Risk assessments are used to determine potential impacts. Avalanche barriers, hazard maps, road and skifield closures, evacuations and the artificial triggering of avalanches have helped reduce the death toll and impact on places.

Learning ladder 3.12

Processes that transform people, places and environments

1. Define an avalanche.
2. Source 2:
   - **a** Outline differences between wet and dry avalanches.
   - **b** Differentiate between 'surface' and 'full depth' avalanches.
   - **c** Differentiate between 'loose snow' and 'trough' avalanches.
3. What features of a snowpack can increase the possibility of an avalanche?
4. Explain management techniques used to control the impact to property and lives.
5. Create a flow diagram to illustrate the formation of loose snow avalanches.

Interconnection

1. Source 1: Identify the type of landscape where avalanches occur.
2. Source 1: Outline factors contributing to the avalanche in Georgia.
3. Explain how gradient influences the occurrence and characteristics of avalanches.
4. Explain the connection between the scale of an avalanche and impacts on people, places and environments.
5. Climate change is causing more frequent storms and increased warming in mountainous areas. How might this influence the frequency of avalanches?

Interconnection, page 392

HOW TO

Thinking geographically

Landscapes and landforms

Geographical concepts, inquiry and tools

Place, environment, sketch map, written or oral report

Learning ladder: page 80

Key inquiry question

How does tectonic activity impact environments and people in Iceland?

In a written or oral report, use the knowledge and understanding developed in the activities below to answer the inquiry question. Include the following:

- the location of Iceland
- tectonic plates and their movement
- landforms and processes caused by tectonic activity
- the value of tectonic landscapes and landforms for tourists and Icelandic people
- one sketch map or simple diagram. Where possible, refer to the sources in this spread to support your judgements.

The geographical features of Iceland

HOW TO

Source 1 activities

1 Describe the location of Iceland using geographical language. Refer to hemisphere, latitude and longitude, and water bodies.

2 What are the spatial dimensions of Iceland?
   - **a** Calculate the distance from coast to coast along the 20° W longitude line and from coast to coast along the 65° N latitude line.
   - **b** Is Iceland a large or small country? Give a reason for your answer.

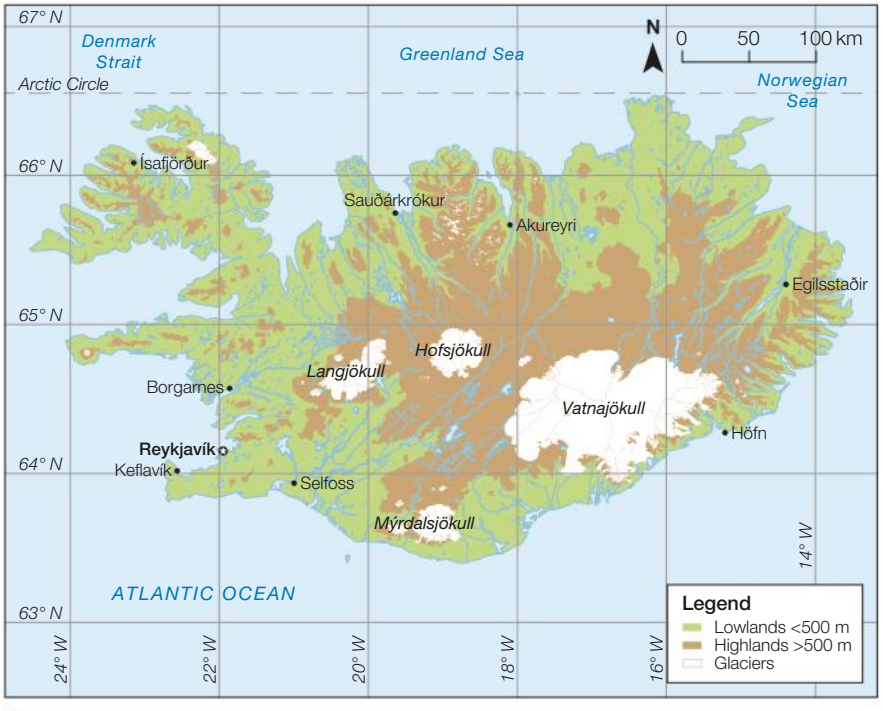
3 If you flew a plane along the 18° W longitude line, describe how the land below you would change. Refer to the height of the land and features you would see. Better answers will use the scale to refer to distances.

4 Suggest two reasons why there are glaciers in Iceland.

5 Identify two agents of erosion evident on the map that shape the landscapes and landforms in Iceland.

See **Geo How-To** for latitude and longitude, page 404

Iceland relief and glaciers



Source: Matilda Education Australia

Source 1: The geographical features of Iceland

How plate tectonics are impacting Iceland

Source 2 activities

Refer also to the tectonic plate map on page 16.

1 Describe the location of the Mid-Atlantic Ridge in Iceland.

2 What is happening along the Mid-Atlantic Ridge? Refer to tectonic plates, movement of plates and magma.

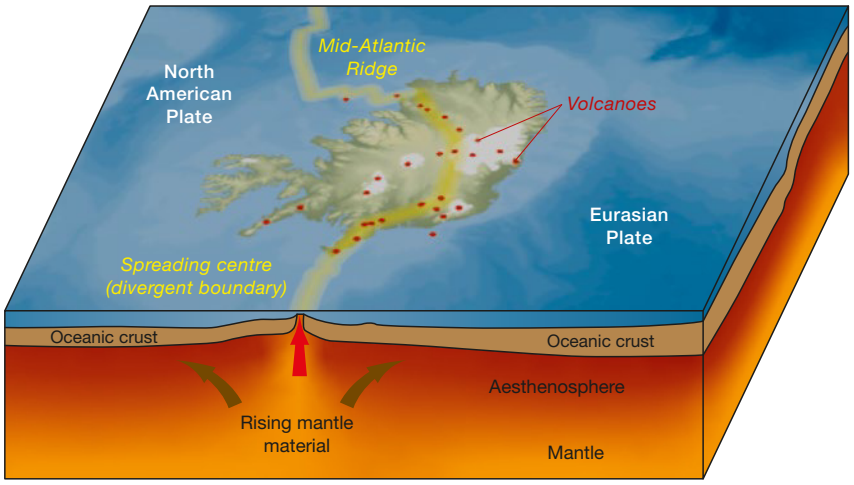
3 Explain the connection between tectonic plates and the location of volcanoes in Iceland.

4 How does tectonic activity affect the natural environment of Iceland?

5 Predict what may happen to the size of Iceland in the future. Give a reason for your answer.

Source 2: The tectonic plate movements that affect Iceland

See **Geo How-To** for interpreting block diagrams, page 418



Tourism in Iceland

Iceland attracts thousands of tourists every year. Tourists walk through the Thingvellir Rift Valley, where the North American and Eurasian tectonic plates are pulling apart. Where water enters the rift valley, tourists dive between the plates at the Silfra fissure, the only place in the world where this is possible. Volcano tourism has grown rapidly in recent years. Iceland is one of the few places where tourists can get close to lava flows. In 2022, 1.8 million tourists visited Iceland. Tourism contributes an average of 5–8 per cent to Iceland's income (GDP) each year and creates around 30 000 jobs in areas such as transport, accommodation and hospitality.

▲ **Source 4:** The contribution of tourism to Iceland's economy

Source 3: Tourists experiencing geomorphic features in Iceland

Sources 3–4 activities

1 Identify the tectonic landforms in the photograph.

2 What is the link between plate tectonics and tourism in Iceland?

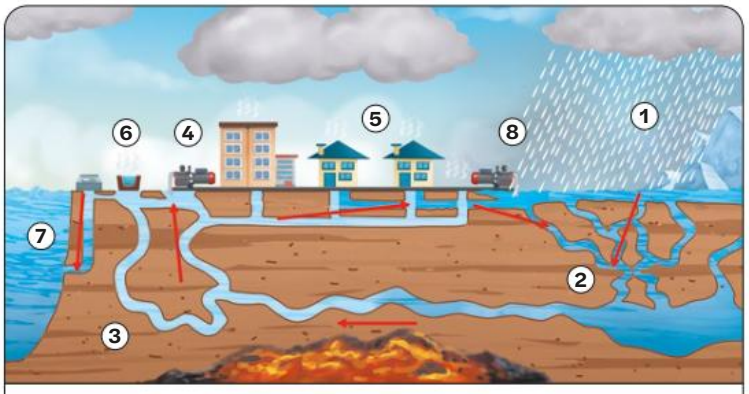
3 Why would tourists be excited to swim at Silfra fissure?

4 Suggest a reason why tourists are increasingly attracted to volcanic eruptions.

5 Assess the economic importance of tectonic landscapes in Iceland.

Impacts of tectonic activity in Iceland

Source 5: Thermal power station and Blue Lagoon heated pools



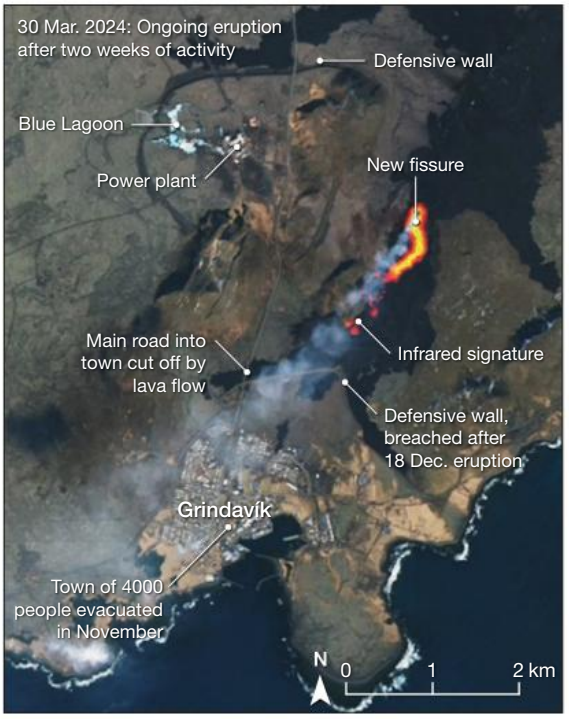
1 Rain and melted glacier water seep into the ground.
2 Water pools underground.
3 Water gets heated by magma.
4 Hot water is pumped up to the surface.
5 The hot water is used to heat homes, greenhouses and roads in the cities.
6 Hot water is also used for geothermal pools and spas.
7 Used water is cleaned in a centrifuge then dumped into the ocean by a 3-kilometre pipe.
8 Cold water is also collected from the country's only cold spring.

▲ **Source 6:** How thermal power is produced in Reykjavik

HOW TO See **Geo How-To** for interpreting flow diagrams, page 419

▲ **Source 7:** Thermal powered greenhouse. The cold climate in Iceland means heated greenhouses are essential for food production.

Satellite image of volcanic eruption in Grindavik 2024



Source: NASA

▲ **Source 8:** Threats to settlements and roads. A 2024 volcanic eruption in Grindavik cut roads, burnt homes and interrupted power supplies.

HOW TO See **Geo How-To** for interpreting satellite images, page 423

Sources 5–8 activities

1 Write your own definition for geothermal energy.
2 Sources 6 and 7: Identify four uses for heated water in Iceland.
3 Explain the link between the water cycle and geothermal energy in Reykjavik.
4 Analyse the importance of geothermal energy for food production in Iceland.
5 Discuss the statement: 'Tectonic activity in Iceland is both a threat and an opportunity'.

Influences on liveability

4

4.0

How can I understand the places where we live?

Australia is classified as a more economically developed country (MEDC). This means that we generally have good access to education, health care, transport, open spaces and other key elements that make our country liveable. In 2023, Melbourne and Sydney were ranked in the top 10 most liveable cities in the world.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
	Outcomes					Geographical tools and inquiry
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information

Source 1: A tent city of homeless people was established in Sydney's Martin Place for most of 2017 before it was dismantled. While Australia has some of the most liveable cities in the world, liveability is not enjoyed by all.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

4.1

Why do we live where we do?

Liveability is a judgement about what a place is like to live in. It impacts wellbeing because people live where they do to try to maximise the 'good' things that will make their lives better. Liveability is about our quality of life.

What we value

People value places that offer freedom and the protection of their human rights; personal safety; the availability of employment, and essential goods and services such as health, transport and educational facilities; and an attractive or healthy environment. If a place provides the things we need and satisfies most of the things we want, then we consider it to be more **liveable**.

Attempts have been made to rate or rank the liveability of large cities in Australia and across the world. Organisations use a range of factors or 'criteria' to judge liveability – they survey people to create these rankings. Rankings are very general and do not account for the perspectives or opinions of individuals at a local scale.

Choosing where to live

The ideal place for a family with young children will be different from the preferred location of an older couple or a university student, because each represents a stage of life with different needs and lifestyle preferences. Medical care might be a priority for the wellbeing of an elderly couple; entertainment and sports facilities may be a high priority for teenagers and young adults; and schools could be a high priority for a young family. The importance of different factors will vary between people – we call these our 'perceptions'. Some factors, such as safety and freedom, will be important for everyone, and our influences will change over time.

Not all people have a choice about where they live, and some people will remain in the same place for their whole lives. People who are able to make choices will be influenced by their own situation and the qualities of different places. These can be placed into two categories:

- the personal characteristics of people that influence their decisions
- the characteristics of places and what they offer to people.

What affects the liveability of places?

Environmental factors: The environment is our total surroundings, the physical and human features. It provides natural resources such as water and land, and determines our capacity to produce food. It affects the availability of housing, services and facilities such as shops, schools, hospitals and transport. An arid or a polluted environment will be perceived as less liveable than a forested location with clean air.

Political factors: Political stability is important for liveability because it means a society is not interrupted by conflict. Many of the least liveable places in the world are in conflict zones where infrastructure has been destroyed and basic needs such as food, water and shelter are not met. High emigration rates reinforce the low liveability of these places. Political policies affect human rights. Where a decent income, freedom of movement and freedom of speech are not protected by law, places are perceived as less liveable.

Personal influences	Locational influences
Age	Affordability
Family	Employment
Aspirations	Resources
Culture	Climate
Gender	Human rights
Income	Transport system
Language and lifestyle	Communications systems
Occupation	Recreational and health facilities
Stage of life	Quality of the environment
Sporting or cultural interests	Safety

▲ **Source 1:** Personal and locational influences on where people live

▲ **Source 2:** Dharavi, slums in Mumbai

Economic factors: The level of development of countries affects the capacity to provide the basic needs of a population, a range of employment opportunities and different types of housing. The poorest countries in the world are perceived as less liveable. Rich nations such as Dubai can create highly liveable places in otherwise inhospitable environments.

Social factors: People value interactions with others in society, particularly those with a common cultural, language or working background. High standards of behaviour, acceptance of cultural diversity, low crime rates and perceptions about freedom and safety are considered important features of highly liveable places.

Dubai and Dharavi

Dubai exists in an **arid** desert environment in an oil-rich country. Political stability and high levels of wealth have created a highly liveable city offering luxury lifestyles, executive employment, world-class services and a high standard of living. It is one of the safest places in the world to live and work. Many workers are 'digital nomads' working remotely for overseas businesses, while enjoying the tax-free, luxury lifestyle and social life the city offers. Dubai is one of the world's fastest-growing remote-working destinations.

Dharavi is an area of Mumbai, India, that attracts poor migrants moving from rural India to find employment to improve their lives. A lack of housing means they settle in **slums** like Dharavi, which lacks infrastructure and is considered a dangerous place. It is liveable because it offers employment, schools and businesses opportunities and is a place where a home can be set up in the middle of the city. It is a very productive place that produces goods and services. Government redevelopment schemes are slowly upgrading housing and infrastructure to make Dharavi more liveable. Most Australians would consider Dubai highly liveable but an expensive place to live, and Dharavi a slum that is highly unliveable because of the lack of sanitation, poor quality housing and lack of basic facilities.

▲ **Source 3:** Dubai

Learning ladder 4.1

Perspectives of people and organisations

1. Source 1: Identify three factors about yourself that would influence the liveability of places if you had a choice to make.
2. Describe how stage of life would influence perceptions about the liveability of places.
3. Sources 2 and 3: Explain how income has influenced the liveability of Dubai and Dharavi to different groups of people.
4. Source 2: Why would people consider Dharavi a liveable place?
5. Assess the importance of safety in people's perceptions of liveability.

Scale

1. Identify three environmental features of your local place that make it liveable.
2. Outline two features of your local place that reduce its liveability.
3. Describe two changes that would make your local place more liveable.
4. Use a Venn diagram to compare the liveability of Dubai and Dharavi.
5. What are international liveability rankings? Suggest reasons why cities such as Sydney and Melbourne like to rank highly on global liveability rankings.

HOW TO

Scale, page 398

4.2

Where do people live in the world?

Ninety per cent of the world's population lives on just 10 per cent of all the available land on Earth. Some places on Earth – such as deserts, high mountains and polar regions – are inhospitable, and it is difficult for humans to live there.

Living on Earth

The most liveable places on Earth are between the Arctic Circle and the Antarctic Circle, where the temperatures are warm enough to grow food.

Antarctica is the only continent that does not have a permanent population. It is the coldest place on Earth. Scientists spend time on Antarctica – but mainly during the summer months, when there are more opportunities to work outside.

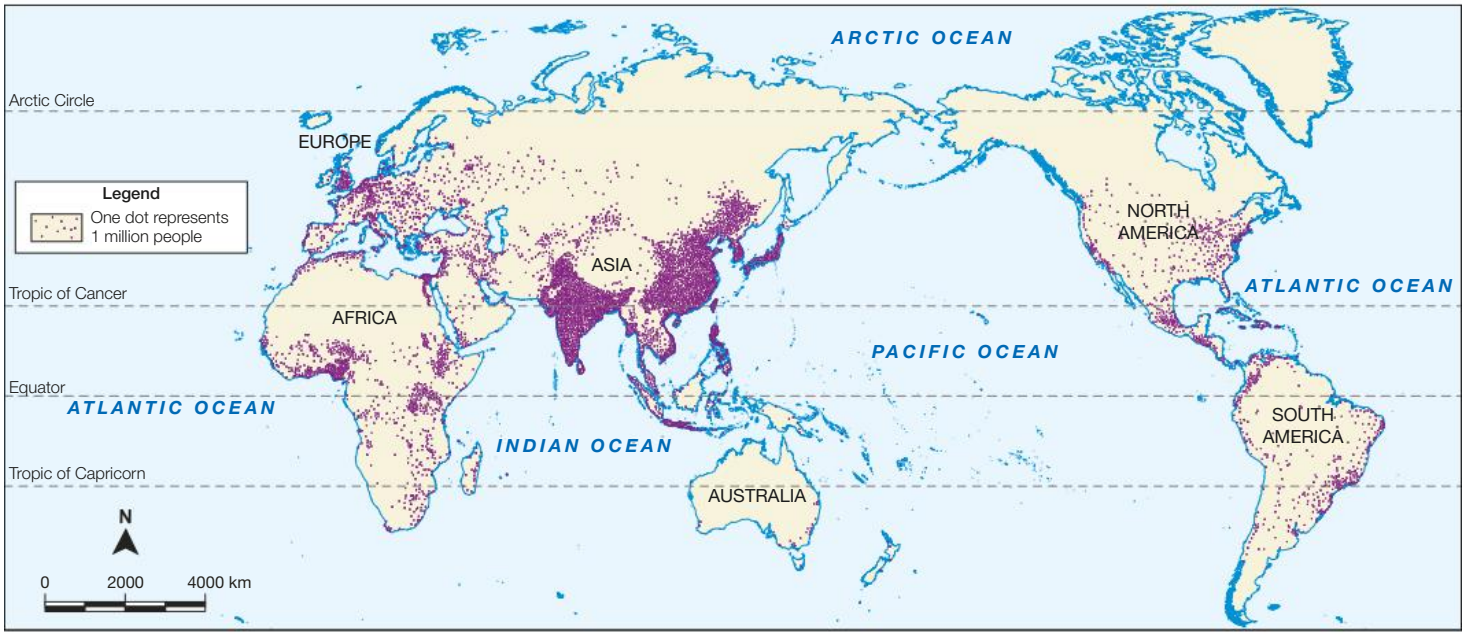
The world's population is 7.8 billion people, and we inhabit six of the seven continents. Asia has the highest population, at 4.5 billion people. Sixty per cent of the world's population lives in Asia, and 36 per cent of the world's people live in just two countries: China and India.

Population density

The **population density** of a region is a measure of how crowded that place is. It is calculated by dividing the population by the area of the region. For example, the continent of Australia has a population of 25 000 000, and an area of 7692 024 square kilometres, so its population density is 3.25 persons per square kilometre.

Population density varies from continent to continent. Australia has the lowest population density of all the populated continents. Asia has the world's highest population density – with 146 people for every square kilometre of land. On average, the world's population density is about 15 people for every square kilometre of land on Earth. However, about 90 per cent of the Earth's population lives on just 10 per cent of the land – mainly along coastlines and near sources of fresh water.

World population distribution



▲ **Source 1:** World population distribution dot map

Source: Matilda Education Australia

Source: Matilda Education Australia

▲ **Source 2:** World environments shown on a satellite image

Least liveable regions

Over half of the Earth's land mass consists of regions with harsh conditions that make it difficult for humans to survive. This is why **polar** regions, deserts and high mountains have very low population densities. Every continent has low population density regions:

- Africa: Northern half contains the Sahara Desert.
- Europe: Far north is in the frozen Arctic Circle.
- Asia: Central Asia has the Himalayan Mountains and desert, northern Asia has the Arctic Circle.
- Australia: All of Central Australia is desert or semi-desert.
- North America: Northern tip is in the Arctic, plus deserts in the south-west.
- South America: Northern half contains the Amazon Rainforest.

Source 3: Reindeer graze in the tundra around a nomadic yurt inside the polar circle in Asia.

Learning ladder 4.2

Characteristics of places and environments

1. Give three examples of places where few people live.
2. Brainstorm a list of basic things that humans require to live in a region.
3. Source 3: Describe the physical and human characteristics of this place.
4. Explain why Antarctica is the only continent with no permanent human population.

Space

1. Source 1: Which continent has the highest population density?
2. Source 1: Describe the spatial distribution of the world's population using the PQE method.
3. Source 2: How does Antarctica's environment contribute to its low population density?
4. Source 2: Identify the environments that provide the least liveable conditions on Earth and suggest the impact these conditions have on liveability.
5. Source 1: How will the pattern shown on this map change as the world's population grows?

HOW TO

PQE, page 412; Space, page 388

How do environments affect liveability?

The quality of the environment is an important factor in the liveability of a place. In large cities, liveability improves with access to clean air and open space. To find clean air and open space, people are increasingly moving away from cities to coastal or rural areas so they can enjoy a more liveable environment.

Sea change

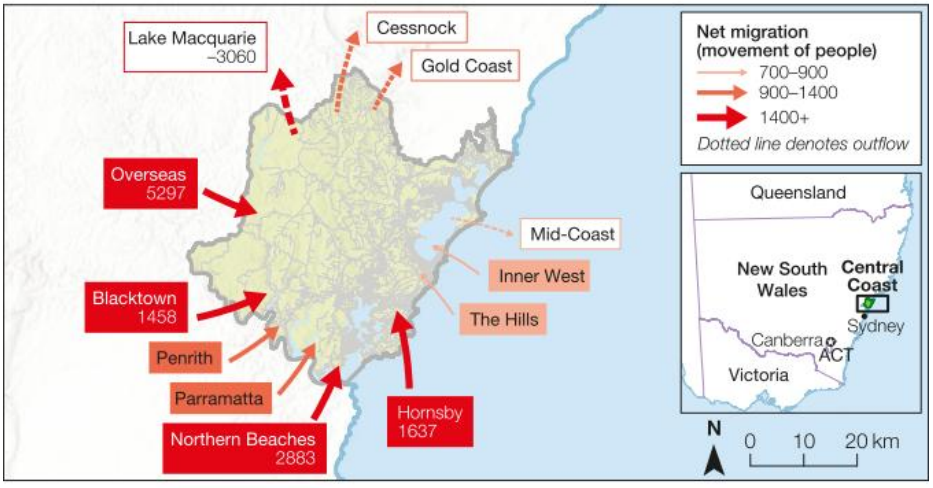
More people are choosing to live in coastal towns, where they can enjoy the natural environment as well as swimming, surfing, fishing and walking along the beach. The decision to move to a coastal location is known as a **sea change**. Increasingly, large numbers of people are moving to coastal areas to get away from the pressures of big city life. Apart from capital cities, coastal communities are the fastest growing regions in Australia.

Tree change

A **tree change** is when people move from the city to a rural area. People usually make the change in search of a more liveable environment. Country towns offer people a better balance of work and leisure (called 'work–life balance'), a lower cost of housing and living, clean air and a slower pace of life.

For people considering a tree change, the lower cost of homes in rural areas is tempting. A buyer might get a large home on a block of land for the price of an apartment in a capital city. Over 30 per cent of people moving to country areas say cost of living was their main reason to move.

Migration in and out of the central coast of NSW, 2016–21



Source: Matilda Education Australia

▲ **Source 1:** A flowline map of migration in and out of the central coast of NSW, 2016–21

▲ **Source 2:** Mudgee is a rural town 260 kilometres north-west of Sydney, with a population approximately of 10 923. Renowned for historical colonial architecture and extensive vineyards, Mudgee lies within the Cudgegong River valley, amid fertile agricultural land. It serves as a nexus of cultural heritage and scenic landscapes.

Source 3: Residents of Victoria's Surf Coast enjoy a pre-dawn surf. Some of them will then head off to work locally. Others will be driving to jobs in Geelong (20 minutes) or Melbourne (90 minutes). More and more people are making a 'sea change' to enjoy the coastal environment and the activities available there.

With improvements to internet connections across Australia, more residents can make a tree change and work from home to minimise their travel time and increase their quality of living.

A key motivation for a person to make a tree change to a rural area is to find a better living environment. The aesthetic appeal of rolling green pastures with grazing animals and fresh air appeals to many people.

Green belts and wedges

Green belts and **green wedges** are undeveloped areas within or around cities that have been set aside for open space. Green belts surround the outer limits of cities, and green wedges run through urban areas.

These green zones help make major cities more liveable, as they:

- protect natural and rural environments
- improve air and water quality
- give city residents access to rural and natural environments
- provide bushwalking, camping and riding areas close to cities
- provide a connected habitat for native animals and plants.

Learning ladder 4.3

Processes that transform people, places and environments

1. Define the term 'sea change'.
2. What is a tree change? Why do people choose to make them?
3. Explain how green belts and green wedges improve liveability.
4. Source 1: Analyse the pattern shown on the map. Where have the greatest population increases occurred? Why do you think this is the case?

Environment

1. Source 3: What type of environment is shown here?
2. Source 2: Describe the physical and human characteristics of this environment.
3. Source 3: Why has Victoria's Surf Coast become such a popular place to live for an increasing number of people?
4. Source 2: Explain the main pull factors for people making a tree change.
5. Source 1: Evaluate the impact on environments in the fastest growing regions. How might the quality of the environment suffer?

HOW TO Environment, page 396

4.4

Can humans live in extreme environments?

Some of the least liveable places on Earth are mountains, deserts and polar regions. Over time, some people have adapted well to living in these harsh environments. Their bodies have become used to extremes in temperature, or less water or oxygen.

Difficult environments

Some environments have very harsh conditions that make it difficult for humans to survive. They may be extremely hot or cold, or there may be no water or little oxygen to breathe. Polar regions, deserts and high mountains are examples of extreme environments where the few humans who live there have had to adapt to survive.

Polar regions

The Arctic and Antarctica are the Earth's two polar regions. The Arctic is the cold area around the North Pole. One Indigenous group who lives there is the Inuit. The Inuit have adapted their diet, clothing, transport and housing to help them live in the extreme cold.

Antarctica is the coldest, highest and windiest place on Earth. It is the only continent that has no permanent human population. Scientists from Australia, New Zealand and many other countries work and live in scientific stations in Antarctica where even in summer the temperature can drop to –50°C.

Buildings on Antarctic stations are heated to 18°C. When working outside, people have to wear lots of layers topped with a thick, quilted freezer suit. **Hypothermia** (lowering of body temperature below normal) and **frostbite** (freezing of the skin and other tissues) are both dangerous risks.

Antarctic air is so dry that a person's body can lose water just through breathing. A person needs to drink 6 to 8 litres of water per day to stay hydrated while in Antarctica.

Desert regions

Deserts are very dry areas that receive less than 250 millimetres of rain a year. Most people think that deserts are hot places, and in the day many deserts are. But overnight, deserts are cold. Deserts known as 'cold deserts' also have relatively low temperatures during the day.

Places without a water supply are difficult to live in. People such as the Bedouins of the Middle East and North Africa are **nomadic** – they herd animals around in search of the most productive land. In Chile's Atacama Desert – the world's driest place – the people of the village of Chungungo use fine nets to capture moisture from the sea fogs that pass over the desert. The water droplets drip into large containers and pipes that supply the village with water.

Mountain regions

People living in the high mountains of the world need to adapt to cold temperatures and rugged terrain. Living in mountains also offers unique challenges for breathing. Many visitors to high altitudes suffer mountain sickness caused by the oxygen-thin air.

Source 2: Traditional Inuit people live in the Arctic areas of Alaska, Canada, Siberia and Greenland. The Inuit learnt to make warm winter homes, known as igloos, from snow and ice. They used animal skins and furs to make warm clothing. The Inuit people are unable to grow their own food because the Arctic climate is so harsh, and mostly eat meat from seals, whales, polar bears and caribou. Originally, Inuit used dog sleds for transport – but today they use snowmobiles.

Symptoms range from shortness of breath, dizziness and headaches, which can result in coma or even death.

Groups that have lived in high altitudes for many generations, such as Tibetans and Sherpas in the Himalayas, and Quechuan in the Andes Mountains, have developed a genetic change in their blood that allows them to comfortably live and work at high altitudes with less oxygen.

Source 1: Bedouin tribes live in desert areas in North Africa and the Middle East. They have herds of camels and other animals that are well adapted to desert conditions. Their traditional nomadic lifestyle means they frequently move to find scarce resources in the dry desert environment. Bedouin tents are designed to allow air to circulate. Animal hair is used to insulate the tents so they stay cool during the hot days but warm during the freezing nights.

Learning ladder 4.4

Characteristics of places and environments

1. Define the term 'extreme environment'.
2. Give two examples of people living in extreme environments.
3. Source 2: Describe the characteristics of this place and its impact on liveability.
4. Explain why Tibetans, Sherpas and Quechuan peoples might have a different perception of the liveability of high mountain areas.

Place

1. Identify three different extreme environments.
2. Source 1: Describe the physical and human characteristics of this environment.
3. Source 2: How have the physical characteristics of this place influenced how the Inuit live?
4. Sources 1 and 2: Compare how the Inuit and Bedouins have responded to living in extreme environments.
5. Compare the strategies for working and living in polar regions used by the Inuit and scientists working in Antarctica.

HOW TO Place, page 390

4.5

Why is a community of place important?

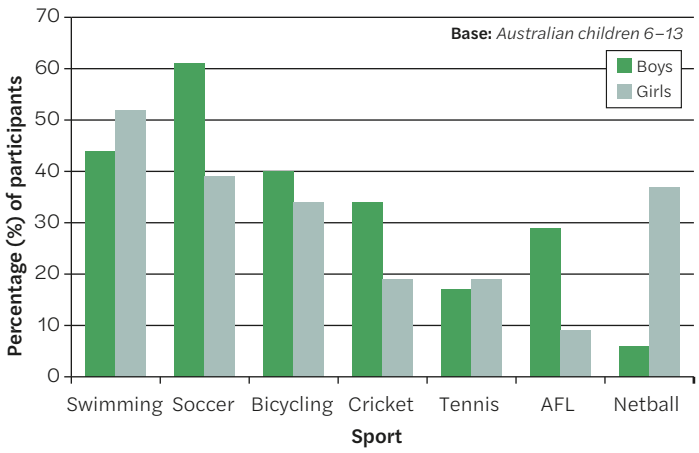
Living in a community brings people together. Being part of a community helps people feel more connected and supported – and makes a place more liveable.

Connected communities

The most liveable places are those where everyone feels connected to the local **community**. A community is a group of people who have something in common such as a neighbourhood, a workplace, a school, a sporting club, a music or crafting club, or a language group.

We are all members of many different communities that make our lives more enjoyable. For example, over 6 million Australians are actively involved in sporting communities. They might play sport at an elite level or just for fun, or they might be a spectator or follow a particular sporting team.

Sports practised by boys and girls aged 6–13 years



Source: Roy Morgan Young Australians Survey, 2015

Source 1: Shri Shiva Vishnu Hindu temple at Carrum Downs is a popular community venue for Melbourne's Indian community.

Source 2: Sports practised by Australian boys and girls aged 6–13 years. People connect with each other when they join up to share a common interest, such as sport. If people feel connected through communities, the place they live in becomes more liveable.

Source 3: Agricultural shows are a way of bringing rural communities together. Local, regional and state shows give an opportunity to showcase livestock and produce. For many people in remote areas, the local show is the highlight of the year – and the focus for the whole community.

Community of place

A **community of place** is a community of people who come together because of where they live, work, visit or spend time.

People living in remote or rural areas need the support and sense of belonging to a local community to overcome the isolation of where they live. Places such as schools, churches, recreational clubs, cafes and hotels are important meeting points for country people. Community events – such as rodeos, agricultural shows, festivals, sporting events and social celebrations – are important to help overcome the loneliness felt by many people on the land.

Cultural communities

People are often attracted to a place where they know there are other people from the same cultural background. Half of Australia's population was either born overseas or has a parent who was born overseas. So some people find specific rural towns – and specific **suburbs** in some cities – are more liveable for them because they know there are other people living there who share their language and culture.

Cultural communities often share the same religious beliefs. Melbourne has Australia's largest Indian community, so Hinduism, which is India's biggest religion, has become Melbourne's fastest growing religion. Belonging to a religious community helps make places more liveable for new Australians who have migrated from another country.

Learning ladder 4.5

Characteristics of places and environments

1. Define the term 'community of place'.
2. How does 'community of place' increase the liveability of an area?
3. Source 1: Describe the characteristics of this place and its impact on liveability.
4. Sources 1 and 3: Explain how the characteristics of these places influence differences in their communities.

Interconnection

1. Source 2: Suggest two reasons why sport enables interconnection.
2. Source 3: Describe how rural shows help country people to come together.
3. List the local community groups in your area. As a class, discuss how these groups contribute to the local community of place.
4. Source 3: Why are opportunities for interconnection through a community of place even more important for people in rural communities?

HOW TO Interconnection, page 392

How does climate change impact liveability?

Climate change refers to increasing global temperatures and changing weather patterns. The current rapid rate of change is a result of additional carbon dioxide and other greenhouse gases emitted into the atmosphere by people, particularly through the burning of fossil fuels. Environmental changes resulting from climate change are impacting the liveability of places.

Rising sea levels

One of the greatest impacts of climate change on where people live, and their quality of life, is rising sea levels. The global average sea level has risen by 21–24 centimetres since 1880 due to increasing melt water from glaciers and ice sheets, and the expansion of warming seawater. According to the United Nations, rising sea levels are already threatening the lives of 40 per cent of the human population: those who live in coastal communities. The most affected places include low-lying Pacific Island nations such as Kiribati and Tuvalu; places with large areas of coastal lowlands such as Bangladesh in Asia, Florida in the United States and the Nile River **delta** in Egypt; and the world's largest cities including New York and Shanghai.

Rising sea levels have many consequences:

- Inhabited land is flooded (inundation).
- Salt invades freshwater supplies, including groundwater (salinisation).
- Crops and plants die as soils become waterlogged and salty.
- Coastal erosion threatens properties and infrastructure.
- Water and food security declines.

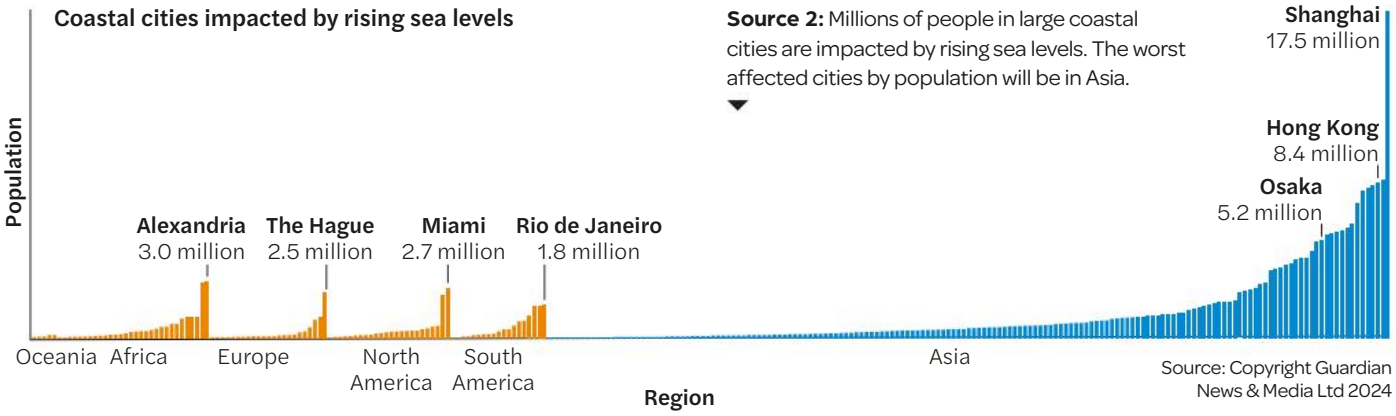
Small coastal communities

Livelihoods and food sources are lost as farmlands flood, and fisheries fail because coastal ecosystems such as mangroves, the nurseries of the sea, collapse. People living in these areas can no longer meet their basic needs of food, water and shelter, making these places unliveable. The most vulnerable people are the poor, who often live on the most flood-prone land and have few other resources. For Indigenous communities, the loss of sacred and culturally important coastal sites means a loss of cultural identity and connection to place. The Philippines is an archipelago with more than half of its cities and communities living on the coasts of its islands. Millions rely on coastal fisheries or farming the narrow coastal plains. The country's sea levels have already risen three times more than the global average.

Large coastal cities

It has been predicted that by 2050, over 800 million people living in 570 cities will be impacted by sea level rises of more than half a metre. High population densities and the concentration of employment in large cities means millions of urban dwellers could be displaced or lose their livelihoods. The largest urban populations vulnerable to flooding are in Asia and include Shanghai where over 17 million people are at risk, and Kolkata, Mumbai and Dhaka where between 11 and 14 million people are at risk.

Source 1: Urban Miami in Florida could be permanently inundated by the ocean if temperatures increase by 3°C in 2050 (top). Farming communities in coastal Bangladesh already face inundation by the sea (bottom).



Source 2: Millions of people in large coastal cities are impacted by rising sea levels. The worst affected cities by population will be in Asia.

Human displacement

Sea-level rise leads to the **forced migration** of millions of people as internally displaced people (within their own nation), migrants to other countries or environmental refugees. An influx of displaced people then reduces the liveability of the places where they arrive through increased pressure on resources, increased population densities and lack of permanent housing and employment opportunities. In Bangladesh, 40 million people are at risk of internal displacement if sea levels rise by one metre.

Holding back the ocean

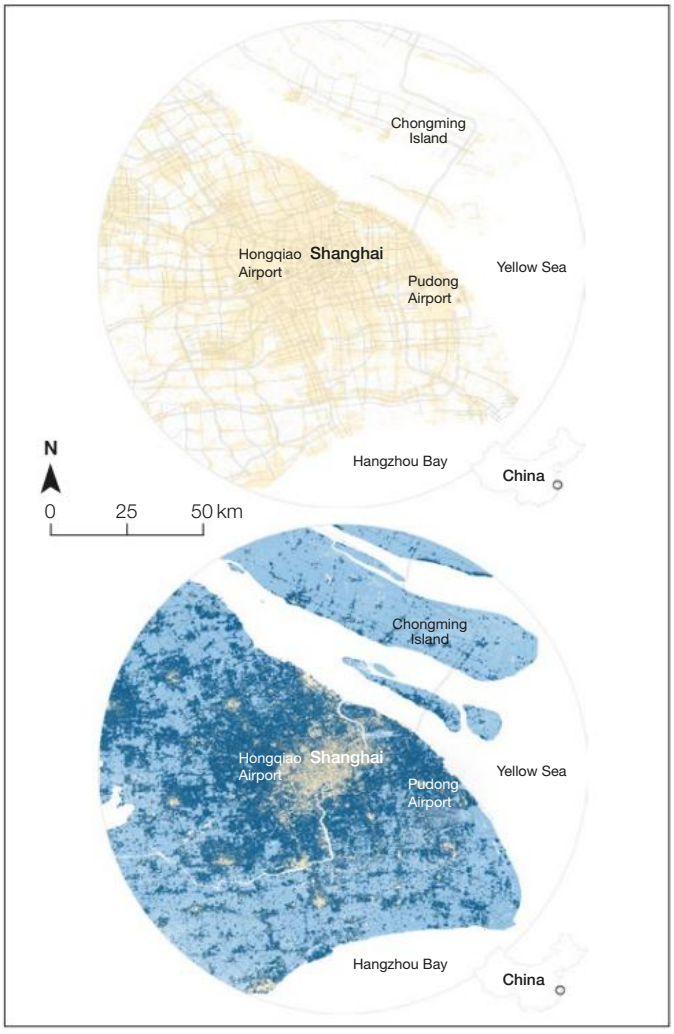
Addressing the causes of climate change is the only action that will prevent further rising sea levels and protect the liveability of places. This means a global commitment to the Paris Agreement to reduce carbon-dioxide emissions. This is called 'mitigation', without which even more places will become unliveable in the future.

To preserve the liveability of places already threatened by rising sea levels, a variety of actions are being taken to protect the coast and coastal communities. This is known as 'adaptation'. Many of the strategies, however, are too expensive for poorer countries and communities to implement. They will require international financial assistance to adapt to climate change. The United Nations has committed to helping low-lying island nations.

- **Retreat:** Relocate populations and infrastructure away from the coast.
- **Elevate:** Create higher land or raise buildings above projected sea levels.
- **Block/defend:** Build structures such as seawalls to protect properties from inundation and increased threats of erosion.
- **Restore:** Replant coastal habitats such as seagrasses, coral reefs, kelp and mangrove forests that protect coastlines from erosion. This will help restore ecosystems and marine life populations.
- **Relocate:** Buy land in other countries and plan for relocation.

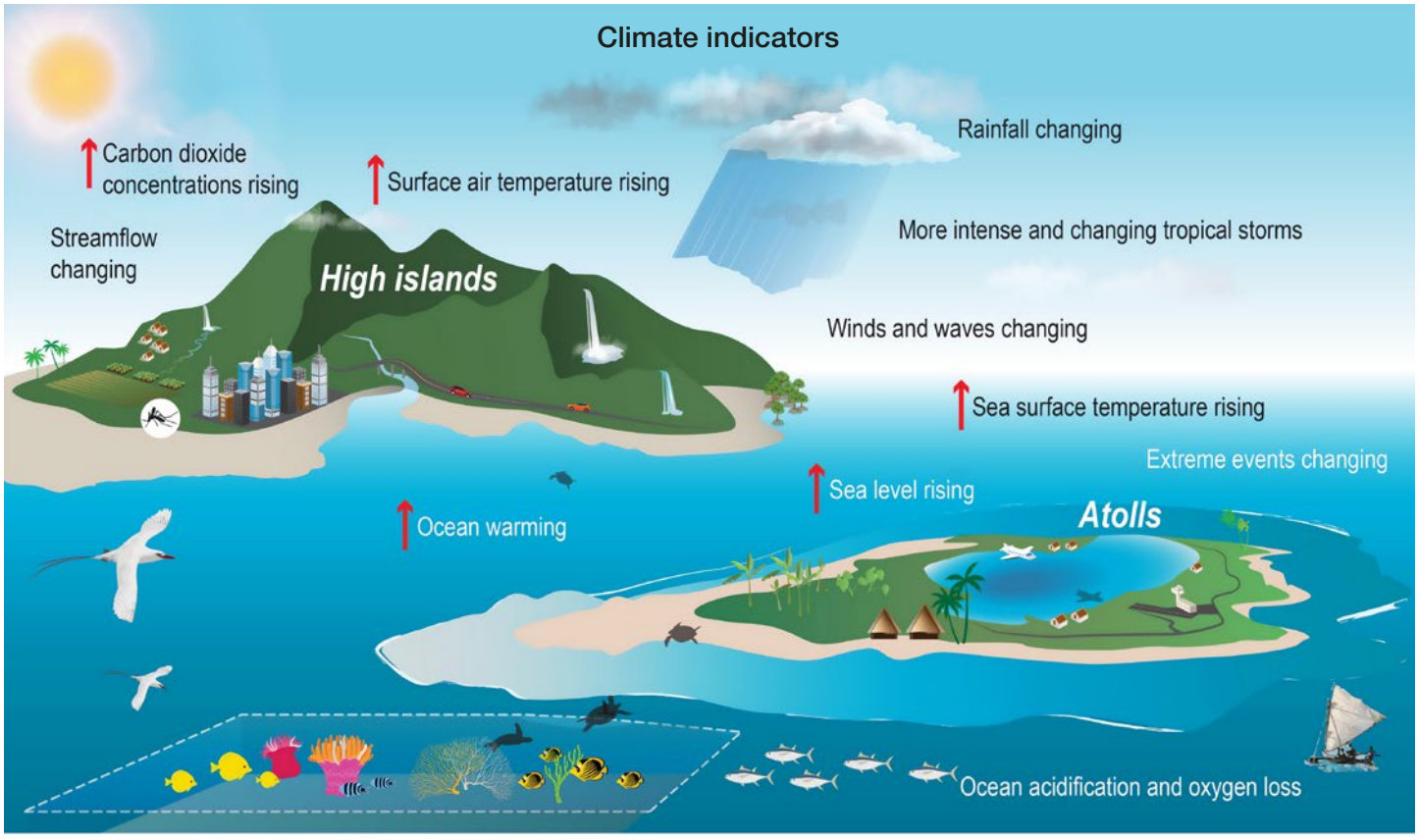
The government of Kiribati has already purchased land in Fiji where extra food could be grown, and as a future place to settle if the nation entirely disappears below the sea.

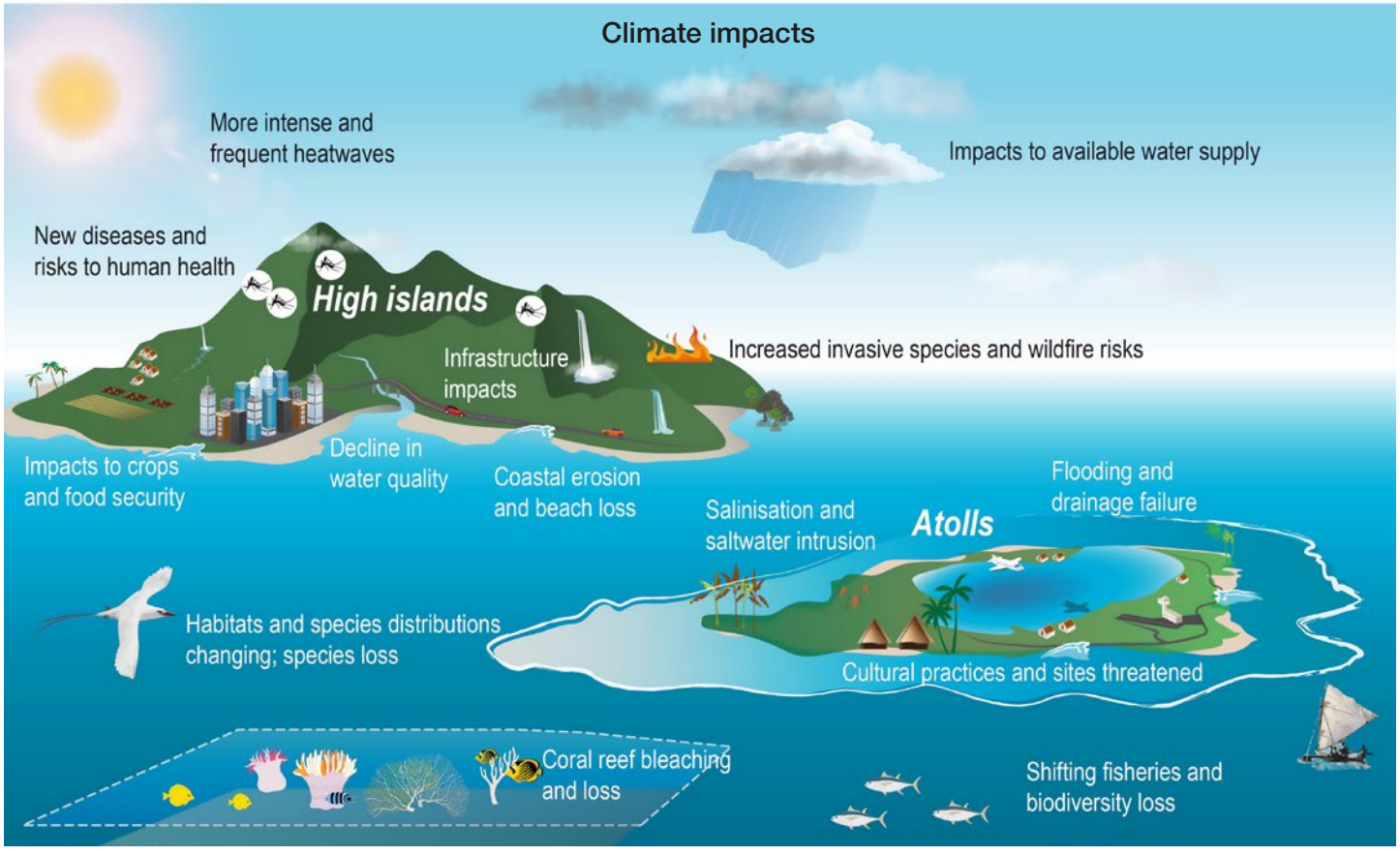
Shanghai 2023 and projected water coverage in 2050



Source: Copyright Guardian News & Media Ltd 2024

Source 3: These two maps show Shanghai, the city that is most vulnerable to sea-level rise by 2050. The top map displays the locations of the highly populated urban space, which accommodated over 29 million people in 2023. The bottom map shows the areas that are vulnerable to being submerged in water if global temperatures increase by 3°C in the next 25 years. Many management strategies are being employed to try to reduce this challenge. These include building seawalls along the waterfront, raising walkways and putting drainage and water controls into place to protect people and property.





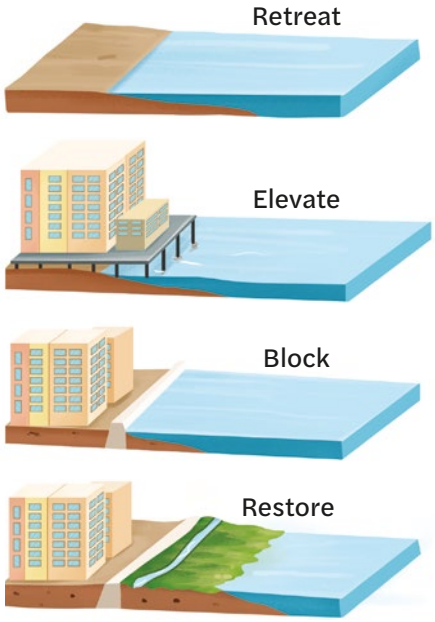
Source 4: Indications and impacts of climate change in Pacific Island nations

Other climate change impacts

Atmospheric warming causes other environmental changes that, in turn, affect liveability:

- Higher average temperatures cause heatwaves and increase heat stress, particularly in large cities where a 'heat island effect' already impacts millions of residents. Heatwaves result in more deaths than any other climate-related disaster, and wildfires start more easily and spread faster in these conditions.
- Fire events increase air pollution and reduce environmental quality. The quality of life of vulnerable groups such as babies, the aged and people with lung diseases is reduced and working outdoors is more difficult.
- Extreme weather events such as floods and droughts, cyclones and bushfires become more common. In recent years, NSW has experienced greater frequency and intensity of heatwaves and heavy rain, while parts of Africa have had more severe droughts and are at increased risk of famine.
- Marine heatwaves change coastal ecosystems that human livelihoods and cultures depend on.
- Melting sea ice and permafrost in polar regions reduces the capacity of traditional communities to travel across their lands and onto sea ice to hunt and fish. The loss of sea ice also means greater coastal erosion and the loss of liveable land. Coastal villages in Alaska are being relocated because of rising sea levels.

All of these climate-related issues reduce liveability: places become unsafe, people face increased risks to their health and survival, and their quality of life deteriorates. The cumulative impact of climate change for small islands is shown in Source 4.



Source 5: Climate change adaptation strategies to defend against overland flooding. If we ignore groundwater, flooding may still happen behind our existing or future defences.

Learning ladder 4.6

Processes that transform people, places and environments

1. Use a mind map to identify the ways climate change impacts people and environments.
2. **a** Write your own definitions for the following terms: inundation, salinisation, heatwave, mitigation, adaptation.
   b Use each term in a sentence about the impacts of climate change.
3. Why are rising sea levels considered the greatest threat to humanity from climate change?
4. Source 5: Rank the adaptation strategies in the diagram from most effective to least effective. Explain your rankings.
5. Source 4:
   a Assess the vulnerability of Pacific Island nations to multiple impacts of climate change.
   b Propose two strategies governments could use to protect the liveability of their island nations.
   c Why is it necessary for the international community to assist Pacific Island nations financially for climate change adaptation?
   d Create an illustration showing an island coastline with a range of strategies in place that will maintain liveability.

Scale

1. Source 1: Identify an impact of climate change at the local scale.
2. Source 2: Describe the regional variations in the impact of climate change on the liveability of large cities. Suggest a reason for the differences.
3. Source 3: Use the scale of the map to calculate how far inland the coastline will be if global temperatures increase by 3°C.
4. Explain how changes on a global scale will have different national and local impacts.
5. Explain how the responses of governments to climate change could affect where and how people live in the future.

HOW TO Scale, page 398

How is safety interconnected with liveability?

Being safe is a key ingredient of a liveable place. Many people in the world live in unsafe places with the threat of volcanoes, earthquakes and tsunamis. Others live with conflict, or are forced to escape war zones as refugees.

Looking for safety

Along with having food, water and shelter, feeling safe is the most important factor in the liveability of a place. Many of the world's least liveable cities are found in war-torn countries such as Syria, Afghanistan and South Sudan.

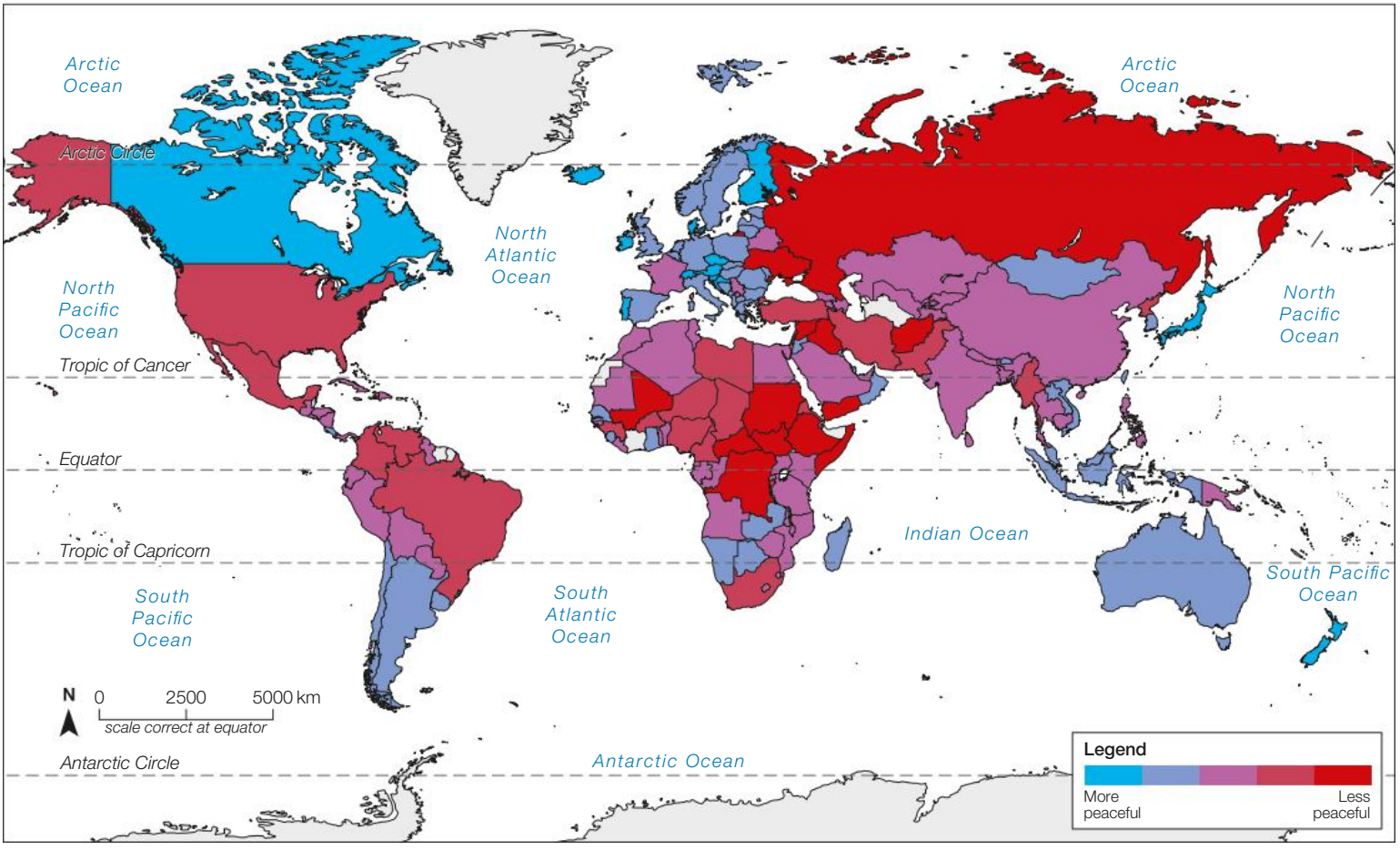
In regions of conflict, people are forced to leave their homes. They seek safety, food and shelter in camps that have been set up by welfare organisations. Some people are forced to flee their homes and move to camps somewhere else in their country – these are called **internally displaced persons**. Many threatened people flee to other countries as refugees in order to escape war, violence or a natural disaster. More than one million refugees from South Sudan are now living across the southern border in Uganda.

Source 1: Global Peace Index 2023 measures global peacefulness. This annual report produced for the Institute for Economics and Peace uses 23 qualitative and quantitative indicators to measure:

- the level of safety and security
- the extent of ongoing conflicts
- the degree of militarisation.

In 2023, deaths from global conflicts doubled from the previous year, with 238 000 people killed and 91 countries involved in a conflict, up from 58 in 2008.

Global peacefulness, 2023



Source: Institute for Economics and Peace, 2023

Source 2: A soldier walks past women in northern South Sudan who are carrying their belongings. One-third of South Sudan's population has been forced to find a safer place to live following a long-running conflict between two rival ethnic groups.

Safe and unsafe countries

The Global Peace Index ranks countries according to their level of peacefulness. In 2023, the countries rated as the most peaceful were New Zealand, Canada and Japan, as well as some countries in Europe. Russia, eastern Europe, the Middle East and central Africa were rated among the world's least peaceful regions.

The following measures (or criteria) are used to measure peacefulness:

- **safety and security:** amount of crime, numbers of people jailed, the threat of terrorism, the number of refugees
- **ongoing conflict:** number of conflicts and casualties
- **militarisation:** military spending and numbers of military personnel.

Learning ladder 4.7

Processes that transform people, places and environments

1. Define the word 'safety' in the context of where people live.
2. Describe two key differences between an internally displaced person and a refugee.
3. Explain the human processes that impact safety and decrease liveability.
4. Compare the performance of New Zealand and Russia in the 2023 Global Peace Index. What actions might have led to these rankings?

Interconnection

1. How is safety interconnected with liveability?
2. Many refugees are escaping conflict. Describe the areas of the world shown in Source 1 where refugees are likely to come from.
3. Where do refugees move to seek safety from the conflict where they live?
4. Source 2: What are the implications for these refugees? Where are they, how might they be feeling, what are they carrying and where are they going?
5. Source 1: Use SHEEPT to explain why Australia is ranked with a high level of peace. Research how the Australian government has reacted to refugees trying to reach Australia by sea. Why have they taken this action?

HOW TO

SHEEPT, page 414; interconnection, page 392

4.8

Why do people live in unsafe places?

The threat of natural hazards can make some areas of Earth less safe than others to live in. For example, floods occur in low-lying areas near water, and earthquakes and volcanoes tend to occur near the boundaries of **tectonic plates**. Fear of crime forces people to avoid places where they feel threatened.

Living in a hazardous place

Hundreds of millions of people around the world choose to live in areas that are prone to **natural hazards**. For example, areas with volcanoes are hazardous, but they attract many people because the rich soil is good for farming.

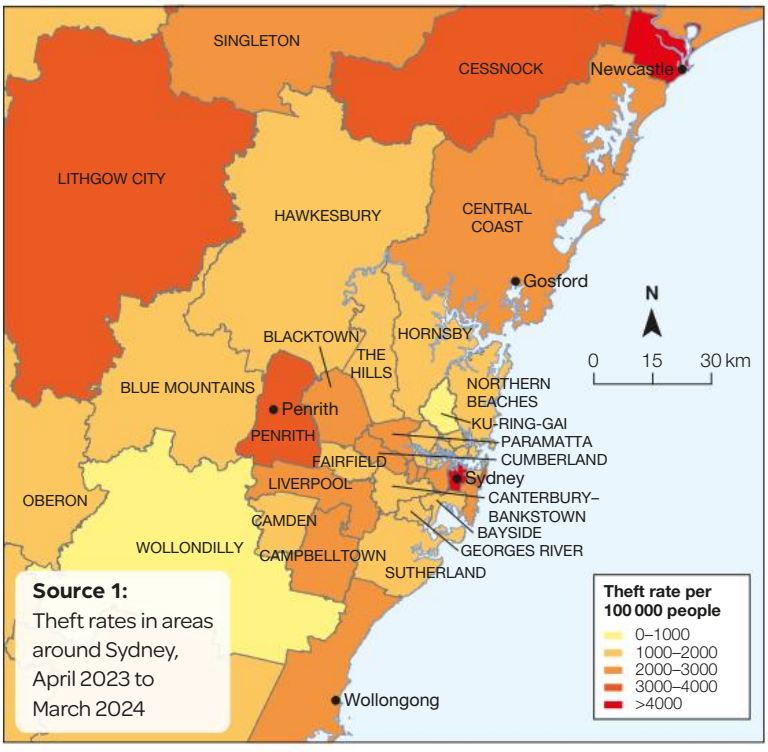
Because so many people have chosen to live in hazardous zones, natural events such as volcanic eruptions, earthquakes, tsunamis and cyclones can quickly turn into natural disasters. In Australia the most common natural disasters are bushfires, floods and cyclones.

Making places safe from crime

The most liveable places are where people feel safe from injury, abuse, theft and damage. Australian cities are regarded as safe by world standards, so they perform well in liveability rankings (see page 158). Governments are continually looking at ways to make places safer. They measure safety by surveying communities and studying crime statistics. Maps can show the areas where most crimes occur and police can be moved to areas of high crime.

Different measures are put in place to make public spaces safer. For example, improved lighting and building design can help make public areas more visible. Police patrols and surveillance cameras help prevent crime and make residents feel safer. These strategies help to reduce the number of crimes because if places are more visible and a police presence is more obvious, then any criminal activity is also easier to see.

Theft rates around Sydney 2023–4



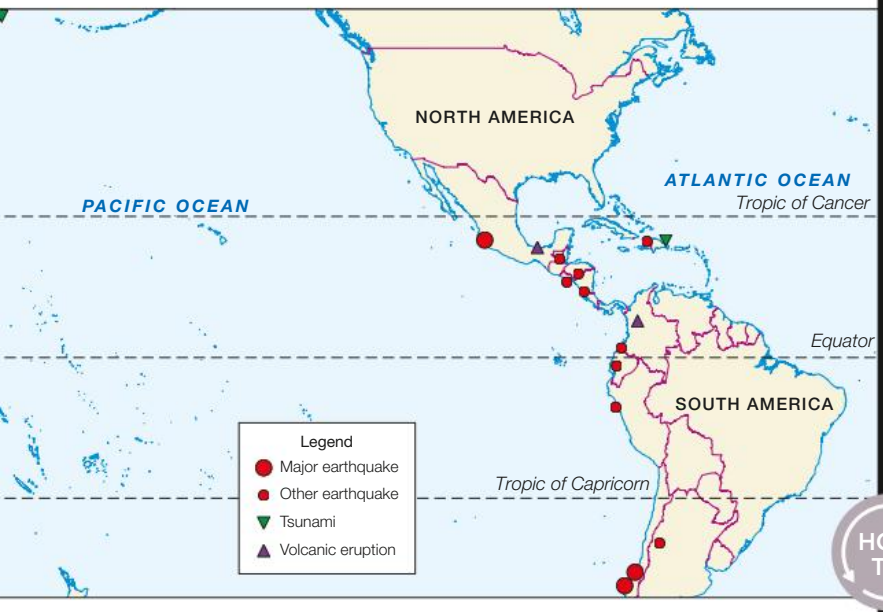
Source 1: Theft rates in areas around Sydney, April 2023 to March 2024

Source: New South Wales Crime Statistics and Research

Geomorphic disasters

Source 2: An aerial view showing the complete destruction of Palu in Sulawesi, Indonesia. The area was devastated in 2018 by an earthquake and tsunami that claimed more than 2000 lives.

Source 3: The dots and triangles on this map indicate major volcanic eruptions, earthquakes and tsunamis.



Source: Matilda Education Australia

Learning ladder 4.8

Characteristics of places and environments

1. What factors cause a place to be 'unsafe'?
2. Source 2: Describe what has happened to this place.
3. How is safety linked to liveability? How important do you think it is for a community to feel safe where they live?
4. Sources 1 and 2: Explain how these places have different experiences of being unsafe.
5. Source 1: Suggest what action could be taken in Sydney to make it a safer place.

Space

1. Source 1: Which is the most liveable region of Sydney in terms of safety?
2. Source 1: Use PQE to describe the distribution of crime across Sydney.
3. Source 3: What natural hazards are shown here and which areas of the world are affected by them?
4. Why do people choose to live in unsafe regions prone to volcanoes, earthquakes and tsunamis?

HOW TO

PQE, page 412; Space, page 388

Why is access to services and facilities important?

Access to services and facilities can impact the quality of life of all people. A service is the provision of something you need done for you, such as transport or health care. Services are intangible and are usually paid for, such as a payment for a doctor or internet access. Services may be provided by an organisation such as a charity for people who are unable to pay. Facilities are tangible and consist of the infrastructure needed to supply goods or services. Examples of facilities include hospitals, shopping centres, sports clubs, and road and railway networks. Parks and other public spaces are considered important community facilities. Facilities in a local area are often referred to as 'social infrastructure' because they benefit society.

Public and private services and facilities

Governments are involved in the provision of facilities for everyone to use. These are public facilities and include hospitals, transport networks, police stations, entertainment, sporting facilities and some public housing. People pay a fee for using these facilities or the services they provide. For example, the Australian Government has built the National Broadband Network (NBN) and consumers pay to use the internet service.

Governments also give approvals for private organisations and businesses to build infrastructure such as shopping centres, schools and hospitals to make sure there is a variety of facilities to provide the goods and services communities want. These private organisations also build specialised facilities such as aged care, child care, churches and schools.

Accessibility

Availability and accessibility impact the liveability of places for different groups. Accessibility is the extent to which a facility or service is able to be used. Factors that impact accessibility include:

- **Location:** It is well known that cities provide a larger range of services and facilities than smaller **settlements** and in greater variety. However, in developing countries, even large cities such as Mumbai in India and Sao Paulo in Brazil cannot provide for their large and growing populations.
- **Physical access:** This means being able to find or get to a place to use its facilities or services. People with disabilities, the aged and people living 'out of town' or in outer suburbs of cities have reduced accessibility.
- **Economic access:** Some people may not be able to afford to use the facilities or services available.
- **Cultural background:** Language barriers, shops selling ethnic foods or clothing and religious services are limited in many locations.

These factors are considered in planning decisions and when looking to enhance the liveability of places for all groups of people in a town, suburb, neighbourhood or community.

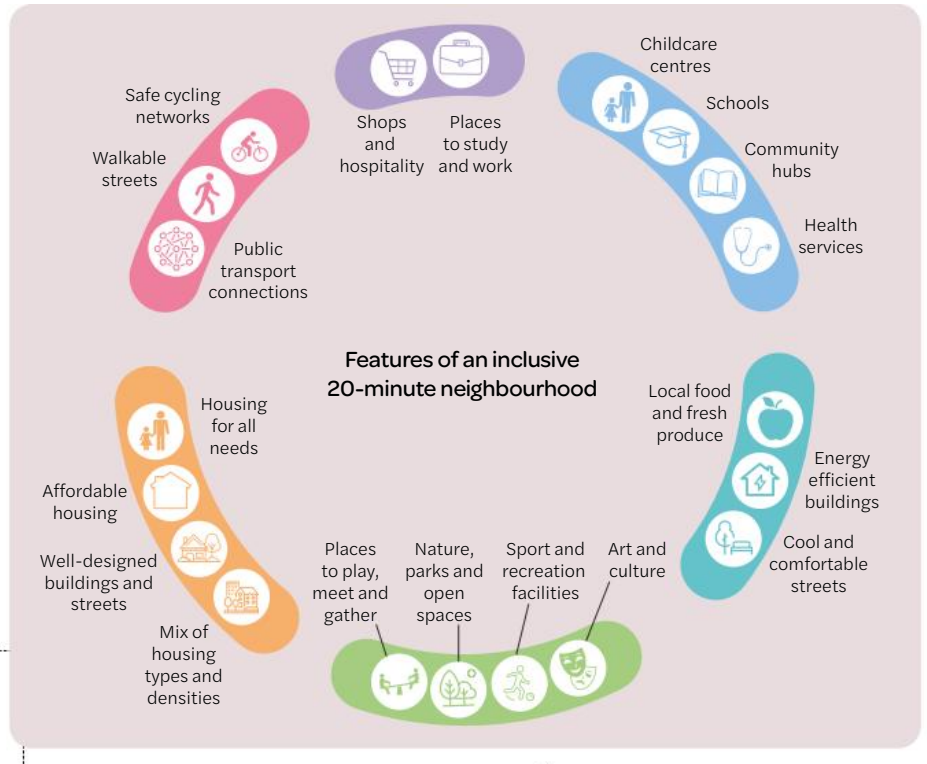
As the population of communities changes, the demand for infrastructure and services will also change. Ageing populations will require specialised housing and health care, and suburbs with a large working population need fast, efficient transport systems.

▼ **Source 1:** An artist's impression of a multi-use public community facility

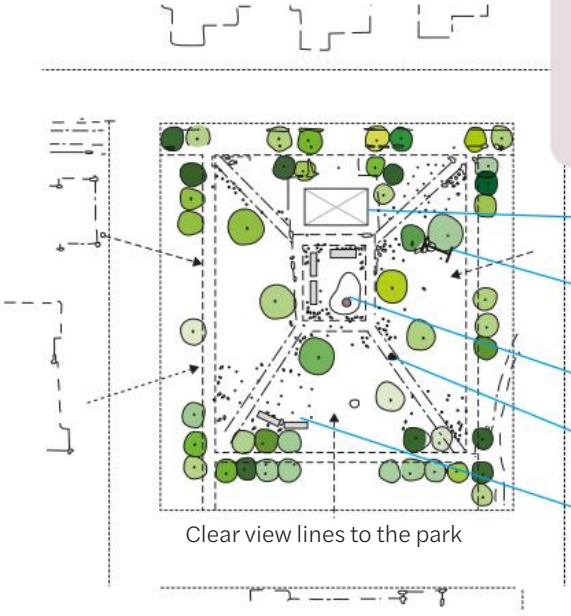
The 20-minute neighbourhood

The 20-minute neighbourhood:

- is about creating liveable neighbourhoods with availability and accessibility of facilities and services
- enables people to meet most of their daily needs within a 20-minute return walk from home
- is a planning tool for creating new urban places and a consideration when planning to enhance the liveability of existing places.



Source 2: Features of a 20-minute neighbourhood



Source 3: Local public community facilities can be made accessible to a diversity of people through careful planning.

Learning ladder 4.9

Characteristics of places and environments

1. List the public facilities you consider important for your quality of life.
2. Define the following terms using examples: services, facilities, availability, accessibility.
3. What is the role of governments in providing facilities and services?
4. Source 3: Explain how the features of this park make it accessible to a range of different groups of people.
5. Explain the factors that make services and facilities inaccessible to some people.

HOW TO Change, page 394

Change

1. Source 3: List three features needed to make a place a 20-minute neighbourhood.
2. How would people's quality of life be impacted if their neighbourhood were changed to a 20-minute neighbourhood?
3. Do you think it is possible for every part of a large city to become a 20-minute neighbourhood? Explain your answer.
4. Use Google Earth or Google Maps to screen capture an image of your neighbourhood. Draw a circle around your house with a radius you think would take 20 minutes to walk. Determine what facilities and services are within your circle – show these with lines connecting your house. Comment on changes needed to become a 20-minute neighbourhood.

4.10

How is health linked to liveability?

The most liveable places are those where the quality of the environment is high, and people have food to eat and the medical services they need to help them live a healthy life.

Environmental quality

The quality of the environment is a key factor that determines how liveable a place is. Characteristics such as clean air and clean water, low noise levels and access to open spaces make a place healthier and more liveable.

Air pollution

Many large cities around the world suffer badly from harmful particles in the air, known as **air pollution**. The major sources of outdoor air pollution are:

- exhaust gases from motor vehicles
- power generation – such as oil and coal power plants
- industrial factories, mines and oil refineries
- burning of agricultural waste
- home cooking, heating and lighting.

If there are too many harmful particles in the air, people breathe them in when they inhale. This can cause serious health conditions, such as lung cancer, heart disease and respiratory diseases.

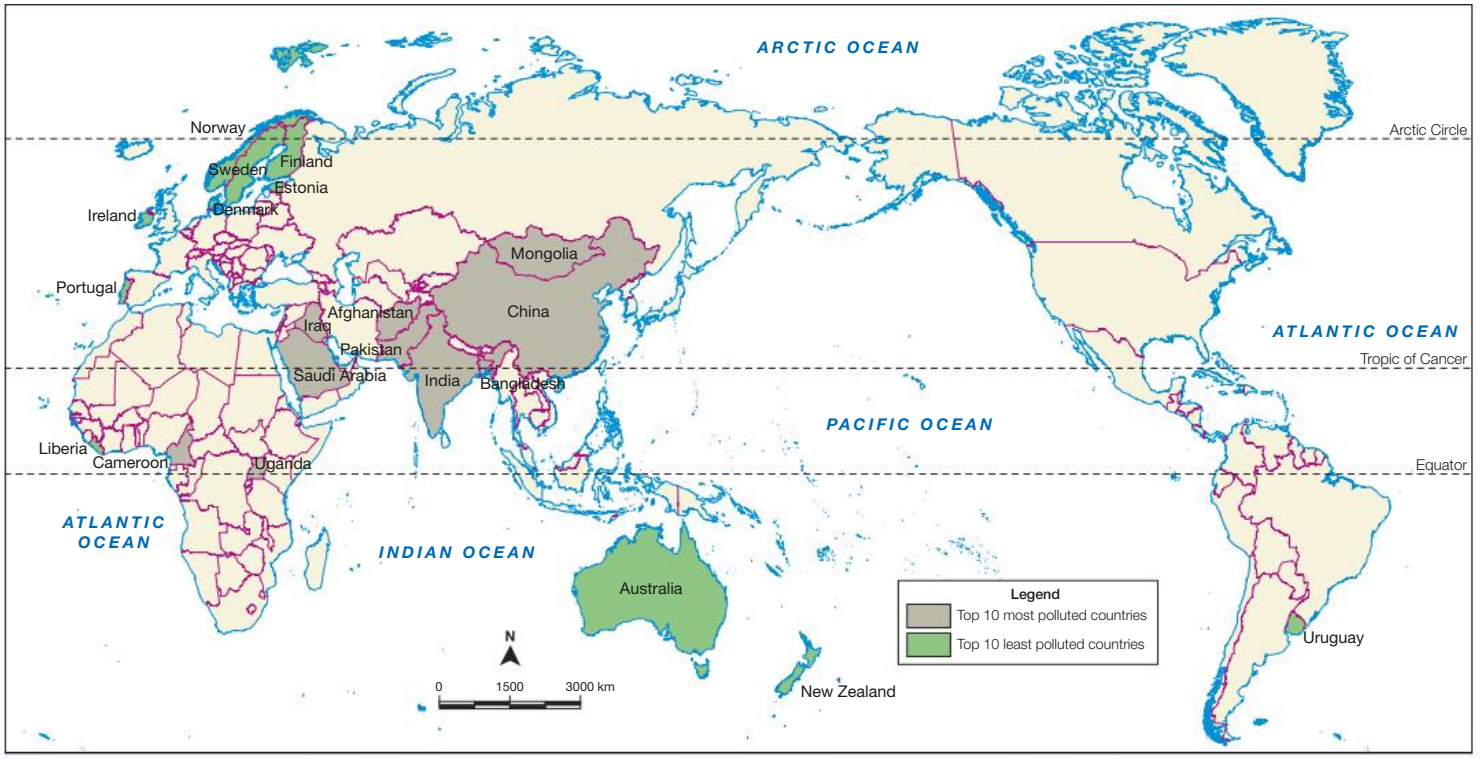
Each year, around 4.2 million people die because of exposure to air pollution – and 91 per cent of the world's population lives in places where air quality is worse than (or 'exceeds') World Health Organization guidelines.

Air pollution affects both high-income and low-income countries, with the highest levels experienced in South-East Asia. In 2018, India had the 14 most polluted cities in the world. In November 2017, air pollution levels in India's capital, New Delhi, were 30 times beyond the level that is safe to breathe. The Indian government closed schools for three days, stopped all construction and warned people to stay indoors for their own safety.

To improve the liveability of cities, India and other countries and cities have been trying to reduce their air pollution levels. Some have banned old, polluting cars, or reduced the number of cars on the road. Other countries are investing in clean energy, such as solar power and wind power.

Source 1: In New Delhi, November 2017, schoolchildren cover their faces with handkerchiefs as they walk to school through heavy smog. Commuters wore masks or covered their mouths with scarves. The government shut the primary schools, as pollution levels were nearly 30 times the World Health Organization safe level.

Global pollution



Source: Matilda Education Australia

Source 2: The world's 10 most polluted and 10 least polluted countries

Source 3: Te Anau in New Zealand is one of the least polluted areas in the world. It is the gateway to the wilderness area of Fiordland National Park.

Improving global health

Over the past 30 years there have been a great advances in the health of the world's population. However, despite the improvements in health care, there are still millions of people who don't have a healthy place to live. Wealthy countries have better health opportunities than poorer countries:

- About 3.9 per cent of all children in the world die before reaching the age of five, which means that on average 15 000 children die every day.
- In Africa, children are 15 times more likely to die before the age of five than children in high-income countries, and one child in every 13 dies before they are five.
- Children living in the world's poorest 20 per cent of households are twice as likely to die before their fifth birthday as children in the richest 20 per cent of households.
- Only 1 per cent of mothers who die during pregnancy or from complications during childbirth live in wealthy countries.

Improving children's health

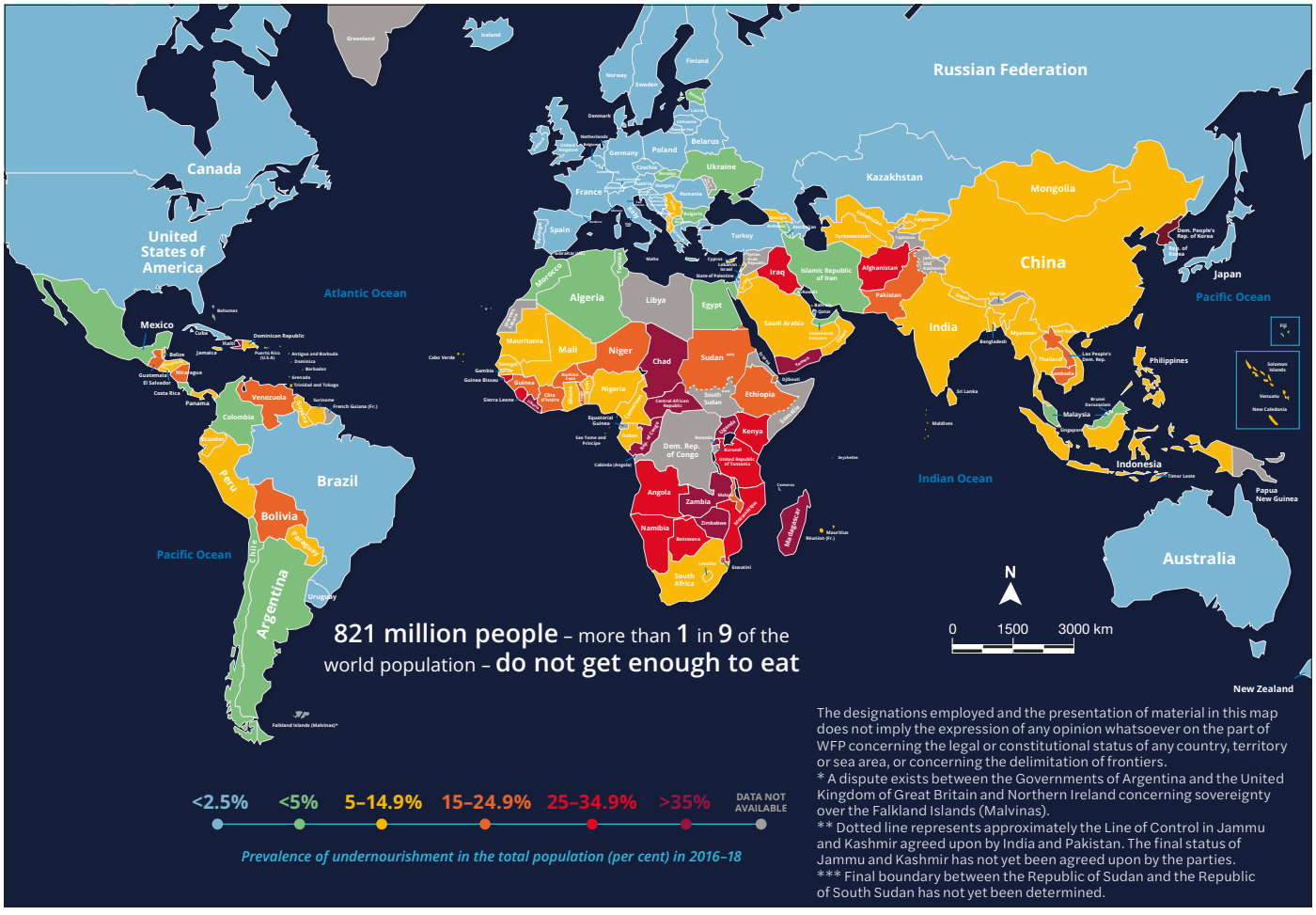
In 2021, more than five million children under the age of five died – and half of these deaths could have been prevented with access to simple and affordable medical care. More than 80 per cent of these deaths occurred in Africa and southern Asia.

Around 45 per cent of all deaths in children under the age of five were because they didn't have enough to eat, or because they did not eat enough of the right things, which is called **malnutrition**. When children suffer from malnutrition, it puts them at greater risk of dying from common infections.

In 2022, there were 45 million underweight children below five years of age – and 14 million of these were severely underweight. More than 50 per cent of all malnourished children live in South Asia, and 25 per cent live in Africa.

The opposite problem of overweight children occurs in many Pacific Island nations and developed nations like Australia and the United States of America.

World undernourishment, 2016–18



▲ **Source 4:** World hunger map, 2016–18

Source: World Food Programme, 2019

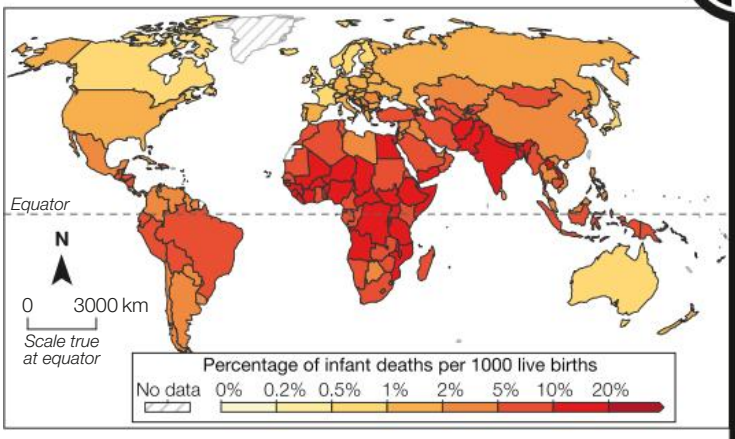
Aboriginal health in Australia

In Australia, a man can expect to live for 81 years and a woman for 85 years. But the **life expectancy** for Indigenous people is much lower. An Aboriginal man can expect to live for only 72 years and an Aboriginal woman for only 76 years. In Australia, which is such a wealthy and liveable country, it is shameful that the health of the Indigenous population lags so far behind.

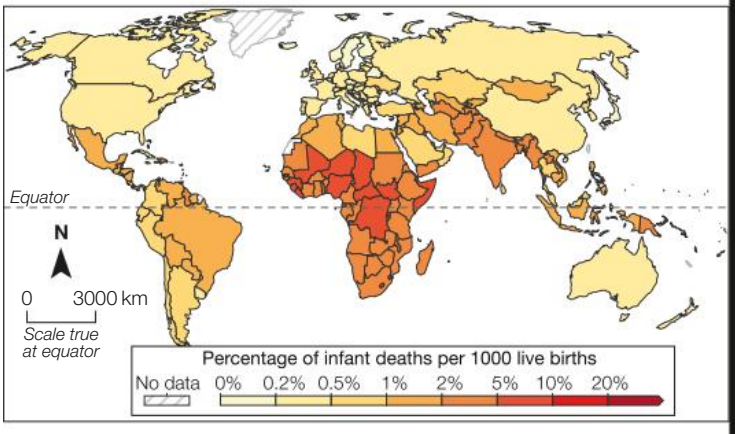
Aboriginal communities have higher rates of **infant mortality** and suffer more from infectious diseases, such as trachoma, which makes people blind. Australia is the only wealthy country in the world where people suffer from trachoma. Trachoma exists in remote Aboriginal communities that lack clean water and have overcrowded housing. Australia's Aboriginal population is also much more likely to contract diabetes and suffer heart disease than the rest of the population.

▲ **Source 5:** The combination of drought and conflict in Sudan has led to food shortages and high levels of malnutrition.

World infant mortality, 1981



World infant mortality, 2021



Source: Our World in Data

▲ **Source 6:** World infant mortality rates, 1981 and 2021. Infant mortality refers to the percentage of deaths of children under one year old per 1000 live births.

Learning ladder 4.10

Processes that transform people, places and environments

1. Source 2: Identify where most of the world's most polluted cities are located.
2. List some key factors that influence the health of the population.
3. Source 6: Explain improvements in infant mortality between 1981 and 2021.
4. Outline three things governments can do to help decrease pollution.
5. Source 4: Evaluate the key actions that should be taken to reduce levels of undernourishment in Africa and South Asia.

Interconnection

1. Source 1: How is air quality connected to liveability?
2. How is the quality of the environment interconnected with the most liveable places?
3. Source 2: Australia has some of the most liveable cities in the world. Is there an interconnection with air pollution to help explain this pattern?
4. Sources 4 and 6: Explain how there is an interconnection between hunger and infant mortality.
5. How is wealth interconnected with health? Give examples to support your view.

HOW TO Interconnection, page 392

How does a pandemic affect liveability?

The coronavirus pandemic swept across the world in 2020, affecting global liveability by affecting health, employment, and access to goods and services. Governments scrambled to slow the spread of the virus for which there was no cure.

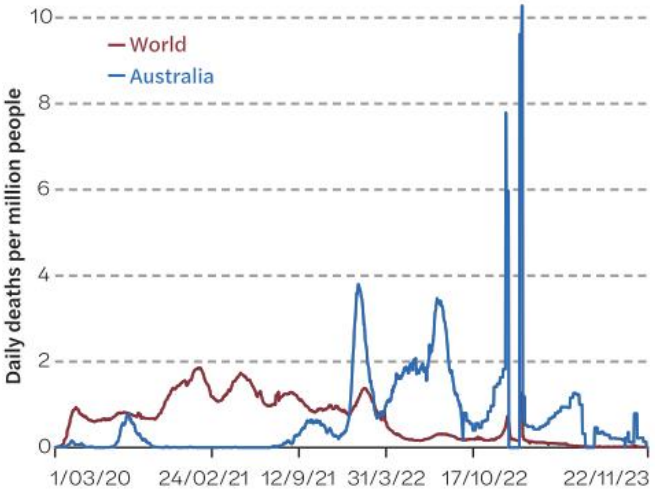
The World Health Organization (WHO) declared the coronavirus COVID-19 a **pandemic** on 11 March 2020. A pandemic is a disease that spreads in multiple countries around the world at the same time, usually affecting a large number of people.

At this time, the pandemic had reached every continent except Antarctica. The outbreak of COVID-19 is believed to have begun at a wildlife market in Wuhan in China.

In mid-March 2020, 80 000 cases and more than 3000 deaths from COVID-19 had occurred in China, where the outbreak began. However, because we live in a highly interconnected world, the virus quickly spread to the rest of the world. More than 60 000 cases of COVID-19 and 2500 deaths were reported in countries other than China. Europe became the new epicentre for the virus as it spread quickly in Italy and Spain, along with large outbreaks in South Korea, Iran and the United States.

The COVID-19 pandemic sparked a public health emergency around the world, with severe restrictions placed on the movement of people to slow the spread of the virus to assist medical resources to deal with the crisis. In Australia, travel bans were put in place, gatherings of people were banned and people arriving back from overseas or in contact with a person infected with COVID-19 were forced to isolate for 14 days. The first COVID-19 vaccinations in Australia took place in February 2021.

Daily COVID-19 deaths (per million people), 2020–23



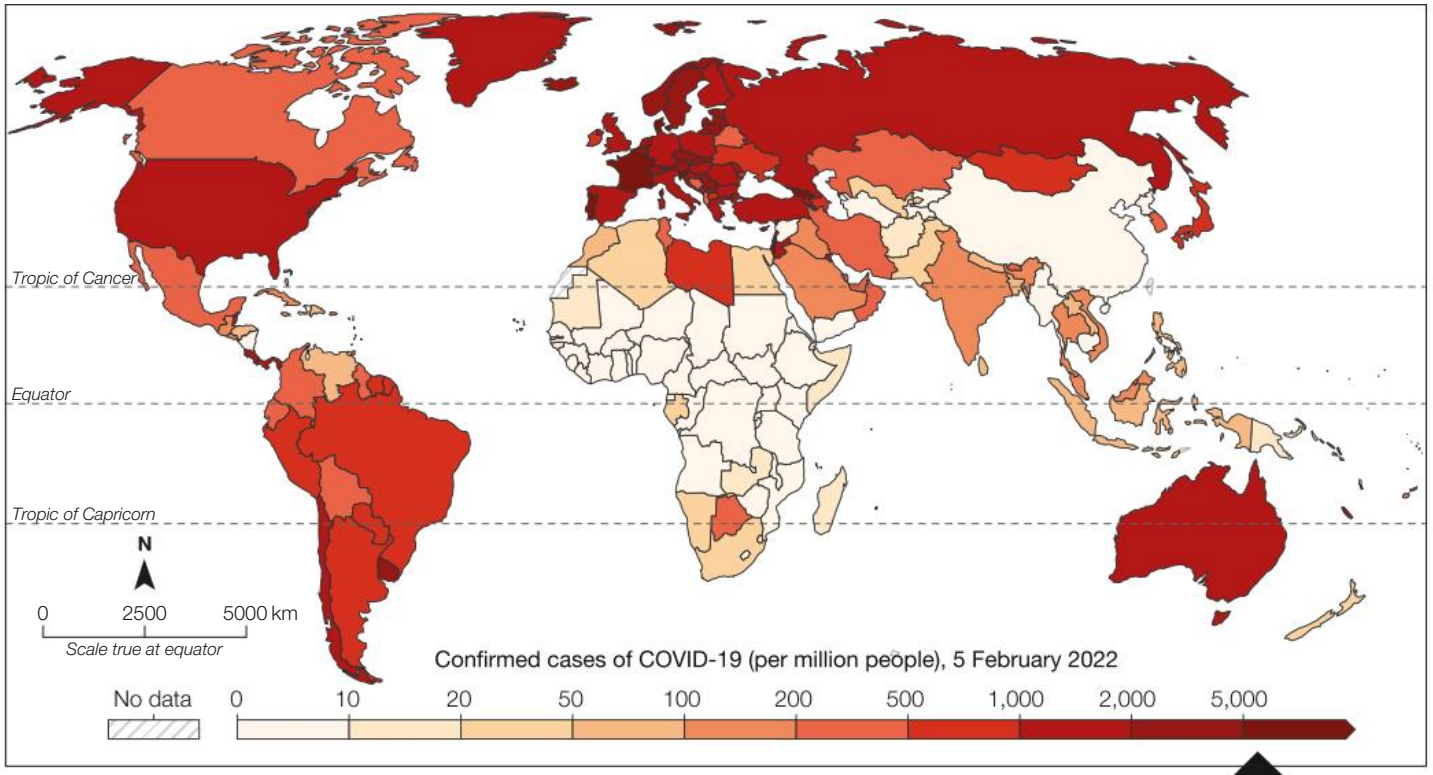
Source: Our World in Data

Source 1: Confirmed daily COVID-19 deaths per million people from January 2020 until November 2023

Source 2: Health personnel at Krakow Airport in Poland monitor the body temperatures of passengers arriving from Italy. They are detecting signs of COVID-19 in an attempt to slow the spread of the virus in Poland.

World COVID-19 cases (per million people), 5 February 2022

Source: Our World in Data



▲ **Source 3:** Confirmed COVID-19 cases per million people at the peak of the pandemic on 5 February 2022

Learning ladder 4.11

Processes that transform people, places and environments

1. What is a pandemic?
2. Describe the changes to the liveability of places caused by the COVID-19 pandemic.
3. Source 2: What action is being taken here to slow the spread of the COVID-19 pandemic in Poland?
4. How did the movement of people around the world contribute to the COVID-19 pandemic? What were the social and economic impacts of this?

Sustainability

1. Source 3: How many Australians were impacted by the COVID-19 pandemic on 5 February 2022?
2. Source 3: Use PQE to describe the spatial distribution of COVID-19 cases on 5 February 2022.
3. Source 1: Explain the reasons for the difference in national and global trends shown in this line graph.
4. Explain how COVID-19 had different impacts at local, national and global scales.

HOW TO

PQE, page 412; Sustainability, page 400

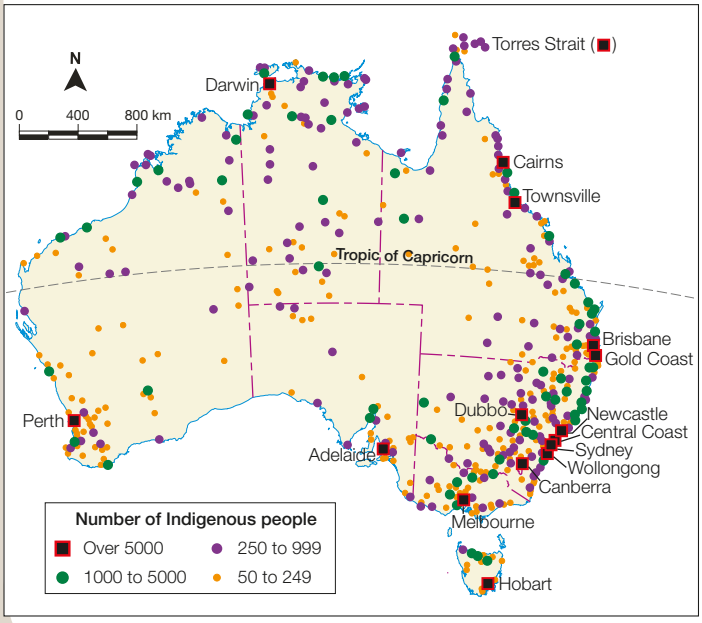
Where do First Nations Peoples live?

Aboriginal and Torres Strait Islander Peoples are the first people to live on the Australian continent and adjacent islands. With an unbroken history of at least 65 000 years on mainland Australia, early First Nations Peoples lived throughout the vast and diverse landscapes of the continent. Most lived along the coast and in river valleys. Today, First Nations Peoples live in all parts of Australia: in cities, in suburbs, and in regional and remote areas.

Connection to Country

The connection to Country is a deep and lasting bond between First Nations Peoples and their ancestral lands. This bond encompasses spiritual, cultural and physical ties, representing a comprehensive relationship that has endured for thousands of years. It involves a profound understanding of the land, its resources, and its crucial role in sustaining life and culture. Throughout their enduring relationship with the land, First Nations Peoples have shown remarkable resilience and adaptability in overcoming the various geographical and cultural challenges they have encountered over tens of thousands of years.

Australia population distribution of First Nations Peoples, 2018



Source: Matilda Education Australia

▲ **Source 1:** Population distribution of First Nations Peoples in Australia

Coastal regions

First Nations communities flourished along Australia's coastal regions, showcasing expertise in harnessing the abundant resources of the sea and land. Among these communities were the Dharawal people, who excelled in fishing, harvesting shellfish and actively engaging in trade to facilitate valuable resource exchange. The Dharawal maintained a trading relationship with the Gandangara, a neighbouring group situated further west. In this exchange, the Dharawal traded sought-after shellfish and waterfowl to the Gandangara in return for possum skins, creating a mutually beneficial trade network that enhanced both communities' access to essential resources.

River regions

First Nations communities thrived in river regions across Australia, harnessing the resources and vitality of these waterways. One example is the Yorta Yorta people, who lived along the Murray River in Victoria and New South Wales. The Yorta Yorta developed sophisticated fishing techniques, using nets, spears and traps to catch fish and other aquatic species. They also cultivated riverbank gardens, growing crops such as yams and waterlilies.

Inland and mountainous regions

First Nations communities flourished in inland and mountainous regions across Australia. In the Snowy Mountains of New South Wales, the Ngarigo people maintained a deep connection to the land. They navigated the rugged terrain and managed the rich biodiversity of the region for sustenance. The Ngarigo people harvested a variety of plant foods, including bogong moths, wild berries and edible

Source 2: Ngarigo woman Simone Davison (Mongta) on Country in the Snowy Mountains of New South Wales. Intimate knowledge of the mountains enabled Ngarigo people to thrive in this challenging environment and sustain their communities for generations.

tubers, adapting their practices to the changing seasons. Their intimate knowledge of the mountains enabled them to thrive in this challenging environment and sustain their communities for generations.

Desert regions

In the arid desert regions of Australia, First Nations communities demonstrated remarkable adaptation and water management techniques. For instance, the Pitjantjatjara people in the central desert created and maintained rock holes called tjukula, which served as vital water reservoirs during dry seasons. This ensured a reliable water supply for the community. Desert people managed a variety of food sources, including bush tomatoes, quandong fruits and honey ants. These nutritious resources played a crucial role in their diets, enabling them to thrive in the challenging desert conditions.

▼ **Source 3:** Children dig for honey ants near Alice Springs.

Learning ladder 4.12

First Nations Peoples' interaction with Country

1. Source 1: Where do First Nations Peoples live in Australia today?
2. Name some of the food sources relied upon by desert people and explain their importance in traditional diets.
3. Explain the trading relationship between the Dharawal and the Gandangara and how it enhanced resource access for both communities.
4. Source 2: Discuss the adaptation strategies used by the Ngarigo people in the Snowy Mountains, including their reliance on plant foods and the practice of harvesting bogong moths.

Environment

1. Source 3: In which environment are these children looking for honey ants?
2. How did First Nations communities in coastal areas, such as the Dharawal, utilise the resources of the sea and land?
3. How did the Yorta Yorta people utilise the resources of the Murray River, and what were their fishing techniques?

HOW TO

Environment, page 396

Where do Australians live today?

Australia is mainly desert, and is one of the world's most sparsely populated countries. Nine out of 10 Australians live in urban areas along the coastline.

Australia's population distribution

In area, Australia is the sixth largest country in the world, but it is only the 53rd largest in terms of population. In summary: large area, not many people. So even though Australia's total population was just under 26.5 million people in 2023, it was still the third most sparsely populated country in the world. The average population density is just 3.3 people per square kilometre.

Australia's low population density – the number of people per square kilometre – is due to the desert land that makes up much of Australia's interior. Seventy per cent of Australia receives less than 500 millimetres of rainfall per year and is classified as desert or semi-desert. Very few Australians live in the arid centre of the continent.

Eighty-nine per cent of Australians live in **urban** areas along the coastline, with 40 per cent of all Australians living in either Sydney or Melbourne. Melbourne is Australia's largest city, with a population of 4.8 million. Melbourne overtook Sydney as Australia's largest city in 2023. Melbourne's growth had been outpacing Sydney's for most of the previous decade, thanks to stronger international and **internal migration** patterns that boosted its population more quickly.

Predicted growth of Australian cities

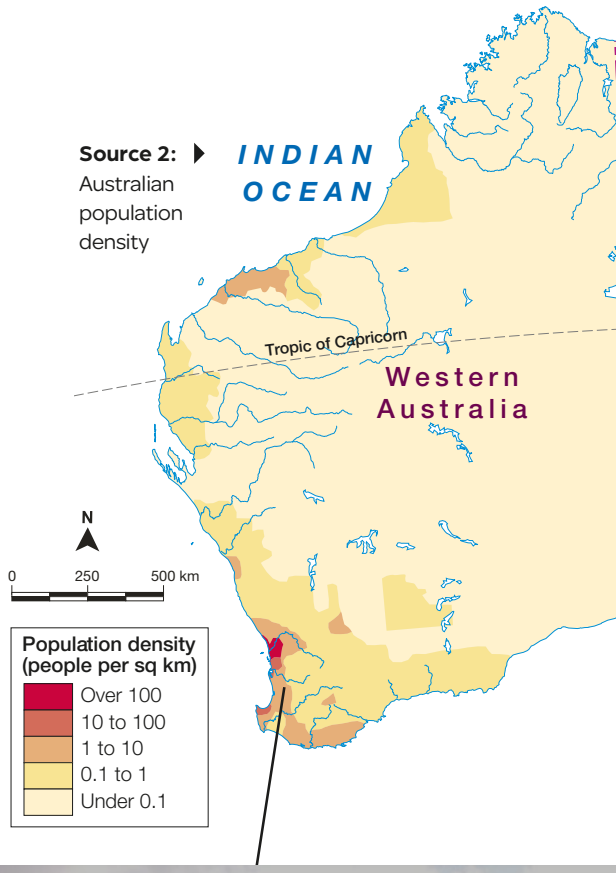
	Growth[1]	2014	2034[2]	2054[2]
		Population (000)	Population (000)	Population (000)
Adelaide	1.06%	1304.6	1604.7	1843.7
Brisbane	1.92%	2274.6	3340.6	4406.6
Canberra	1.70%	386.0	N/A	N/A
Darwin	2.30%	140.4	175.5	212.6
Hobart	0.67%	219.2	250.4	266.6
Melbourne	1.95%	4440.3	6238.1	7982.4
Perth	3.05%	2021.2	3451.8	4923.0
Sydney	1.50%	4840.6	6432.6	7966.4

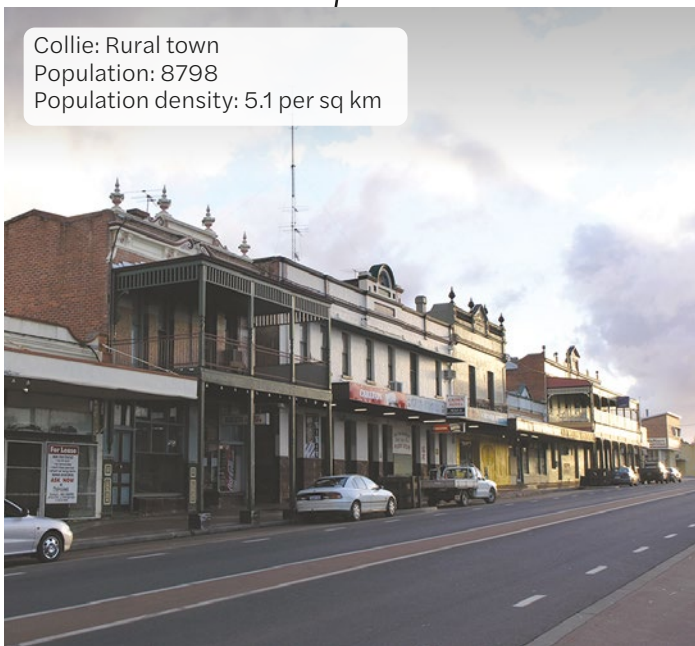
1 Annual population growth rate between 2009 and 2014

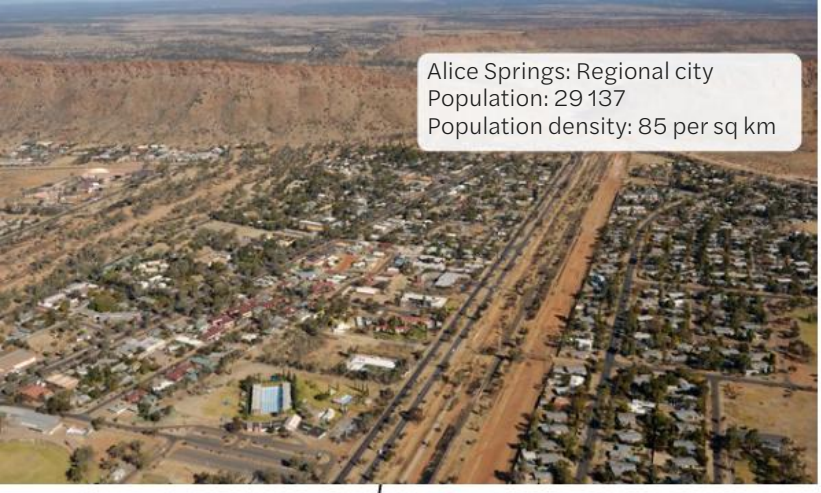
2 Estimates based on medium levels of fertility, overseas migration, life expectancy and interstate migration flows

Source 1: Predicted growth of Australia's capital cities' metropolitan area populations

Australian population density







Alice Springs: Regional city
Population: 29 137
Population density: 85 per sq km

Longreach: Remote town
Population: 3660
Population density: 0.1 per sq km

Source: Matilda Education Australia

Sydney: Major city
Population: 4 856 300
Population density: 407 per sq km

Learning ladder 4.13

Characteristics of places and environments

1. Source 2: Rank the four example towns/cities shown according to population density.
2. Source 2: Which of the four examples shown would have the greatest number of services available to its people?
3. Source 2: Describe the characteristics of Collie and suggest how these features might impact on liveability at this place.
4. Source 2: Why do you think people choose to live in remote locations such as Longreach? What are some advantages and disadvantages of living in remote locations?

Space

1. Source 1: Use the table to rank Australia's capital cities based on their predicted metropolitan area populations in 2054.
2. Source 2: Use PQE to describe the distribution of people in Australia per square kilometre.
3. Source 2: Use SHEEPT to explain Australia's population distribution.
4. Source 1: Use the data in the table to create a graph showing how the population is expected to grow between 2014 and 2054 in Australia's eight capital cities. Using the graph you create, describe those cities that are expected to grow the fastest and slowest over the 40-year period. Suggest reasons to support the trends.

HOW TO

Space, page 388; PQE, page 412; SHEEPT, page 414

4.14

Why do Australians live where they do?

Early Indigenous Australians made decisions on where to live based on natural factors they needed to survive. European settlers had to make these decisions too. Towns and cities in Australia have developed in these areas. Today, the liveability of a place also includes access to services and work, and the quality of the environment.

Natural factors

Liveability in Australia depends on water, climate and flat land.

Fresh water

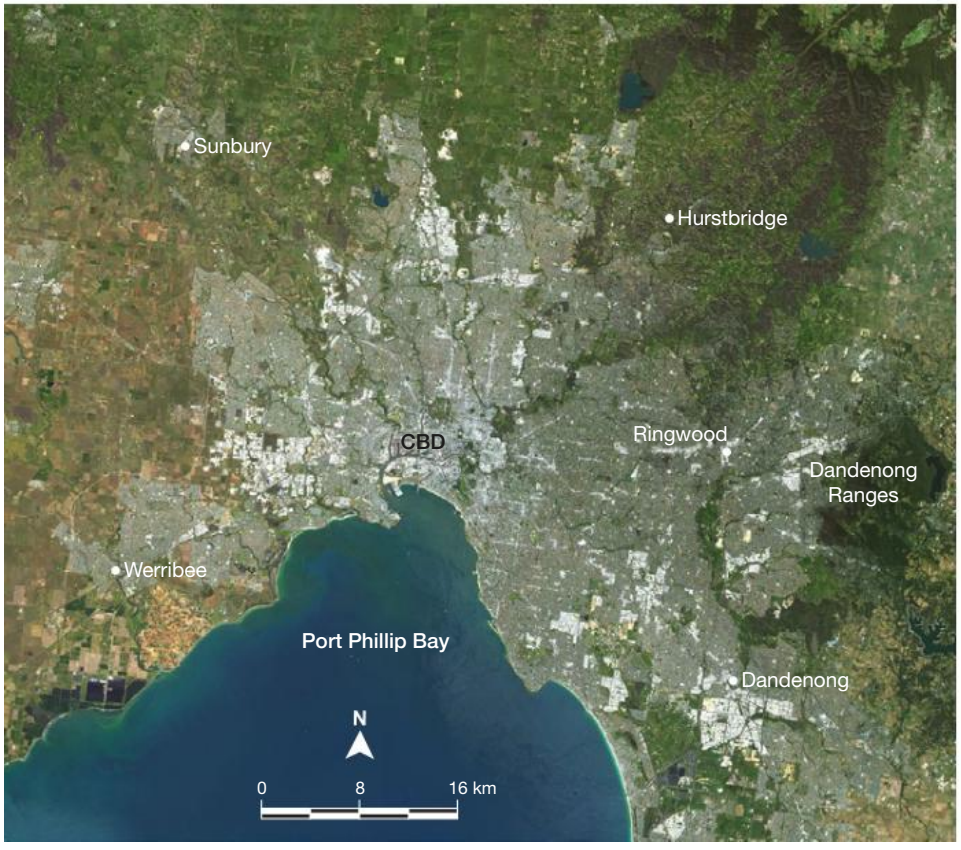
Access to fresh water is the most important factor in the liveability of a place. People originally settled near rivers and lakes, and in areas of high rainfall. Today, modern technology means that food and water are available right across Australia.

Settlements in Australia are mainly located around the coastline, where there is the highest rainfall. The biggest towns and cities are mainly located along the east coast, between the Great Dividing Range and the coastline.

Climate

Climate is a very important factor for liveability. Most Australians choose to live in regions that have a mild climate, without extremes of heat or cold. Other people prefer hotter or cooler climates.

Many retired Australians prefer the warmer coastal climates of Queensland's Sunshine Coast and Gold Coast.



Source: Planet Observer\UIG

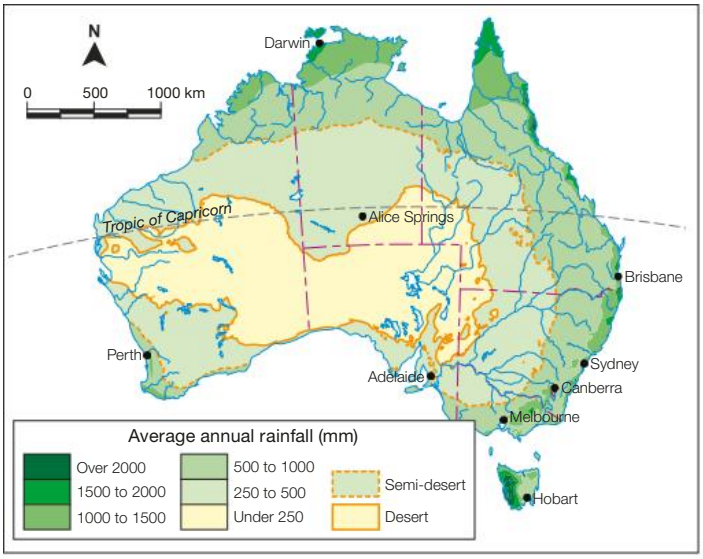
Flat land

Flat or gently sloping lands are the most densely populated areas in Australia. Most Australian towns and cities have developed on the flatter coastal plains, and along mountain valleys. That's because farms and transport networks are easier to develop on flat land, and it is easier and cheaper to build on than hilly land.

The most liveable areas of Melbourne are on the flat coastal plain surrounding Port Phillip Bay, as shown in the satellite image in Source 1.

Source 1: Satellite image of Melbourne's metropolitan area, which spreads out across the flat coastal plain between Port Phillip Bay and the Dandenong Ranges

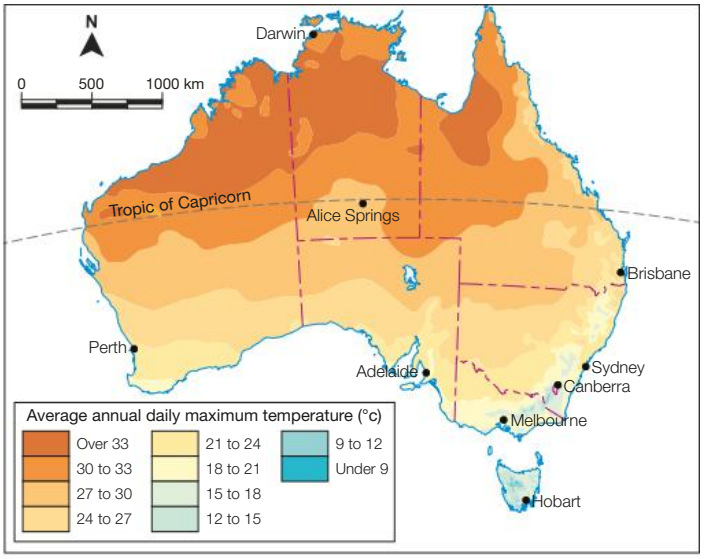
Australia average annual rainfall



Source 2: Australia's average annual rainfall

Source: Matilda Education Australia

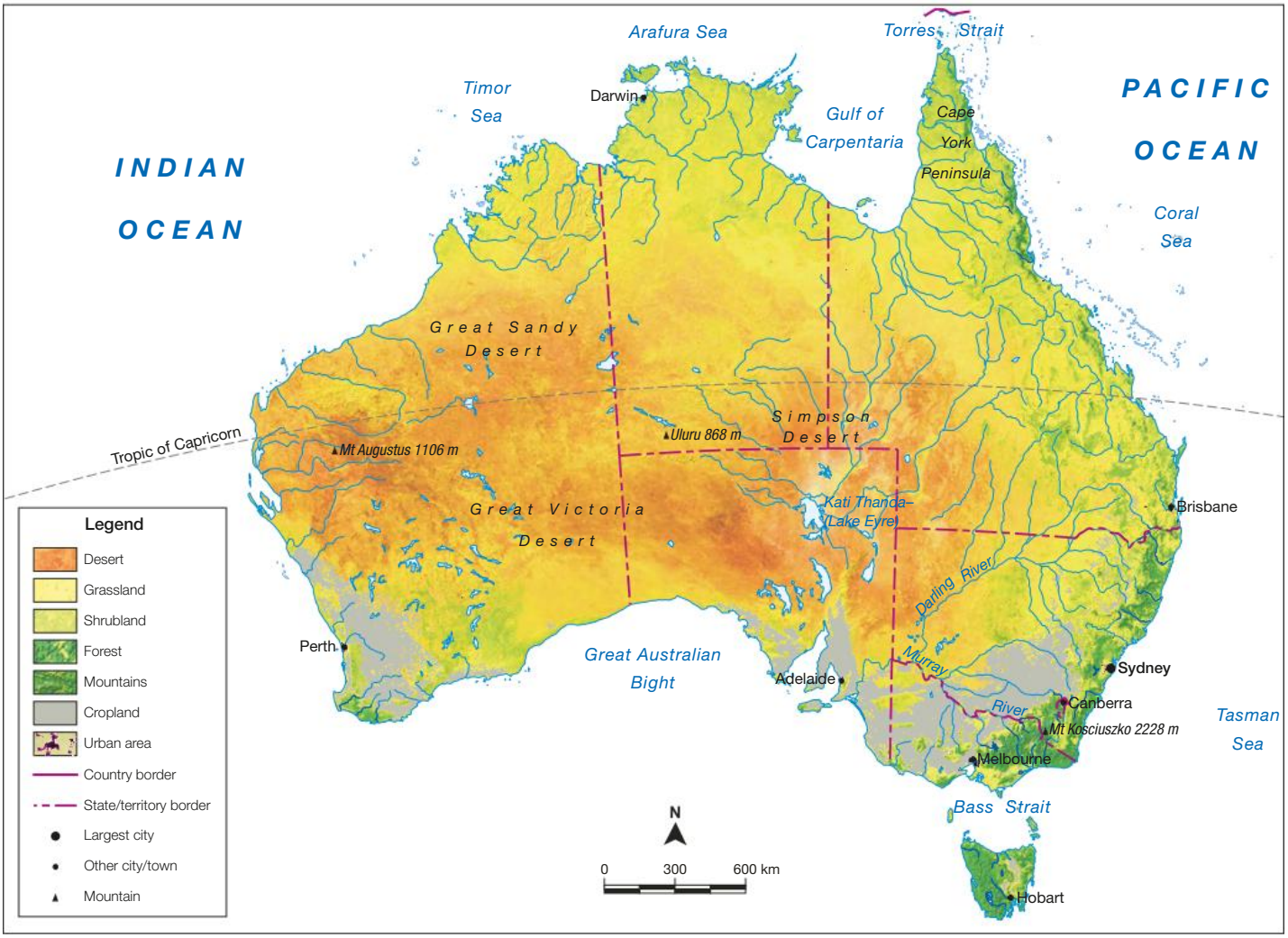
Australia average daily maximum temperature



Source 3: Australia's average daily maximum temperatures

Source: Matilda Education Australia

Australia physical and human environments



Source 4: This map shows different environments in Australia, including the location of capital cities.

Source: Matilda Education Australia

Human factors

Where people choose to live also depends on human factors – such as access to services and facilities, the quality of the environment, safety, and closeness to friends and family. A person's ideas about liveability change depending on their age and stage of life. School-age children might rate the liveability of an area highly if they are close to school, friends, public transport and facilities such as sporting grounds and shops. Adults with families might need schools, health care, affordable housing, outdoor recreation areas and access to jobs. How liveable a place is depends on what is important to you.

Employment

People of working age need to live in a place where they can access employment. The most jobs are generally in capital cities and larger towns, so many young people move from country towns to cities to study and to find employment. Mining towns with very few facilities and services can also be a magnet for workers because they offer high-paying jobs.

Services

Liveabilty increases with good access to services. Local shopping centres give people access to supermarkets, shops and restaurants, as well as services such as doctors and hairdressers. Good access to public transport and an efficient road system help people to move around. Other community facilities that can improve liveability include playgrounds, sports arenas, parks, skate ramps and bike tracks.

Source 5: ▶ Example of a community environment

Cultural connections

A key factor in making a place liveable is feeling part of the community. People often choose to live near family members and friends, or to find areas where people with similar interests live. People migrating from overseas to an Australian town or city might be attracted to a town or city where other people from their cultural background live. This gives them some familiarity, with local shops selling products from their home country, and local services available from people who speak their language. More than 60 per cent of the population of the Melbourne suburb Box Hill were born in China, or have Chinese ancestry.

Housing

Selecting a home is based on finding the most liveable area where you can afford to buy or rent. Some key decisions include how close the housing is to facilities such as shops, transport and parks. The size and type of the home selected will differ – some people will want a large home with a garden, while other people will want a low-maintenance apartment.

Safety

A very important factor in the liveability of a place is that people feel safe in their homes and within their communities. Areas with lower crime rates are the most liveable. Safety is even more important in countries that suffer from war and conflict.

Environment

Environmental quality affects the liveability of places and the quality of life for people living there. Factors that contribute to the quality of the environment are the climate, the quality of the air and water, the availability of parks and open spaces, and how it looks – the **aesthetic value**. Increasing numbers of Australians are choosing to move to coastal areas or rural areas to enjoy the natural environment and leave the pressures of urban life behind.

Learning ladder 4.14

Processes that transform people, places and environments

1. Source 5: Identify a cultural connection that makes this community more liveable for one cultural group.
2. Source 5: Describe how safety influences liveability.
3. Source 2: Explain why rainfall in Australia influences the liveability of a region.
4. Source 5: Explain how community features in your local area influence its liveability.

Environment

1. Source 1: Suggest two reasons why most Australian cities developed on the flatter coastal plains.
2. Sources 2 and 3. Why do fewer Australians choose to live in central Australia?
3. Source 5: List the factors that make a town or community more liveable. Rank your list according to the factors that make your community liveable.
4. How is population density interconnected with the physical features of the land?

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Environment, page 396

4.15

Why do we live in different settlements?

Settlements are human population centres where communities live. Settlements can be as complex as a large city or as simple as a few isolated dwellings. They have different names according to their size, such as megacity, town and hamlet.

Different types of settlement

Settlements vary in size and the services and facilities they offer. Different types of settlements include farms, hamlets, villages, towns, cities, **conurbations** and **megacities**, and they will change in size and character over time. Ranking settlements from largest to smallest creates a **hierarchy**. Urban places are densely populated towns and cities that provide a wide range of educational, medical, entertainment, retail, manufacturing and business services. Rural places include farms, hamlets, villages and towns with low population densities. Rural areas are often associated with agriculture, and usually offer open spaces and fewer services. The zone where rural areas merge with urban areas is known as the **rural–urban fringe**. Settlements at the higher levels of the hierarchy offer the greatest number and widest range of services and facilities, employment and other opportunities.

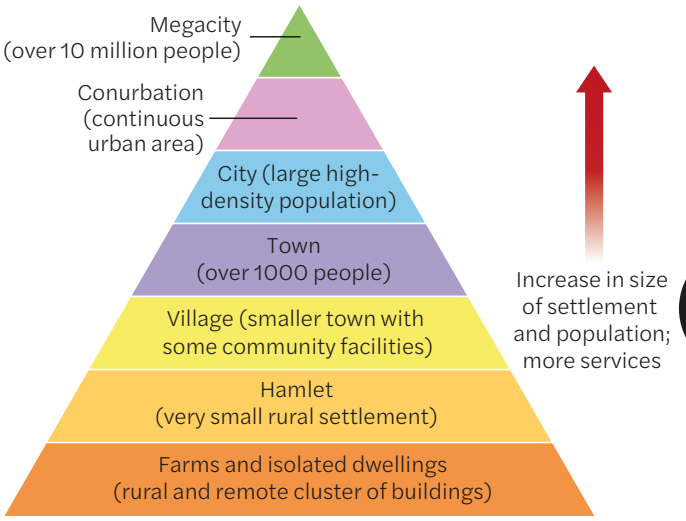
Change over time

There is a global decline in rural populations and an increase in the proportion of people living in urban places. This process is known as **urbanisation**, and it impacts on the character and liveability of cities as housing becomes less affordable and traffic increases. Liveability declines in rural centres when services and businesses close down in settlements with ageing and declining populations. While some people have no choice about where they live, others relocate to different types of settlements over their lifetime for economic, environmental, social and cultural reasons. For example, after the COVID-19 pandemic (2020–21) the population of many rural and coastal places surged when people sought alternative, quieter and healthier places to live.

▲ **Source 1:** The southern Queensland settlement of Thallon is a village with a population of 230.

▲ **Source 2:** The central-west NSW settlement of Cowra is a town with a population of 9863.

▲ **Source 3:** Kiwirrkurra is Australia's most remote settlement. It is located in the Gibson Desert, 1200 kilometres east of Port Hedland and 700 kilometres west of Alice Springs. It had a population of 180 in 2021, mostly Kiwirrkurra peoples. The school teaches Pintupi language and culture.



▲ **Source 4:** Hierarchy of settlements

▲ **Source 5:** The settlement of Perth in Western Australia is a conurbation joined to Mandurah with a population of 2.5 million.

Remote places

Remoteness refers to the distance of a place from other places as well as access to goods and services. People live in remote places for cultural, economic and lifestyle reasons. For example, Arnhem Land in the Northern Territory is a remote Aboriginal Reserve where traditional Aboriginal cultures thrive. Since tour operators began bringing small tourist groups to the area, economic opportunities for its residents have increased. Some communities in Arnhem Land, such as the Yolngu, have developed successful economic enterprises, including art, ecotourism and cattle farming. The Bawaka community shares stories, ceremonies, hunting and fishing methods, medicine, and art and crafts with tourists and visitors, promoting the Bawaka culture.

Learning ladder 4.15

Characteristics of places and environments

1. What is a settlement hierarchy?
2. Outline the difference between urban and rural settlements.
3. Source 1: Describe the location and characteristics of this place.
4. Source 4: Describe changes in the population, services and facilities of settlements from the base to the top of the settlement hierarchy.
5. Sources 3 and 5: Create a Venn diagram showing the similarities and differences in the characteristics of these two places.

Place

1. Source 2: What type of settlement is Cowra?
2. Source 3: Describe the physical and human characteristics shown in this photograph.
3. Sources 3 and 4: Use the hierarchy of settlements diagram to classify the settlement of Kiwirrkurra.
4. Justify the need for a range of different types of settlements.

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Place, page 390

4.16

How liveable are cities, rural and remote places?

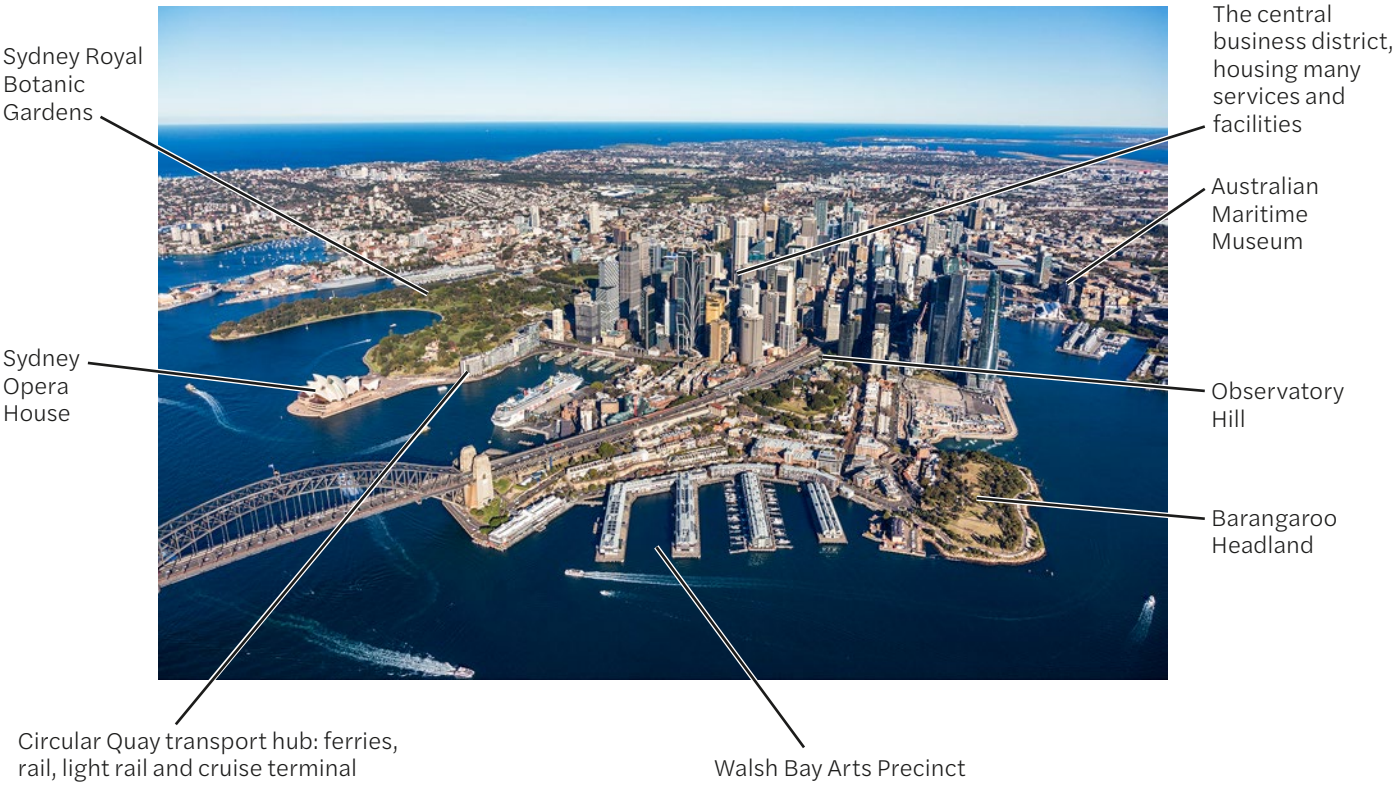
Australia is one of the most urbanised countries in the world – with 89 per cent of our population living in urban places (towns and cities) and over 66 per cent living in the metropolitan area of its eight capital cities. Large cities attract people because of the employment opportunities, services and facilities, and the lifestyle they offer. Around 75 per cent of all jobs are based in Australia's major cities.

The liveability of large cities

Cities offer people a large range of educational facilities (public and private schools, universities and training colleges); shops and businesses; entertainment and cultural facilities (sporting arenas, theatres, cinemas, museums and art galleries); transport networks (airports, major highways and railway lines); and health services, including specialists and large hospitals.

Australian cities are continually voted the most liveable cities in the world. In 2023, both Melbourne and Sydney were listed in the top five most liveable cities in the world. The Global Liveability Index ranks 140 cities in the world according to:

- stability – the threat of terror, war and crime
- health care availability and quality
- culture and environment
- education availability and quality
- infrastructure – quality of housing, transportation, water, energy and telecommunications.



Source 1: Cultural facilities such as the Sydney Opera House and Walsh Bay Arts Precinct, transport networks such as Sydney ferries and trains, public parks and open spaces such as the Sydney Royal Botanic Gardens and Barangaroo Headland are facilities that contribute to Sydney's liveability as a large city.

Source 2: Facilities for recreation and quiet relaxation are important for people's quality of life, particularly in large cities such as Melbourne and Sydney.

Inequalities in large cities

As the populations of Australia's largest cities have risen, liveability has declined for some groups. Those commuting to work in Sydney and Melbourne are affected by traffic congestion and now spend, on average, 1 hour and 10 minutes commuting to and from work each day. By 2031, commute times are predicted to be 2 hours a day. Open spaces have been replaced with housing, particularly on the rural–urban fringes. Where services and facilities cannot keep pace with population growth, residents must travel long distances to access schools, shopping centres, medical centres and sporting facilities. Inequalities have increased, with many residents unable to access key services such as housing.

Rural liveability

Rural settlements are outside major urban areas. In Australia, they vary from isolated cattle stations, mining centres and farms, to small villages with a general store, to large service centres that support a number of smaller country towns. Living in rural environments has the advantage of more open space; less traffic, noise and pollution; a greater sense of safety; and cheaper housing and living costs. With fewer people there is generally a stronger sense of local community developed through sporting and community clubs and organisations such as rural fire brigades. Rural shows, rodeos and other competitions bring rural communities together. The disadvantages of living in a rural area are fewer job opportunities, and less access to services such as schools, shops, public transportation and doctors, and utilities such as power, water and internet. Many young people in rural areas move to boarding schools and universities in major urban centres to access a wider range of education options and improved job opportunities.

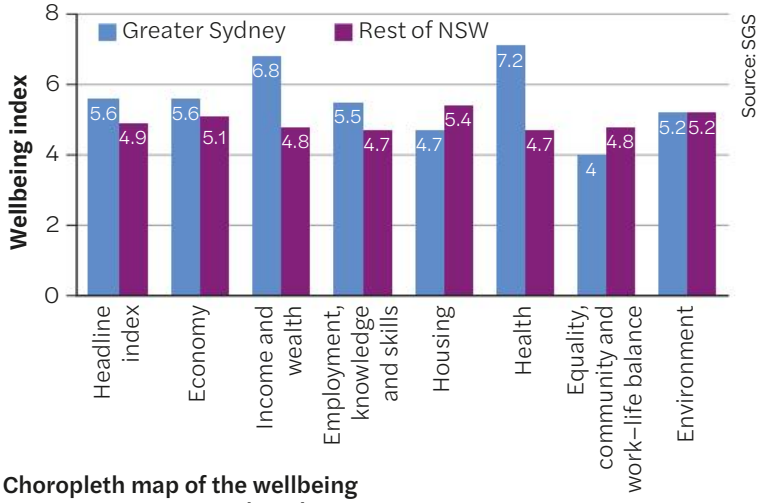
Source 3: Country shows bring rural communities together to enhance liveability. They bring the community together to enjoy using existing facilities and new infrastructure provided for the events.

The 2023 SGS Cities and Regions Wellbeing Index uses a number of indicators to track wellness in urban and rural places across Australia. The top-rated regions for liveability were inner-city regions in large cities. Many rural regions scored lower on these economic factors, but scored higher on wellness indicators like quality of life. Rural residents were found to have a better work–life balance and improved housing affordability.

Remote settlements

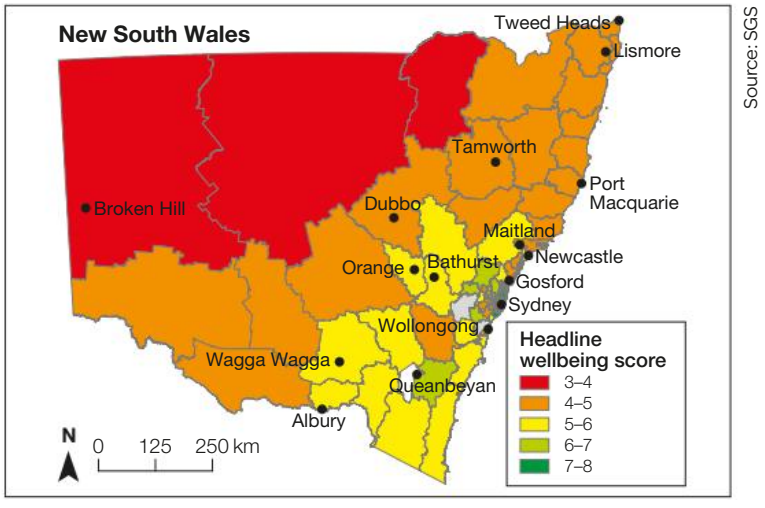
People live and work in remote places where basic services such as water, power and health care are difficult to supply. First Nations Peoples account for 15 per cent of all people in remote areas and 49 per cent of very remote populations in Australia. People choose to live in remote locations for work. Examples include mines operations, cattle stations, scientific research stations and security bases. Many remote settlements have cultural importance: Yuelamu is located on the traditional lands of the Anmatyerre and Warlpiri peoples.

New South Wales wellbeing index



Source: SGS

Choropleth map of the wellbeing score across New South Wales



Source: SGS

Source 4: New South Wales Wellbeing Index

Providing basic services to remote settlements is difficult and expensive. Residents of Yuelamu in the Northern Territory drive 4 hours to reach Alice Springs to access goods not stocked at the small community store, and services such as banking and specialist health care. Yuelamu is connected to the electricity grid; however, the dam is contaminated and unusable so bore water is connected to a water treatment plant to supply safe water. Yuelamu also has an airstrip, a Prep to Year 12 school, an art gallery and sports oval. The early childhood centre, aged care centre and a night patrol help residents remain healthy and safe. The land is owned and managed by the Yalpirakinu Aboriginal Land Trust and Anmatyerre and Warlpiri languages are spoken at home.

Source 5: Yuelamu is a very remote community located in the Tanami Desert, 277 kilometres north-west of Alice Springs. The dam is contaminated from blue-green algae and is no longer safe as a water supply for the community.

Learning ladder 4.16

Characteristics of places and environments

1. Comment on differences in the provision of services and facilities in cities, rural and remote places.
2. Sources 1 and 3:
   - **a** Explain why cultural facilities are important for liveability. Refer to quality of life in your response.
   - **b** What cultural role do country shows play in the liveability of rural places?
   - **c** What is the link between culture and liveability in remote settlements?
3. Source 4: Which aspects of a rural environment scored more highly than an urban environment? Why might this be the case?
4. Source 5:
   - **a** What factors make Yuelamu a remote settlement?
   - **b** What services are available at Yuelamu?
   - **c** Why is the provision of water of such importance in Yuelamu?
5. Explain the factors that make services and facilities inaccessible to some people.

Environment

1. What factors attract people to city environments?
2. Source 1 and Source 5: For each of the sources describe the physical and built environments you can see.
3. What environmental features are important in the Global Liveability Index.
4. There are inequalities in people's access to services and facilities as a result of where they live. Discuss this statement using examples from the text.
5. Source 5: How would this place change if its population tripled in one year?

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First Nations Peoples

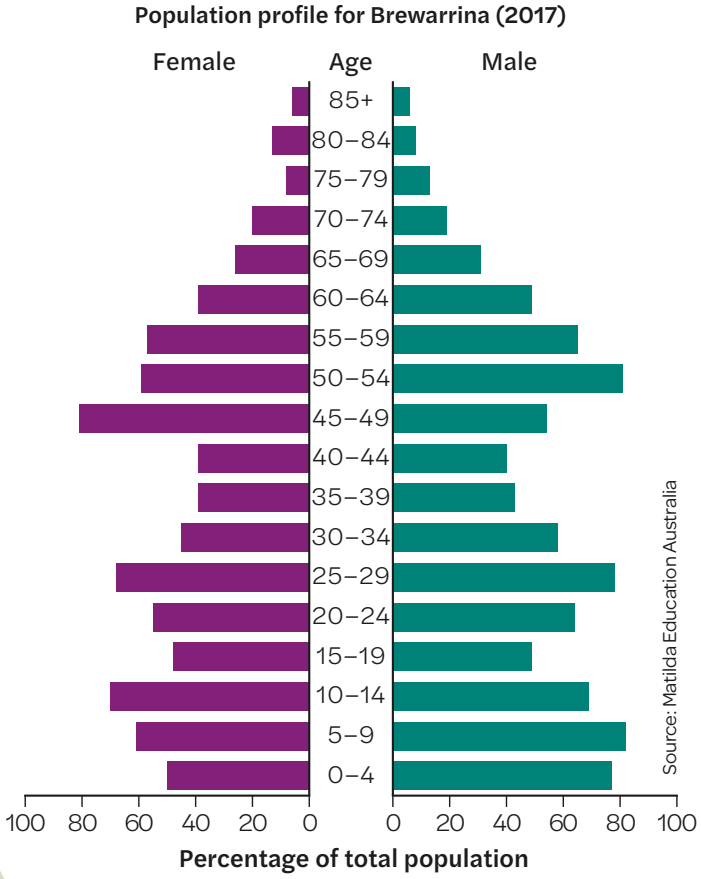
How do people live in remote communities?

Rural and remote communities like Brewarrina depend heavily on community and school initiatives to staff and support environmental programs that ensure the liveability of their towns and the maintenance of cultural integrity.

Brewarrina

Brewarrina is a remote community located in the outback region of north-west New South Wales on the banks of the Barwon River. The town is located on the traditional lands of the Muruwari, Ngemba, Weilwan and Yualwarri Peoples.

In 2021 the town had a population of 1339 people, with more than 50 per cent of the population identifying as Aboriginal. The population of the town has declined by 40 per cent over the past 25 years.



▲ **Source 1:** Age/sex profile for Brewarrina in 2017

Barwon River fish traps

The Barwon River cuts through the town of Brewarrina and then wanders through parts of western NSW, feeding downstream into the mighty Darling River. This river sustains the broader community in many ways but was established by First Nations Peoples long before non-Indigenous people came to the area.

The Barwon River flows through the oldest built structure on Earth at Brewarrina, the Ngunnhu (Aboriginal fish traps). Ngunnhu's dry-stone rock **weirs** and fish-holding pens allowed large numbers of fish to be sustainably herded and caught, particularly during spring migrations. Archaeologists estimate the Ngunnhu to be over 40 000 years old.

Today's custodians (caretakers) are the Ngemba people. As the key custodians of the fishery, maintenance and use of the fish traps is shared with other First Nations communities in the area, including the Barabinja, Morowari, Paarkinji, Ualarai, Weilwan, and Kamilaroi peoples. Ngunnhu provides tourists with a range of experiences that include story sharing about the complex river hydrology, fish ecology and Aboriginal connections to this special place in western NSW.

Ecosystems under threat

Introduced to the Barwon River, fish like carp are a key threat to ecological communities and the fish trap structures if they undermine riverbanks. Carp feeding behaviours have led to reduced clarity levels in the Barwon River.

A number of native fish species have become threatened: trout cod, Macquarie perch, silver perch, southern purple-spotted gudgeon, olive perchlet, Murray hardyhead and southern pygmy perch. All these species are declining in numbers as a result of the ongoing competition these carp bring to

a number of rivers in Australia. Each year the community at Brewarrina have a big river clean-up, and undertake regeneration programs such as the supply of native fingerlings to the waterways. The aim is to increase the number of native fish in the Barwon River as a longer-term management strategy.

Living and working in Brewarrina

Burra McHughes is an 'on-call' firefighter with NSW Fire and Rescue. Employing First Nations people and working interculturally is an important way for councils like Brewarrina Shire to work 'both ways' and develop respectful relationships with local First Nations knowledge holders.

Burra works on community and council initiatives that focus on improving the liveability of his community through a range of land and water management strategies. Some of this is done as part of his volunteer roles, while others are a result of his work activities with Brewarrina Shire Council.

Burra was successful in winning a position to be part of a small team to travel to Canada to learn about other global First Nations communities and share his growing knowledge about traditional burning methods back in Australia. First Nations communities in Australia have used cultural burning as part of a larger land-management practices for at least 65 000 years as just one way communities care for Country.

Source 2: Burra McHughes is team leader of one of NSW's first Indigenous fire crews.

Source 3: Introduced species like carp can cause problems in natural ecosystems.

Learning ladder 4.17

First Nations Peoples' interaction with Country

1. What percentage of Brewarrina's population was made up of people identifying as Aboriginal in 2021?
2. What is the importance of the Brewarrina region to First Nations Peoples?
3. Describe how the local community is working to improve the quality of the Barwon River.
4. Does access to knowledge exchanges improve the liveability of places?
5. Source 2: Why are the responsibilities and Custondianship to Country of Burra McHughes so important?

Place

1. Where is Brewarrina located?
2. Source 1: Which age groups are best and worst represented on Brewarrina's profile?
3. Describe the characteristics of Ngunnhu.
4. Explain how the physical and human characteristics of Brewarrina interrelate for the Ngemba people.
5. What are the difficulties of living in remote communities such as Brewarrina?

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Liveability of places

Improving liveability

5

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5.0

How can I understand liveability of places?

Liveability varies between regions. High-income countries tend to have access to resources, high-quality education and advanced health care, while low-income countries may not have the technology and infrastructure to support their growing populations.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information
	Outcomes					Geographical tools and inquiry

Source 1: An example of inequality in liveability in Mumbai, India. In the background we see large skyscrapers, parklands and road networks, and in the foreground are slums characterised by their tarp roofs and cramped living conditions.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

5.1

How can we measure liveability?

Some of the key characteristics of a liveable city are that it is safe and comfortable, with good services available to the population. Australian cities perform well in liveability rankings.

Measuring liveability

Every person will have their own view about what makes a place more liveable or less liveable. A person's ideas about the liveability of a place will vary according to their age, background, income and lifestyle choices.

Every year the Economist Intelligence Unit (EIU) publishes a Global Liveability Index, where it ranks 140 major cities around the world, from most liveable to least liveable. Austria's capital, Vienna, was ranked the most liveable city in 2022 and 2023, having previously won in 2018 and 2019. Melbourne held first position from 2011 to 2017. Melbourne held the third position in 2023, closely followed by Sydney in fourth position. Adelaide and Perth were in equal twelfth position.

All Australian cities rebounded strongly in the 2023 liveability index, following challenging years of lockdowns associated with the COVID-19 pandemic.

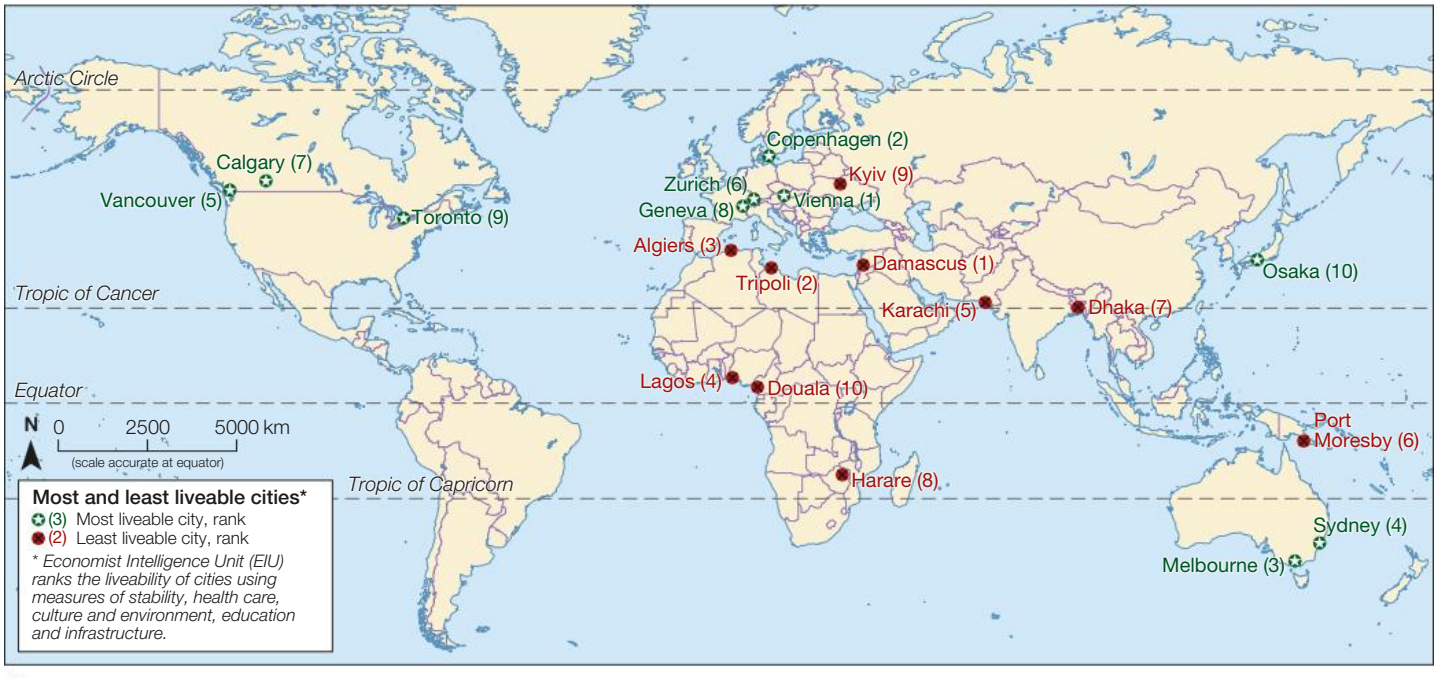
Damascus in Syria was assessed as the least liveable city from 2013 to 2023 because of the **civil war** that raged until late 2024.

Liveability criteria

The EIU uses these considerations (or criteria) to determine the liveability of places. Each consideration is given a percentage to show its importance.

1. **Stability** (25 per cent): Extent of small and violent crime, the threat of terrorism and military and civil conflict
2. **Health care** (20 per cent): Health standards, the availability and quality of health care and the availability of medicine

World's most liveable and least liveable cities, 2023



Source: Matilda Education Australia

Source 1: The 10 most liveable and least liveable cities in the world, from the 2023 Global Liveability Index

Source 2: With perfect scores for education, healthcare and infrastructure, and near-perfect scores for stability, culture and environment, Sydney climbed to fourth place (up from thirteenth place the previous year) in the 2023 Global Liveability Index.

3 **Culture and environment** (25 per cent): The comfort of the climate, level of goods and services, evidence of corruption and censorship, and availability of sporting and cultural activities

4 **Education** (10 per cent): Education standards and the availability and quality of private education

5 **Infrastructure** (20 per cent): Quality of roads, international and public transport, housing, water, energy and telecommunications

Source 3: Damascus is the capital city of Syria, in the Middle East. It was judged the world's least liveable city for 2023 and for the decade before that, because of the civil war and its effects. It scored poorly in all categories. Education has suffered greatly, with schools and universities closing. The destruction of hospitals has made it nearly impossible to cope with the constant influx of patients from the war zone. Infrastructure and environmental damage has further reduced liveability in Damascus.

Learning ladder 5.1

Perspectives of people and organisations

1. List the criteria used to judge the liveability of world cities according to the EIU.
2. How have Australian cities fared in the 2023 Global Liveability Index?
3. Source 3: Explain the difficulties faced by Damascus on improving liveability for its citizens.
4. Review the five criteria developed by the EIU. Rank them according to the importance you would give each category. Justify your response.

Place

1. Source 1: Which nearby city to Australia was ranked in the 10 least liveable cities in 2023?
2. Source 2: Describe the physical and human characteristics shown in this photograph of Sydney.
3. Source 3: Identify the cause of the damage shown in this image and explain the impact it is having on liveability in Damascus.
4. Source 1: Analyse the pattern of the most and least liveable cities in 2023. Use the EIU liveability criteria to suggest reasons for the pattern shown.

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5.2

What will liveable places look like in the future?

Liveable places meet the needs of people while providing them with the best quality of life they can have. Sustainable places do this while making sure that the Earth's natural resources and environments are conserved and will be available to meet the needs of future generations. There is no single strategy to create liveable, sustainable places. Mass transit transport networks, renewable energy, recycling programs, cycling infrastructure, open spaces and the restoration of natural environments are strategies transforming towns, suburbs and neighbourhoods across the globe.

Barangaroo

Barangaroo in Sydney is the first carbon-neutral development in Australia and provides an example of how to integrate liveability and sustainability into new urban projects. Features of liveability include the natural environment, access to services and facilities within the precinct and the adjacent Sydney Central Business District; accessible public transport (bus, rail, light rail, ferry) and walkability; and proximity to cultural precincts such as the Sydney Opera House, Sydney Theatre Company and Australian Maritime Museum.

Features of sustainability include five- and six-star energy ratings for residences and for commercial facilities; water and waste recycling; vertical window shading to save energy; rainwater tanks; LED lighting and the use of water-efficient appliances.

▲ **Source 1:** Barangaroo, a model liveable and sustainable urban precinct

Marlinja

Marlinja in the Northern Territory is a remote community of 60 people, 700 kilometres south of Darwin. Working with Indigenous clean-energy organisation Original Power, the community has become almost energy self-sufficient by building its own solar farm and installing a battery to use the power at night. Like many isolated Indigenous communities, Marlinja had relied on diesel generators for electricity. Diesel supplies were often disrupted in the wet season and generators failed.

A reliable source of clean energy will reduce power costs, and improve health and wellbeing through better access to refrigeration and air-conditioning. Summer temperatures regularly exceed 40°C across the Northern Territory. There is a vision that all remote communities can benefit from similar solar projects.

▲ **Source 2:** Marlinja community celebrating the installation of a battery to allow their solar power to be stored for use at night

The Maldives

The Maldives has 1190 low-lying islands, mostly less than 1 metre above sea level. Sea-level rise threatens to submerge the country. Using new technologies, a floating city to house 20 000 people is being built in the lagoon near the capital, Male, as an adaptation to climate change. Built in a brain coral-like pattern, the city will have 5000 floating parts containing services and facilities as well as housing. This is one of many global projects creating floating places for people to live in the future, as they adapt to the results of climate change.

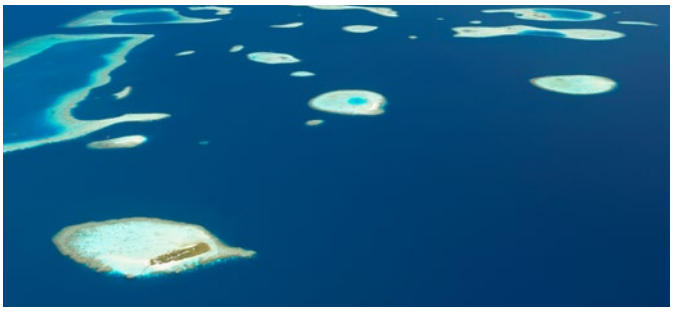
Neom

Neom in Saudi Arabia is a massive project being viewed as the future of liveable, sustainable urban places. The Line is the most innovative component of the project, with a planned 170-kilometre structure extending from the mountains to the Red Sea to house 9 million people. The goal is 100 per cent renewable energy, no cars, high-speed rail and 95 per cent of land set aside for nature. Everything needed for living a quality life will be within five minutes' travel and within a climate-controlled structure

Location of The Line, Neom, Saudi Arabia

Source 4: Neom, Saudi Arabia: The Line

Source: Adobe/ Peter Hermes Furian



Source 3: The Maldives: A floating city to create liveable places in a world of rising seas

Learning ladder 5.2

Characteristics of places and environments

1. Identify the features of Barangaroo that make it a liveable urban place.
2. Source 3: Describe the features of the Maldives that are making the islands unliveable.
3. Source 4: Describe the location of Neom and The Line.
4. Discuss the role of technology in creating liveable communities for the future.
5. Investigate the planned features of The Line in Neom that will make it a liveable place for future generations.

Sustainability

1. Identify one sustainability feature for each of Barangaroo, Marlinja, The Maldives floating city and Neom's The Line.
2. Source 2: Why is a reliable and cost-effective source of energy important for all remote Indigenous communities?
3. Source 3: How will a floating city make the Maldives liveable and sustainable in the future?

HOW TO

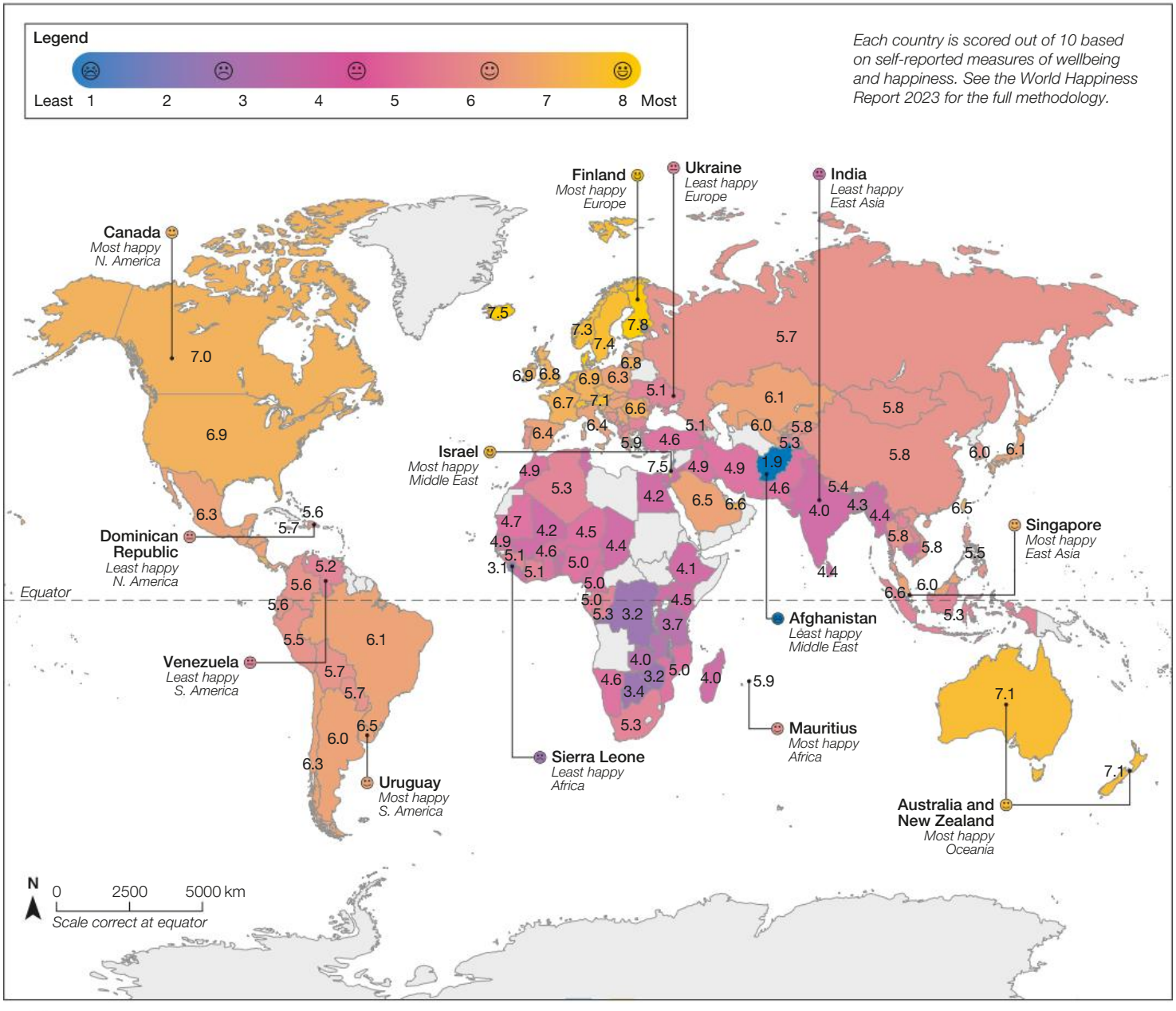
Sustainability, page 400

5.3

Where are the world's happiest countries?

The 2023 United Nations annual poll of the happiest countries of the world selected Finland as the winner for the sixth year in a row. A representative sample of people in each country were interviewed about how satisfied they are with their lives.

The world's happiest countries, 2020–22



Source: World Happiness Report, 2023

Source 1: The world's happiest countries, 2020–22, as ranked in the World Happiness Report 2023. Zero represents the worst possible life and 10 the best possible life.

World Happiness Report

The happiest countries in the world have been ranked in the World Happiness Report 2023. The report combines the happiness rankings for 2020–22, and Finland ranked number one, while its Scandinavian neighbours Denmark, Iceland, Sweden and Norway were all in the top seven happiest countries in the world.

Each year since 2012, the United Nations has measured the quality of life of citizens by surveying over 1000 people in more than 150 countries around the world. The surveys measure how happy citizens say they are – and this is added to data about wealth, life expectancy, social support, generosity, freedom and corruption to arrive at an overall score.

Source 2: Finland has been named the happiest country in the world for 2023 in research conducted on behalf of the United Nations. Scandinavian countries filled five of the top seven rankings.

Happy countries

European countries feature highly in the list of the happiest countries in the world, holding 15 of the top 20 positions. Finland is one of the most peaceful nations on Earth. Its residents enjoy high environmental standards, and access to more forest per square kilometre than any other European country. Filling five of the top seven places, Scandinavia just has to be the happiest region on Earth. On the other side of the globe, New Zealand and Australia are also happy places, coming in 10th and 12th respectively.

What makes these countries so happy? It's no surprise that the top-rated countries are all wealthy countries that enjoy a high quality of life. They also have a strong sense of community and mutual respect.

Unhappy countries

There is a strong link between unhappiness and the poorest and most dangerous nations on Earth. According to the report's indicators, war-torn Afghanistan and Lebanon remain the two least happy nations on Earth. Fifteen of the bottom 20 scores belong to countries in Africa that are suffering from conflict and poverty. Three other nations in the bottom 20 are in the Middle East.

Interestingly, the Middle Eastern nation of Israel was ranked the fourth happiest country in the world in 2023. Israel went to war with the Islamist militant group Hamas in October 2023, so it is unlikely that Israel will have such a high level of happiness in the 2024 report.

Learning ladder 5.3

Characteristics of places and environments

1. What factors define happiness according to the World Happiness Report?
2. Why was Finland ranked the happiest country in 2023?
3. Source 2: Describe the characteristics of this place and its impact on liveability.
4. Using SHEEPT, discuss why you think that Australia is rated as one of the happiest places on Earth.
5. Explain how less happy countries could improve their happiness scores.

Space

1. Source 1: Which are the happiest continents?
2. Source 1: Use PQE to describe the distribution of happiness across the globe.
   - **a** What patterns do you see? Are there particular areas in the world that are happier than others?
   - **b** What data can you use to quantify the pattern you outlined?
   - **c** What is an exception to the pattern you outlined?
3. What processes influence the world's unhappiest places?
4. Source 1: Do you think these spatial patterns will be the same in 2050? Why or why not?

HOW TO

PQE, page 412; SHEEPT, page 414; Space, page 388

5.4

Case study

Why is Vienna the world's most liveable city?

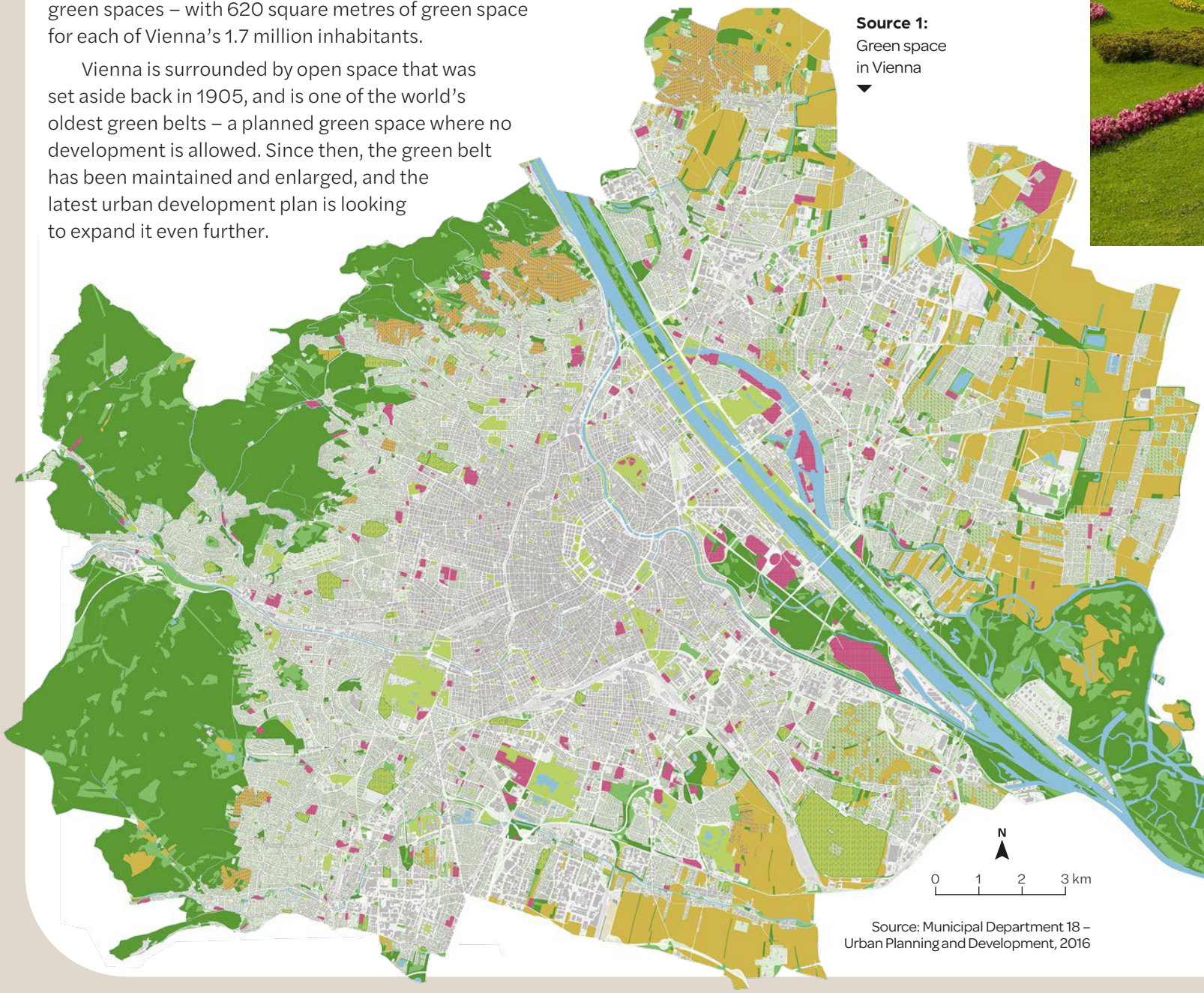
Vienna was judged the world's most liveable city for 2018, 2019, 2022 and 2023, after a comparison of 172 cities. It is one of the safest cities in Europe, and also offers great health care and education, as well as cheap and efficient public transport.

Vienna is one of the greenest and cleanest large cities in the world. Half of the metropolitan area is made up of green spaces – with 620 square metres of green space for each of Vienna's 1.7 million inhabitants.

Vienna is surrounded by open space that was set aside back in 1905, and is one of the world's oldest green belts – a planned green space where no development is allowed. Since then, the green belt has been maintained and enlarged, and the latest urban development plan is looking to expand it even further.

Green space uses in Vienna

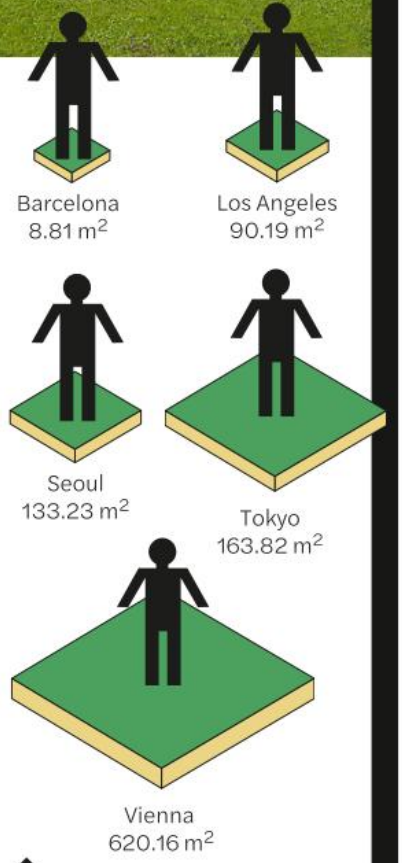
Source 1: Green space in Vienna



Source: Municipal Department 18 – Urban Planning and Development, 2016

Source 2: The large park at Schönbrunn Palace, Vienna, was opened to the public in 1779. The gardens and the palace were named a World Heritage Site in 1996. Urban parks and gardens provide safe routes for walking and cycling, and are good places for other recreation, such as picnics. Parklands play a critical role in cooling urban areas where buildings and roads heat up the environment.

Green spaces, such as parks, sports fields, forests, meadows and wetlands, give residents a chance for physical activity and relaxation. Trees produce oxygen, and help to filter out harmful air pollution that is usually a problem in large cities (see page 132).



Source 3: Green space in cities around the world **per capita**

Source: Humanitarian Data Exchange, 2018

Green space uses
- Forest
- Meadows
- Fields
- Vineyards
- Green houses and plantations
- Cemeteries
- Parks and gardens
- Outdoor sports facilities and public pools/campsites
- Bodies of water

Learning ladder 5.4

Processes that transform people, places and environments

1. How do green spaces improve the liveability of a place?
2. Source 2: Describe how the pictured gardens improve liveability in Vienna.
3. What are green belts and why are they important to liveability?
4. Use SHEEPT factors to explain why Vienna is the world's most liveable city.

Space

1. Source 1: Where are the largest areas of green space found in Vienna?
2. Source 3: Look carefully at the pictograph and answer the following questions.
   - **a** How many square metres of green space per person does each resident of Vienna have?
   - **b** Which city in the pictograph has the least amount of green space per resident?
   - **c** How could you calculate the amount of green space per resident for your town or suburb?
3. Source 1: Which three types of green space dominate the areas on the fringe of the city of Vienna? Why do you think they are located here?
4. Source 1: Analyse the different types of green space that are only located in the suburbs of Vienna. Why do you think they are located here?
5. Source 3: Analyse the variations in access to green space in the selected large cities. What does the information tell you about the priorities given to green space in cities?

HOW TO

SHEEPT, page 414; Space, page 388

5.5

Case study

Why is Kyiv an unsafe place to live?

In 2013 Kyiv, the capital city of Ukraine, was ranked the 91st most liveable city in the world. In 2023 it was ranked in the 10 least liveable cities at position 165 in the Economist Intelligence Unit Global Liveability Index (see page 158). The key reason for the decline in liveability has been the sustained conflict with Russia, which escalated into full warfare in early 2022.

Impact of conflict on liveability

The conflict in Kyiv has impacted liveability in a variety of ways. All of the criteria used to measure liveability have been affected:

1. **Stability:** Warfare heavily impacts on the safety of people in Ukraine and the stability of their lives. Between 2022 and 2023, there were nearly 30 000 civilians killed or injured and more than 7000 left homeless as families were forced to leave their homes in search of safety.
2. **Health care:** High numbers of casualties and widespread destruction of hospitals and other health facilities is making access to health care difficult for citizens in Kyiv and Ukraine.
3. **Culture and environment:** The freedom to enjoy normal activities and access goods and services has been greatly impacted by the war with Russia. There has been a heavy reliance on aid from other countries.
4. **Education:** Attacks on schools have left students without safe spaces to learn. Ukraine's children are struggling to progress learning with great interruptions to their education.
5. **Infrastructure:** The ongoing war continues to result in the destruction of residential buildings, schools, hospitals, roads, airports, ports, power supply, water and other infrastructure in Kyiv.

Implications of warfare

The conflict has also disrupted **supply chains**, as companies and organisations cannot safely import resources into the city. There are also too many disruptions to the transport networks they rely on to bring goods in and out of the city. This results in reduced supply of products, which is not enough to meet the demand of people living in the city.

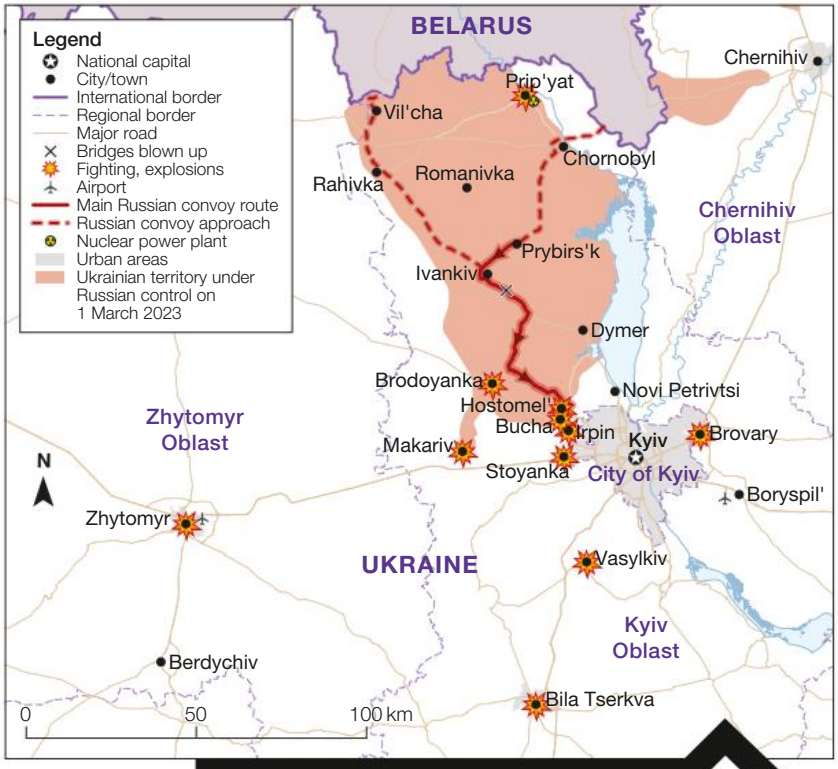
Source 1: Firefighters work to contain fires after a drone attack on buildings in Kyiv on 17 October 2022. By September 2023, 167 200 houses in Ukraine had been destroyed or damaged, most severely in Donetsk, Kyiv and Luhansk. Other infrastructure attacks caused damage to 18 airports, 344 bridges, 25 000 kilometres of road, 426 industrial complexes, 2700 schools, 586 higher education institutions and 1223 medical facilities.

Source 2: Kyiv residents began evacuating the city as a 64-kilometre line of tanks approached Ukraine's capital in March 2022.

It increases the price of the goods and makes it difficult for families to access affordable and nutritious food, or resources such as petrol. This affects the ability for people to work in industries that import and export goods and services, further impacting the income of families in Kyiv.

As a result of this decreased liveability, safety and access to services, many Kyiv residents are migrating out of the city. Over three million people from Kyiv have sought refuge in neighbouring countries and a similar number have been moved to more rural and remote areas away from the direct conflict. This can impact the future of Kyiv, as there are fewer people to re-establish communities, improve the local economy or lead important services, such as teachers in schools, and doctors and nurses in hospitals.

Russians tanks approach Kyiv, March 2022



Source: Matilda Education Australia

Learning ladder 5.5

Processes that transform people, places and environments

1. Why has liveability declined in Kyiv?
2. Source 1: Describe how conflict has affected the liveability in Kyiv.
3. Explain how the impact of conflict on supply chains impacts the liveability in Kyiv.
4. Analyse the impact of conflict on access to services and facilities in Kyiv.
5. Develop a strategy that could address the liveability concerns in Kyiv.

Scale

1. Source 1: Identify a local impact of the conflict in Kyiv.
2. Describe how this conflict has one impact at the national scale.
3. Explain how the conflict in Kyiv has impacted liveability at both a local level (within the city) and a national level (across Ukraine).
4. How does the destruction of infrastructure in Kyiv affect the global supply chain, and what impact does this have on local communities in Kyiv?
5. How do decisions made at a global scale and at a local scale influence the liveability of Kyiv during the conflict?

HOW TO Scale, page 398

5.6

Case study

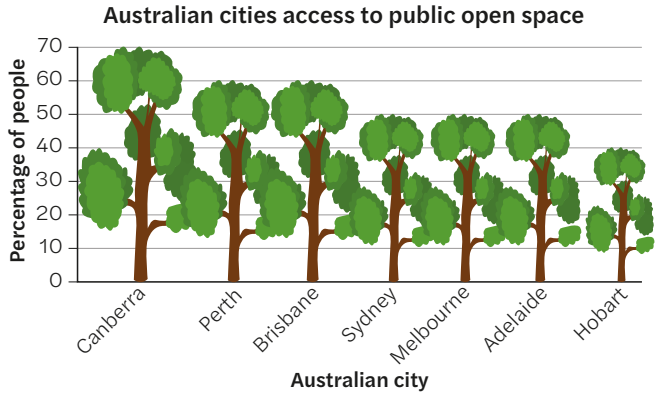
Is Canberra the world's most sustainable city?

In 2021 Canberra was named the most sustainable city in the world in a study conducted by UK company Uswitch. The study scores cities according to sustainability measures such as energy, transportation, affordability, air quality, carbon dioxide emissions and green space.

Measuring sustainable cities

Canberra was named the world's most sustainable city, according to a report published by UK comparison company Uswitch. Canberra scored highly in the rankings due to the fact that all of its energy comes from renewable resources generated from nearby solar and wind farms. Madrid in Spain was listed at number two and Brisbane in Queensland was ranked at number three. Cities were assessed on a range of sustainability measures:

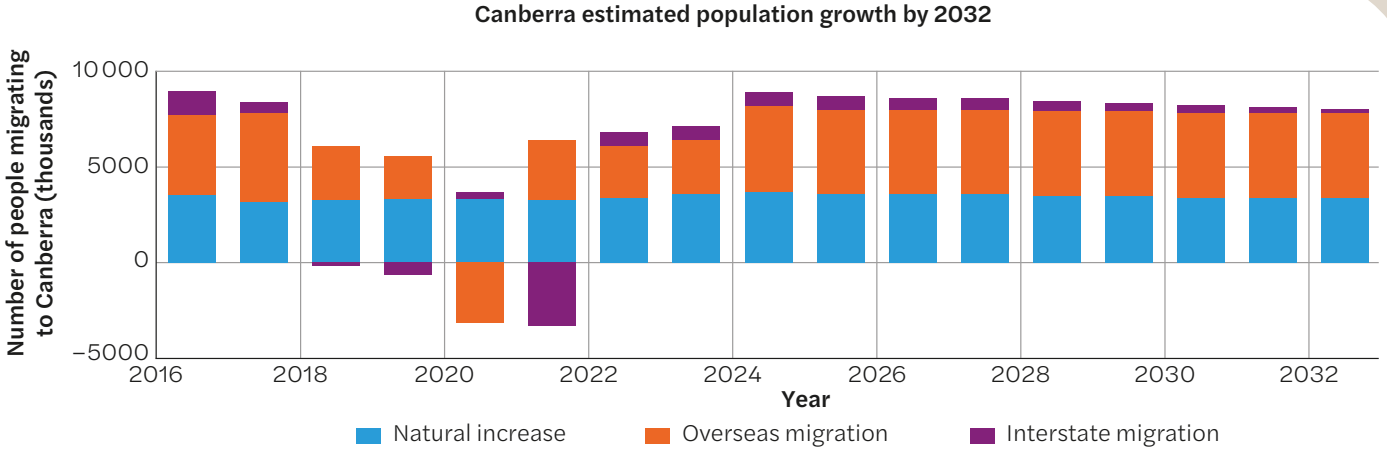
1. **Transportation infrastructure:** Canberra ranked number one for this measure, with 88.6 per cent 'green' transport services. Public transport is fast and ride-sharing services reduce traffic.
2. **Energy:** Canberra uses 100 per cent **renewable energy**. About 5 per cent of electricity is produced by local solar farms and the rest is supplied from wind and solar providers throughout Australia.
3. **Housing availability and affordability:** Canberra only improved housing availability a little, and needs to improve in this measure of liveability.
4. **Pollution control and air quality:** Canberra has low pollution levels, with a score of 13.89, meaning out of every 100 particles of air, only 13.89 are polluted. Canberra came in second behind Wellington in New Zealand for this measure.
5. **Carbon dioxide emissions:** Canberra's use of renewable energy drives low carbon emissions. The ACT government aims to have net-zero carbon emissions by 2045.
6. **Green space:** Canberra has 353 square metres of green space for each of its residents, whereas Sydney has 81 square metres and Melbourne has 116 square metres.



Source 1: Percentage of people living within 400 metres of public open space of 1.5 hectares or more in Australian cities

Source: Matilda Education Australia

Source 2: The National Arboretum in Canberra contains more than 44 000 rare and endangered trees across a 250-hectare site.



Source 3: Canberra's estimated population growth by 2032

Source: Australian Bureau of Statistics, Centre for Population

Source 4: The Mugga Lane Solar Park in Canberra contains 53 000 solar modules and generates 24 500 megawatt hours of electricity to power more than 3000 homes.

Learning ladder 5.6

Perspectives of people and organisations

1. List the criteria used to judge the sustainability of world cities according to Uswitch.
2. How did Australian cities fare in the 2021 sustainability index?
3. Explain why Canberra rated highly in the sustainability rankings.
4. Review the six criteria developed by Uswitch. Rank them according to the importance you would give each category. Justify your response.
5. How can Canberra improve its liveability further? What is one thing that could help with achieving this?

Place

1. Source 2: Give three different examples of green space shown in this oblique aerial view of Canberra.
2. Source 4: Describe the physical and human characteristics shown in this photograph.
3. What advantage does Canberra have over Sydney and Melbourne when comparing the amount of green space per head of population?
4. Source 1: Describe the pattern of access to open space. Why is this an important factor for liveability?
4. Source 3: Explain the projected population growth of Canberra by 2032.

HOW TO

Place, page 390

5.7

How can we improve liveability?

Countries around the world have different challenges to improve the liveability of places for their people. Those challenges depend very much on where you live.

Different challenges

In poorer **low–income countries**, some of the challenges to improve liveability are to provide a secure supply of food, give access to clean water, provide somewhere for people to shelter and supply education for all.

In richer **high–income countries**, governments are solving problems such as reducing travel times, improving technology, developing entertainment facilities and making places greener and more sustainable.

Low–income countries

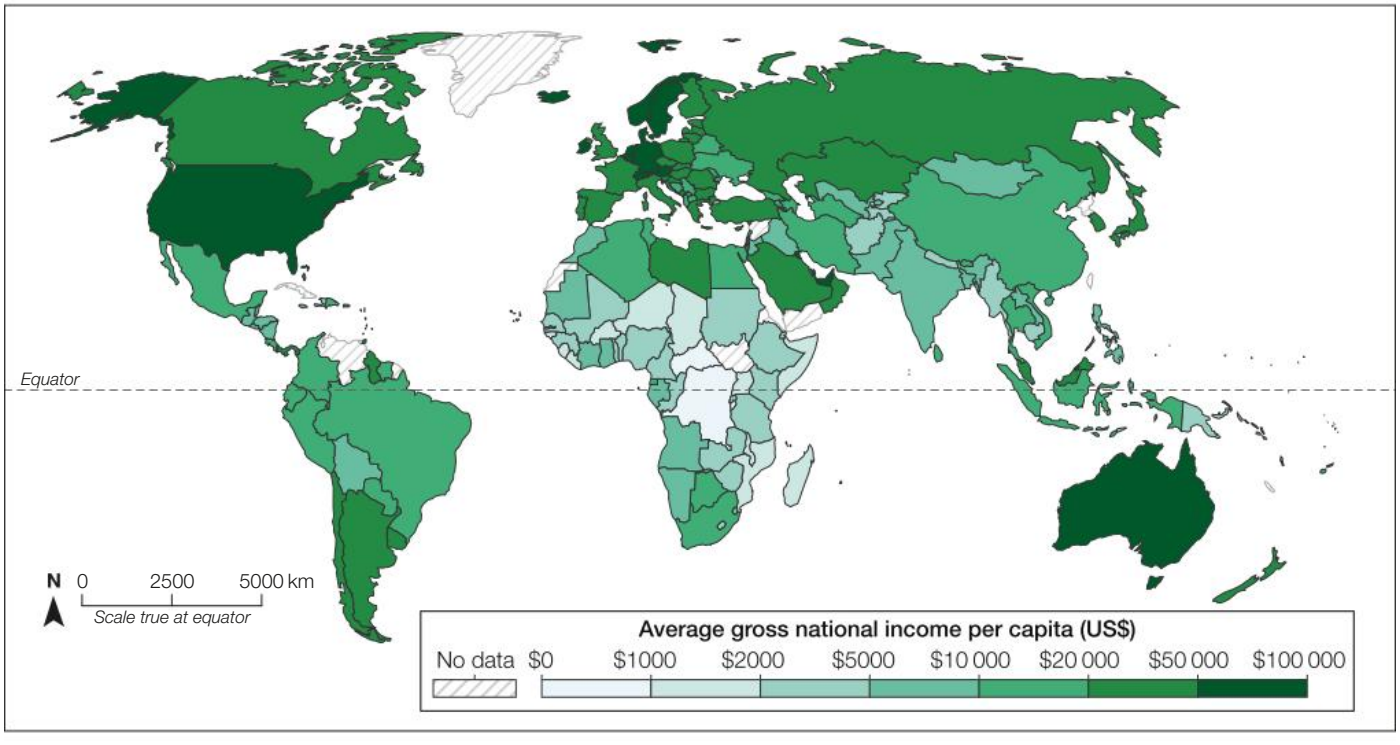
Low-income countries have an income of US$1045 or less per person, per year. The percentage of people living in low-income countries has fallen by more than 80 per cent.

In 1994, there were 64 low-income countries. By 2023, there were just 28 countries classified as low-income countries by the World Bank. Most low-income countries are now in Africa – the only low-income countries outside Africa are Afghanistan, North Korea, Syria and Yemen.

Improving young lives

Ninety per cent of people aged between 10 and 24 live in low-income and **middle–income countries**. In general, young people in these countries have less access to education, health care and good work opportunities than young people in high-income countries. Children in low-income and middle-income countries also tend to have more family responsibilities than children in high-income countries.

World gross national income per capita, 2021



▲ **Source 1:** Gross national income per head of population in 2021. Gross national income is the total amount of money earnt by a nation's people and businesses.

Source: Our World in Data

Source 2: Students at a primary school in Kenya are having a lunch supplied by a school feeding program. Students receive a healthy meal, which is extra encouragement to come to school each day.

Young women in low-income and middle-income countries face extra challenges. About 90 per cent of births to teenagers occur in low-income and middle-income countries – and the leading cause of death for young women aged 15 to 19 in low-income and middle-income countries is complications from pregnancy and childbirth.

Education is the key to improving the lives of people in low-income and middle-income countries:

- A child born to an educated mother is twice as likely to survive to the age of five.
- Educated mothers are 50 per cent more likely to immunise their children against disease.
- Individual earnings increase by 10 per cent for each year of school completed.

School feeding programs

Statistics from the United Nations show that 66 million primary-school-aged children in the world go hungry every day – with 23 million of these hungry children living in Africa. Further, 75 million school-aged children do not attend school – of these, 55 per cent are girls and 47 per cent live in Africa.

To overcome this, feeding programs have been set up to supply meals for children who attend school. Meals are given to children at school during morning and afternoon meal and snack times. These meals might be a bowl of porridge or some crackers rich in nutrients. Families whose children regularly attend school might also receive packs of basic food items, such as rice and cooking oil.

School feeding programs provide both educational and health benefits to the most vulnerable children in the world. They reduce hunger, improve the health of children, increase the numbers of children at school – and give parents a reason *not* to send their child to work.

School feeding programs in low-income countries often begin through funding by **humanitarian organisations** such as the United Nations World Food Programme. Schools have also been used to introduce other health programs, such as health education.

Improving liveability in high-income countries

As cities grow and change, governments and urban planners are working to make cities more liveable. For people who live in cities in wealthy countries, this means:

- reducing transport times
- creating and protecting open space
- providing resources for recreation and entertainment
- providing affordable housing
- making sure there is work available
- providing a clean and sustainable environment.

Transport

As cities grow, traffic problems increase – as well as noise and air pollution. Australian cities (and many cities) have largely been designed for cars.

To manage the increasing number of cars on the road, urban planners have introduced a number of measures to control city traffic.

Source 3: The Marina Reserve in the inner-city Melbourne suburb of St Kilda is community space that has been created for young people. It includes a huge skatepark and an off-leash dog area.

These include:

- introducing special traffic lanes for cars with passengers
- introducing 'park and ride' systems to encourage drivers to park their cars and travel into the city by bus, train or tram
- banning cars from the central business district and allowing only public transport, pedestrians and bicycles
- charging car drivers a toll to enter the city centre
- restricting the times or days people can access the city by car.

Liveable cities promote public transport, walking and cycling instead of driving. Effective public transport systems are those within easy walking distance and that provide a frequent and convenient service.

Bike paths encourage people to commute to work or school by bicycle, as well as to ride for fun. Recently, over 500 cities in 49 countries had bike-sharing programs, where people could rent a bike for a period of time. A bike-sharing scheme was introduced in Paris in 2007 – and by 2024 over 49 million bicycle trips were made around the city that year, with nearly 500 000 subscribers.

Open space

In liveable communities, most people live near an open space such as a park or playground. Parks provide green spaces in urban areas for plants and animals – they also cool urban areas and purify the air. For nearby residents they provide a space for activities such as exercise, ball sports, jogging and walking dogs.

The inner-city area of Prahran in Melbourne has among the least open space per head of population in Victoria. Stonnington Council is investing $60 million to build an urban oasis on top of a car park. The community space, completed in 2019 is 9000 square metres in size and features a forest, gardens, lawns and water features, as well as spaces for community events.

Resources for youth

In planning to make cities more liveable, the views of young people need to be considered. Public transport needs to be safe and reliable, and it needs to service local schools and shops, as well as sports and entertainment facilities.

Source 4: The original artist's impression of the urban park on top of a car park in Prahran, Melbourne. In urban areas, parks provide healthy green spaces for residents to enjoy.

Public spaces and facilities need to be designed to cater for the interests of young people. Young children need playgrounds and parks. Teenagers require sports grounds, stadiums, skateparks, mountain-bike tracks, cafes, cinemas and music venues.

Educational facilities need to be designed to cater for different types of learners, with flexibility in learning spaces and freely available technology, such as wi-fi and fast internet.

Learning ladder 5.7

Sustainable management strategies

1. **a** What are some of the challenges low-income countries face to improve liveability?
   b What are some of the issues that high-income countries are facing to improve liveability?
2. Source 2: Describe how school feeding programs operate.
3. Source 4: Explain the strategy employed by Stonnington Council to improve liveability for residents in Prahran.
4. Analyse the role and actions of humanitarian organisations to enhance liveability through school feeding programs. What benefits do programs like this bring to low-income countries?
5. Research and evaluate the role of a non-government organisation such as World Vision to improve liveability in low-income countries.

Change

1. How has the number of low-income countries changed since 1994?
2. Source 4: Describe the change that has taken place on the roof of this car park.
3. Source 3: Explain why changes to the Marina Reserve were made in this inner-city suburb.
4. What additional challenges do young women in low- and middle-income countries face and what changes need to be made to improve their lives?
5. Evaluate the importance of actions in low-income and high-income countries to improve liveability. Which is more critical and why?

HOW TO Change, page 394

How can liveability factors be improved for First Nations Peoples?

First Nations people play a significant role in enhancing liveability through their contributions to preserve cultures, sustainably manage the land and empower communites to help improve living conditions. Their efforts contribute to the creation of a more inclusive and equitable society that benefits all Australians.

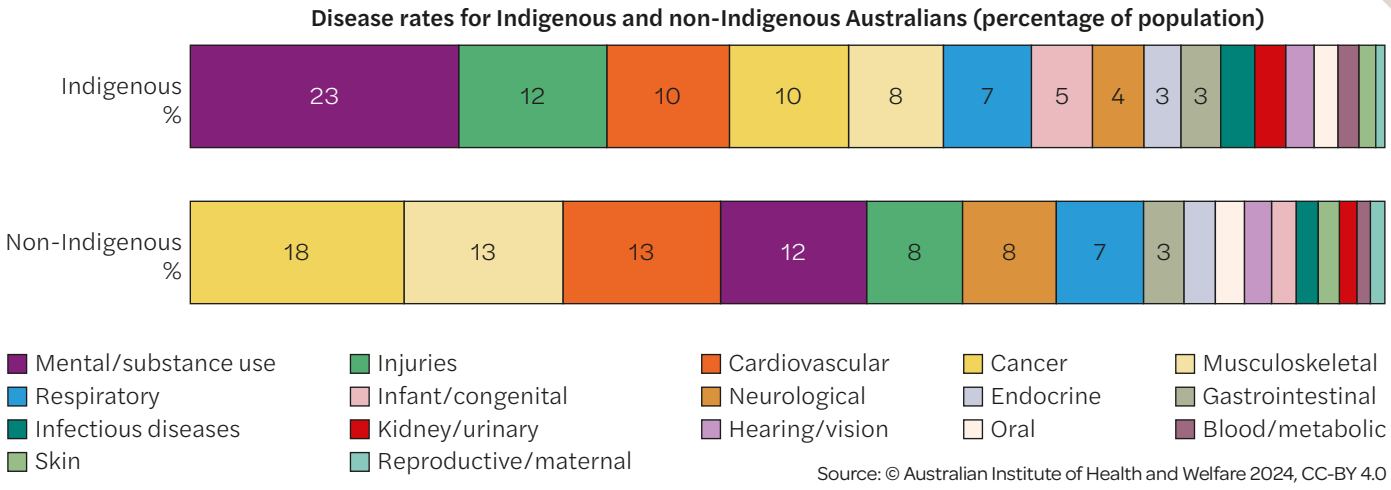
Improving liveability

The liveability of a place relates the quality of the environment, its **infrastructure** and the health, culture and safety of the community. Many First Nations communities face barriers to improving their wellbeing. Ineffective government policies have made it difficult for First Nations people to achieve home ownership, business opportunities and parity with non-Indigenous Australians in health and education.

Healthcare

There is an unacceptable gap in health and life expectancy between Indigenous and non-Indigenous Australians. Nationally, First Nations males are expected to live to 71.6 years and females to 75.6 years. Non-Indigenous Australians live about eight years longer than Indigenous Australians.

A number of factors contribute to the gap in life expectancy for First Nations people, including maternal health, education, poverty, safety, housing and racism. An Australian Bureau of Statistics survey indicated that about one-third of the total health gap between Indigenous and non-Indigenous Australians is due to poor access to local affordable and culturally appropriate health services.

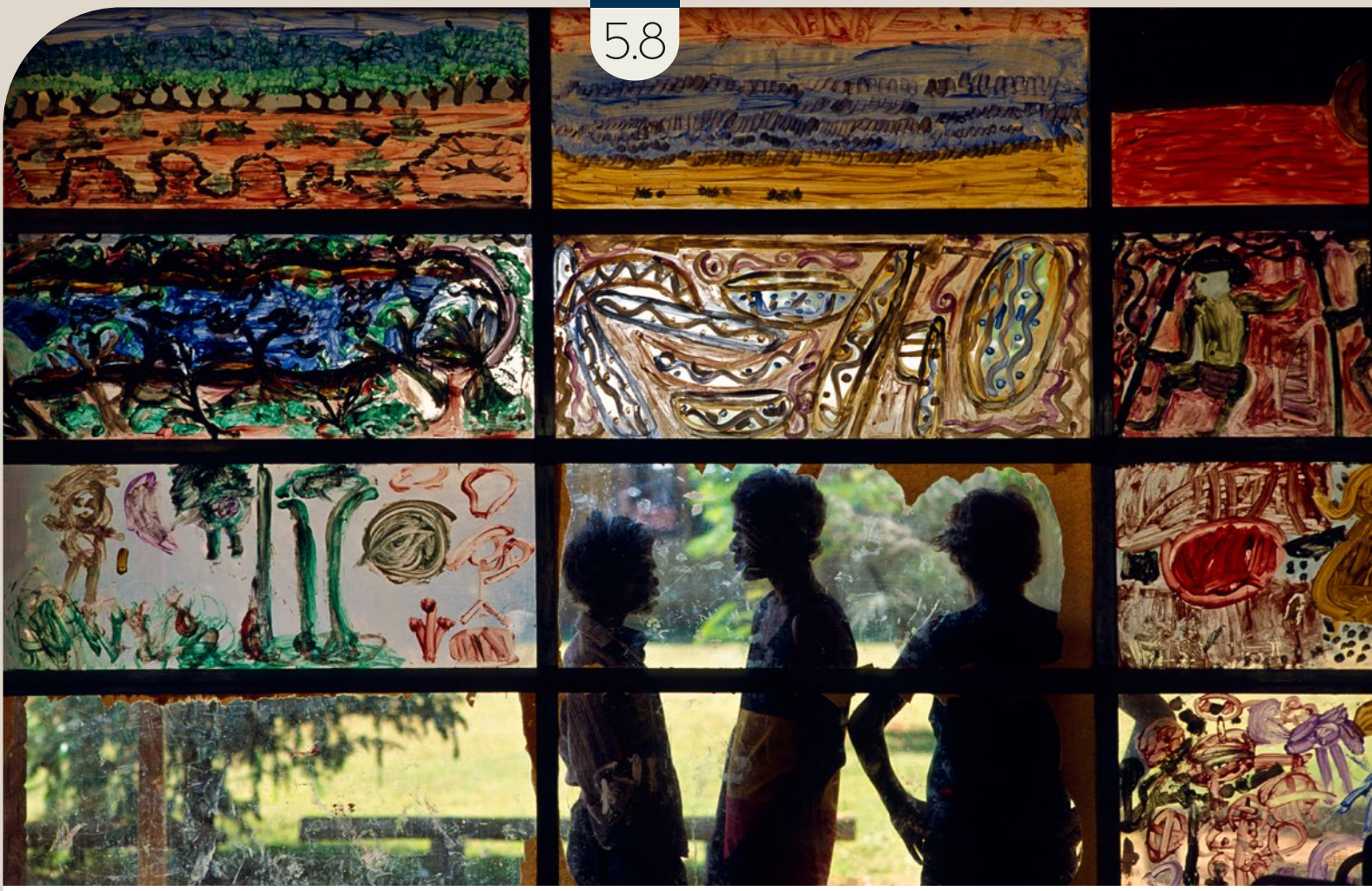


Source 1: In 2018, the impact of disease among Aboriginal and Torres Strait Islander people was 2.3 times greater than among non-Indigenous Australians. Those in remote areas experienced even higher rates of disease than those living in cities.

To improve the health outcomes for First Nations people, dramatic improvements to the health system are needed. Governments must increase the number of healthcare professionals in First Nations communities, improve healthcare infrastructure, and integrate First Nations healing practices into mainstream healthcare systems. Additionally, addressing the socioeconomic factors that contribute to health disparities, such as inadequate housing, is crucial. Promoting cultural pride, supporting community-led initiatives, and actively combating racism and discrimination are also important steps in creating a more equitable and liveable future for all Australians.

The Koori Maternity Service is an example of a culturally responsive program that supports First Nations women and families during pregnancy and childbirth. By providing culturally sensitive antenatal care, birthing support, postnatal care and breastfeeding support, this service aims to improve maternal and child health outcomes while honouring cultural identity and traditions.

Source 2: Koori Maternity Service delivers culturally appropriate health care to help First Nations women and their families feel safe and included throughout pregnancy, delivery and postnatal care.



Source 3: Bililuna Community school is a remote school located in a desert region approximately 1100 kilometres east of Broome and 150 kilometres south of Halls Creek in Western Australia.

Education

When discussing education in Australia, government priorities such as school attendance and attainment of literacy and numeracy standards are seen as an issue to be solved in Indigenous communities. Colonised classrooms often harm First Nations students by erasing First Nations knowledge and cultural practices, disconnecting them from their identities.

A culturally relevant school curriculum including the use of First Nations languages can help preserve cultural identity and improve educational outcomes. Students may occasionally need to miss school to participate in ceremony or cultural practices, which are integral to their cultural identity and wellbeing.

A study involving Indigenous and non-Indigenous educators in Queensland in 2022 highlighted building confidence in young Indigenous people to deal with issues such as identity and racism. This helps young people feel safer and more connected.

> In our school, once students knew their identity, they excelled. Nurturing identity and culture is very important – growing young people in an environment where being Indigenous was negative but turning that into a positive is re-imagining the story for all Indigenous students.
>
> Culture and identity play an important role in students believing in themselves and striving to be the best version of themselves [...] students have to know that they [are] included and recognised as Aboriginal and Torres Strait Islander people [...] space to call their own is important. They like to be there.

Source 4: Statements from educators working with First Nations students, *The Conversation*, 9 November 2022

Housing, infrastructure and economic development

Improvements to housing, infrastructure and economic development can lead to improved liveability and better health, social and economic outcomes for First Nations Peoples.

The Redfern Aboriginal Housing Company in Sydney is a community-led initiative that focuses on improving housing options for First Nations people. By involving community members in decision-making processes and providing safe, affordable and culturally appropriate housing choices, this organisation empowers First Nations communities to shape their living environments and promote self-determination.

The government can enhance liveability by investing in infrastructure projects that improve community facilities based on the needs and priorities of local First Nations communities.

Source 5: The Pemulwuy Project is the redevelopment of the Aboriginal Housing Company land known as 'the Block' in Redfern, Sydney. The new site will contain affordable housing for 62 First Nations families, student accommodation spaces for 110 First Nations students, a childcare centre, and commercial and retail spaces.

For example, the construction of the Wiradjuri Study Centre in Condobolin provides a space for cultural education, language preservation and community gatherings, contributing to inclusive and thriving community spaces.

Initiatives like the Indigenous Procurement Policy (IPP) and the Aboriginal Economic Development Strategy support the growth of Aboriginal businesses and employment opportunities. These initiatives aim to create economic opportunities, foster economic self-sufficiency and improve wellbeing within Aboriginal communities, thereby improving liveability.

Learning ladder 5.8

Sustainable management strategies

1. Source 5: What is the role of the Redfern Aboriginal Housing Company?
2. How do services such as the Koori Maternity Service contribute to improving health outcomes for First Nations women and families?
3. Source 5: Explain how The Pemulwuy Project aims to sustainably improve the outcomes for First Nations people?
4. Explain the health inequities experienced by First Nations people and the barriers preventing improvement.
5. How can the government or community groups overcome social and economic barriers that impact First Nations peoples' access to quality education, employment and health care?

Change

1. Source 4: What change is occurring to improve education for First Nations students?
2. Source 3: Identify changes to a traditional classroom to make the Bililuna classroom more culturally appropriate for First Nations students.
3. Provide an example of new infrastructure development that enhances liveability for First Nations communities.
4. Source 5: Explain the changes that have occured in Redfern to improve liveability for First Nations people.
5. Source 1: What are the implications of the pattern shown here and what is one way that they can be addressed?

HOW TO
Change, page 394

5.9

How can liveability be improved for people with disabilities?

The Disability Discrimination Act (DDA) makes it illegal for public places to be inaccessible to people with disabilities. A person with a disability has a right to have access to places, services and facilities used by the public. Examples of places include footpaths and walkways, education facilities, shops, parks, swimming pools, restaurants, libraries, public transport, hospitals and health facilities, and government-run services such as Centrelink. In an inclusive society, places are more liveable because people with disabilities have equal access to services and facilities.

What does accessibility look like?

It can be difficult for able-bodied people to see the world from the perspective of a person with a disability and to comprehend the barriers to accessibility. Over time this situation is changing, as new places are planned to be inclusive, and older facilities are retro-fitted so that all people can make the same use of places. Change can be slow, often because of the expense involved. Some places, particularly restaurants and airlines, have resisted change, particularly in regard to guide dogs.

The ability to get into and move within a facility, without segregation and with all of the information needed to use the facility, are essential to accessibility. Actions being taken to make places more liveable by improving access include:

- local governments providing footpath ramps, lifts and dedicated public toilets and parking spaces, or relocating obstacles to movement such as post boxes, garbage bins or seating in public places
- organisations such as banks and restaurants installing ramps and reorganising furniture to cater for wheelchairs and guide dogs
- signage in braille (tactile points to represent letters) and audio messaging.

Source 1: Access to public facilities is essential to a good quality of life for people with physical disabilities.

Public transport

Evidence shows that one-sixth of young people aged 15 years or more with a disability face barriers to using public transport. Their challenges include physical access, information and safety. Public transport is an essential service for full participation in community life because it connects people socially (family, friends and community) and economically (employment and services). In Australia, state rail authorities and public and private bus companies have integrated assistance measures into their transport services.

The role of groups and organisations

Advocacy is when a group or organisation acts on behalf of a group that has been disadvantaged or to help groups gain access to services and facilities available to the general public. Vision Australia is a social enterprise that works with organisations such as banks, arts and culture providers, and education facilities to break down the barriers for the vision-impaired. The enterprise estimates that 453 000 Australians are blind or have low vision, a number expected to grow to 564 000 in 2030 as the population ages. Assistance animals enable the vision-, hearing- and mobility-impaired to safely access places. Guide Dogs NSW trains and provides guide dogs for this purpose. Under the DDA it is illegal to discriminate against a person with a disability accompanied by an animal trained to reduce the effects of their disability.

▲ **Source 3:** Accessible features for public transport include level platforms, tactile surfaces and edges, and available ramps and assistance.

Source 2: There is increasing pressure globally for change that will improve access to services and facilities for people needing the use of assistance or guide dogs.

Learning ladder 5.9

Perspectives of people and organisations

1. What is a perspective?
2. What is the perspective of the DDA to people with disabilities?
3. Suggest why able-bodied people find it difficult to see the perspective of a person with a disability.
4. What is the role of advocacy groups in improving the liveability of places for people with disabilities?
5. Suggest one strategy that could be implemented in a school to help students see the world from the perspective of a person who uses a wheelchair.

Interconnection

1. Source 1:
   - **a** Identify each of the strategies that help people with disabilities to access services and facilities.
   - **b** How do these strategies improve the quality of life and social connectedness of people with disabilities?
2. Explain the implications for society of planning places for people with disabilities in mind.
3. What is the link between legislation such as the DDA and improvements in accessibility to services and facilities for those with a physical disability.
4. Create a photo collage of signs at places in your community that would improve connections to places for people with visual or mobility disabilities.

HOW TO

Interconnection, page 392

How can we enhance the liveability of a local place?

Geographers can use the findings from inquiries into the liveability of places to suggest improvements that enhance liveability. When you communicate suggestions to appropriate authorities or experts, you are being an active citizen, an important skill for your future role in your community. Assess the liveability of a local public place and use your findings to propose strategies to enhance its liveability.

1 Step 1: Undertake fieldwork to gather evidence

Identify a local public place you can visit for fieldwork, such as:

- shopping street, mall or plaza
- transport node such as a railway station or bus interchange
- park, a playground or recreational area.
- popular travel route such as from school to a bus station.

Develop inquiry questions appropriate to assessing liveability. Work in groups to develop questions and get a class consensus on the questions that will be used. Questions should focus on access to services and facilities, environmental quality and opportunities for social, cultural and community connections.

Find secondary information about the selected place. This could be a map, a detailed plan of the place or a population profile of the community. Look for media reports about local events or features that decrease the liveability of places, such as crime or safety issues.

▲ **Source 1:** Identify a local public place you can visit for fieldwork. Consider the advantages and disadvantages of a site when making a choice.

Undertake fieldwork to gather primary data. Observe and record evidence to assess the following:

- environmental quality such as natural surroundings, buildings, shade, visible pollution, noise and temperature. Fieldwork methods could include field sketching, taking photographs and taking measurements or undertaking tests such as water quality tests.
- access to services and facilities such as shops, transport links or special provisions such as ramps for wheelchairs and prams. Record evidence using photographs, maps, tables and tally sheets.
- opportunities for social, cultural and community connections such as places to meet, transport, walkability, community facilities and meeting places.

The data you collect should be a mix of quantitative (from measurements, tallies or calculations) and qualitative data (descriptions, photographs, field sketches). Surveys can obtain quantitative and qualitative data.

Use surveys and questionnaires to see how liveability is perceived differently by various groups. Simple surveys and questionnaires are useful for data from the perspective of people based on age, life stage, cultural background and working status. This could be as simple as an open-response survey or a more detailed set of questions. Work in groups to approach people for their views.

Surveys can be conducted digitally through tools such as Google Forms. Responses and questionnaires can be graphed by demographic. This is also an opportunity to collect people's ideas on enhancing liveability.

If time for fieldwork is limited:

- Focus on one aspect of liveability such as environmental quality.
- Work in groups to investigate different aspects of liveability and then share your findings.
- Consider the 'liveability' of different places in the school grounds for students during breaks. Identify several locations using spatial technology tools before undertaking observations and recording data. This would make a good practice activity before completing a liveability assessment at a local place outside the school grounds.

▲ **Source 2:** Collecting data in the field

2 Step 2: Propose strategies to enhance liveability

During your fieldwork take time to consider the types of improvements that could be made. Refer to at least two different groups of people in your suggestions – for example, the elderly, parents with strollers and teenagers.

Strategies could include the provision of garbage bins, seating, lighting and shade; footpaths; outdoor fitness equipment; coffee shops or food vans; bus stops to improve access; and multicultural signs. A sketch map or field sketch could be created to locate the site where improvements could be made. Take photographs of these locations. The views of community members can be obtained through surveys such as in Source 3.

Please complete the statements on enhancing the liveability of a local place.	
Wouldn't it be great if …	
Where?	
So that people could …	
Because I want my local place to be …	

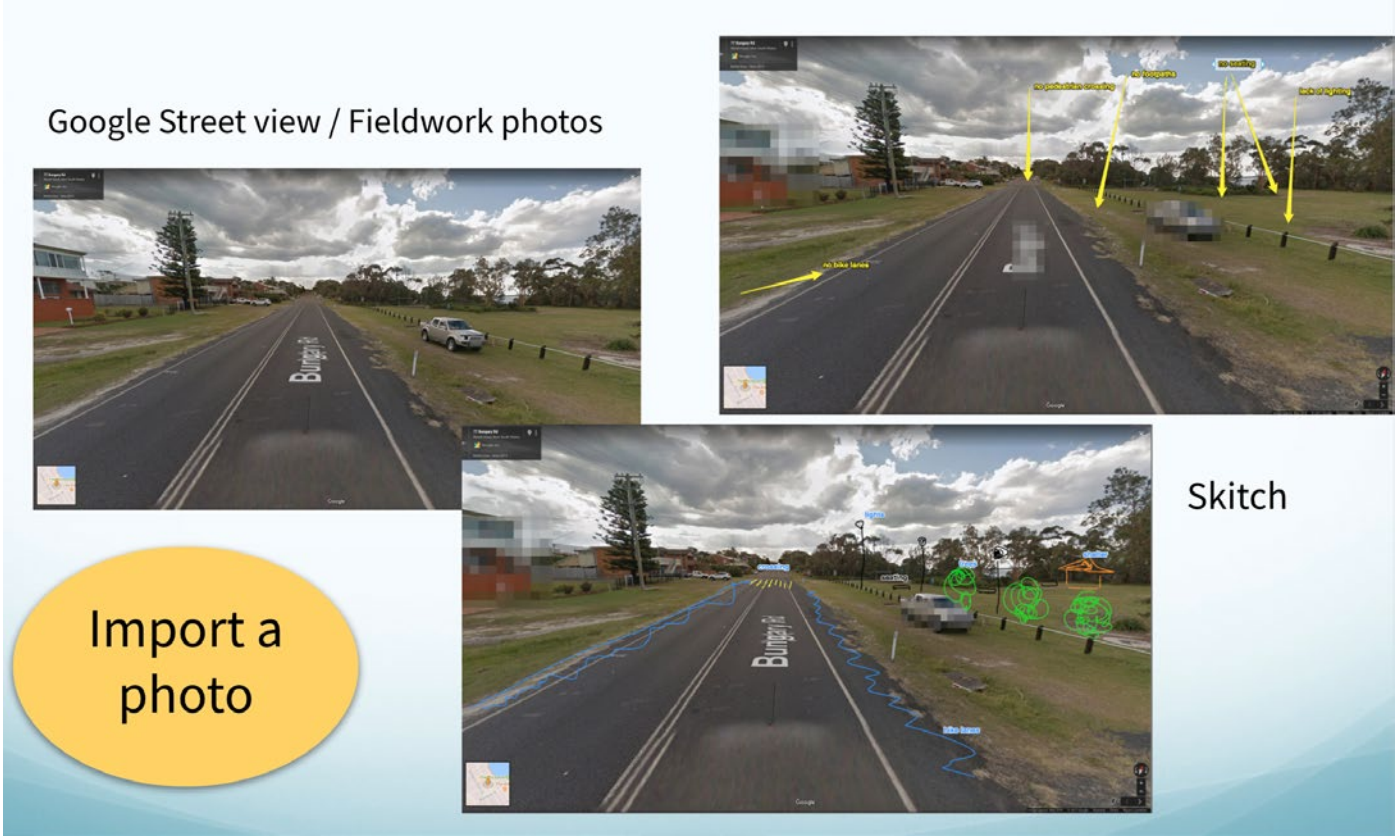
▲ **Source 3:** An open survey can be provided to community members asking them to complete the statements that relate to enhancing liveability.

3 Step 3: Communicate your findings and proposals

Use the evidence you collected during fieldwork to answer your inquiry questions and make an assessment about liveability. Represent statistical data in tables or graphs. Annotate your photographs. There are many suitable formats to communicate your research and proposals:

- written report with appropriate graphs, maps and photographs incorporated
- collage of annotated photographs
- TED talk or short documentary
- Google Tour or similar using a spatial technology tool such as Scribble Maps
- webpage or digital poster.

▲ **Source 4:** Use a spatial tool to map school locations where you could gather data on environmental factors affecting liveability or suggestions for improvements within the school grounds. Use a similar activity to select the local site for fieldwork outside the school.



Citizenship

As citizens, you can influence decision-makers by presenting your research findings and proposals. Think about local authorities such as your local council, a community group that undertakes projects in local communities or influential people in the community. You may consider a letter to the editor of the local newspaper.

Source 5: Annotate photographs to show proposals to enhance liveability. These annotated photographs were created using a screen-captured map from Google Maps streetview imported into Skitch, a tool for annotating photographs. Fieldwork photos can be used to create the same type of map.

Learning ladder 5.10

Representing and communicating information

1. Identify a local public place you could investigate using fieldwork.
2. Write two questions about the environment of that place to assess its liveability.
3. Source 1:
   - **a** Describe features of this public place that contribute to the liveability of the neighbourhood or suburb it is in. Refer to services, facilities, environmental quality or community connections.
   - **b** Explain one piece of quantitative data and one piece of qualitative data you could collect from the location. What would that data tell you about liveability?
4. Source 3:
   - **a** Respond to the statements for a local public place in your neighbourhood.
   - **b** How would the changes you recommend enhance liveability?
5. Assess the value of spatial technology tools in investigating liveability.
6. Create a word cloud that contains terms that you use during your investigation of liveability. List the most important concepts several times and they will appear larger on your word cloud.

Place, page 390

HOW TO

5.11

How can cultural connection enhance liveability for First Nations Peoples?

For millennia, First Nations Peoples have been caring for Country by applying fundamental scientific principles to manage the landscape and ecology. The connection to Country, however, goes far beyond the 'how' of managing the landscape; it also includes important spiritual connections to Country that address the overall question of why caring for Country is important.

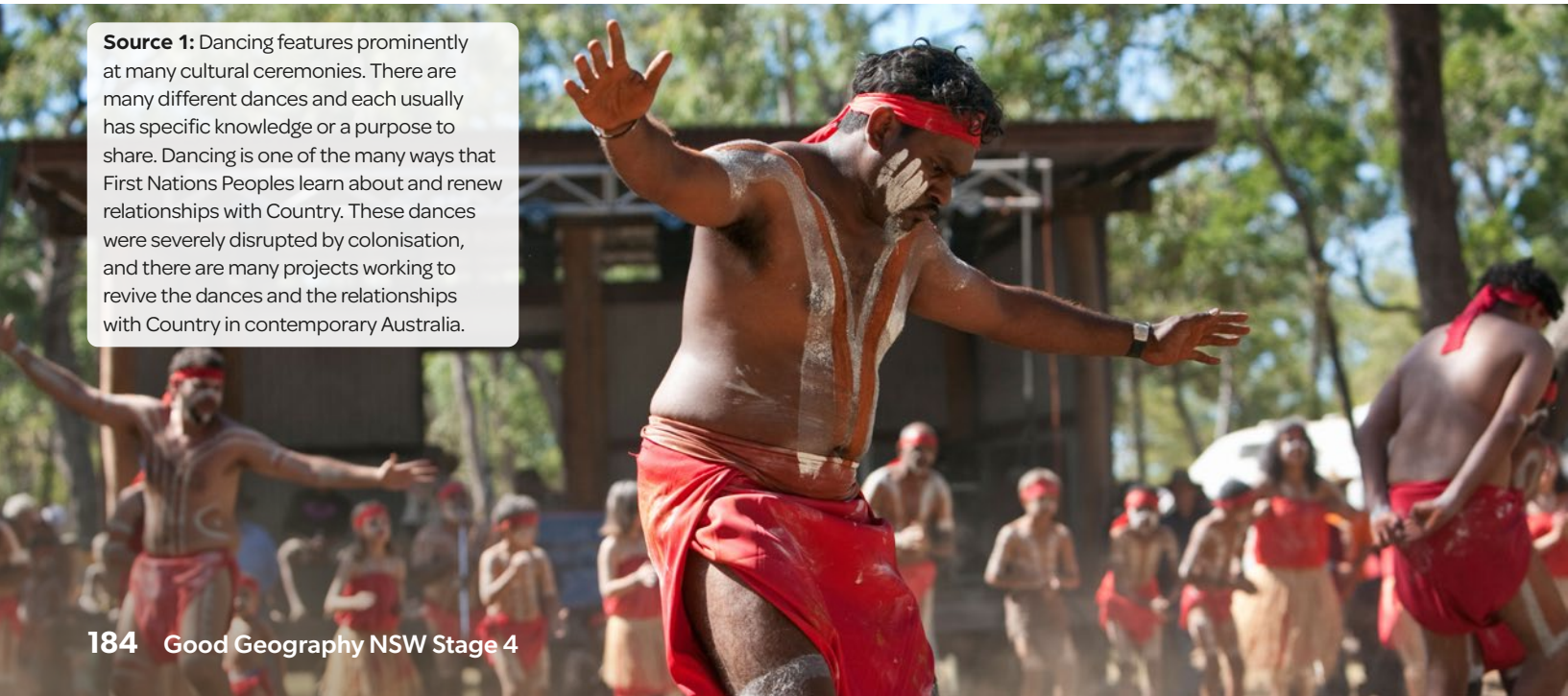
The science of caring for Country

The application of scientific principles has impacted the ecology and landscape on the Australian continent and the adjacent islands for millennia. These scientific principles have included complex understandings of ecology, botany, geology, zoology, meteorology and many other sciences focused on observations of the environment. This meant that prior to colonisation, First Nations Peoples had extensive knowledge of Country, and were able to maintain its fertility and productivity.

At the heart of the science of caring for Country was an understanding that all outcomes had to be sustainable. This meant that people cared for Country and considered both the immediate needs as well as the needs of those yet to come. Plants were cultivated with consideration for the impact they would have in the years and decades to come. This was also true in relation to the waterways, soil, insects, animals and bird life.

The spirituality of caring for Country

The science of caring for Country was not enough to ensure there would always be enough for the future. Another central aspect to connecting to Country is recognising that people are, and have always been, part of the landscape. This is in contrast with many non-Indigenous cultures that consider humans to be at the top of, or separate from, the environment. Because people are not considered to be separate from Country in the First Nations' perspective, it means a different concept of ownership of Country. Ownership of Country in a non-Indigenous context is a 'one-way' relationship;



Source 1: Dancing features prominently at many cultural ceremonies. There are many different dances and each usually has specific knowledge or a purpose to share. Dancing is one of the many ways that First Nations Peoples learn about and renew relationships with Country. These dances were severely disrupted by colonisation, and there are many projects working to revive the dances and the relationships with Country in contemporary Australia.

My Country © Yilpi Marks/Copyright Agency, 2024

Source 2: This painting is about Country. Note that the sacred parts of Country are shown, demonstrating how First Nations Peoples have a complex relationship to the environment.

Country has been commodified and is bought, sold, developed and exploited. For many First Nations Peoples, Country is not a commodity, but as Country is owned by people, people are also owned by Country. For some, Country is like part of the extended family; for others, Country feels like an extension of self. In these cases, it is a 'two-way' relationship where people are responsible to Country as Country is responsible to people.

This means that people have a responsibility and an obligation to care for Country and everything that lives and exists there, and because of this, First Nations land management practices are sustainable to ensure that Country is always able to provide for those who need it. Furthermore, this also means that there are specific places where Country is considered sacred, and these are places where First Nations Peoples conduct ceremony. It is not uncommon for these places to have restrictions on who can access them and when. There are many different types of ceremony and these collectively support First Nations Peoples to connect with Country, language, culture, community, ancestors, spirits and self, and this results in renewed focus on the relationship and responsibility to Country.

By connecting to Country in both scientific and sociocultural ways, First Nations people have been able to improve liveability to ensure constant and sustainable access to food, medicine, textiles, building materials, and important cultural materials like various ochres and other sacred substances.

Learning ladder 5.11

First Nations Peoples' interaction with Country

1. Identify a traditional practice used by First Nations Peoples to interact with and care for Country.
2. Describe how First Nations Peoples applied scientific knowledge to manage and sustain the landscape over generations.
3. Source 1: Explain how dancing is used in managing and caring for Country.
4. Analyse the importance of Caring for Country to the cultures of First Nations Peoples.

Sustainability

1. Identify one benefit of the sustainable practices of First Nations Peoples.
2. Describe how important sustainability is in First Nations Peoples' land management practices.
3. Explain how First Nations Peoples' sustainable land management balances the environmental need to preserve resources with the social and cultural significance of Country.
4. How can the use of First Nations Peoples' management practices contribute to long-term sustainability in Australian landscapes?

HOW TO Sustainability, page 400

Thinking geographically

Liveability of places

Geographical concepts, inquiry and tools

Space, place, environment, connection, inquiry

Learning ladder: page 156

Key inquiry question

What is my perspective on the liveability of Singapore?

See **Geo How-To** for sketches and annotating, page 416

In a slide presentation consisting of seven slides, use the knowledge and understanding developed in the activities below to answer the inquiry question. Include the following:

- the location of Singapore
- features of Singapore that make it a liveable city
- features of Singapore that reduce its liveability
- an annotated photo sketch or original diagram showing features of Singapore city that influence liveability
- an assessment of Singapore's liveability based on your perspective, including reasons for your judgement and the criteria you used.

Where possible, refer to the sources in this spread to support your response.

The geographical features of Singapore

See **Geo How-To** for place, page 390; scale, page 398; direction, page 404

Sources 1–2 activities

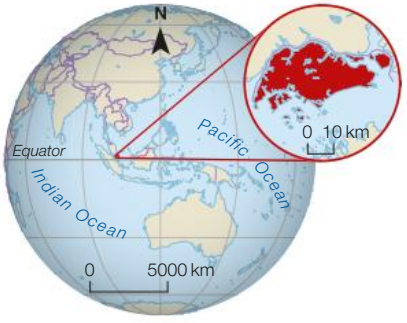
1 Identify the scale of the two maps (local, regional, national or global) in Source 1.

2 Describe the location of Singapore in the world and from Australia. Refer to latitude, direction, northern and southern hemispheres.

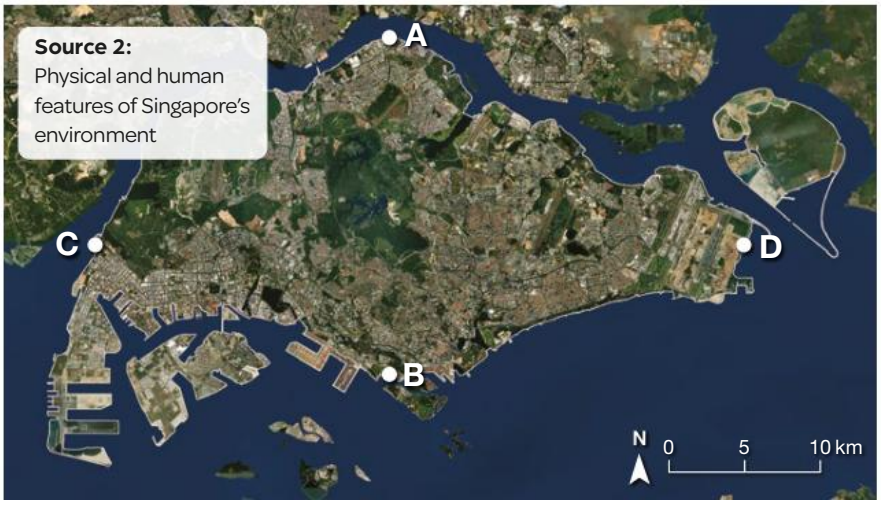
3 Calculate the following:
   - **a** the distance across Singapore between A and B and C and D using Source 2
   - **b** the population density of Singapore Island using Source 1. This is the number of people for per square kilometre of land.

4 Australia has a population density of three people per square kilometre, and Sydney has a population density of 440 people per square kilometre.
   - **a** How does the population density of Singapore compare to Australia and Sydney?
   - **b** Do you like crowded places? Give a reason for your answer.

5 Estimate the percentage of Singapore Island in Source 2 not covered in human structures such as buildings.



Source 1: Singapore is an island nation in South-East Asia, between 1 and 2 degrees north of the equator. The country consists of Singapore Island plus 62 smaller islands. Singapore city occupies all of Singapore Island, which is 720 square kilometres in size. In 2024 the multicultural population of Singapore was six million. This means Singapore is very crowded. However, Singapore is also ranked as one of the most liveable cities in Asia and is an important trade, business and tourist destination, with jobs for skilled workers and low unemployment.

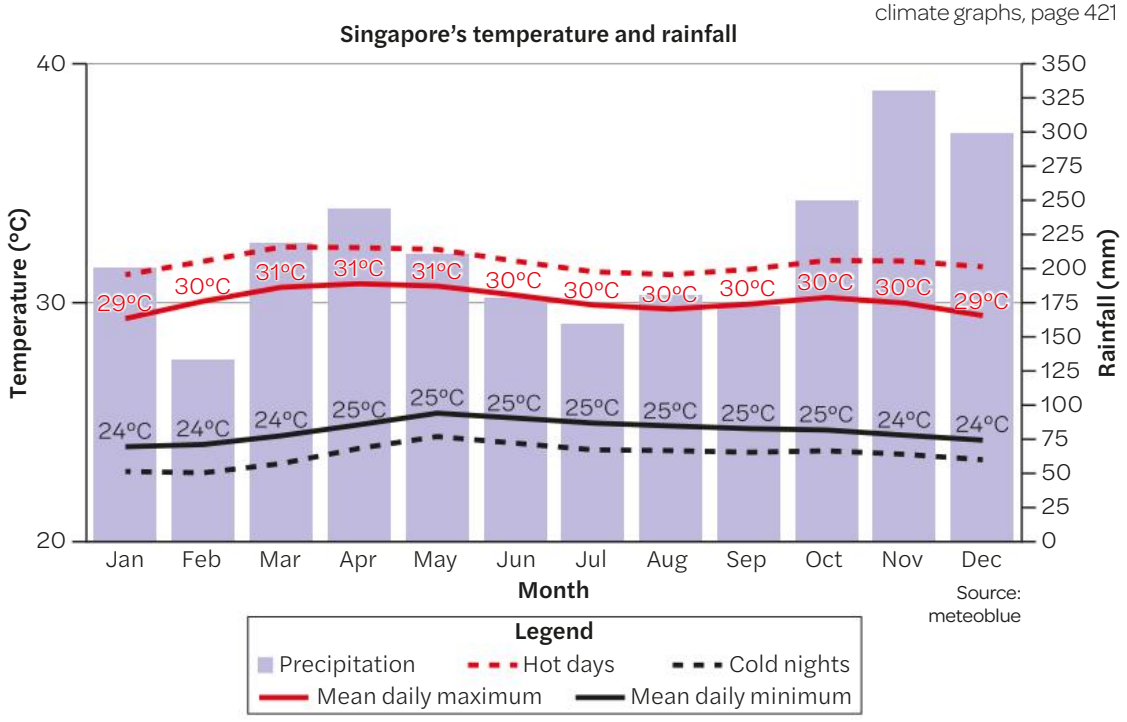


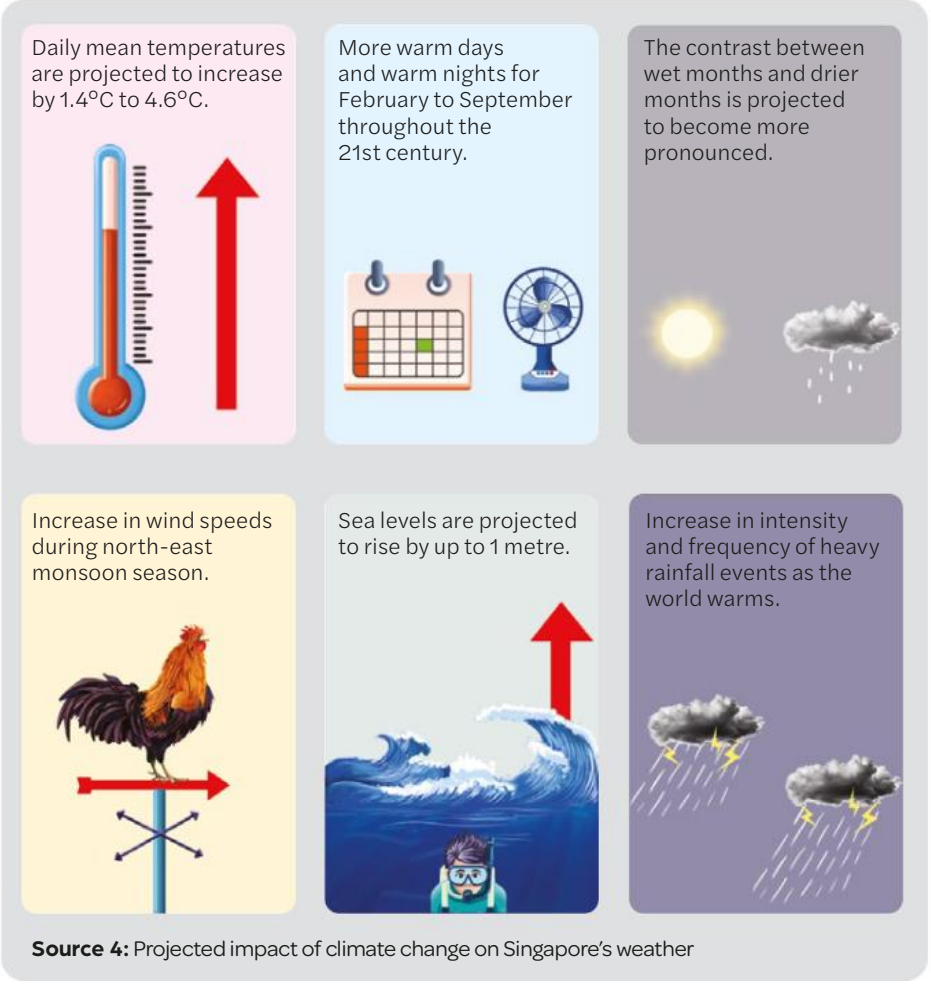
Source 2: Physical and human features of Singapore's environment

Source: © Zelwanka

See **Geo How-To** for climate graphs, page 421

Source 3: Singapore has a tropical climate. It is hot, humid and rainy throughout the year and receives rain almost every day. There are two monsoon seasons that are wetter. Humidity averages 84.2 per cent, but can reach 100 per cent in the wettest season. Singapore does not have four seasons (spring, summer, autumn and winter), just like much of Australia.





Source 4: Projected impact of climate change on Singapore's weather

Sources 3–4 activities

1 Identify the following features of Singapore's climate:
   - **a** the three hottest months of the year and the temperature of each
   - **b** Singapore's two monsoon seasons
   - **c** the temperature range for January and July (you will need to calculate this)
   - **d** the annual precipitation (you will need to calculate this).

2 Describe the rainfall distribution for Singapore.

3 Explain why Singapore has high rainfall and humidity as described in Source 3.

4 Assess if you would enjoy living in Singapore's climate.

5 Analyse the impact of climate change on Singapore's weather and climate, and if this would influence your answer to question 4.

Human influences on environmental quality and access to services and facilities

See **Geo How-To** for for PQE, page 412

Source 5: A city of high rise buildings. The majority of Singapore's population live in high-rise apartments built by the government to ensure everyone has a place to live. Around 90 per cent of the population own their homes in these buildings. Some wealthier residents live in 'landed' properties, homes or duplexes with gardens or in private luxury condominiums.

Source 6: A city in a garden. Since the 1970s, the government has planned Singapore to create a more liveable environment. This includes planting greenery on and around buildings, providing parks and gardens, protecting remaining natural areas as reserves and replanting. This has improved liveability and helped cool the city.

Sources 5–7 activities

1. Identify features of Singapore's built environment shown in Sources 5, 6 and 7.
2. Use a table with two columns to outline your ideas on the advantages and disadvantages of living in the type of housing shown in Sources 5 and 6.
3. Explain why Singapore needs to be a vertical city.
4. Analyse the value of green places to the liveability of Singapore. Refer to Source 6 and Source 2.
5. Examine Source 7.
   - **a** Use PQE to describe how the MRT connects the places where most Singaporeans live (the grey areas).
   - **b** Evaluate the importance of public transport in moving Singapore's population between home, work and facilities such as shopping centres and recreation centres.

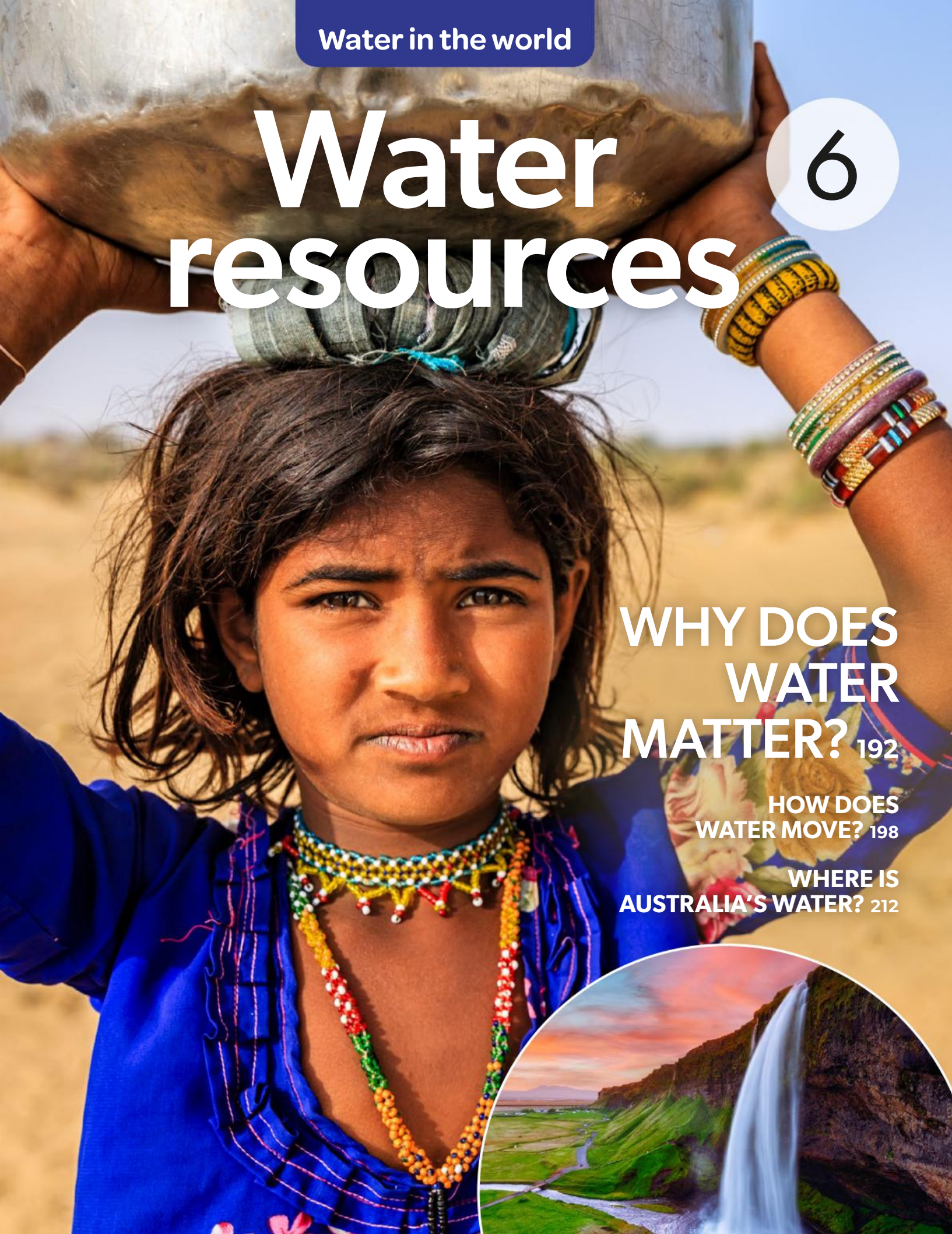
Singapore's rail network (MRT)

Source: Adobe/Lesniewski

▲ **Source 7:** Singapore has a sophisticated and efficient public transport system that connects people across the country and reduces the need for cars that cause traffic congestion and air pollution and contribute to climate change. Cycleways, covered walkways, underground walkways and trains are used by millions of people every day.

Water resources

6



6.0

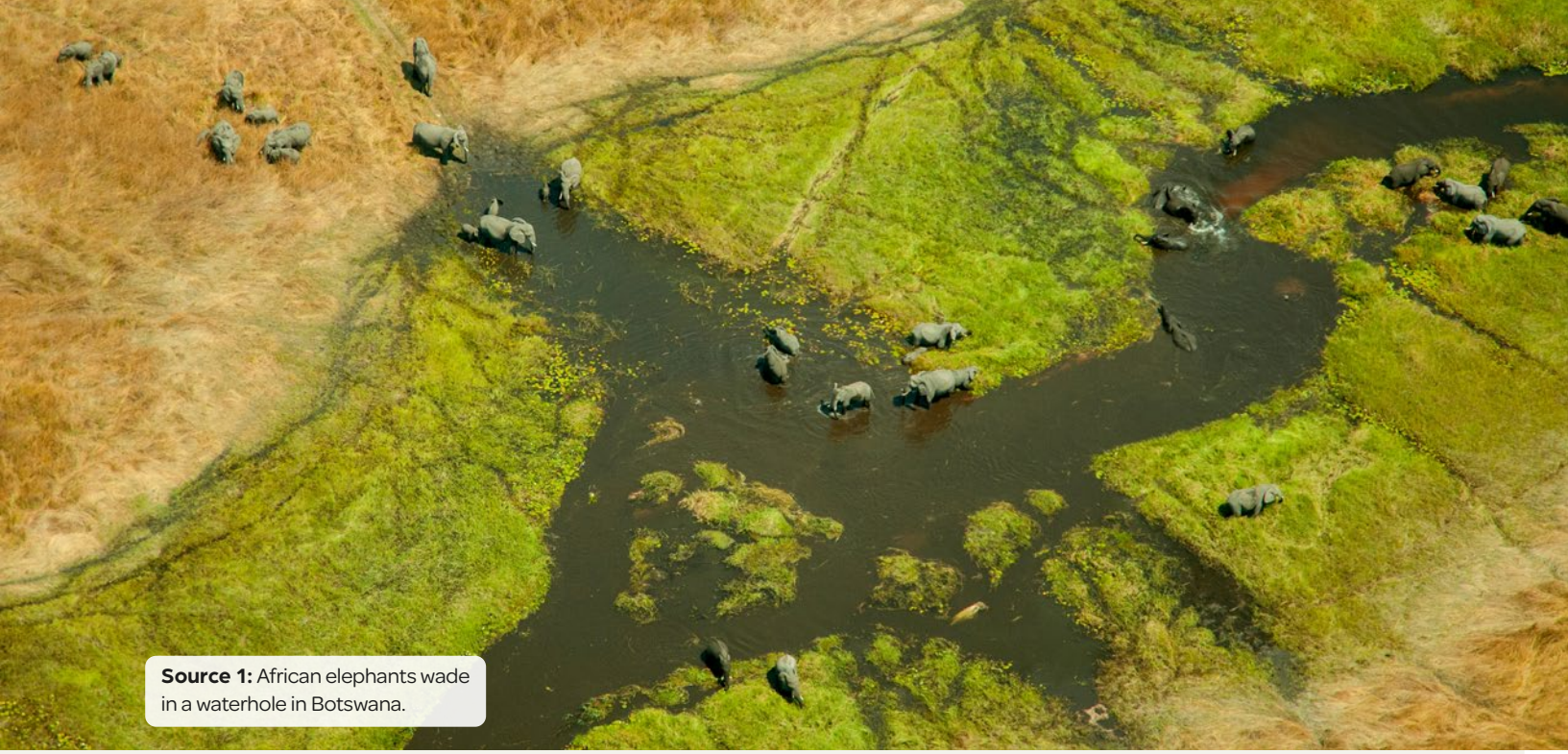
How can I understand water resources?

Without water, no living thing can survive. Two-thirds of the Earth is covered in water, but just 2.5 per cent of this water is fresh water. Most of the Earth's fresh water is locked up as ice. Fresh water is one of our most precious environmental resources, but increases in population are putting the quality and availability of water at risk.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information
	Outcomes					Geographical tools and inquiry



Source 1: African elephants wade in a waterhole in Botswana.

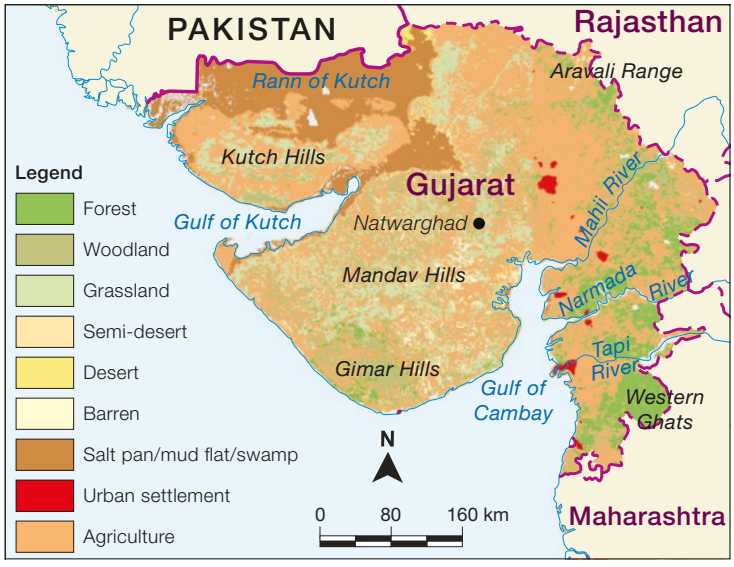
Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1

Geographical concepts

Why does water matter?

Water connects places around the world as people settle near **freshwater** resources to access water for drinking, cleaning, farming, industry, power generation, transport and recreation. Human activity clusters around the available fresh water in rivers, lakes and underground sources. These **water resources** can vary according to the amount of rainfall received and how quickly water resources are used. Water needs to be shared by communities and carefully managed.

Gujarat environments



Source: Matilda Education Australia

▲ **Source 1:** A map showing different environments in the state of Gujarat, India

Gujarat population distribution

Source: Matilda Education Australia

▲ **Source 2:** A dot map showing **population density** in the state of Gujarat, India

Source 3: People crowd to get water from a large well in the village of Natwarghad in the Indian state of Gujarat in June 2003. The state was facing its worst drought in over a decade. Dams, wells and ponds dried up as the region sweltered in temperatures over 44°C. People were forced to walk long distances and wait for hours around village ponds for water tankers to arrive.

Source 4: Heavy water containers are balanced on the heads of young girls to carry water back to their village.

Learning ladder 6.1

Sustainable management strategies

1. How are freshwater resources used?
2. Source 3: Describe what is happening in this scene.
3. Explain why water is such an important resource.
4. Source 4: Millions of women and children spend many hours each day collecting and carrying enough water to sustain their families. Why do they do this and what are the alternatives?

Place

1. Source 2: Describe the location of Gujarat.
2. Source 2: Do the least number of people in the state of Gujarat live in the north, south, east or west of the state?
3. Source 3: How do the characteristics of this place impact the people who live there?
4. Sources 1 and 2: Compare the two maps. How does the availability of water impact where people live in Gujarat?
5. Create a photo essay to illustrate how one of the following processes has changed the characteristics of a place:
   - drought
   - flood
   - irrigation.

HOW TO

Photo essays, page 419; Place, page 390

6.2

What type of resource is water?

Humans depend on the Earth's **environmental resources**: water from rainfall; food from the land and oceans; and energy from the atmosphere, land and water. Some environmental resources will last forever (they are perpetual) and others are renewable. But some resources are not renewable – if we overuse them, they will run out.

Types of environmental resources

Renewable resources

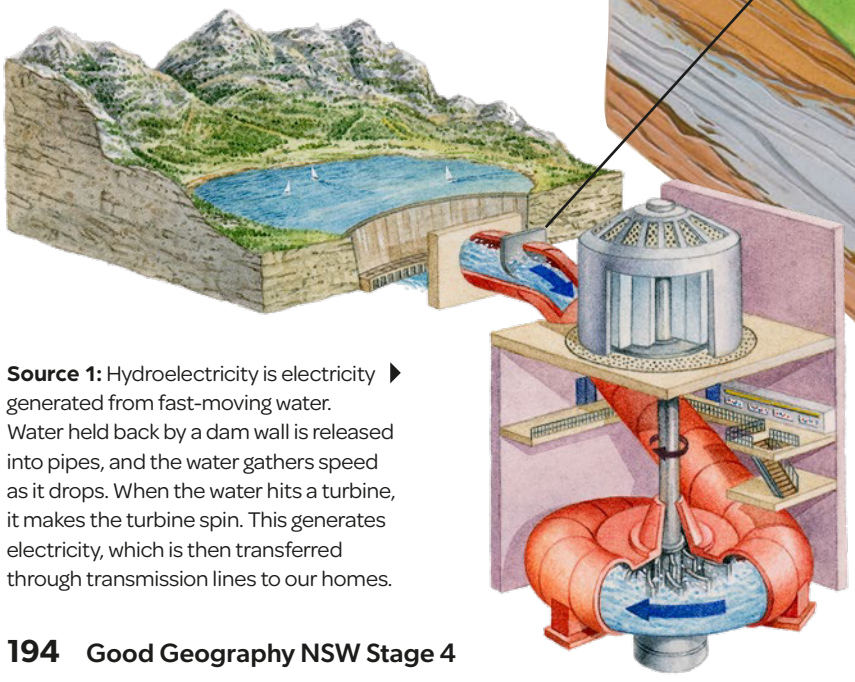
Renewable resources will naturally renew themselves if we do not use them too quickly. We need to manage renewable resources to ensure they have a chance to recover (or regenerate).

Fresh water is considered a renewable resource, but this does not mean that it is an unlimited resource. Water pollution and population increases can put our freshwater resources at risk.

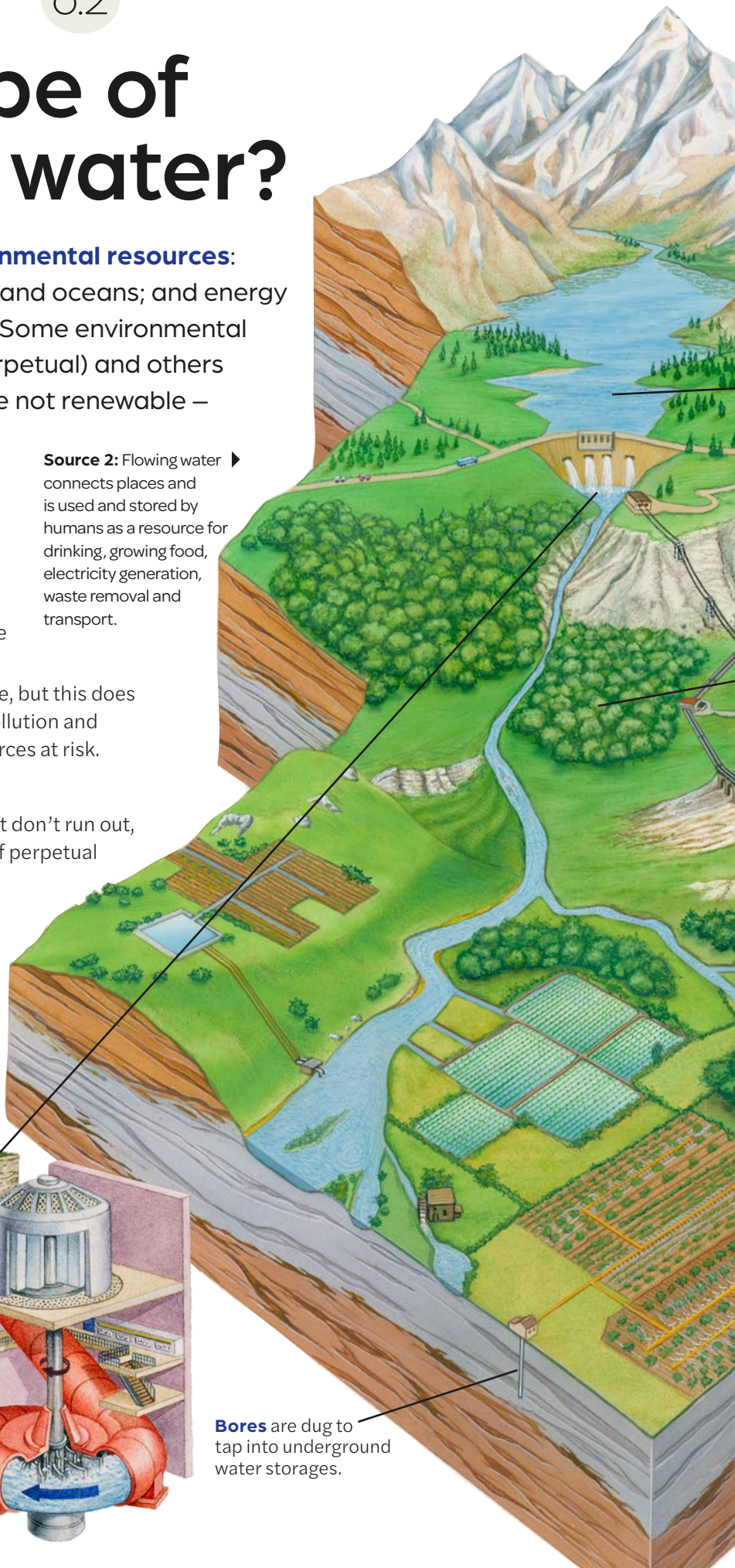
Perpetual resources

Perpetual resources are renewable resources that don't run out, regardless of how much they are used. Examples of perpetual resources include:

- wind energy
- solar energy
- waves and tides
- **geothermal energy**
- **hydroelectricity**.



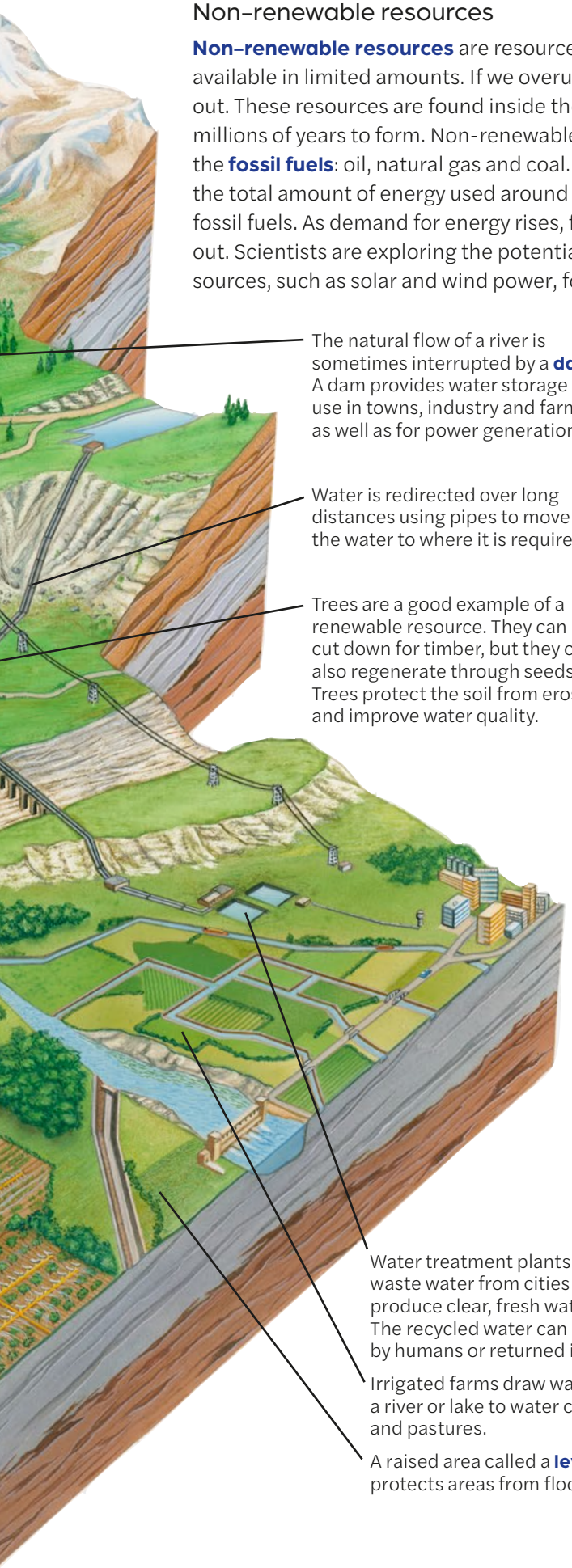
Source 1: Hydroelectricity is electricity generated from fast-moving water. Water held back by a dam wall is released into pipes, and the water gathers speed as it drops. When the water hits a turbine, it makes the turbine spin. This generates electricity, which is then transferred through transmission lines to our homes.

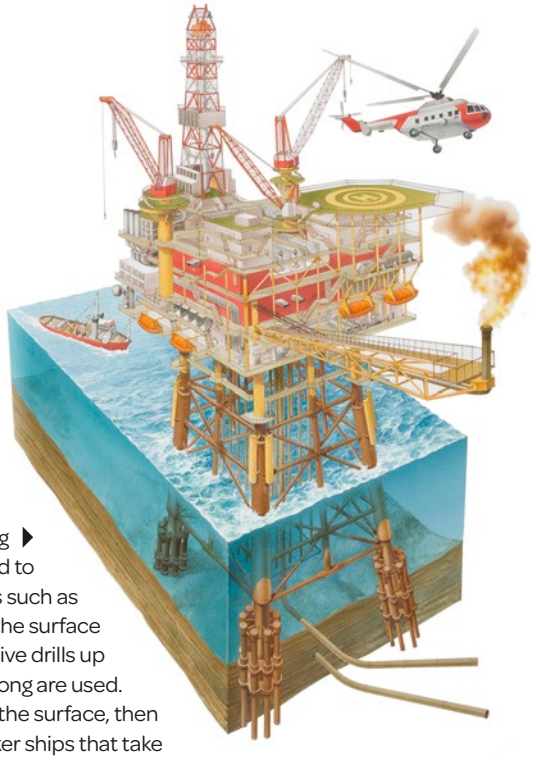


Source 2: Flowing water connects places and is used and stored by humans as a resource for drinking, growing food, electricity generation, waste removal and transport.

Non-renewable resources

Non-renewable resources are resources that are only available in limited amounts. If we overuse them, they will run out. These resources are found inside the Earth and they took millions of years to form. Non-renewable resources include the **fossil fuels**: oil, natural gas and coal. Today, 84 per cent of the total amount of energy used around the world comes from fossil fuels. As demand for energy rises, fossil fuels are running out. Scientists are exploring the potential of renewable energy sources, such as solar and wind power, for the future.





Source 3: Floating platforms are used to extract fossil fuels such as oil from beneath the surface of the Earth. Massive drills up to 2.5 kilometres long are used. Oil is drawn up to the surface, then pumped into tanker ships that take it away to be processed.

Learning ladder 6.2

Characteristics of places and environments

1. Is fresh water an unlimited resource?
2. Source 2: Give three examples of how humans have changed the river for their own use.
3. Source 1: Describe how water can be used to generate electricity through hydroelectricity.
4. Source 3: Explain why fossil fuels are running out. What action needs to be taken to ensure we still have power resources in the future?
5. Evaluate perpetual resources. How can we make better use of these resources that don't run out no matter how much they are used?

Sustainability

1. Which is the most unsustainable type of environmental resource and why?
2. Describe the risks to freshwater supplies.
3. Explain the importance of carefully managing renewable resources.
4. Source 1: Analyse the the positive and negative impacts on the environment from the use of hydroelectricity resources.

HOW TO

Sustainability, page 400

How can I display data to show the amount of water on Earth?

Water on Earth

Water is an essential resource that we need to survive. It is also a renewable resource that occurs naturally on Earth. The same amount of water that was available in the time of the dinosaurs is still available today.

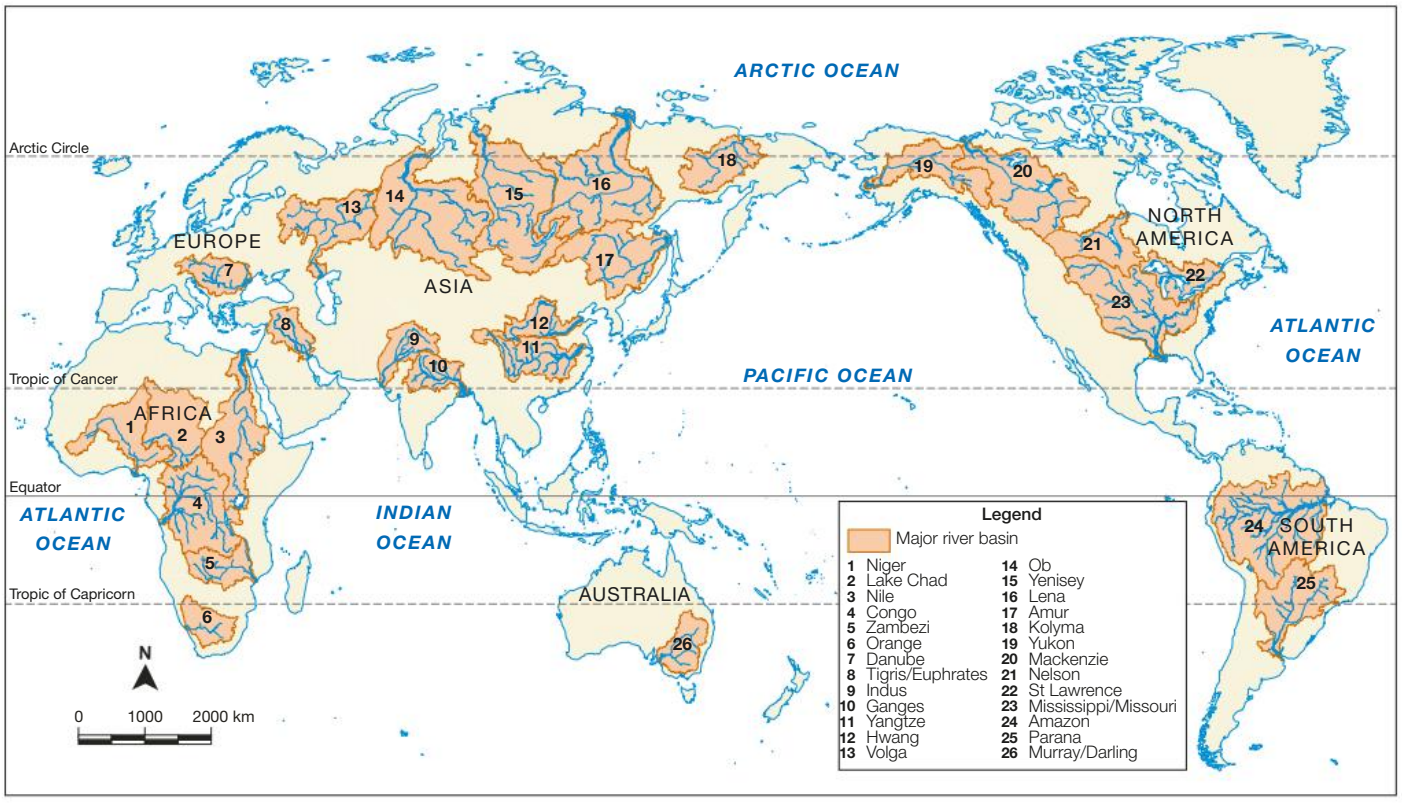
Water constantly changes state and moves through oceans, rivers and the atmosphere in a system known as the water cycle (see pages 198–9). To say water 'changes state' means that it changes from being a solid (ice), to a liquid (water), to a gas (vapour).

Water is a renewable resource because of the water cycle, which continually returns water to rivers, lakes and underground storage for humans to use.

Over 70 per cent of the Earth's surface is covered in water, but 96.5 per cent of that is salt water in our oceans.

The fresh water that all living things need to survive makes up only 2.5 per cent of our total water. Only a tiny amount of all fresh water is easily accessible in rivers, lakes, ice and snow – just 1.3 per cent. The rest of the fresh water is locked away underground or frozen in **glaciers** and **ice caps**.

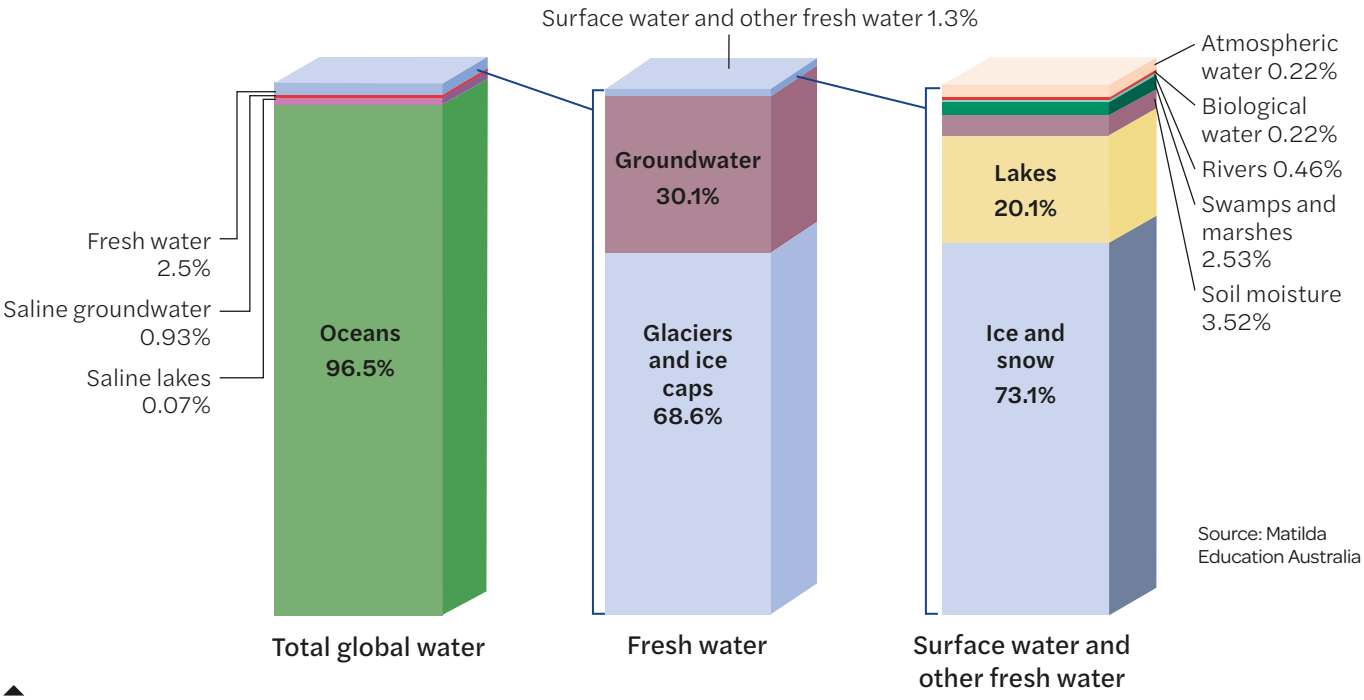
World drainage basins



Source: Matilda Education Australia

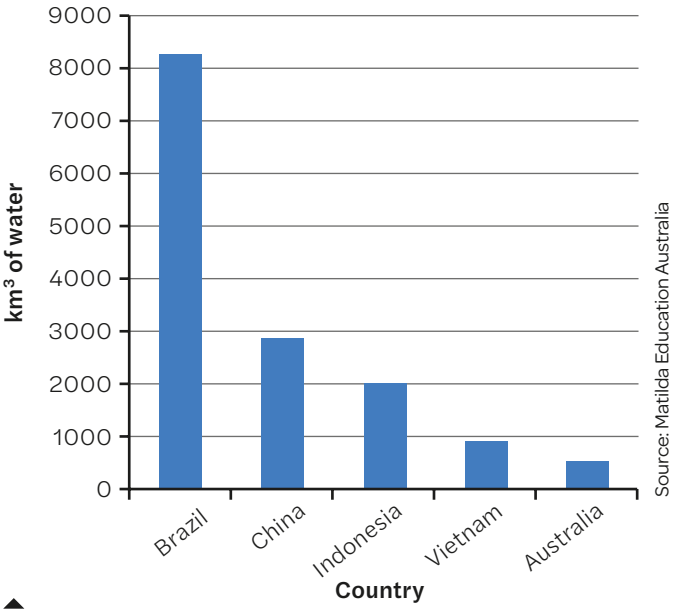
Source 1: A drainage basin (or catchment) is the area contributing water to a river system. Tha map shows the location and size of the world's major drainage basins. Australia's largest drainage basin is the Murray–Darling, covering 14 per cent of total land area.

The world's freshwater resources



Source 2: A stacked bar graph (or chart) divides each bar into categories. In this example, the first bar shows the categories that make up all of the Earth's water. Fresh water represents only 2.5 per cent of all water. The categories of fresh water are shown in the second bar. Easily accessible fresh water in lakes and rivers only accounts for 1.3 per cent of all fresh water. The third bar represents the categories of surface water and other fresh water. The amount of water in rivers represents just 0.46 per cent of surface water. The Amazon River in Brazil and Peru carries 15 per cent of the Earth's river water.

Total renewable water resources in selected countries



Source 3: A bar graph (or bar chart) is a graph that uses bars of different heights or lengths to display different amounts of things. This bar graph compares the amount of fresh water in five different countries. **Water-rich** countries are those with high rainfall, such as Indonesia, or with large river systems, such as the Amazon River in Brazil. Dry countries, such as Australia, are **water poor**.

Learning ladder 6.3

Representing and communicating information

1. Source 1: How is the distribution of of the world's drainage basins shown?
2. Source 3: What is a bar graph and when is it used?
3. Source 2: What extra information does a stacked bar graph show? Give an example.
4. Source 1: The map gives some indication of the size of drainage basins. How else could you display a comparison of the size of drainage basins?
5. Source 1: What is a drainage basin and where is the Amazon River drainage basin located?
6. Source 3: How much fresh water is in Brazil?
7. Sources 1 and 3: Why is Australia a 'water poor' nation?
8. Source 2: How much does the fresh water bar (in the middle) represent? How much of this water is stored water that is not easy to access?

HOW TO

Mapping with BOLTSS, page 402;
Graphing, page 420

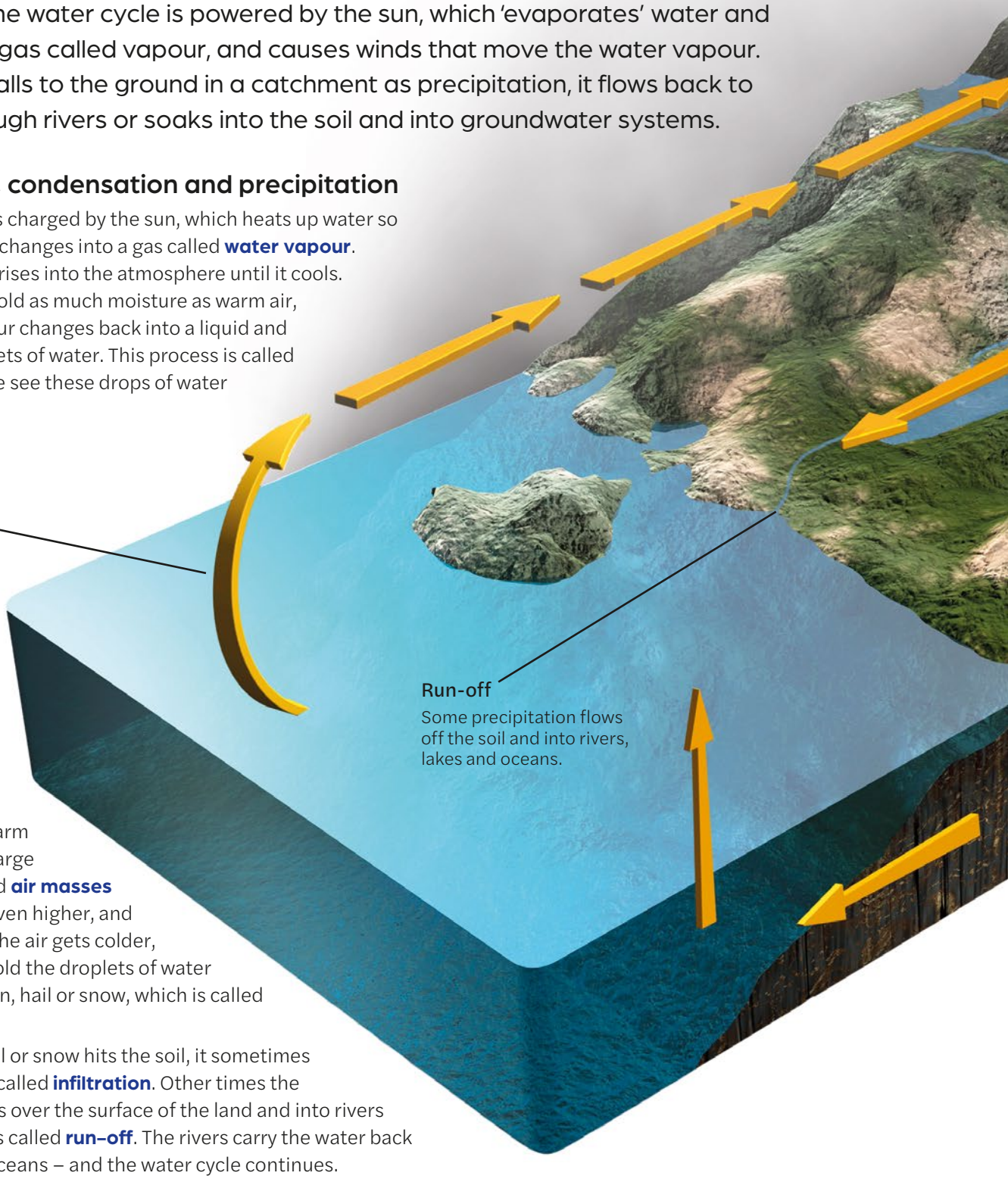
6.4

How does water move through a catchment?

In the water cycle, water changes from liquid to gas, and then back to liquid or solid again. The water cycle is powered by the sun, which 'evaporates' water and turns it into a gas called vapour, and causes winds that move the water vapour. When water falls to the ground in a catchment as precipitation, it flows back to the seas through rivers or soaks into the soil and into groundwater systems.

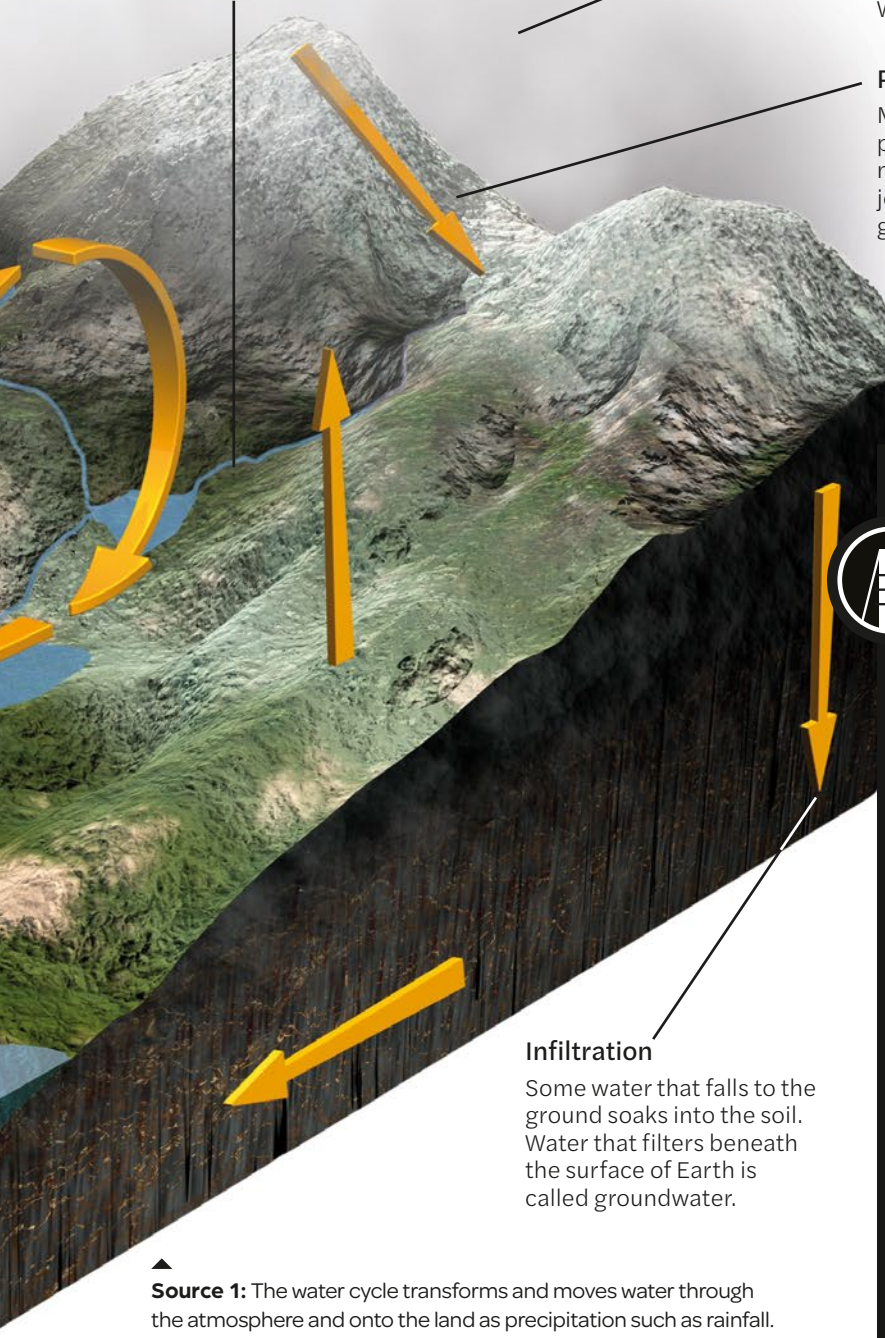
Evaporation, condensation and precipitation

The **water cycle** is charged by the sun, which heats up water so it evaporates and changes into a gas called **water vapour**. The water vapour rises into the atmosphere until it cools. Cold air doesn't hold as much moisture as warm air, so the water vapour changes back into a liquid and forms small droplets of water. This process is called **condensation**. We see these drops of water as clouds.



Mountains, warm temperatures or large bodies of air called **air masses** can push the air even higher, and it cools again. As the air gets colder, it can no longer hold the droplets of water and they fall as rain, hail or snow, which is called **precipitation**.

When rain, hail or snow hits the soil, it sometimes soaks in, which is called **infiltration**. Other times the precipitation flows over the surface of the land and into rivers and lakes, which is called **run–off**. The rivers carry the water back to the lakes and oceans – and the water cycle continues.



Source 1: The water cycle transforms and moves water through the atmosphere and onto the land as precipitation such as rainfall. A **catchment** is an area of land surrounded by hills or mountains where water collects when it rains. The water flows over the landscape and into rivers or underground storage. The water eventually moves back to the sea or a lake .

Water balance

The water cycle has a **water balance**. If there is too much precipitation on land, it is returned to the oceans by run-off. If there is too much **evaporation**, it is returned to the land by winds that blow the moist air from the sea onto the land.

Learning ladder 6.4

Processes that transform people, places and environments

1. How does the sun power the water cycle?
2. Source 1: Describe how water moves through the air and the landscape.
3. Explain the process of water moving through infiltration.
4. Source 1: Explain how the shape of a catchment helps move water through river systems.
5. Give an example to explain how the water cycle has a water balance.

Interconnection

1. Outline the process of water turning from a liquid to a gas and to a solid as a series of steps.
2. Construct a flow diagram to show how water moves through the environment. Use these labels: evaporation, condensation, precipitation, transpiration, run-off.
3. Source 1: What is the interconnection between rising air and condensation?
4. Source 1: Look carefully at the three dams shown in the diagram.
   - **a** Why has the flow of the river been interrupted by a dam wall?
   - **b** Suggest two ways that water can enter the dam.
   - **c** Suggest two ways that water can leave the dam.

HOW TO
Interconnection, page 392

How do rivers move water through the catchment?

Rivers are moving bodies of water that flow quickly downhill, eroding the land to form valleys. Rivers slow and spread out as they reach flatter land and then finally flow into the ocean, lake or larger river.

Rivers in mountains

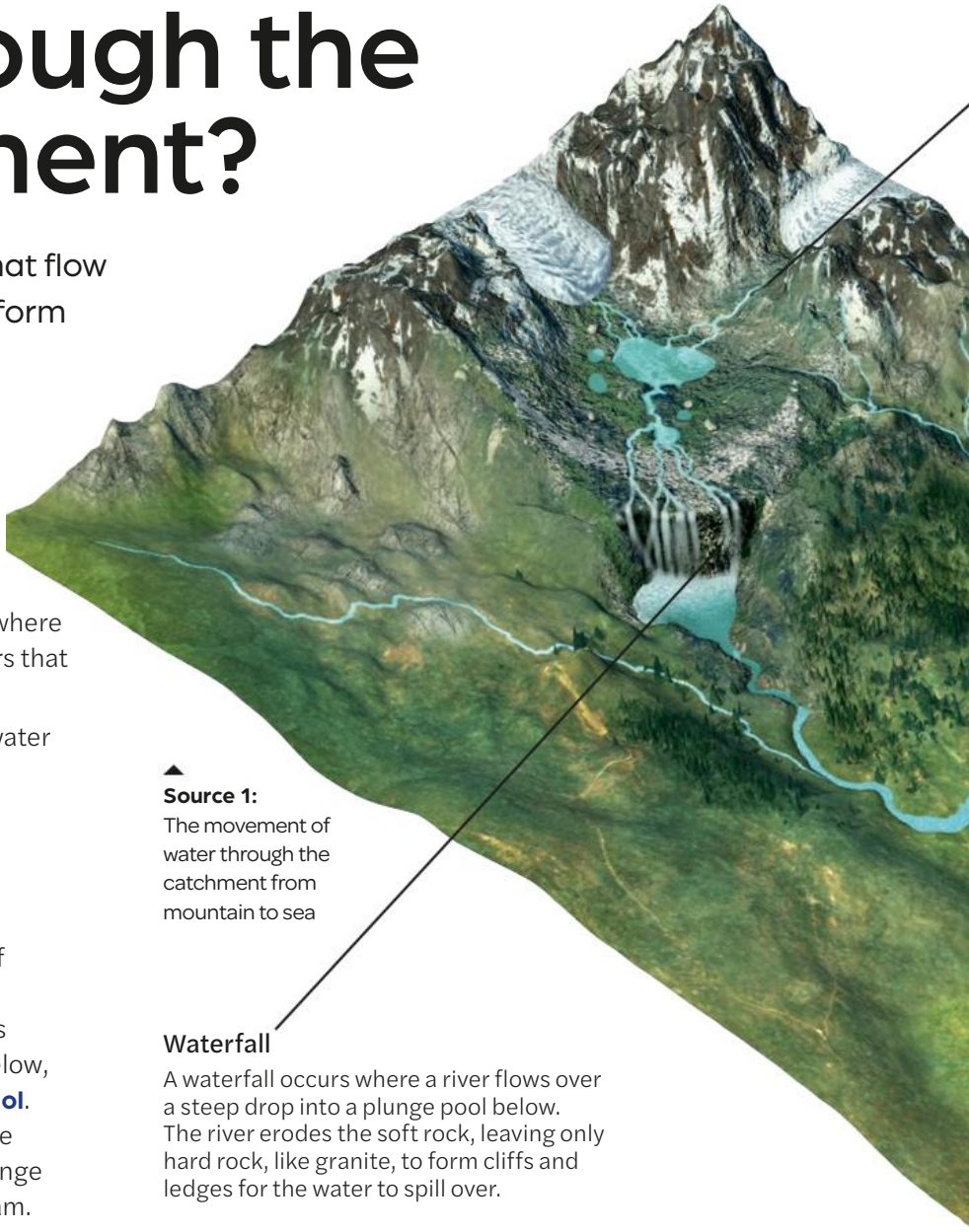
Mountains form the boundary of a **catchment**, where water is collected as precipitation runs into rivers that flow into larger rivers.

When a river is near its source, the force of water moving down a steep slope erodes the ground vertically to form v-shaped **valleys**. The moving water picks up rocks and soil (called sediment). The sediment erodes the riverbed further, in a process called **abrasion**.

Waterfalls often form in the upper stages of a river, where rivers meet harder rock that is not easily worn away, or eroded. Instead, water spills over the harder rock and erodes the soft rock below, forming a large pool of water called a **plunge pool**. Eventually, continued erosion will undermine the harder rock, and it will crack and fall into the plunge pool. Then a new waterfall forms further upstream. As the process continues, it forms a steep-sided valley, called a **gorge**.

Rivers on flatter land

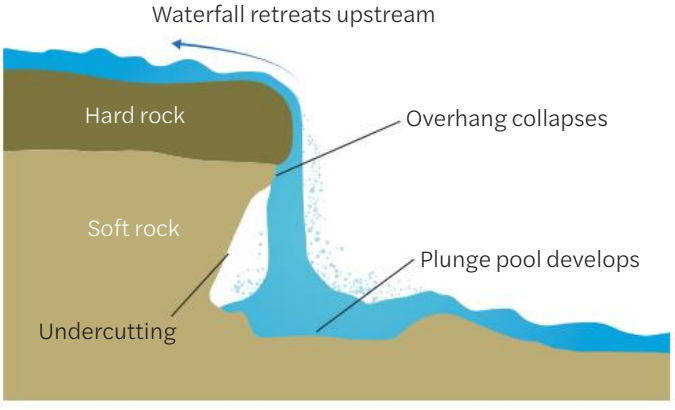
As the river reaches lower, flatter land, the eroded stones, sand and soil carried in the river begin to wear away the floor and sides of the valley. On the flatter land (called a floodplain, because it floods when there is too much water), rivers slow down and erode horizontally, creating snake-like **meanders**. The water speed is greatest on the outside of a bend, which is where erosion takes place. Water speed is slowest on the inside of a bend, and that's where eroded rock and soil is dropped, in a process called deposition.



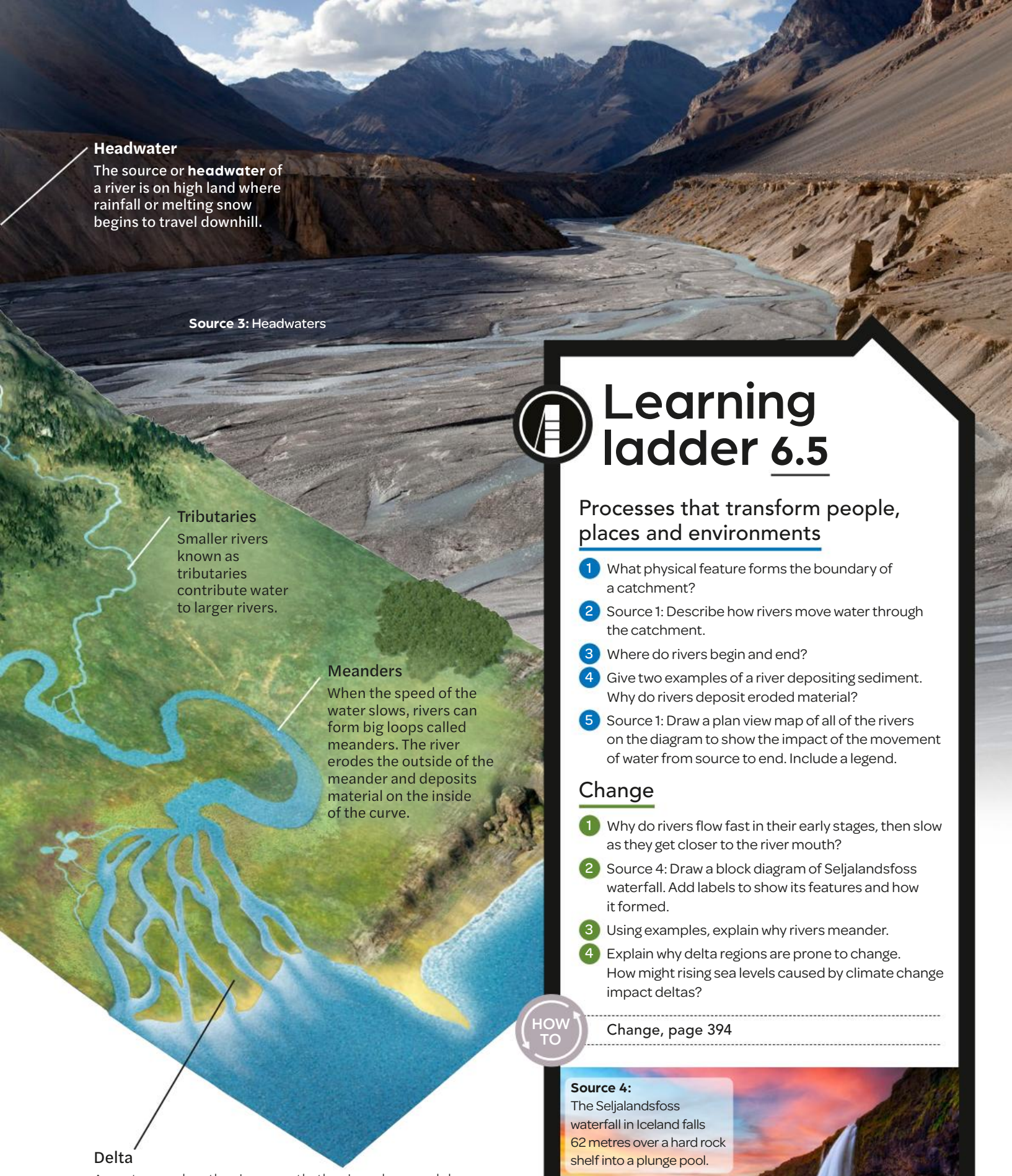
▲ **Source 1:** The movement of water through the catchment from mountain to sea

Waterfall

A waterfall occurs where a river flows over a steep drop into a plunge pool below. The river erodes the soft rock, leaving only hard rock, like granite, to form cliffs and ledges for the water to spill over.



▲ **Source 2:** Cross-section of a waterfall



Source 3: Headwaters

Learning ladder 6.5

Processes that transform people, places and environments

1. What physical feature forms the boundary of a catchment?
2. Source 1: Describe how rivers move water through the catchment.
3. Where do rivers begin and end?
4. Give two examples of a river depositing sediment. Why do rivers deposit eroded material?
5. Source 1: Draw a plan view map of all of the rivers on the diagram to show the impact of the movement of water from source to end. Include a legend.

Change

1. Why do rivers flow fast in their early stages, then slow as they get closer to the river mouth?
2. Source 4: Draw a block diagram of Seljalandsfoss waterfall. Add labels to show its features and how it formed.
3. Using examples, explain why rivers meander.
4. Explain why delta regions are prone to change. How might rising sea levels caused by climate change impact deltas?

HOW TO Change, page 394

Source 4: The Seljalandsfoss waterfall in Iceland falls 62 metres over a hard rock shelf into a plunge pool.

Case study

Why is the Ganges an important river?

People value water resources for many reasons. Water is important for the health of environments, essential for human wellbeing, critical for food production and industry, and for many people, water is central to religion, culture and their stories. India's Ganges River has important environmental, agricultural, industrial, domestic and cultural value.

Values of the Ganges River

The Ganges River begins high in the Himalayan Mountains. It runs through northern India to the Bay of Bengal. The Ganges River carries sediment full of nutrients, which it deposits along its banks to support life in the natural environment and provide fertile soil for agriculture.

The Ganges River and its surrounding catchment support a population of more than 400 million people – 16 times the entire population of Australia. The Ganges River is a vital resource to India. It provides fresh water for domestic and industrial use, irrigation for agriculture, and bathing for millions who worship the river as goddess Mother Ganga.

India's Ganges River faces many threats:

- Human and industrial pollutants fill the river in populated areas, making the Ganges River one of the most polluted rivers in the world.
- Competition for water increases as the population of the Ganges catchment grows, particularly through demands for agriculture.
- Climate change has already led to a decrease in glaciers, an important source of water for the Ganges.

Source 1: The Ganges River catchment is bounded by the world's highest mountain range, the Himalayas, to the north.

Ganges River catchment

Source: Matilda Education Australia

Source 2: During the Kartik Purnima festival in Patna, India, tens of thousands of Hindus come together on the banks of the Ganges River to bathe and offer prayers.

The holy Ganges River

The Ganges River in India is perhaps the holiest river in any religion. The Ganges is worshipped by Hindus, who believe they are purified by bathing and praying in the river. The Ganges is worshipped as a goddess in the Hindu religion, and is referred to as Mother Ganga. Hindus believe that the waters of the Ganges are sacred and can wash away the sins of previous lives.

It is believed that people who die near the Ganges reach heaven, escaping the cycle of rebirth. As a result, cremating a dead body on the banks of the Ganges – or spreading the ashes of the deceased in the water – is believed to lead to heaven. The city of Varanasi on the banks of the Ganges is India's spiritual capital. Every year, 32 000 corpses are cremated in Varanasi, and up to 200 tonnes of half-burnt flesh ends up in the Ganges, along with the unburned bodies of those Hindus who cannot afford firewood for their cremation.

The waters of the Ganges River that Hindus believe are so purifying are also dangerous to their health. It is estimated that two-thirds of the people who regularly use the Ganges for bathing, or for washing clothes or dishes, will suffer a serious illness. In 2023, 120 000 Indian children died from the effects of diarrhoea, a waterborne disease (see page 236). This death toll was higher than for any other country in the world.

Learning ladder 6.6

Characteristics of places and environments

1. List the different values of the Ganges River.
2. What does the sediment carried by the Ganges River support?
3. Source 1: Draw a sketch map that shows the path of the Ganges River from the Himalayan Mountains to the Bay of Bengal.
4. What impact have humans had on the Ganges River?
5. Evaluate the conflicts between different uses of the Ganges River, impacting on water availability and quality.

Interconnection

1. Why do so many people choose to live in the Ganges River catchment?
2. Source 2: Describe the interconnection between the followers of the Hindu religion and the Ganges River.
3. Explain the interconnection between human and industrial pollutants and deaths from diarrhoea in India.
4. As a class, discuss:
   - **a** the impact that the spiritual connection with the Ganges River has on the health of the people who bathe in it
   - **b** how the Indian government can help to clean up the Ganges River, yet still respect people's spiritual beliefs.

HOW TO

Interconnection, page 392

6.7

How and where does rain fall?

Rain falls when warm moist air cools and condenses into water droplets. Warm air can hold more water than cool air, so when warmer air rises and cools, it eventually reaches a point where it cannot hold any more water. This is called the dew point.

When warm air cools below its **dew point**, the water vapour it is holding condenses into a liquid and it rains. There are three different ways of forcing air to rise and cool, and condense into rain:

- **frontal rainfall:** when cold air meets warm air
- **orographic rainfall:** when warm air is lifted over a mountain
- **convectional rainfall:** when land heats the air above it.

Frontal rainfall

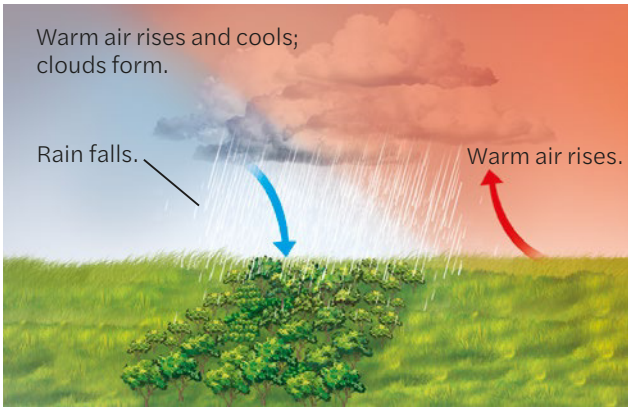
Frontal rain occurs when a warm air mass meets a cold air mass. The lighter warm air is less dense and is pushed up over the heavier cold air. This creates a 'front'. As the warm air mass rises, it cools. Then the water vapour in the air mass condenses into water and falls as raindrops along the front.

Orographic rainfall

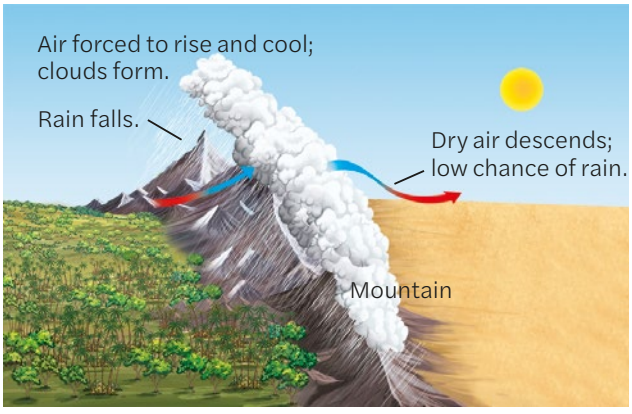
Orographic rainfall is when moist air meets high land and is forced to rise. As it rises, the air cools and condenses into raindrops on the side of the mountain the wind is blowing from (the windward side). As the air descends from the high land on the other side of the range (the leeward side), it warms and creates dry regions. The deserts of central Australia are located on the leeward side of the Great Dividing Range.

Convectional rainfall

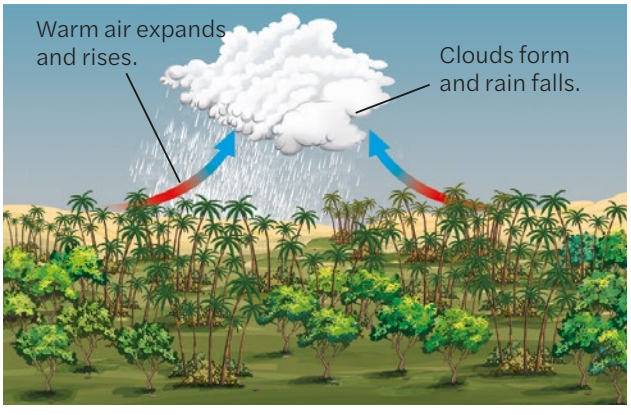
Convectional rainfall is common in **tropical** areas where the ground is heated by the hot sun. The sun heats the land and, as the moisture from the ground evaporates, the heat from the ground heats the air above it. The warm air rises rapidly, then condenses to form clouds as it starts to cool. Convection can produce towering **cumulonimbus clouds**, which produce heavy rainfall, thunderstorms and lightning.



▲ **Source 1:** Frontal rainfall

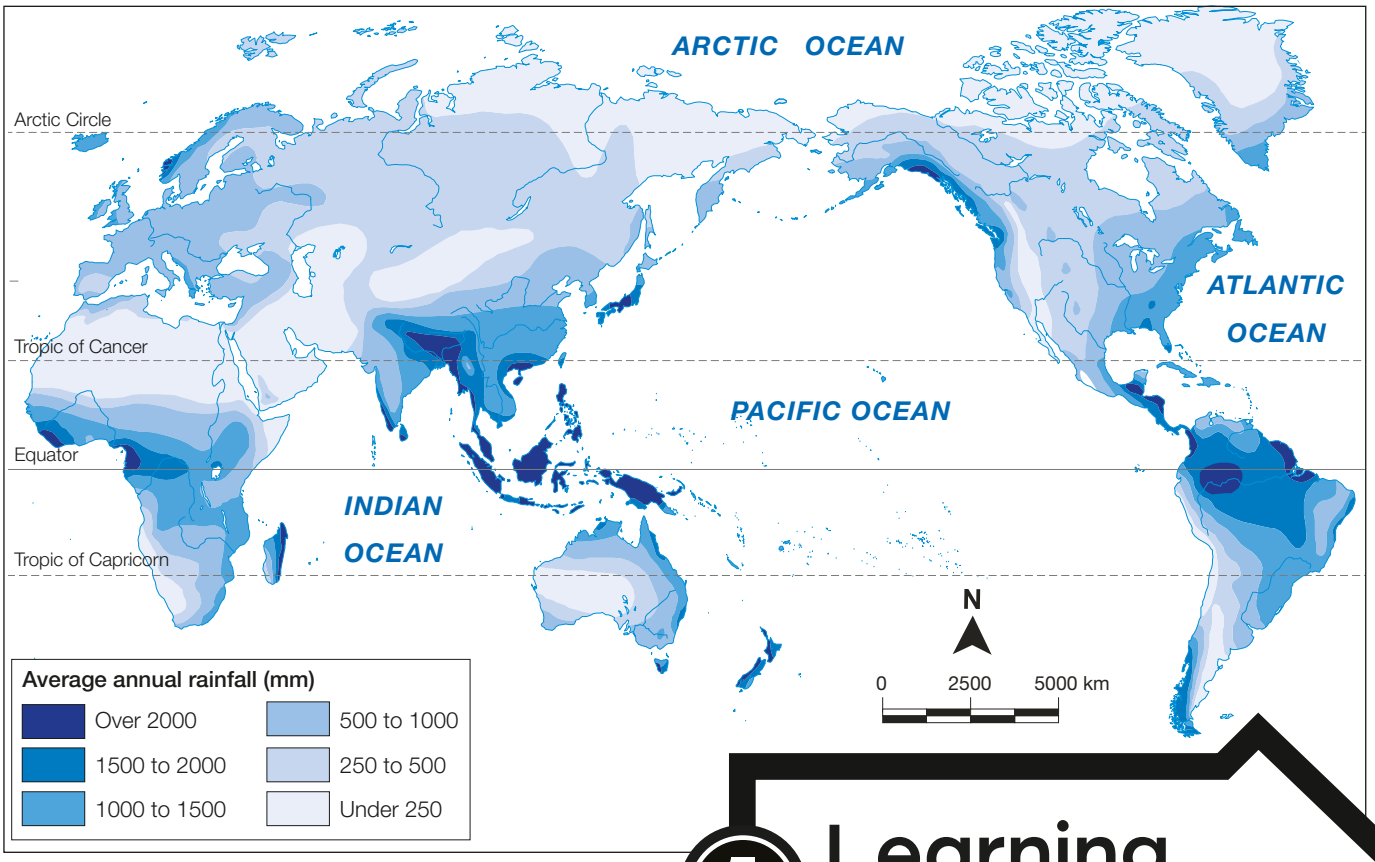


▲ **Source 2:** Orographic rainfall



▲ **Source 3:** Convectional rainfall

World average annual rainfall



Source: Matilda Education Australia

▲ **Source 4:** World average annual rainfall

▲ **Source 5:** A supercell thunderstorm in Kansas. Supercell thunderstorms are the biggest and most severe type of thunderstorm. They form when warm, humid air is trapped under a layer of cold air. The rising warm air and sinking cold air create powerful spiralling convection currents that produce hail, downpours and sometimes tornadoes.

Learning ladder 6.7

Processes that transform people, places and environments

1. When does rainfall occur?
2. Describe the key similarities and differences between frontal and orographic rainfall.
3. Source 5: Create a labelled diagram to explain how a supercell thunderstorm occurs.
4. Source 2: What impact do mountain ranges have over the amount of rain falling on the windward and leeward sides of the range?

Space

1. Source 2: Are drier regions found on the windward or leeward side of a mountain range?
2. Source 4: Use the PQE method to describe the pattern of world rainfall.
3. Sources 2 and 4: Explain why Australia's deserts are located where they are.
4. Visit https://mea.digital/n0f. What symbol is used to show a cold front on a weather map? What do the triangles indicate?
5. Source 4: There is a large mountain range to the north of India. How does this help to explain India's patterns of annual rainfall?

HOW TO

PQE, page 412; Space, page 388

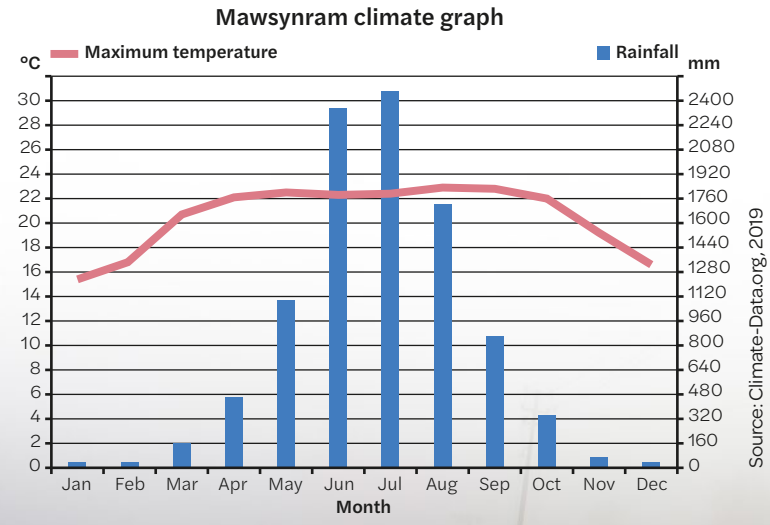
Case study

Why is Mawsynram the world's wettest place?

Mawsynram in India has an average annual rainfall of 11 871 millimetres, and is the wettest inhabited place in the world. Cherrapunji, just 15 kilometres from Mawsynram, is the second-wettest place in the world. Mawsynram and Cherrapunji are both located in north-eastern India, about 1400 metres above **sea level**.

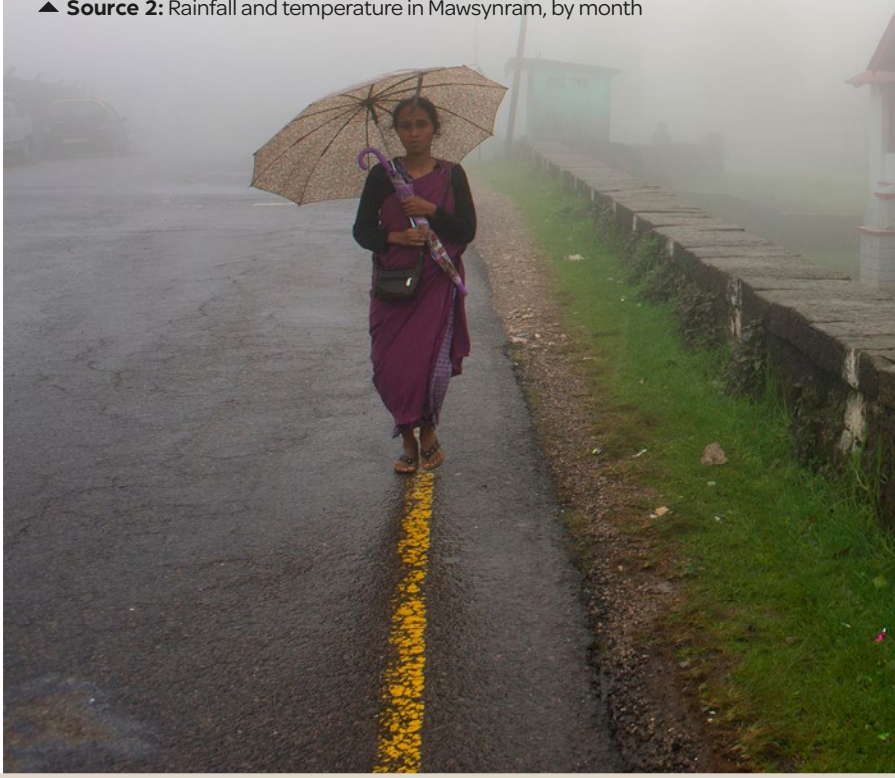
During the rainy season, or monsoon, much of India receives heavy rainfall. The monsoon months from June to September produce the heaviest rainfall in the north-eastern part of India, on the foothills of the Himalayan Mountains. Winds coming from the Indian Ocean absorb moist air and are forced to rise as they meet the mountains. The air cools and condenses into raindrops, in a process known as orographic rainfall (see page 204). On the other side of the Himalayas it is dry and warm.

With little forest cover, poor soil and just a few reservoirs, little water stays in Mawsynram. When the monsoon ends, residents get limited water supply for just two hours in the morning and two hours in the evening.

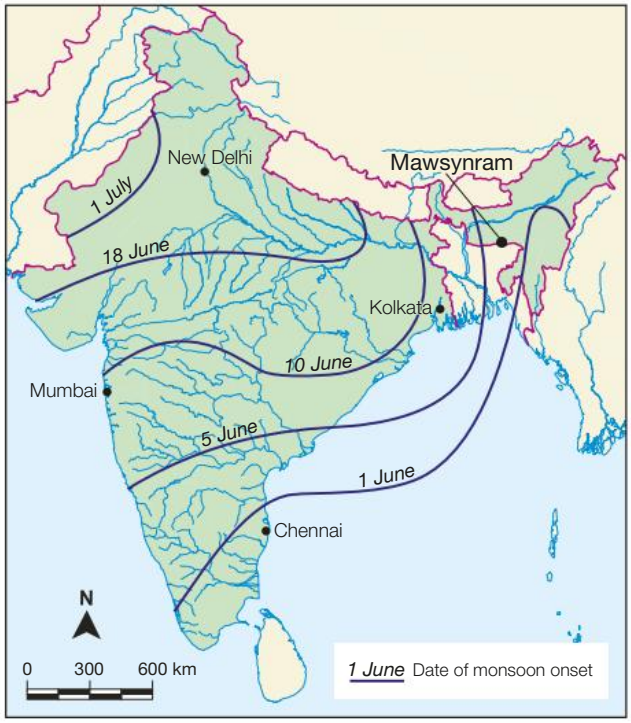


Source 2: Rainfall and temperature in Mawsynram, by month

Source 1: The monsoon season in Mawsynram produces heavy rain over an extended period. People plan for its arrival by stocking up on food. Women make body umbrellas, called *knups*, from bamboo, grass and plastic.



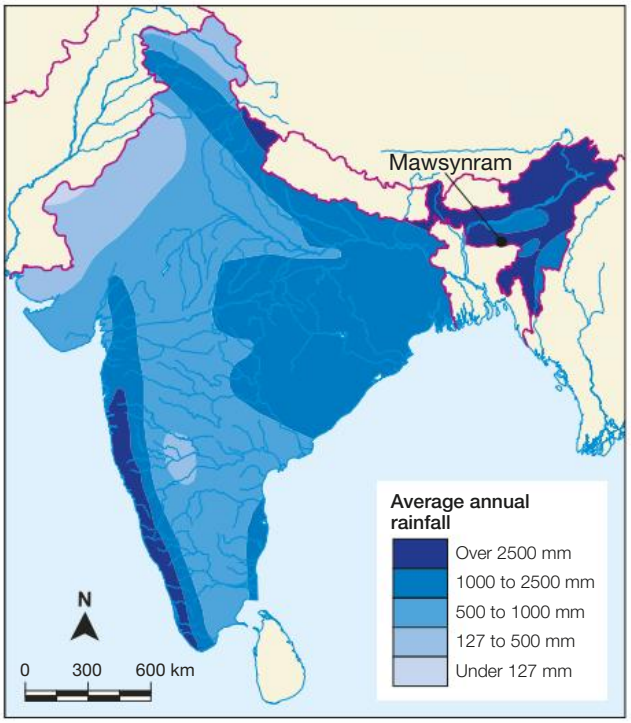
India monsoon onset



Source: Matilda Education Australia

▲ **Source 3:** The onset of monsoons in India

India average annual rainfall



Source: Matilda Education Australia

▲ **Source 4:** India's average annual rainfall

Source 5: Maysynram in India is the world's wettest place. During the monsoon season, the rain is so heavy that you can barely see a metre in front of you. Heavy rain can continue for up to a week at a time and clouds float into the homes of the people. Everything is damp inside the homes and clothes need to be dried up to three times per day. Classes are cancelled on days when the deafening sound of rain on the tin school roof makes it impossible for the teachers to be heard.

Learning ladder 6.8

Characteristics of places and environments

1. Define the term 'monsoon'.
2. Sources 1 and 5: List the impact of the monsoon on the residents of Mawsynram.
3. Describe how orographic rainfall delivers so much rain to Mawsynram.
4. Why do residents of Mawsynram have only a limited water supply following the end of the monsoon in October? How could this be improved?

Space

1. Source 4: According to the map, how much rainfall does Mawsynram receive each year?
2. Source 4: Look at the map of India's average rainfall. Use compass points to describe the driest and wettest regions in India.
3. Compare Sources 2 and 3:
   - **a** What is the connection between the highest rainfall months and the monsoon?
   - **b** Why do you think the north-westerly winter winds don't bring much rain to Mawsynram?

HOW TO Space, page 388

6.9

How is water stored?

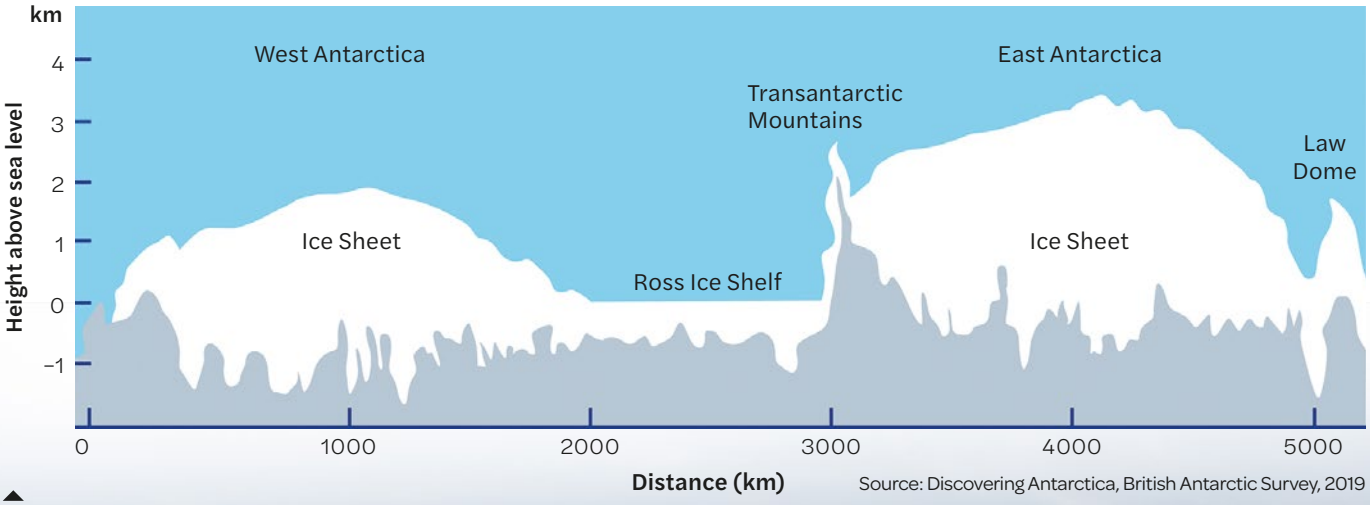
Fresh water is an essential renewable resource that we need to survive. Only a tiny percentage of all water on Earth is fresh water – just 2.5 per cent. Most of the fresh water is frozen and locked up in glaciers and ice sheets, or stored beneath the surface as groundwater.

Frozen water

Nearly 70 per cent of all fresh water on Earth is stored in **ice sheets**, **ice shelves**, glaciers and **icebergs**. In Antarctica, a huge ice sheet with an average thickness of 2.5 kilometres covers the solid rock below.

The freezing Antarctic temperatures prevent most of the snow from melting, and the ice sheet it has formed is up to 4.7 kilometres deep at its deepest level. If the Antarctic ice sheet were to melt completely, the world's sea levels would rise by up to 60 metres.

A cross-section through the Antarctic



Source: Discovering Antarctica, British Antarctic Survey, 2019

Source 1: A cross-section through the Antarctic continent

Source 2: Most of the world's fresh water is stored as ice. Huge ice sheets move and break off into icebergs when they reach the sea in a process known as calving. These Adelie penguins are on an iceberg that calved from Antarctica's Cape Adare peninsula.

Groundwater

Groundwater is water that is located under the Earth's surface. It is fed by surface water from rainfall and rivers. Groundwater can appear on the surface at low points as a **spring** or in dry areas as an **oasis**.

Groundwater fills spaces between grains of soil or rock. In an area way below the soil, called the **saturated zone**, all the spaces between soil and rock particles are filled with water. The top of this zone is called the **water table**.

Australia is the driest inhabited continent on Earth, and surface water resources are limited. Groundwater is a very important renewable resource, and it provides a third of Australia's total consumable water. About 90 per cent of the Northern Territory's water is sourced from groundwater.

Farmers sink bores to pump water to the surface from underground rocks, called **aquifers**, that hold water. Windmills use wind energy to pump water to the surface.

Building dams

Humans create their own water storages, called dams or **reservoirs**, which collect and retain water. Large dams on rivers provide a reliable water supply for **irrigation**, hydroelectricity or for urban use.

To build a dam, the flow of a river is stopped by the dam wall (see page 194). Water builds up behind the wall and floods the valley. The release of water in front of the dam wall is then regulated to make sure there is enough river water for people and for the river ecosystem.

Learning ladder 6.9

Sustainable management strategies

1. Source 2: Why can't we use 70 per cent of the fresh water on Earth?
2. Why are groundwater sources important in Australia?
3. How do humans make their own water storages? What environmental issues are involved in the process?
4. Groundwater resources are heavily used throughout the world. Research why this can be a problem if not carefully managed.

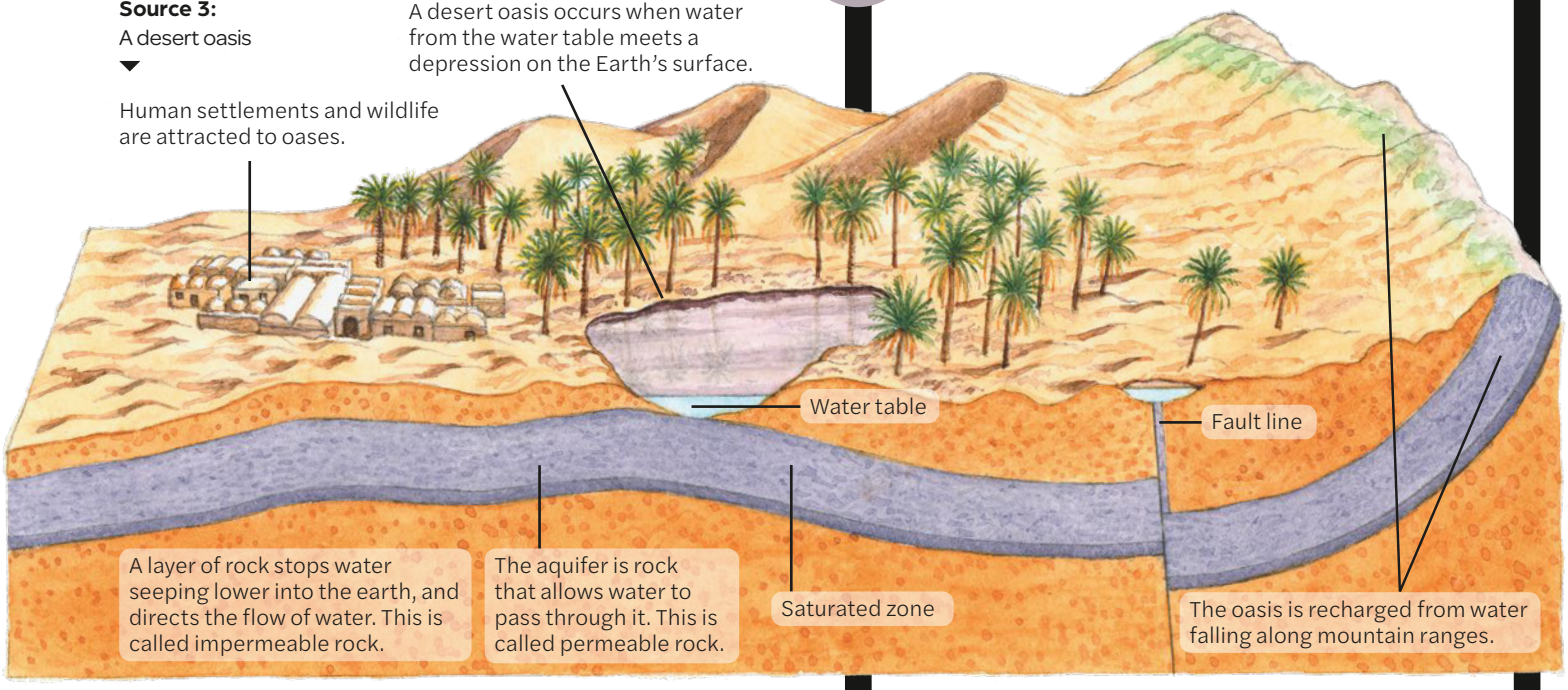
Environment

1. Source 2: Why do polar environments have most of the world's fresh water?
2. Source 1: How deep is the Antarctic ice sheet at its greatest depth?
3. Source 3: How is an aquifer like a river?
4. Analyse the impact of building a dam on the environment and local community.
5. Create an experiment to show what happens when a dam wall blocks river flow. What happens to the environments on the land behind the wall? What alternative could give humans a reliable water supply?

HOW TO

Environment, page 396

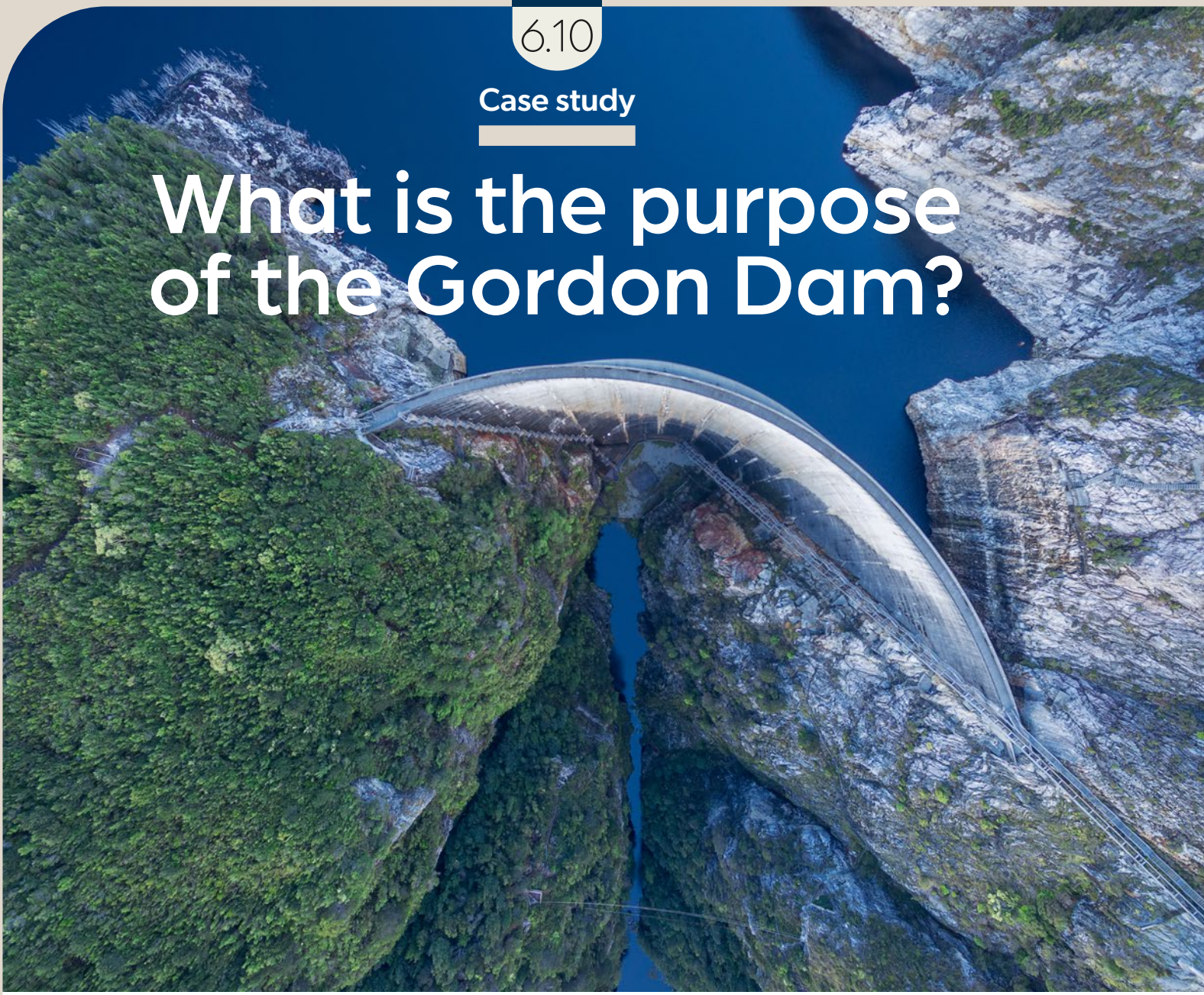
Source 3:
A desert oasis



6.10

Case study

What is the purpose of the Gordon Dam?



Lake Gordon in south-west Tasmania contains up to 12 359 040 megalitres of water (a megalitre is 1 million litres), making it Australia's largest reservoir. The combination of Lake Gordon and Lake Pedder is by far Australia's largest water storage.

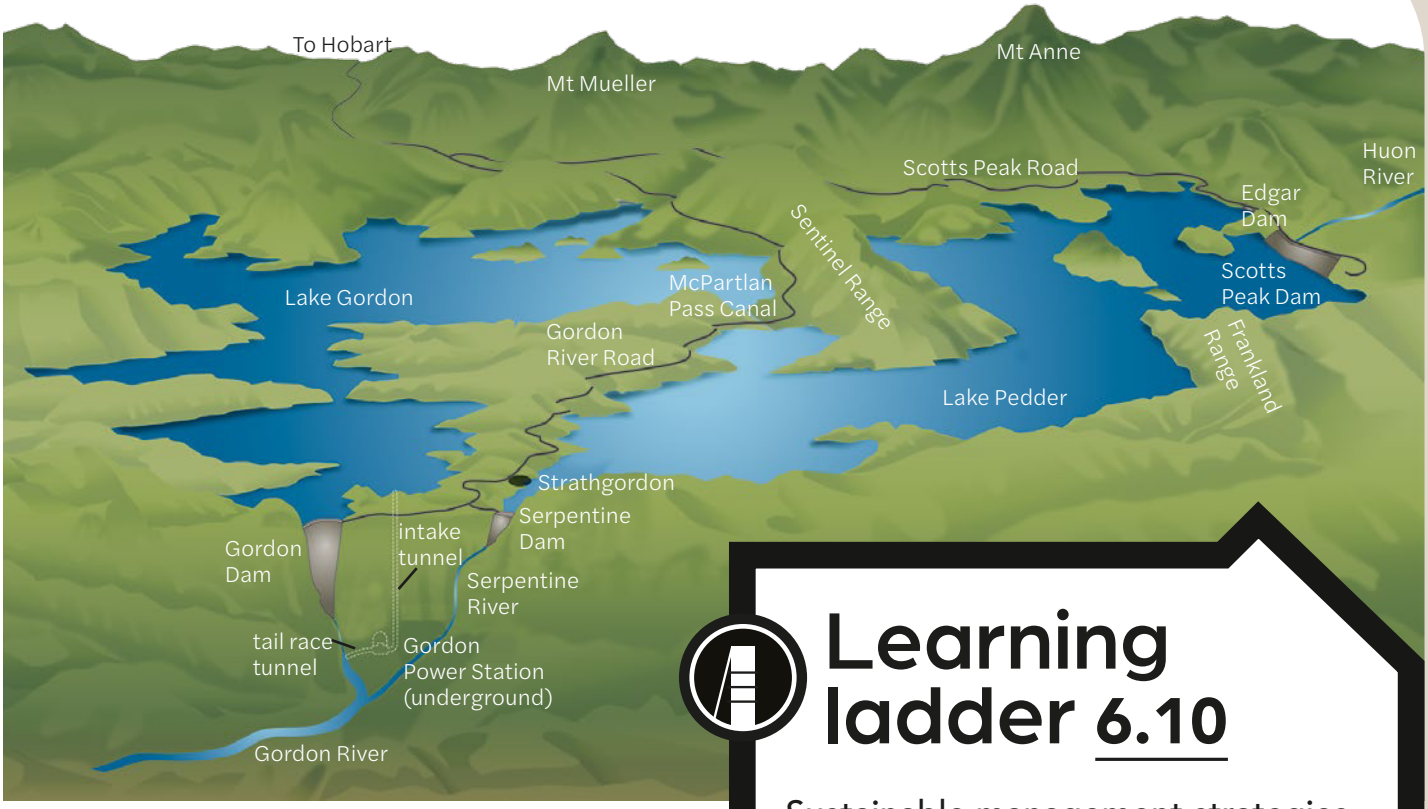
How was Australia's largest water storage formed?

Lake Pedder used to be much smaller. It was flooded in 1972 to make a larger lake as part of the Gordon **hydroelectric** power scheme. The water in Lake Pedder flows to Lake Gordon via the McPartlan Pass Canal, providing 40 per cent of the water used in the Gordon Power Station.

Source 1: A plan aerial view of Gordon Dam

The Gordon Power Station is located on the Gordon River. The power station and the dam were constructed and are now operated and maintained by Hydro Tasmania. Water from the combined water reservoir falls 173 metres through a vertical shaft into the power station. The force of the moving water turns **turbines** and a shaft connected to a rotor and a stator where electrons are stimulated, resulting in the generation of electricity. The Gordon Power Station provides 13 per cent of Tasmania's electricity, or 450 megawatts, from three turbines.

Source: Hydro Tasmania – Gordon Power Scheme



Source 2: The Gordon River hydroelectric power scheme

Source 3: An oblique aerial view of the Gordon Dam

Learning ladder 6.10

Sustainable management strategies

1. Source 2: What is the purpose of the Gordon Dam?
2. Source 2: Describe how three dams have been used to create Lake Peddar and Lake Gordon.
3. Why is hydroelectricity a sustainable method of power generation for Tasmania?
4. There were many protests against the creation of Lake Pedder as an artifical lake. Research why it became an important environmental issue.

Place

1. Sources 1 and 3: Look carefully at the photos.
   - **a** One photo is taken directly above and one is taken from an angle. What names do geographers use for these two views?
   - **b** Which view is more like a map? Why?
   - **c** What extra information does an oblique view give you?
2. Source 3: Describe the physical and human characteristics of Gordon Dam.
3. Look at the diagram in Source 2.
   - **a** Identify the dams that have been built and the rivers that have been dammed to create the water storage.
   - **b** Where has the power station been built? Why does it need to be in this location?
4. Redraw Source 2 as it might have looked before the rivers were dammed. Using SHEEPT, explain how the area has changed.

HOW TO

SHEEPT, page 414; Place, page 390

6.11

Where is water in Australia?

Australia is the driest inhabited continent on Earth – the only continent with less rain is Antarctica. Most of Australia's rain falls in thin strips along the coast, with desert occupying much of the centre of the continent. Only 12 per cent of the rain that falls is collected in rivers, so 30 per cent of Australians use groundwater for water supply.

Rainfall in Australia

Australia is the driest populated continent on Earth. Two-thirds of the continent is classified as **desert** or **semi-desert**. This classification depends on the amount of rainfall.

- Desert: less than 250 millimetres rainfall per year
- Semi-desert: 250–500 millimetres rainfall per year

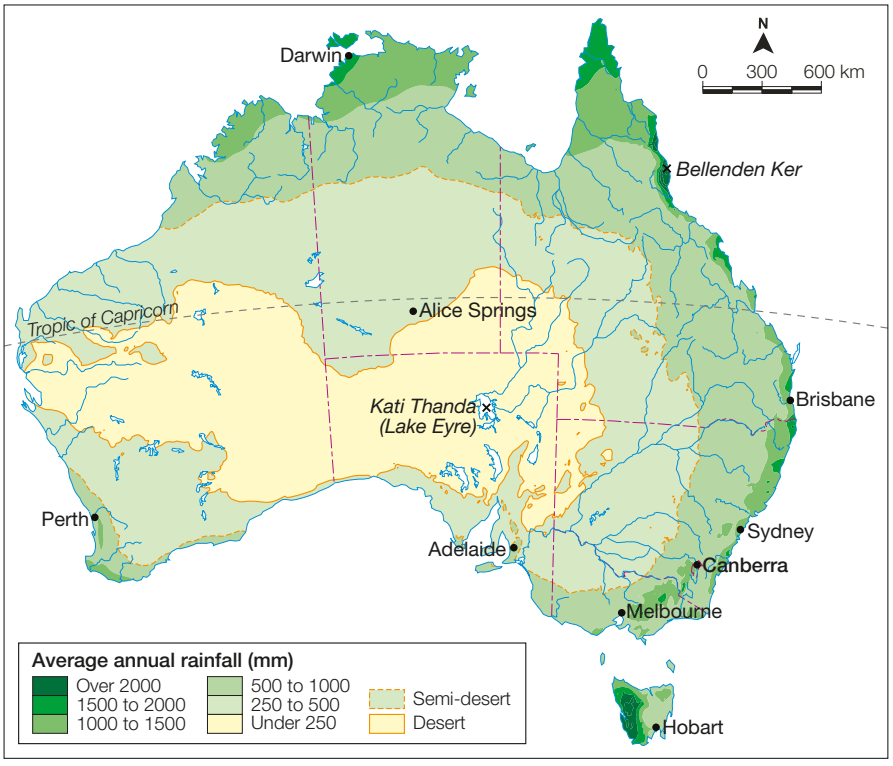
Most of Australia's rain falls on its northern, eastern and south-western coasts. Australia's north coast receives most of its tropical rainfall in summer with the arrival of the monsoon.

The Great Dividing Range runs the entire length of Australia's east coast and forces winds to drop their moisture as rain along the coastal strip. Then, having released moisture to the east of the range, the winds sink as dry air to the desert and semi-desert regions to the west of the Great Dividing Range. This process is known as orographic rainfall (see page 204).

The wettest place in Australia is Bellenden Ker in north Queensland. Bellenden Ker averages 8312 millimetres of rainfall per year. It receives so much rain because of its tropical location on the eastern slopes of the Great Dividing Range.

The driest place in Australia is Kati Thanda (Lake Eyre) in South Australia. It averages only 125 millimetres of rainfall per year. Air masses have usually dropped their rain on the south-west corner of Western Australia, and are dry by the time they reach so far inland.

Australia average annual rainfall



▲ **Source 1:** Australian average rainfall per year

Source: Matilda Education Australia

Australian rivers

Because Australia is such a dry continent, it doesn't have many large rivers or large permanent lakes. In fact, Australia has the lowest volume of water in rivers of any inhabited continent in the world. Just 12 per cent of Australia's rainfall is collected in rivers.

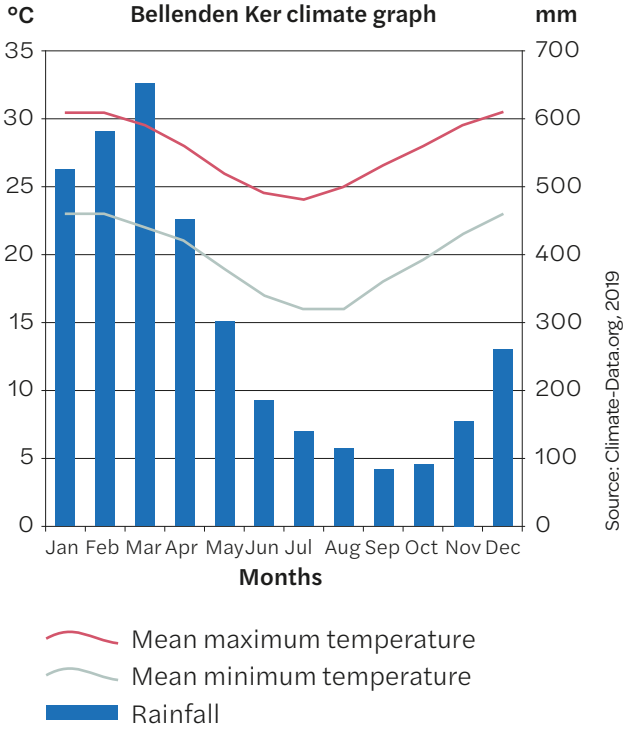
Australia's inland rivers are different from all other rivers in the world. The volume of water in most rivers increases the further the river courses, but Australia's inland rivers tend to lose water. The Darling River, which is Australia's longest river, loses enough water through evaporation each year to fill Sydney Harbour four times!

Many Australian rivers flow mainly – or only – when floods come down from far upstream. Heavy tropical rain falling in north Queensland is sometimes channelled through rivers to South Australia, where it floods the Kati Thanda **salt pan**.

Australian groundwater

One-third of Australia's residents rely on groundwater as their main source of water. Groundwater is water that is located in aquifers beneath the Earth's surface. The aquifers are fed by surface water from rainfall and rivers. Communities access underground aquifers by drilling a well or bore and pumping water to the surface.

The Great Artesian Basin in eastern Australia is the world's largest aquifer as it covers more than 1.7 million square kilometres – or 22 per cent of Australia's land mass. Water in an aquifer is trapped underground in a layer of sandstone covered by **sedimentary rock**, and can be more than one million years old.



Source 2: Climate graphs of the wettest and driest places in Australia

Learning ladder 6.11

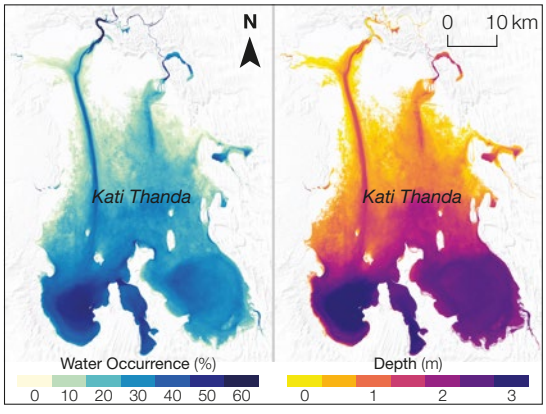
Characteristics of places and environments

1. Which is the driest inhabited continent on Earth?
2. How do Australian rivers differ from most other rivers in the world?
3. Look carefully at Source 2:
   - **a** How much rainfall does Bellenden Ker receive in February?
   - **b** How much rainfall does Kati Thanda receive for the entire year?
4. Why are aquifers important to Australians?

Space

1. How much of Australia is desert or semi-desert?
2. Source 1: Use PQE to describe the distribution of rainfall in Australia.
3. Which section of Kati Thanda usually has water? Where does the water come from?

Kati Thanda



Source: NASA Earth Observatory images by Joshua Stevens, using data from Armon et al, 2020

HOW TO

PQE page 412; Climate graphs, page 421; Space, page 388

Case study

How do we use the Murray River?

At 2508 kilometres, the Murray River is Australia's longest single river. It is a key source of fresh water and connects places on its banks that rely on water for farming, industry and town water.

Changes to the Murray River

The Murray River has been greatly modified through the installation of **locks**, **weirs** and dams to allow navigation and to make more water available for agriculture through irrigation. In the 20th century, a large number of dams, locks and weirs were constructed along the river to control its flow. This made the Murray River valley Australia's most productive agricultural region – but it also seriously damaged ecosystems along the river by changing natural river flows and interrupting the movement of fish and other organisms.

Upstream gates open as a vessel enters the lock chamber.

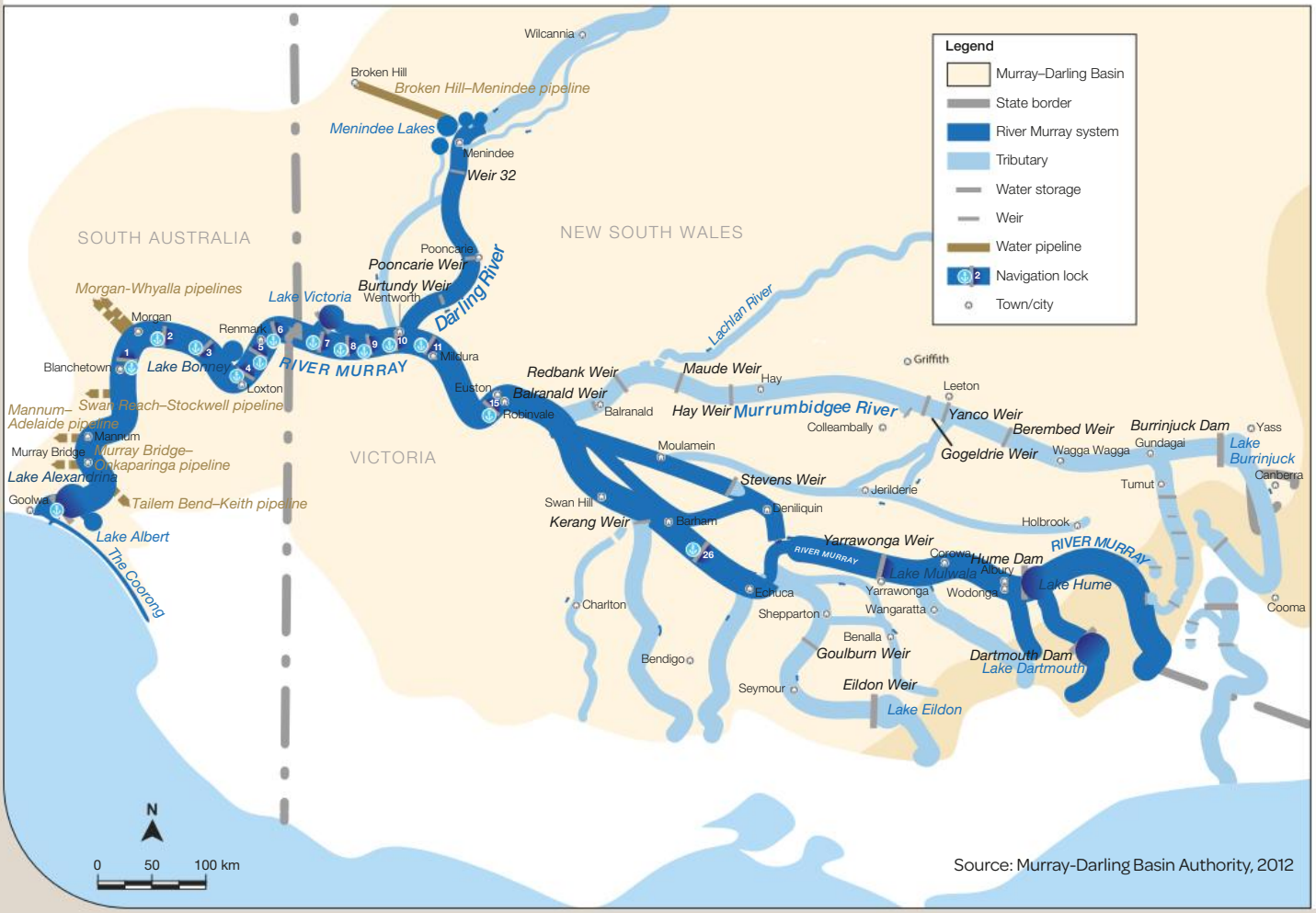
Upstream gates close. Water is released downstream through butterfly valves. Water in lock chamber lowers.

When water levels are equal downstream, gates open.

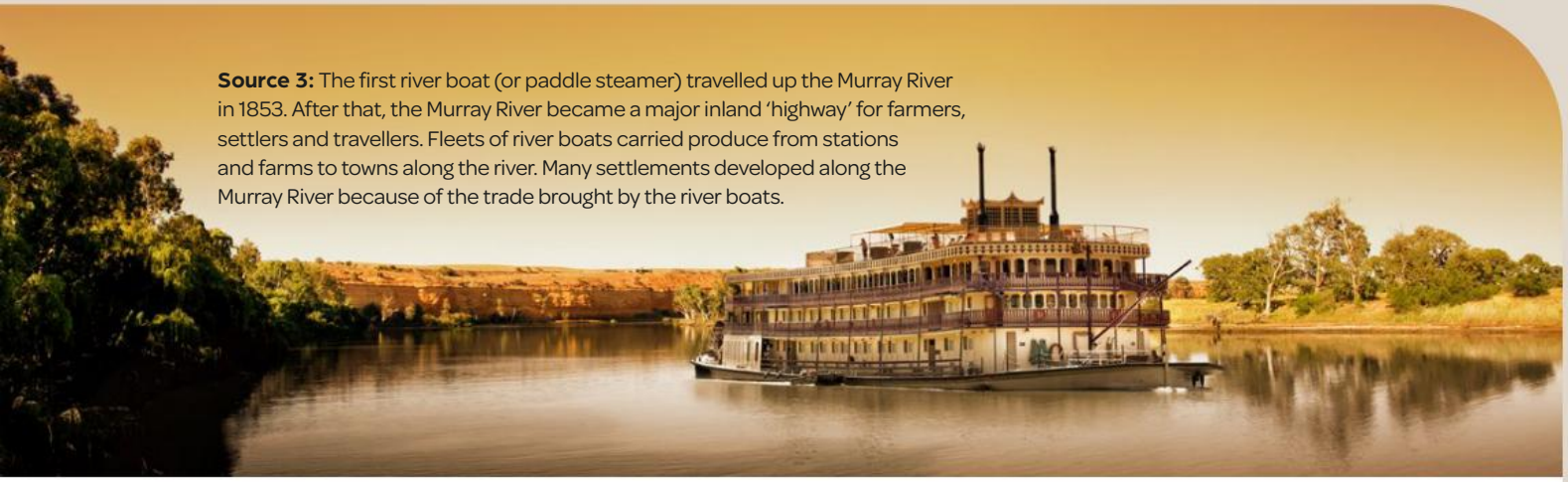
▲ **Source 2:** How a lock works

Murray River locks, weirs and dams

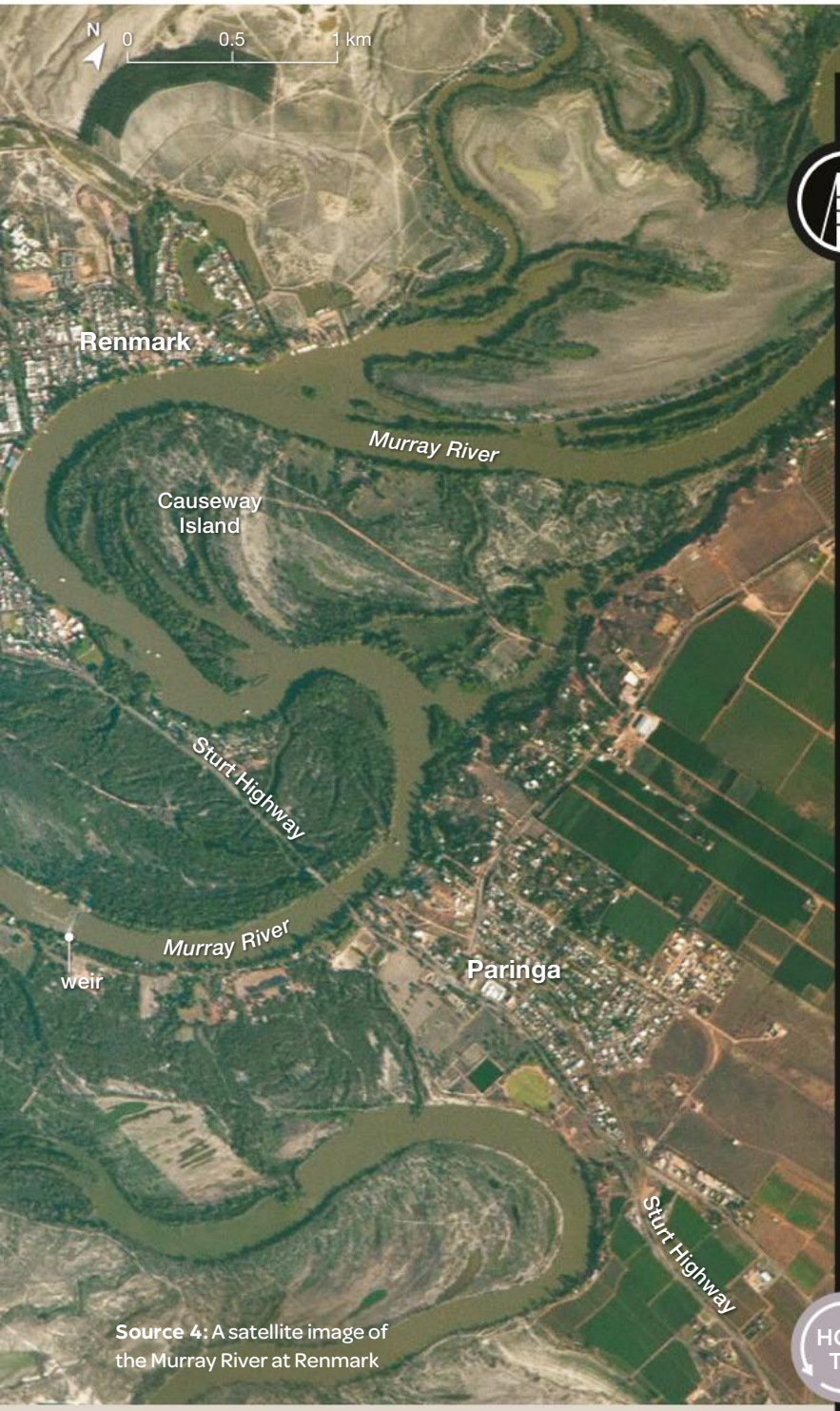
▼ **Source 1:** Murray River locks, weirs, dams and barrages



Source: Murray-Darling Basin Authority, 2012



Source 3: The first river boat (or paddle steamer) travelled up the Murray River in 1853. After that, the Murray River became a major inland 'highway' for farmers, settlers and travellers. Fleets of river boats carried produce from stations and farms to towns along the river. Many settlements developed along the Murray River because of the trade brought by the river boats.



Source 4: A satellite image of the Murray River at Renmark

Learning ladder 6.12

Processes that transform people, places and environments

1. Source 3: How did the Murray River become a highway?
2. Source 1: Where does the Murray River flow?
3. Why did people build weirs and dams along the Murray River?
4. What are the positive and negative impacts of controlling water in the Murray River with dams, locks and weirs?

Interconnection

1. Source 4: Draw a map of the area shown in this satellite image using BOLTSS. Then create a key to show activities that are interconnected with the Murray River – irrigated farmland and towns.
2. On the map you prepared in step 1, label the following:
   - the large town of Renmark on the north bank of the river
   - Paringa on the south bank
   - the weir that crosses the Murray River to the south-west of Renmark.
3. Source 4: Places and their people are interconnected with other places. How does the satellite image show that rivers connect communities?
4. Source 2: How do locks help improve interconnection along the Murray River?
5. Source 2: How do locks hinder interconnection along the Murray River?

HOW TO

Interconnection, page 392

How do First Nations Peoples value water?

Water is central to the ongoing connection to Country and the ability of First Nations Peoples to thrive in some of the most arid conditions in the world. For many First Nations people, water is understood to be life itself.

Saltwater and freshwater people

Many First Nations Peoples will identify as being a part of the landscape from Country. This includes people who are freshwater, saltwater and desert people among many other descriptions. The geographical descriptions also often indicate how water is experienced and valued in the different places, landscapes and Countries.

In addition to the identification with Country, many First Nations cultures also have stories that relate to the proper ways of caring for the waterways, as well as many stories that describe how the waterways were formed and where the ancestors and spirits rest and reside in the Dreaming. In many ways, the valuing of water is very similar to the valuing of Country. For many First Nations people, unlike many non-Indigenous people, water is not a product to be bought, sold or exploited. Water is a vital resource to be cared for as part of caring for Country to support all the organisms that rely on it for their survival.

Using the water

Water is used to drink, hunt, fish and harvest vegetables and fruits that are cultivated in the landscape around water in abundance. Water is also valued as sacred places where medicines grow as well as where health care can be provided. Places around water have also been valued as important for giving birth. Some of these places are considered sacred women's places and there are also many sacred men's places in close proximity to water.

Source 1: Slowly, the federal and state governments have begun to recognise the important knowledge that First Nations people have that relate to caring for Country and the waterways. One example of this is the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC). These rangers are at Amity Point on North Stradbroke Island, Queensland.

Source 2: This aerial view shows the Brewarrina fish traps on the Barwon River in the far north-west of New South Wales. Nearly half a kilometre in length, the fish traps were a clever invention used by First Nations Peoples to fish sustainably for thousands of years without disrupting the natural flow of the river or the seasonal spawning paths of the fish.

Caring for the water

Like caring for Country, the water and waterways have been looked after for all time. This allowed First Nations peoples to thrive through ice ages and ancient climate changes, as well as several severe droughts that sometimes lasted many decades. In more recent times, the ability of First Nations people to care for water has been severely disrupted due to colonisation. This has meant that there has been limited opportunity to care for water as part of the incredibly complex and interconnected aspects of Country, air, earth, fire, and the plants and animals.

In recent times, this has caused much concern in many First Nations communities, especially those located near important river systems. With the recent fish kill events that have damaged the riverine systems, many First Nations people are worried that the rivers are sick. This has been caused by a reduction of water in the river systems for irrigation and agriculture, climate change, and the run-off of damaging chemicals, pesticides and fertilisers into the river systems.

Learning ladder 6.13

First Nations Peoples' interaction with Country

1. Source 2: The traditional custodians of the fish traps are the Ngemba Wayilwan. Are they saltwater or freshwater people?
2. What connects First Nations Peoples to water?
3. Source 1: How is the Queensland Indigenous Women's Ranger Network caring for waterways?
4. Source 2: Explain how First Nations Peoples have used geographical and scientific knowledge to sustainably manage the Barwon River.

Sustainability

1. How do First Nations people view water as a resource?
2. Source 2: Why are the fish traps a sustainable method of obtaining a food supply?
3. Source 1: Why is a First Nations perspective on caring for the environment important?
4. Explain some of the key issues that are negatively impacting our waterways. How has the ability of First Nations Peoples to manage waterways been disrupted?

HOW TO Sustainability, page 400

How much water is used to make goods?

Every day you consume 3496 litres of water without being aware of it. Most of this water is hidden in the food you eat and the products you use. Geographers call this virtual water. It is the responsibility of every consumer and every business to consider virtual water when making economic decisions.

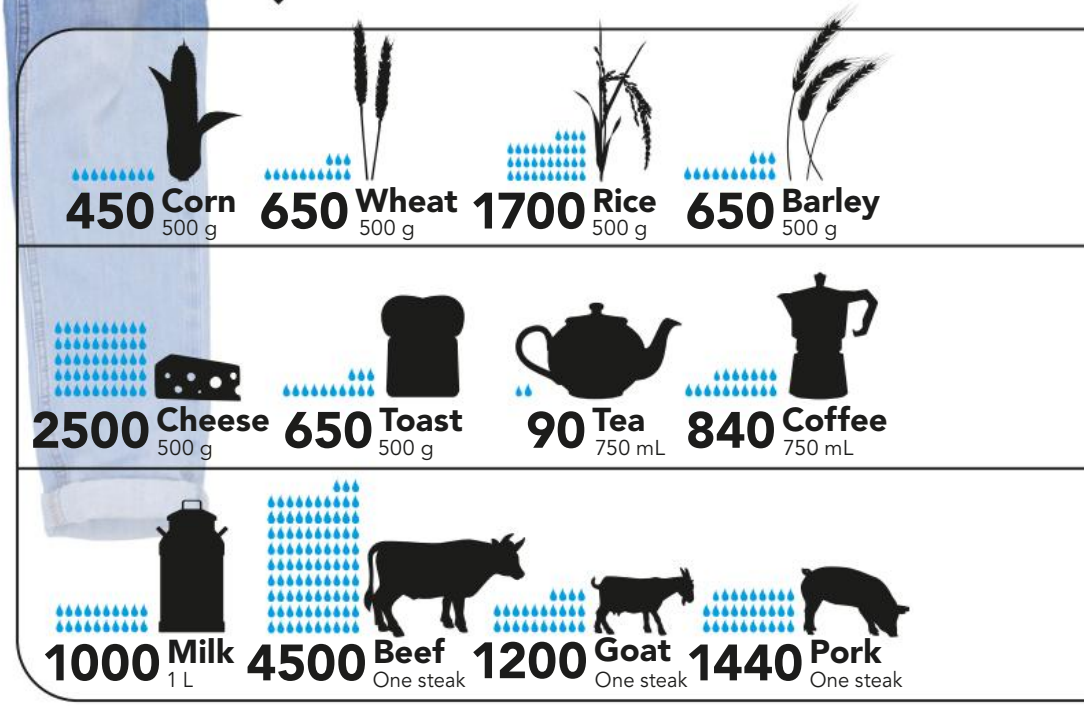
Source 1: Creating jeans is a water-hungry process.

Virtual water

Although it is invisible, millions of litres of water go into making the products we use every day. We don't physically drink this **virtual water**, but it is used in the production of almost every product we use.

The water footprint of a product is the total amount of water used in each step of producing and transporting that product. To make a pair of jeans, cotton needs to be grown, spun and weaved into denim. Water is used during the production process to create steam for power, to cool machinery, and to flush and clean equipment. More water is required to make packaging and to transport the jeans overseas.

Source 2: Water footprint of various foods and drinks (in litres)



3 060 000

The production of the grain, pasture and hay to feed a cow over three years requires more than 3 million litres of water.

During three years of growth the grain-fed cow eats nearly 1300 kilograms of grains, such as wheat, oats, barley and corn.

1300

7200

The cow also eats 7200 kilograms of pasture and hay.

It requires 7000 litres of water per cow to service the farmhouse and the slaughterhouse.

7000

A single cow drinks 24 000 litres of water in three years.

24 000

In total, we need 4500 litres of water to make just one steak.

4500

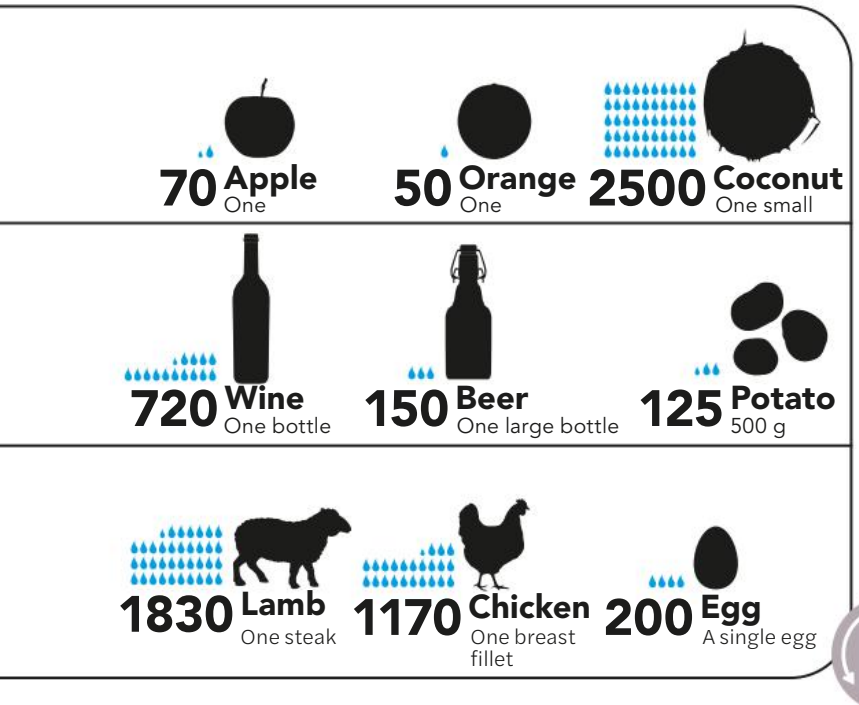
▲ **Source 3:** It takes 4500 litres of water to make one beef steak.

Water for farming

In most parts of the world, more than 70 per cent of fresh water is used for agriculture. By 2050, the world's population will have grown to 9 billion people, and that will require a 50 per cent increase in farm production and a 15 per cent increase in water use.

Of all water used for agricultural production in Australia, 90 per cent is used for irrigation of crops and pastures. Irrigation is the supply of water to farmland that doesn't receive enough rain to raise cattle or grow crops.

Water is required in the production of all foods – one-third of all water used in agriculture is for growing grain to feed livestock. Beef is the most 'water hungry' meat to produce, needing 4500 litres of virtual water to produce just one steak.



Learning ladder 6.14

Sustainable management strategies

1. Source 1: What is the total water footprint of one pair of jeans?
2. Why does it take so much water to produce one beef steak?
3. Source 2: Calculate the amount of water required to produce a meal of bacon and eggs on toast.
4. Source 1: Look at the example of the life cycle of a pair of jeans.
   - **a** Which stage of the jeans-making process uses the most water? Why?
   - **b** Can you suggest an alternative to this stage that would require less water?
5. Calculate your own water footprint using the Water Footprint Network website. In what ways could you reduce your water footprint?

Scale

1. Why is water vital at a local scale?
2. Describe how water is used at each scale to produce everyday items, from local manufacturing to global transportation.
3. Explain how water usage differs at local, national and global scales.
4. How might decisions to increase agricultural production to meet global demand impact water availability at local, national and global scales?

HOW TO

Scale, page 398

Case Study

Why does rice need so much water to grow?

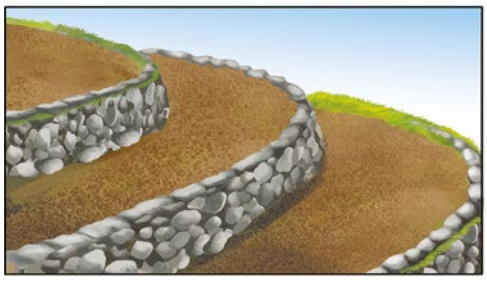
Bali paddies

To grow rice, you need plenty of heat and water. Rice is well suited to warm, wet, tropical places such as Bali in Indonesia. Bali's rainy season from November to March is interconnected with the north-west monsoon. April to October is relatively dry.

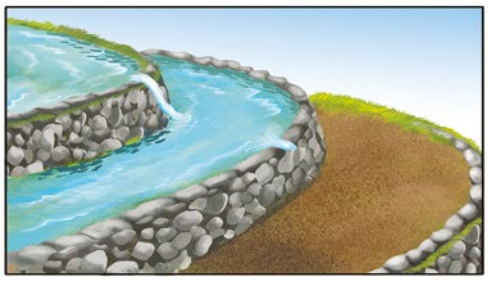
Rice fields are known as **paddy** fields. They are surrounded by low walls so that the paddies can be flooded with water. In hilly areas, flat rice fields are cut into hillsides as a series of steps, or **terraces**. Paddy rice requires 3400 litres of water to produce just 1 kilogram of grain.

In Bali, native oxen known as *banteng* are used to plough the muddy fields before planting in January and February. After ploughing, the paddies are flooded. Rice seedlings are planted in rows by hand, and rainfall or irrigation is used to keep the paddies flooded for about four months. When the rice plants are a metre tall and turning yellow, they are harvested. To do this, the water in the rice paddies is reduced, and workers use sharp knives to cut the stalks off at ground level. The rice plants are then tied in bundles and left to dry in the sun.

Source 1: Constructing a terraced farm to grow rice



A stone retaining wall is built and backfilled with soil. The soil is flattened to provide a smooth terrace surface.



The terrace is flooded. The depth is controlled by an opening where water can be let out.

Other terraces are built and connected by a water supply.

Source 2: A plan aerial view of terraced rice paddies in Bali, Indonesia. These paddies are ready to be ploughed and planted.

Source 3: Rice plants grow in neat rows on flooded terraced fields called paddies. When the plants are fully grown, the water in the rice paddy is reduced to allow for easier harvesting.

Learning ladder 6.15

Processes that transform people, places and environments

1. Where does the water come from to flood the fields and keep them flooded during the growing season?
2. Source 3: Describe the characteristics of rice paddies in Bali.
3. Source 1: Describe how terraced farms are constructed and flooded.
4. Explain the timing of planting and harvesting of rice crops.
5. Use the SHEEPT factors to explain why Bali is an ideal place to grow rice.

Place

1. Locate Bali on a world map. Describe where Bali is in relation to the equator.
2. Source 3: Describe the natural and human features of the environment shown.
3. Source 2: Draw the plan aerial view of terraced rice paddies as a map. Include a key to its features.
4. How does Bali's climate support rice growing?
5. Research online to discover how rice is grown, sewn and harvested in Australia. Why would harvesting in Australia be different from in Bali?

HOW TO

SHEEPT, page 414; Place, page 390

6.16

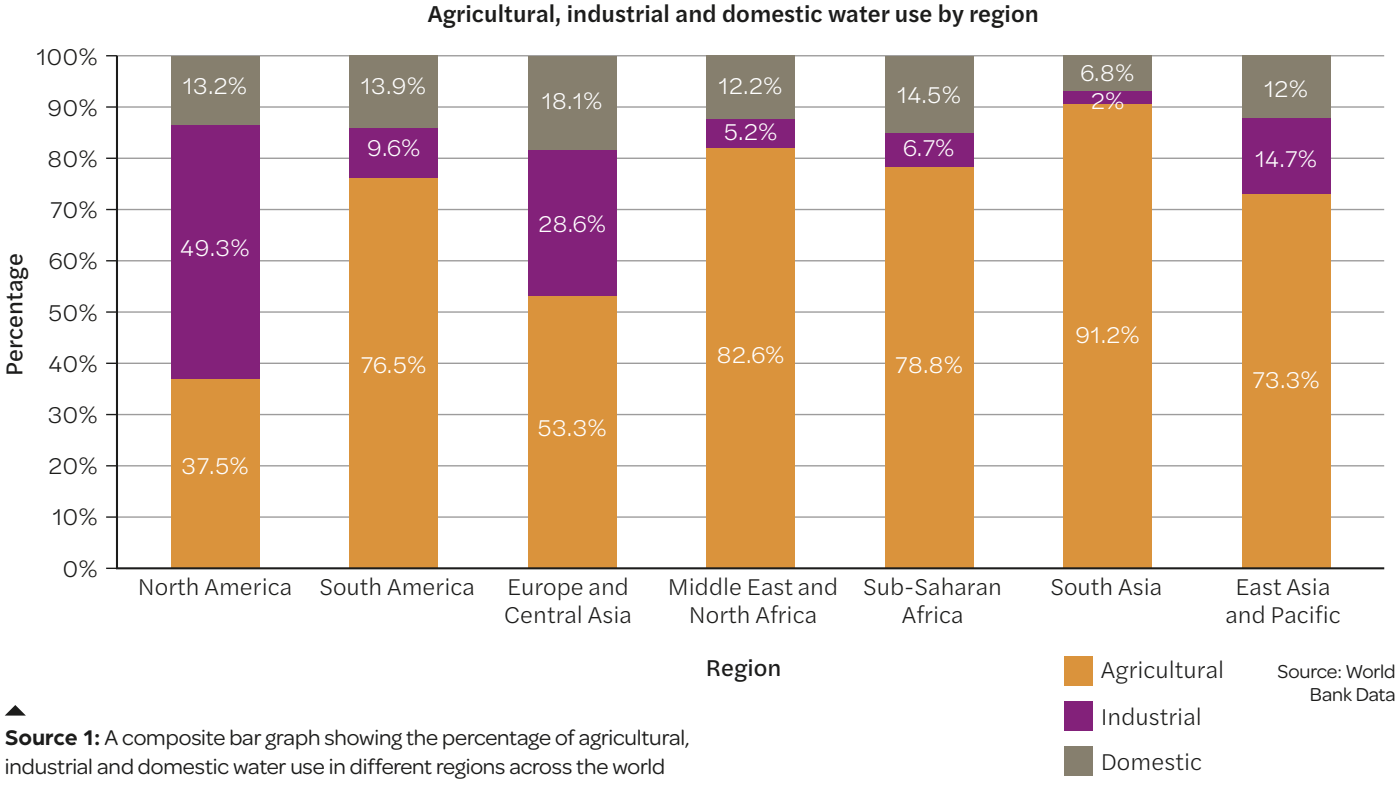
How much water do different countries use?

When countries develop economically and expand their populations, they require more building and manufacturing materials, and people consume more food, water and energy. These products all require the use of water and, as a result, six times more fresh water is used in the world today than it was in 1900. Countries around the world prioritise their water use differently, leading to global variations in the amount of water used for agriculture, industry and domestic use.

Global variations in agricultural water use

Agricultural water use includes irrigation of crops, livestock production and aquaculture. It is the most water-intensive industry in the world as food sources require large amounts of water. The amount of water used by countries is influenced by:

- **Population size:** Larger populations require more food. Countries with vastly growing populations could require up to 60 per cent more food by 2050, increasing the amount of water used in agriculture in the future.
- **Types of crops produced:** Some crops are more water intensive than others. As a result, countries that grow rice or wheat, or produce large amounts of beef tend to use higher amounts of water.
- **Access to water:** Countries experiencing drought or dry periods will use more irrigation.
- **Economy:** Countries that rely on agriculture to trade will use more water for agriculture.
- **Development:** More developed countries can often invest in water-conserving technologies, such as drip irrigation, reducing the amount of water they use in agriculture.

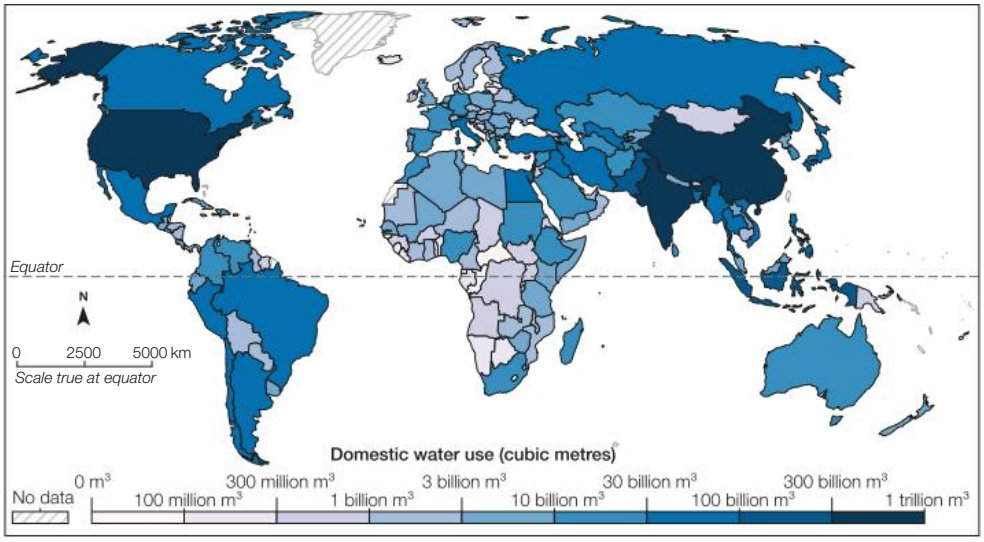


Source 1: A composite bar graph showing the percentage of agricultural, industrial and domestic water use in different regions across the world

Global variations in industrial water use

Industrial water use encompasses water used in manufacturing, processing, cooling and other industrial processes. Developed countries with advanced manufacturing industries typically have higher industrial water use compared to developing nations. As more countries develop economically in the future, it is expected that 406 per cent more water will be required for manufacturing and 144 per cent more for electricity by 2050.

World domestic water use, 2021



Source: Our World in Data

▲ **Source 2:** A choropleth map of the use of water for domestic purposes across the world, 2015

Global variations in domestic water use

Domestic water use refers to water used for household purposes, such as drinking, cooking, bathing, cleaning and sanitation. Wealthier countries with large urban areas generally have higher domestic water use due to higher population densities, and greater access to water-supply infrastructure. They also require water to maintain amenities such as landscaping, pools and household appliances. It is expected that 125 per cent more water will be used to meet domestic demands globally by 2050 as more countries develop economically.

Source 3: An oblique aerial photograph of irrigation systems watering crops. The most fresh water in the world is used in agriculture, and this is expected to increase in the future.

Learning ladder 6.16

Characteristics of places and environments

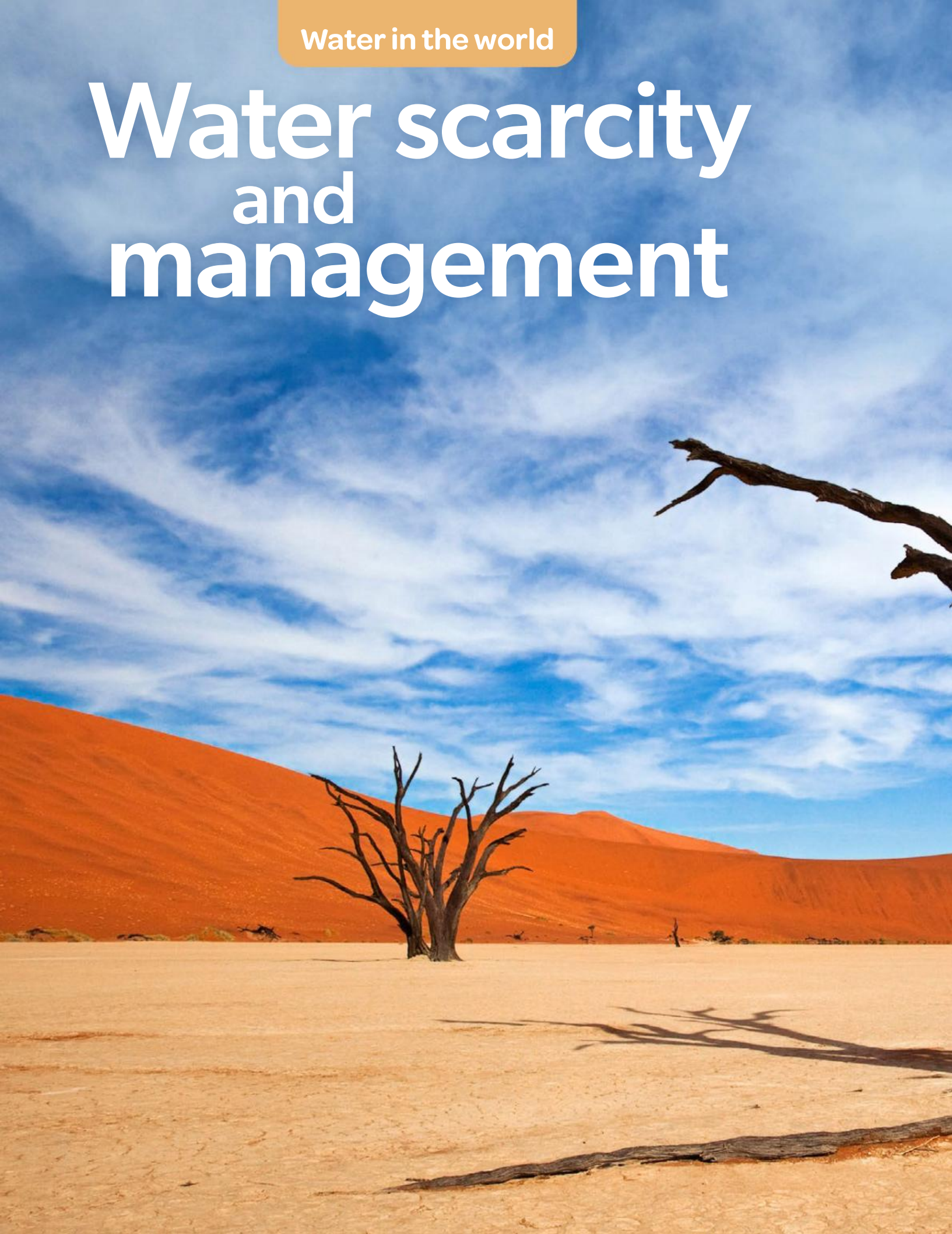
1. Why has water use increased in the world since 1900?
2. Source 2: Identify two countries that use large amounts of water for domestic purposes.
3. Source 1: Explain why South Asia uses the largest amount of water for agriculture in the world.
4. Propose strategies for improving water efficiency in agriculture at both local and global scales. Consider technological innovations and economic development.
5. Discuss the following statement: Technology will reduce the amount of water used in the world by 2100.

Space

1. Source 1: Identify the regions that use the most water for industrial purposes, and the regions that use it the least.
2. Source 1: Explain the global variations in agricultural water use, using data from the graph.
3. Source 2: Explain the spatial distribution of domestic water use; what types of countries use the most and why?
4. Compare and contrast the spatial distribution of industrial water use between developed and developing regions.
5. How will the global variations of water use change in the future? Consider changes in population sizes, economic development and population needs in the future.

HOW TO
Space, page 388

Water scarcity and management



7

WHY IS WATER SCARCE? 228

How can I understand water scarcity and management?

Water is an essential part of life. Without water, life as we know it could not exist on Earth. The way we use and preserve water is important to ensure a sustainable future.

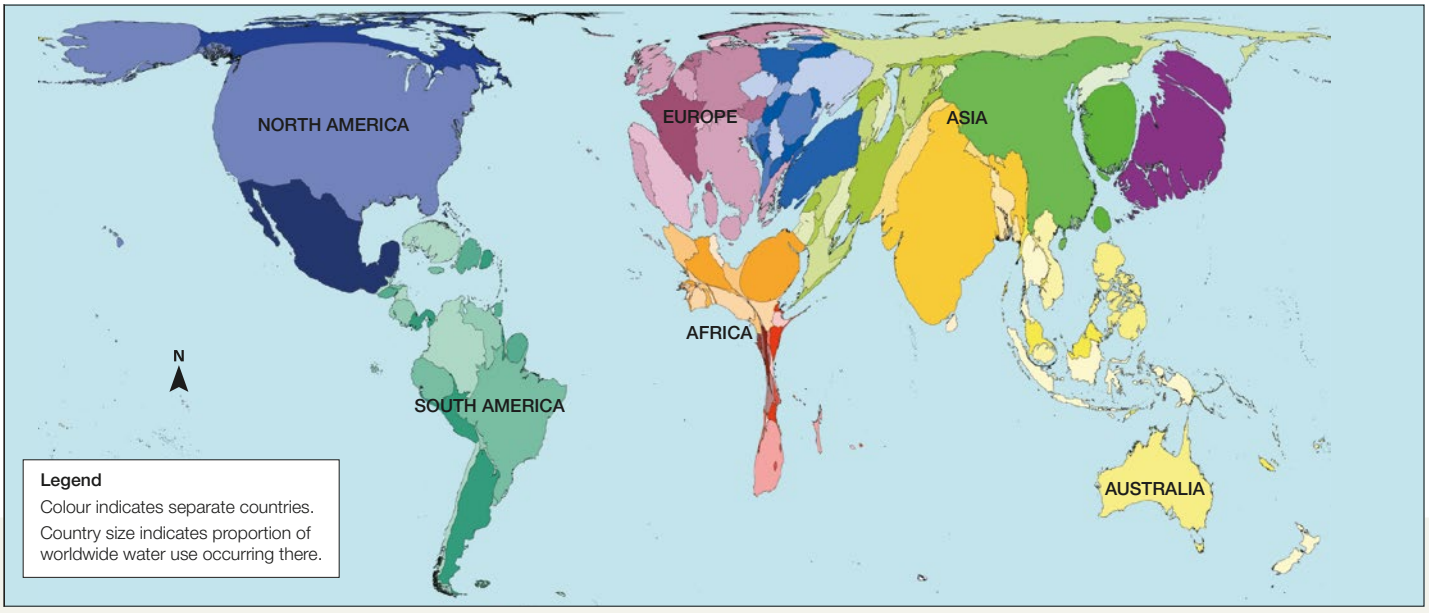
Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
	Outcomes					Geographical tools and inquiry
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information

Global domestic water use

Source: Matilda Education Australia



▲ **Source 1:** The world – but not quite as you expect! In this map, the size of each country shows the proportion of the world's water that is used in households there.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

Why is water scarce?

Clean water is essential for survival, yet the access people have to water varies greatly, depending on where in the world they live. Annually, billions of people around the world don't have access to a safe supply of water.

Supplying the world with water

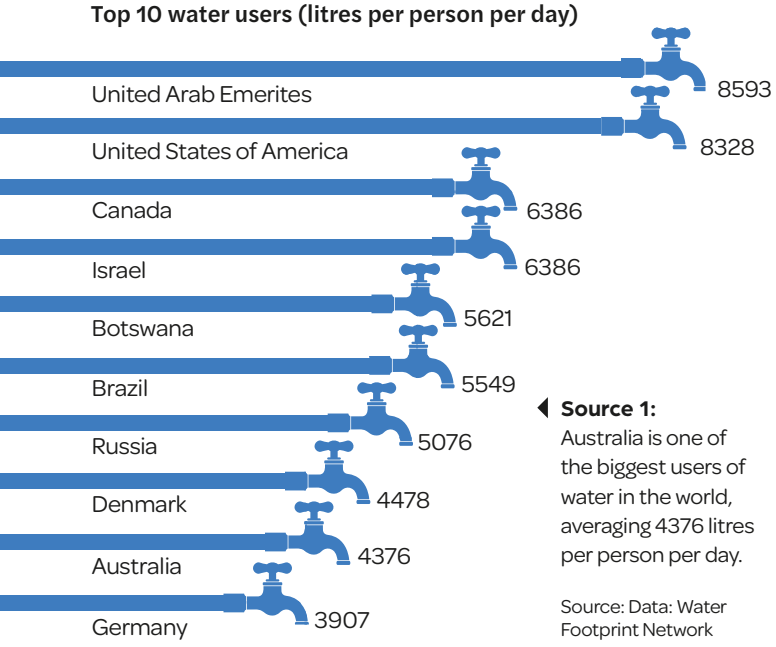
In the 1900s, the world's population tripled and water usage increased by six times. Agriculture accounts for 70 per cent of all water consumed, compared to 20 per cent for industry and 10 per cent for home use.

Supplying the world with enough water is now a huge issue. In Australia in 2022, we consumed 79 000 gigalitres of water – that's enough water to completely fill Sydney Harbour 158 times.

Throughout the world there are places that are **water rich** and places that are **water poor**. Australia is water poor. It is the world's driest inhabited **continent**, and the quantity of water resources varies greatly across the continent.

However, Australia is a wealthy country (referred to in geography as a **more economically developed country (MEDC)**), so nearly everyone can access **safe water** to drink. Many other countries in the world are not so lucky. One in nine people in the world doesn't have access to safe water, and millions of people get sick or die from drinking dirty water.

Top 10 water users (litres per person per day)



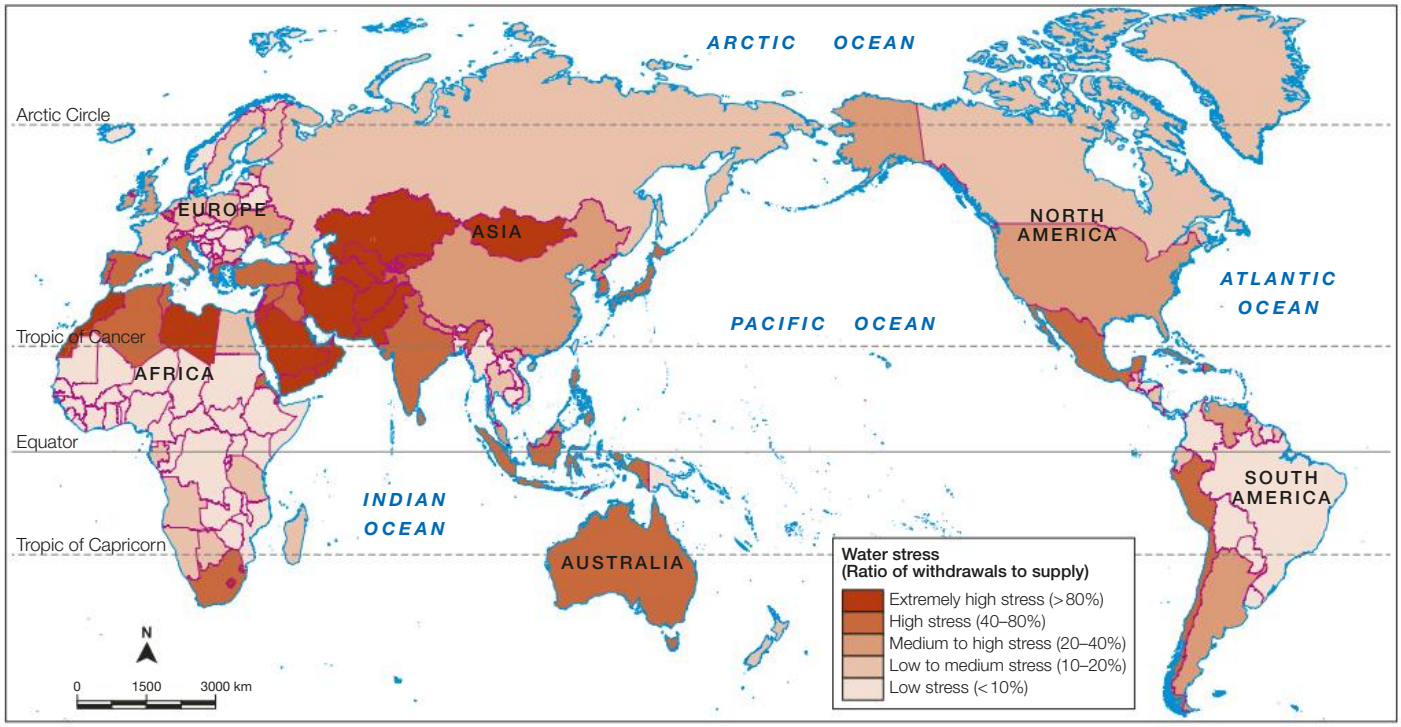
Source 1: Australia is one of the biggest users of water in the world, averaging 4376 litres per person per day.

Source: Data: Water Footprint Network

Per person, Australians are one of the biggest users of water in the world. We need to manage our valuable water resources carefully, so that we balance the needs of different users in homes and on farms, as well as the needs of industry. By making a few simple changes, we can all help save precious water resources.

Source 2: Children drinking from a tap at a primary school in a displaced people's camp in Nigeria. The school and the fresh water pump were supplied by UNICEF – the United Nations Children's Fund aid agency.

World water stress



▲ **Source 3:** The level of water stress per country. Countries under a high level of water stress struggle to meet the demands for water from agriculture, industry and homes.

Source: Matilda Education Australia

Learning ladder 7.1

Characteristics of places and environments

1. Source 3: What does 'water stress' measure?
2. Source 2: Answer these questions.
   - **a** Where do these children live?
   - **b** What are the children queuing up to do?
   - **c** Who supplied this safe water?
3. Source 3: Use PQE to describe the global pattern of water stress.
4. Sources 1 and 3: Suggest reasons why Australia has a high level of water stress.

Sustainability

1. Source 2: Why is it important that the children drink safe water?
2. Describe the risks to freshwater supplies.
3. Explain why MEDCs have an advantage in accessing safe water.
4. Source 1: The United Arab Emerites is one of the most water-poor places in the world. How has this impacted their water use?

HOW TO

PQE, page 412; Sustainability, page 400

Who uses the most water?

In the last 50 years, the human population of Earth has grown to over eight billion people – and in that time, water use has doubled. India, China and the United States consume 40 per cent of all the water used globally.

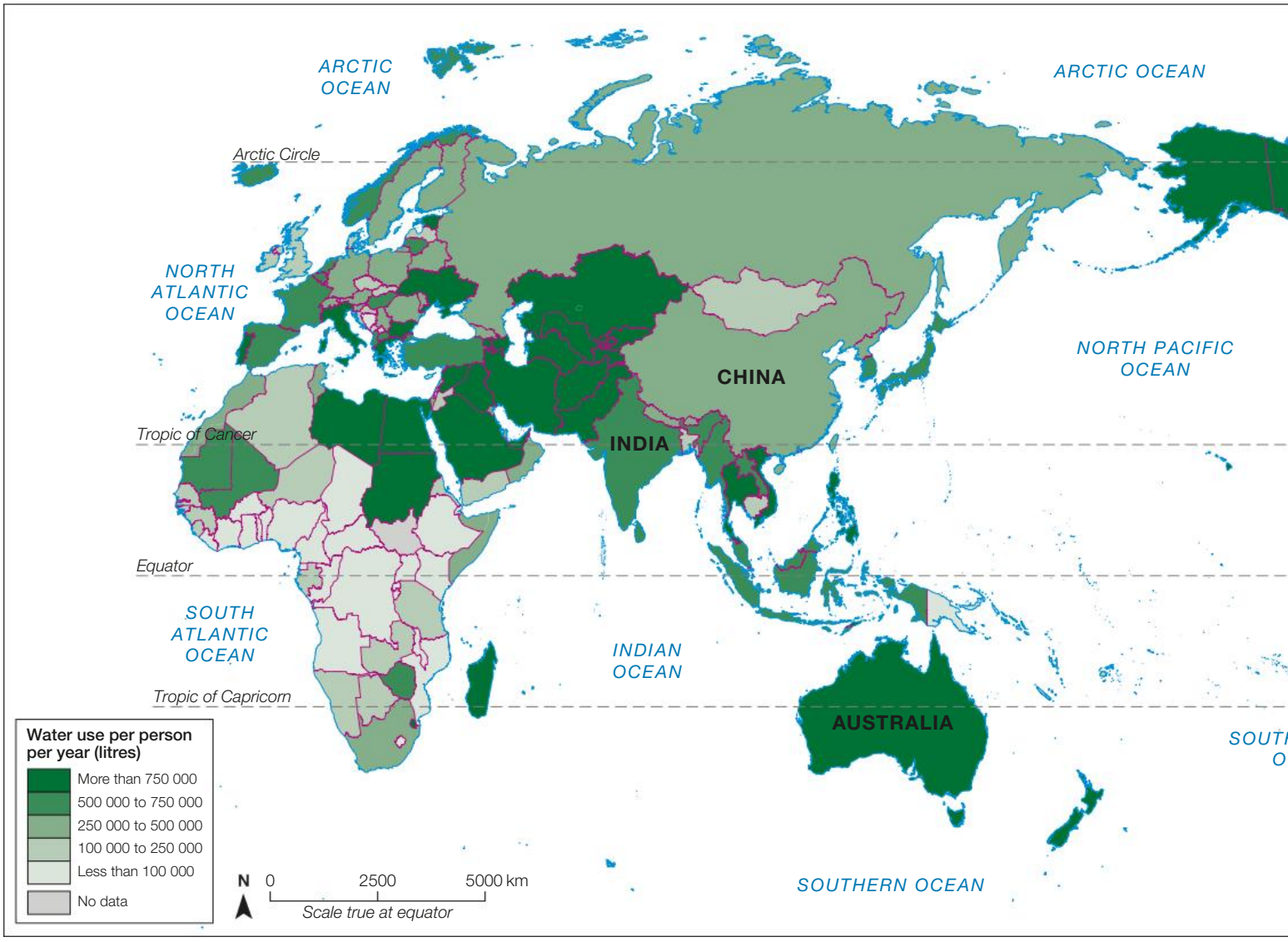
World water use

Nearly 4000 cubic kilometres of **fresh water** is taken from the world's lakes, rivers and aquifers each year. This amount of water would fill Sydney Harbour 7000 times. World water withdrawals have doubled in the last 50 years. Most of the water used by humans is eventually returned to the environment – but the quality of this water may be less than when it was originally taken from the environment.

India, China and the USA consume 40 per cent of the water withdrawn for human use. India and China both use a lot of water to grow their food because combined they have more than one-third of the world's population. The United States has the world's highest use of water for industry at 300 billion cubic metres per year. This is twice the amount used by the second-largest industrial water user, China.

World water use

▼ **Source 1:** World water use per person per year



Top water consumption countries (percentage of world total), 2023

Source 2: The world's largest water consumers in 2023

Source: Matilda Education Australia

In total water use, Australia is a small water user, but per head of population we are one of the thirstiest nations on the planet. In neighbouring Papua New Guinea, only 37 per cent of the population have access to safe water resources.

Source: Matilda Education Australia

Learning ladder 7.2

Characteristics of places and environments

1. How have world water withdrawals changed in the past 50 years?
2. Source 2: Which three countries consume more water than any others, and why?
3. Source 2: How much of the world's water do the top seven countries withdraw?
4. Source 1: Explain why Papua New Guinea is in the lowest category and Australia is in the highest category for water use per head of population.

Space

1. Source 1: Compare the difference in water use per person in the northern and southern hemispheres.
2. Source 1: Use the PQE method to describe the global pattern of water use per person.
3. Source 1: Look at the map of water withdrawals per capita.
   - **a** How do Australia and New Zealand compare with the rest of the world?
   - **b** Which continent has the smallest water withdrawals per head of population and why?
   - **c** As a class, discuss why some countries use more water per person than others.
4. Compare Source 1 with Source 2. Give reasons to explain why India is high in one category and lower in the other.

HOW TO

PQE, page 412; Space, page 388

Case study

What happens when the water runs out?

Cape Town in South Africa nearly became the world's first major city to run out of water when drought brought the large city of 4.5 million people to its knees, with people queuing for water rations.

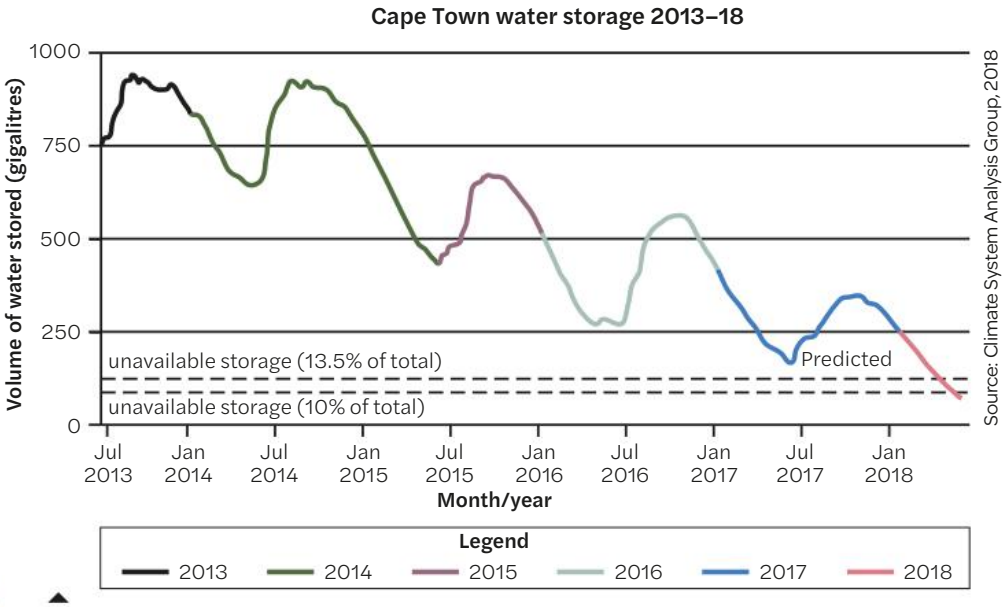
Water crisis

On 23 February 2018, Cape Town had just 100 days of water left. Day Zero for Cape Town was 4 June, when the city's taps would run dry, cutting off water to its 4.5 million residents. At the time, the city's largest water supply, the Theewaterskloof Dam, held just 12 per cent of its massive 480 000 million cubic metre capacity.

At the start of 2018, Cape Town residents faced Level 6B water restrictions, which meant a limit of just 50 litres of water per person, per day. Queues formed at natural springs around Cape Town as people filled up water containers to build up their emergency supplies. Shops sold out of bottled water.

If Day Zero arrived, all water to homes would have been shut off and diverted to 200 distribution centres, where people would have to collect their daily rations of 25 litres of water.

Thankfully, Day Zero never eventuated. In response to the crisis, the people of Cape Town became extremely water wise: households using too much water were fined, and limits on water use for agriculture were introduced. Finally, in June 2018, the region experienced average rainfall for the first time in four years. However, Cape Town's water reserves are still critically low.



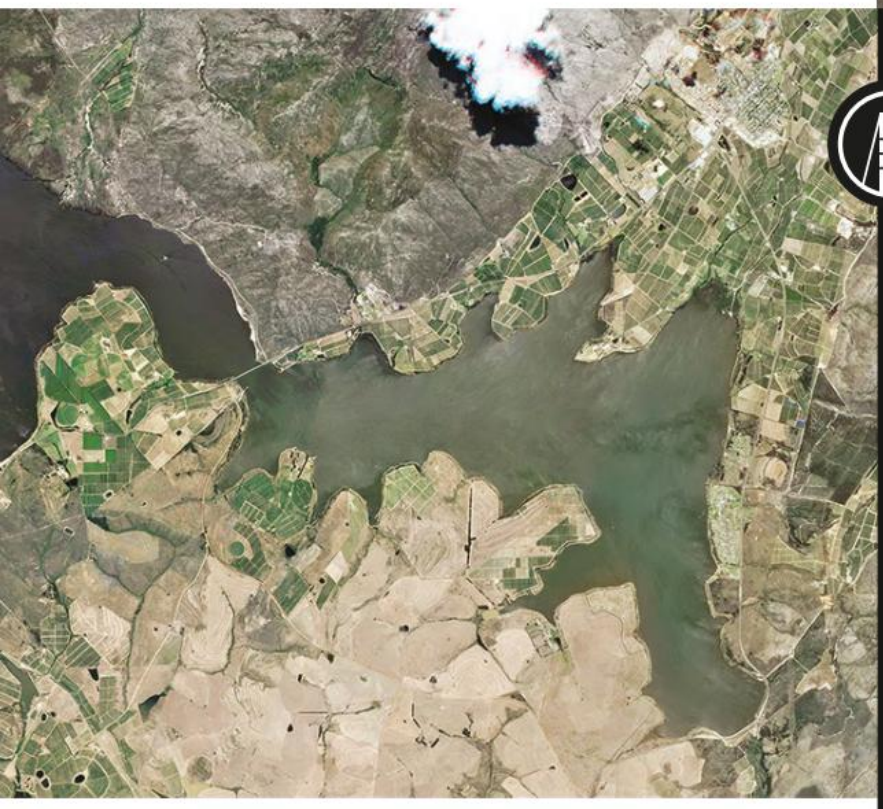
Source 1: This graph shows Cape Town's water storage levels during the period 2013–2018.

Source: Planet Labs Inc.

Causes of the problem

The twin problems behind Cape Town's water crisis were drought and massive population growth. The year 2017 was the driest on record for Cape Town, and 2015–2017 was the driest three-year period since 1933. In May 2017, the drought was declared the city's worst in a century. Since 1915, Cape Town's population has grown by nearly 80 per cent, but dam water storage has increased by only 15 per cent.

Source 2: Satellite images of Theewaterskloof Dam in 2013 and 2018



Source 3: Cape Town residents queue for free water from a well in February 2018.

Learning ladder 7.3

Processes that transform people, places and environments

1. What were the two major causes of Cape Town's water crisis?
2. Source 2: Use the satellite images to draw a map of Theewaterskloof Dam with a key that shows the changes that took place between 2013 and 2018. Include the following in your key: very deep water, deep water, shallow water and no water.
3. Explain the impact of drought on Cape Town. How long did the drought last and how did it come to an end?
4. Source 1: What were the natural and human causes of Cape Town's changing water storage?
5. Cape Town is now looking to desalination plants to help increase its water storage. Look at page 252 to explain this technology and how it might help solve Cape Town's water resource issue.

Sustainability

1. What was Day Zero, and how did the threat of it come about?
2. What action was taken to respond to the crisis?
3. What action could have been taken earlier to avert the water crisis?
4. As a class, develop two strategies that could be undertaken to reduce the impacts of water shortages in Cape Town.
5. Research Cape Town's current water restrictions. What types of water use are targeted by the restrictions? How effective do you think they will be?

HOW TO

Sustainability, page 400

Is all water safe to drink?

More than 2 billion people in the world do not have access to a reliable and safe fresh water supply. Millions of people around the world get sick or die from drinking contaminated (or dirty) water. Millions of women and children around the world spend several hours a day collecting and carrying enough water to sustain their families for another day.

The burden of thirst

Even at 4 am, Binayo can run down the rocks to the river by starlight alone and climb the steep mountain back up to her village with 20 kilograms of water on her back. She has made this journey three times a day for nearly all her 25 years. So has every other woman in her village of Poro, in the Konso district of south-western Ethiopia.

Binayo dropped out of school when she was eight years old, in part because she had to help her mother fetch water from the Toiro River. The water is dirty and unsafe to drink; every year that the drought continues, the once-mighty river grows more exhausted. But it is the only water Poro has ever had.

The task of fetching water defines life for Binayo. She must also help her husband grow cassava and beans in their fields, gather grass for their goats, dry grain and take it to the mill for grinding into flour, cook meals, keep the family compound clean and take care of her three small sons. None of these jobs is as important or as consuming as the eight hours or so she spends each day fetching water.

In wealthy parts of the world, people turn on a faucet [tap] and out pours abundant, clean water. Yet [in 2010] nearly 900 million people in the world have no access to clean water, and 2.5 billion people have no safe way to dispose of human waste – many defecate in open fields or near the same rivers they drink from. Dirty water and lack of a toilet and proper hygiene kill 3.3 million people around the world annually, most of them children under age five. Here in southern Ethiopia, and in northern Kenya, a lack of rain over the past few years has made even dirty water hard to find.

Where clean water is scarcest, fetching it is almost always women's work. In Konso a man hauls water only during the few weeks following the birth of a baby. Very young boys fetch water, but only up to the age of seven or eight. The rule is enforced fiercely – by men and women. 'If the boys are older, people gossip that the woman is lazy,' Binayo says. The reputation of a woman in Konso, she says, rests on hard work: 'If I sit and stay at home and do nothing, nobody likes me. But if I run up and down to get water, they say I'm a clever woman and work hard.'

Source 1: 'The burden of thirst', *National Geographic,* April 2010. Tina Rosenberg (text) and Lynn Johnson (photograph)

Source 2: One of the biggest problems facing many is the lack of clean drinking water. People have to travel far to fetch water from wells, which are mostly salty water, not fresh water. This is the case in Mandira, Kenya.

Waterborne diseases

Fresh water is essential for drinking, cooking, food production and hygiene, as well as for cleanliness. Many countries in the world lack safe water supplies and have poor sanitation (safe disposal of human urine and faeces). People get diarrhoea from drinking and bathing in contaminated water, and this can lead to diseases such as cholera, typhoid fever and dysentery. These illnesses kill 6000 children every day – and 3.4 million people die every year from waterborne diseases.

Water scarcity in Africa

Rapid population growth in Africa has made it even more difficult for African communities to find a reliable source of fresh water. In Africa, **water scarcity** affects one person in every three – and it is getting worse.

Reduced access to water means that people use water of poorer quality. The journeys women take to fetch water for their families become even longer. When they can get water, people store it in their homes – but this provides a breeding ground for mosquitoes, which carry dengue fever, malaria and other diseases.

Better access to safe water

World Vision and other **aid agencies** work with local communities to improve their access to safe water.

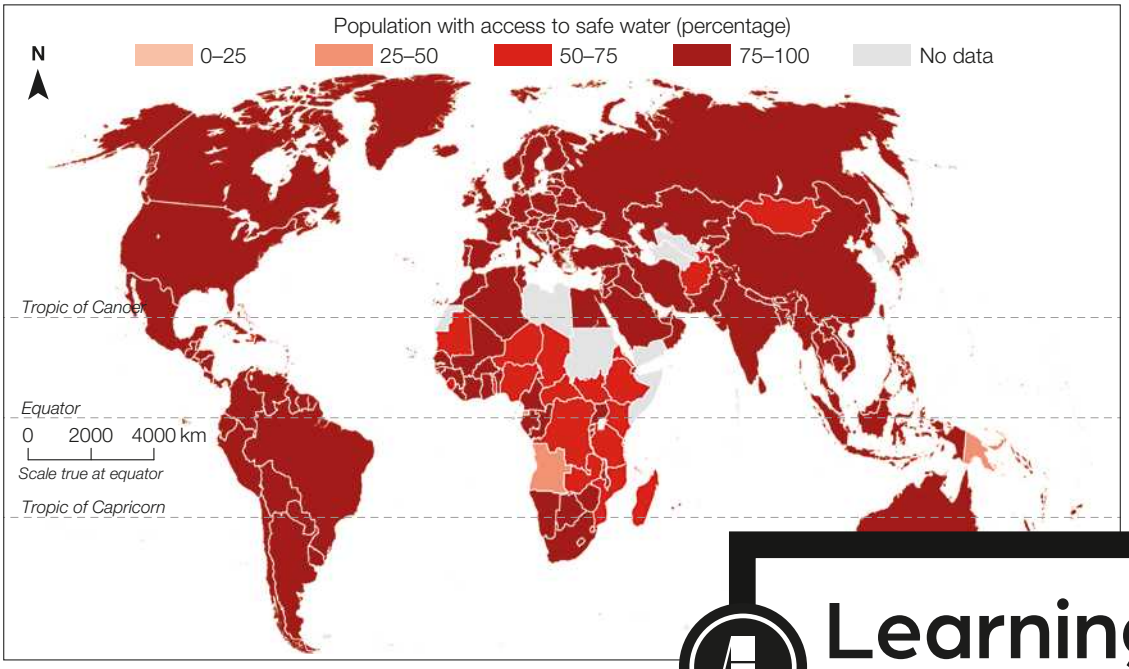
Just two protected wells provide the daily water for the 33 000 people of the Mwinilunga community in Zambia. Women and girls walk long distances to fetch water from unprotected wells and contaminated streams. Half of the Mwinilunga children suffer from life-threatening malaria or diseases caused by diarrhoea.

However, family health is improving in the Mwinilunga community as families gain access to safe water for the first time. World Vision has worked with the local community to:

- drill 15 boreholes and equip them with pumps
- protect five wells against contamination
- build toilets for homes and schools
- train locals to operate and look after the borehole pumps
- conduct hygiene education sessions and train teachers.

Source 3: Climate change in East Africa is causing the worst drought in its history. It has not rained here for more than three years and more than 36 million people are facing the disastrous consequences caused by a heat wave. According to forecasts, the heat wave will not end anytime soon. In Turkana, northern Kenya, people are fighting to survive.

World population with access to safe water



Source 4: This map shows the percentage of people in each country with access to safe, clean water.

Source: World Health Organization, 2023

5000 children die each day from waterborne diseases

1 in 9 people have no access to safe water

Learning ladder 7.4

Perspectives of people and organisations

1. What problems does water scarcity bring?
2. Source 3: What is happening in this photograph and why is it so important to Turkana villagers?
3. Explain the different perspectives the following stakeholders have of poor water access in Mwinilunga: government, non-government organisations, farmers, community members.
4. How has access to safe water for the Mwinilunga community improved?
5. Source 4: Use the map to locate target regions for action to improve safe water access.
   - **a** In which continent is maintaining a sustainable safe water supply a major issue?
   - **b** Which two countries have the worst access to safe water?
   - **c** What action could Australia take to improve access to safe water in neighbouring Papua New Guinea?

Environment

1. Source 2: Identify the physical and built features of this environment.
2. Source 1: Read the story 'The burden of thirst' on page 234.
   - **a** What is Binayo's most important job? Describe how she performs this task.
   - **b** How far away is the Toiro River and how many times does she travel to it each day?
3. Source 3: What aspects of the natural environment suggest that the region is in drought?

HOW TO
Environment, page 396

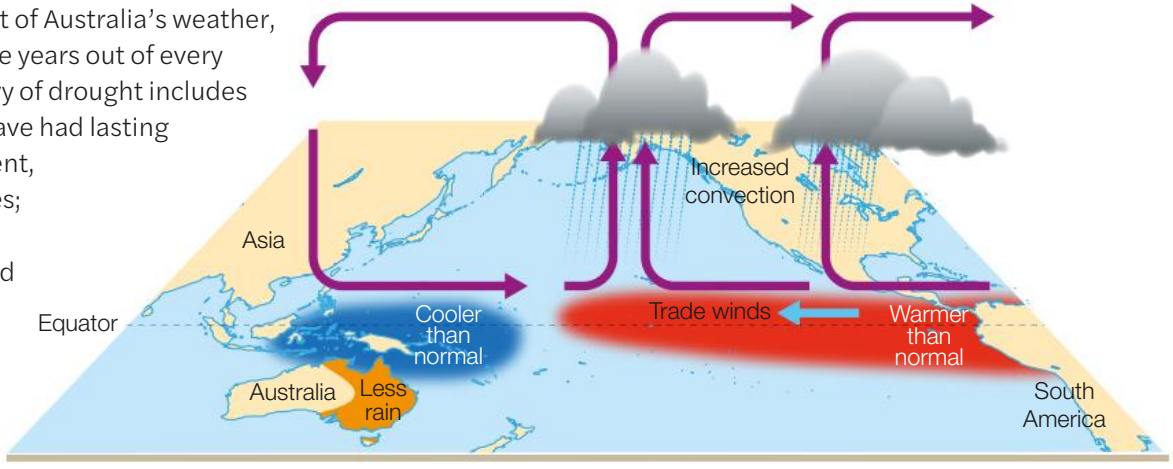
How do droughts occur?

Droughts are long periods of reduced rainfall, leading to water shortages that affect communities and environments. During droughts, native plants and animals struggle to survive, environments become more vulnerable to bushfires, water shortages affect cities and rural communities often face economic stress as the dry conditions impact their agricultural sectors.

Why is Australia prone to droughts?

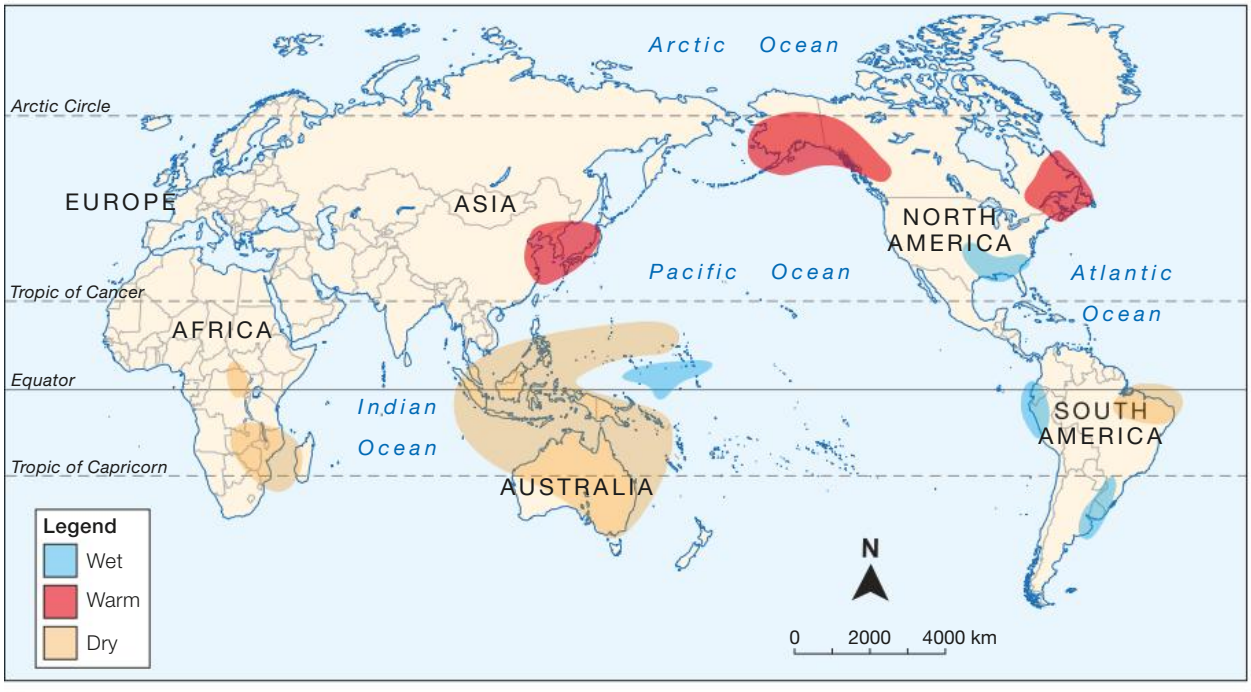
Australia is one of the driest inhabited continents on Earth. Rainfall patterns in Australia are highly variable, with some years bringing heavy rain while others bring very little. Because of this climate variability, droughts are a natural part of Australia's weather, occurring on average three years out of every ten. Australia's long history of drought includes some major events that have had lasting impacts on the environment, economy and communities; including the Millennium Drought (1997–2009) and the Tinderbox Drought (2017–19).

Ocean patterns play an important role in determining Australia's rainfall. When ocean temperatures near Australia are cooler, less water evaporates into the air, which means fewer rain clouds can form.



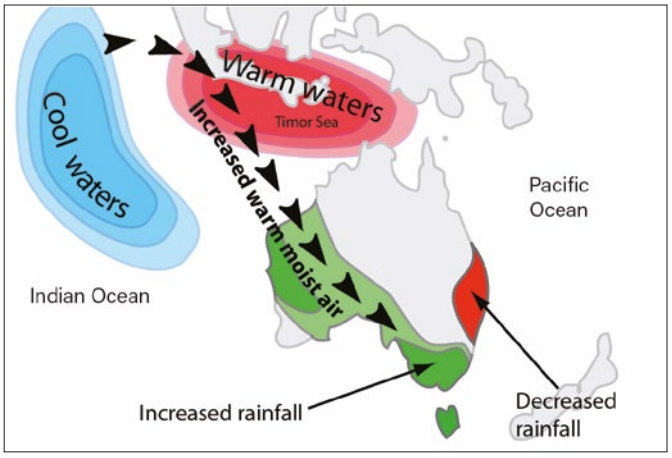
▲ **Source 2:** Pacific Ocean conditions during an El Niño Southern Oscillation cycle

Some weather effects of El Niño



▲ **Source 1:** Regions most affected by El Niño

Source: Matilda Education Australia



Source: Matilda Eduation Australia

▲ **Source 3:** Prolonged droughts in south-east Australia are driven by the positive Indian Ocean Dipole phase.

Two key ocean systems that influence this are:

- **El Niño Southern Oscillation (ENSO):** During El Niño, warm water moves away from Australia and towards South America. This causes dry air and high-pressure systems to form over eastern Australia, leading to less cloud formation, reduced rainfall and a higher risk of drought. The effect, called La Niña, usually brings more rain and floods.
- **Indian Ocean Dipole (IOD):** When the IOD is in a positive phase, warm waters are located in the western Indian Ocean and cold water is brought to the surface in the eastern Indian Ocean around Australia. This leads to less moisture in the atmosphere, less rainfall and higher temperatures over most of Australia during winter and spring.

Source 4: A dust storm hits Parkes in central western New South Wales during the 2019–20 Australian drought driven by a strong positive Indian Ocean Dipole and an El Niño event.

Scientists use the **Southern Oscillation Index (SOI)** to measure changes in air pressure and ocean temperatures in the Pacific Ocean. This helps meteorologists predict the likelihood of drought, allowing communities and governments to plan and prepare.

Learning ladder 7.5

Processes that transform people, places and environments

1. What are the two main causes of drought in Australia?
2. Source 2: Describe how an El Niño Southern Oscillation cycle can cause drought conditions in Australia.
3. Source 4: What processes drove this dust storm hazard?
4. Source 3: Explain the difference between a negative and a positive Indian Ocean Dipole and their impacts on Australia.

Space

1. Source 1: What conditions does most of Australia face during an El Niño Southern Oscillation cycle?
2. Source 1: Describe the distribution of wet regions during an El Niño Southern Oscillation cycle.
3. Source 4: Explain why drought in Australia is associated with a positive Indian Ocean Dipole.
4. Source 2: What are the implications of increased convection (warm rising air) in the eastern Pacific Ocean during an El Niño Southern Oscillation cycle?
5. Source 2: Evaluate the impact of cool sinking air in the western Pacific Ocean during an El Niño cycle on drought in Australia.

HOW TO Space, page 388

How does water scarcity impact Australia?

Water scarcity is a persistent issue in Australia due to our dry and variable climate. Scientists have warned that global warming is resulting in an even hotter and drier climate in Australia, which will drive more frequent droughts and severe bushfires.

Water scarcity

Water scarcity refers to a shortage of fresh water to meet demand. Physical water scarcity occurs when a region's demand for water resources is higher than the limited water resources found there. Economic water scarcity occurs when water resources are adequate, but they are not available to people due to a lack of infrastructure such as wells, pipes, pumps and water sanitation.

Physical water security in Australia is a consistent and growing issue. Australia is the driest inhabited continent in the world, with one of the most variable rainfall patterns. The dry and variable nature of Australia's climate was well captured by Dorothea Mackellar in her famous poem, 'My country', written in 1908:

I love a sunburnt country,
A land of sweeping plains,
Of ragged mountain ranges,
Of droughts and flooding rains.
I love her far horizons,
I love her jewel-sea,
Her beauty and her terror –
The wide brown land for me!

Source 1: Dorothea Mackellar, 'My country', 1908

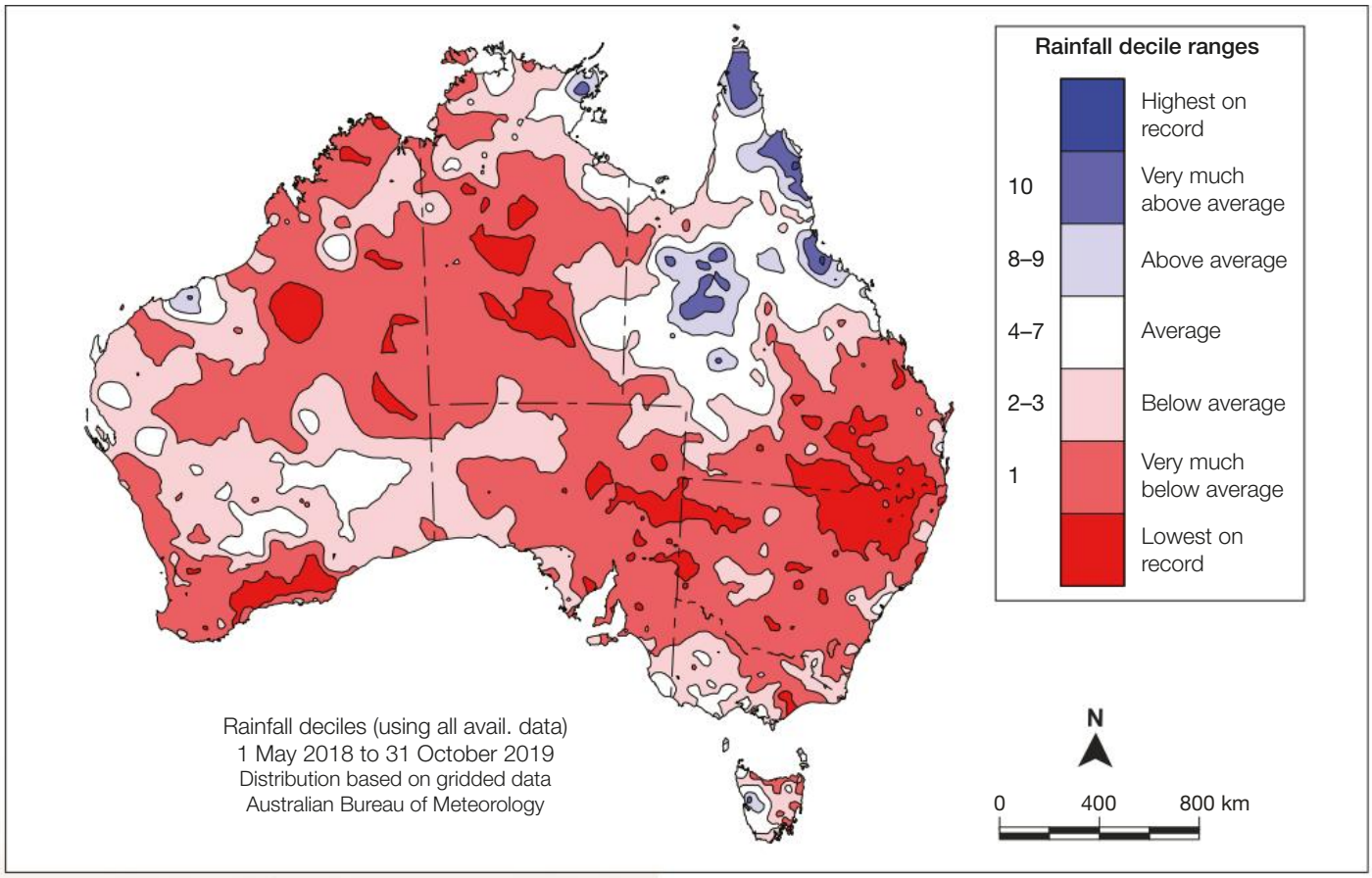
Australia in drought

A drought is a prolonged period of water shortages caused by below-average rainfall, increased evaporation from higher temperatures or a reduction in surface water or groundwater supplies. A drought can last for months or years and is driven by not only lack of rainfall and high temperatures but also overuse from growing populations.

In 2019 Australia recorded its driest year ever, with the lowest annual rainfall the country has ever seen. Lower than average rainfall plunged most of New South Wales and Queensland into drought from 2017 to 2019. Rainfall shortages were most extreme in the northern half of New South Wales and southern Queensland, where rainfall totals were the lowest ever recorded.

Source 2: Farmer Gary Mooring feeds sheep on his drought-ravaged farm at Louth in northern New South Wales in February 2019. In a three-year period very little rain fell over most of New South Wales and Queensland. Families who have lived on the land for generations were forced to sell their properties, starving livestock died and some rural towns ran out of water.

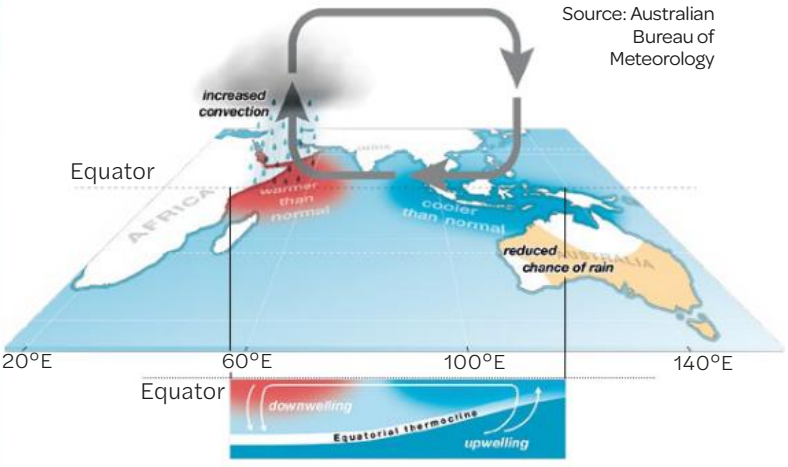
Australian rainfall shortages in 2018 and 2019



Source 3: Australian rainfall shortages in 2018 and 2019

Indian Ocean Dipole

The 2017–19 drought was driven by a positive Indian Ocean Dipole; an event where temperatures on the sea surface are warmer in the western Indian Ocean, and cooler in the east. The difference between the two temperatures was the largest in 60 years, leading to high rainfall and floods in eastern Africa and droughts in Australia and South-East Asia.



Source 4: Drought caused by a positive Indian Ocean Dipole

Australian bushfires 2019–20

The combination of drought across much of Australia and heatwaves in New South Wales and Queensland caused some of the worst fires in Australian history in the 2019–20 spring and summer period.

Bushfires occur when weather conditions are hot, dry and windy and there is enough dry fuel to burn. In these conditions, it only takes a spark from a machine or a lightning strike for a fire to begin.

Once fires have started, wind fuels the fire with oxygen and moves the fire forwards. Wind also carries burning leaves, twigs and bark, known as **embers**, ahead of the fire. Embers cause new **spot fires** to ignite. The intense heat from the 2019–20 bushfires caused rare **pyrocumulonimbus clouds** to form above them. These clouds can produce thunderstorms and lightning that can spark other bushfires or downpours to put them out.

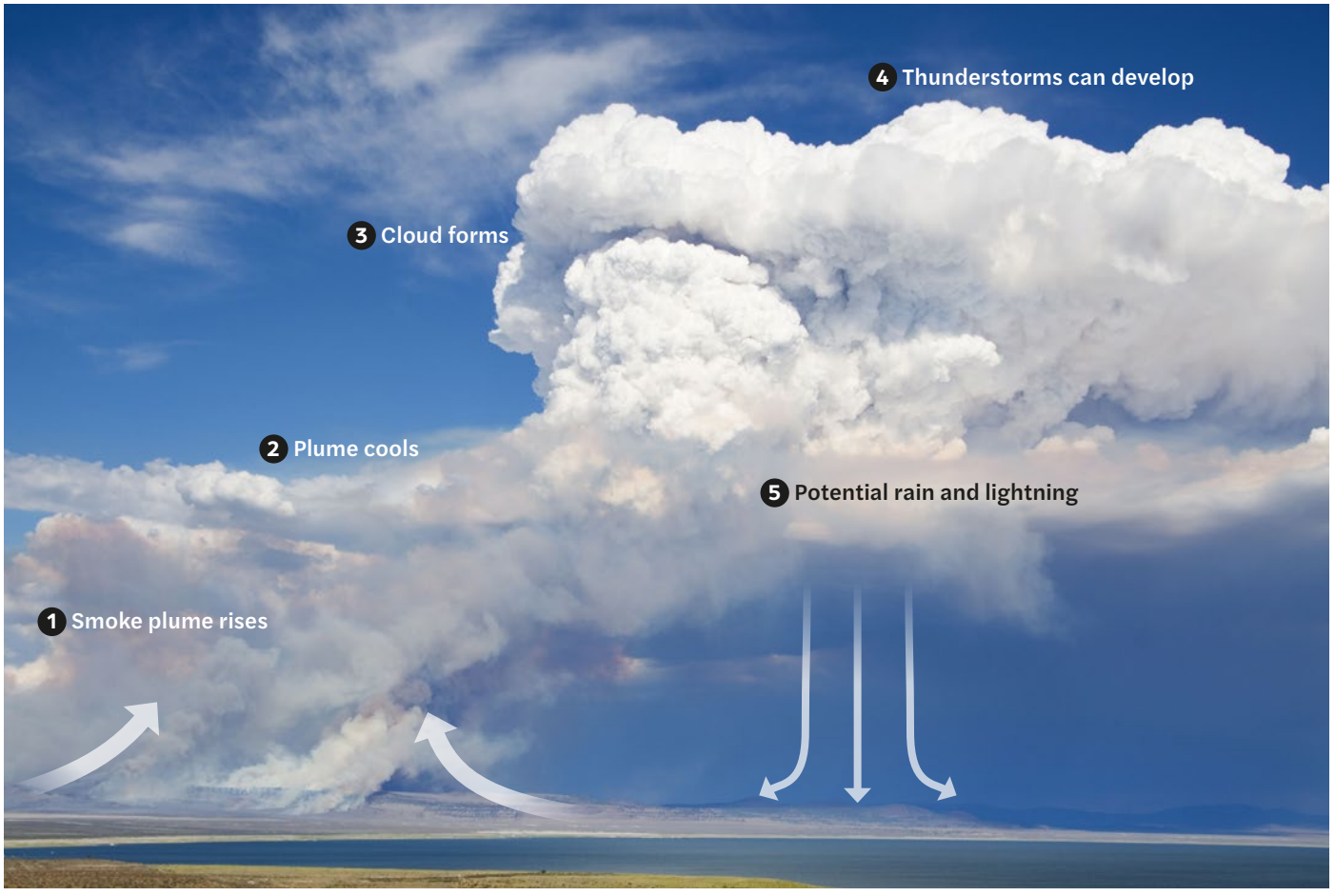
Record-breaking temperatures and months of severe drought created perfect conditions for bushfires to spread rapidly and difficult conditions for the thousands of firefighters called into action.

The 2019–20 bushfires affected all states and territories of Australia except the Australian Capital Territory, although smoke from the fires blanketed the nation's capital. More than 17 million hectares of land burned, an area greater than the size of England. At least 24 people died, along with 100 000 head of cattle and 1 billion animals, birds and reptiles. More than 3000 homes were destroyed, forcing thousands of people to seek shelter elsewhere.

A state of emergency for all of New South Wales and affected areas of Victoria came into force. Parks, camping grounds and roads were closed, and holidaymakers in the peak holiday season were told to leave coastal towns in danger along a 260-kilometre stretch of NSW coast.

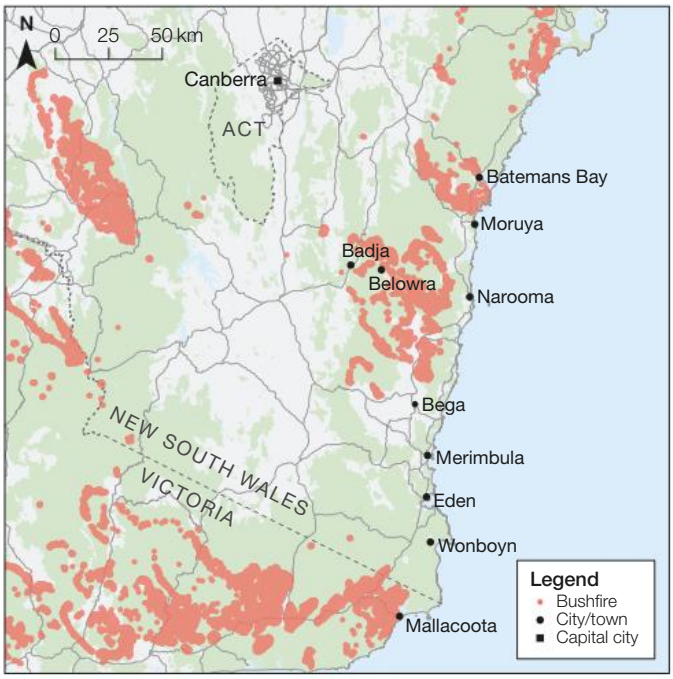
In the holiday town of Mallacoota in far eastern Victoria, 4000 residents and tourists fled to the beach on New Year's Eve in 2019. Only a change in wind direction stopped the fire from reaching them on the foreshore. The stranded people were eventually evacuated by the Australian navy.

Source 5: Bushfires can make their own weather by creating pyrocumulonimbus clouds that produce thunderstorms with lightning.



Source 6: Flames illuminate the sky over a property on Putty Road on 15 November 2019 in Colo Heights, NSW. An 80 000-hectare blaze at Gospers Mountain is burning in the direction of Colo Heights.

Major bushfires in eastern Australia, 2 January 2020



Source: NSW Rural Fire Service

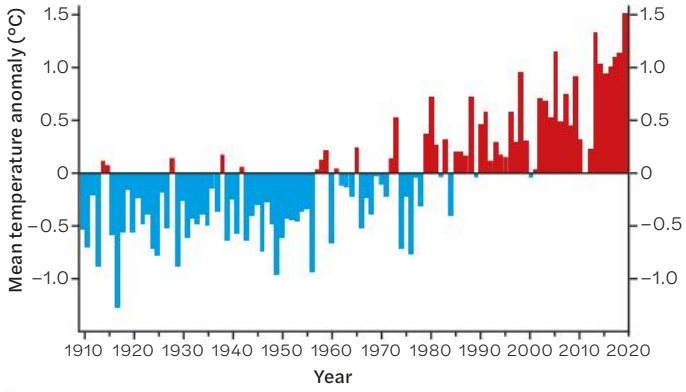
Source 7: Bushfires in south-eastern NSW and eastern Victoria in early January 2020

Australia is getting warmer

Since 1910 Australia's climate has warmed by more than 1°C. **Climate change** is largely driven by increased carbon dioxide and other human-made emissions into the atmosphere. These gases trap heat just like the glass roof of a greenhouse. The greenhouse effect is expected to deliver even hotter and drier conditions to Australia.

Climate change is already leading to more severe heatwave conditions in Australia. Nine of the 10 warmest years on record have occurred since 2005. In 2019 Australia's annual mean temperature was 1.52°C above average – making 2019 the hottest year ever recorded in Australia.

Annual mean temperature anomaly, Australia (1910–2019)



Source: Matilda Education Australia

Source 8: Variations to the average annual temperature in Australia.

Learning ladder 7.6

Characteristics of places and environments

1. What is the difference between physical and economic water scarcity?
2. Source 2: Describe what is happening in this aerial photograph and why it is taking place.
3. Source 3: Which areas of New South Wales had the lowest rainfall on record in 2018–19?
4. Source 7: Which areas of New South Wales and Victoria were burned and what was the impact of bushfires across Australia?

Interconnection

1. Source 5: Suggest two ways that pyrocumulonimbus clouds are interconnected to bushfires.
2. Source 8: Describe the impact of climate change on temperatures in Australia.
3. Explain how drought and bushfires are interconnected.
4. Source 4: Explain how the Indian Ocean Dipole is interconnected with drought conditions in Australia.

HOW TO Interconnection, page 392

Case study

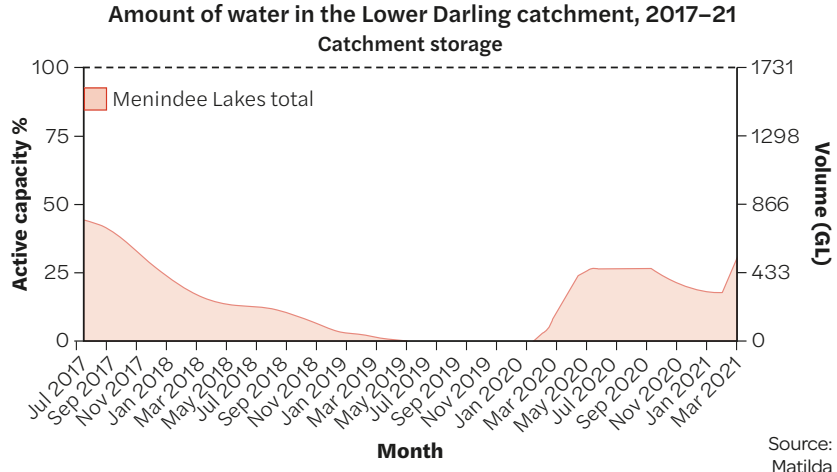
How did the 2020 drought impact New South Wales?

Between 2017 and 2020, New South Wales experienced a record-breaking drought that was the hottest and driest on record in over 120 years. This drought resulted in water shortages across the state and had significant social, economic and environmental impacts.

Impacts of the drought

Environmental impacts

The lowest rainfall on record reduced water storage in dams and reservoirs. In some cases, water sources had dried up entirely, which led to hundreds of native species, livestock and fish dying. Further, the dry soils increased dust storms, resulting in the erosion of important topsoil in many parts of NSW. This reduced the capacity for the land to grow vegetation, further impacting species habitats and food sources.



Source: Matilda Education Australia

▲ **Source 2:** A graph displaying the volume of water in the Lower Darling dam, NSW, flowing from the Menindee Lakes between 2017 and 2021

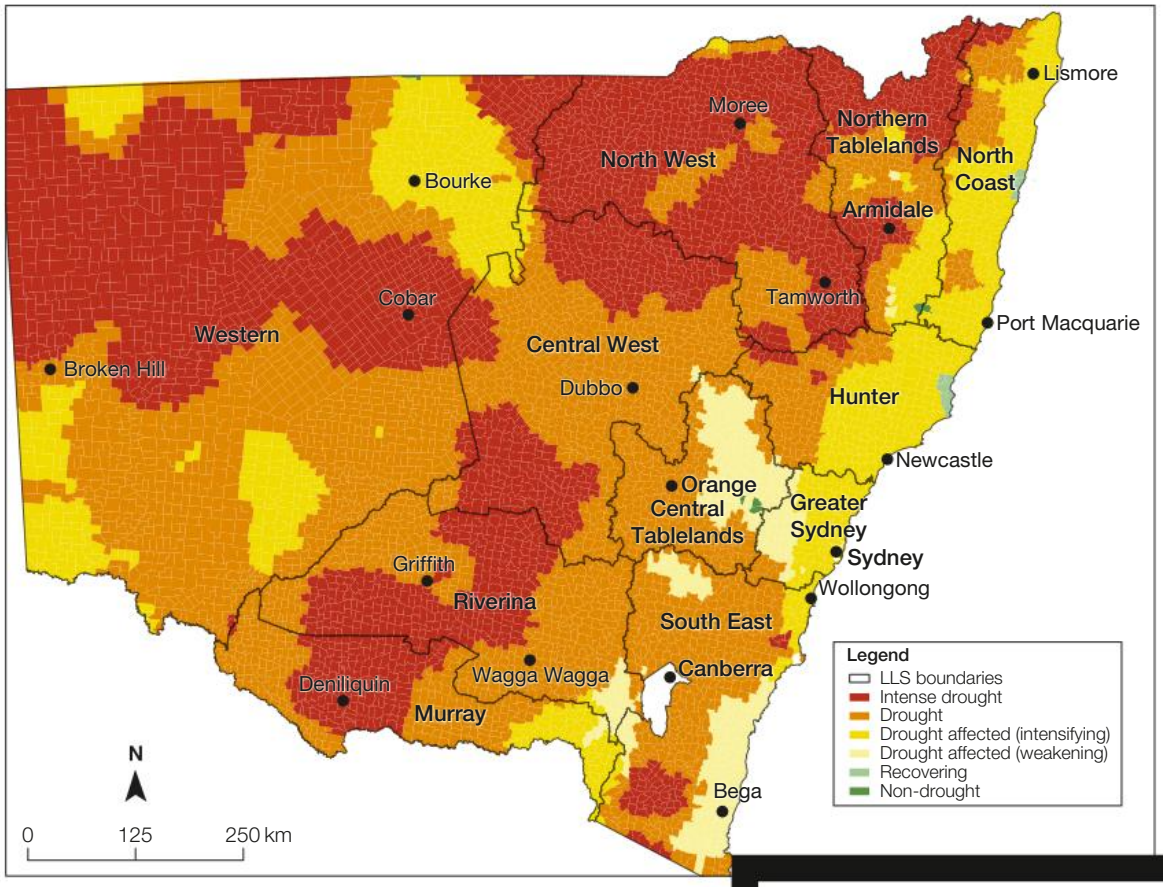
The dry and warm weather, combined with low humidity and strong winds resulted in a prolonged period of bushfires across NSW in 2019 and 2020. Over 17 million hectares of land was burned and more than 1 billion mammals, bird and reptiles perished.

Economic impacts

The drought had a substantial impact on the agricultural sector, preventing crops from growing and resulting in the loss of livestock for many farmers. Farmers were forced to buy water and feed for their livestock. Further, the drought degraded the land and made it difficult to plant crops, resulting in many farmers not growing crops to sell for four years in a row. This had many economic implications. It reduced the number of jobs available in rural areas, reduced the amount of money people in rural areas had to spend at local businesses, and increased the price of food across Australia, as it became more difficult to access fruit, vegetables and meat. The government attempted to help farmers through various support schemes that provided financial aid and resources to drought-affected farmers.

Source 1: Supplementary feeding and watering of livestock saw some farmers spending up to $50 000 per month to keep their livestock nourished during the 2017–20 drought in New South Wales. ▶

New South Wales drought severity, 2019



Source 3: A choropleth map of drought conditions by 2019. The darker the areas, the more intense the drought they were experiencing.

Source: Matilda Education Australia

Social impacts

Dams across NSW either dried up or reached record lows. As a result, the government implemented strict water restrictions that forced families to reduce their use of water and prevented people across NSW from using water for particular activities, such as washing their cars or watering their gardens. The drought also affected the livelihood and wellbeing of communities across the state as people lost their income and sense of connection to the land, especially those in regional areas.

Learning ladder 7.7

Processes that transform people, places and environments

1. List the characteristics of a drought.
2. Source 3: Describe the location of regions that suffered intense drought.
3. Explain the cause and extent of the drought in NSW between 2017 and 2020.
4. Source 2: Assess the impact of drought on people living at Menindee.

Change

1. Identify one short-term and one long-term impact of the 2017–20 drought.
2. Source 2: Describe the changes in the volume of the Lower Darling catchment at Menindee.
3. Source 1: What was the economic impact of the drought for farmers?
4. Suggest a strategy to reduce the impact of a future drought in NSW, then evaluate it.

HOW TO Change, page 394

What is the link between avocados, water scarcity and food security?

Water scarcity is caused by natural and human factors, including the uneven distribution of water, high population growth, food production, waste and pollution. Agriculture uses 70 per cent of the world's water to satisfy the growing global demand for food; however, while contributing to food security, agriculture also causes water scarcity. In poorer countries rain-fed agriculture feeds millions of people and is often supplemented by traditional irrigation techniques. Increasingly, however, large commercial food producers growing water-demanding crops, often in places where water is already scarce, are taking over smallholder farms and impacting their water supplies. The result is increased water scarcity.

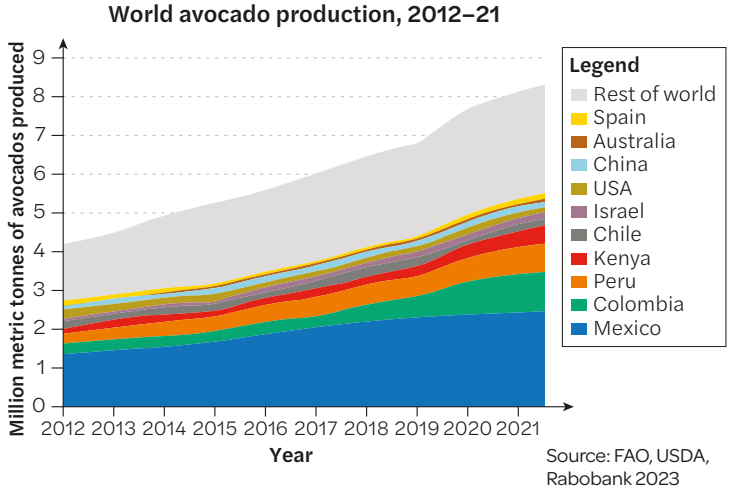
Avocados

For thousands of years, avocados have been a staple crop and traditional food for millions of people across South America, particularly in Mexico and Chile. The fruits were produced sustainably using agroforestry (multi-cropping) or in small orchards, using rainfall or water from local creeks during the dry season. Avocados are a thirsty crop. When grown on large plantations, they require on average 600–700 litres of water to produce 1 kilogram of the fruit, although statistics vary between countries and regions. In drier regions, such as in Petorca, Chile, the average is 1200 litres. The World Economic Forum states that around 9.5 billion litres of water are used daily to grow avocados.

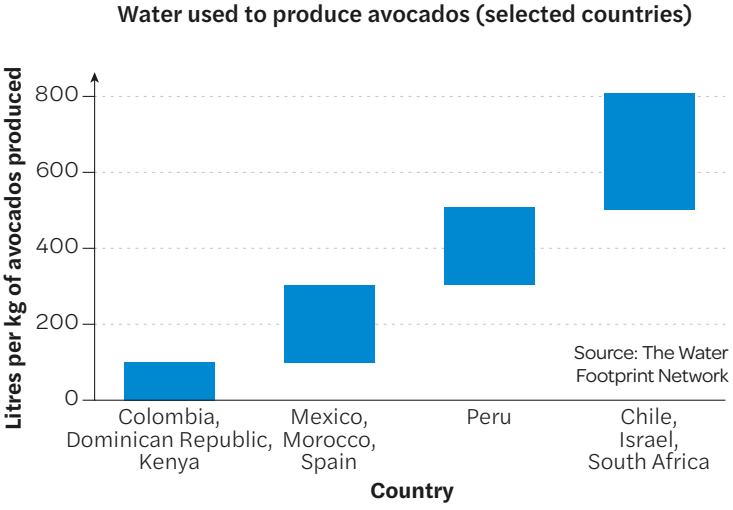
Water scarcity and livelihoods

Over the past decade, avocados have become a trendy 'superfood' in wealthy countries, resulting in rapid growth in demand and big profits from exports. To meet the demand and benefit from the 'green gold', large avocado plantations are expanding in traditional avocado-producing countries, impacting water scarcity and food security.

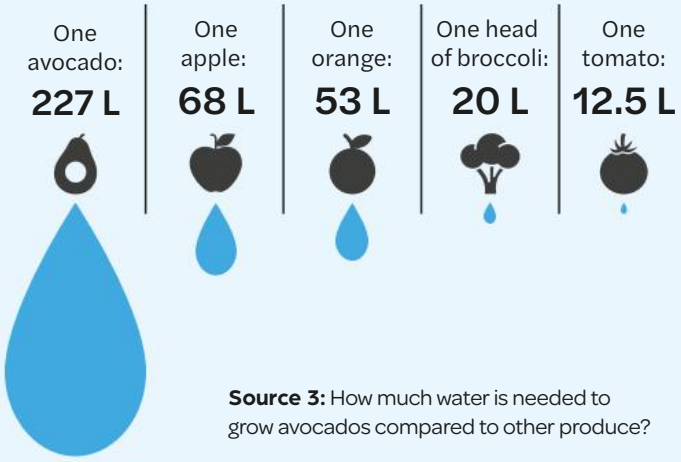
- Deforestation to grow avocados interrupts the natural water cycle by reducing infiltration and runoff into local streams and aquifers.
- Avocado plants have shallow roots and require constant irrigation when grown as a monoculture crop.



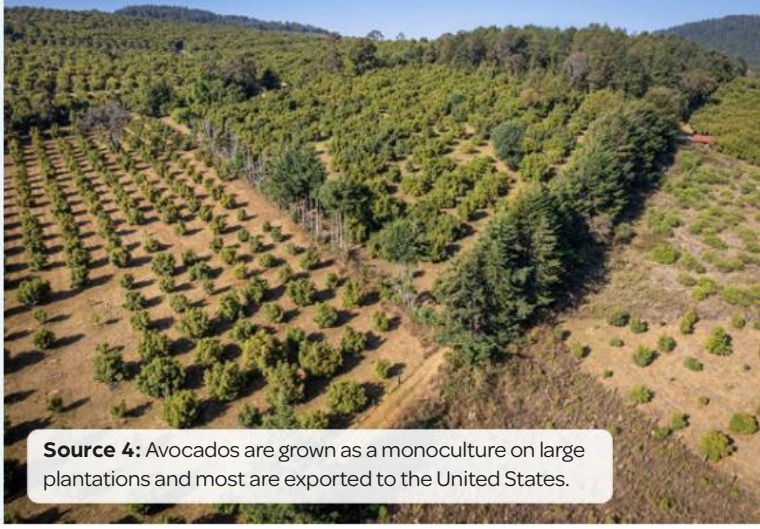
▲ **Source 1:** Growth of global avocado production



▲ **Source 2:** Water footprint of producing avocados varies between countries.



Source 3: How much water is needed to grow avocados compared to other produce?



Source 4: Avocados are grown as a monoculture on large plantations and most are exported to the United States.

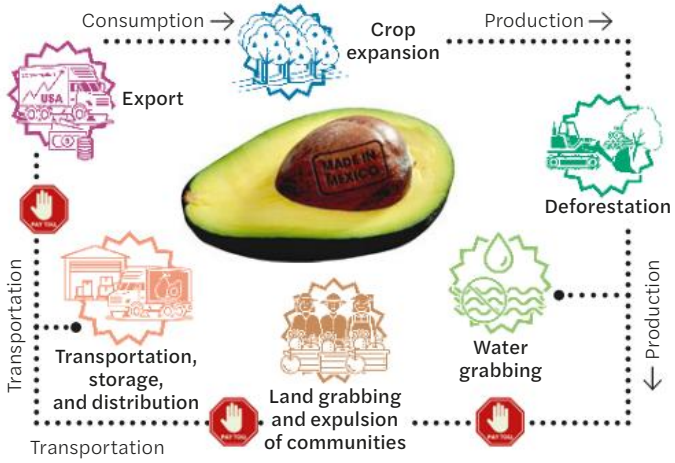
- Illegal pipes and wells are being used to divert irrigation water from rivers and aquifers, causing regional droughts.
- Rivers and wells downstream from plantations are drying up and communities have to buy water from water carriers.
- Local communities cannot afford to buy their traditional foods because they are more valuable as exports.

Water scarcity and conflict

'Water grabbing' refers to the actions of organisations or individuals who take control of water for their own benefit at the expense of local communities. In Mexico, large drug cartels are among the powerful organisations taking water illegally. In 2024, local protests and conflicts escalated in Michoacan state, the largest producer of avocados in Mexico, as communities and small-scale farmers responded to rivers and lakes drying up and increasing drought. As the industry expands into drier landscapes, requiring more irrigation, conflicts over water are expected to escalate. These issues are also impacting Chile, Spain, Portugal and other avocado-producing areas.

The avocados of wrath

Mexico is the world's number one producer and exporter of avocados. But its supply and value chains are laden with devastation and extortion.



▲ **Source 5:** Issues caused by irrigated avocado production in Mexico

Learning ladder 7.8

Sustainable management strategies

1. Define the following terms: rain-fed agriculture, irrigation, agroforestry, monoculture and water grabbing.
2. Source 2: Describe variations in the water footprint of avocado production.
3. Source 1:
   - **a** Identify the three largest avocado-producing nations in the world.
   - **b** Calculate the combined production of the four largest avocado producers in South America.
4. Explain the difference between traditional small-scale avocado production and large-scale plantation production.
5. Suggest strategies to reduce the water footprint of avocado production.

Interconnection

1. What is the connection between water scarcity and agricultural production?
2. How does avocado production put pressure on water resources?
3. How does the demand for avocados in wealthy countries cause water scarcity in the countries where avocados are grown?
4. Why might governments allow the rapid expansion of avocado production for export at the expense of local communities?
5. Discuss the following statement: The consumption of traditional foods should be a higher priority than producing foods for export.

HOW TO Interconnection, page 392

Geographical tools

How can I interpret water variability data?

Access to safe and quality drinking water is different across the world. Some places have regular access to high-quality water, while others do not have access or only have access to polluted and contaminated water. There are different ways to use data to understand who has access to quality water, and who does not.

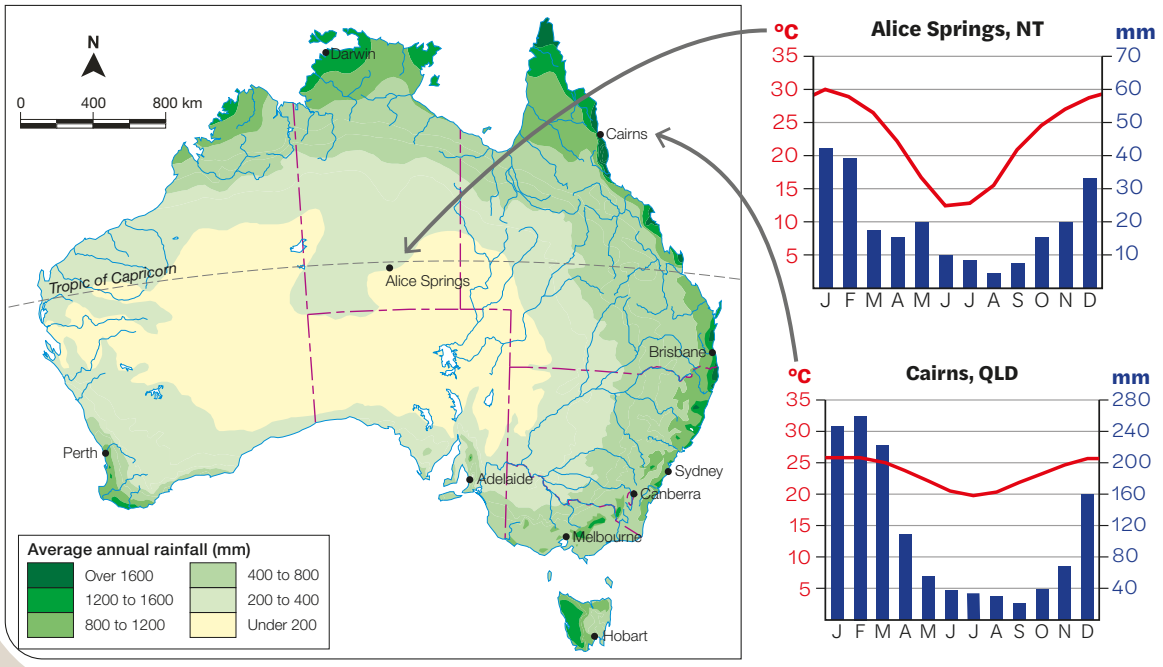
Water availability

Many factors influence water availability in a place, such as the amount of precipitation received or the over-use of water by farms, businesses and communities. Data on the amount of rainfall a location receives helps to understand how much water is accessible for that area across the year. Areas that have high rainfall tend to have a surplus of water, and authorities use that data to plan for infrastructure that prevents flooding and supports high water storage. Places with low rainfall tend to have a water deficit, where the demand for water exceeds supply. Authorities in these areas often spend more money on transporting water, or they rely on lower quality recycled or desalinated water.

Interpreting climate graphs

Climate graphs display the average rainfall and temperatures in a place across a year. Each climate graph has the months of the year along the ***x***-axis (the bottom), and for each month there is an average temperature (a line graph) and the average precipitation (a bar graph). As seen in Source 1, Alice Springs has an average temperature of 30°C in January and an average precipitation of 42 millimetres. This access to rainfall is vastly different to Cairns, which has a much higher average of 245 millimetres of rainfall in January. When comparing these graphs, it can also be seen that there is a pattern of more rainfall in summer months and the least amount of rainfall in August and September.

Australia average rainfall (millimetres)



Source 1: A map of Australia that shows the average precipitation each year across Australia. Two climate graphs are shown alongside this map, showing the difference in access to water between parts of Australia. The line graphs reflect temperature, and the bar graphs reflect rainfall.

Source: Matilda Education Australia

Australian cities variabillity in water quality

Location	pH	Turbidity (NTU)	Total dissolved solids (mg/L)	*E. Coli* (CFU/ 100 mL)
Sydney	7.2	1.2	600	0
Melbourne	7.4	0.8	500	0
Brisbane	7.1	1.5	650	2
Perth	7.3	1.0	550	0
Adelaide	7.5	1.3	700	1
Hobart	7.2	0.9	500	0

▲ **Source 2:** A table of data showcasing variability in the quality of water across Australian cities

Source: Matilda Education Australia

Geographers can use the trends to make predictions about the amount of water available and to assess if there are any changes to normal trends, such as if there is a drought or a flood.

Water quality

Water quality varies between places due to runoff, the geology of the area, land cover and discharges from industries. Some places in the world, such as cities in Indonesia, have over 6 million tonnes of sewage and waste released into rivers and lakes. This contributes to 50 000 deaths each year in Indonesia from people consuming poor-quality water. There are different factors that can be tested to assess the quality of water in a place:

- **Physical factors:** The colour, taste, odour and **turbidity** of water. High turbidity (over 10 NTU), a darker colour or an odour indicate a high concentration of particles.
- **Total dissolved solids (TDS):** The amount of minerals, salts or metals dissolved per litre of water. High concentrations of TDS can indicate pollution, lead, pesticides and nitrates.
- **General hardness (GH):** High concentrations of calcium and magnesium increase water hardness, shown in Source 2. This can impact fish species and cause a build-up in pipes.
- **pH:** An indication of how acidic water is. It ranges from 0 to 14, with 7 being neutral. Freshwater sources should be between 6.5 and 9.0. Some species need a specific pH to survive.
- **Bacteria factors:** The presence of bacteria, such as *Escherichia Coli*, indicates recent sewage or animal waste contamination. This can make people sick if they drink it.

Interpreting tables

Source 2 displays the differences in water quality between cities in Australia. Using this data, it can be identified which cities have higher water quality. Authorities could interpret this information to determine which cities require improved water treatment systems. According to this data, Brisbane has a lower water quality than Melbourne, as it has a higher TDS, turbidity and higher presence of *E. Coli*. However, when assessing data such as this it is important to consider how valid the data is by considering if the results could have been affected by where, how or when the information was collected.

Learning ladder 7.9

Representing and communicating information

1. Source 2: Create a bar graph that displays the difference in the total dissolved solids of water in the cities of Australia.
2. Source 1: Use the data at https://mea.digital/c6x to create a climate graph of Sydney. Start by creating the *x*-axis with the months. Then create a *y*-axis on the left that increases by 5 for temperature, and a *y*-axis on the right that increases by 20 for rainfall. Then plot all the maximum average temperatures for each month and connect the dots in a line graph. Do the same for the minimum temperatures. Next, create a bar graph using the right *y*-axis to plot the precipitation for each month.
3. Source 1: In which season is rainfall lowest in Alice Springs and Cairns?
4. Source 1: Compare the average rainfall in February for Alice Springs and Cairns.
5. Source 2: Which capital city has the best quality water? Justify your answer.

HOW TO

Climate graphs, page 421

How do we manage water?

Water resources need to be carefully managed to make sure there are reliable supplies of safe water and a healthy environment. There is great competition for water use from farms, factories and cities.

Maintaining water balance

Water balance describes the flow of water in and out of a system. Managing our water supply requires having an understanding of all of the water that comes in and out of that system (Source 2).

Inputs refer to water coming *into* the system. This includes rainfall, runoff into rivers and lakes, and water flowing into underground reserves, as well as additional water piped in from outside the system.

Outputs refer to water going *out* from a system. This includes evaporation from land and bodies of water, **transpiration** from plants, and our use of surface water and groundwater.

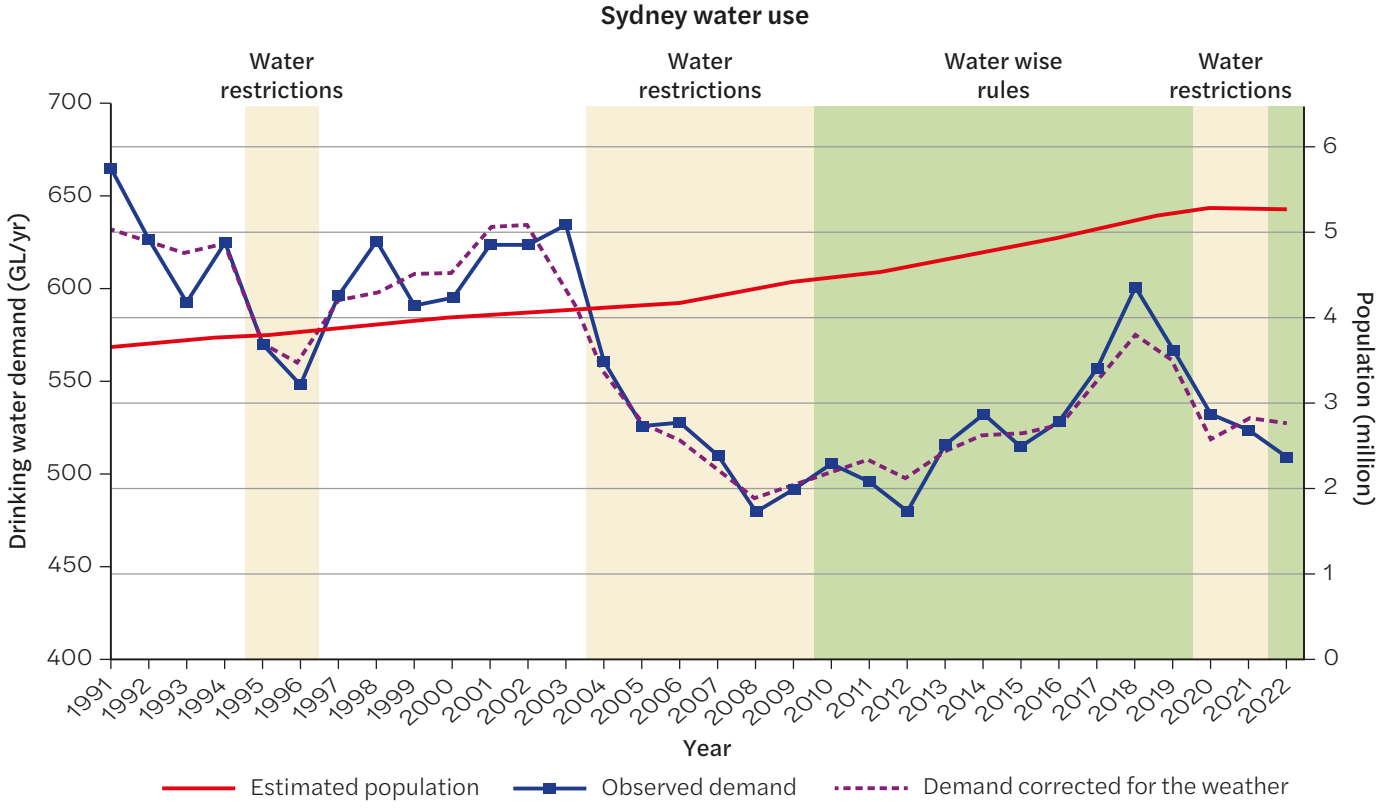
Governments and water authorities estimate the size of future water resources in a region. To do this, they have to calculate all of the inputs and all of the outputs.

Reliable water supply

Managing our precious fresh water supply is not easy, because:

- it is an essential resource for all
- water availability changes depending on rainfall, usage and evaporation
- water resources are shared among many competing users.

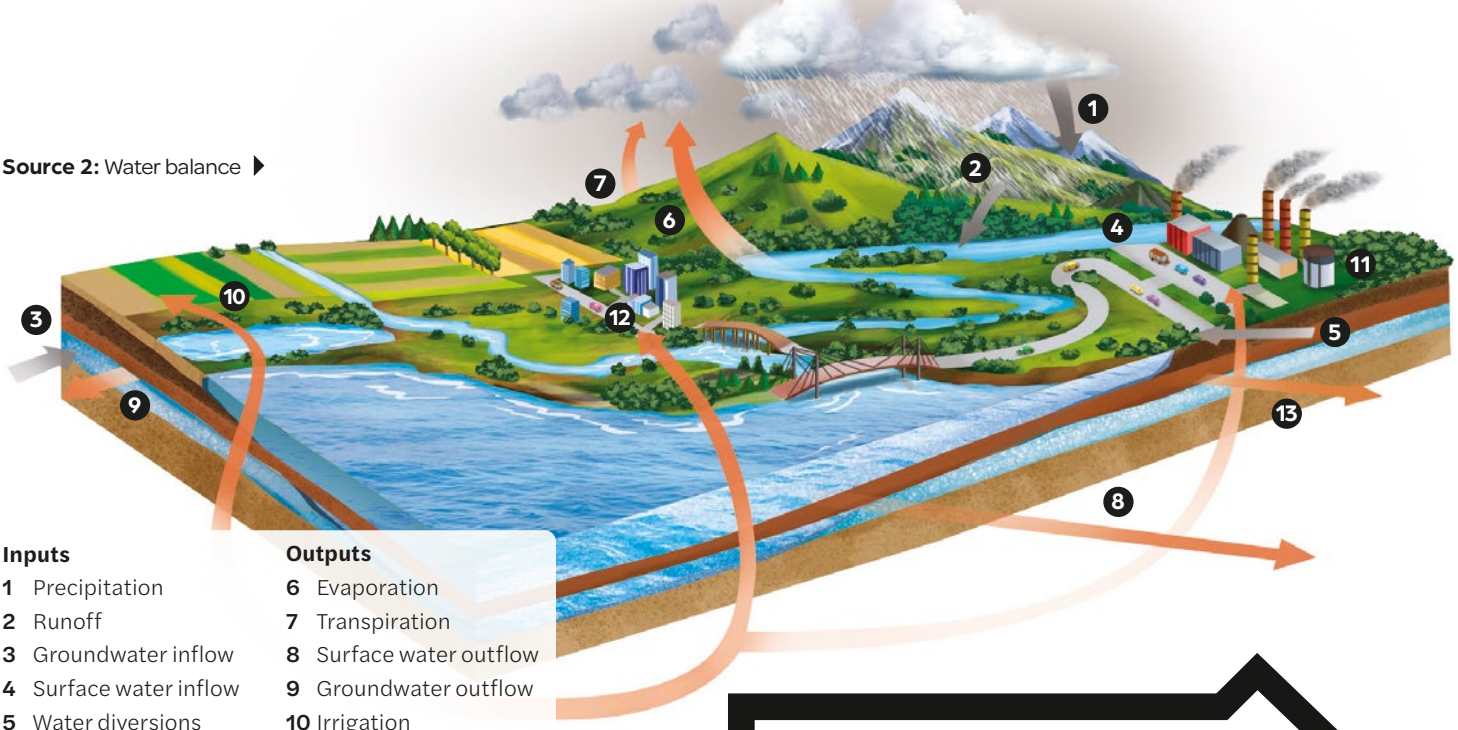
Every day, 1.5 billion litres of drinking water is supplied to over 5.3 million people in their homes and businesses in Sydney. About 80 per cent comes from Warragamba Dam, with the rest coming from other dams, the Hawkesbury-Nepean River and Sydney Desalination Plant at Kurnell. Water authorities monitor storage levels in the dams to ensure that there is enough water available to meet demands. Water restrictions are sometimes put in place to help balance supply and demand.



▲ **Source 1:** Sydney's demand for water 1991–2022

Source: Matilda Education Australia

Source 2: Water balance



Inputs
1 Precipitation
2 Runoff
3 Groundwater inflow
4 Surface water inflow
5 Water diversions

Outputs
6 Evaporation
7 Transpiration
8 Surface water outflow
9 Groundwater outflow
10 Irrigation
11 Industrial uses
12 Residential uses
13 Water diversions

Competition for Murray–Darling River water

Our largest river system, the Murray–Darling, does not carry much water compared to other rivers in the world. The **drainage basin** that supplies water to the Murray–Darling system receives about 530 000 gigalitres of water as rainfall – but then loses 94 per cent of this to evaporation and transpiration. Because Australia's climate varies so much, the actual amount of water in the river system can vary from less than 7000 gigalitres (in 2006) to almost 118 000 gigalitres (in 1956).

To ensure a regular supply of water from the Murray–Darling system, a series of water storages have been built: four major dams, 16 storage **weirs** and 15 navigable locks. The amount of water released from these dams depends on the amount of water entering the Murray–Darling system.

There are many competing uses for water from the Murray–Darling River system, including irrigation, recreation, navigation, hydroelectricity and water storage, along with water for cities, industry and maintaining the natural environment. Competition also exists between upstream and downstream users of water from the Murray–Darling River system and users in different states.

The Murray River spans three states: Victoria, New South Wales and South Australia. As a downstream user of the Murray River, South Australia is always affected by how the water is used upstream. To ensure fairness in management, the river system is controlled by the independent Murray–Darling Basin Authority.

Learning ladder 7.10

Sustainable management strategies

1. Why are water storages such as dams an important part of water supply?
2. Source 1: Look at the graph. Use the PQE method to describe and quantify the pattern.
3. How have changes in water use helped maintain Sydney's water supply?
4. What are competing uses for water from the Murray–Darling River system?
5. What advantages do skinny, deep dams have over wide, shallow dams in terms of evaporation? What other strategies could reduce evaporation loss of water supplies?

Interconnection

1. What water movements in and out of the Murray–Darling Basin cause the water supply to vary so much?
2. Source 2: Use the block diagram to describe interconnections in this environment.
   - **a** What are the natural inputs and outputs of a water system?
   - **b** What are the human inputs and outputs?
3. Source 1: What is the interconnection between water restrictions and demand for water?
4. Source 2: Summarise how our environment maintains a water balance. Use the concept of interconnection in your writing.

HOW TO

PQE, page 412; Interconnection, page 392

Case study

How can we make fresh water?

Australia's largest desalination plant is the Dalyston facility in Victoria. A desalination plant removes salt and impurities from sea water and turns it into fresh water.

Planning for the **desalination** plant started in 2007, when Melbourne's dam water storages fell below 30 per cent – their lowest level ever. The plant was built to supply Melbourne with water in times of drought. It was completed in 2012, but not used until 2017.

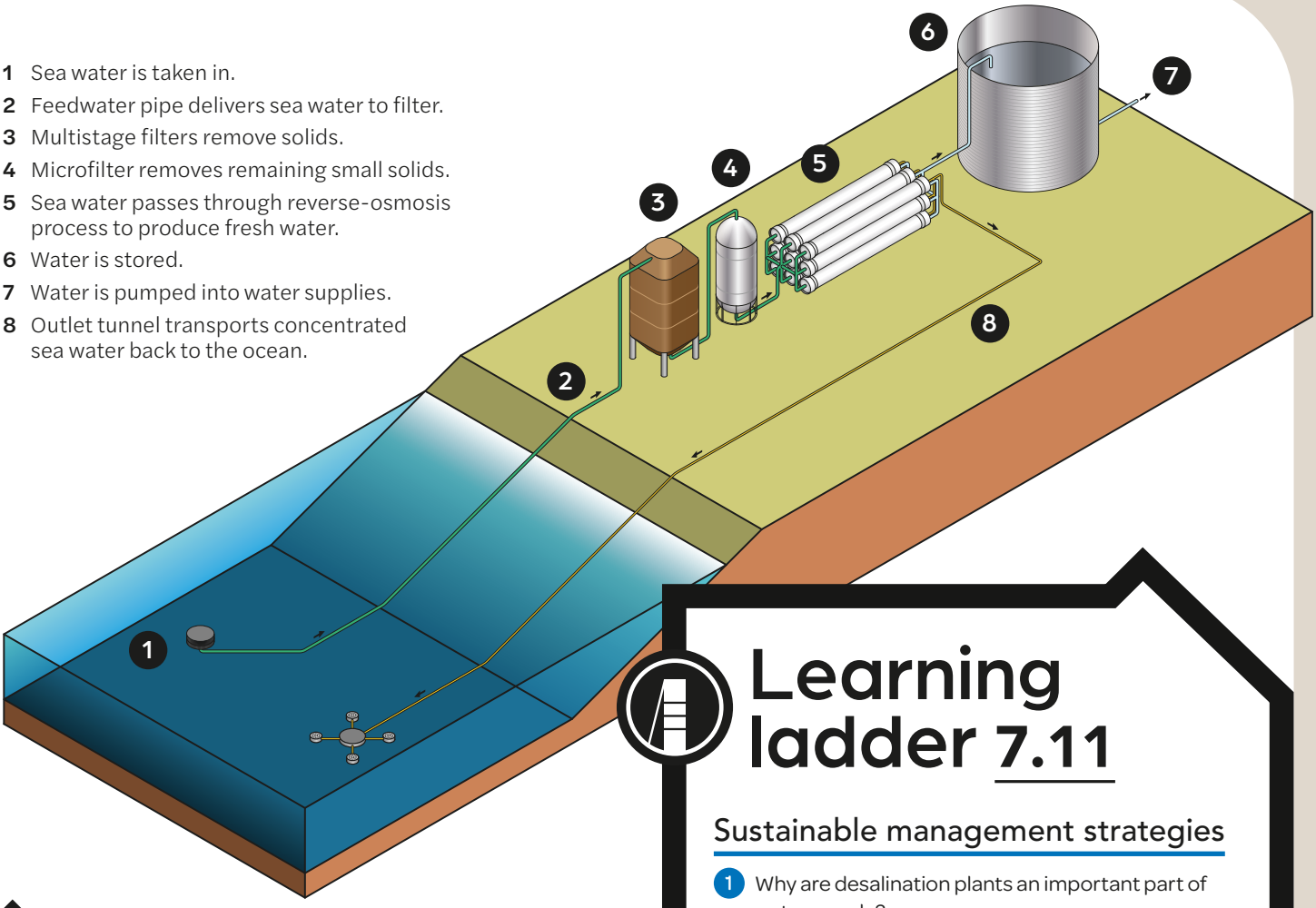
The desalination plant costs over $600 million per year to run and can produce up to 150 gigalitres (150 billion litres) of water each year. It is powered by 100 per cent renewable energy. The desalination plant has supplied 455 gigalitres of water since 2017.

The plant takes in sea water through a pipeline 1.2 kilometres long. Sea water passes through filters and then through two stages of a process called **reverse osmosis**, where it is pushed under high pressure through ultra-fine filters (called membranes). Fresh water passes through the membranes and leaves the salt and other impurities behind.

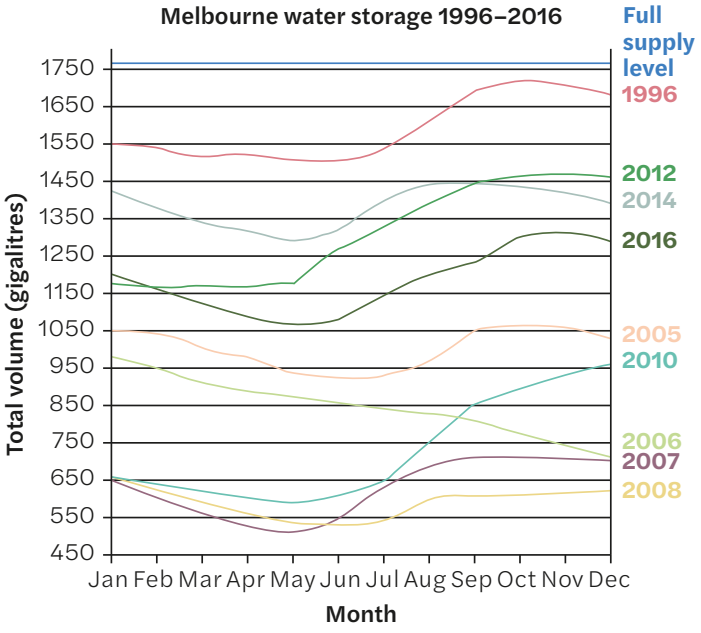
Drinking water is then pumped via an 84-kilometre pipeline from the Dalyston plant to Cardinia Reservoir, near Melbourne.

Source 1: Oblique aerial view of the Dalyston desalination plant. The long intake and outlet tunnels are buried beneath the ground and are not visible in this image.

1 Sea water is taken in.
2 Feedwater pipe delivers sea water to filter.
3 Multistage filters remove solids.
4 Microfilter removes remaining small solids.
5 Sea water passes through reverse-osmosis process to produce fresh water.
6 Water is stored.
7 Water is pumped into water supplies.
8 Outlet tunnel transports concentrated sea water back to the ocean.



Source 2: How a reverse-osmosis water desalination plant works



Source 3: Total volume of water in Melbourne water storage, 1996–2016

Source: State Government of Victoria, Department of Environment, Land, Water and Planning, 2017

Learning ladder 7.11

Sustainable management strategies

1 Why are desalination plants an important part of water supply?
2 Source 2: Describe the steps involved in making fresh water from sea water.
3 How was the construction of the desalination plant a response to water scarcity?
4 In 2024–25, no water was ordered at all from the Dalyston desalination facility. Why do you think this was the case?
5 Source 2: What threats do you think the inlet and outlet tunnels pose to the environment?

Change

1 Why was the desalination plant at Dalyston built?
2 Source 3: Look at the graph. Use the data to answer these questions.
   a At what time of year does water storage peak?
   b When were the lowest storage levels recorded?
3 Source 3: Look at the graph.
   a Why do you think plans to build a desalination plant began in 2007?
   b Why do you think the desalination plant was not used until 2017?
4 Many people living near Dalyston protested against the plant being built. Discuss the issues they might have raised.

HOW TO

Change, page 394

How can we save water at home?

Most Australians are lucky to have instant access to clean, safe water at home. Per person, Australia is one of the biggest users of water in the world – but we can all help save water in the home with a few simple changes.

Domestic water use

Most Australian homes have good access to a reliable supply of clean water. As the country's supply of fresh water is low and varies a lot, Australian governments have encouraged water conservation and introduced water restrictions during times of drought.

Domestic use of water only accounts for 12 per cent of Australia's total water use, but Australia has one of the highest rates of water consumption per person in the world. The average daily water use for Sydney in 2023 was 200 litres per person. Average water consumption ranges from 100 litres per person in some coastal areas to more than 800 litres per person in the **arid** inland areas.

Most homes have a water meter at the front of the property. You can measure how much water your home uses in a day by recording the difference between meter readings, 24 hours apart. The red numbers show water use in litres.

Saving water in the home

More than 1.7 million Australian households have installed rainwater tanks – saving both water and money. Water collected in rainwater tanks is usually used for watering the garden and flushing toilets. It also provides an alternative supply of water during times of drought.

To improve water management in the home, we can capture water, **recycle** water or use less water. We can select water-saving appliances such as low-flush toilets and water-efficient showerheads to reduce the amount of water we use.

Source 1: Water-saving measures at home help to save our valuable water. Between water restrictions and changes in water use, the amount of water used by Australian households fell 12 per cent between 2003 and 2009 – despite a population increase of 7.7 per cent.

2 Roof
- Install rainwater catchment system.
- Connect gutters to water tanks.

3 Bathroom
- Use water-saving showerhead.
- Install low-flush toilet.

1 Laundry
- Install water-saving appliances.
- Install greywater system.

4 Kitchen
- Install water-saving appliances.
- Use low-flow taps.

6 External
- Ensure pipes are in good order.
- Fix leaks quickly.
- Install and check water meter to measure usage.

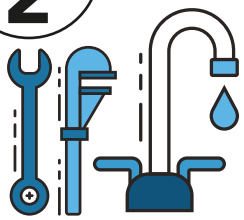
5 Garden
- Use drip irrigation.
- Plant drought-resistant plants.
- Obtain water from rain tanks.

TOP TIPS FOR SAVING WATER

TIP 1

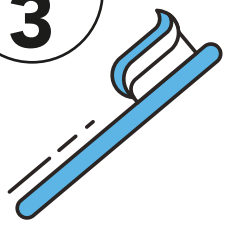
Install a dual-flush toilet and do not dispose of rubbish in toilets.

TIP 2



Check and repair all leaks.

TIP 3



Do not leave water running when brushing your teeth, shaving or washing dishes.

TIP 4

Install water-saving showerheads and limit showers to 4 minutes.

TIP 5

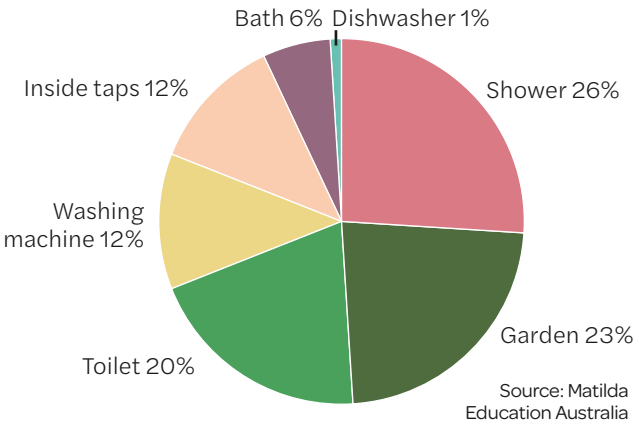
Use full loads in the dishwasher and washing machine. Use an eco setting where possible.

TIP 6

Other ways you can save water include watering the garden in the early morning and late evening, installing a rainwater tank and using buckets of water for cleaning.

▲ **Source 2:** Tips for saving water

Australia: Domestic water use



▲ **Source 3:** Domestic water use in Australia

Learning ladder 7.12

Sustainable management strategies

1. How much of Australia's total water use occurs in our homes?
2. Source 3: Examine the pie chart.
   - **a** Where is most domestic water used? List three ways we can reduce domestic water use.
   - **b** Which is the most water-hungry appliance inside the house? How can we reduce water use in this area?
3. Source 1: Which of the water-saving measures shown here do you use at your home?
4. Sources 2 and 3: Which type of savings will make the greatest difference in home water useage and why?

Scale

1. Source 2: What scale are these initiatives implemented at: local, national or global?
2. Source 1: List water-saving appliances that can reduce the amount of water you use on a local scale.
3. Sydney's population is around 5 million people. How much water could Sydney save if average daily use was cut to 150 litres per person?
4. Water restrictions are implemented by governments on a state scale. How do these influence decisions people make on a local scale?
5. Develop a strategy that the national government could implement to reduce people's water use at home. Explain how it would work, and what its limitations would be.

HOW TO Scale, page 398

Can India 'catch the rain' to overcome economic water scarcity?

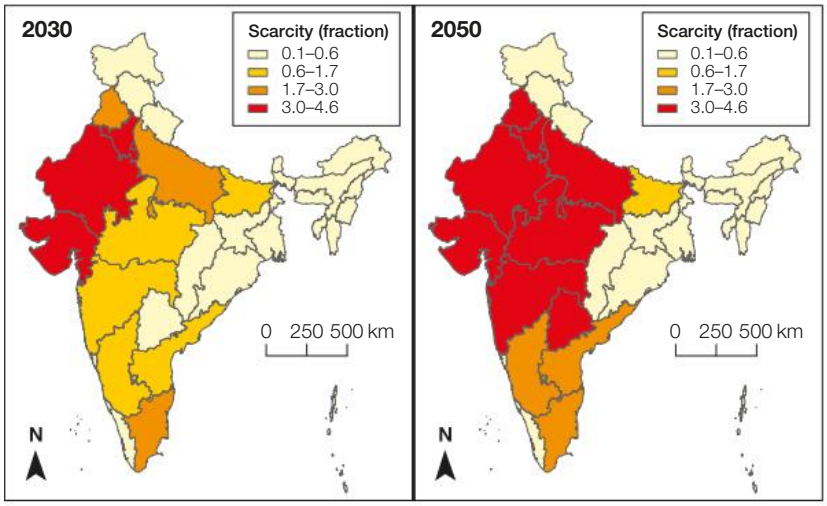
Economic water scarcity occurs when a place lacks the necessary infrastructure or resources to manage its available water effectively, leading to less water being available for communities, agriculture and industries.

India's economic water scarcity

India, a country with only 4 per cent of the world's water resources, experiences significant economic water scarcity challenges. Reasons for this include the increasing population, which is already as high as 1.4 billion people, the overexploitation of existing water sources, high levels of water pollution and inadequate infrastructure resulting in poor water supply networks. These challenges all contribute to a reduced supply of quality drinking water and high costs to treat the water that is accessible. Water is then unaffordable for families, resulting in nearly 400 000 people dying in India per year due to water scarcity issues.

These challenges reduce access to water, increasing the cost communities and families need to pay to access safe drinking water. Nearly 400 000 people die a year in India as a result of these water-scarcity challenges.

India projected water scarcity



▲ **Source 1:** The projected changing water scarcity across India is shown in these choropleth maps.

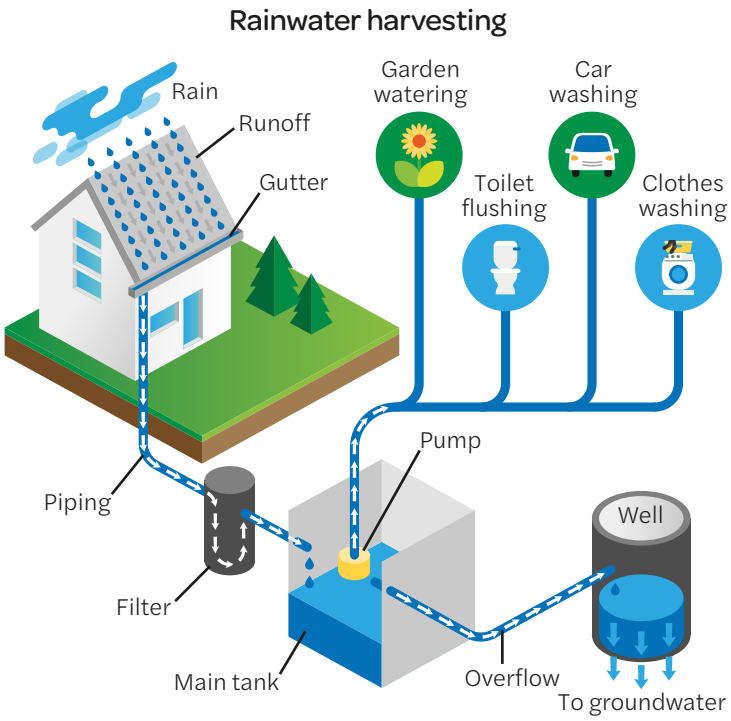
Source: Matilda Education Australia

Can the 'Catch the rain' campaign help?

In 2021, the Indian government introduced a 'Catch the rain' campaign aimed at diversifying water resources across the country to improve water scarcity. Through the campaign, the government aims to improve water conservation long term, so more people can access safe and affordable water. Central and state funding is allocated to achieve the main aims, including:

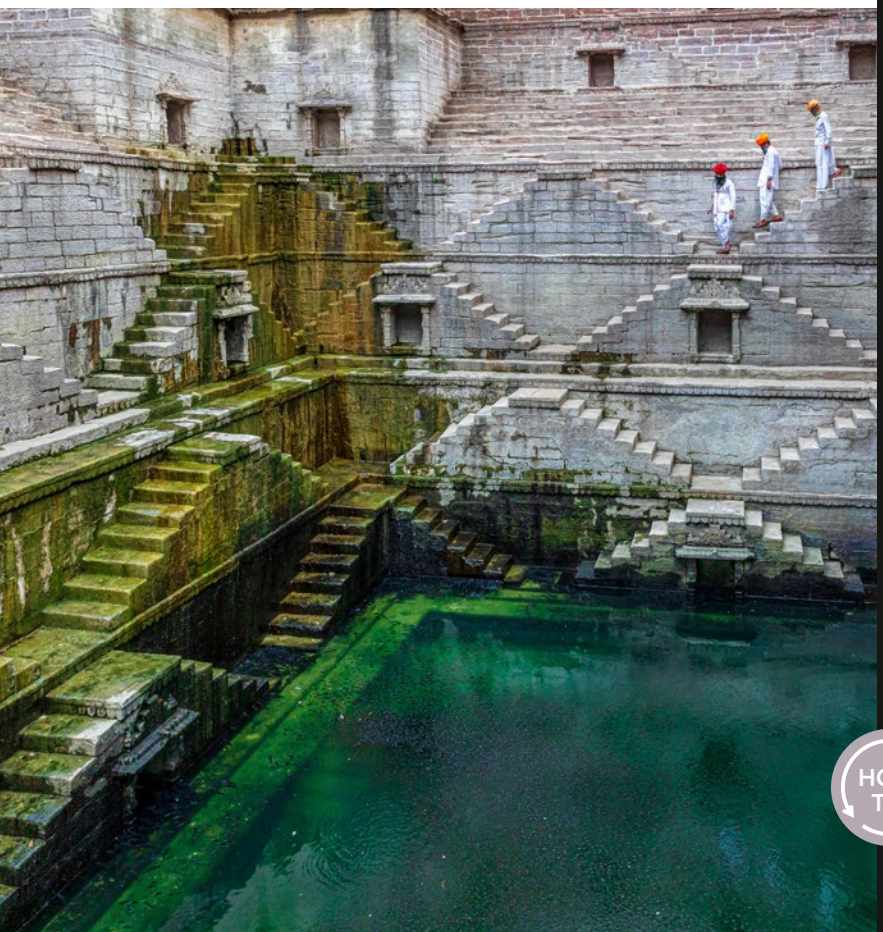
- developing new and repairing existing rainwater-harvesting structures (RWHS), such as rainwater tanks, stepwells (see Source 3) and snow harvesting
- geotagging all water bodies so researchers and communities can monitor water levels across the nation and plan the use of water effectively
- setting up Jal Shakti Kendras in all districts, which are knowledge centres that help communities understand water-conservation strategies
- afforestation around natural water bodies so runoff replenishes groundwater and catchments each monsoon season.

Each of these aims are prioritising 'catching' natural rainfall to improve access to clean water. Since its inception, over 256 water-stressed districts across India have developed new RWHS and over 527 districts have developed new water conservation plans. RWHS systems are beneficial, as they allow water to be collected and treated on a local scale without having a large impact on natural water-cycle processes or downstream, the way larger scale strategies such as dams do. They are also cost-effective, enabling many structures to be implemented quickly and maintained easily for the long term.



Source 2: Building rainwater-harvesting structures (RWHS) is a key aim of the 'Catch the rain' campaign. These systems collect and filter rainwater, which is used by families and communities. Excessive water is released to replenish groundwater resources, making this a more sustainable water solution.

Source 3: A stepwell in India. These are traditional rainwater-harvesting systems that have served as water reservoirs across India for years. Repairing and maintaining these traditional systems can improve access to water for many communities.



However, they require reliable rainfall and may not store enough water to supply local areas with excessive populations.

Snow harvesting

Some dry areas in northern India experience minimal rainfall and very dry summers, making traditional RWHS ineffective. Under the 'Catch the rain' campaign, investment is being made to create new snow-harvesting technologies. These technologies catch melting snow and glaciers, either at a household level or a community level, and store them in tanks or vertical ice stupas, which store up to 15000 cubic litres of water each. The water can be treated and desilted to become safe for drinking, or it can be used to water crops or for sanitation.

Learning ladder 7.13

Sustainable management strategies

1. Identify one strategy used in the 'Catch the rain' campaign.
2. How does the 'Catch the rain' campaign aim to address economic water scarcity in India?
3. Source 2: Explain how rainwater-harvesting structures (RWHS) contribute to long-term water conservation and sustainability in India.
4. Source 3: Explain how repairing and maintaining traditional rainwater-harvesting structures can have social, environmental and economic benefits.
5. Assess the effectiveness of afforestation around natural water bodies as a strategy for improving water availability in India.

Sustainability

1. Define 'economic water scarcity' and explain how it affects communities.
2. Source 1: Describe the challenges of addressing water scarcity in different parts of India.
3. Explain the social and economic impacts of the 'Catch the rain' campaign.
4. How effective is the 'Catch the rain' campaign at improving unsustainable practices?
5. Discuss the potential limitations of snow-harvesting technologies as being sustainable solutions to water scarcity.

HOW TO Sustainability, page 400

Can China's sponge cities improve the sustainability of their catchments?

China has implemented 'sponge cities' to sustainably manage their catchments. A catchment is an area of land where all precipitation collects and drains off into a common outlet, such as a river, lake or other body of water. Human activities such as urbanisation and agriculture have impacted the natural water cycle in catchments around the world by changing the surface and topography of land (Source 1). Increased concrete surfaces reduce water infiltration to soils, leading to excess water runoff into catchments that can result in flooding or the pollution of local water sources. Altered topography can also change the natural direction of water flows, or impact natural evaporation or transpiration rates.

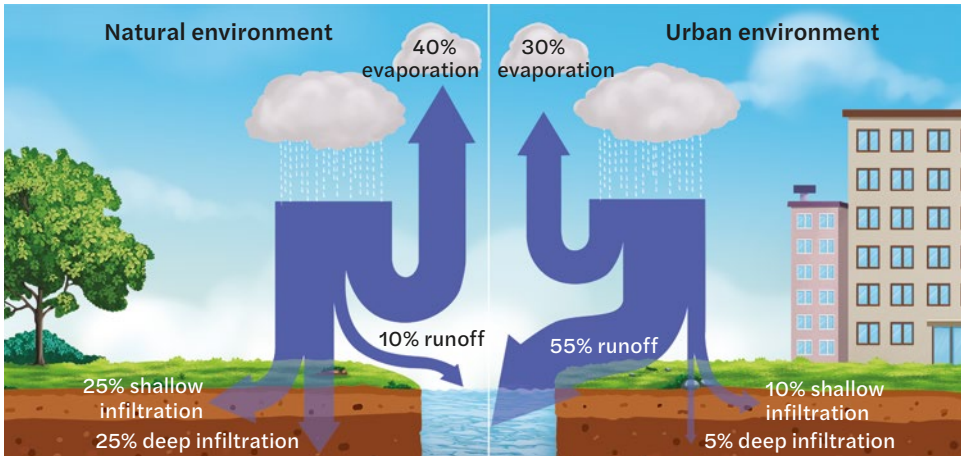
What are 'sponge cities'?

By 2030, China aims to develop 80 per cent of their urban spaces into sponge cities. This involves replacing concrete and asphalt with green infrastructure in cities that absorb, store and purify rainwater. Instead, there will be large permeable surfaces, green roofs, parks, wetlands, drainage systems and trenches called bioswales that channel stormwater runoff and use vegetation to filter out debris and pollution. This infrastructure acts like a sponge, absorbing and filtering water during rainfall events, slowing the flow of runoff and encouraging the reabsorption of water back into the groundwater system. This more closely mimics natural water-cycle processes and improves access to water for the city's population.

The benefits

This strategy is sustainable as it considers the whole water cycle, is environmentally adaptive, and aims for sustainable and resilient urban water systems. There are many benefits:

- The volume and flow of water runoff is reduced, which improves infiltration and evapotranspiration. This reduces the chance of flooding and protects downstream water resources such as wetlands from excessive runoff.
- Up to 70 per cent of rainwater is recycled and reused, increasing access to water for city residents.
- Groundwater aquifers are recharged.
- The amount of water discharged into sewerage systems is reduced, protecting water from sewer overflows and contamination.
- Increased vegetation through the parks and wetlands filters urban pollution from entering natural waterways. They also offset carbon emissions by absorbing greenhouse gases.
- The green infrastructure provides habitat and food for birds, fish and mammals, increasing the biodiversity of urban spaces.



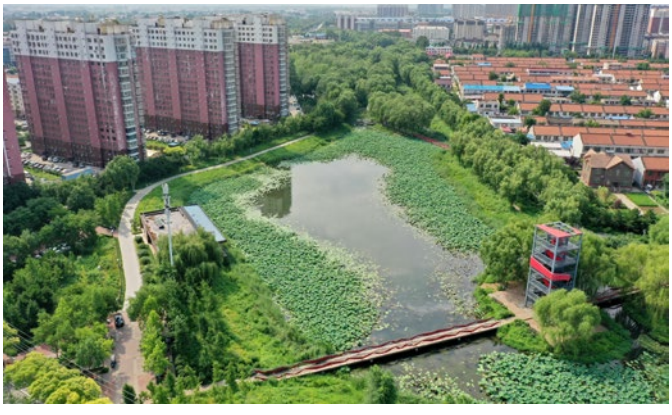
▲ **Source 1:** This diagram shows the impacts of urban environments on natural water cycles, as the concrete and asphalt prevent water from infiltrating the ground, leading to excessive runoff, flooding urban spaces and local water bodies.

Source 2: Photographs of the Haikou Meishe River before (left) and after (right) implementing the sponge-city initiative. These green spaces improve water infiltration and slow runoff into water sources. This water storage enables the city to access water in times of drought.

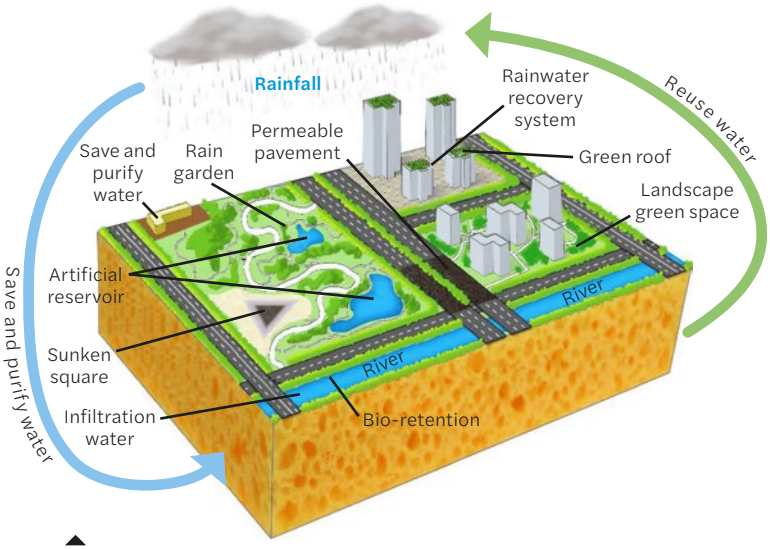
- The low-technology solution helps overheated city neighbourhoods, as the evaporated water from green infrastructure has a cooling effect.
- The terraces, ponds and wetlands provide additional recreational spaces for urban residents.

Considerations

Many cities are already established spaces with large amounts of concrete and asphalt, making it difficult and expensive to demolish and implement large green infrastructure and floodplains, such as ponds and wetlands. By 2023, only 64 of the 654 Chinese cities had legislation to implement sponge-city guidelines. In addition, recent research states that sponge-city infrastructure can handle no more than 200 millilitres of rain per day. With climate change increasing the severity of storms, some Chinese cities are receiving more than that per storm, with the city of Zhengzhou receiving 200 millilitres of rain in just one hour in 2021. Irrespective, the sponge-city model is being adopted by other cities in the world, including Copenhagen, Philadelphia and Malmo.



Source 4: A photograph of a pond that helps reserve precipitation in the ecological corridor in Qian'an City of north China's Hebei Province.



Source 3: A diagram of the strategies used to implement the sponge-city initiative. Combining these strategies can improve natural water-cycle processes in a city, increasing the infiltration and storage of rainwater while reducing flooding and excessive runoff. The stored water is recycled and used to improve water access in the city.

Learning ladder 7.14

Sustainable management strategies

1. What are 'sponge cities'?
2. Source 1: Describe how sponge cities aim to mimic natural water cycles.
3. Source 3: Explain three ways in which sponge cities reduce the impact of urban runoff.
4. Discuss the challenges faced by sponge cities in managing extreme rainfall events.
5. Referring to Sources 2 and 4, assess how sponge cities integrate social, economic and environmental aspects of sustainability.

Place

1. What are the natural and human characteristics of Chinese sponge cities?
2. Sources 2 and 4: Describe how the sponge-city initiative changed the characteristics of Chinese cities.
3. Source 3: Explain the social and economic benefits of implementing sponge-city strategies in Chinese cities.
4. Can the sponge-city initiative protect places in the future? Explain your answer.

HOW TO

Place, page 390

First Nation Peoples

How do First Nations Peoples care for water Country?

First Nations Peoples have understood the importance of water forever. Water has always been considered a precious resource and one that is crucial for life to survive and thrive across the Australian continent and adjacent islands. With the colonisation of Australia by the British, the land and waterscapes across Australia were severely changed and this has impacted Australia's ecology and environment ever since.

Stories of water

There are many First Nations stories focused on the importance of water and why it should be managed as part of caring for Country. One of the more well-known stories is about Tiddalik the frog, who drank all the water in the landscape. This story highlights, among other aspects, the importance of managing water across Country to ensure that it is used sustainably and there is enough for everyone. For many First Nations communities, there has always been an understanding that water is life, and as such, it needs to be considered when caring for Country.

Freshwater and Saltwater

Broadly, First Nations Peoples' relationships with water can be split into two main groups: Saltwater people, from coastal regions of Australia, and Freshwater people mostly from inland riverine systems. In these places much of the law and lore regarding water is unique to the local geography, meteorology, biodiversity and cultural contexts, but a consistent theme is caring for water and waterways for sustainability.

Source 1: This is an example from Erub (Darnley) island, Torres Strait, of intertidal fish traps that were once common across Australia's coastline. The effects of colonisation have caused significant damage to many of these traps. The trap was designed with the contours of the coastline and allowed for sustainable fishing for millennia.

For all First Nations groups, caring for water is influenced by many factors such as geographical formations, weather patterns and seasons, reproductive cycles of plants, animals and fish, tidal cycles and migration cycles. An intimate knowledge of the interactions of these systems has meant that they they have always been sustainable and supported food security.

In a Saltwater context, tidal movements and water flows are modified and incorporated into aquacultural farming practices. In one example, large rocks were moved into position adjacent to some naturally occurring rock pools off the coast of Northern Lutruwita/Tasmania. This allowed the water to flow into the rock pools at high tide as well as providing channels for the fish to enter to eat the carefully cultivated food sources in the pools; when the tide lowered, the fish were unable to leave and were easily caught. Part of this process was also an understanding that Country and the fish had to be honoured by only taking what was needed. Any remaining fish were able to leave once the tide came in again. This practice was common across many places around the Australian continent and adjacent islands.

In a Freshwater context, the Brewarrina fish traps are an example where intertidal traps have been constructed

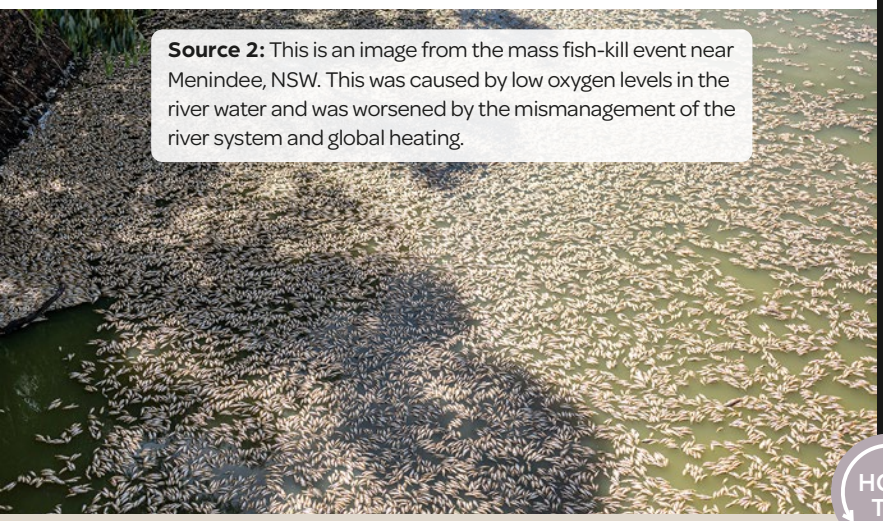
in the river in partnership with the river bed and the water flow to allow freshwater fish to be gathered in semicircular stone weirs. The fish are captured by these traps and can be held there for some time before they are caught and eaten. To maintain sustainability, the rocks can be removed to allow the free flow of many species of freshwater fish to their migratory spawning places.

In addition to the fish traps themselves, another important way that freshwater systems were managed was through constructing rock and earth weirs from alternating points in the riverbanks. This would force the water into a slower flowing, zigzag motion. This meant it would remain in the river system for longer and a greater volume would be absorbed into the soil to support the plant, animal and bird life further from the river. Many of these were destroyed to make way for the large paddle steamers, which used the extensive Murray–Darling River system to support inland trade routes.

When things go wrong

Climate change and global heating is beginning to seriously impact freshwater riverine systems globally. At the end of 2018 and the beginning of 2019, there was a mass fish-kill event across a 40-kilometre stretch of the Darling River. During this event it is estimated that over 1 million fish died from a lack of oxygen in the water system. This event was caused by drought, a sudden drop in the temperature, bushfire runoff, algal blooms, and too much water being taken from the system for unsustainable farming practices and water-intensive crops.

Many riverine First Nations communities were directly impacted by this event, and this impacted food and water sources. It should be noted that there were many factors outside of human control, but that these factors were made more severe due to unsustainable water-usage practices and human-caused global heating.



Source 2: This is an image from the mass fish-kill event near Menindee, NSW. This was caused by low oxygen levels in the river water and was worsened by the mismanagement of the river system and global heating.

First Nations knowledge leading the way

There has been much debate focused on more sustainable water management practices in Australia, and one way forward is better integration of First Nations knowledge and leadership when making decisions on matters relating to water. An example of how effective this approach has been is the establishment of the Aboriginal Ranger Program in NSW. This program has been successful in several important ways. It has provided opportunities for First Nations people to gain valuable experience and qualification in land management, has provided opportunities to strengthen cultural knowledge, and has begun to impact the landscape directly to offset the impacts of global heating and biodiversity loss caused by colonisation.

Learning ladder 7.15

First Nations Peoples' interaction with Country

1. What is one story that has been used to teach First Nations children about the importance of water?
2. What are the two main distinctions made between coastal and non-arid inland First Nations people?
3. List three or more factors that influenced how First Nations people have cared for water?
4. Source 2: How did the farming practices in the Murray–Darling River system contribute to the mass fish-kill event?
5. How has the Aboriginal Ranger Program successfully supported people and Country?

Sustainability

1. Source 1: What are the renewable sources of food that can be caught from intertidal traps?
2. How did First Nations people adjust the river banks to make the water stay in the river system for longer?
3. Source 1: How were the fish traps designed to ensure that surplus fish caught in them didn't die?
4. How do First Nations people understand water, and what does this mean for future generations?
5. How do the water management practices in the Murray–Darling system differ between First Nations and non-Indigenous communities? How would these practices have impacted, for better or worse, the fish-kill event?

HOW TO

Sustainability, page 400

Hydrological and atmospheric hazards

8

WHAT IS THE IMPACT OF FLOODS? 282

8.0

How can I understand hydrological and atmospheric hazards?

Hydrological and atmospheric hazards account for 90 per cent of environmental hazards. Droughts, floods and other hazards are becoming more intense due to climate change.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
	Outcomes					Geographical tools and inquiry
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information

Source 1: Commuters wade through floodwaters in Pakistan in July 2023 when the Chenab River burst its banks and inundated at least 50 villages.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							Steps in skill progression

What are hydrological and atmospheric hazards?

Environmental hazards are extreme natural events that can threaten people and ecosystems. Hydrological and atmospheric hazards are types of environmental hazards linked to water and weather systems, such as tropical cyclones and droughts. When these events cause widespread damage or loss of life, they are called natural disasters.

The water cycle and the weather

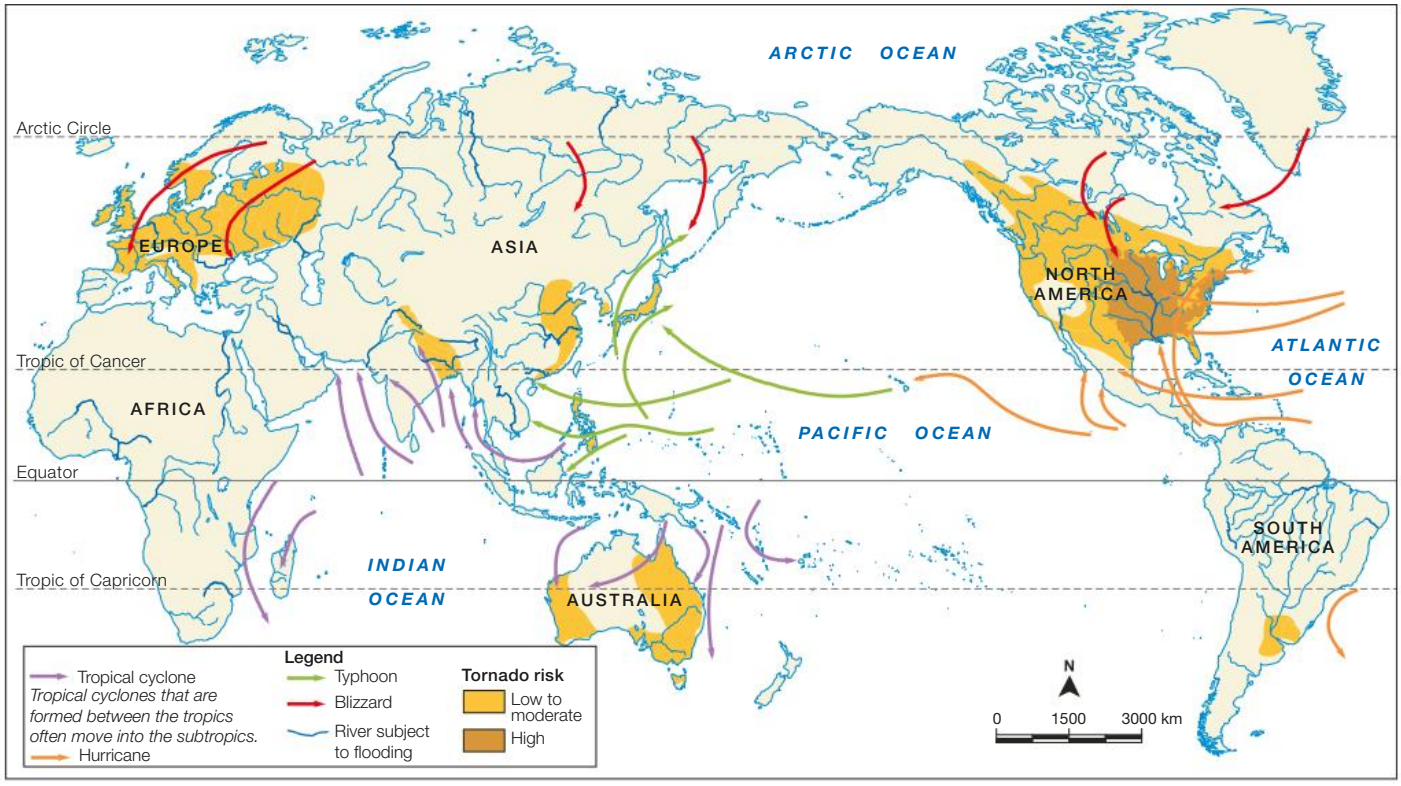
Hydrological and atmospheric hazards are often grouped together because the atmosphere and hydrosphere are closely linked. For example, **tropical cyclones** form in the atmosphere over warm oceans and produce heavy rain and **storm surges** in the ocean. Currently over 90 per cent of environmental hazards are hydrological or atmospheric. They are increasing in frequency and intensity due to climate change. As heatwaves and heavy rainfall events become more common, cyclones become stronger due to warming waters, and rising sea levels worsen the impacts of coastal flooding and storm surges. As these hazards are natural events, prevention is not possible and communities need to be prepared with warning systems and evacuation plans.

Different scales

Hazards can occur on different scales. Some are localised, affecting only a few cities or towns, such as the 2011 tornado in Joplin, United States. It had wind speeds of 320 km/hr and killed 158 people, injuring over 1000 and destroying thousands of homes, schools and businesses. It caused more than US$2.8 billion in damage. Some other atmospheric and hydrologic hazards can affect entire regions and countries, such as the 2019–2020 Black Summer bushfires and drought in Australia. In this instance multiple states were affected, over 3000 homes were destroyed and more than 18 million hectares of land burnt. The combination of prolonged drought, extreme heat and low humidity created dangerous fire conditions across the country. The widespread impacts included loss of life, damaged ecosystems, poor air quality, and economic losses in national agriculture and tourism.

Source 1: Tornadoes are an atmospheric hazard. They form within large thunderclouds called supercells. Tornadoes are fast-spinning winds of up to 400 kilometres per hour. They descend in a funnel of spinning wind from the supercell to the ground. Low air pressure at the centre of the tornado forces surrounding air to quickly move into this low-pressure area, picking up, cars, buildings, trees, livestock and people with it. Tornadoes forming over the sea or a lake can lift large amounts of water to form waterspouts.

World atmospheric and hydrological hazards



Source: Matilda Education Australia

▲ **Source 2:** Spatial distribution of atmospheric and hydrological hazards

Learning ladder 8.1

Processes that transform people, places and environments

1. What are atmospheric hazards? Provide an example.
2. What is the main difference between a natural hazard and a natural disaster?
3. How is a cyclone both an atmospheric and hydrological disaster?
4. Source 1: Create a labelled diagram of a tornado to explain how this atmospheric hazard is formed and its impacts.

Space

1. Source 1: Where do waterspouts form?
2. Source 2: Describe the region of the world where tornado risk is the greatest.
3. Sources 2: Suggest reasons to explain the pattern of cyclones, hurricanes and typhoons.
4. Sources 1 and 2: What steps might people take to manage the risk of living in a high-risk tornado area?

HOW TO Space, page 388

How does climate change lead to more intense and frequent hazards?

Climate change refers to long-term shifts in the Earth's climate patterns, primarily caused by human activities releasing greenhouse gases into the atmosphere. These gases, such as methane and carbon dioxide, trap heat in the atmosphere and lead to global warming. This increases temperatures, changes precipitation patterns and affects water access around the world, leading to more frequent and severe hydrological and atmospheric hazards, such as cyclones, droughts and floods. These hazards are five times more frequent today than they were in 1970.

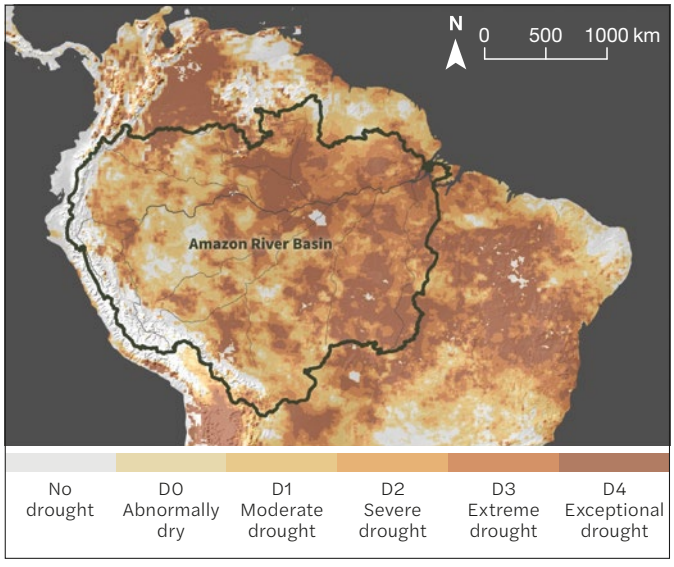
Heatwaves and drought

Climate change increases average daily temperatures around the world, leading to hotter days, and more frequent and intense heatwaves. Heatwaves increase evaporation and dry out soils, making the air above the Earth warm up more quickly and increasing intense heat further. Warmer temperatures also reduce snowfall, decreasing the amount of water that melts and runs downstream of rivers in spring. These factors increase the risk of drought events, as seen in East Africa, which suffered its worst drought between 2020 and 2022, as they had five consecutive failed rainy seasons. This displaced more than 1.2 million people in Somalia alone.

Wildfires

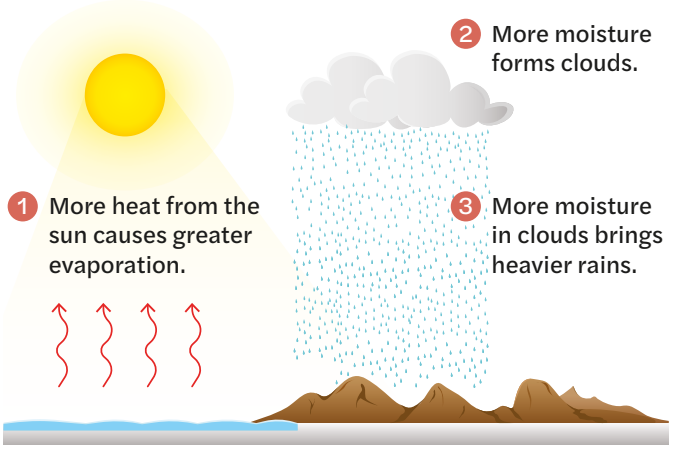
Higher temperatures and dry conditions lead to dried-out vegetation, such as dead trees and fallen branches, increasing the risk of wildfires. Dry vegetation and grasses fuel fires, making them move faster and burn more intensely. This has affected places such as Canada, the United States, Siberia and Australia in the last decade alone. Further, as vegetation burns it releases more greenhouse gases and removes trees

Amazon Basin drought June–November 2023

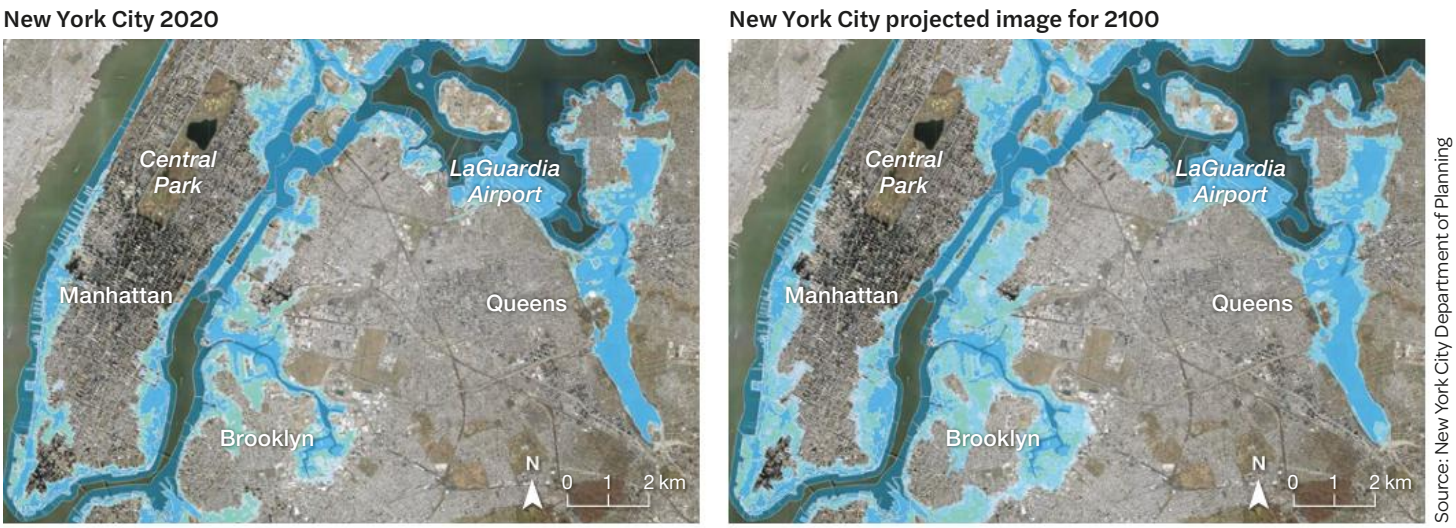


Source: NOAA Climate.gov; data: WAA/Ben Clarke

Source 1: A map showcasing the increase in frequency and intensity of drought periods in the Amazon Basin. This has effects on environmental processes, habitats and species.



Source 2: A diagram explaining how increased temperatures can result in extreme rainfall



▲ **Source 3:** A satellite image of New York City showcasing the threat of floods in 2020 (left) and a projection for 2100 (right). Most coastal cities and towns are at risk of flooding, due to climate change influenced sea level rise and heavier rainfall.

that absorb carbon dioxide, increasing the rate of climate change around the world. It is predicted that wildfires will be 54 per cent more frequent by 2050.

Tropical cyclones

Warmer ocean temperatures provide more energy to fuel tropical cyclones, leading to stronger and more destructive storms. Additionally, changes in atmospheric circulation patterns may affect the tracks and intensities of these storms, increasing the likelihood of severe impacts such as storm surges, heavy rainfall and wind damage. The formation of cyclones usually requires a greater temperature difference between the ocean and cooler atmosphere, so as the Earth warms, there is likely to be less frequent cyclones. However, the cyclones that do form will be more severe.

Floods

Climate change can also disrupt traditional precipitation patterns, leading to more frequent and intense rainfall events in some regions. For every 1°C rise in average temperature, the atmosphere can hold about 7 per cent more moisture. This results in heavier rainfall and more intense storms and cyclones, further increasing the risk of flooding and landslides.

Climate change also accelerates the melting of glaciers and ice caps, contributing to sea-level rise. As glaciers retreat, they release large volumes of meltwater into rivers and oceans, increasing the risk of coastal inundation. For example, the rapid melting of glaciers in the Himalayas poses significant **flood** risks to communities downstream in countries like Nepal, India and Bangladesh.

Learning ladder 8.2

Processes that transform people, places and environments

1. Source 1: Describe the areas of the Amazon Basin that experience extreme drought. Use geographic teminology, such as north and west.
2. Describe how climate change can increase droughts.
3. Explain the impact of climate change on wildfires.
4. Analyse how increased frequency and intensity of hazards will affect different places in the world.
5. Select one country and conduct research on it to evaluate the impact climate change will have on hazards there by 2050.

Change

1. Describe how climate change alters temperature patterns and precipitation distribution on a global scale.
2. Describe how heat waves can contribute to more intense droughts.
3. Source 3: Explain how climate change will contribute to change in New York City by 2100.
4. Assess the social, economic and environmental impacts of hazards caused by climate change in the future.
5. Rank the hazards from most impactful to least, and justify your rankings.

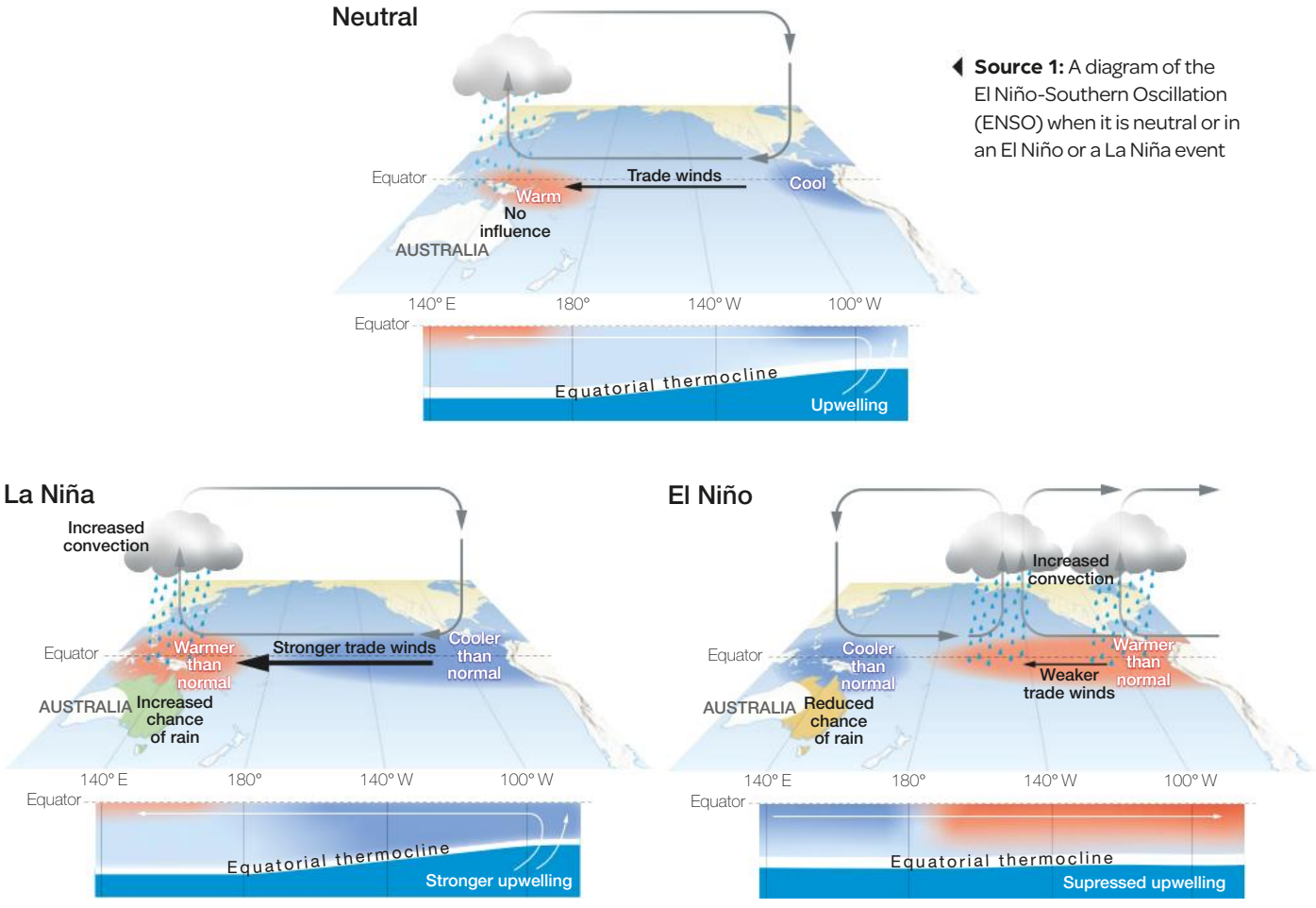
HOW TO

Change, page 394

8.3

How have humans influenced La Niña and El Niño?

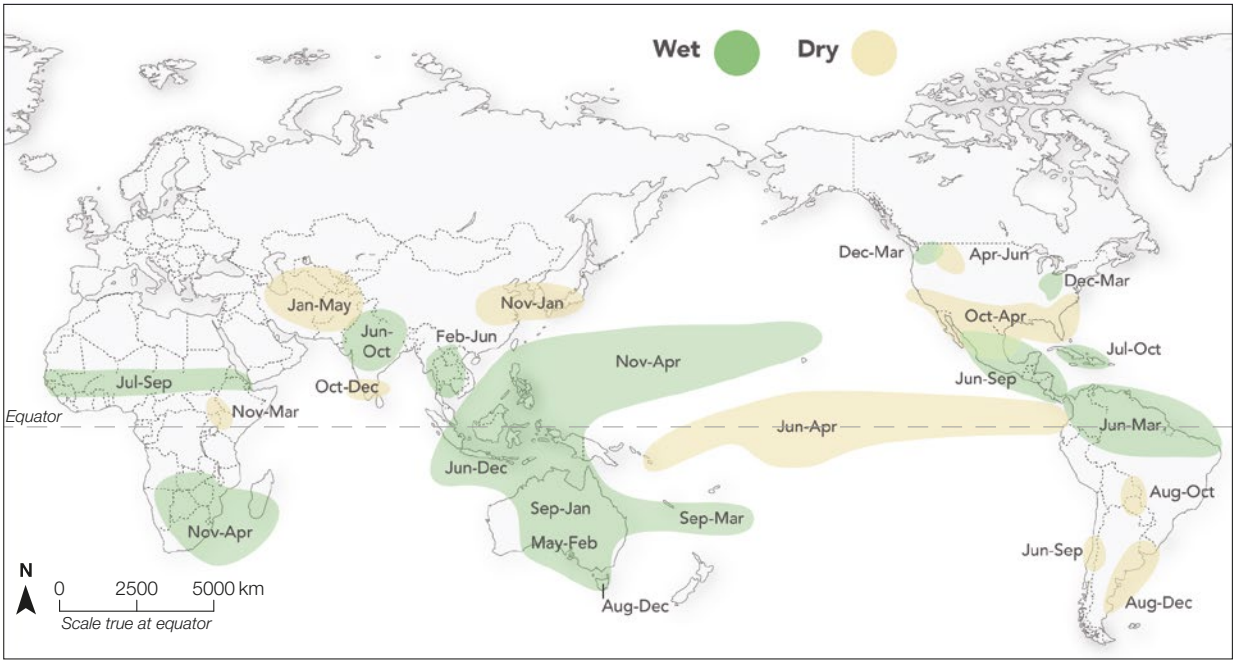
The atmosphere is full of circulations that transport air and energy around the world and influence global weather patterns. The Walker Circulation occurs between South America and Australia in the Pacific Ocean. It is caused when air rises above the warm waters near northern Australia and over the Pacific Ocean, to descend near South America, before being pushed back across the Pacific Ocean as large trade winds, shown as 'neutral' in Source 1. This circulation results in rainy low-pressure systems above Australia and South-East Asia, and dry high-pressure systems near South America. The Walker Circulation cycles between periods of La Niña and El Niño, known as the El Niño-Southern Oscillation (ENSO). El Niño and La Niña events typically last nine to 12 months, but can sometimes last for years. Both have global impacts on weather, wildfires and ecosystems, and can affect communities and economies.



Source 1: A diagram of the El Niño-Southern Oscillation (ENSO) when it is neutral or in an El Niño or a La Niña event

La Niña and rainfall

La Niña conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. The regions and seasons shown on the map below indicate typical but not guaranteed impacts of La Niña. For further information, consult the probabilistic information that the map is based on.



*iridl.ldeo.columbia.edu/expert/home/.lenssen/.enso Teleconnections/

For more information on El Niño and La Niña: iri.columbia.edu/enso

Sources:

1. Lenssen, Goddard and Mason, 2020. Seasonal Forecast Skill of ENSO Teleconnection Maps. Weather Forecasting, 2387–2406.

2. Mason and Goddard, 2001. Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619–638.

Source: International Research Institute for Climate and Society/Earth Institute/Columbia University

El Niño and rainfall

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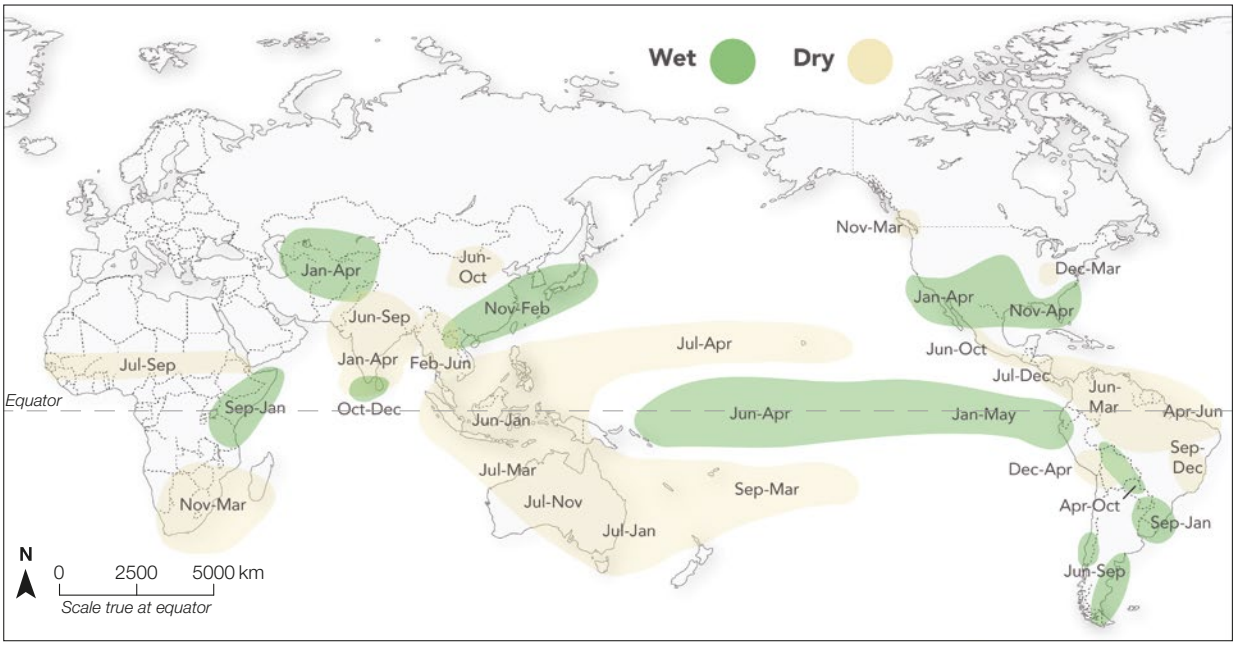

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2. Mason and Goddard, 2001. Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619–638.

Source: International Research Institute for Climate and Society/Earth Institute/Columbia University

Source 2: Maps displaying the impact La Niña (top) and El Niño (bottom) have on global rainfall patterns

La Niña

When western Pacific Ocean surface temperatures are warmer than usual, it results in a more intense Walker Circulation called La Niña. The warmer water causes more air to rise faster above the western Pacific Ocean, resulting in increased trade winds from South America as the air attempts to 'fill' the new gaps in the atmosphere. Trade winds move ocean currents with them, increasing upwelling around South America as deep cold ocean water rises to the surface to replace the moving water. This intensified Walker Circulation leads to heavier rainfall across the north and east of Australia, and increased frequency and intensity of floods and tropical cyclones. The severe floods of 1955, 1988, 1998, 2010–11 and 2022 in Australia were all associated with La Niña. The increase in cloud cover also lowers the average maximum temperatures across Australia, and insulation caused by the clouds increases the minimum temperatures.

Source 3: A firefighter mopping up near Sussex Inlet, Sydney, on 31 December 2019. The dry conditions in El Niño events increase the frequency and intensity of bushfires.

El Niño

When the surface temperatures in the central and eastern Pacific Ocean become substantially warmer than average, it can weaken or reverse the Walker Circulation and result in El Niño. Air instead rises in the east near South America and descends in the west near Australia and South-East Asia, resulting in drier conditions across northern Australia. On average 30 per cent less rain falls in Australia throughout El Niño, and the drier and warmer conditions increase the risk of droughts and fire. The severe droughts of 1982, 1994, 2002, 2006 and 2015 and many severe summer fires are associated with El Niño events.

Human impacts of ENSO

Human activities can affect the ENSO cycle. Global warming caused by the emission of greenhouse gases in industries, agriculture and transport has resulted in significant changes to sea surface temperatures. This, in turn, influences the frequency, intensity and length of El Niño and La Niña events. Human-induced climate change can also lead to alterations in sea ice concentration, snow cover and permafrost.

Source 4: A flooded residential area in Queensland during the 2010–11 floods. La Niña events and land use changes can increase the frequency and intensity of flood hazards.

This can change the heat exchange between Earth and the atmosphere, influencing global and regional climate patterns that are connected to ENSO. Further, human changes to land use and water management can affect natural precipitation and temperature patterns, further affecting ENSO cycles or the impact of El Niño and La Niña events. Deforestation can lead to fewer trees to intercept rainfall, leading to more water running off into rivers and streams. This also increases the risk of flooding during La Niña events.

In addition to influencing the strength and frequency of ENSO events, human activities are also changing their timing. This could mean changes in length of El Niño or La Niña phases and the indicators that meteorologists use to predict them. This complicates efforts to predict and prepare for ENSO effects. These changes in ENSO patterns can have significant economic implications, affecting agriculture, fisheries, tourism and water resources management. Communities dependent on these sectors may face increased vulnerability and economic instability due to the unpredictability and severity of ENSO-driven climate events.

Learning ladder 8.3

Processes that transform people, places and environments

1. Source 1: What is the Walker Circulation and where does it occur?
2. Describe the effects of El Niño.
3. Source 2: Explain how La Niña events affect rainfall patterns in Australia and South-East Asia.
4. Source 2: Compare the impacts of La Niña and El Niño on South America.
5. How do human activities influence the intensity of El Niño and La Niña extreme weather events, such as floods and droughts?

Scale

1. Identify one global impact of El Niño events.
2. Compare the impacts of La Niña events on Australia's climate with those of El Niño events.
3. Explain how changes in surface temperatures in the Pacific Ocean can have both local and global effects on weather patterns.
4. Source 4: Justify the claim that La Niña has a bigger economic impact than El Niño.
5. Analyse how the severity of droughts associated with El Niño events might differ at local, national and global scales.

HOW TO Scale, page 398

8.4

Why do floods occur?

Floods are caused by heavy rains that force rivers to carry more water than their channels can hold. The water spills over the river banks and onto the flat land next to rivers, known as floodplains.

Why rivers flood

Each river can hold only a certain amount of water – this is known as its **carrying capacity**. Heavy rain or a collapsed dam wall or levee can lead to a river exceeding its carrying capacity. When this happens, the river bursts its banks and floods the surrounding land.

Floodplains

The flat lands next to river channels are called **floodplains**. Land on floodplains is usually reserved for parks, golf courses and farmland, with few permanent buildings.

Floodplains are some of the richest and most productive land in the world. The soil carried by floodwaters is spread over the surrounding land. After each flood, more and more soil is **deposited** on the floodplain.

Billions of people around the world live on floodplains because the fertile soil and direct access to fresh water make it easy to live there and grow food.

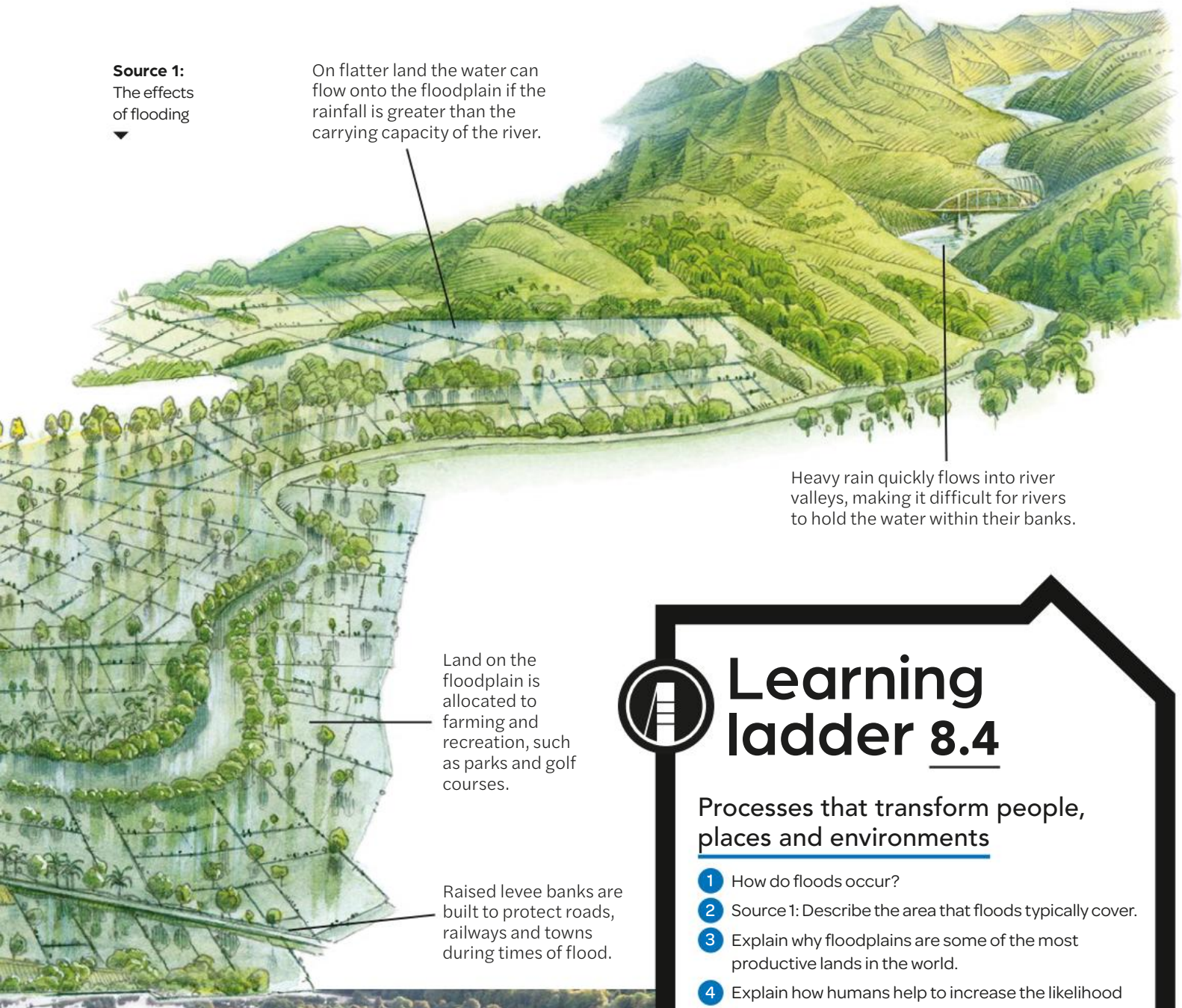
Humans cause flooding

When humans clear vegetation, the plants and trees no longer bind the soil together and absorb the water. Instead, water flows into rivers, putting pressure on their carrying capacity. Removing vegetation also leads to increased soil **erosion**.

When we build towns and cities, we replace natural environments with hard surfaces – such as concrete and roads – that prevent water from soaking into the ground. When we build levee banks along rivers, we stop floodwaters, but we also increase the carrying capacity of the river. With levees, the river runs faster and deeper, and carries more water.

Source 2: Flooded golf course in Aberdeen, Scotland, when the nearby River Dee burst its banks in October 2023. Golf courses are one form of land use that are permitted on floodplains, along with sporting fields, parks and farms.

Source 1: The effects of flooding



Learning ladder 8.4

Processes that transform people, places and environments

1. How do floods occur?
2. Source 1: Describe the area that floods typically cover.
3. Explain why floodplains are some of the most productive lands in the world.
4. Explain how humans help to increase the likelihood of floods.
5. Source 1: Evaluate the usefulness of levee banks in times of flood. What are the advantages and disadvantages of this form of flood management.

Place

1. Source 2: How is land on the floodplain used?
2. Source 1: Prepare a map of the area shown, and include and label the following features: river, floodplain, levee bank, bridge, houses.
3. Source 1: Why does flooding occur on the floodplain?
4. Source 2: Explain why the golf course is prone to flooding and how it impacts the golf club.

HOW TO Place, page 390

8.5

Where do floods occur in Australia?

There are three main types of floods in Australia: riverine floods, flash floods and coastal or storm surge floods. If you live near a river system, a **drainage basin** or along the coast, you may be in a flood zone and at risk of water inundation.

Types of floods

Riverine floods

In Australia, **riverine floods** are the most common form of flooding. They are usually caused by heavy rainfall leading to river systems overflowing onto adjacent low-lying land. Coastal rivers are steeper and flow more quickly. Coastal riverine flooding occurs over a short period of time and poses a greater risk because there is less time to take preventative action.

Inland rivers with low gradients have floods that move slowly down the river, sometimes lasting for several months. Inland Australia is characterised by wide expanses of low-lying flat land. When rivers in these regions reach capacity, thousands of square kilometres are at risk of flooding. Floods may be over 3 metres deep and last for over a month before they begin to dry.

Coastal flooding

Coastal flooding occurs when the sea level rises above usual heights, causing **inundation** of the surrounding coastline. Storm surges are a common cause of local coastal flooding through events such as tropical cyclones (see page 294). As the Earth's climate warms, rising global sea levels are also resulting in increased flood risk in many of our capital cities, which are located along coastlines and major river systems.

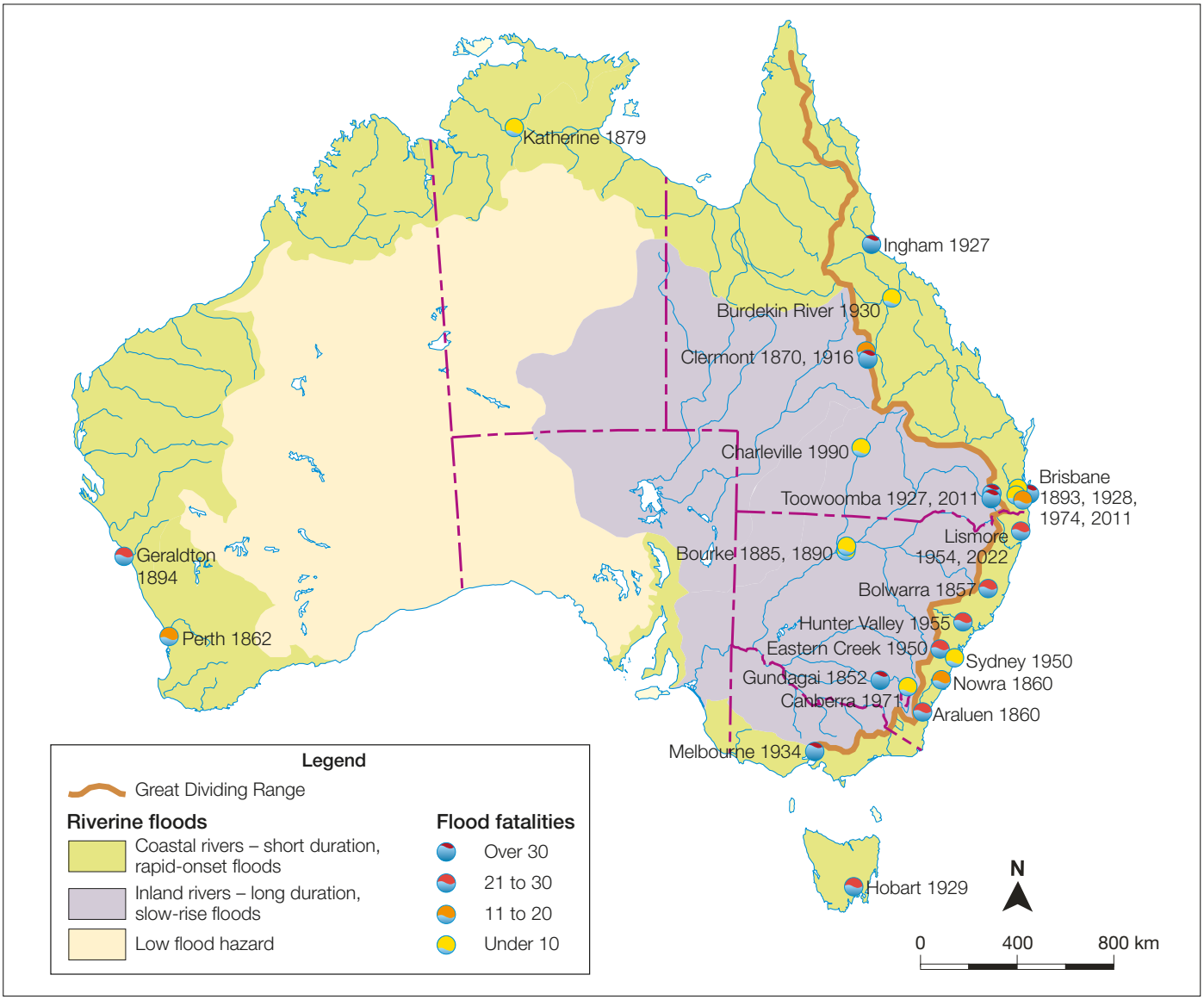
Flash floods

Flash floods or 'overland floods' are harder to predict and are brought on by sudden and intense downpours of rain. Urban regions in Australia are at particular risk of flash flooding due to infrastructure like gutters and stormwater drains not being able to cope with the excessive rainfall, leading to inundation of roads and property. These floods are usually short-lived and drain relatively quickly once the infrastructure is under less strain.

Source 1: The Windsor Bridge in north-western Sydney was submerged under rising floodwaters along the Hawkesbury River on 22 March 2021.

Severe storms in March 2021 across the east coast of Australia resulted in riverine flooding and flash flooding. These events resulted in significant damage to 63 NSW local government areas. Daily rain totals of over 150 millimetres in some regions resulted in over 65 000 people being told to evacuate across Sydney, particularly in the Hawkesbury-Nepean Valley. These floods were declared a natural disaster and described as a one-in-100-year event.

Riverine floods in Australia



Source: Matilda Education Australia

▲ **Source 2:** The distribution of coastal and inland riverine floods and major flood events in Australia

Learning ladder 8.5

Characteristics of places and environments

1. What are the three different types of floods?
2. Source 2: Which NSW towns have lost more than 21 lives to flooding?
3. Source 2: Describe the region of Australia where inland riverine flooding takes place.
4. Explain why coastal riverine flooding has a greater impact than inland riverine flooding.
5. How would being located in a flood-prone area influence a place's human and physical characteristics?

Change

1. Which type of flooding brings slow change over a long period of time?
2. Source 1: Describe the changes that have occurred at Windsor.
3. Create a photo essay of the 2021 NSW floods. For each photo, describe the change that has occurred to the location and the type of flooding involved.

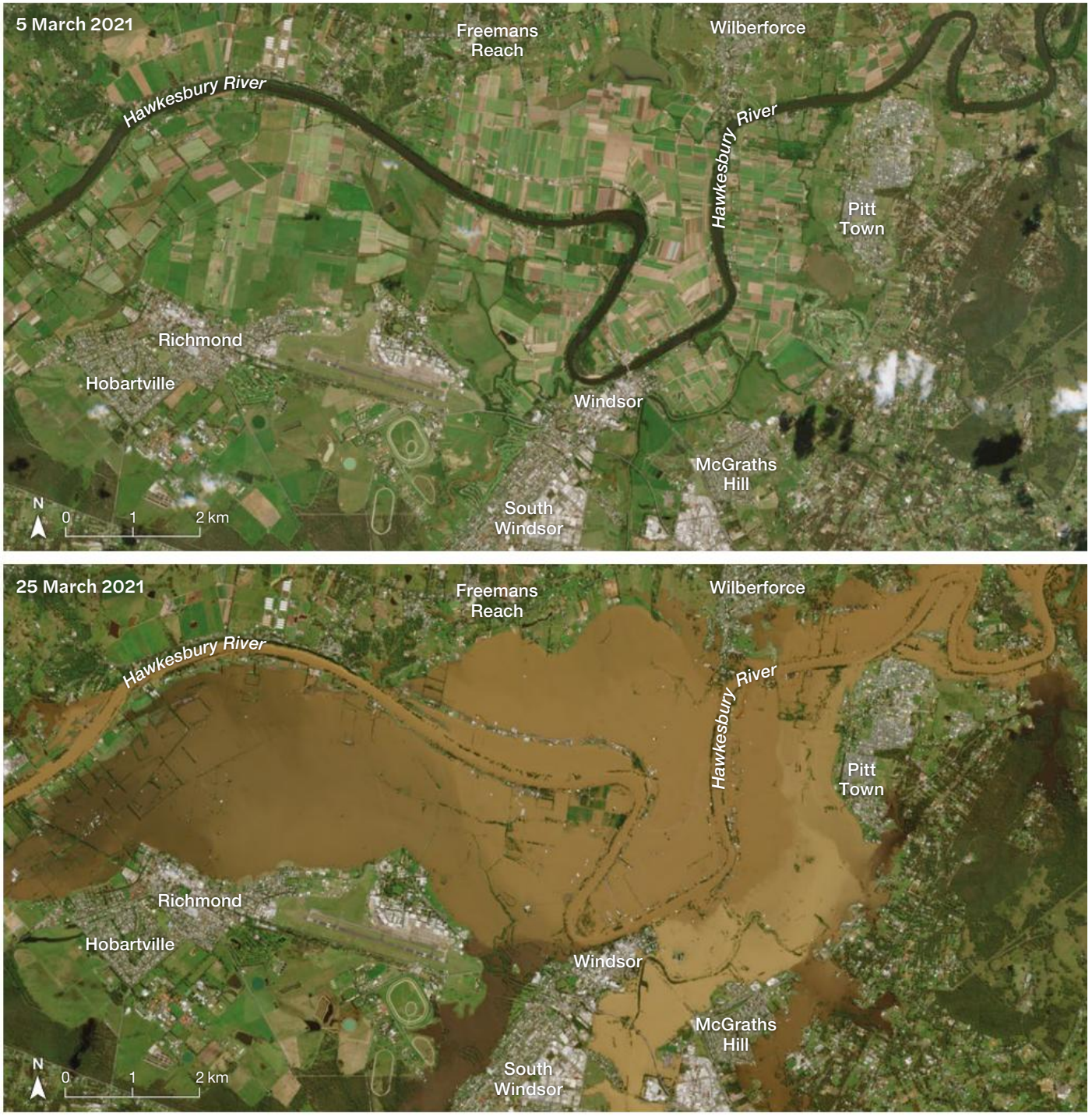
Photo essays, page 419; Change page 394

HOW TO

8.6

How can we plan for floods?

We can help reduce the impact of flooding by predicting when and where a flood will hit, building protective structures and practising emergency drills.



Source: Copernicus Sentinel data 2021 for Sentinel data

▲ **Source 1:** The Hawkesbury River flood peak at Richmond on 21 March 2021 was the highest in more than 30 years after downpours of three times the average March rainfall for Sydney.

Preparing for floods

Flooding occurs naturally for many rivers, so it is almost impossible to stop floods altogether. However, there are three steps we can take to reduce the impact of floods.

1 Predicting floods

Flood forecasters predict when and where floods will occur, giving people time to prepare and evacuate. Forecasters use a network of **rain gauges** that monitor rainfall along the river catchment, and use **stream gauging stations** along the rivers to measure river heights. Computer models estimate how much rainfall will runoff the catchment, and how long the runoff will take to reach the river and travel downstream.

2 Preparing communities

Flood engineers study past flood records to design flood protection strategies. Sometimes large raised banks, called **levees**, are built in flood-prone areas to deflect the flow of water and make it run in a certain direction. During large floods, levees sometimes help the river to run faster and deeper, which transfers the flood problem downstream.

Local councils map flood-prone areas, and make and enforce rules about building in these zones. Sporting fields and farming are allowed on flood-prone land, but housing and industry are not, and are usually zoned for development on higher land or in areas protected by levees.

3 Responding effectively

Planning for a flood emergency means that we can respond quickly to save lives and make the flooded area safe. Critical facilities, such as emergency hospitals and evacuation shelters, are located in areas that will not flood. Evacuation plans, emergency drills and education programs are conducted to help communities get ready for a flood emergency. During a flood, warnings are sent to mobile phones, and spread via social media networks such as Facebook and X (formerly Twitter).

Using spatial technology

In geography, we rely on maps and other visual representations of our landscape to make decisions and to understand patterns. These maps and images are made using digital software and hardware, which is referred to as **spatial technology**.

Maps and satellite images can be used during emergencies, such as floods, to help plan, prepare for and manage the situation. For example, emergency vehicles can use satellite images to know which roads have been flooded and need to be avoided. **Global positioning systems (GPS)** are also used to locate missing people or to pinpoint rescue operations.

Learning ladder 8.6

Sustainable management strategies

1. What rules do local councils enforce about building in flood-prone areas? Why?
2. Describe how levees are used to protect flood-prone areas.
3. Source 1: Use Google Maps to help you prepare a sketch map of Richmond in New South Wales. Mark the flooded area using the information shown on the satellite image. Explain why satellite images are useful for managing and predicting flooding events.
4. Make a list of the types of data collection methods useful in planning for floods and predicting them. Put an asterisk next to each of the methods that involves spatial technologies.

Scale

1. Describe a flood management activity that occurs at a local scale.
2. How do activities at the local scale, like the use of rain gauges in a community, impact flood management at a regional scale?
3. How can technologies improve the management of floods on national and local scales?
4. Analyse how the construction of levees in one area can affect flood management at local and downstream scales.
5. Assess how flood preparedness strategies are implemented differently at local, regional and national scales. What factors must be considered at each scale to ensure sustainability?

HOW TO

Satellite images, page 423; Scale, page 398

How can I use synoptic charts to plan for floods?

Synoptic charts

A **synoptic chart** (also called a weather map) displays surface weather conditions for an area at a specific point in time. It uses symbols and lines to represent different elements like air pressure, wind, rainfall, and weather systems. **Meteorologists** gather this information using satellites, weather balloons, ships, aircraft and computer models. These charts are used to create weather forecasts and warnings, including alerts for floods, fires and storms. When a weather map shows expected conditions in the coming days, it's called a **prognostic chart**.

Reading synoptic charts: key features

Isobars

Lines on a synoptic chart are called **isobars**. They represent areas experiencing equal atmospheric pressure, measured in hectopascals (hPa). Isobars provide a lot of information, such as:

- **Weather:** Isobars show us where high and low pressure systems can be found, helping us to determine weather conditions. These are large-scale atmospheric systems where the pressure either rises (high) or falls (low) towards the centre. High-pressure systems (labelled H) have isobars that show pressure increasing towards the centre and are usually linked with clear skies and calm weather. This can be seen on top of New Zealand in Source 1. Low-pressure systems (labelled L) have isobars that decrease towards the centre and are often associated with cloudy, rainy or stormy conditions. Tropical cyclones are intense low pressure systems.
- **Wind:** When isobars are close together, it indicates a steep change in air pressure and strong winds. When the lines are further apart, winds are usually light and conditions calmer.

Wind direction

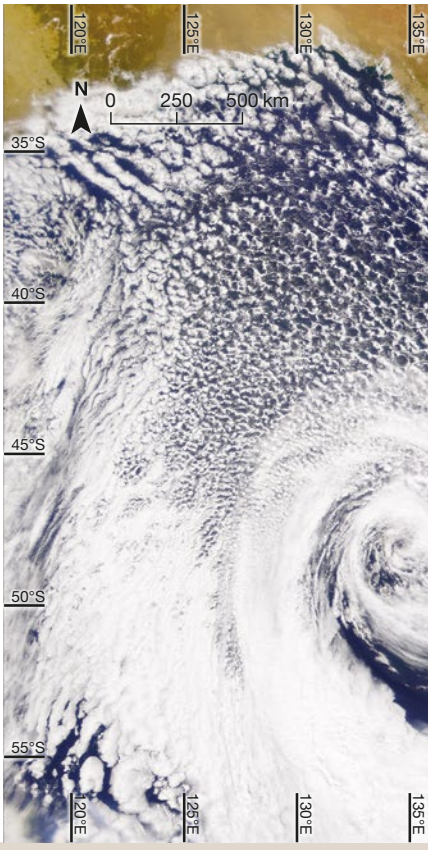
Air generally moves from areas of high pressure to low pressure. In the southern hemisphere, high pressure systems move anti-clockwise and low pressure systems move clockwise. A good way to remember this is to draw the letter S, where the top curve (high pressure) moves your pen anti-clockwise, and the bottom curve (low pressure) moves it clockwise. These pressure systems turn in the opposite direction in the northern hemisphere. It is important to note that winds are named after the direction they originate from, not where they are going. For example, a westerly wind comes from the west. Some synoptic charts also have wind barbs that look like little arrows, pointing in the direction the wind is moving.

Troughs and ridges

A trough is a stretched-out area of low pressure. It often appears as a dashed line. These are common in northern Australia in summer and can bring monsoonal rain and flooding. A ridge is an extended area of high pressure, often linked with stable and dry conditions.

Fronts

Fronts are boundaries that occur between cold and warm air masses. They are shown on synoptic charts using lines with triangles (for cold fronts) or semicircles (for warm fronts). The symbols point in the direction the front is moving. Fronts bring rapidly changing weather conditions. In Australia, cold winds from southern Antarctic oceans often collide with warm air sitting above the continent. This results in many cold fronts moving from west to east in southern Australia. These cold fronts can bring strong winds, heavy rain, cooler temperatures, and sometimes snow.



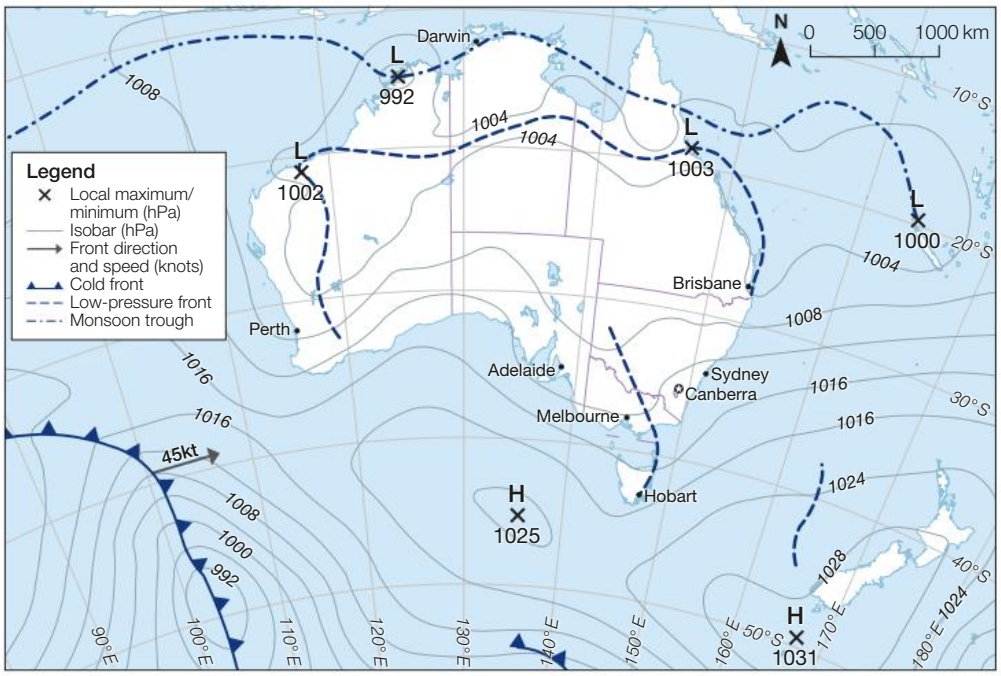
Predicting flood conditions

Reliable weather forecasting, in particular rainfall, can allow advance warning of floods. Tracking of troughs and cold fronts using synoptic charts allows meteorologists to accurately predict rainfall many days ahead of its arrival.

Meteorologists also use live radar images to track areas of heavy rain and their movement. This helps predict rainfall a few hours ahead, giving a little time for a response if a flood risk exists.

While heavy rain is an important cause of flooding, other factors are involved in causing floods. Flooding is more likely to occur if the soil is already full of moisture or if vegetation has been removed from an area. The Bureau of Meteorology's flood forecasting uses rainfall and streamflow data, along with soil moisture and landform and landscape information.

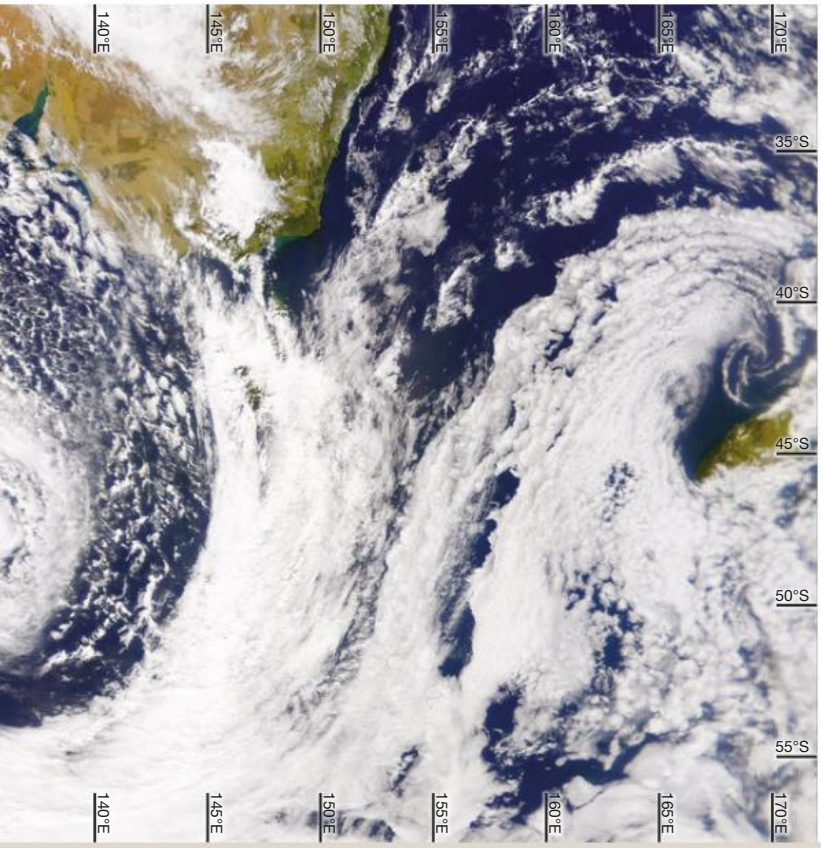
Australia synoptic chart for 6pm on 27 February 2022



Source: Australian Bureau of Meteorology

▲ **Source 1:** The synoptic chart for 6pm on 27 February 2022. A slow-moving trough (shown as a dashed line) that had caused record rains in Queensland in early February, moved into northern NSW. Extreme rainfall in north-eastern NSW on 27 February led to significant flooding in towns such as Lismore.

▼ **Source 2:** Low-pressure system off Australia



Source: Image courtesy the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

Learning ladder 8.7

Representing and communicating information

1. Describe what synoptic charts are.
2. Describe what isobars are and what information they tell us.
3. Explain what high and low pressure systems are.
4. How are troughs and cold fronts similar?
5. Use Source 1 to answer the following questions:
   - **a** What passed over north-eastern NSW to bring heavy rain?
   - **b** Was the Australian continent mainly affected by a low- or high-pressure system?
   - **c** Describe the location of the cold front and its direction of travel.
   - **d** What is the wind direction for Tasmania based on the location of the high-pressure system?

HOW TO Weather maps, page 406

Case study

What were the causes and impacts of the 2022 Lismore floods?

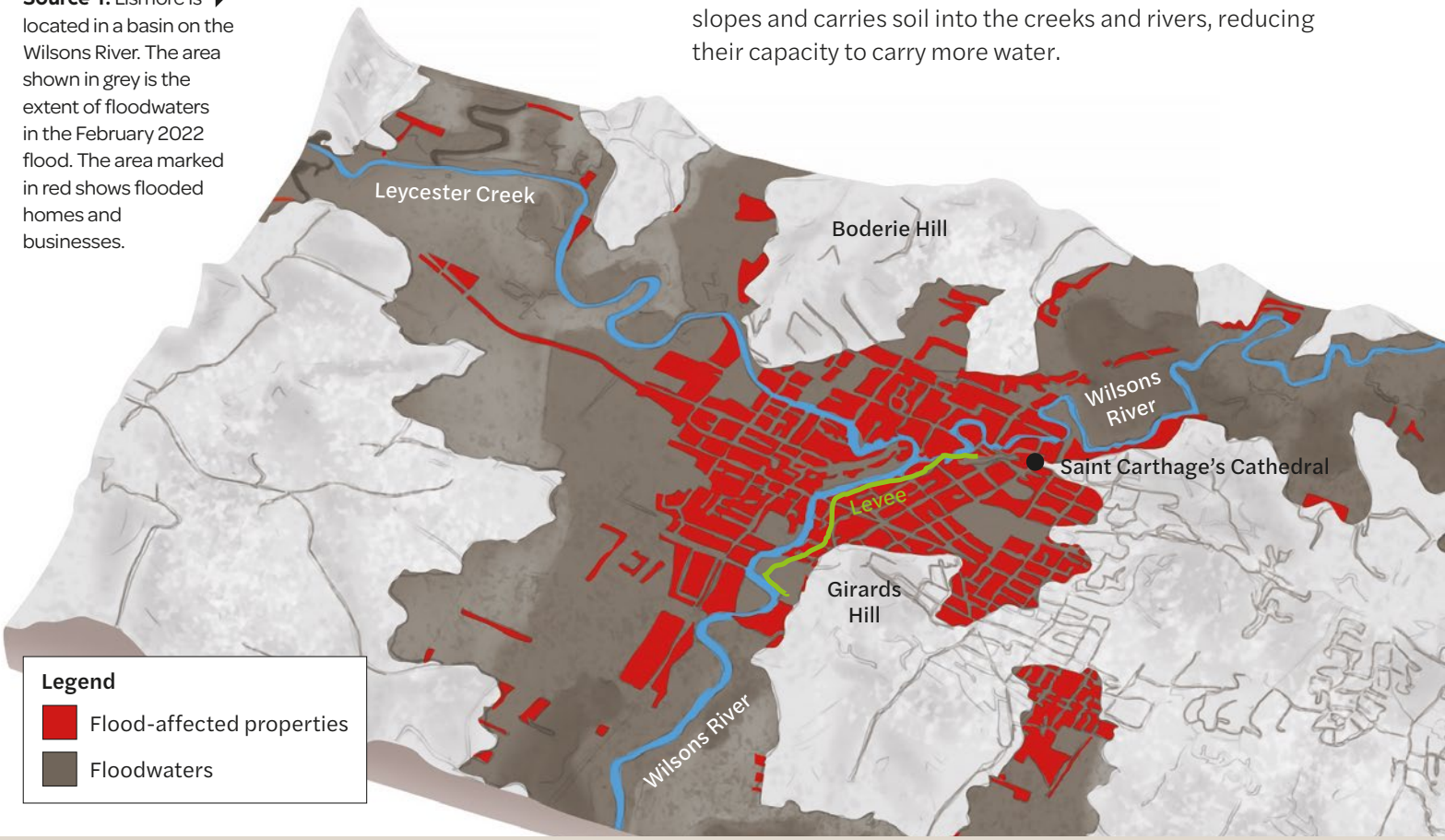
In February and March of 2022, the large regional city of Lismore in northern New South Wales experienced extreme rainfall events. A twin peak flood disaster unfolded that set new historical flood peaks for Lismore (14.4 metres) and other downstream towns such as Coraki (7.65 metres) and Woodburn (7.17 metres).

Lismore is a flood-prone city

Lismore has experienced over 150 floods since records began, with major floods over 10 metres high in 1954, 1974, 1999 and 2017. The flood record of 14.4 metres set in February 2022 was more than 2 metres higher than the previous record of 12.27 metres in 1954.

The city of Lismore developed around the river port on the Wilsons River at a time when produce such as timber was exported from the region by ship. Deforestation on the catchments above Lismore for forestry and agriculture has reduced the ability of the land to slow runoff and protect soil from erosion. The Big Scrub rainforest that once protected the catchment is now small fragments of remnant forest. Runoff flows quickly off the slopes and carries soil into the creeks and rivers, reducing their capacity to carry more water.

Source 1: Lismore is located in a basin on the Wilsons River. The area shown in grey is the extent of floodwaters in the February 2022 flood. The area marked in red shows flooded homes and businesses.



Source 2: Satellite image on 2 March 2022, showing Lismore inundated by floodwaters as water overflowed the banks of the Wilsons River. Flood levels are beginning to recede in this image. On 28 February the flood level had peaked at 14.4 metres, breaking all previous levels. Saint Carthage's Cathedral sits 13.9 metres above sea level and was considered safe from flooding until this event. Up to a metre of water came into the cathedral causing significant damage to its marble floor.

Lismore is highly prone to flooding as a result of its geography:

- The Wilsons River and Leycester Creek drain hilly catchments to the north and north-east. When these areas experience high rainfall, the water discharges downstream through Lismore forming a flood 'choke point' where they converge in the city.
- The centre of Lismore is a low-lying basin that retains rainwater and stormwater runoff, and experiences local flooding after heavy rain. Thousands of people live within this basin.

- Lismore is only 10 metres above sea level despite being 100 kilometres upstream of the river mouth. Floodwaters from the upper catchment arrive quickly, but a low gradient and flat land on the floodplain mean flooding is fast but can take weeks to recede.

Throughout Lismore's flood history, individuals and businesses marked new flood levels on walls and telegraph poles, and houses were raised by several metres. Some properties were purchased to become open spaces and levees were built to keep floodwaters out. These flood-mitigation measures, including a 10-metre-high levee wall built in 2005 to protect the city centre, failed to prevent Lismore flooding again. The levee was overtopped by bigger and higher floods in 2017 and 2022. Raised houses flooded and thousands of people who still lived in vulnerable areas were directly impacted.

The record-breaking 2022 flood

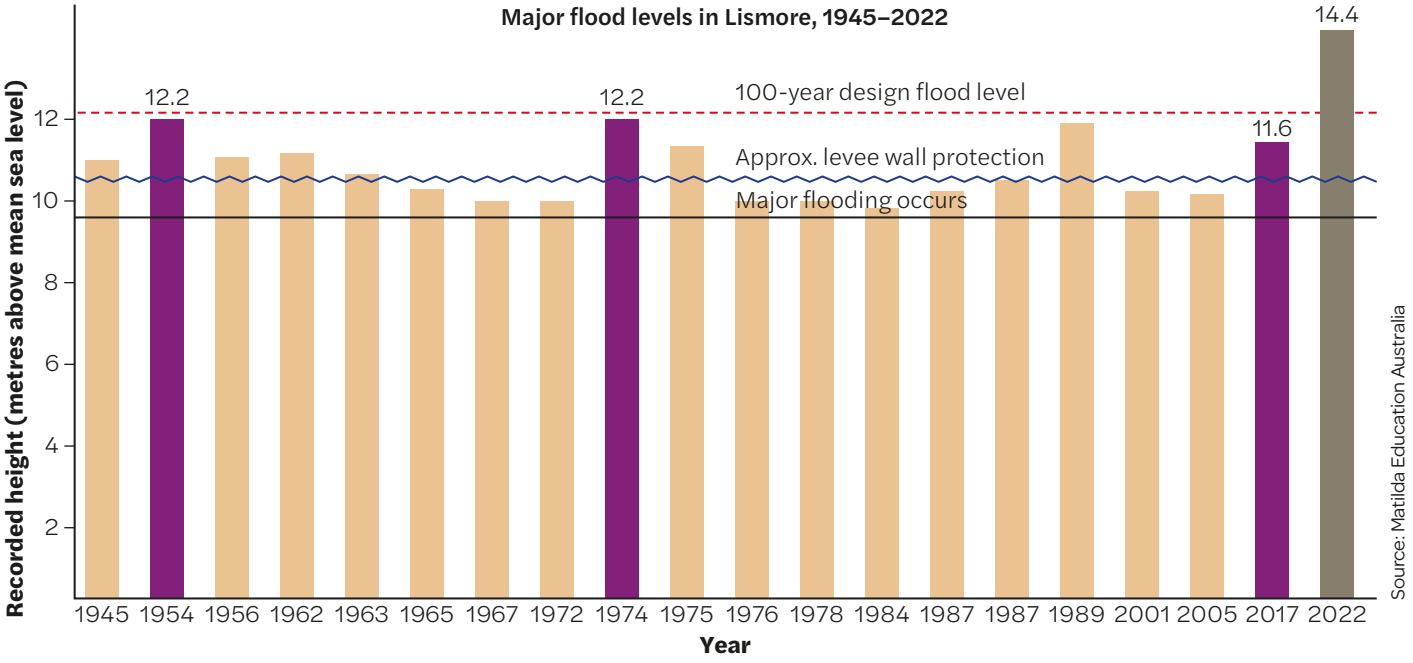
Extreme rainfall was recorded in the Wilsons River and Leycester Creek catchments, including 406 millimetres on 27 February at Lismore. Saturated soils from months of rainfall in late 2021 and early 2022 reduced the ability of the land to absorb or hold additional water. The result was increased runoff. The rain flooded off the slopes, creating record stream flows and water levels.

▲ **Source 3:** People stranded by floodwaters in a Lismore hotel await rescue by helicopter.

In the 24 hours between 27 and 28 February, an estimated 240 gigalitres of water flowed into Lismore, equivalent to the water flowing over Niagara Falls in a day. Sydney Harbour is approximately 500 gigalitres. After the Wilsons River overtopped the levee, the floodwaters continued rising for a further 12 hours and rainfall continued for over a week. Local flooding from the torrential rainfall also raised flood levels.

Nobody was prepared for the speed of the flooding and the volume of water, including the local State Emergency Service (SES), who were without sufficient personnel and equipment to respond appropriately. According to one resident and reported by ABC news, 'The rain was roaring. Raging. Relentless'. With little time to plan, people were trapped by rapidly rising floodwater, in many cases escaping to rooftops where they waited for hours in the rain for the SES and other volunteers to rescue them.

A 'tinny army' of volunteers on small watercraft including kayaks and jet skis rescued hundreds of people and are credited with saving many lives. Relief centres provided emergency accommodation, food and shelter. A massive clean-up began when the water receded, assisted by a 'mud army' of volunteers, emergency workers and Australian Army personnel. A month later, as the clean-up continued, a second major flood hit the city on 30 March. Some businesses had reopened and many residents had cleaned and repaired their houses. Wilsons River peaked at 12.11 metres.



▲ **Source 4:** Lismore major flood levels, 1945–2022

Source 5: Saint Carthage's Cathedral and surrounding area inundated by floodwaters on 28 February 2022

Impacts, responses and recovery

In Lismore, five lives were lost, 1400 properties were severely damaged and 2000 people were instantly homeless. On the floodplain, farmland was inundated, crops were destroyed, livestock were washed away or stranded and infrastructure was destroyed. Homesteads and small settlements were isolated for days. The estimated damage bill was $350 million, including $200 million for roads and bridges.

The SES were supported by the Rural Fire Service, police, Australian Defence Force and other organisations along with thousands of volunteers in search-and-rescue operations and clean-up activities. Recovery centres provided access to government support, and community hubs run by charities provided meals, clothing and counselling services. Housing pod villages were built for longer term accommodation.

Planning for the future

Recommendations for improved flood mitigation and responses in Lismore include:

- raising levees and using pipelines to divert floodwater away from Lismore
- relocating the city centre and rezoning the worst affected residential and commercial areas
- reforestation of the river valleys and the re-establishment of wetlands drained for farming to reduce water in the river in times of flood.

Learning ladder 8.8

Processes that transform people, places and environments

1. What were the main causes of the 2022 Lismore flood?
2. Sources 2 and 5: Create a sketch map of Lismore. Label the waterways. Add arrows to show the direction water flows in the river and the creek. Show the extent of the floodwaters using Source 2 as a guide.
3. Explain how floodwaters transformed Lismore into a flood disaster zone in February and March 2022.
4. Sources 1 and 4: Assess the success of the 10-metre-high levee built in 2005. What options does Lismore have to improve its protection other than building a higher levee?

Interconnection

1. Identify three factors that make Lismore vulnerable to flooding.
2. Sources 2 and 5: Describe why Saint Carthage's Cathedral had never been flooded before February 2022.
3. Explain how changes to the catchments around Lismore contribute to flooding.
4. Analyse the proposal to increase the height of the levee wall. What might this mean for towns downstream of Lismore?

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8.9

What strategies are used to manage floods?

People have been responding to floods for thousands of years and over time have developed strategies to reduce the negative impacts of flooding.

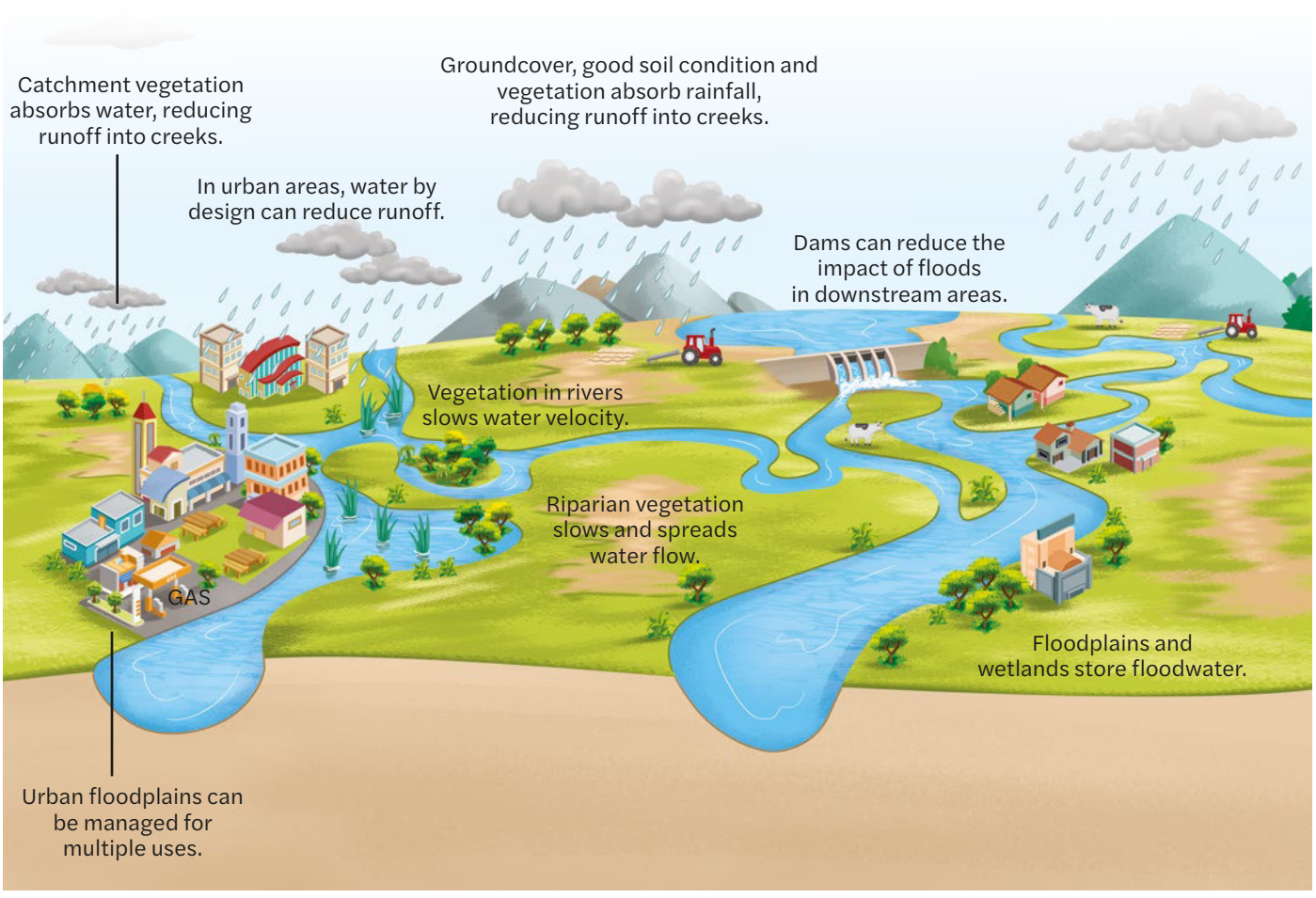
Approaches to management

Flood management occurs:

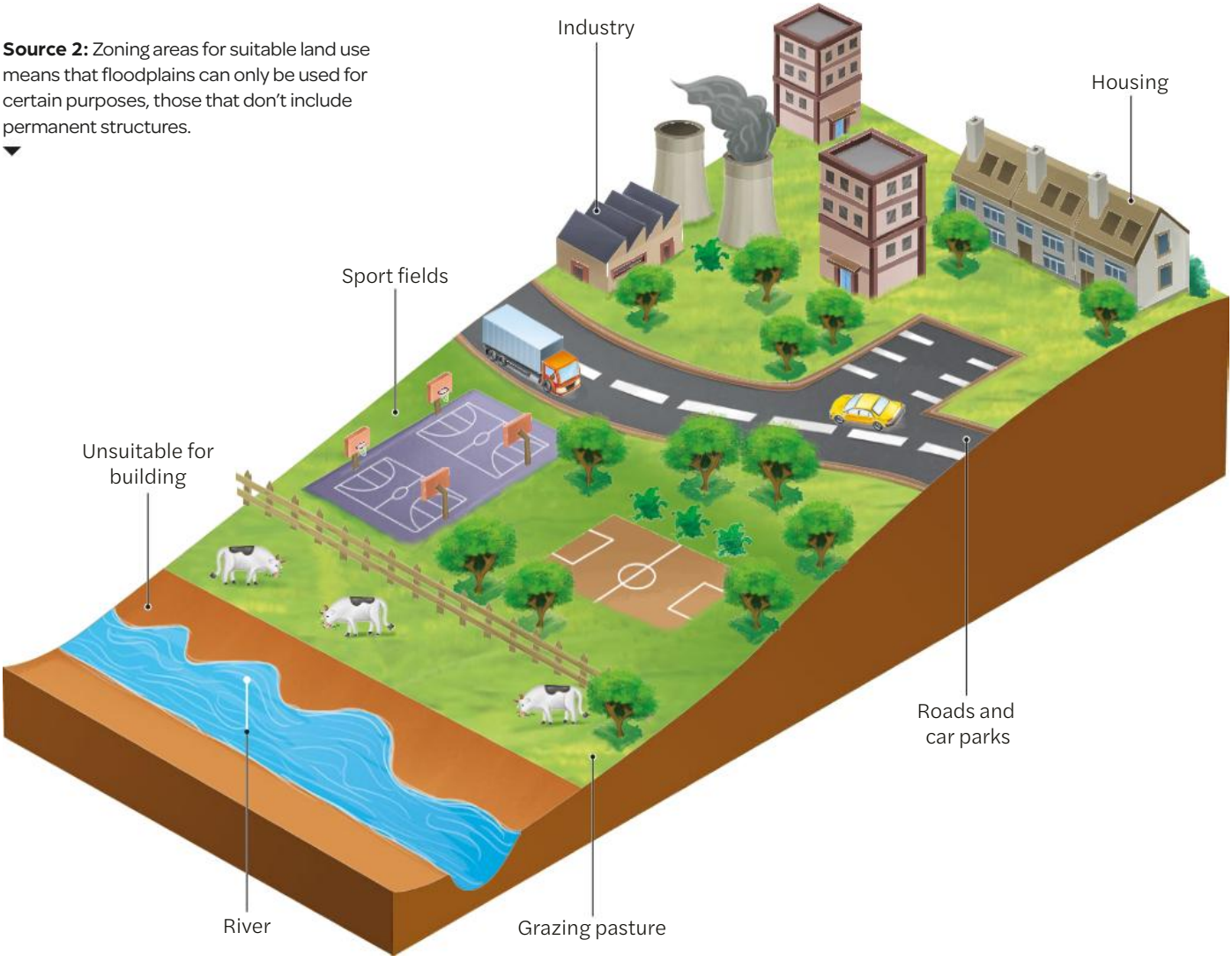
- before an impending flood event through weather forecasting, warning systems and building levees and dams
- during a flood event through evacuations and temporary measures such as sandbagging, moving property and boarding windows
- after floods when disaster relief is provided and planning begins to prevent similar impacts in the future.

In Australia most disaster funding is spent on helping flood victims, repairing the impacts of floods and building infrastructure to divert floodwaters away from human settlements. Disaster relief, recovery centres, recovery packages and pod villages were among the responses to the 2021–22 eastern Australia floods. In many flood-affected places such as Lismore, levee banks failed as record flood levels were reached, warning systems proved inadequate and evacuation systems were slow to respond.

Source 1: Hard-engineering and soft-engineering techniques can be integrated for a single flood-mitigation strategy.



Source 2: Zoning areas for suitable land use means that floodplains can only be used for certain purposes, those that don't include permanent structures.



Climate change is contributing to more intense and frequent extreme weather events. Media reports talk about 'rain bombs' and 'atmospheric rivers' bringing more saturated moist air into coastal catchments, causing extreme rainfall. Increased runoff causes flooding, especially where land has been cleared and the ground is already saturated with water. As many traditional approaches to flood management are failing, governments are increasingly considering nature-based management solutions.

Management strategies

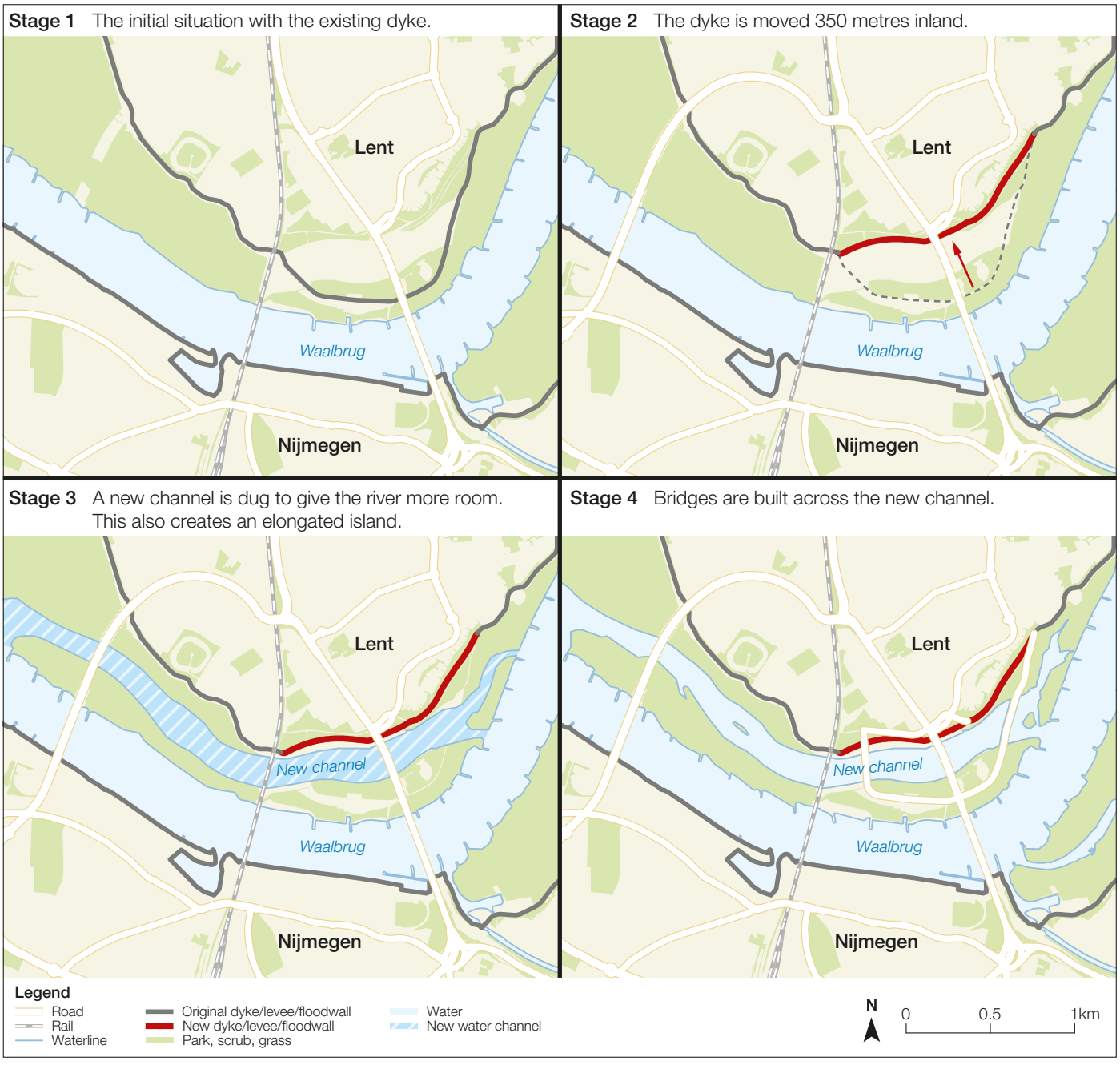
Hard- and soft-engineering measures are often integrated in a single flood-mitigation strategy. Hard engineering involves building structures to protect coastlines against erosion. Soft engineering is a more natural, sustainable approach to coastal management, working with the natural environment.

Hard engineering

There are several examples of hard-engineering strategies for flood management.

- **Artificial levees and walls** prevent rivers spilling onto their floodplains. Channelled rivers have huge erosive power because the water flows faster in straightened channels and carries more sediment. It can wash entire buildings away. When levees are breached or overtopped and water rushes into protection zones, it cannot drain back into the river, requiring sophisticated pumping systems.
- **Flood-mitigation dams** are used to catch runoff in an upper catchment to control flooding downstream. In extreme events, dams can cause floods when water overtops dam walls or is released so dams do not burst.
- **Flood bypasses** are artificial channels to divert water around settlements and back into a river further away. These can protect settlements but also move the flood impact further downstream.
- **Flood-resilient buildings** allow floodwaters to pass through or beneath them, and are constructed from materials not damaged by water, such as concrete and marine ply.

Room for the River program



▲ **Source 3:** The Netherlands' Room for the River program

Source: Matilda Education Australia

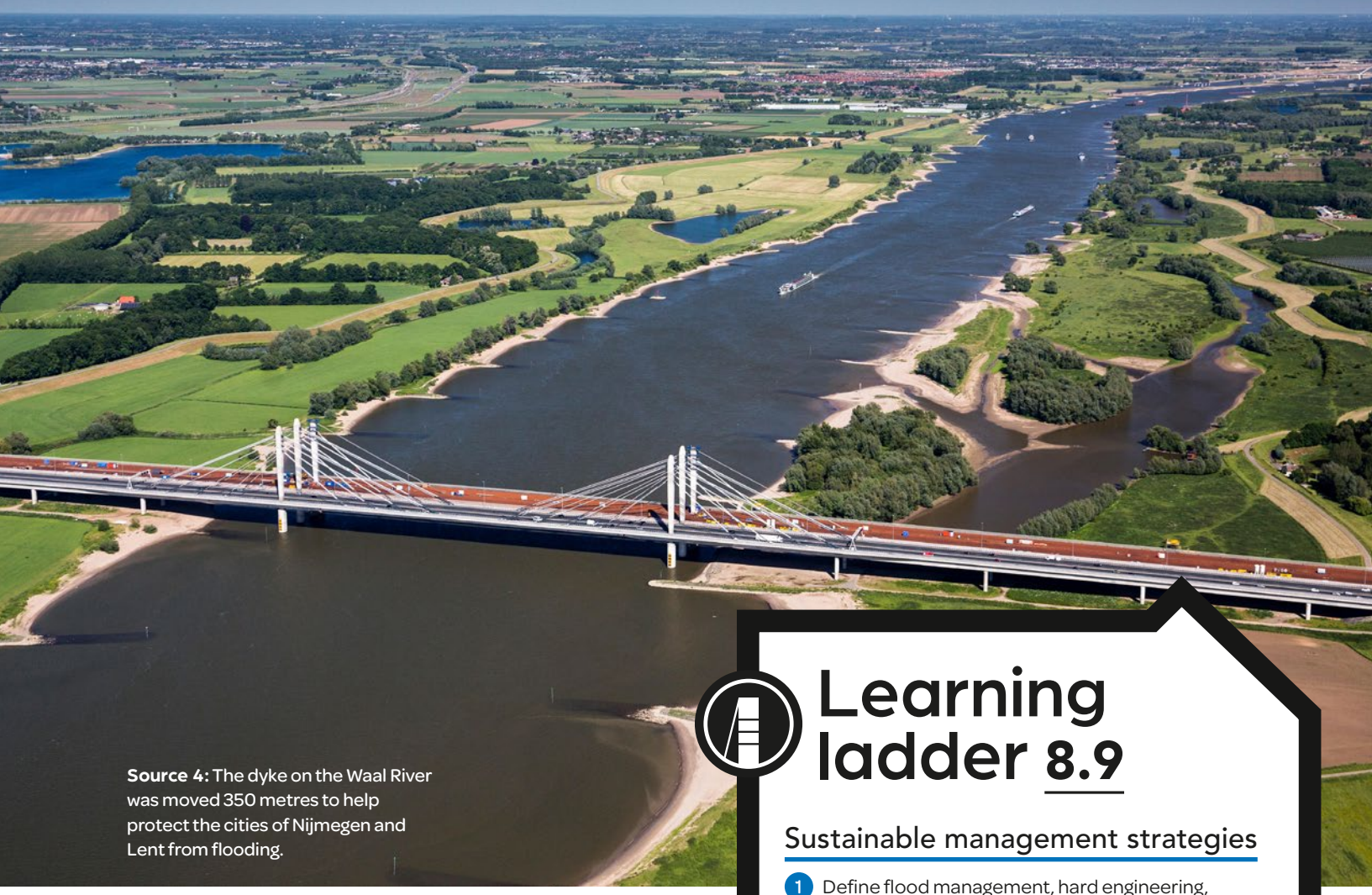
Soft engineering

There are several examples of soft-engineering strategies for flood management.

- **Land-use zoning** restricts floodplains to uses such as sporting fields and parklands.
- **Property buyback and relocation** of housing and businesses removes the flood threat.
- **Artificial flood detention basins** are low-lying areas of land designed to hold floodwaters.

Nature-based solutions are considered the most sustainable because they restore natural environmental processes.

- **Floodplain restoration** re-creates river channels, levees and wetlands.
- **Artificial wetlands** absorb excess runoff in urban places.
- **Sponge cities** incorporate artificial wetlands and other water design features that have flood-mitigation benefits.
- **Reforestation and afforestation** of land reduces the speed of runoff and increases infiltration.



Source 4: The dyke on the Waal River was moved 350 metres to help protect the cities of Nijmegen and Lent from flooding.

Recent developments in Lismore and the Netherlands

Suggestions for making Lismore more resilient to future flooding included raising the existing levees, constructing dams and diverting floodwater in Leycester Creek and Wilsons River away from the city using pipelines or canals. Property buybacks, rezoning the worst affected flood areas for non-residential and non-commercial use, and rebuilding flood-resilient housing with materials such as marine ply have already begun. Reforestation, protecting riparian zones and re-creating floodplain wetlands are nature-based solutions to flood management.

The Netherlands is recognised as a world leader in flood management. Traditional hard-engineering solutions such as dykes and barriers were replaced under the Room for the River program. Dykes (walls) were removed or moved, farmland and settlements were relocated, and new 'natural' channels and islands were constructed to widen rivers and slow the water down. The restored floodplains store floodwater, public squares double as catchments, floating houses minimise flood damage and new recreational areas on the restored floodplains benefit communities.

Learning ladder 8.9

Sustainable management strategies

1. Define flood management, hard engineering, soft engineering and nature-based solutions.
2. Identify three situations when flood management is undertaken.
3. Source 2: Describe how land-use zoning can reduce the impact of flooding in settlements built along rivers.
4. Explain why hard-engineering solutions are less sustainable than soft-engineering and nature-based solutions.
5. Analyse the Room for the River program in the Netherlands as a sustainable flood management strategy.

Environment

1. How does hard engineering change a river environment?
2. What features of the environment are considered in land-use zoning to reduce the impact of floods?
3. How can housing be adapted to survive in a flood-prone river environment?
4. Source 3: Explain how the Room for the River program changed the environment at Nijmegen and Lent.
5. Analyse the following statement: Hard engineering defends places from floods, but nature-based solutions use the environment to prevent floods.

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8.10

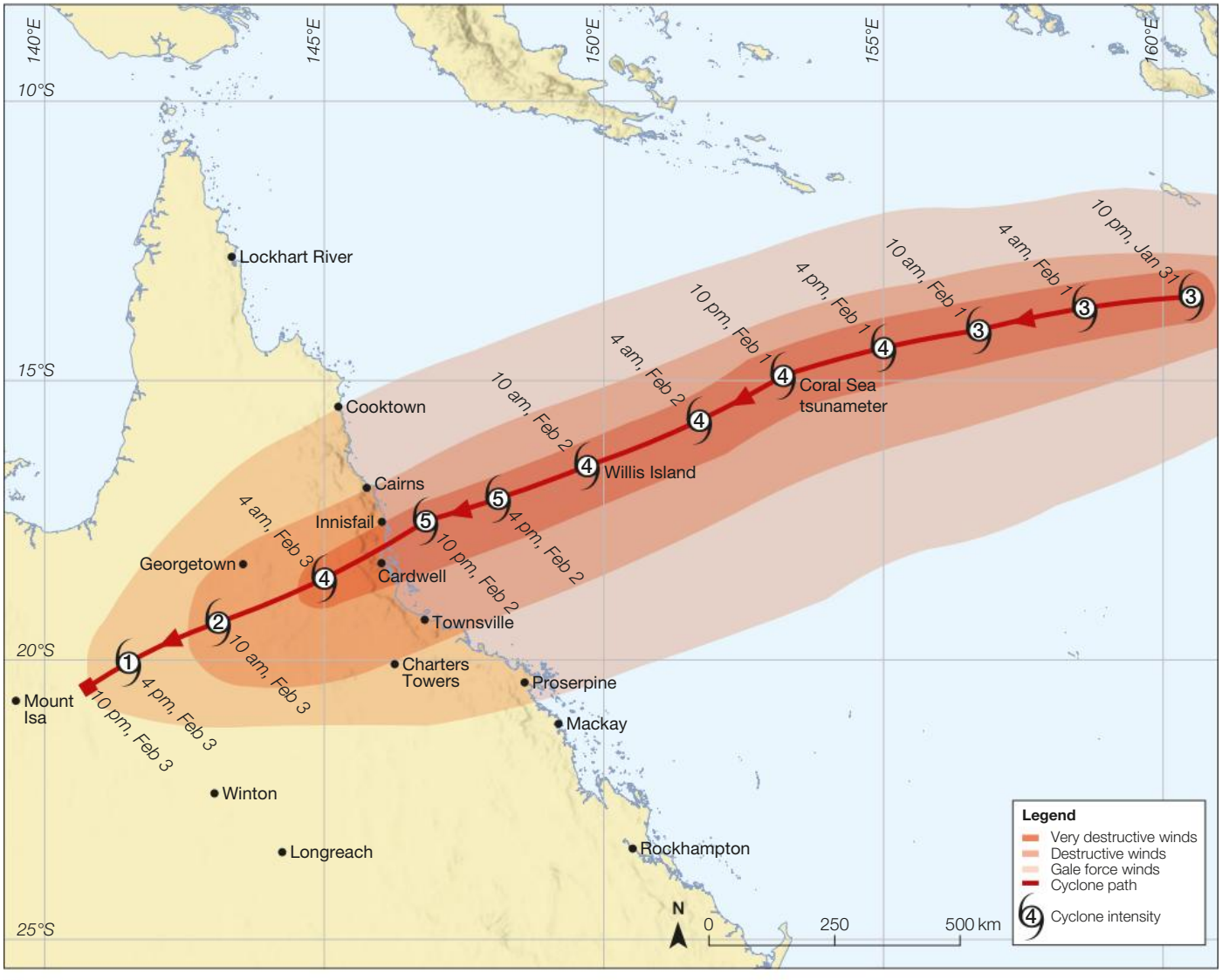
Where and why do tropical cyclones occur?

Tropical cyclones are intense low-pressure systems formed over warm oceans between the Tropics of Cancer and Capricorn. They produce destructive winds, heavy rainfall and storm surges that inundate low-lying coastal areas.

Cyclones, typhoons and hurricanes

In Australia we call intense low pressure systems tropical cyclones, while in the United States they are called hurricanes, and in East and Southeast Asia they are called typhoons. In the southern hemisphere, cyclone season usually runs from November to April, while in the northern hemisphere, hurricane and typhoon activity is most common between June and November. This is because tropical cyclones form in warm ocean waters with temperatures above 26.5°C, and these months align with the warmer seasons in each hemisphere. When sea surface temperatures are at their highest, it provides the heat and moisture needed to fuel cyclone development.

The path of Tropical Cyclone Yasi



▲ **Source 1:** Deadly path of destruction of Tropical Cyclone Yasi, February 2011

Source: News Limited/Mario Lendvai

Source 2: Boats are left crushed against each other at Cardwell in the aftermath of Cyclone Yasi

Because the Pacific Ocean contains a vast area of warm water during cyclone seasons, it generates nearly half of the world's tropical cyclones each year.

According to the Bureau of Statistics, a Category 1 cyclone has sustained winds of at least 63 kilometres per hour while a Category 5 cyclone can produce winds exceeding 200 kilometres per hour. At the centre of each cyclone is the eye, a calm and clear area surrounded by a wall of intense winds and rain. As the cyclone moves over land, it gradually loses strength due to the absence of warm ocean water to maintain it.

Cyclone Yasi

Tropical Cyclone Yasi was the biggest storm in Queensland's history. It occurred on 3 February 2011, moving towards the coast of north Queensland from the Pacific Ocean. It had intensified from a Category 3 cyclone to a Category 5 cyclone, with wind speeds of 285 km/h when it made landfall at Mission Beach, south of Cairns. A storm surge increased the water level by 7 metres and pushed up to 300 metres inland. A total of 471 millimetres of heavy rain fell at South Mission Beach and a record low pressure of 929 hPa was measured as the eye passed over Tully.

The 10 000 people in the path of the cyclone were evacuated from their homes. Only one death was recorded, thanks to the advanced warning of the cyclone. More than 1000 homes were badly damaged, with 30 per cent of houses in Tully destroyed. Damage to power lines left more than 150 000 homes without power. Cyclone Yasi destroyed 75 per cent of Australia's banana crops, and damage to sugarcane farms cost in excess of $500 million.

Learning ladder 8.10

Processes that transform people, places and environments

1. Where do tropical cyclones occur?
2. Source 1: Describe how Cyclone Yasi changed categories on its path.
3. Draw a labelled diagram to explain the characteristics of a tropical cyclone.
4. Source 2: What impact did Cyclone Yasi have on communities and activities along the Far North Queensland coastline?
5. Source 1: What tools were used to measure the cyclone and predict its movement? What action was taken to reduce the danger to the community?

Interconnection

1. How are tropical cyclones and warm sea temperatures interconnected?
2. Source 1: Describe the interconnection between the zone of very destructive winds and the category of cyclone.
3. Explain the interconnection between tropical cyclones and wind direction.

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8.11

Case study

How is Cyclone Ilsa an example of future storms?

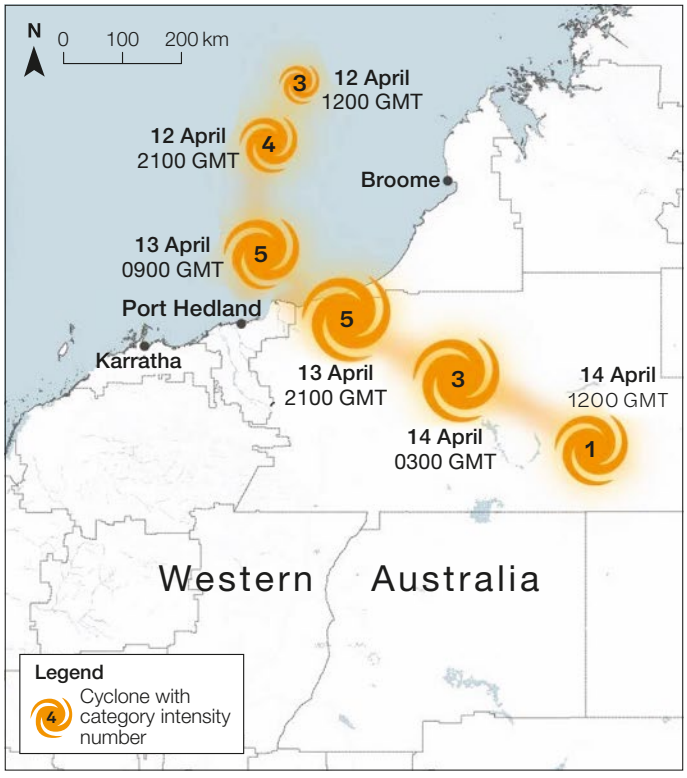
In the 2022–23 season, six tropical cyclones were named, of which three were dangerous Category 5 systems and the remaining were severe Category 3 storms. The only Category 5 tropical cyclone to impact the mainland was Tropical Cyclone Ilsa.

Cyclone Ilsa

While cyclones can occur at any time of year, the tropical cyclone season in Australia is from 1 November until 30 April. As a result of climate change, there are now fewer total tropical cyclones each year, but they tend to be much more intense and cause more damage. Ilsa was so powerful that over a 10-minute period, record-breaking wind gusts of 288 kilometres per hour were recorded on Bedout Island off Western Australia's north-western coast.

Ilsa crossed Western Australia's Pilbara coast on 13 April 2023 in a sparsely populated location, which limited the damage to infrastructure. The Pardoo Roadhouse and pastoral stations sustained severe damage. Cyclone Ilsa isolated communities, damaged infrastructure and impacted local fishing and tourism industries. In total, it was estimated that Ilsa caused around $4 million in damage and eight deaths when two boats capsized after being caught in the cyclone offshore.

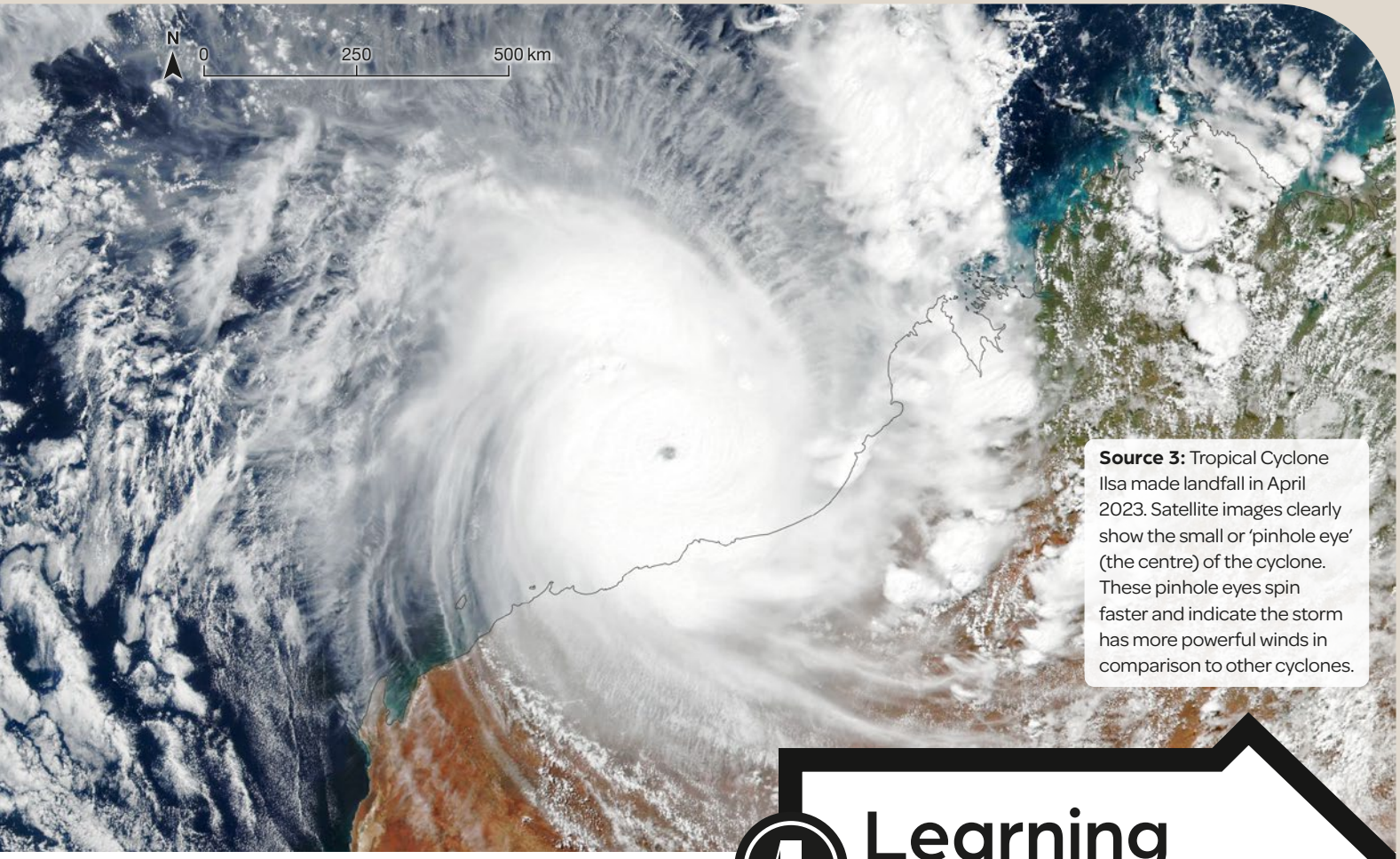
The path of Tropical Cyclone Ilsa



Source: Getty Images

Source 1: Tropical Cyclone Ilsa changed categories as it moved across the coast of north-western Australia in April 2023. Category 5 cyclones can produce wind speeds above 280 km/h and cause total destruction.

Source 2: Destruction at Pardoo Roadhouse and Tavern after Tropical Cyclone Ilsa



Source 3: Tropical Cyclone Ilsa made landfall in April 2023. Satellite images clearly show the small or 'pinhole eye' (the centre) of the cyclone. These pinhole eyes spin faster and indicate the storm has more powerful winds in comparison to other cyclones.

Learning ladder 8.11

Processes that transform people, places and environments

1. Outline how the pattern of tropical cyclones in Australia has changed over time.
2. Source 3: Describe what you can see in this satellite image. Why do you think these images are helpful for understanding tropical cyclones?
3. Source 3: Explain how and why the severity of Cyclone Ilsa changed along its path.
4. The current tropical cyclone 1–5 Category system has been criticised as it only takes into account wind speed, not other factors. Suggest an alternative way of rating tropical cyclones that would provide better insights into their strength and potential impacts. What would Ilsa have ranked in your new system?

Place

1. Source 2: Where is this place and what happened?
2. Sources 1 and 3: Describe where Cyclone Ilsa made landfall.
3. Source 2: Explain why damage from such a severe tropical cyclone was limited to a few properties.

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What are the impacts of cyclones in Australia?

Between November and April each year, northern Australia experiences an average of 11 cyclones. These cyclones are categorised based on their wind speed, with weaker cyclones classed Category 1 up to stronger cyclones that are classed Category 5 (see Source 1). Cyclones, particularly Categories 3–5, have significant social, economic and environmental impacts.

Social and economic

Cyclones significantly affect communities and local economies. Between 1970 and 2017, approximately 206 deaths in Australia were linked to tropical cyclones. Advances in technology have improved prediction and response strategies, allowing for earlier evacuations and better warning systems. However, the social aftermath includes widespread displacement, with over 1000 Queensland residents remaining homeless 6 months after Cyclone Yasi, and a surge in waterborne diseases like cholera and typhoid due to contaminated water sources and damaged sanitary infrastructure.

Economically, cyclones wreak havoc by damaging critical infrastructure such as telecommunications, transport systems and utilities, which disrupts key industries including fisheries and tourism, reducing productivity and causing substantial income losses. Recovery is costly, with natural disasters projected to cost the Australian economy $73 billion annually by 2060. The diversion of government resources towards recovery efforts also impacts funding available for other crucial sectors like health care and education.

Environmental

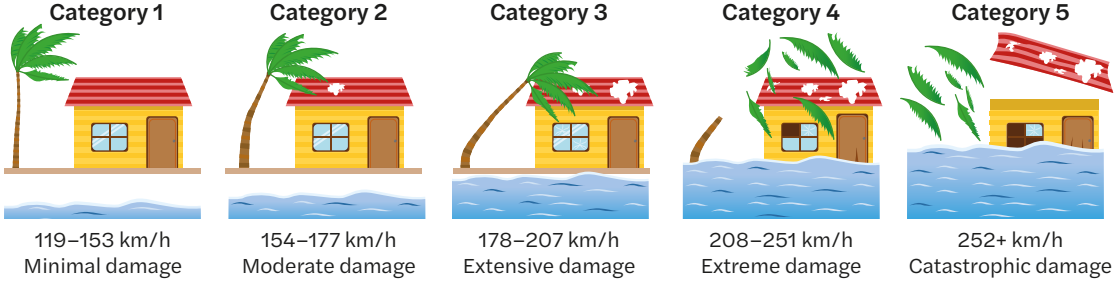
Wind and rain

Tropical cyclones have gale force winds, with the most powerful winds in the centre that reach anywhere from 90 kilometres per hour to over 280 kilometres per hour. These winds extend a long way from the centre of the cyclone, in some cases up to several hundred kilometres. Heavy rainfall associated with a tropical cyclone can also produce extensive flooding. The heavy rain can persist as the cyclone moves inland and weakens into a low-pressure system, causing flooding to happen a long way from where the cyclone makes landfall. Environmental impacts of this include:

- **Deforestation:** Winds can uproot trees and damage forests, leading to widespread deforestation. This reduces habitats and causes habitat fragmentation, affecting local wildlife. Following Cyclone Yasi, cassowary populations fell in the Daintree Rainforest. Cassowaries play an important role in dispersing seeds throughout the forest. Declining numbers had a direct impact on the dispersal of many native tree species.
- **Soil erosion:** Winds and heavy rain strip topsoil and cause soil erosion, which can degrade the land, reduce agricultural productivity and increase sediments running off into rivers and waterways. This can have adverse effects on fish species and aquatic plants.

Storm surge

A storm surge is an abnormal rise in sea level above the regular tide level. It is caused by the strong winds and atmospheric pressure associated with cyclones.



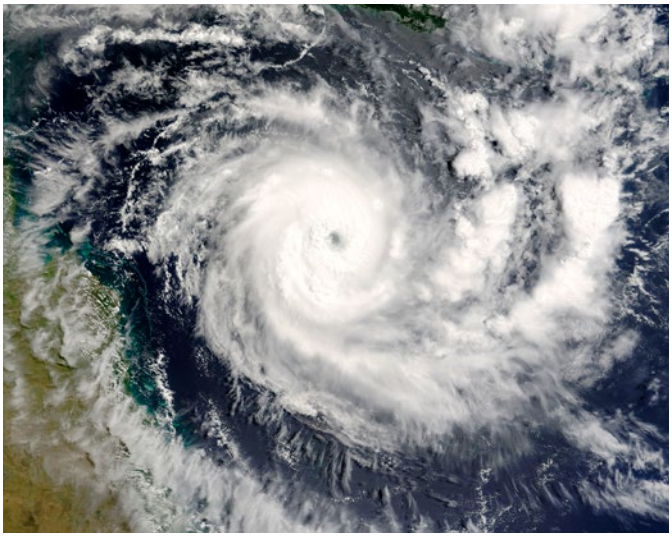
Source 1: Cyclones are classed into categories based on their wind speed. Category 1 cyclones have weaker winds compared to the severe winds of Category 5.

Source 2: A house is destroyed in Tully Heads by Cyclone Yasi, showing the damage caused to Australia's environment.

Cyclone	Date	State	Normalised loss value ($ in 2017)
Cyclone Tracey	21–25 December 1974	NT	5.04B
Cyclone Dinah	22–31 January 1967	QLD	4.68B
Cyclone Elaine	13–19 March 1967	QLD, NSW	2.13B
Cyclone Debbie	28 March – 10 April 2017	QLD, NSW	1.78B
Cyclone Madge	12–18 March 1973	NT, WA, QLD	1.48B
Cyclone Yasi	26 January – 6 February 2011	QLD	1.48B
Qld flooding ex Cyclone Oswald	20–29 January 2013	QLD	1.13B
Cyclone Althea	19–29 December 1971	QLD	811.4M
Cyclone Justin	6–23 March 1997	QLD	705.1M
Cyclone Larry	17–21 March 2006	QLD	633.49M

▲ **Source 3:** The top 10 most economically impactful cyclones in Australia since 1965

A storm tide is the water level that results from the combination of the storm surge and the normal tide. Storm surges are at their most dangerous when they occur at the same time as a regular high tide. This occurred when Hurricane Katrina made landfall in New Orleans in 2005, resulting in the worst floods and loss of life in the city in over 100 years. Storm tides and the large waves created by winds can inundate low-lying areas, sometimes for kilometres inland. This creates waterlogged soils, increases pollution and sediment entering natural waterways and causes increased erosion in coastal areas.



▲ **Source 4:** Satellite image of Cyclone Ingrid in 2005. Cyclones are intense low-pressure systems, which move clockwise in the southern hemisphere. Institutions map the development of cyclones using satellite technology, and this enables them to give early warnings to communities to evacuate, reducing the social impacts of cyclones.

Learning ladder 8.12

Processes that transform people, places and environments

1. What are cyclones, and how are they categorised based on their wind speed?
2. Explain the social impacts of cyclones.
3. How do cyclones disrupt economic activities, and what are the long-term consequences for affected regions?
4. Analyse the environmental impacts of cyclones. Rank them from most impactful to least and justify your rankings.
5. Evaluate the role of storm surges in shaping coastal environments and communities.

Environment

1. Describe one environmental impact of cyclone winds.
2. How do cyclones affect marine ecosystems?
3. Discuss the role of cyclones in creating long-term environmental impacts.
4. Propose strategies for mitigating the challenges of cyclones in cyclone-prone areas.
5. Research one of the following cyclones and analyse the social, economic and environmental impacts of it: Cyclone Debbie, Cyclone Yasi, Cyclone Jasper.

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8.13

How can we manage the impact of cyclones?

Governments, organisations and communities can implement a range of proactive and reactive strategies to manage the impact of cyclones. This can reduce the vulnerability of places and communities when faced with cyclones.

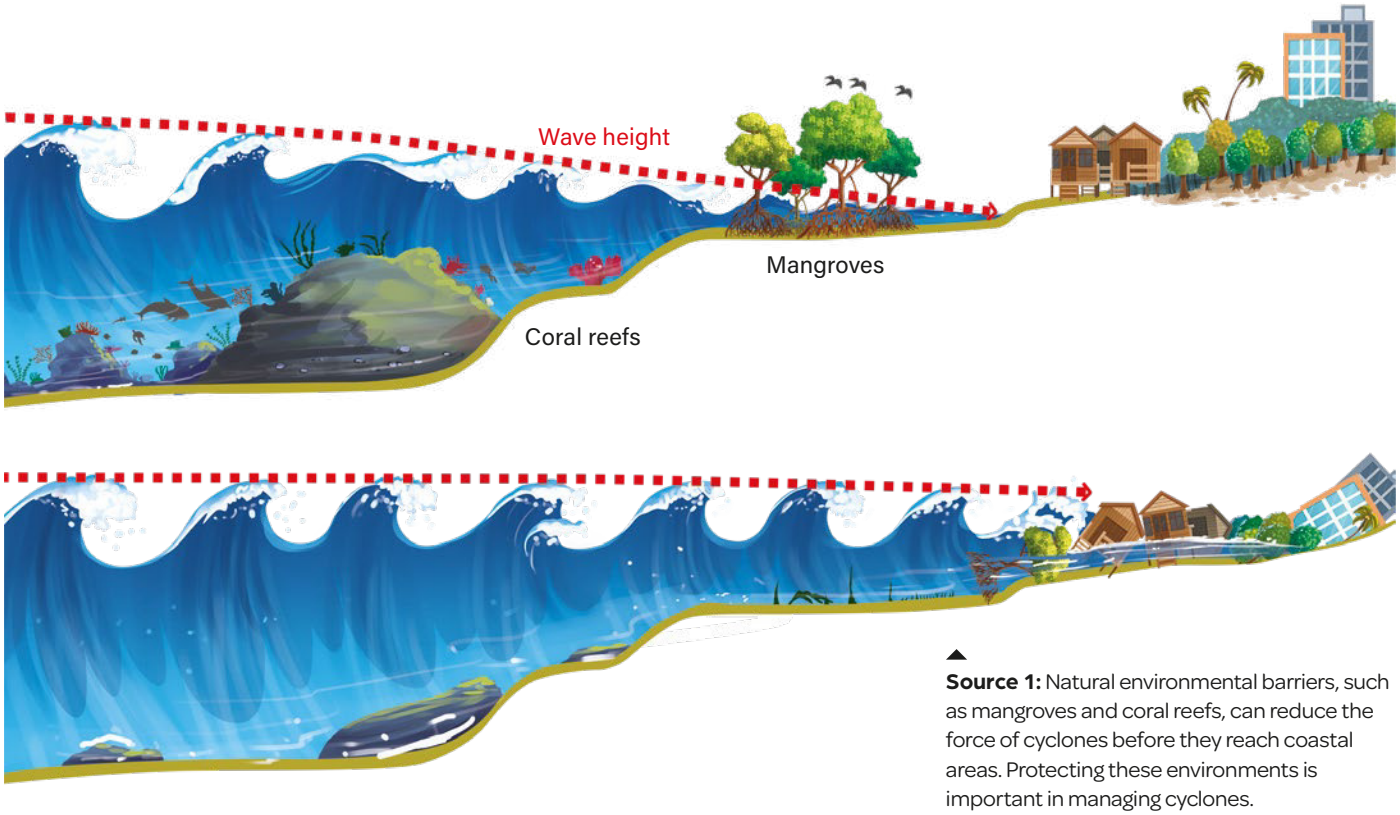
Proactive strategies

Proactive strategies aim to reduce the cause or intensity of cyclones. Some examples include:

- enhancing natural environmental barriers
- building barriers
- reducing greenhouse gas emissions.

Enhancing natural environmental barriers

Coral reefs, mangroves, wetlands and barrier islands absorb some of the force from cyclones, reducing their impact on coasts and communities. Human changes to these natural barriers, such as the deforestation of mangroves or draining of wetlands, have reduced their size and effectiveness. Governments and organisations can implement strategies that protect and extend these natural barriers, to mitigate the severity of cyclones before they reach communities. In Bangladesh, the government is implementing strategies to protect and expand the Sundarbans mangroves that act as a natural buffer against storm surges and cyclonic winds. They have planted artificial mangrove forests and implemented electronic patrolling, where they use GIS equipment to monitor if any forests have been illegally cleared.



Source 1: Natural environmental barriers, such as mangroves and coral reefs, can reduce the force of cyclones before they reach coastal areas. Protecting these environments is important in managing cyclones.

Building barriers

Building seawalls, storm surge barriers, floodwalls and levees can reduce the energy of waves and flooding caused by cyclones. This mitigates damage to infrastructure and communities.

Reducing greenhouse gas emissions

Human-induced climate change leads to warmer ocean surfaces, resulting in more frequent and intense cyclones around the world. Strategies that reduce the amount of greenhouse gases released into the atmosphere can help. Many people are switching to solar energy systems in their homes to reduce their contribution to climate change.

Reactive strategies

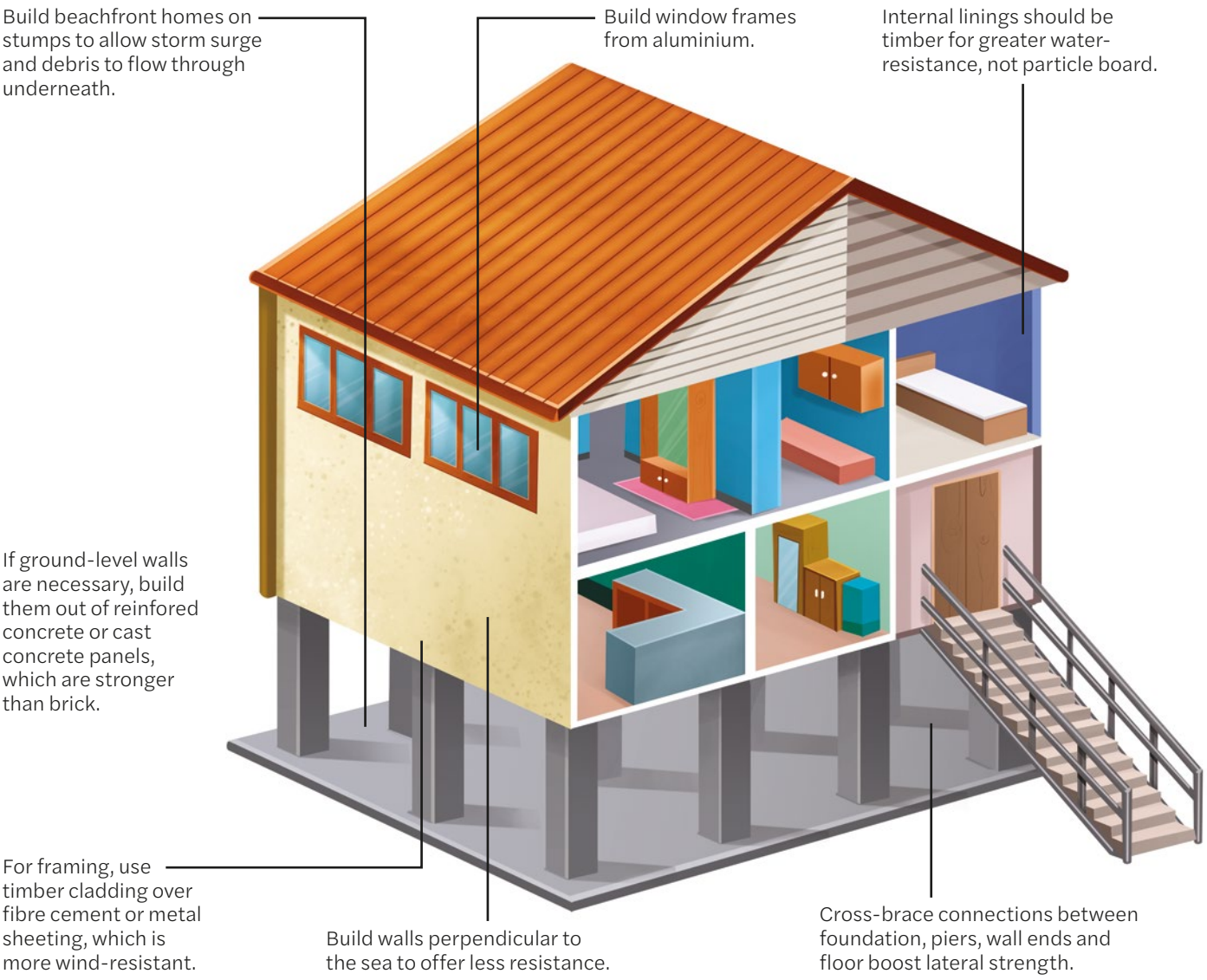
Reactive strategies are changes made to a community and its infrastructure to better prepare for hazards, and reduce their social and economic consequences. Examples include:

- infrastructure development
- early warning systems
- disaster response plans.

Infrastructure development

Constructing buildings and infrastructure, such as telecommunications networks and water supplies, that can withstand the force of cyclones can provide more shelter for people during hazardous conditions.

Source 2: An aerial image of the Sundarbans, the world's largest mangrove forest, in Bangladesh. Mangrove forests act as an important natural barrier from cyclones.



▲ **Source 3:** There are many ways a house can be built to be more resistant to cyclones. It is important to construct buildings with these features in areas at risk from cyclones.

It also helps to reduce the cost of repairs afterwards. Elevating these buildings offers further protection from storm surges and flooding during cyclones. It is important for governments to enforce zoning regulations when constructing these buildings, which prevents development in high-risk areas such as floodplains and low-lying coastal zones.

Early warning systems

Advanced satellite technologies can help governments and organisations identify cyclones early and use telecommunication technologies (such as phones, radios and televisions) to notify communities in their local language straight away. Early warning systems in Mozambique (such as weather radars, community radios and car-mounted megaphones) were highly effective for alerting people to evacuate or move to high ground during Cyclone Freddy in 2023. This directly led to substantially fewer deaths than previous cyclones of the same strength.

Disaster response plans

Creating clear evacuation routes and procedures, building communication systems, and training community volunteers in first aid and disaster response can improve recovery after a cyclone. Having plans in place and a knowledgeable volunteer service can help rescue people, distribute relief supplies and provide medical assistance quickly to support as many people as possible. Educating people in at-risk areas on these procedures regularly also ensures everyone in the community knows how to act when a hazard occurs. State Emergency Services in Australia are vital for supporting communities after hazards, such as cyclones and floods.

Source 4: Community members in Bangladesh place sandbags on the bank of the river after a cyclone to protect it from further flooding and erosion. This is part of the disaster response plan to protect communities and the environment after a cyclone.

Cyclone Pam

Cyclone Pam affected Vanuatu in 2015. It was one of the strongest cyclones to hit the region, with winds reaching up to 250 kilometres per hour. Effective preparedness and rapid responses enabled Vanuatu to mitigate the impact of Cyclone Pam:

- **Early warning systems:** The Vanuatu Meteorological Services, along with regional and international weather agencies, provided early warnings and regular updates as Cyclone Pam approached. This enabled timely public advisories and preparedness measures.
- **Evacuation:** Before the cyclone reached land, the government issued evacuation orders for vulnerable areas and set up over 100 evacuation centres across the country to shelter thousands of people.
- **International aid:** Countries (such as Australia and New Zealand) along with international organisations (such as the Red Cross) provided emergency aid, including water, food and medical supplies.
- **Recovery:** The government and communities organised the rebuilding of destroyed homes and repairing infrastructure. New buildings were designed to be more resilient against future cyclones.

Learning ladder 8.13

Sustainable management strategies

1. Describe one strategy that can reduce the impact of cyclones.
2. Are all countries equipped to manage cyclones equally? Why/why not?
3. Analyse the effectiveness of one management strategy used to combat cyclones.
4. Justify whether proactive or reactive strategies are more effective.
5. Evaluate the long-term sustainability of a strategy implemented to manage cyclones.

Environment

1. List three different types of environments affected by cyclones.
2. Describe the physical and built characteristics of mangroves and seawalls, and how they contribute to cyclone management.
3. Explain how natural barriers like coral reefs and mangroves protect against cyclones.
4. Analyse the impact of deforestation of mangroves and the construction of levees on the effectiveness of cyclone management.
5. Evaluate the construction of barriers on coastal areas to mitigate the impacts of cyclones. Consider the advantages and disadvantages in your response.

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Thinking geographically

Water in the world

Geographical concepts, inquiry and tools

Place, space, choropleth maps and synoptic charts

Learning ladder: page 264

See **Geo How-To** for Geographic tools, see pages 402 and 406

Key inquiry question

How do floods and droughts affect Queensland differently?

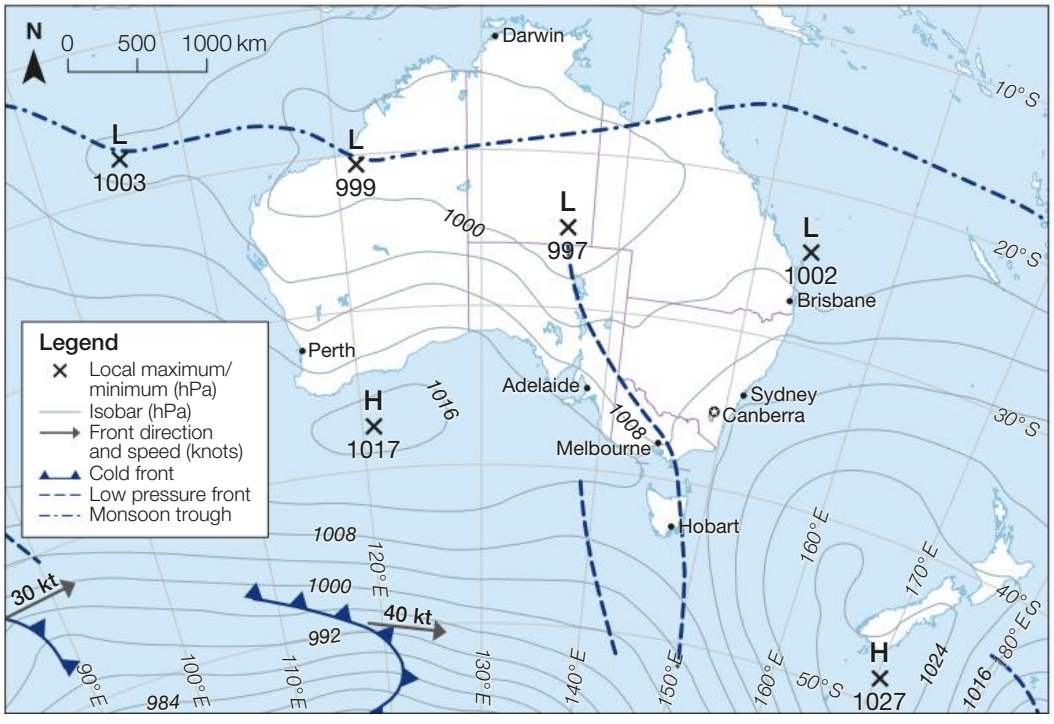
In a written or oral report, use the knowledge and understanding developed in the activities below to answer the inquiry question. Include the following:

- the location of Queensland
- the factors influencing the availability of water in Queensland over time
- compare the extent of environmental, social and economic impacts of floods and droughts
- one sketch map or simple diagram.

Where possible, refer to the sources in this spread to support your judgements.

Queensland floods, 2011

Weather conditions, 2011



Source 1: A synoptic chart of the weather conditions during the 2011 floods in Queensland

Source: Australian Bureau of Meteorology

Source 1 activities

1 Identify the air pressure (hPa) at the following cities:
a Sydney **b** Melbourne **c** Adelaide.

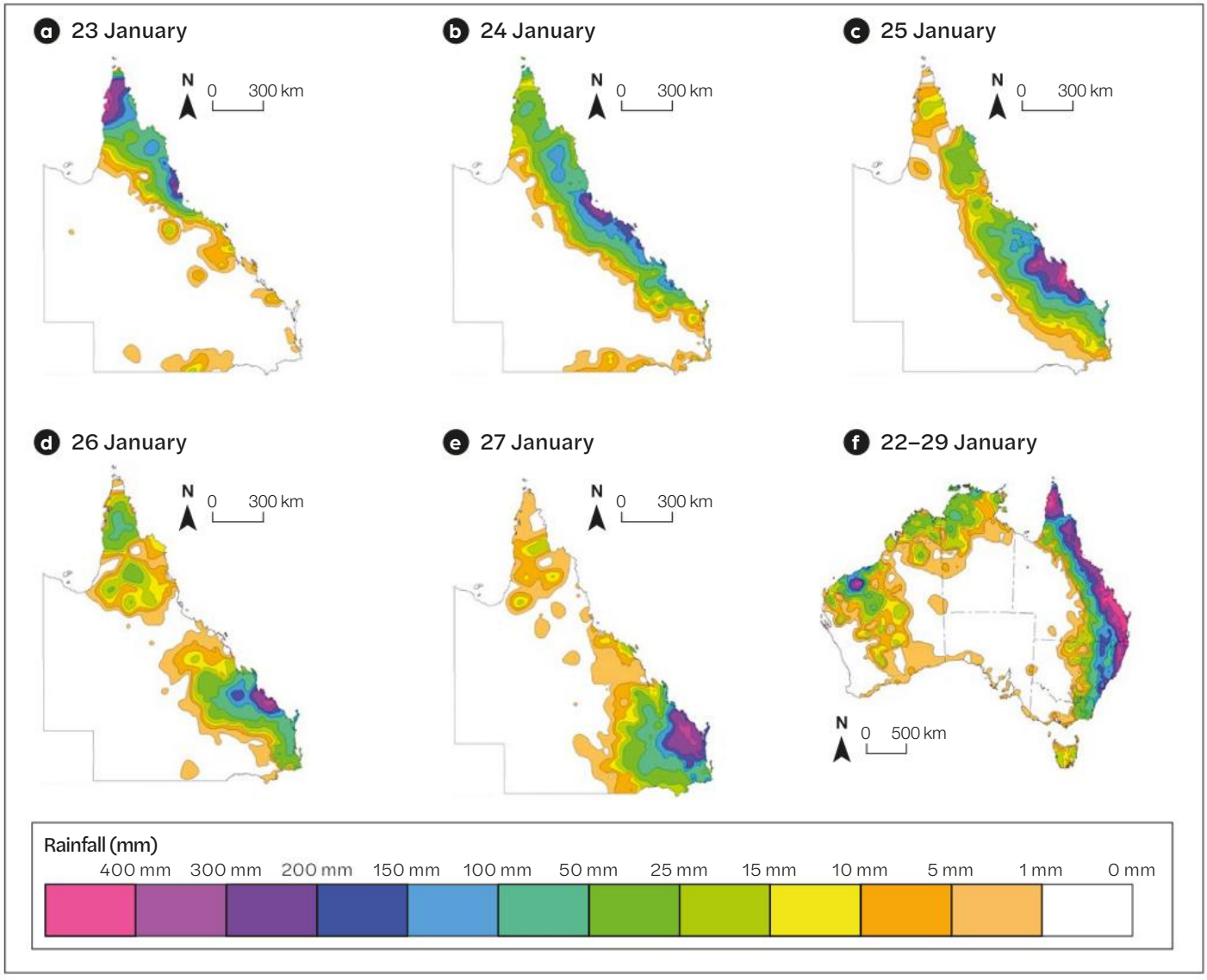
2 Describe the weather conditions in:
a Adelaide **b** Perth **c** Brisbane.

3 Justify the weather conditions likely to occur in the following cities within the next three to four days:
a Darwin **b** Melbourne **c** Hobart.

4 Determine what season it is likely to be, by comparing the weather systems in the northern and southern parts of Australia.

Queensland floods, 2013

Accumulated rainfall, Queensland, 23–29 January 2013



Source 2: Maps showing the accumulated rainfall in Queensland between 23 and 29 January 2013, and Australia between 22 and 29 January 2013. This rainfall contributed to the significant Queensland floods that year.

Source 2 activities

1 Identify the location of Sydney, Perth and Brisbane on these maps.

2 Identify how much rainfall the following locations experienced between 22 January and 29 January:
a Brisbane **b** Sydney **c** Perth.

3 Referring to Source 2, which day experienced the most amount of rain?

4 Referring to Source 2, which day experienced the most land covered in rain?

5 Describe the rainfall patterns that occurred in Queensland between 23 January and 27 January.

6 Explain how the rainfall across this week contributed to excessive flooding in Brisbane.

Flooding in Rockhampton

Flooding in Rockhampton, 2017

Source: Copernicus/Sentinel 2

Source 3: Before and after photographs of the 2017 flooding in Rockhampton

Source 3 activities

1 Identify the type of photograph used: aerial/oblique aerial/ground level.

2 Describe the changes to the environment caused by floods in Rockhampton.

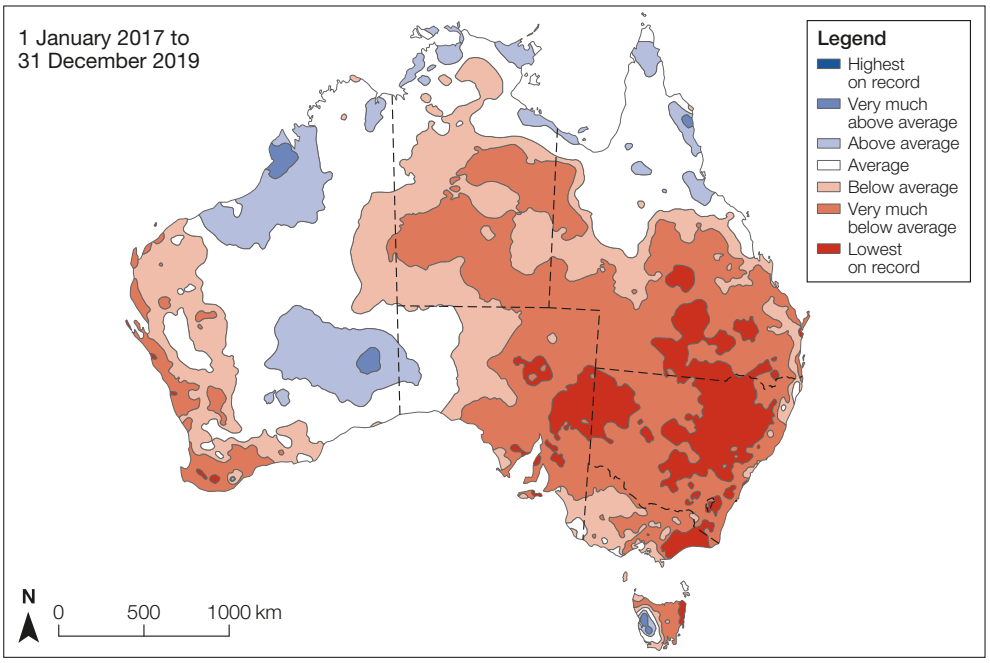
3 If the scale is 1:50 000, calculate:
- **a** the length from west to east shown in the photograph
- **b** the length of the river
- **c** the area (square metres) shown in the photograph.

4 Analyse the environmental impacts caused by floods shown in the photographs.

5 Analyse how these changes would have social and economic impacts.

Rainfall across Australia

Australia rainfall deciles, 2018–19



Source: Australian Bureau of Meteorology

Source 4: A choropleth map showing the patterns of rainfall across Australia from 2017 to 2019, with many areas experiencing below average or lowest on record numbers

Source 4 activities

1. Identify the category of rainfall received to the following places:
   - **a** Perth
   - **b** Sydney
   - **c** Darwin.
2. Describe the locations most at risk of drought in 2017–19.
3. Using the scale, how far inland from the east coast was rainfall below average?

Low rainfall leads to drought

Source 5 activities

1. Identify the type of photograph shown: aerial/oblique aerial/ground level.
2. Describe the impact of droughts on the environment of Queensland.
3. Analyse how these changes would have social and economic impacts.
4. Compare the impacts shown in this photograph to those shown in Source 3.

Source 5: Dry arid soils during low rainfall in Queensland in 2019. This results in low dam levels with impacts on agriculture and possible water restrictions.

Social, economic and environmental impacts of droughts and floods

More than 1400 km of roads were damaged or closed.

Communities have water carted in to survive. For example, Stanthorpe carted in about 40 truckloads of water daily over 18 months. It cost them $800 000 a month, equating to more than $14 million in total.

180 000 households lost power.

Droughts contributed to increased food prices, with the price of fresh fruit and vegetables rising by 43% and 33% respectively during significant drought periods.

2500 primary producers accounted a total loss of 30%, costing about $254 million.

Droughts have severely impacted mental health in farming communities, contributing to stress, anxiety and depression among farmers due to financial strain and environmental uncertainty.

15 local government areas activated Disaster Recovery Funding Arrangements.

Droughts cause migration from rural areas, weakening social structures and diminishing the vitality of local economies.

Over 500 weather warnings were issued.

Severe water shortages, with 60% of Queensland farmers reporting having less than half of their water supply during droughts, further stress ecosystems and reduce agricultural output.

Source 6: An infographic comparing the social, economic and environmental impacts of droughts and floods in Queensland

Source 6 activities

1 Identify one of each of the following:
   - **a** an economic impact of floods
   - **b** an environmental impact of droughts
   - **c** a social impact of floods.

2 Describe the difference in the social impacts of floods and droughts.

3 Explain whether floods or droughts have more of an economic impact.

4 Assess whether the impacts of floods or droughts are more difficult to manage.

Interconnections and trade

Connecting people and places

9

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HOW IS AUSTRALIA CONNECTED WITH OTHER PLACES? 312

WHAT IS CULTURALLY RESPONSIBLE TOURISM? 332

9.0

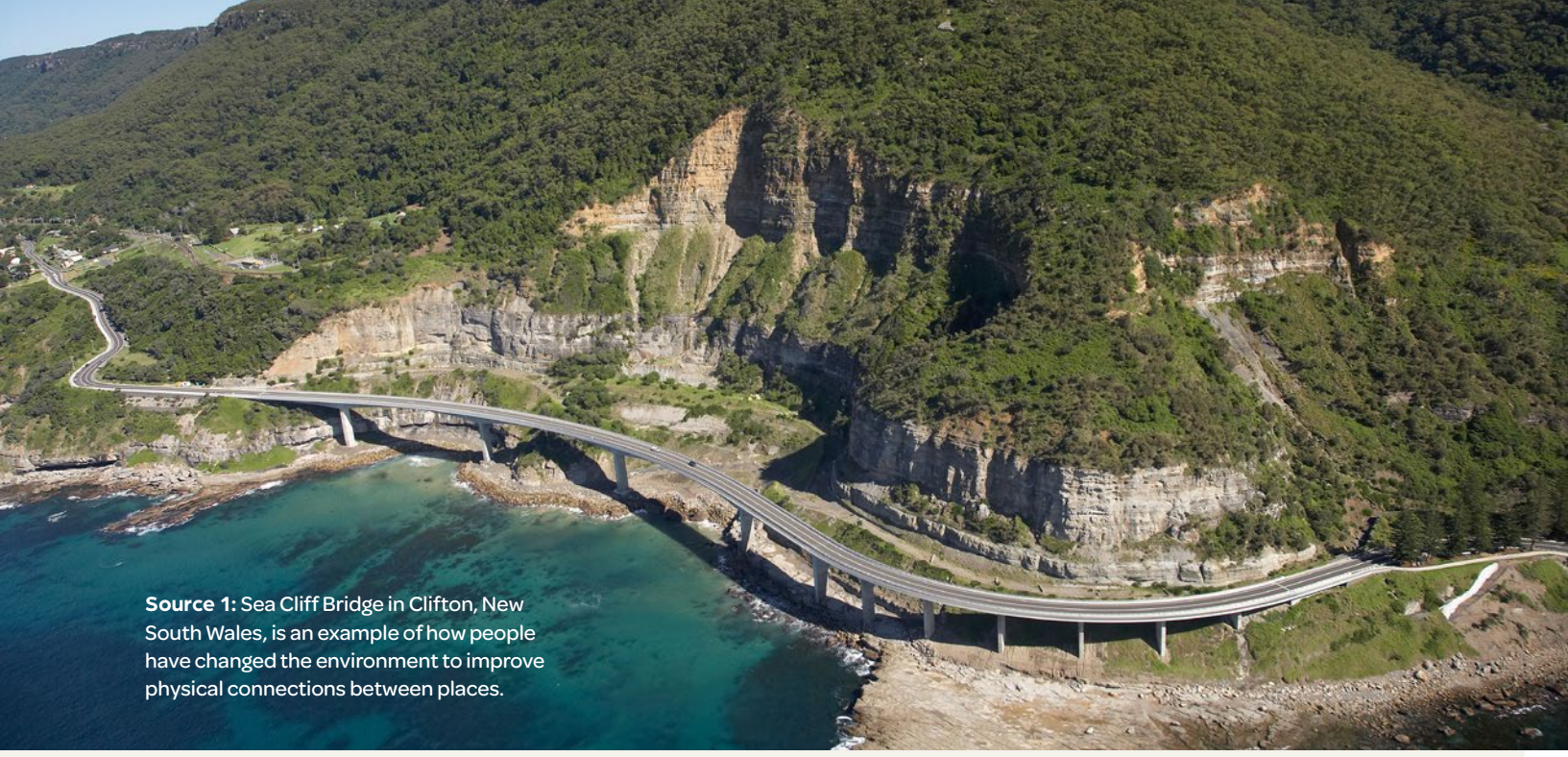
How can I understand connecting people and places?

The *geography of interconnections* focuses on investigating how people are connected to places throughout the world in a wide variety of ways.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
	Outcomes					Geographical tools and inquiry
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information



Source 1: Sea Cliff Bridge in Clifton, New South Wales, is an example of how people have changed the environment to improve physical connections between places.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

9.1

How are people connected to places?

People connect to places through social and cultural connections, personal heritage, travel and even consumer purchases. A sense of connection is different for each person and group in society, and each one of us has places that mean something special.

Connection to place

Places are parts of the Earth's surface that are identified and given meaning by people. People form connections to places that help shape their identity, their values and their sense of belonging. These places can be as small as your bedroom or as large as a country. They can be human features such as a building or natural places such as a forest. Understanding how people connect to place is valuable for many vocations, such as urban planning and community development. By recognising connections, places can be developed to be sustainable and meet the needs of the population. There are many reasons people develop connections to place.

Social and cultural connections

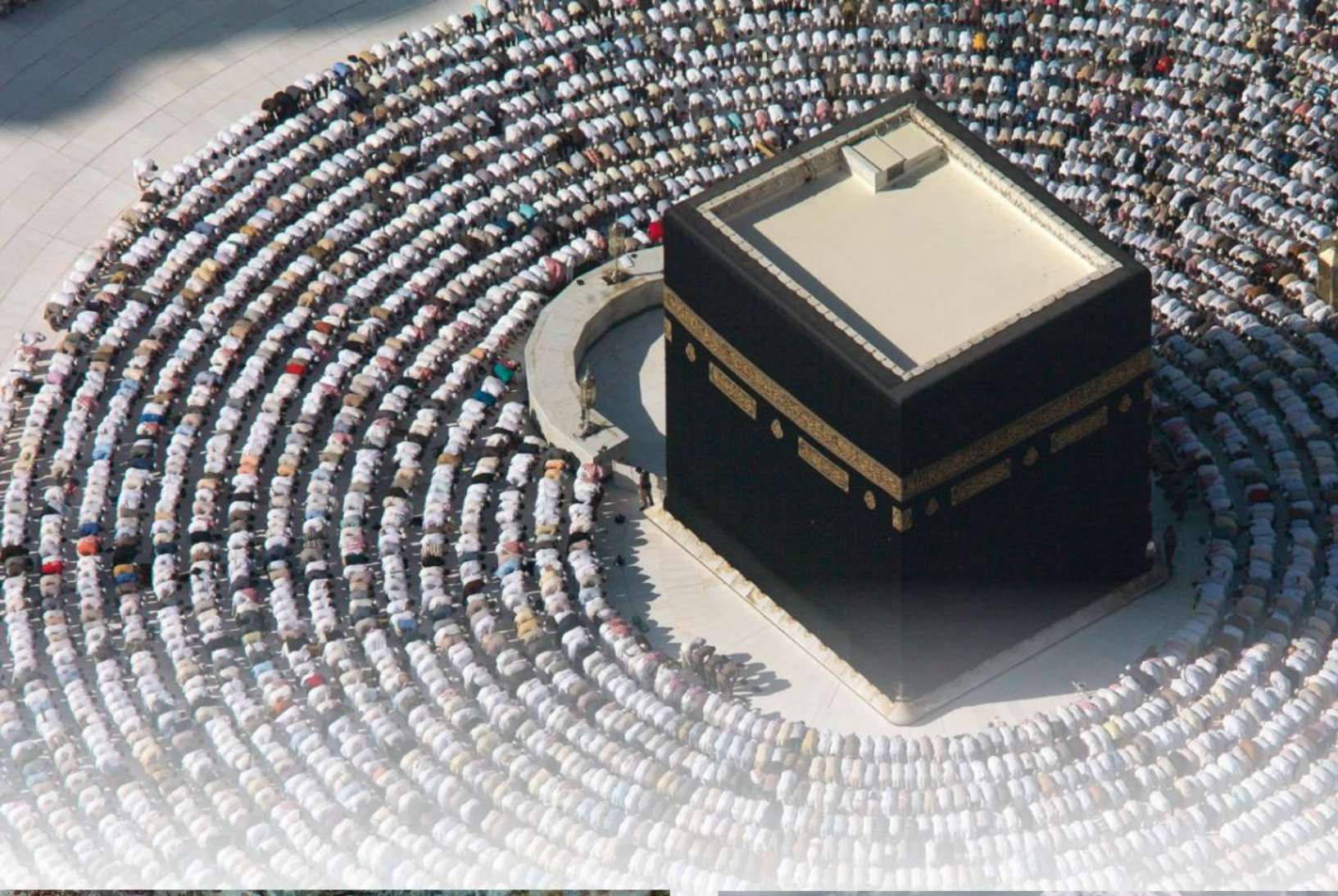
Places are where we build relationships with others, connect with community and share experiences. As people connect to their local community and places, the values and expectations of that group influence their own behaviours and beliefs. As an example, living in a rural area might foster a connection to nature and independence, whereas living in an urban area might foster adaptability and a fast-paced mindset.

Traditions and customs

Places also create a shared space for traditions and customs, which further connects people and influences a sense of identity. As an example, throughout every year, pagan Druids hold festivals and rituals at Stonehenge to celebrate solstices and equinoxes. Some places can also spiritually connect people through religious customs, such as the Kaaba in Mecca, Saudi Arabia. This site is significant to Muslim people around the world as every Muslim faces the Kaaba when they pray and visits the Kaaba at least once in their life to complete the Hajj, one of the five pillars of Islam. As a result, this place holds significant value to Muslim adherents, connecting them and providing a sense of belonging to all from across the world through tradition.

Source 2: The Kaaba in Mecca, Saudi Arabia. Muslim communities are surrounding the vessel in prayer. Every Muslim in the world faces the Kaaba when they pray, connecting them all to one place.

Source 1: Ancient Aboriginal rock art, found at Mount Borradaile in West Arnhem Land, Northern Territory. This art was one way of sharing knowledge and traditions for First Nations groups, enhancing their understanding and connection to place. First Nations Peoples have a strong belief in belonging to the land, and images of hands are often a symbol of this connection. Images of hands in rock art indicate that the ancestors who painted them belong to and respect that place.



Source 3: Druids gather for the winter solstice at Stonehenge to celebrate the rebirth of the sun for the year ahead. Stonehenge provides a place for Druids to connect and engage in tradition.

Historical connections

Communities can also develop a deep connection to place through their role in caring for the environment and contributing to its sustainability. This can be seen with the strong connection to Country among First Nations groups, who have established traditions, rituals and significant sites across Australia that demonstrate their deep understanding of place and responsibility to land. This can also be seen with the Indigenous Bishnoi group in the Thar Desert in India, protecters of the khejri trees. This tree is significant in maintaining the desert **ecosystem**, and more than 363 Bishnoi people were killed by soldiers while protecting them from desecration in 1730. Today, Bishnoi communities gather on National Forest Martyrs Day to plant more khejri trees, seen in Source 4.

Travel

Places become meaningful through our engagement with them, so through travel, people foster wider connections to places. Over 1.2 billion people travel every year for work, to meet with family or to experience new places. Through this, people try new foods, participate in local customs, observe new diverse environments and often develop a desire to conserve different places that become important to them. This is seen with the 1.5 million tourists who hike through the Andes mountains to visit the ancient city of Machu Picchu in Peru. These tourists gain a connection to the natural mountainous landscape and develop an appreciation for the resilience of the ancient Inca civilisation and their culture. Many tourists state they feel connected to the spiritual energy at the site.

Personal heritage

Nearly 30 per cent of Australia's population today was born overseas. This is due to technology and transport making it easier for people to migrate. This results in people across the world sharing many cultural heritages. The heritage of a person can influence their family, culture, religion and languages spoken. Connecting to personal heritage can build a sense of belonging to a larger community and different places. As an example, there are over 1.4 million people with a Chinese heritage living in Australia. These communities not only connect to their place within Australia, but through family and traditions they also share a connection to China. As seen in Source 6, migrant communities around the world travel to and within the countries of their heritage to engage in annual traditions. These communities often influence place by integrating their heritage into the places they live, such as the Chinatown district in Sydney.

Consumer purchases

People are able to connect to place by purchasing goods, foods, technologies and materials associated with it. Buying produce directly from farmers or local artisans, such as beekeepers, can connect people to their community. Or when consumers purchase sustainable and ethical global products, such as fair trade chocolate or coffee, they are connecting to the place and people where that product was made. This builds a sense of connection across the world. People can also connect to places by consuming sports, music or movies associated with different places.

▼ **Source 4:** Bishnoi women planting a khejri tree in the Thar Desert on National Forest Martyrs Day. This is a day that is in memory of the 363 Bishnoi people who died protecting these trees 300 years ago. This activity connects the community to their place and history.

▲ **Source 5:** The famous 'I heart NY' T-shirts. These shirts are iconic around the world and demonstrate the vast connection people have to this city.

This is seen with the Arsenal football club in North London, who have 100 million football fans that live outside of the UK. These fans all connect to this place by watching Arsenal games, buying magazines and products associated with the football team, and travelling to watch the team play. This place then connects these fans all around the world.

Source 6: The estimated number of people travelling to significant traditions and events in the world in 2019. This indicates that many migrant communities around the world still share a strong connection to their place of heritage, as they travel to engage in important traditions each year.

Learning ladder 9.1

Perspectives of people and organisations

1. In what ways do people connect to places?
2. Describe a place you feel connected to, and why.
3. Source 4: Explain why these women have a historical connection to this place.
4. Source 2: Explain the importance of the Kaaba in Mecca to Muslims, and how people around the world can connect to it.

Place

1. Brainstorm the different places you feel connected to. What are the different reasons for the connections?
2. Source 6: Describe the pattern of travel for traditions and events in 2019.
3. Sources 3 and 4: Explain how significant places are at influencing culture and community.
4. Create a questionnaire that determines the places people are connected to, the extent of the connection and the reasons for the connection. Distribute it to your class or school and graph the results.

HOW TO

Place, page 390; surveys, page 430

How is Australia connected with other places and cultures?

As Australians, we are connected to people from around the globe through personal and virtual connections and through the pursuits we share: cultural, social, religious, culinary and so on. Trade, migration and tourism are three major ways we connect with others.

Trade

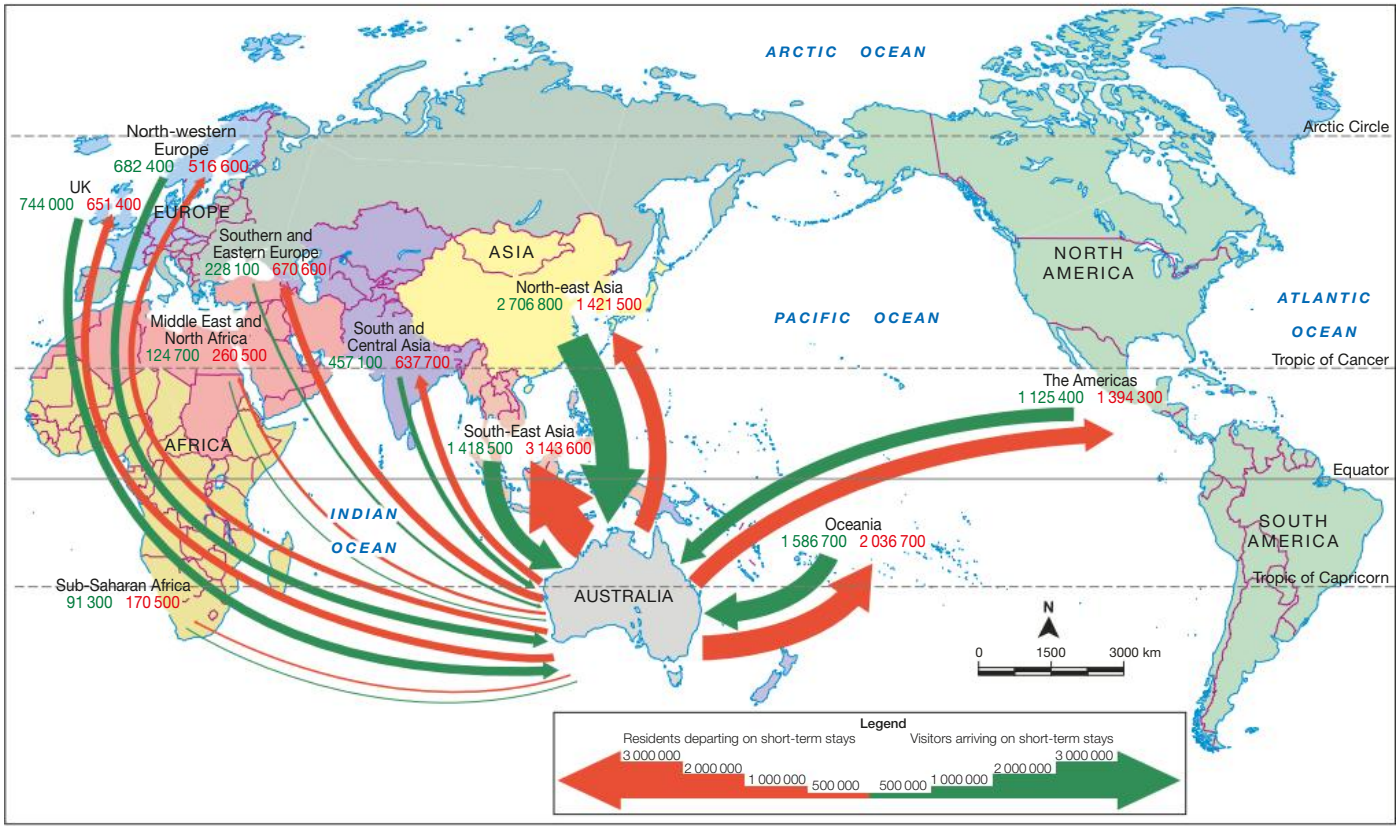
Trade is the exchanging, selling or buying of goods and services. Trade connects us with different regions of the world. Our major trading partners include East Asia and Europe. In 2022, our exports earned Australia $61 927 million. China is a major market for Australia's imports and exports. Our main exports are primary products, including food, minerals and fuel.

Australia also connects with other countries through free trade agreements (FTAs). FTAs with key partners, such as New Zealand, the UK and China, make it cheaper for Australia to purchase goods from, and sell goods to, other countries. This supports Australian businesses, providing a competitive edge for them to sell their products internationally. Australia currently has over 20 FTAs.

International migration

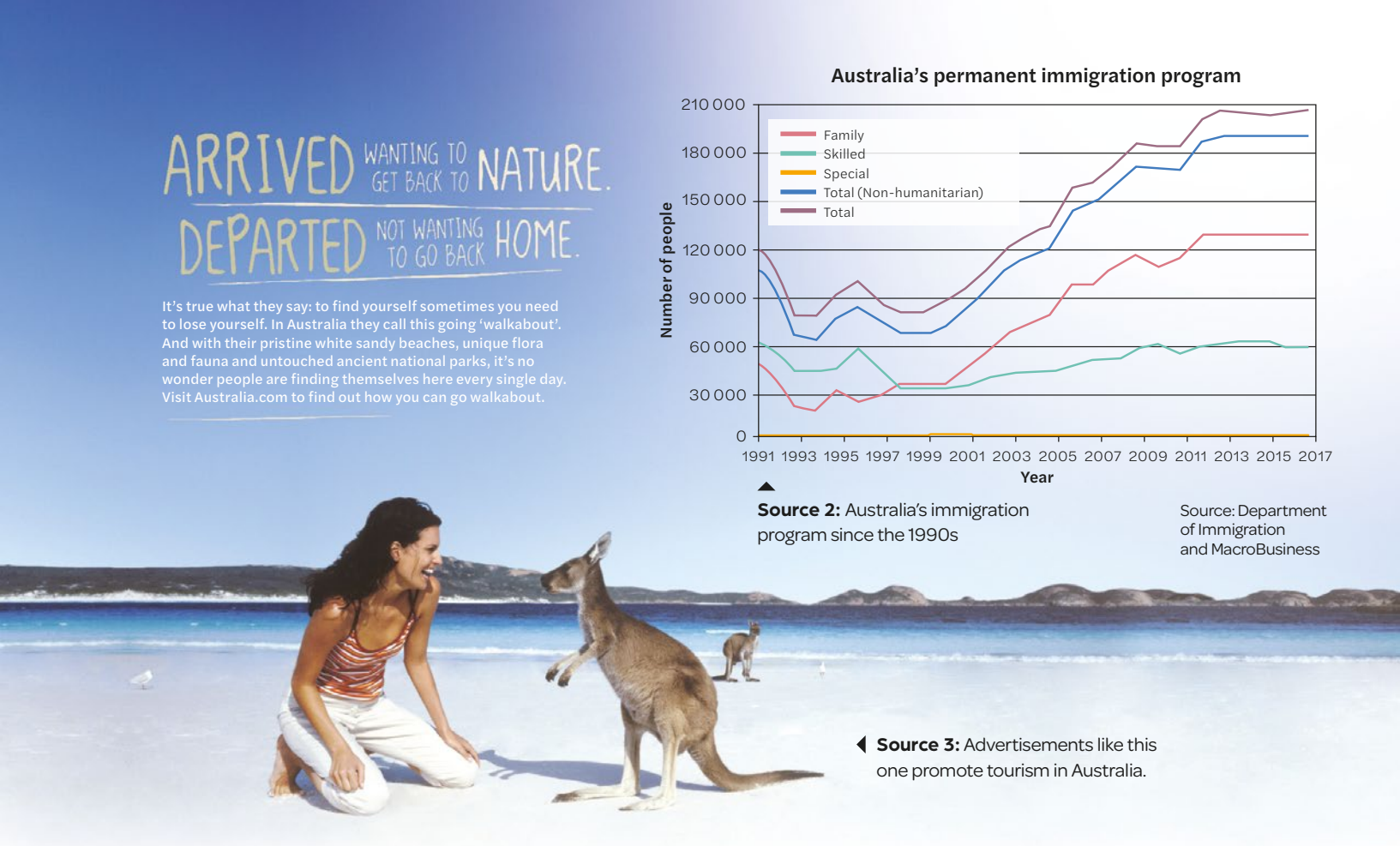
International migration is the movement of people into (immigration) and out of (emigration) a country. Australia's migrant intake is adjusted each year and includes places for **skilled workers** (designed to fill gaps in Australia's labour market), family members of existing residents or citizens, and people seeking asylum.

Australia international arrivals and departures



▲ **Source 1:** International arrivals to and departures from Australia

Source: Matilda Education Australia



Australia's permanent immigration program

Source 2: Australia's immigration program since the 1990s

Source: Department of Immigration and MacroBusiness

Source 3: Advertisements like this one promote tourism in Australia.

Nearly half of all Australians were born overseas or have at least one parent who was. Migrants bring customs, languages and foods to Australia, increasing the cultural landscape. The diverse origins of Australia's population mean that the country has a vested interest in the stability of regions around the world, influencing Australia's aid and strengthening our relationships with other countries. Many migrants also establish businesses that have connections with their country of origin, strengthening Australia's economic ties.

Tourism

In 2022, the Australian **tourism** industry employed over 713 000 people, and the value of international and domestic tourist spend was $143 billion dollars.

Learning ladder 9.2

Processes that transform people, places and environments

1. Define the term 'trade'.
2. Source 1: Outline what the arrows and colours represent on the map. List nationalities of the people who travel to and from Australia the most.
3. Source 2: Explain why there may have been a shift in the trends of family migration in 2020–21.
4. Create a mindmap that highlights how improved technology may have impacted trade and tourism rates over time for Australia.
5. Consider how Australia is restricted in terms of trade, even as technology improves.

Scale

1. List two potential tourism attractions on a local scale. Consider whether these attractions would be more suitable to domestic or international travellers.
2. How do migration and tourism play a major role in connecting us with other people, cultures and places?
3. Source 2: Describe how Australia's immigration program changed at a national scale.
4. List some of the positive impacts of migration considering the national economy and workforce.
5. How can free trade agreements increase Australia's connection with the world?

Scale, page 398

HOW TO

Case study

Why is Harris Park called Little India?

Harris Park is a suburb located in Sydney's west, and is part of the Parramatta local government area. It is often referred to as 'Little India' due to its large and vibrant Indian community. In 2021, 45 per cent of the people living in Harris Park were born in India.

How did it become Little India?

Since the 2000s, Harris Park has had a large influx of Indian migrants moving to the area, as seen in Source 3. Since the 1970s, Australia's immigration policies have encouraged skilled professionals, such as engineers and doctors, to move to Australia. Harris Park became a good place for Indian migrants to settle in as it is close to the Parramatta CBD for employment and education opportunities, is close to bus and train networks, and has affordable housing. These migrants formed strong community networks, often sponsoring more family members or friends to migrate to Australia and also settle in Harris Park.

Source 1: Indian fashion from The Saree Shop in Harris Park

What makes it a Little India?

As the Indian population increases in Harris Park, more Indian businesses continue to open up to cater to the culture of people living in the area. The number of Indian businesses has increased from 30 per cent in 2015 to over 70 per cent today. This includes sari and fashion shops, Indian restaurants, and specialised supermarkets that sell Indian produce and grocery items. Even local signs use various Indian languages to help the residents. At the heart of Harris Park today is Wigram Street, famous for its trays of gulab jamun, coconut desserts, swirls of fried jalebi and fragrant chai teas.

Many Indian celebrations and cultural events are held in Harris Park each year, such as Diwali festivals and Holi. These events bring the Indian diaspora from across Sydney to Harris Park to connect to culture and community. Together they honour traditions and rituals, complete **multi–faith** walks, watch classical performances, view Indian art forms and observe Bollywood dances.

Source 2: Chatkazz Indian Restaurant in Harris Park serves Indian street food including the popular dish Pav Bhaji.

Harris Park census data

		2001	2011	2021
Country of birth (%)	India	9.2	39.9	45.4
	Australia	35	21.8	19.1
	China	6.7	4.7	5.9
Language used at home (%)	Gujarati	1.7	20.4	15.1
	Hindi	4.1	8.3	11.6
	Punjabi	1	6.5	6.4
Religious affiliation (%)	Hinduism	8.6	37	46.9
	Catholic	27.2	15.1	12.7
	Islam	11.7	9.9	6.1

Source: Australian Bureau of Statistics

Source 3: Census data for Harris Park in 2001, 2011 and 2021. This shows a large increase of an Indian demographic in Harris Park.

Connection to place

The establishment of this strong Indian culture through Harris Park has contributed to a strong sense of belonging for Indian Australians and fostered a vibrant Indian community. Through this, the community has maintained traditions and languages, and contributed to a strong local economy in the area. As the Indian community in Harris Park grows, it also strengthens and maintains its strong sense of connection to place.

Learning ladder 9.3

Processes that transform people, places and environments

1. What is one reason Indian migrants choose to settle in Harris Park?
2. Source 3: How has migration changed the cultural characteristics of Harris Park since 2001?
3. Use Google Maps to create a list of activities, businesses and restaurants a tourist could visit to experience Indian culture in Harris Park.
4. Source 3: Many migrants move to areas where they will have a cultural connection. Use the data to predict future changes to Harris Park's demographics.

Place

1. Sources 1 and 2: What businesses support the local Indian population of Harris Park?
2. Source 1: Describe the human characteristics of Harris Park.
3. Explain the importance of culture in influencing the businesses and the local economy of a place.
4. The government discussed formally naming Harris Park 'Little India' in 2023. Discuss with a partner the advantages and disadvantages of this.
5. Create a photo essay of a local suburb, including at least one photo or graph, that explains its culture.

HOW TO

Photo essays, page 419; Place, page 390

How are different places physically connected?

Places are physically connected by road and rail networks and air and shipping routes. It is through these networks that people travel, and goods are transported and traded. To overcome physical barriers such as mountains, seas and rivers, humans have built tunnels, bridges and canals.

Local road networks

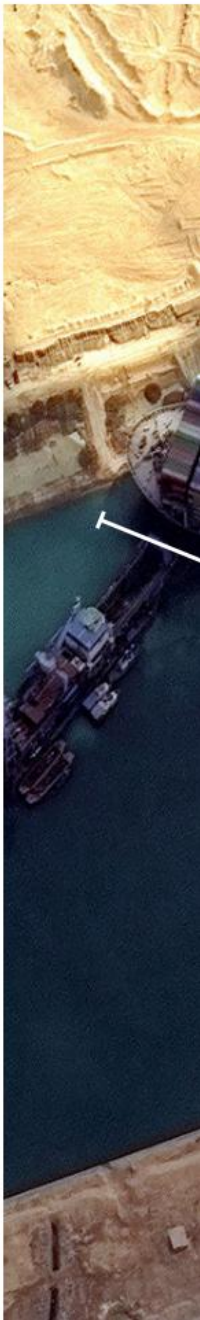
All nations have road networks. The density of roads will be determined by the density of population. This can be seen on the map of Australia in Source 3, with more roads close to the coast where the population is concentrated, and very few on the sparsely populated interior. Approximately 874 500 kilometres of road connect people with places in Australia; however, the greatest movements of people occurs between places within our capital cities, where travel is slowed by traffic congestion. In Sydney, it is estimated that if you travel just 10 kilometres per day, you spend around 203 hours a year in your car, of which 79 hours is stuck in traffic. Your car would emit around 907 kilograms of carbon dioxide annually and take around 91 mature trees to offset.

Public transport networks

Public transport includes buses, trams and trains, designed to move large numbers of people between places as quickly and cheaply as possible. This is a more sustainable and economic transport solution. Public transport routes and networks are constantly being upgraded as technology improves and new housing estates are built in the outer suburbs of cities. In 2021, around 11 950 people took a train, bus, tram or ferry to work in the City of Sydney, while around 19 000 drove. Large road vehicles transport cattle from remote farmlands to the coast. Rail networks are also used to transport bulky goods overland and are particularly important in Australia for transporting minerals and agricultural products to markets, for use in Australia or for export. Australia's iron-ore trains are some of the longest in the world, with over 200 wagons that stretch for 2.5 kilometres.

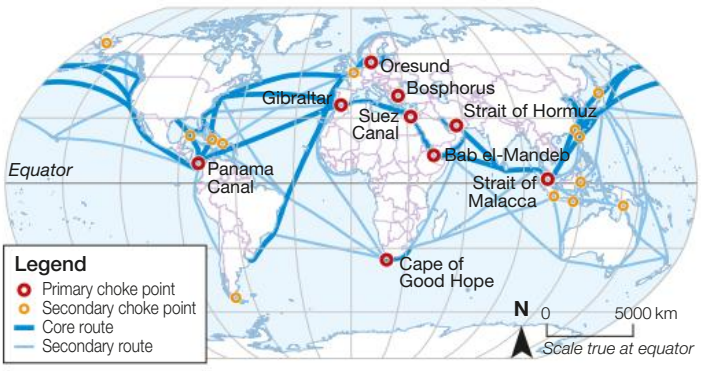
Shipping and air routes

The world's shipping routes are used to transport 90 per cent of the goods moved and traded between countries. This makes maritime transport critical to international trade. Bulky goods are transported in tankers and cargo ships, and other goods in increasingly large container ships. Today there are more than 50 000 container ships operating across the world's oceans. The largest, MSC *Irina*, is 400 metres long, 61.3 metres wide, and can carry 24 346 containers. The world's ports have been rebuilt to fit these large vessels. People travel by air because of the speed of travel. Cargo planes can also transport goods, but shipping is four to five times cheaper than air freight for bulkier items.



Source 1: In March 2021, the Suez Canal was blocked for six days by the *Ever Given*. The 400-metre-long container ship had run aground, blocking the entire canal. The Suez Canal is one of the world's busiest trade routes and the incident delayed the movement of 369 ships with an estimated US$9.6 billion of goods.

Major global shipping routes and choke points



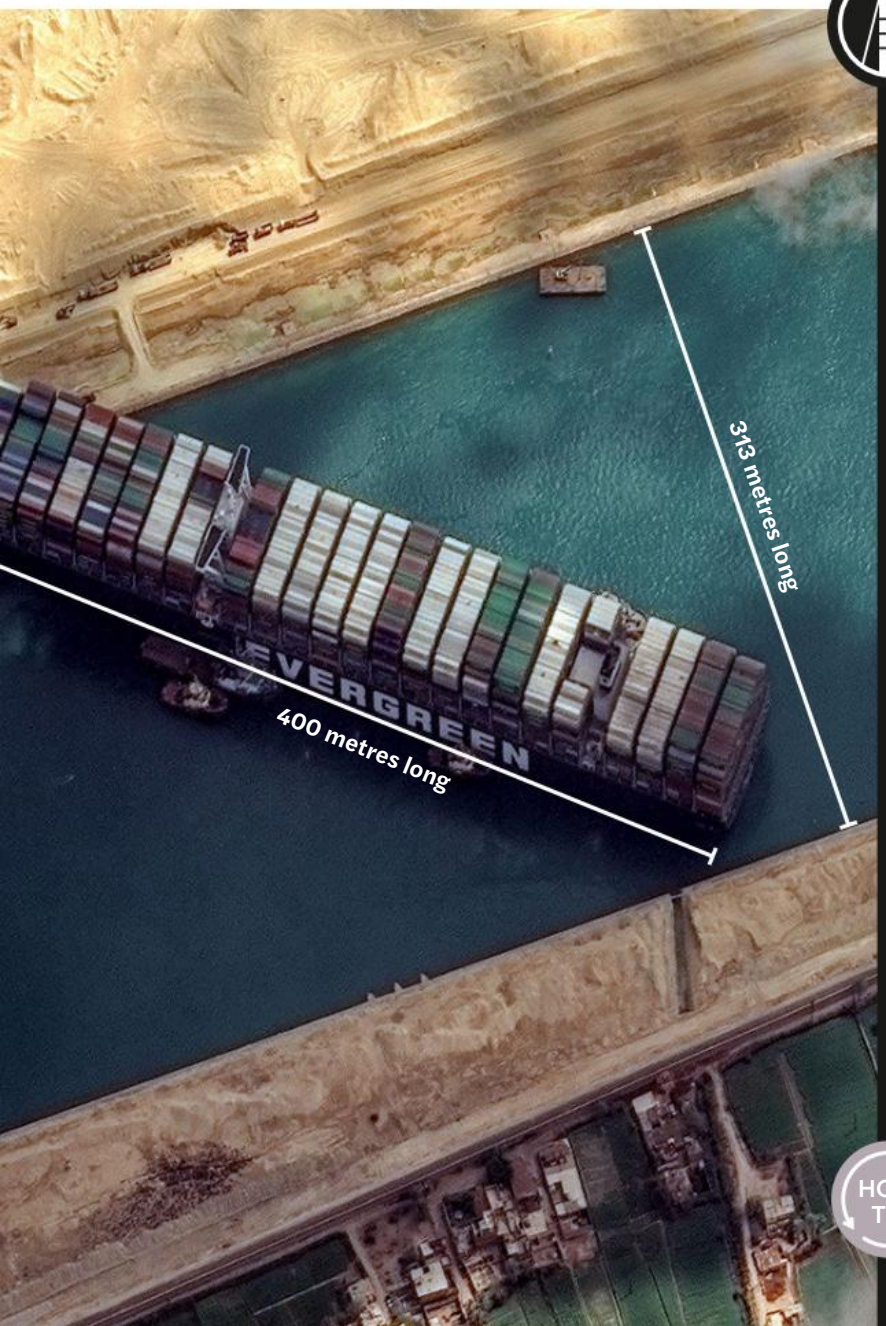
Source 2: Major global shipping routes, straits, canals and choke points

Source: Matilda Education Australia

Source 3: In 2021, 20.1 million motor vehicles were registered in Australia. Road and transport routes tend to be clustered along the coastlines of Australia to service the major capital cities.

Canals and choke points

To save travel times and costs, canals have been constructed to shorten the travel distances between the world's main oceans and continents. The two most well-known canals are the Panama Canal and the Suez Canal. Sometimes delays occur when passage through canals is interrupted. This occurred in 2021 in the Suez Canal. Delays through the Panama Canal were caused by drought and very low water levels. Several new canals reduce traffic routes, including one through Thailand to shorten the route between South-East Asia and India. Places along major shipping routes where traffic builds up and delays occur are called choke points – they include canals and narrow straits.



Main roads and highways around Australia, 2021

Source: Matilda Education Australia

Learning ladder 9.4

Processes that transform people, places and environments

1. What is the link between population density and road networks? Use the example of Australia.
2. Source 1:
   - **a** What led to the Suez Canal being blocked for six days and what impact did it have?
   - **b** Why is the Suez Canal in Egypt an important transport route?
3. Source 2:
   - **a** Suggest why the world's main shipping routes are in the northern hemisphere.
   - **b** Why are choke points bad for international trade?
   - **c** Explain the importance of shipping to international trade.
4. How important is international trade in connecting places? What have been the social, economic and environmental impacts of these connections?

Scale

1. How wide is the Suez Canal at the point where the *Ever Given* became stuck?
2. Source 3: Describe Australia's road network at a national scale. For example, is it clustered, linear, random or uniform?
3. How is your local community interconnected with the surrounding region?
4. Source 3: Analyse how international and national trade has influenced the pattern of roads and highways in Australia.

HOW TO

Scale, page 398

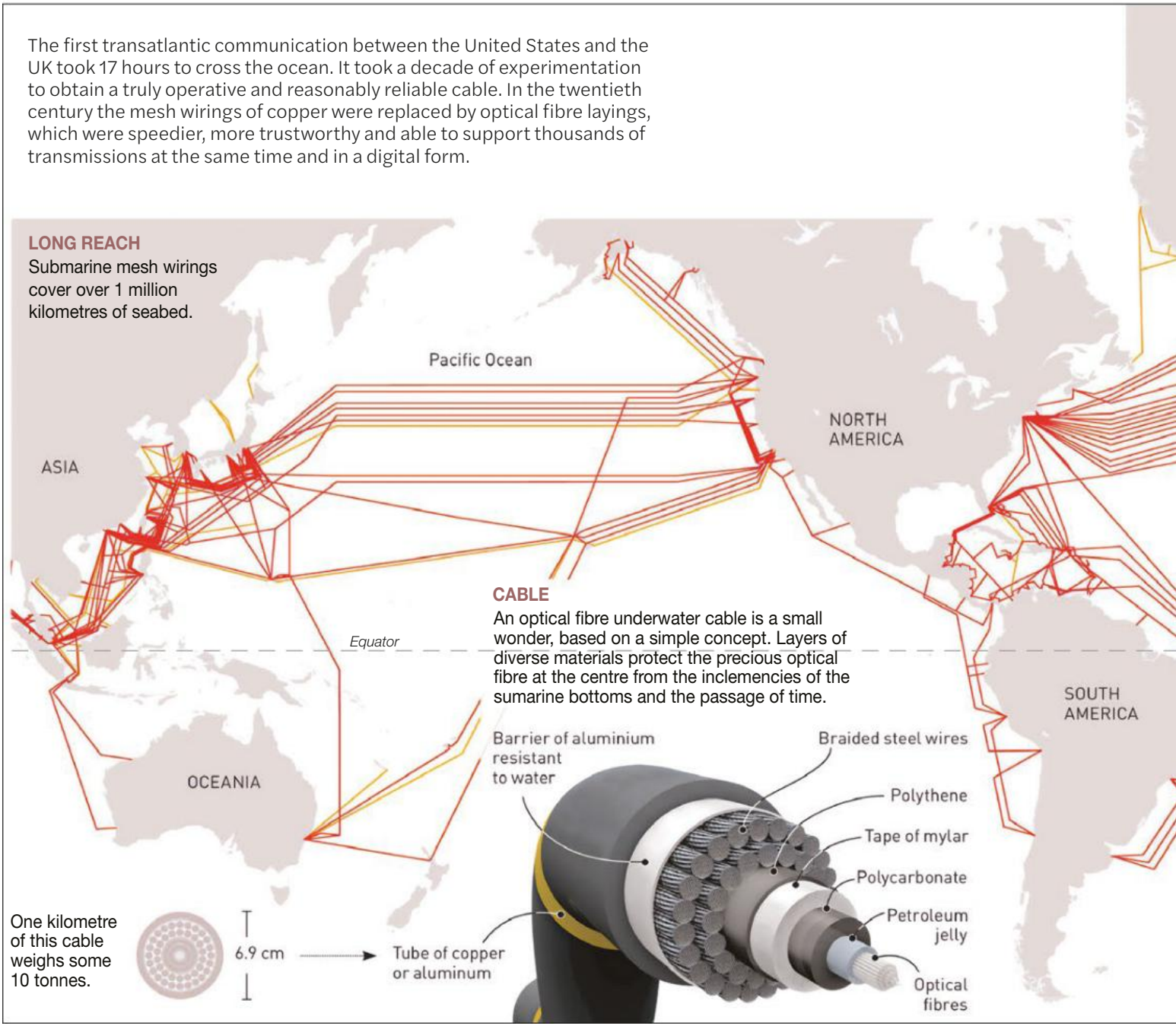
How do undersea cables connect the world?

Submarine fibre-optic cables cross the world's oceans and seas, where they transmit 99 per cent of the data shared between people and places via the internet. The remaining 1 per cent is transmitted by satellites.

World underwater cable network

▼ **Source 1:** Map showing the underwater cable network

The first transatlantic communication between the United States and the UK took 17 hours to cross the ocean. It took a decade of experimentation to obtain a truly operative and reasonably reliable cable. In the twentieth century the mesh wirings of copper were replaced by optical fibre layings, which were speedier, more trustworthy and able to support thousands of transmissions at the same time and in a digital form.

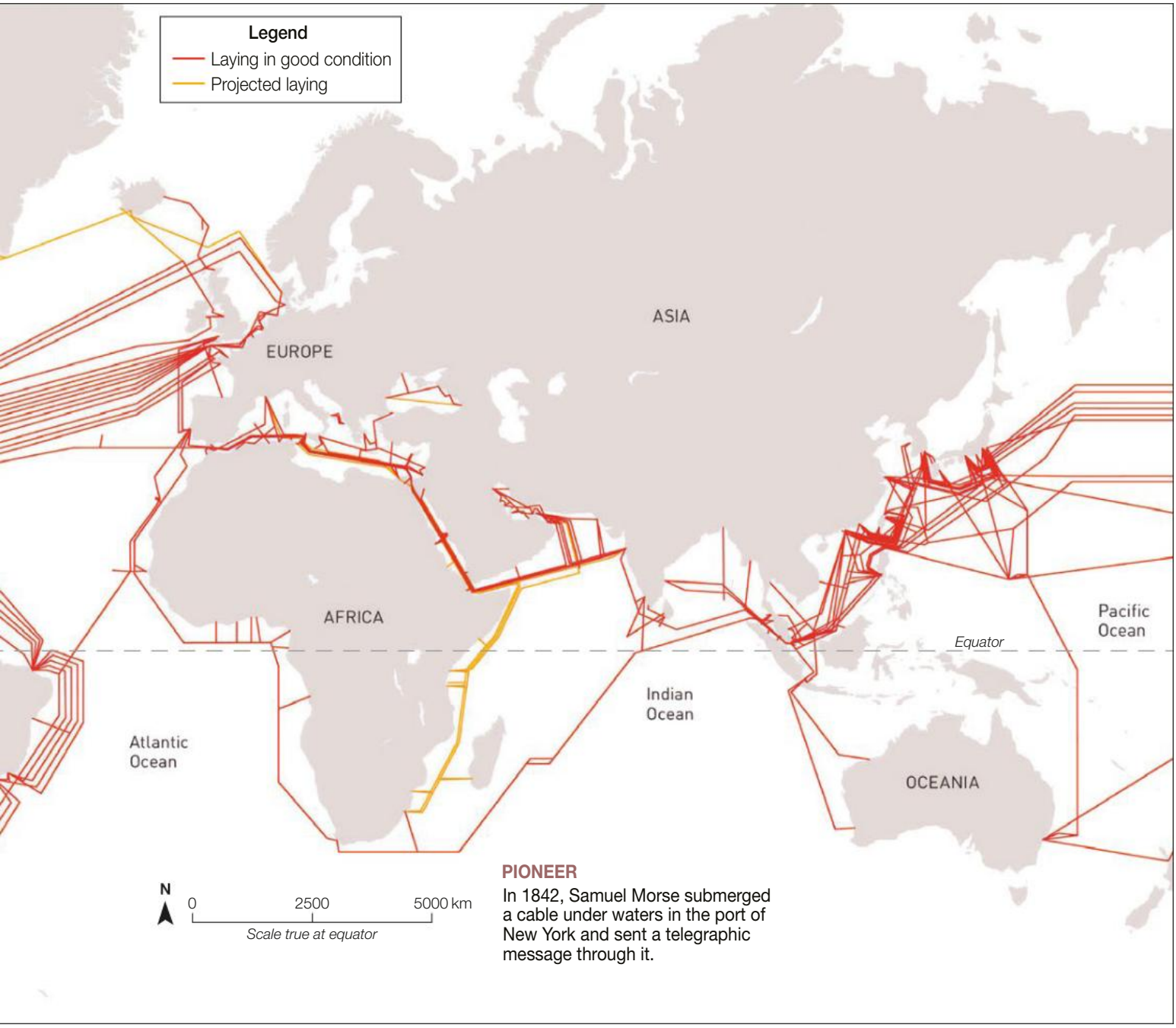


The cable network

In 2024, there were 493 undersea cables covering over 1.4 million kilometres of seabed around the world. Compared to the cost of satellite networks, this is the most reliable and fastest telecommunication system available, capable of transmitting many terabytes of data over long distances within seconds. Cables, consisting of optic fibres bundled together and covered in protective layers, are laid by large ships across mapped areas of seabed that have the lowest risk of damage from earthquakes, volcanic eruptions and fishing activities. If cables break, accidentally or by sabotage, which occurred in Africa during 2022, they are repaired using submersible vehicles. Each year it is estimated that 100–150 cables are cut, interrupting the lives and livelihoods of thousands of people.

Rapid expansion

Since the first fibre-optic cable was laid across the Atlantic Ocean in 1988, there has been a boom in laying new cables, linking more and more places to the system, including remote places and developing countries. As the demand for the **internet** grows and the amount of data being transmitted continues to increase, demand for new cables continues. Video streaming is driving a large amount of that demand. In the four years between 2106 and 2020, more than 100 new cables, worth over $14 billion, were laid.



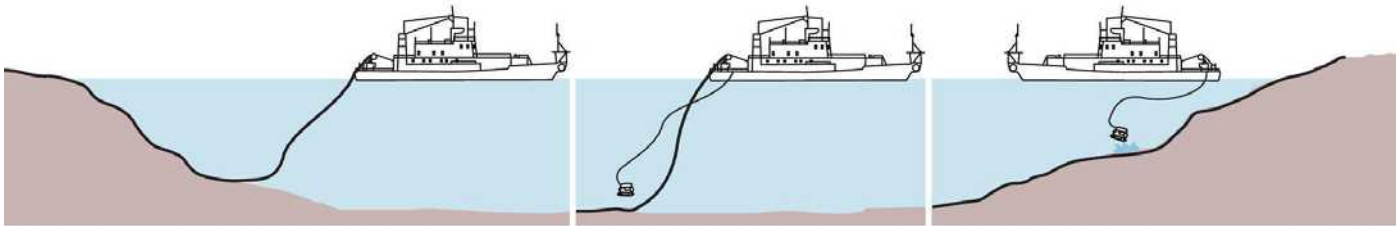
PIONEER

In 1842, Samuel Morse submerged a cable under waters in the port of New York and sent a telegraphic message through it.

Source: AlamyAlbum

The arduous task of the laying

The positioning of an underwater cable is a complex task that requires work on the surface and on the bottom of the water, sometimes to thousands of metres of depth.



1. A detailed sounding is realised of the marine floor.
2. A provided boat with special equipment and GPS realises the laying.
3. While, on the marine floor, a robot monitors the position of the cable and realises small corrections.
4. When arriving at the opposed coast, the boat releases the leftover cable.
5. Special robots under pressure bury the cable by means of a water system.

Source 2: How cables are laid

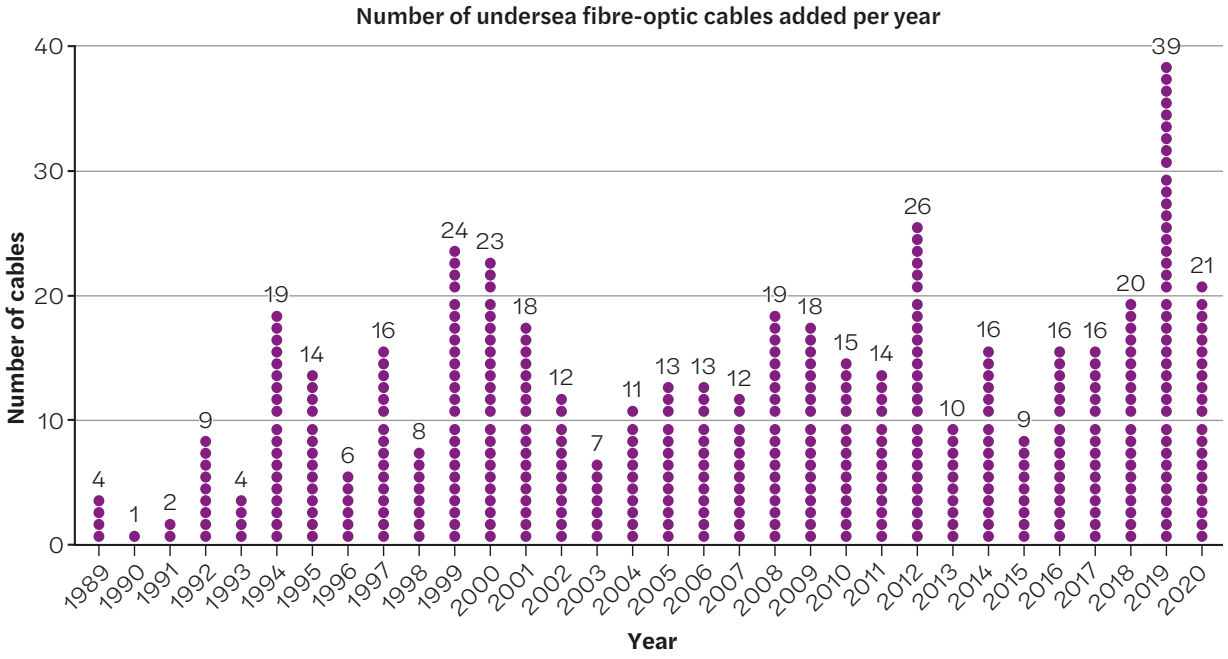
Who owns the cables?

Most cables have been financed by consortiums of telecommunication companies or in partnerships between governments; however, large media and technology content providers have become increasingly involved as their demand for more bandwidth grows. These include Alphabet (companies owned by Google), Microsoft, Huawei, Amazon and Meta (the owner of Facebook, Instagram, Threads and WhatsApp). In 2019, Google, Microsoft and Amazon owned over 100 000 kilometres of cables. A Meta-led consortium has begun the 2Africa Project that will encircle the coast of Africa with 45 000 kilometres of cable and link 33 African, Asian and European countries. In 2024 Google announced plans to directly connect Africa to Australia, and Chile in South America to Australia and other Pacific nations such as French Polynesia.

The value of connectivity

Remote places and developing countries will benefit from access to the latest digital technologies and global connections that will assist in their economic development. The everyday operations of governments and organisations and the lives of millions of individuals depend on the interconnections provided by undersea cable networks.

Source 4: Undersea cable lying on the sea floor. In some places, such as close to shore, cables are buried to protect them.



Source 3: The number of undersea fibre-optic cables added each year shows the rapid expansion since 1989.

Source: TeleGeography

Learning ladder 9.5

Characteristics of places and environments

1. Identify two types of telecommunication networks.
2. Source 3: Describe the trend in the construction of undersea cable networks since 1989 using examples from the source.
3. Why is it necessary to put cables under the sea to connect the world's continents?
4. Why are media and technology companies building undersea cable networks?
5. Assess the importance of fibre-optic internet cables for remote places and developing countries.

Interconnection

1. Describe the process of laying undersea cables.
2. How can undersea cable connections be broken?
3. Source 4:
   - **a** Fibre optics work using light. Why do they need layers of protection?
   - **b** Where and why are cables buried in the sea floor instead of lying on it?
4. Source 1: Describe where the majority of undersea cables are located.
5. Source 1: Analyse the importance of connecting Australia directly to Africa and South America (Chile).

HOW TO Interconnection, page 392

How are we virtually connected to place?

Places are connected not only via physical roads, public transport networks and landscapes but also through technology such as the internet, which enables communication through social media and online shopping.

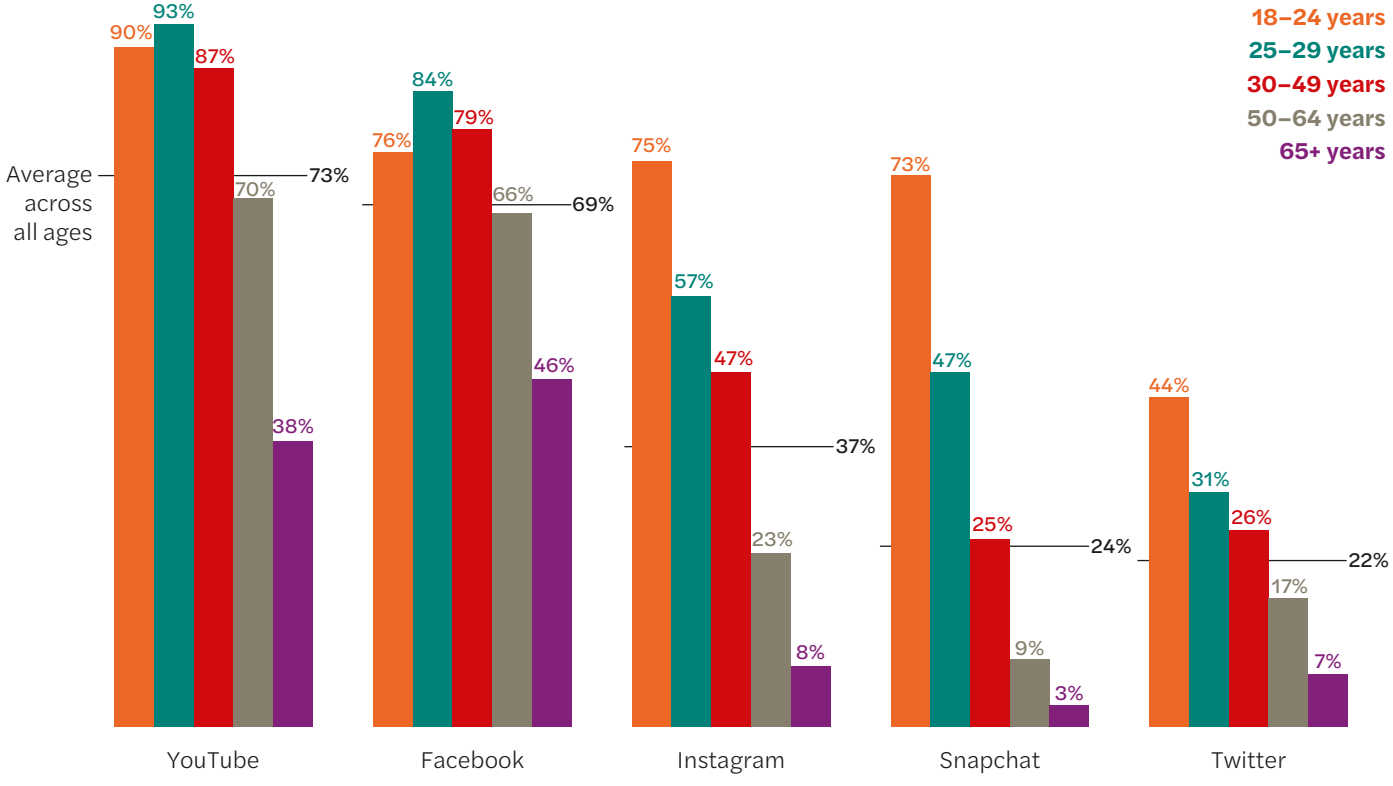
Everyday virtual connections

As technology has improved, we have changed the way we talk and connect with the people and places around us. While your grandparents may have used traditional post mail to communicate over long distances and the newspaper to catch up on global events, you may now send an instant message to someone on WhatsApp or learn what's happening around the world through online news.

Social media has allowed people to instantly share, communicate and even virtually experience places without physically visiting them. Instant connections are enabled through the internet, a global network of billions of computers and other electronic devices. By connecting a computer, phone or tablet to the internet you can go online to connect to anyone and any place at any time.

These new technologies have also changed how we learn, with access to almost any information (both accurate and inaccurate) available online. Trading is possible with the emergence of digital currencies such as Bitcoin and online shopping, which enables you to buy a new shirt through a website at midnight, long after the physical stores have closed.

United States different age groups usage of social media platforms, 2019 (percentage)



Source: Our World in Data

Source 1: The use of social media platforms by different age groups in the United States in 2019

Source 2: An output from Snap Map – this feature within the Snapchat app allows users to see where their friends are. While you can tag your location on other social media apps, Snap Map turns sharing your location into a visual experience.

Source 3: GPS tracking allows us to watch our food being delivered in real time. It can be used to track our fitness and help us find our way.

Source 4: Social media, such as Instagram, connects us to places we may have never visited.

Learning ladder 9.6

Perspectives of people and organisations

1. Why is technology such an important part of our connection to people and place today?
2. How can virtual connection change people's sense of place?
3. Source 1: Explain how our reliance on technology for connection, trade and communication may be limiting for older or elderly people. How might an older person access technology differently from a teenager?
4. 'The government should be responsible to ensure that all people have access to reliable and fast internet.' Do you agree with this statement? Why/why not?

Interconnection

1. List two phone applications (apps) that allow us to connect to other people. List two other phone apps that allow us to connect to a place.
2. Describe the interconnection between the increased use of technology and the decline of physical clothing stores.
3. Source 1: Using the data, explain the relationship between the use of social media and a person's age.
4. Technology is already such a large part of the way we communicate with others. Research two new apps or programs being developed to increase our connective capabilities.

Interconnection, page 392

HOW TO

How is technology improving connections?

Technology has improved our ability to connect with people and places on the other side of the world. You can now video chat with a family member in Australia when travelling overseas, or buy online from shops overseas.

Temporal scale

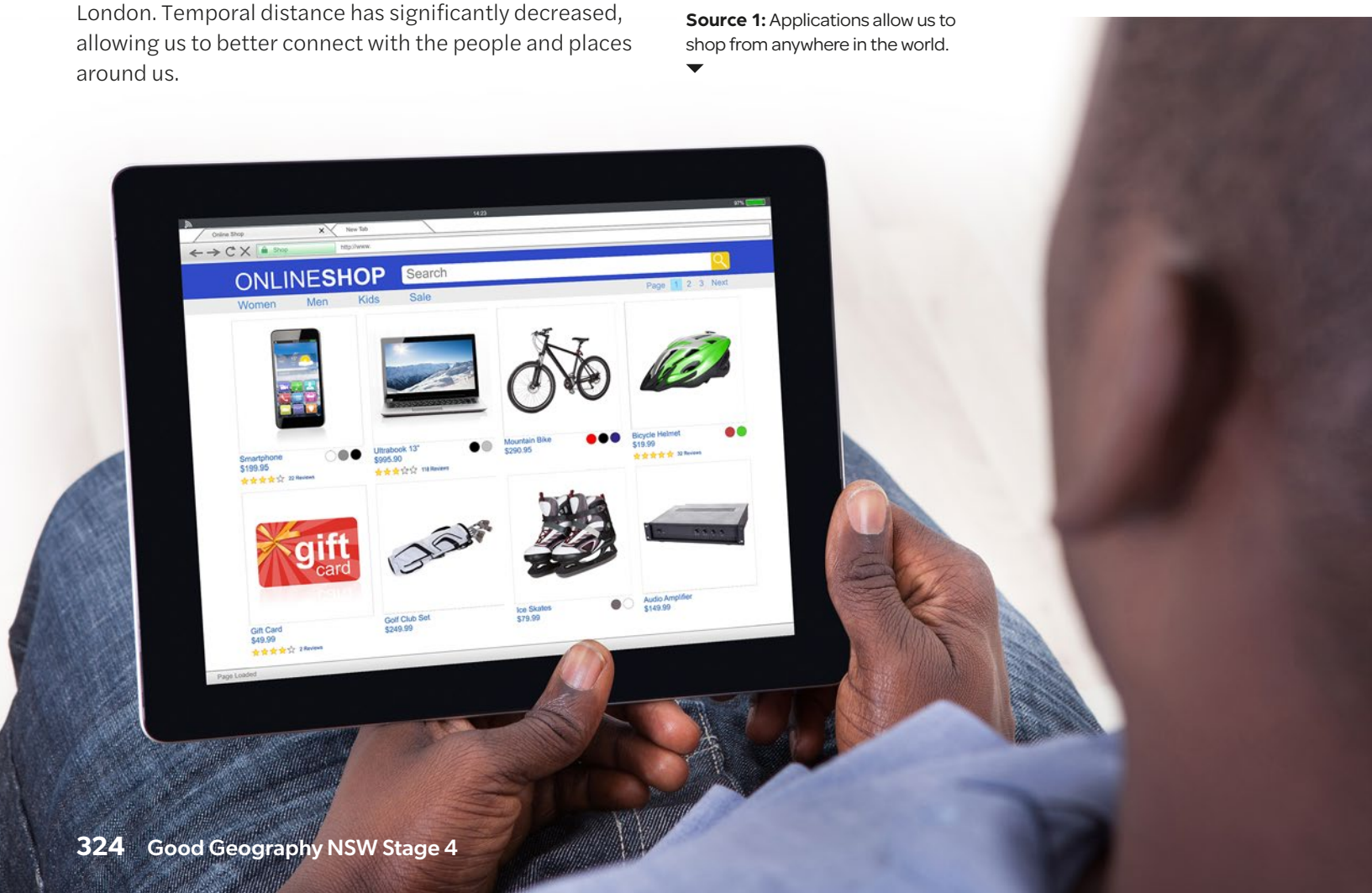
Spatial distance refers to the amount of space between two places. For example, you may live 6 kilometres from your school. Temporal distance refers to time between places. For example, it may take 10 minutes by car to get to school from home. **Temporal scale** measures the time it takes for a process or event to occur.

While the spatial distance between countries has not changed, technology has meant that temporal distance has. For example, in 1947 a flight from Sydney to England took four days and included more than six stops and two overnight stays. Today, non-stop flights that take around 20 hours are available from Sydney to London. Temporal distance has significantly decreased, allowing us to better connect with the people and places around us.

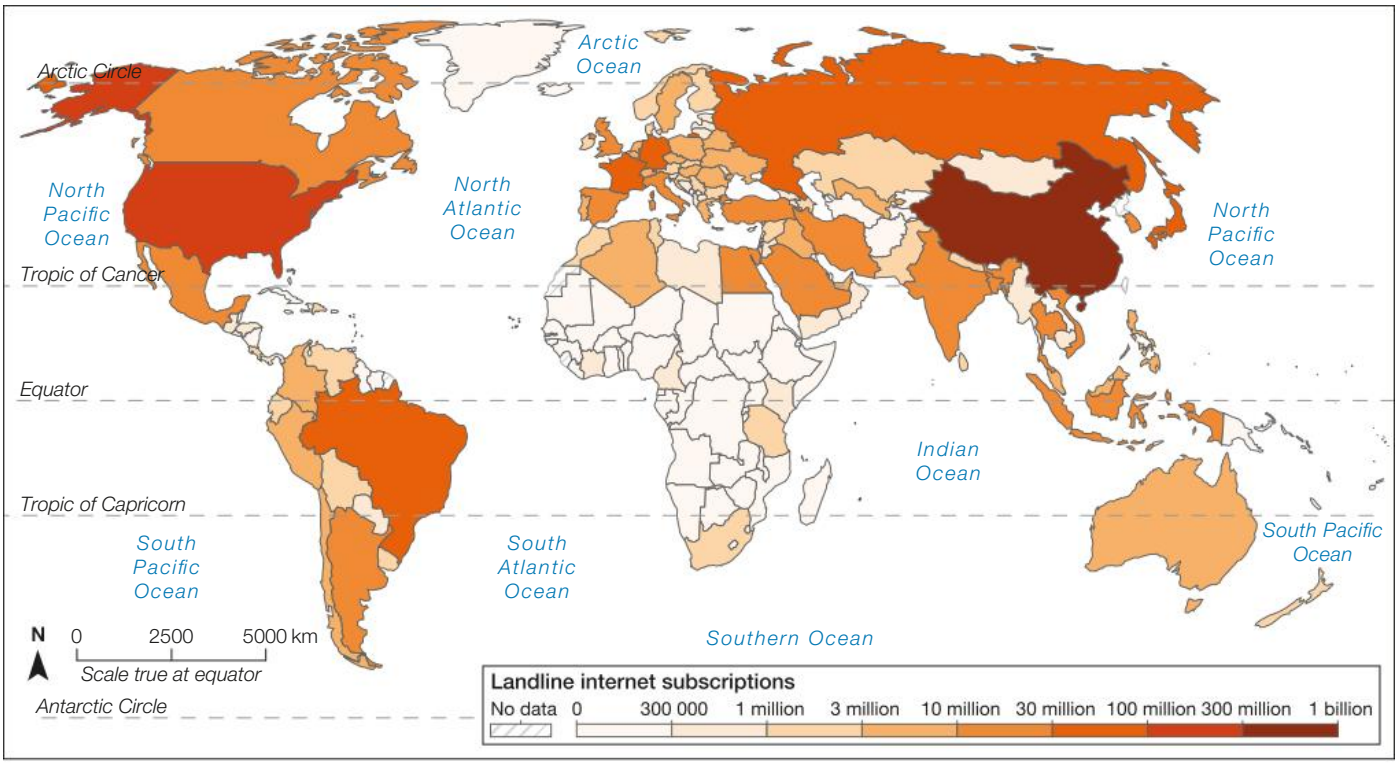
Reducing the urban–rural divide

Technology means that we no longer have to wait for a letter in the post or travel long distances for services. People in rural or remote communities now have better access to resources enjoyed by people living in urban regions. Historically, rural communities were isolated and often lacked access to a range of medical services. Thanks to the growth of online education, telehealth and video conferencing, these communities are now able to access these services online from their own homes.

Source 1: Applications allow us to shop from anywhere in the world.



Number of landline internet subscriptions, 2021



Source: Our World in Data

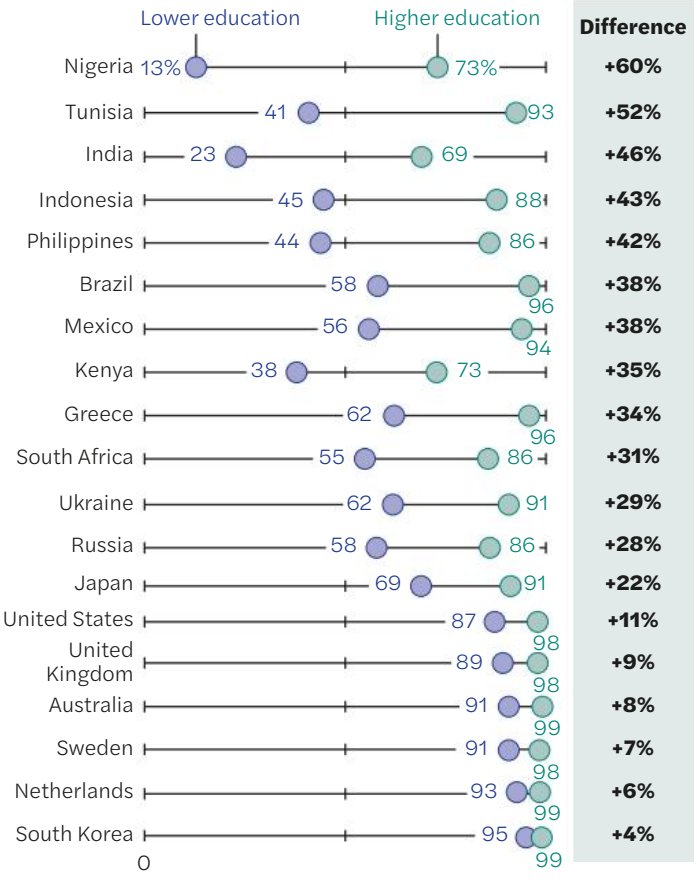
Source 2: Access to to the internet from homes and businesses on a global scale. While many of us can't imagine our lives without the internet, only 60 per cent of the world's population was online in 2021. Regions such as Africa and South Asia have poor digital access.

Global access to the internet

Despite the range of benefits brought about by technology, access to technology is not evenly distributed on a global scale. It is estimated that 94 per cent of youth have access to the internet in more economically developed countries (MEDC) compared with 30–67 per cent in **less economically developed countries (LEDC)**.

Many countries monitor internet use and restrict access to social media platforms. People in LEDCs may not have the financial capacity to purchase devices, or maintain an internet presence, and therefore are less able to access global opportunities to connect with places, people, services and resources. However, while differences are clear, LEDCs are catching up and their access to technology is improving.

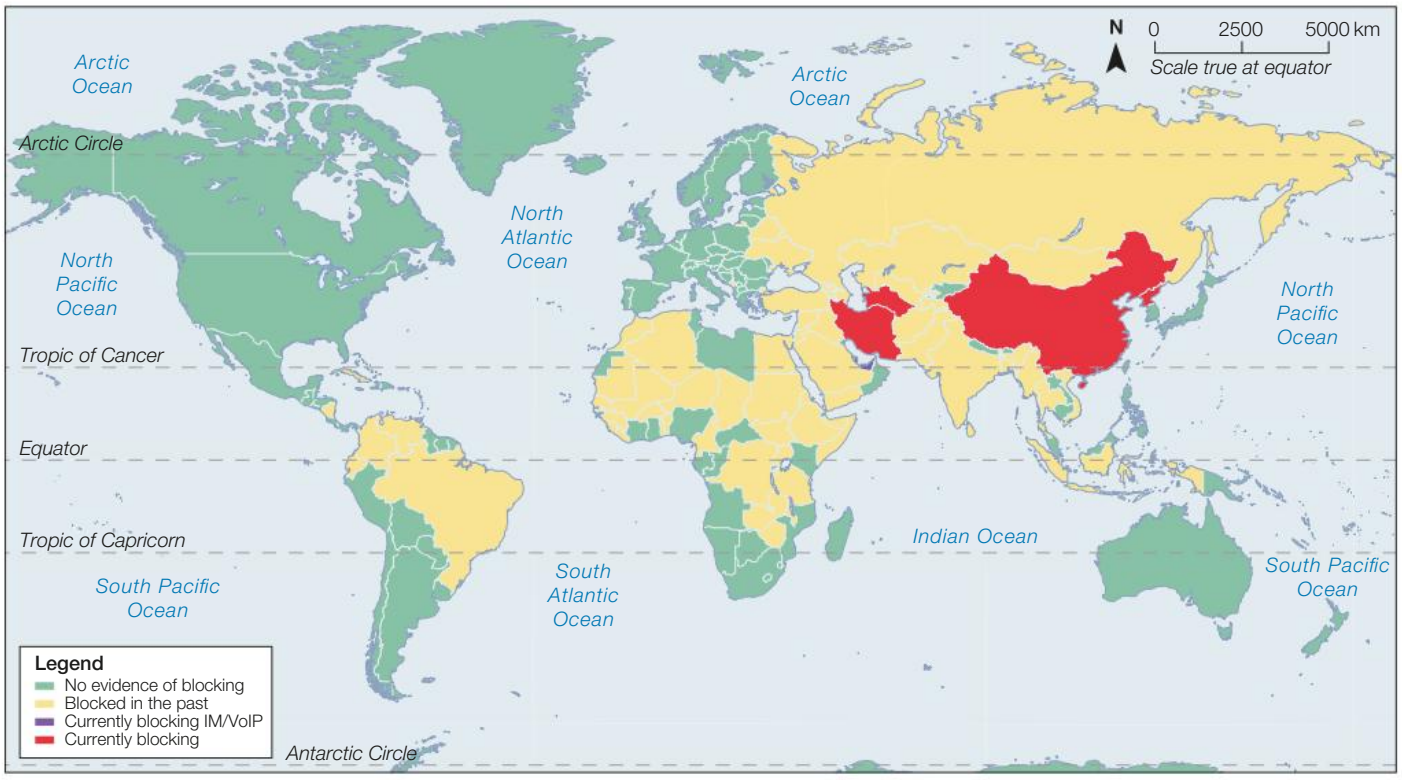
Level of education and internet usage, 2019 (selected countries)



Source: Matilda Education Australia

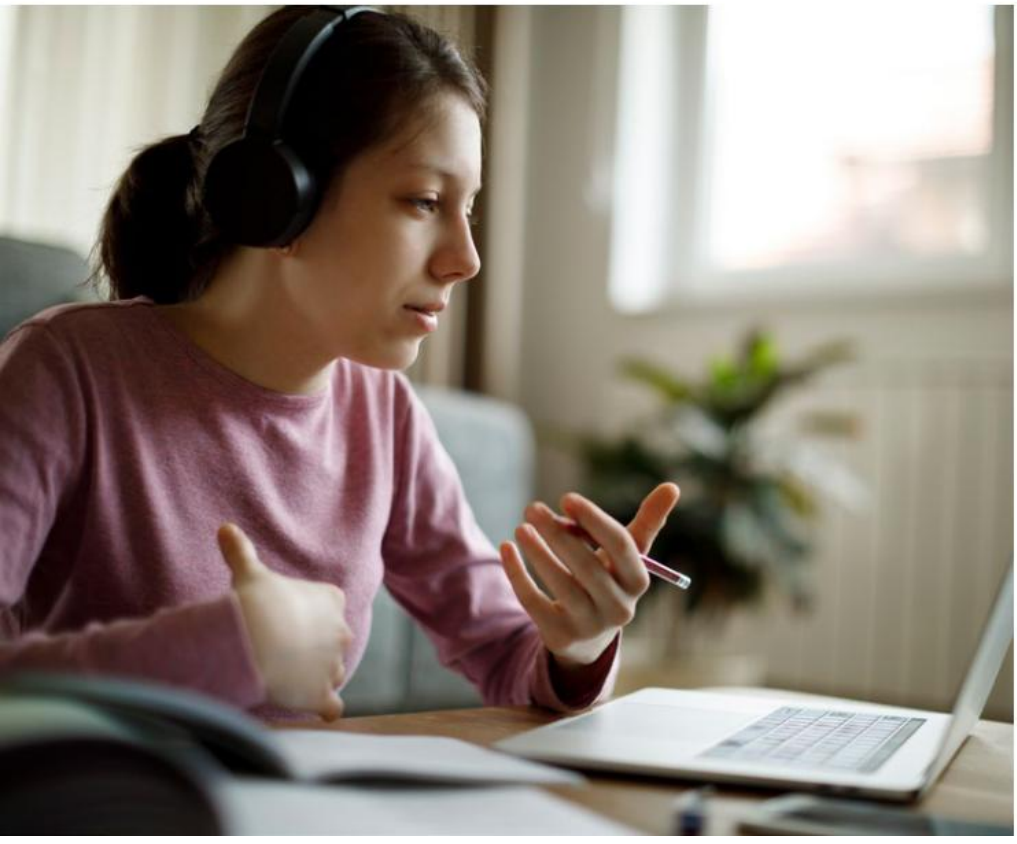
Source 3: People's use of the internet varies greatly, particularly in LEDCs. For example, only 13 per cent of people with a lower education in Nigeria said they used the internet, compared with 73 per cent with a higher education. In MEDCs like Australia, the education makes less of a difference – 91 per cent with a lower level of completed education in Australia had internet access compared to 99 per cent of those with a higher education.

Countries where social media is blocked, 2022



Source 4: Some countries block or limit access to the internet, including social media sites.

Source 5: Technology has made remote learning accessible to nearly all students.



Source 6: Historically, students that needed to travel long spatial distances to access an education would tune into School of the Air to complete their learning.

Remote learning

Not only does technology increase our ability to interact with other places and people, it also allows us to access education. Fifty years ago, if you lived in a remote rural community, going to school or university required you either to board at the institution or to travel long distances every day. For some students, the only way they could get their education was via the School of the Air. This remote learning school provided young people with access to teachers and resources by using CB radio connections and broadcasts.

In the present day, remote learning via technology and virtual spaces has developed dramatically, meaning students can complete their HSC online and attend university lectures and seminars virtually.

During the recent COVID-19 crisis, remote learning became vital to help young Australians continue their learning. Students of all ages from pre-school to Year 12 needed to be highly adaptable and to access learning via online platforms during the restrictions. Some students reported that online learning fostered independent learning, while allowing them to stay home and learn in their own environment. Others reported that virtual connection for schooling did not allow for the same level of discussion, interaction, class involvement and teacher communication as traditional face-to-face learning.

In addition, while remote learning meant that lessons could still take place, school events such as sport days, dances and performances could not, reinforcing that school is more than just what happens in the classroom.

Learning ladder 9.7

Processes that transform people, places and environments

1. List two ways technology has reduced temporal distance.
2. Source 2: Use PQE to describe global differences in access to the internet.
3. Source 3: Explain why people with higher levels of education are more likely to use the internet. Consider the skills you learn at school that are linked to internet usage.
4. 'Social media is the best tool for connecting people over long spatial distances.' Discuss whether you agree or disagree with this statement and why.
5. Source 4: Evaluate how the level of internet censorship in countries may impact access to goods and services in our increasingly technological world.

Change

1. During COVID-19 lockdowns, many students were forced to work from home. How is online schooling different from face-to-face learning?
2. Source 5: Describe how access to education and other services has changed for people in rural or isolated communities.
3. Source 4: Use an atlas or online resource to help you identify three countries that once blocked social media, but no longer do. Why might governments seek to block social media?
4. Create a photo essay, including at least one map or graph, depicting how technology has impacted connectivity of people in different world regions. Provide detailed captions for each image explaining the impact.
5. Predict what education might look like in 2100. How might technology continue to reduce temporal scale and connectivity? How might it negatively impact learning on various scales?

HOW TO

Change, page 394; photo essays, page 419; PQE, page 412

How do people connect through tourism?

Tourism is defined as a person, or group of people, visiting a place other than where they live or work, for more than 24 hours and less than 12 months. Tourism encourages movement of people from place to place to explore new environments, visit friends or family and experience other cultures.

Domestic tourism

Domestic tourism is the movement of people within their own country. For example, you may visit the theme parks in Queensland for a family holiday. In 2022, the north and south coasts of NSW received around 5.7 million domestic overnight tourists. Sydney was ranked the top destination for domestic travel in Australia for 2022 with over three million visitors recorded. Given the size of Australia, air travel still remains popular, with over five million people travelling domestically across Australia by plane in August 2023 alone.

International tourism

International tourism is when you travel to a different country from where you live or work. The country that you travel to is referred to as the host country. You may travel to a host country by plane or on a cruise ship. More and more international visitors were travelling to Australia each year between 2010 and 2019. However, when the COVID-19 pandemic hit in 2020, it restricted international movement and visitor numbers dropped from 8.6 million in 2019 to 140 000 people in 2021. As restrictions have now eased, we are seeing a slow rise again in international tourists. In 2023, over five million people came to visit Australia.

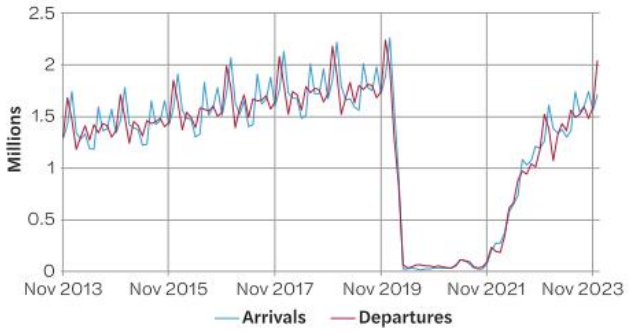
International tourists to Australia in August 2023

Region of stay	Aug 2023	12-month change (%)
NSW	230 460	90.7
Victoria	146 660	67.9
Queensland	141 410	71.0
SA	14 860	43.0
WA	54 240	57.7
Tasmania	4 140	51.6
NT	4 960	–10.9
ACT	6 640	48.9
Australia	603 360	73.2

Source: Australian Bureau of Statistics

▲ **Source 1:** International tourists in Australian states and territories in August 2023. International travel was restricted during the COVID-19 pandemic crisis from 2020 to 2022, but is showing signs of recovery.

International tourists to Australia, 2013–2023



▲ **Source 2:** The number of international tourists to Australia from 2013 to 2023

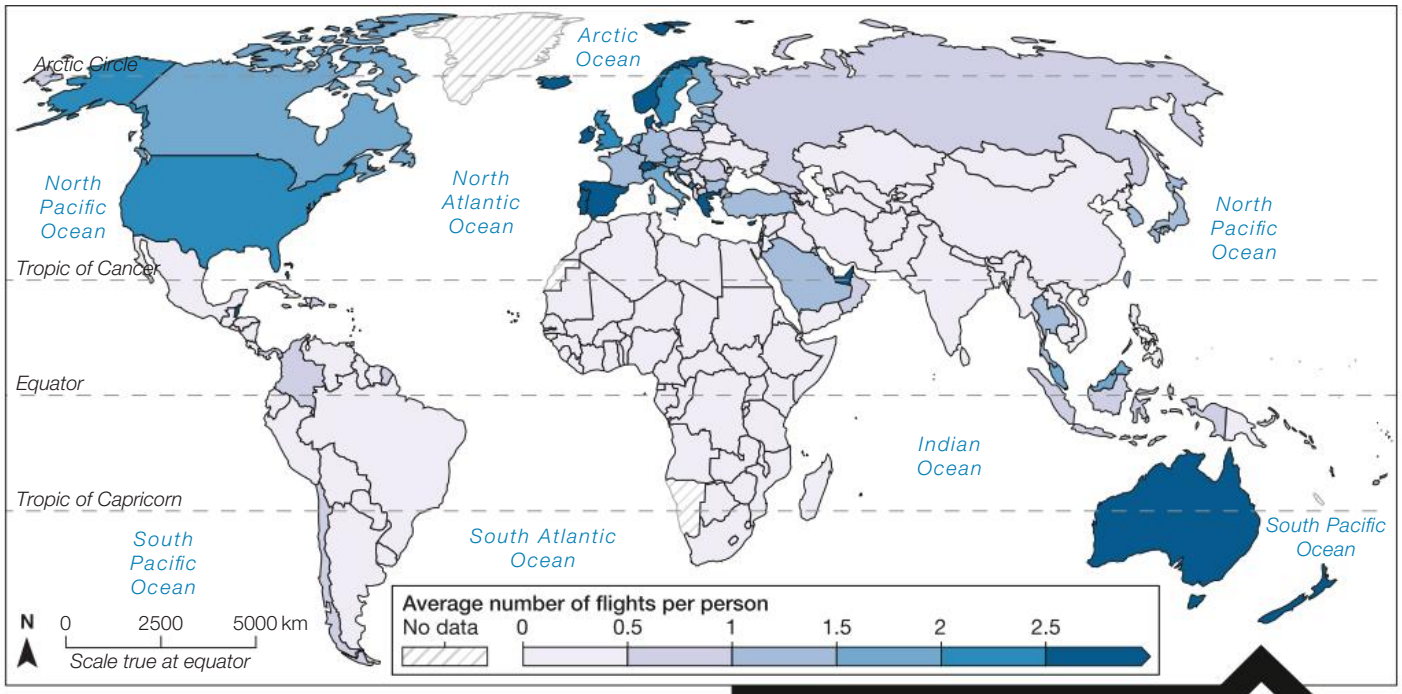
Source: Australian Bureau of Statistics

Tourist connections in the world

Through tourism, people are able to connect to places and different environments, engage in new traditions, consume new foods and develop a deeper appreciation of the many cultures in the world. For example, Cappadocia in Türkiye attracts millions of tourists annually. Tourists can hike the unique landscapes, engage in tradition by visiting historical sites, share experiences such as the famous balloon rides, and develop an appreciation for Türkiye culture by trying the foods and learning the customs. This increased sense of connection with places in the world improves global cultural understanding.

Source 5: Tourists can experience hot-air ballooning over the famous valleys in Cappadocia, Türkiye.

World airline trips per head of population, 2019



Source: Our World in Data

Source 3: The number of domestic and international airline trips per head of population in 2019

Source 4: The Sydney Opera House is Australia's most visited tourist destination, with 10.9 million visitors annually.

Learning ladder 9.8

Processes that transform people, places and environments

1. Which of the following are tourists?
   - **a** A sports group travelling to the United States for five nights to watch two NBA games
   - **b** An employee travelling from Castle Hill to Sydney CBD for work
   - **c** A Year 8 boarding student travelling home for school holidays from the ACT
2. Source 2: Describe the change in the number of international tourists to Australia between 2013 and 2023.
3. Source 1: Explain reasons for the pattern shown.
4. What are the positive and negative impacts of tourism on places and environments?

Place

1. Source 1: Graph the number of international visitor arrivals and list the states with the highest and lowest number of arrivals.
2. Source 3: Use PQE to describe the countries with the highest number of air trips per head of population.
3. Source 4: Suggest three reasons why this place in Sydney is popular with tourists.

HOW TO

Place, page 390; PQE, page 412

9.9

What are the impacts of tourism?

Tourism can have positive and negative effects on places. Positive impacts include contributing to the local economy; negative impacts include increased carbon emissions from your flight or disrespecting local cutures and traditions.

Positive impacts on people and place

Tourism is a huge global industry. It is estimated that in 2023, tourism employed over 320 million people worldwide. Tourism can support places by creating jobs, encouraging the construction of **infrastructure** and spreading understanding and appreciation of local cultures and environments. Tourists can also provide a short-term workforce to the host country. Prior to the pandemic, backpackers visting Australia accounted for 80 per cent of the country's fruit-picking and harvest jobs.

Travel gives tourists the opportunity to experience different cultures, taste new foods and meet new people. Consuming local foods and drinks, buying handcrafts, and watching local cultural performances of music, theatre and dance helps support local employment, preserve traditional customs and improve cultural understanding.

Source 1: Traditional Aspara dancers perform at Siem Reap, Cambodia.

Negative impacts on people and place

One of the largest negative impacts tourism has is on the environment, whether it is **biodiversity** loss as a result of land clearing for development, creating physical disturbance to natural areas or overcrowding. Unfortunately, while plane travel has resulted in reduced **temporal distance** between places, it is also one of the biggest greenhouse gas emitters. Around 8–11 per cent of global emissions are linked to tourism – more than the construction industry. Around 17 per cent of emissions are linked with aviation.

It is predicted that by 2030, two billion people will travel internationally each year. As influencers advertise trips to exotic and 'untouched' locations on social media, it can create a sudden influx of visitors to a place that is not built to cater for masses of people. In some instances that can mean there are not enough toilets, roads are not safe for travel, or there may not be safety barriers or infrastructure in place to prevent accidents.

The term **overtourism** is used to describe the sudden and dramatic increase in numbers to a place. For example, in Venice, Italy, around 20 million people visit annually. The number of visitors has had a huge impact on Venetian locals, the historical city, and the water quality from increased pollution and waste output. To combat overtourism, as of January 2023, tourists travelling to Venice have to register their visit and in some instances pay an entry fee.

Source 2: Overtourism dramatically impacted Maya Bay in Thailand. Tourist numbers skyrocketed following the release of the movie *The Beach* in 2000, about a group of backpackers staying at beautiful Maya Bay in Thailand. Tourist numbers increased from less than 1000 to as many as 8000 visitors a day, with up to 100 boats in the bay at the same time. The boats' propellers pushed sand over the coral, and their anchors broke the delicate coral. Soon just 8 per cent of the bay's reef remained undamaged. The bay was closed to tourism in 2018 to replant coral and help wildlife such as clownfish, lobsters and sharks to regenerate. It has reopened with strict conditions on the number of tourists and the areas they can go.

Culturally sensitive tourism

Culturally sensitive tourism involves being polite according to the culture of the country you're visiting, so that you show respect and don't insult people. Some simple rules to follow to be a culturally sensitive tourist include:

- Learn a few words of the local language, such as 'Hello' and 'Thank you'.
- Try local foods and observe local table manners like sitting on the floor or using chopsticks.
- Wear clothing that is sensitive to local cultures such as wearing loose clothing to cover arms and legs.

Learning ladder 9.9

Sustainable management strategies

1. Define the term 'overtourism'.
2. Source 2: What impact of tourism is shown in this photograph of Maya Bay in Thailand?
3. Explain how you can behave as a culturally sensitive tourist.
4. Source 2: Analyse the response to overtourism in Maya Bay. Considering the local people, environment and economy, do you think this will be a sustainable tourist management strategy?

Interconnection

1. List a positive and a negative impact of tourism.
2. Source 1: Describe the interconnection between local Cambodians and tourists shown here.
3. How can tourism provide a short-term workforce?
4. Source 2: Predict what might have happened to the environment of Maya Bay if no action had been taken to protect it.
5. What are the environmental implications of increased international travel and what action can be taken to make tourism more sustainable?

HOW TO Interconnection, page 392

First Nations Peoples

What is culturally responsible tourism?

Culturally responsible tourism empowers Indigenous communities to share knowledge with tourists to help provide a more meaningful understanding of local cultural, social and environmental issues.

Culturally responsible tourism

Responsible cultural tourism, when developed in close consultation with, or led by, First Nations people, can empower and elevate the voices of their communities. By shedding light on their ancestral knowledge, land and water management practices, as well as their relationship with Country, cultural tourism has the potential to disrupt colonial myths and misconceptions. It can serve as a powerful medium to impart the rich history and wisdom of First Nations to the world.

Culturally responsible tourism in Byron Bay

The Bundjalung people of Byron Bay hold a rich history spanning thousands of years. They are the Traditional Custodians of land and waters and their presence holds profound significance in the region.

Acknowledging the ability of cultural tourism to empower First Nations communities, Explore Byron Bay took the initiative to introduce tours led by Delta Kay, a Byron Bay Bundjalung woman. She is deeply passionate about sharing her cultural heritage, while making positive behaviour change with travellers coming to Byron Bay. Through these tours, visitors experience a profound personal connection with the land, so they learn and understand to be part of nature and not separate from it.

Delving into pre-colonial history and witnessing ongoing sustainable land management practices shows visitors how First Nation Peoples have always acted to protect the health of the environment for generations to come.

Delta Kay's personal stories play a vital role in these tours, shedding light on the historical impact of colonisation and displacement on her people.

Source 1: Delta Kay is a tour guide around Cape Byron who shares her knowledge of local bush tucker, medicine, tools and weapons.

She shares their journey towards securing Native Title, which further enriches the understanding of visitors about the struggles and resilience of the Byron Bay Bundjalung community.

At the heart of the tour is the preservation of the Bundjalung language, as participants are encouraged to learn Bundjalung phrases, fostering cross-cultural communication and appreciation for kinship ties to the wider Bundjalung Nation. Additionally, the tour provides bushfood tasting and medicinal practices, fostering appreciation for the relationship with the land in First Nations customs and culture.

Delta Kay's teachings, alongside these immersive experiences, empower visitors and uplift the voices of the Bundjalung community to protect traditional knowledge and land sovereignty.

Culturally irresponsible practices in the First Nations art industry

The First Nations art industry is an important part of cultural tourism and economic self-sufficiency. First Nations art galleries, exhibitions and workshops attract tourists interested in Indigenous cultures and art. Millions of other visitors go to tourist shops selling boomerangs, didgeridoos and other 'Aboriginal' souvenirs with no genuine connection to First Nations communities or their cultures. It is estimated that up to 80 per cent of stores offering these items are selling fakes made overseas.

Birubi Art Pty Ltd, a company supplying products featuring First Nations art symbols and designs, engaged in culturally irresponsible practices by falsely claiming that the items were handpainted by First Nations artists and made in Australia. Following action by the Australian Competition & Consumer Commission (ACCC), the Federal Court of Australia found the company guilty of misleading consumers, revealing that the products were manufactured in Indonesia, not by First Nations artists. As a result of the court's findings, Birubi Art was ordered to pay a significant penalty of $2.3 million, emphasising the gravity of misleading practices that harm First Nations communities.

Source 3: Producing fake products is a culturally irresponsible practice that exploits First Nations Peoples.

> Being in and part of Country keeps us connected to our culture and our ancestors. In traditional ways of managing the health of Country, there is no strict separation of water, land, air, plants and animals, as all are perceived as interconnected. They are managed as a whole to keep Country healthy.

Source 2: Delta Kay is a proud Bundjalung woman who offers an experience for tourists to Byron Bay to learn about the importance of connection to culture and Country.

Learning ladder 9.10

First Nations Peoples' interaction with Country

1. What is an example of a town in Bundjalung Country?
2. Source 2: Describe how Delta Kay shows tourists how Bundjalung people use resources on Country.
3. Source 2: How does Delta Kay explain the importance of being a part of Country?
4. What is meant by the following sentence: 'Cultural tourism has the potential to disrupt colonial myths and misconceptions'.

Sustainability

1. What is culturally responsible tourism?
2. Source 2: How does Delta Kay explain how her people have always managed the environment?
3. Source 3: Explain why the production of fake Aboriginal items does not help the sustainability of First Nations businesses.
4. Given the close connection of First Nations Peoples to Country, what other actions might be considered culturally irresponsible?

HOW TO Sustainability, page 400

Case study

What impact is tourism having on Venice?

Venice is a famous island city in Italy that was built on top of a marshy lagoon. It attracts more than 25 million tourists every year, who come to seek out its unique canal architecture and culture. Tourism has a significant impact on the local environment.

Water degradation

Millions of tourists in Venice generate large amounts of pollution, such as plastic bottles, food scraps and litter. Most of Venice's sewage flows directly into the canals. Increasing tourist numbers has resulted in more untreated wastewater being released into the lagoon. This can release harmful bacteria, pathogens and nutrients, increasing the growth of algae and decreasing local wildlife.

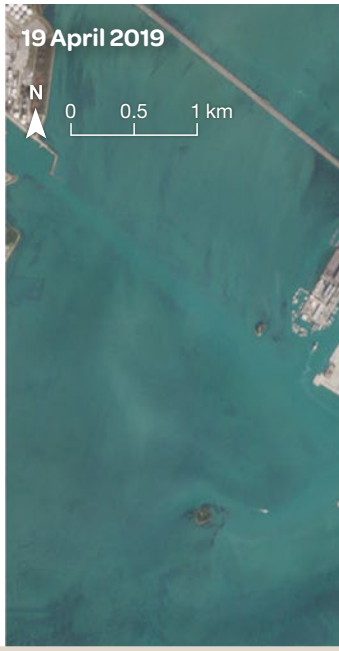
The boats that transport tourists around Venice release boat fuels and oils, and the protective paint on the underneath of boats can leak toxins and heavy metals into the water. This affects the quality of the water and impacts local fish species and the birds that feed on them. The large number of boats can also erode the banks of the lagoon and canals, releasing sediments into the water and decreasing the clarity of the water. This limits the ability of the underwater seagrass meadows and seaweed to photosynthesise.

Through the lockdowns during the COVID-19 pandemic, the reduction of tourists in Venice resulted in clearer waters and higher water quality, as seen in Source 2.

Wildlife

The construction of infrastructure, hotels and transportation for tourists in Venice has impacted and fragmented natural habitats and vegetation. This reduces access to food, breeding grounds and shelter for local species such as crabs, sea bream and black-headed gulls. The loud noise and bright lights of the island city can stress species and affect their normal behaviours.

Discarded food and litter from tourists, along with tourist infrastructure providing a great site for nests, has contributed to a pigeon population in excess of 100 000 in Venice. Pigeons disrupt native species by increasing competition for food, and the excessive pigeon faeces can contaminate water sources and soil.



Source 1: Venice's crowded waterways increase water **turbidity** and pollution in the lagoon.

Source 2: A satellite image taken on 13 April 2020 during Italy's COVID-19 lockdown shows the impact of tourism on the clarity of Venice's water. This image shows darker blue water as sediment has been allowed to settle on the floor of the lagoon. The same scene a year earlier shows busy boat traffic and milky waters full of sediment stirred up by boats in the canals and waterways.

Source: Copernicus Sentinel data 2019 and 2020 for Sentinel data

Learning ladder 9.11

Processes that transform people, places and environments

1. Source 1: Describe why tourists would like to visit Venice.
2. Source 2: Describe the change in water quality and water traffic shown in the two satellite images.
3. Source 2: Explain how lockdowns during the pandemic influenced the environment in Venice.
4. Analyse how technology could improve the environmental impacts in Venice.
5. Create a strategy to reduce the impact of tourists in Venice.

Environment

1. Identify three different threats to the natural environment of Venice.
2. Source 2: Describe the the natural and built characteristics of this environment.
3. Explain the impact of high pigeon numbers in Venice.
4. Analyse the impact of tourists on water quality in Venice.

HOW TO
Environment, page 396

Can tourism be sustainable?

Ecotourism helps to protect the wellbeing of local people and the environment. It encourages nature-based activities that increase the tourist's appreciation and understanding of natural environments and cultural values.

Ecotourism

Tourists now are becoming more aware of their impacts and are working to travel more sustainably. One way to travel more sustainably is to engage in ecotourism. The primary aim of **ecotourism** is to experience the natural world and learn how to protect, sustain and conserve the environment for future generations. In order to be considered an ecotourism destination, tours or resorts must meet the following criteria:

- protection of the environment through habitat, species and traditional culture conservation and the minimisation of waste
- presentation of information that educates tourists about local values, heritage and culture
- honesty in marketing, reporting of pollution, managing protected areas and supporting local Indigenous communities.

▲ **Source 2:** Do you agree with this cartoon?

Source 1: A safari tour in a national park in Tanzania

Source 3: Ecotourism does not require you to camp or 'rough it'. In fact, some luxury resorts have been certified as ecotourism destinations in Australia. The way they operate, educate and market are seen to meet the requirements for ECO certification.

On a global scale, in 2022 it was estimated that the ecotourism market was worth US$172.4 billion and it is projected to more than double by 2028. Countries such as Iceland, Kenya and Nepal were some of the most popular ecotourism destinations. Increased popularity is due to more affordable sustainable travel options, increasing climate change awareness, and social media influence in highlighting ecotourism locations and activities. Unfortunately, in many regions, political instability remains a limiting factor to the expansion of ecotourism, and overtourism is a problem in some areas.

Learning ladder 9.12

Sustainable management strategies

1. Using the definition of ecotourism, list two examples of ecotourism destinations that you have visited or would like to visit.
2. Source 1: Describe how this is an example of ecotourism.
3. Source 3: Explain how a luxury resort can still be classified as an ecotourism destination. How can a resort be 'luxury' and also sustainable?
4. Consider one of your favourite or dream holiday destinations. Does this location meet the three criteria to be an ecotourism destination? Why or why not?
5. Research ecotourism destinations in Australia. Critically investigate the activities offered at one of these places. Discuss as a class whether it is a true ecotourism destinations and analyse how its features make it sustainable.

Sustainability

1. One of the ecotourism criteria is education. Suggest why this is important to encourage sustainable travel.
2. Source 1: Write a list of five rules that tourists must obey on a safari to follow ecoturism guidelines.
3. Source 2: Explain what this cartoon is trying to say. Do you agree with it?
4. Prepare a brochure to advertise your own ecotourist resort or adventure.

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Interconnections and trade

Global trading

10

WHAT IS FAIR TRADE? 362

HOW DO TRANSNATIONAL CORPORATIONS CONNECT THE WORLD? 350

WHY IS LITHIUM A GROWING EXPORT FOR AUSTRALIA? 358

10.0

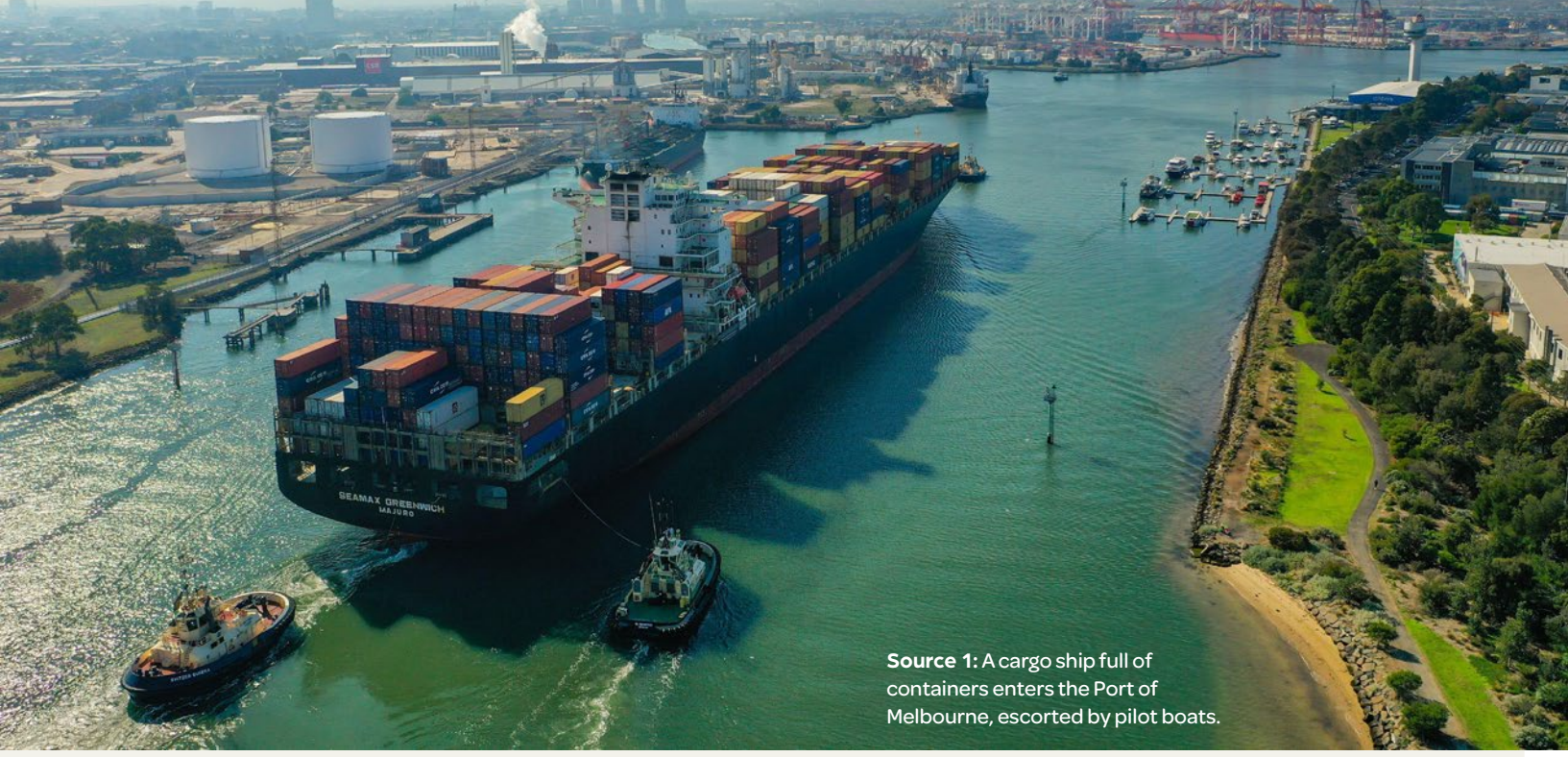
How can I understand global trading?

The production and consumption of goods connects people to places, and trading between places creates regional and global connections via imports and exports of goods and services. Large transnational corporations operate in many countries to design, manufacture and distribute products.

Learning ladder

The Learning ladder lists the knowledge and skills you will develop throughout the year, with five levels of increasing difficulty. By mastering foundational knowledge and skills at the lower levels, you will build a solid understanding that prepares you to tackle more advanced concepts and skills as you progress towards the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
	Outcomes					Geographical tools and inquiry
5	I can analyse how characteristics shape places	I can predict the impact of processes and interactions	I can evaluate the fairness of perspectives	I can suggest improvements to strategies	I can evaluate the contribution of First Nations Custodianship	I can apply a range of tools, terms and concepts to communicate geographic information
4	I can explain factors that influence diversity across places	I can examine the impacts of processes	I can analyse how perspectives influence decisions	I can assess the impact of strategies	I can analyse the importance of First Nations Custodianship of Country	I can use a range of tools, concepts and terms to understand geographic information
3	I can describe the characteristics of places	I can explain how interaction leads to change	I can explain different perspectives	I can explain how strategies protect places	I can explain the role of First Nations Peoples in caring for and managing Country	I can use geographic tools, concepts and terms
2	I can locate features and characteristics of places	I can describe processes	I can describe perspectives	I can describe management strategies	I can describe how First Nations Peoples care for and manage Country	I can list geographical tools, concepts and terms
1	I can identify features of places	I can list processes	I can identify perspectives	I can list management strategies	I can identify ways First Nations Peoples interact with Country	I can identify geographic information



Source 1: A cargo ship full of containers enters the Port of Melbourne, escorted by pilot boats.

Place	Space	Environment	Inter-connection	Scale	Sustainability	Change	Steps in skill progression
I can analyse the impact of places on people and environments	I can assess changes to spatial distributions and their effects	I can examine the impact of change on environments	I can assess the impact of changes to interconnections	I can assess how decisions are influenced by a range of scales	I can evaluate strategies to improve sustainability	I can assess how changes to processes shape places	5
I can explain how places are interconnected	I can analyse the impact of spatial distributions	I can analyse processes that change places	I can assess the effects of inter-connections	I can analyse how scales interract to influence geographic processes	I can analyse the long-term impacts of sustainable and unsustainable practices	I can analyse the impact of change	4
I can use geographic vocabulary to describe a place	I can explain spatial distributions	I can explain physical processes	I can explain the influence of inter-connections	I can explain how processes vary across scales	I can explain the importance of sustainability	I can explain the causes and effects of change	3
I can describe a place	I can describe spatial distribution	I can summarise the characteristics of environments	I can describe interconnections	I can describe processes at a range of scales	I can describe sustainability	I can describe change	2
I can identify the location of a place	I can identify spatial distribution	I can identify environments	I can recognise an interconnection	I can recognise different scales	I can identify sustainability	I can identify change	1
Geographical concepts							

What are the stages of production and consumption?

A **supply chain** outlines the path of a product through the stages of production and consumption. Supply chains connect people and places through the process of trading.

1 Extracting or growing raw materials

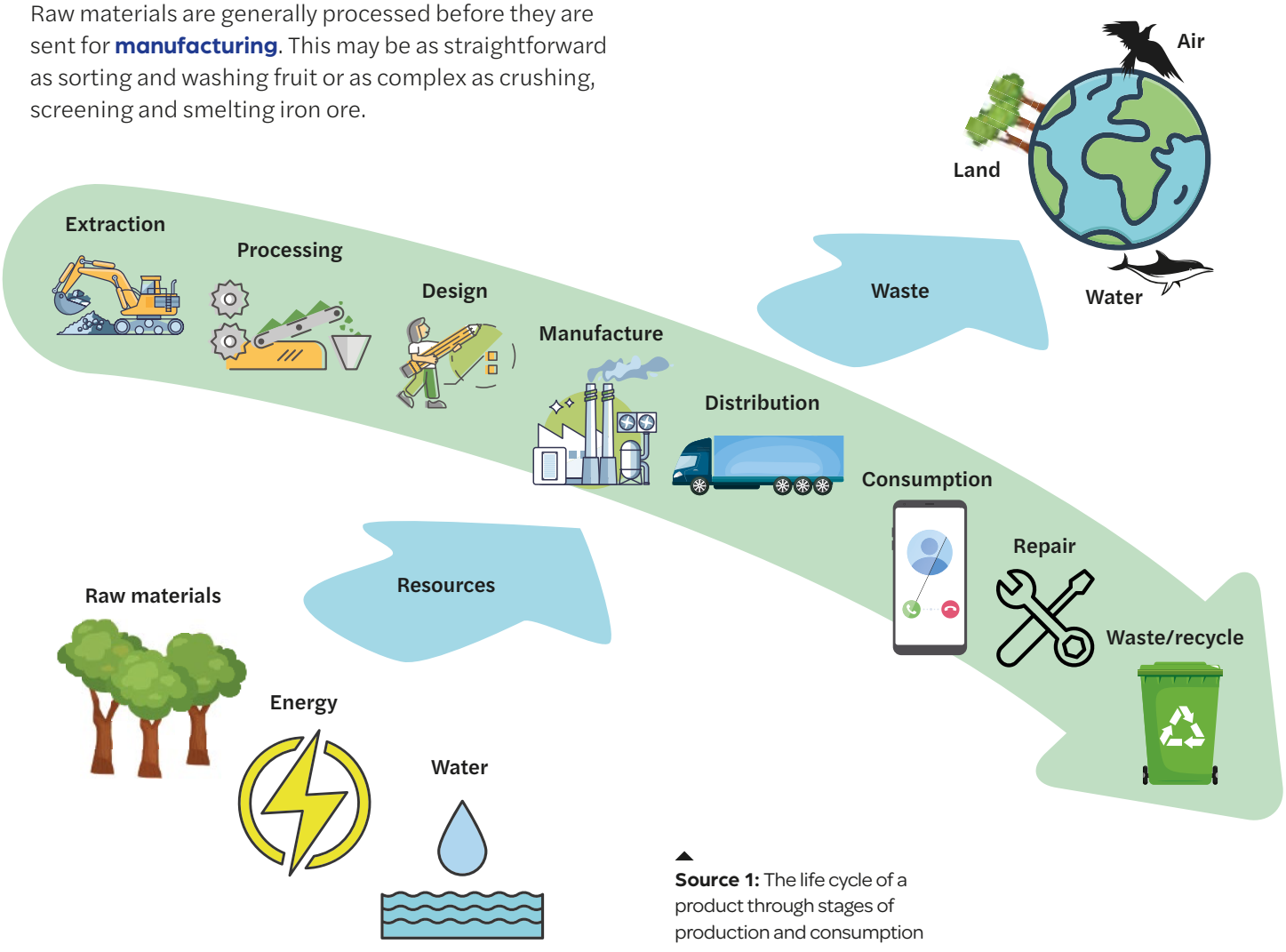
The **production**, or making, of consumer goods begins with raw materials that are extracted from the ground in mines, taken from forests, rivers and oceans, or grown or raised on farms.

2 Processing raw materials

Raw materials are generally processed before they are sent for **manufacturing**. This may be as straightforward as sorting and washing fruit or as complex as crushing, screening and smelting iron ore.

3 Manufacturing

Manufacturers take the processed raw materials and use them to make goods to sell. Manufacturers generally use machines and labour to make their products. Different companies work together to make products. For example, making a car includes the manufacture of car bodies, windows and tyres.



Source 1: The life cycle of a product through stages of production and consumption

Source 2: A pair of denim jeans can travel up to 65000 kilometres through its supply chain before it reaches its final customer, beginning with the raw material of cotton grown in India, China, Pakistan, Brazil, United States and Australia.

4 Distribution

Manufactured goods need to be transported to the consumer. Ships carry the greatest volumes of manufactured goods by travelling from country to country. Goods are also transported by plane, train and truck. Goods are often transported to warehouses for storage until final distribution takes place to shops and customers.

5 Consumption

Consumption refers to the use of goods and services. As populations grow and more people move out of poverty, the rate of consumption increases. Demand for more goods and services puts greater pressure on our natural resources and leads to increased carbon dioxide emissions that increase global warming.

6 Waste and recycling

When products are no longer useful they are dumped as waste or recycled into other products. Increases in consumption lead to increase in waste. **Developed** countries produce more waste **per capita** because they have higher levels of consumption.

Source 3: This chair has been manufactured from recycled plastic. The plastic is processed by sorting, washing, shredding and melting into pellets ready for manufacture.

Learning ladder 10.1

Processes that transform people, places and environments

1. What is a supply chain?
2. Source 1: Describe the life cycle of a product through the supply chain.
3. Source 2: Explain why a pair of jeans can travel up to 65000 kilometres through its supply chain.
4. Source 3: Explain how a recycled plastic chair goes through a similar process to other products as it moves through the supply chain.

Interconnection

1. Source 2: What raw material is used to manufacture denim jeans?
2. Source 3: Decribe the processing stage in the manufacture of recycled plastic products.
3. Source 1: Where is waste produced in the supply chain and what happens to it?
4. Explain how increased demand for products puts pressure on natural environments and waste management.

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Interconnection, page 392

10.2

What is the impact of extracting or growing on places?

The initial stage in the production and consumption supply chain centres around the extraction of minerals, natural gas or oil through mining, or agricultural activities, such as logging for timber or growing and raising food on farms. Each of these activities brings about change to to environments and ecosystems that is often permanent.

Growing and harvesting products

Agriculture provides many raw resources we use to make products, such as growing wheat to make Weet-Bix and harvesting timber to make furniture and paper. Growing and harvesting products has a major impact on environments.

Clearing the land

Before agricultural production even begins, habitats and ecosystems are destroyed when clearing land for farms. Agricultural land now covers about 38 per cent of the global land surface and this is increasing each year. One-third of agricultural land is used to grow crops and two-thirds is pasture for grazing livestock.

Source 1: Between 2017 and 2023, more than 800 million trees were cut down in the Amazon Rainforest to create cattle ranches for beef cattle.

Habitat loss for agricultural land is one of the leading causes of population decline and extinction in wildlife species. Deforestation for farmland is also a major contributor to climate change, as forests remove greenhouse gases from the atmosphere.

Chemicals for agriculture

To help the growth of crops and pasture, fertilisers are added to the soil to increase nutrients to ensure better crop yields. Once planted, herbicides and pesticides are used to promote plant health, kill weeds and destroy crop-eating pests. Agricultural runoff following heavy rains washes chemicals from farms and transports them into rivers and oceans, polluting soils and freshwater and marine environments.

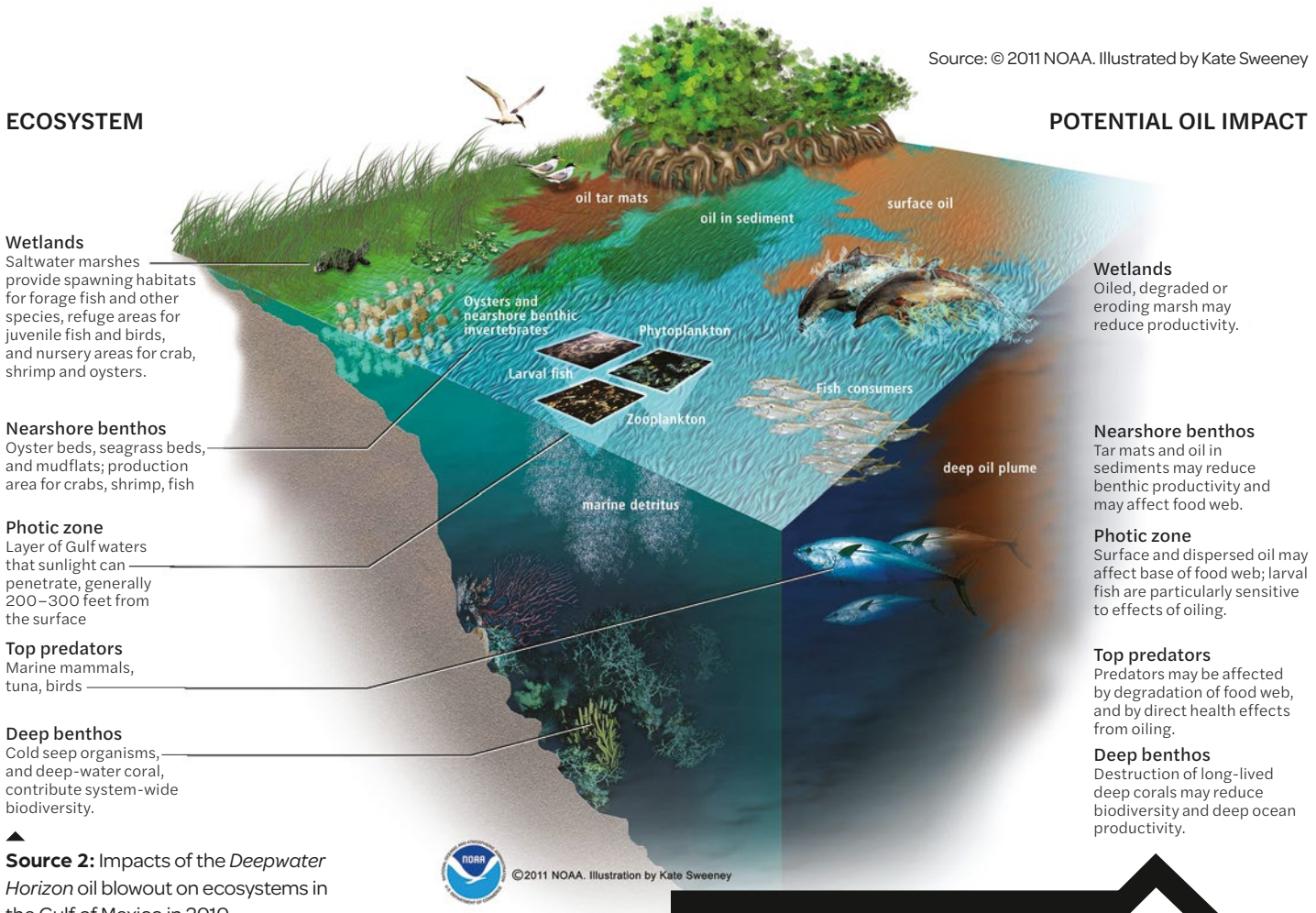
Agricultural chemicals are absorbed into the tissues of organisms, and eaten by larger animals in the food chain. The chemicals accumulate in the bodies of the larger animals over time through a process called **bioaccumulation**.

Extracting raw materials

Mining provides many raw resources required to make the products we use, such as iron ore used in the production of steel and oil which is a key ingredient in making plastic. The mining process can be hazardous to the natural environment.

Surface mines

Surface mines use explosives and heavy machinery to expose



Source 2: Impacts of the *Deepwater Horizon* oil blowout on ecosystems in the Gulf of Mexico in 2010

minerals near the Earth's surface. They create huge holes in the land and result in clearing the land of soil and plants and wildlife habitats to access the minerals below. Surface mines create a huge amount of waste materials known as **tailings**. These materials are often stored in large tailings dams to prevent environmental damage from radioactive, toxic or acidic waste. The accidental release of water from tailings dams can have a catastrophic effect on local waterways and communities. In 2019 the Brumadinho tailings dam in Brazil collapsed, killing 270 people and releasing 12 million cubic metres of toxic mining waste that destroyed houses and farms, and polluted the Paraopeba River.

Drilling for oil and gas

Oil wells are drilled deep into the ground on land and in the water to extract oil and gas and pump it up to the surface. Roads, pipelines and other infrastructure constructed by oil companies degrade environments. Harmful pollutants may be released into the air and dangerous chemicals can be leaked into the water. In 2010 the *Deepwater Horizon* offshore drilling rig in the Gulf of Mexico suffered a blowout and the release of 4.9 million barrels of oil into the ocean, killing thousands of marine mammals, sea turtles and fish, and contaminating their habitats.

Learning ladder 10.2

Processes that transform people, places and environments

1. How are raw materials extracted from the Earth?
2. Source 1: Describe what has occurred here and why it has occurred.
3. Source 2: Explain the impacts of the *Deepwater Horizon* oil blowout on ecosystems.
4. Analyse how chemicals used on farms can impact the health of environments long distances from the source.

Environment

1. What changes does agriculture bring to environments?
2. Describe changes to the natural environment caused by the establishment of surface mines.
3. Explain how hundreds of people died, and land and water was degraded at Brumadinho in Brazil.
4. Source 2: What is one strategy that could be employed to reduce one of these environmental changes?

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Environment, page 396

10.3

Case study

How has demand for palm oil impacted Asian countries?

The rapid expansion of the highly productive and profitable palm oil industry, mainly in South-East Asia, has seen large tracts of tropical rainforest cut down and alarming declines in endangered species such as the orangutan.

Palm oil production

Palm oil is a very efficient crop, producing more oil per land area than any other vegetable oil crop. Today it is the most widely used vegetable oil in the world and it is an ingredient in half of packaged products found in supermarkets. Countries in southeast Asia have ideal conditions for growing the African oil palm, the tree from which palm oil is extracted. As a result, Indonesia and Malaysia supply over 80 per cent of the world's palm oil exports.

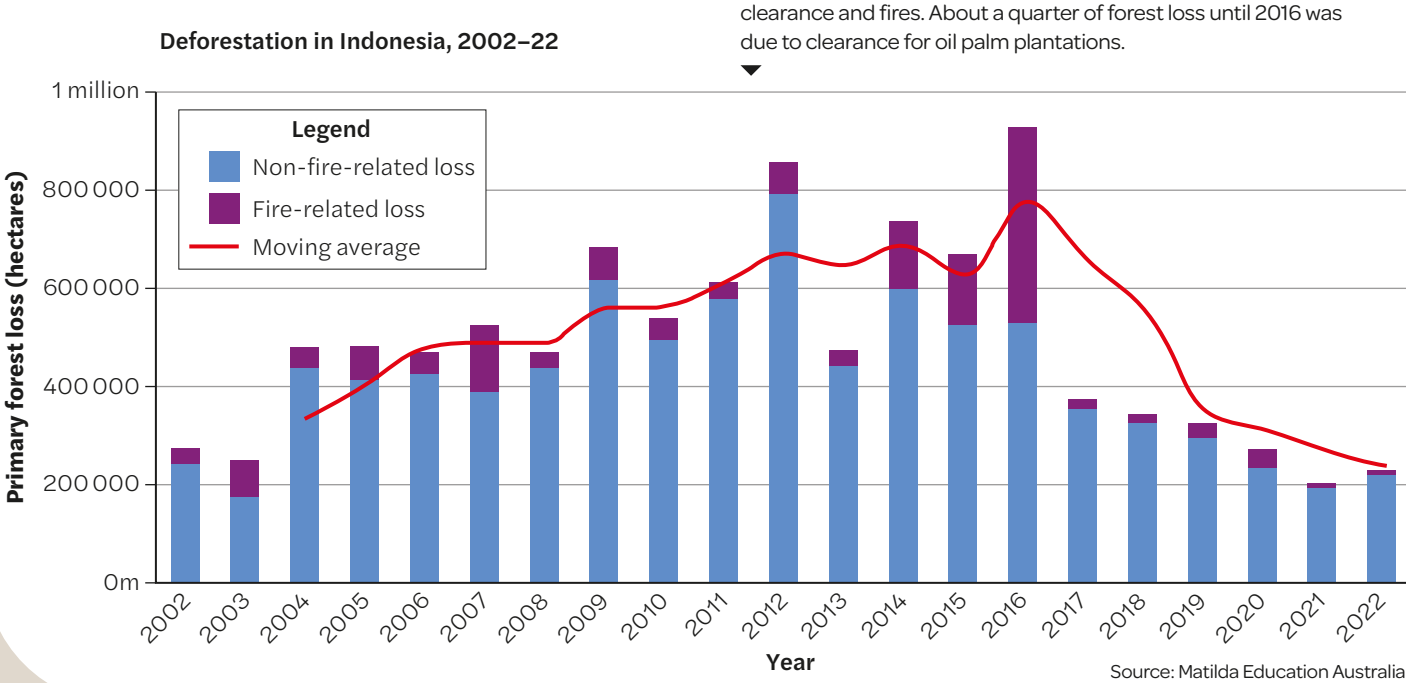
Impacts on environments

Between 2001 and 2016, palm oil plantations accounted for 23 per cent of all deforestation in Indonesia. To clear land quickly and cheaply, some companies use fire, producing thick smoke. This worsens air quality across the region and releases carbon into the atmosphere, increasing climate change.

This large-scale clearing also destroys habitats and causes habitat fragmentation, disrupting wildlife movement and reducing breeding opportunities for endangered species, such as the Sumatran tiger and Asian elephant.

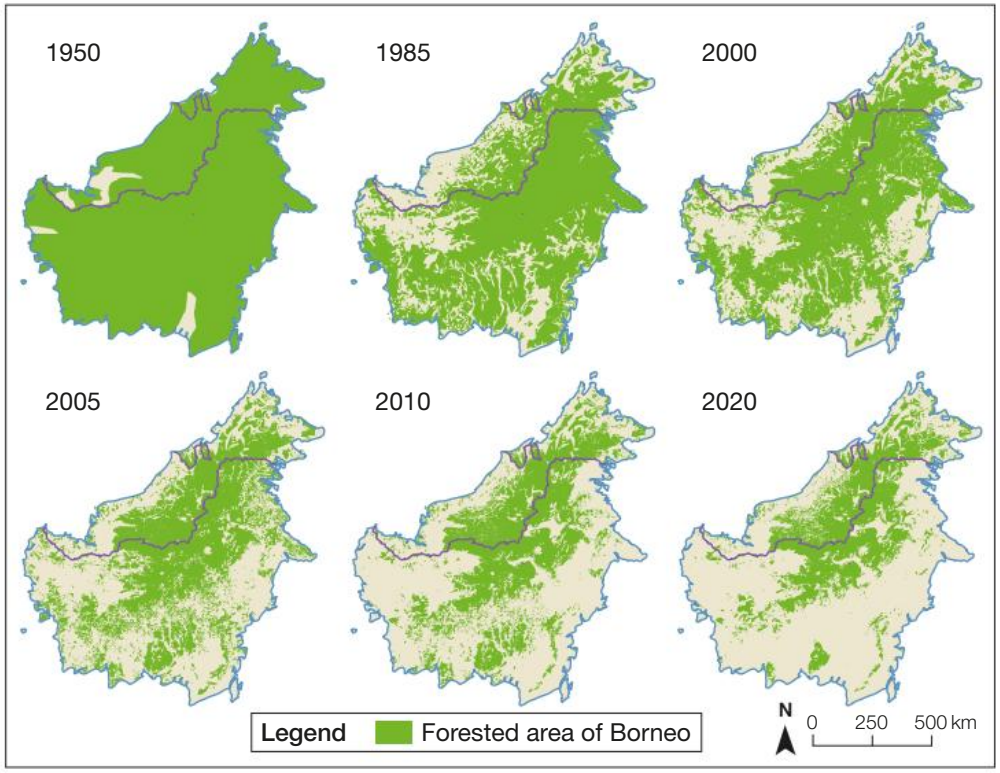
Deforestation from palm oil plantations is one of the main threats to the survival of orangutan populations in the Indonesian islands of Borneo and Sumatra. About 80 per cent of original orangutan habitats have been lost and the orangutan population has been halved.

Source 1: The amount of deforestation in Indonesia due to forest clearance and fires. About a quarter of forest loss until 2016 was due to clearance for oil palm plantations.



Source: Matilda Education Australia

Deforestation in Borneo, 1950–2020



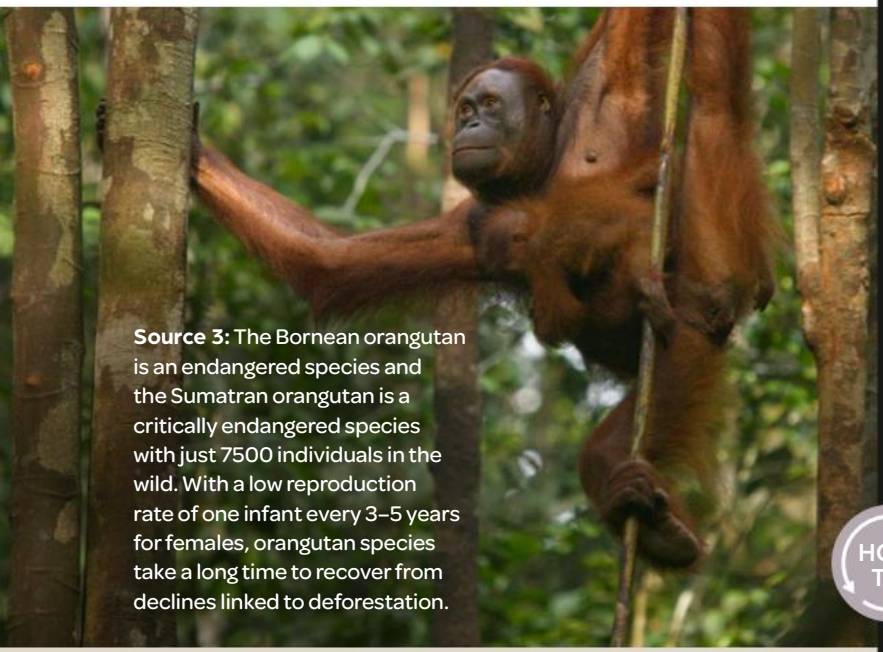
Source 2: Deforestation on the island of Borneo from 1950 to 2020. Borneo is home to some of the Earth's most ancient rainforests, containing unique species such as orangutans. Sadly, decades of logging and land clearing to establish farms and oil palm plantations mean that only 50 per cent of this rainforest remains.

Conservation efforts from the Indonesian government and conservation groups has seen action to protect habitats and important species. In 2007 the Worldwide Fund for Nature (WWF) established a Heart of Borneo program in association with the Indonesian, Malaysian and Bruneian governments. The program has set up protected areas and promoted sustainable forest management on Borneo.

Source: Matilda Education Australia

Action to reduce deforestation

Indonesia's rate of deforestation has slowed greatly from 2017. The Indonesian government introduced fines to landowners growing oil palm plantations in newly protected forests, while plantations on existing protected forest land must be converted back into forests. Although both legal and illegal deforestation continues in Indonesia, the amount of deforestation has decreased from 930 000 hectares in 2016 to 230 000 hectares in 2022. The Indonesian government announced in 2023 that 200 000 hectares of oil palm plantations would be converted into protected forests.



Source 3: The Bornean orangutan is an endangered species and the Sumatran orangutan is a critically endangered species with just 7500 individuals in the wild. With a low reproduction rate of one infant every 3–5 years for females, orangutan species take a long time to recover from declines linked to deforestation.

Learning ladder 10.3

Sustainable management strategies

1. Source 3: What has led to a decline in orangutan numbers?
2. Describe the impact that palm oil production has had on deforestation in Indonesia.
3. Source 2: What is the Heart of Borneo project and what does it aim to do?
4. Source 1: What action did the Indonesian government take to reduce deforestation and how successful has it been?

Change

1. How have populations of orangutans changed?
2. Source 1: Describe the trend in deforestation in Indonesia between 2002 and 2022.
3. Source 2: Describe and explain the changes to the forested area that have taken place on Borneo.
4. Source 3: What are the implications of deforestation for orangutans and what can be done to protect them?

HOW TO Change, page 394

How does manufacturing impact places?

The products you use or consume each day have been processed or manufactured. The impact of this activity on the workers and the natural environment depends on the laws in place to protect them and the type of product manufactured.

Manufacturing

Manufacturing refers to the assembly of parts into finished goods through the use of human labour, tools, machinery and chemical processing. Large-scale manufacturing allows for the mass production of goods using assembly lines and advanced technology. Small-scale manufacturing is dominant in many developing countries, where capital investment is low and labour is the key resource.

China is the world's largest manufacturing nation, accounting for 29 per cent of the world's output. The growth of manufacturing in China has been driven by the modernisation of factories and distribution networks, and the **rural–to–urban migration** of workers. In 1992, just 28 per cent of people in China lived in urban areas. By 2022, 64 per cent of all Chinese lived in urban centres and 29 per cent of all workers were involved in manufacturing.

Impact on the environment

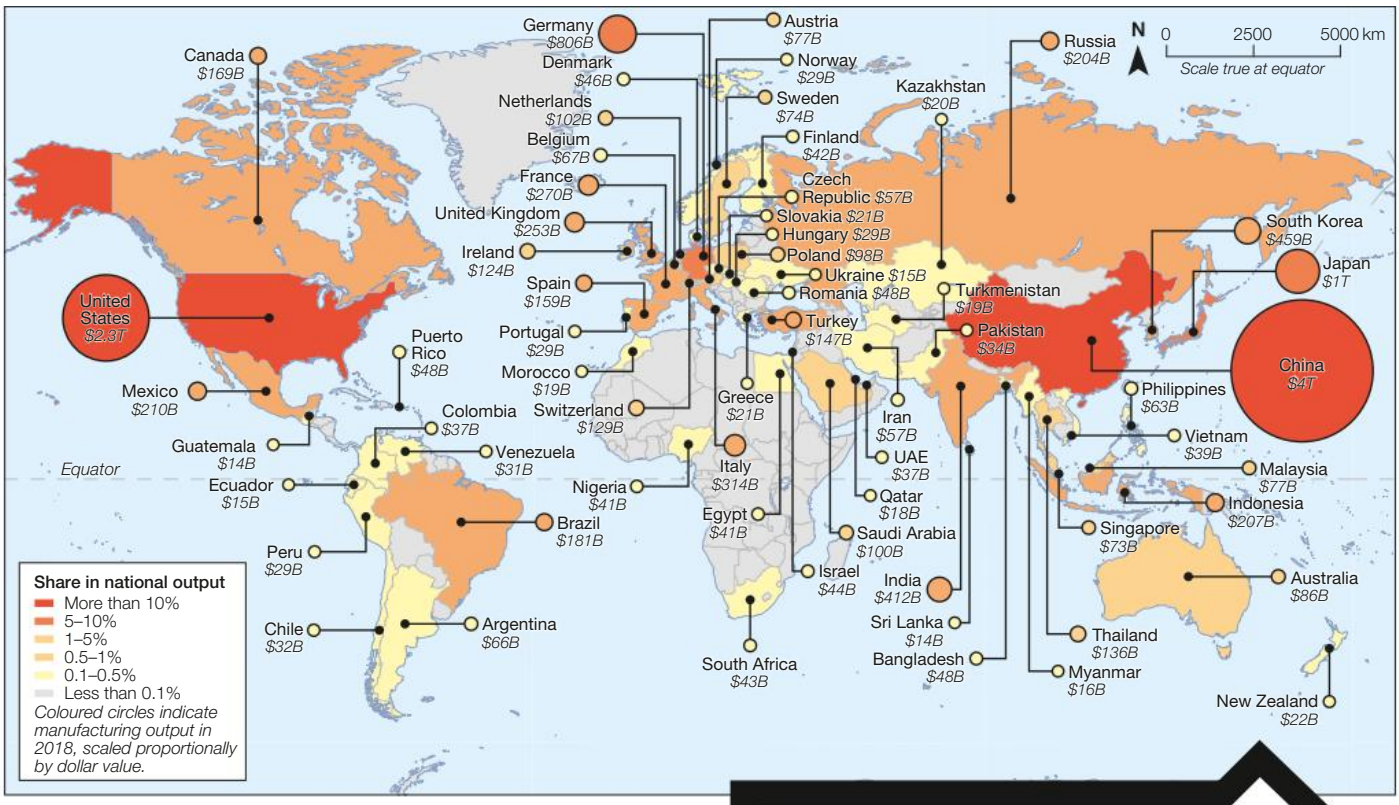
Air pollution, toxic waste disposal and water contamination are negative impacts of manufacturing industries. China's poor air quality leads to 1.2 million deaths each year. The large increase in coal-powered industries and upsurge in electricity demand have led to increased pollution. It is estimated that 48 per cent of Chinese carbon dioxide emissions come from the manufacturing sector, and 40 per cent from the power needed to generate them. Nearly all of China's groundwater has been contaminated by toxic human and industrial waste dumping, and 70 per cent of water in rivers and lakes is considered to be unsafe for human use.

The worst ever industrial spill occurred at Bhopal in India in 1984 when a leak at the Union Carbide pesticide plant exposed 500 000 people in the towns surrounding the plant to a highly toxic gas. At least 16 000 people died along with thousands of animals and plants. Hundreds of thousands of survivors have suffered cancer, stillbirths, miscarriages, and lung and heart disease from the Bhopal disaster.

Impact on workers

Manufacturing creates jobs for people involved in making and assembling components, along with those who market, sell and distribute the goods. Growth in manufacturing in China has led to improved levels of wellbeing for millions of workers. In Australia, employment in manufacturing industries has declined from 25 per cent of all workers in 1970 to just 5 per cent today. In countries such as Bangladesh, expoitation of child workers is an issue. More than 1.7 million children are forced to work to help their poverty-stricken families.

World manufacturing output, 2018



Source: Matilda Education Australia

Source 1: World manufacturing output by country in 2018

Source 2: This young girl is one of thousands of child workers in Bangladesh who work in factories supplying designer clothes for sale in affluent countries.

Learning ladder 10.4

Processes that transform people, places and environments

1. Source 1: Which three countries had the greatest manufacturing output in 2018?
2. Describe the negative impacts of manufacturing on the environment.
3. What was the impact of the Bhopal leak in India in 1984?
4. Source 2: Explain where and why a 15-year-old girl is working in a garment factory.

Change

1. How has China's manufacturing growth impacted rural-to-urban migration?
2. Source 2: Describe the impact manufacturing has had on the population of China.
3. Why do companies such as Levi Strauss jeans have policies to stop the exploitation of child labour?
4. What reasons can you think of to explain the declining importance of manufacturing in the Australian economy?

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Change, page 394

10.5

How do transnational corporations connect the world?

A transnational corporation has its headquarters located in the country of origin, with centres of production or expansion overseas. As a corporation becomes more global, regional research and development and organisation headquarters will develop.

Transnational corporations

Transnational corporations (TNCs), such as Apple and McDonald's, are businesses that produce and sell goods and services in more than one country. Transnational corporations are responsible for 80 per cent of global **trade**, and 69 of the top 100 economic entities in the world are corporations rather than countries. In 2023, Apple was the world's largest TNC with a market value of nearly US$3 trillion.

Transnational corporations aim to maximise profits and lower costs, so the production of the goods or service might take place in a country where the costs of materials and labour are lower. When Apple began in 1976, they manufactered all of their computers in the United States. Now virtually all of the products Apple sells are made outside the United States, mostly in China.

While labour and manufacturing costs were a major factor in moving Apple's production to China, other considerations were expertise in electronics manufucture and availability of components such as computer chips and batteries. China has seven of the 10 busiest ports in the world, so shipping Apple products such as the iPhone around the world is easier.

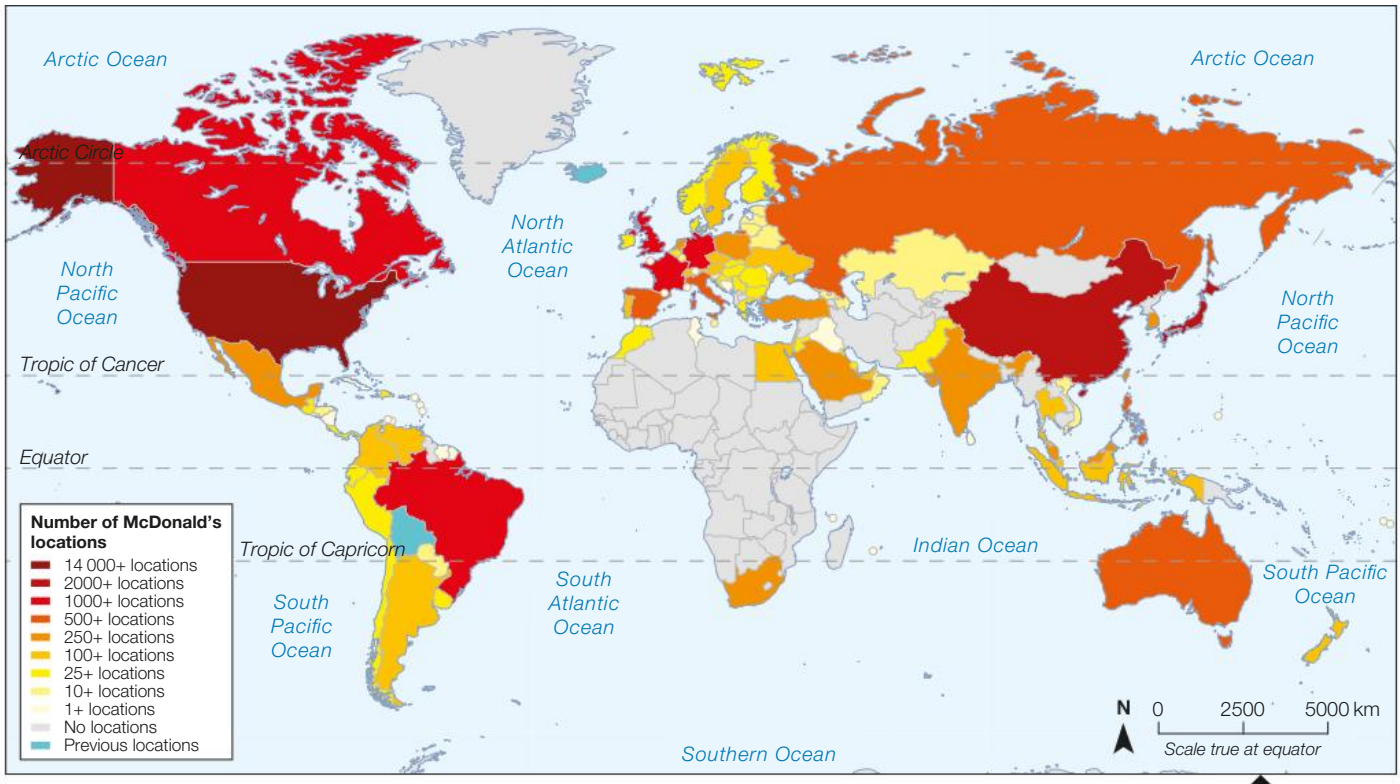
Impact of transnational corporations

There are positive and negative outcomes for countries hosting TNC activities. The TNC:

- creates employment and investment in the host country
- introduces new ideas, systems and training
- can exploit cheap labour or improve wages
- may drive urbanisation by establishing factories in major urban centres
- competes with local businesses
- uses their economic power to influence governments.

Source 1: McDonald's and KFC restaurants in the city of Shenzhen in China stand out among the traditional Chinese building styles. The first McDonald's store in China did not open until 1990, but now China has more than 3500 stores, second only to the United States. Growth in TNCs has been referred to as 'McDonaldisation', due to the spread of the US-based McDonald's corporation as the world's largest fast-food chain. McDonald's is a transnational corporation with over 36 000 stores in 114 countries.

World McDonald's stores



Source: Matilda Education Australia

▲ **Source 2:** Choropleth map showing the number of McDonald's stores throughout the world.

Learning ladder 10.5

Perspectives of people and organisations

1. How do transnational corporations link people and places?
2. Source 2: Use PQE to describe the global distribution of McDonald's stores.
3. Explain two different perspectives of McDonaldisation.
4. Create a table outlining the positive and negative impacts of TNCs on countries that host their activities.

Place

1. Source 2: Identify a country where McDonald's has:
   - between 25 and 100 locations
   - between 500 and 1000 locations
   - more than 14 000 locations.
2. Source 1: Describe the influence of McDonald's on Shenzhen's human characteristics.
3. Explain why China was a good place for Apple to move its manufacturing to.
4. Source 1: How do corporations make adjustments to fit into different places? Refer to the architecture in Source 1 as an example.

HOW TO

Place, page 390; PQE, page 412

How does the distribution of goods connect places?

'Global trade' is the term now used for the import and export of goods and services within and between countries.

The benefits of trade

Countries are interconnected through trade. Trade is the buying and selling of goods between and within countries. We use planes, ships and trains to move goods and services on various scales. Without realising it, you are involved in supporting trade everyday by purchasing clothes online, buying produce grown overseas from your local supermarket or putting petrol in your car.

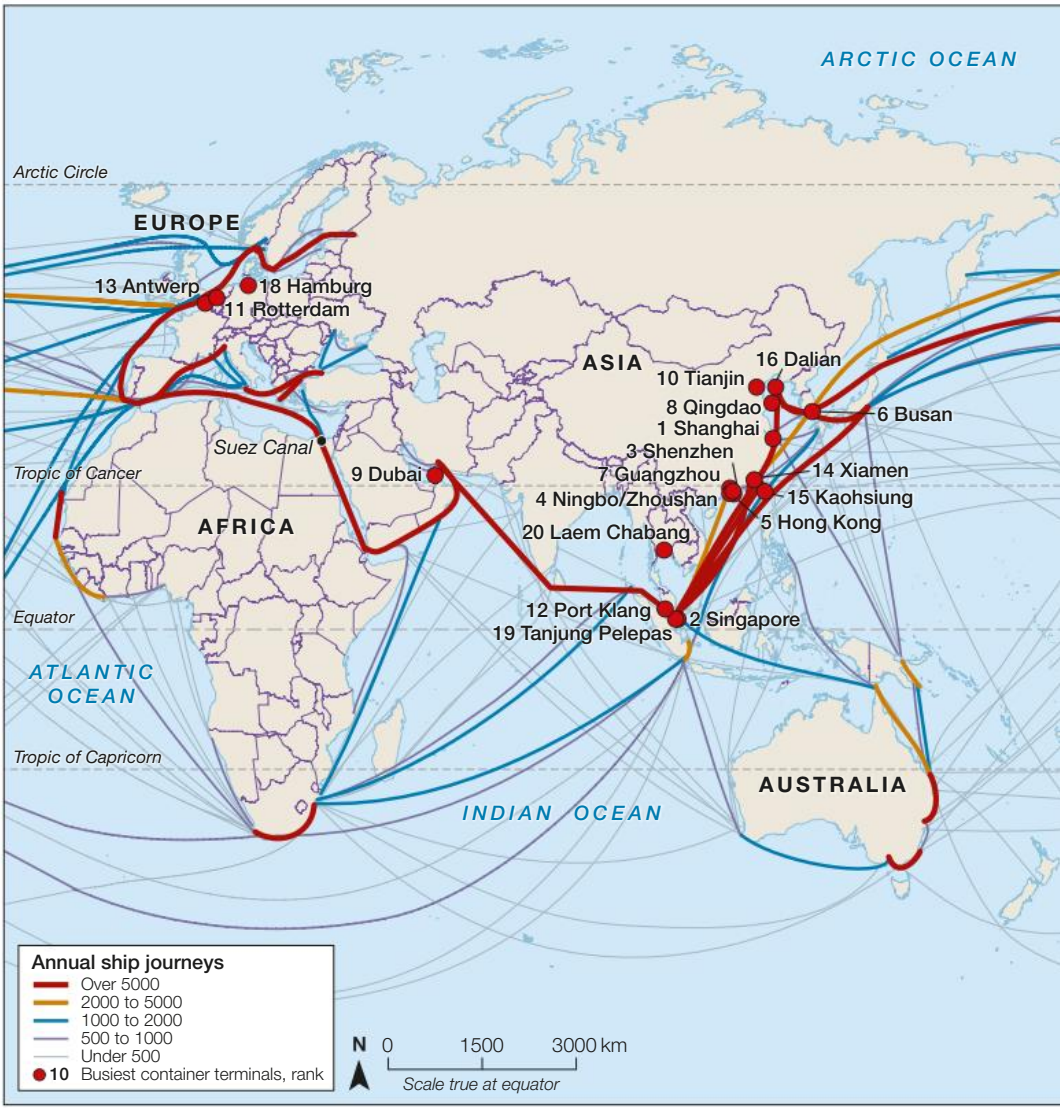
Trade is often described using imports and exports. An **import** is a good or service that a country brings in from the country that produced it. For example, Australia's top imports in 2021 were refined fuels worth around $30.3 billion and cars worth around $29.1 billion. In 2019, Australia imported over one million vehicles from countries such as Japan, Thailand, Germany and Korea.

An **export** is a good or service produced in one country, which is sold to another country. In 2022, Australia's biggest exports were iron ore worth over $48.1 billion and petroleum gas worth over $17.6 billion. China is Australia's biggest export partner.

Today, 25 per cent of all products produced globally are exported. Trade is good for a country's **gross domestic product (GDP)**. The GDP is the amount of money that a country earns from all its goods and services, and is often measured over a year. GDP is also measured per head of population to allow comparisons between countries.

If a country exports more goods than it imports, the value of its GDP increases. GDP is often used by economists as a way of assessing how well a country's economy is doing. In other words, if the GDP is increasing, it is thought that a country's economy is healthy.

World shipping routes



Source 1: Trade routes on a global scale.

Source 2: Shipping containers full of goods for export waiting to be loaded on a dock

Source: Matilda Education Australia

Learning ladder 10.6

Processes that transform people, places and environments

1. Outline why trade is important for connecting people and places.
2. Describe the difference between an import and and export.
3. Source 1: This map shows the trade routes on a global scale.
   - **a** Describe the distribution of the busiest container terminals on a global scale.
   - **b** Explain why these terminals would be the busiest.
4. Source 2: Suggest two technological advancements at container terminals that could lead to increased trading capacity of countries.

Scale

1. What are Australia's top imports and exports?
2. Source 1:
   - **a** How far do container ships travel from Singapore to Sydney with goods for Australian customers?
   - **b** How many ships leave Singapore each year bound for Australia?
3. Australia's last car manufacturer closed in 2017. Why do you think we now import cars rather than produce them in Australia?
4. Source 1: Using SHEEPT factors, explain why so many of the top 20 busiest container terminals are in China.
5. Analyse how the reliance on China for manufacturing may impact world trade. Research some data or examples to support your answer.

HOW TO

SHEEPT, page 414; Scale, page 398

Case study

How does Amazon connect customers to goods?

Amazon has developed a sophisticated distribution system to supply goods to its customers. In 2023, around 5.6 million Australian households shopped online every month and over 9.4 million, or 82 per cent of, households purchased goods online.

Distribution of goods from Amazon

Amazon is the world's largest online store. In 1995, Amazon opened as an online bookseller, but now has over 12 million goods available such as books, electrical items and alcohol. It also offers services such as artificial intelligence and movie streaming.

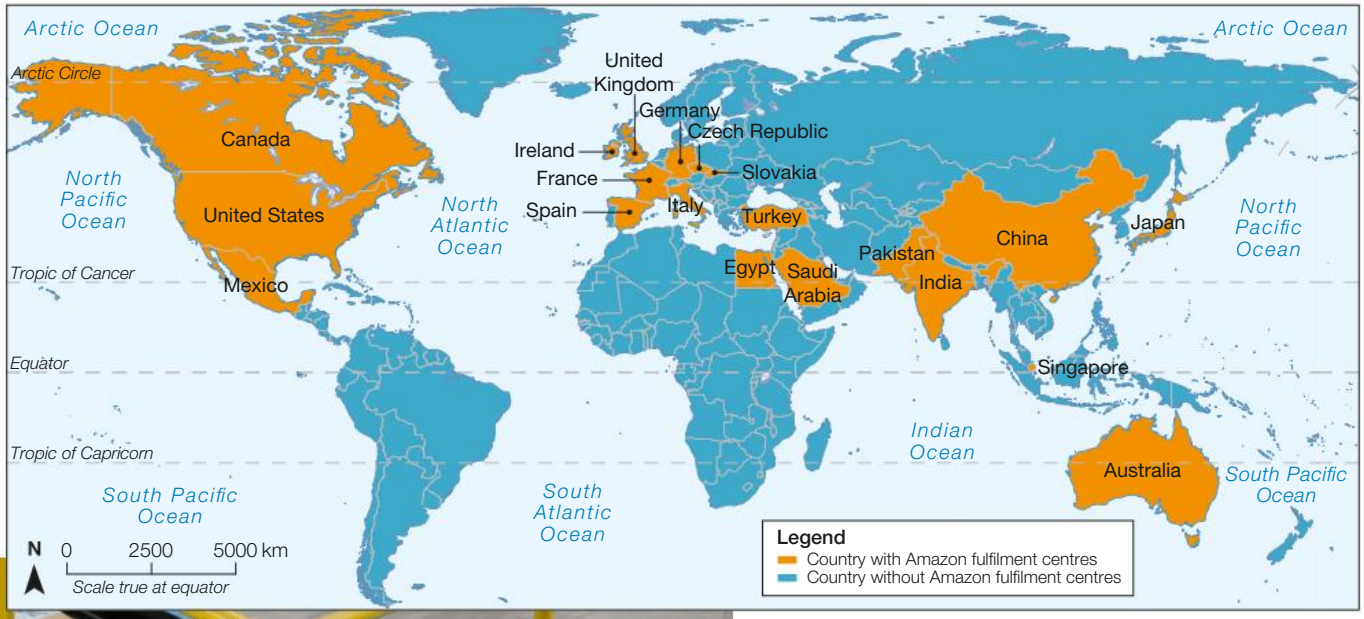
Amazon's head offices are in Seattle, United States, and many of its warehouses, where products are stored and shipped (known as fulfilment centres), are clustered in North America. As the popularity of Amazon has increased, fulfilment infrastructure has been expanded around the world to over 175 locations in Europe, Asia, South America, Africa and, more recently, Australia. This allows for local storage of products and fast shipping to customers.

When you buy a product from Amazon's online website and receive a confirmation of purchase, Amazon employees then select and box your item at a fulfilment centre. If your item is located overseas, it will be transported along with many other customer orders to an Amazon Air Site, where is it flown to Australia. From there packages are sorted according to region or postcode and delivered by truck to partner facilities like Australia Post. Once packages are sorted according to a local delivery route, a driver collects your order and you are then notified that your order is on its way to you. Your package can be delivered to your door or a parcel locker.

Source 2: Amazon has enlisted the use of robots in warehouses and has recently been trialling the use of drones that fly at over 80 kilometres per hour to increase the efficiency of item packing and delivery. The robotics fulfilment centre in Kemps Creek in Western Sydney is Australia's largest warehouse, covering an area of 200 000 square metres and capable of holding 20 million items.

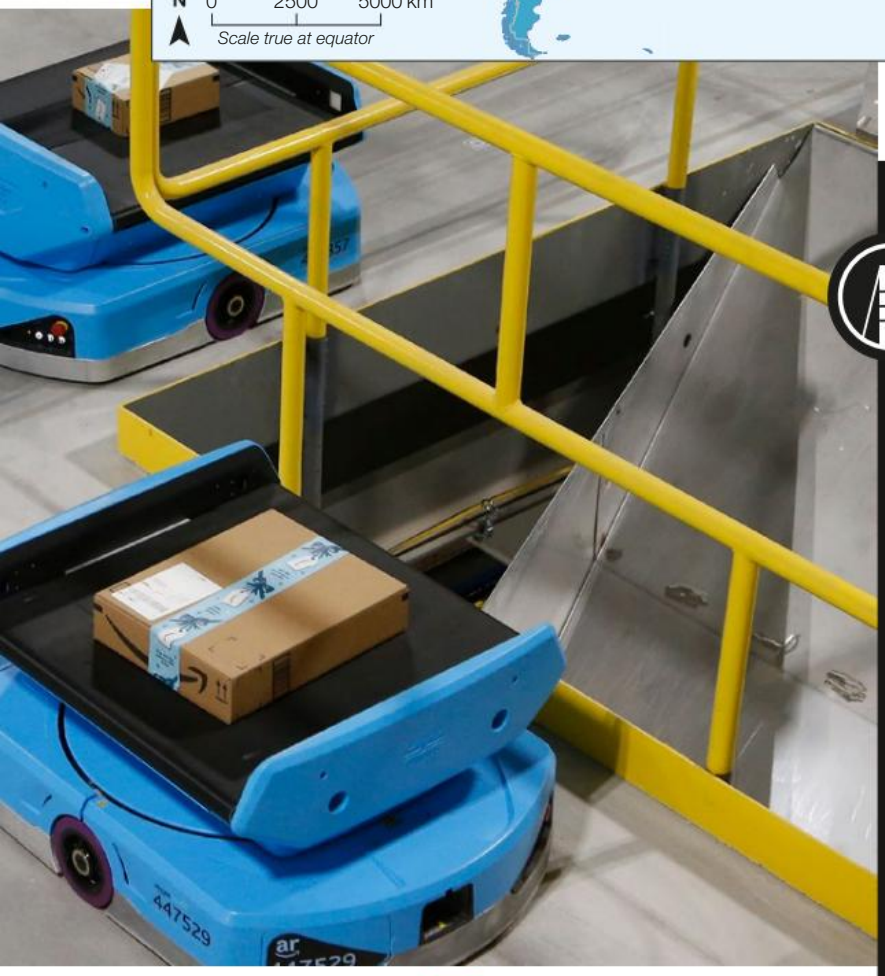
Source 1: Flow diagram of Amazon's fulfilment process

Countries with Amazon fulfilment centres



Source: Matilda Education Australia

▲ **Source 3:** Countries containing Amazon fulfilment centres. Most are found in the United States.



6 Customer receives an order confirmation.

7 Amazon ships the order.

8 Customer receives their package.

Learning ladder 10.7

Processes that transform people, places and environments

1. Source 3: Suggest why even though Amazon has its headquarters in the United States, it would have distribution facilities and infrastructure all around the world.
2. What are Amazon Air Sites and how do they link different places?
3. Source 1: Describe how connections between places take place through Amazon's fulfilment process.
4. Source 2: Explain how technology is changing the functioning of warehouses and connection to customers.

Interconnection

1. Provide two examples of how e-commerce businesses such as Amazon connect people and place.
2. Source 3: Using PQE, describe the distribution of Amazon fulfilment centres. Are there any world regions that are not serviced by Amazon?
3. Consider the data that suggests that Amazon will account for 20 per cent of all internet sales in Australia by 2026. Explain what this means for people's connections to traditional walk-in stores.

HOW TO

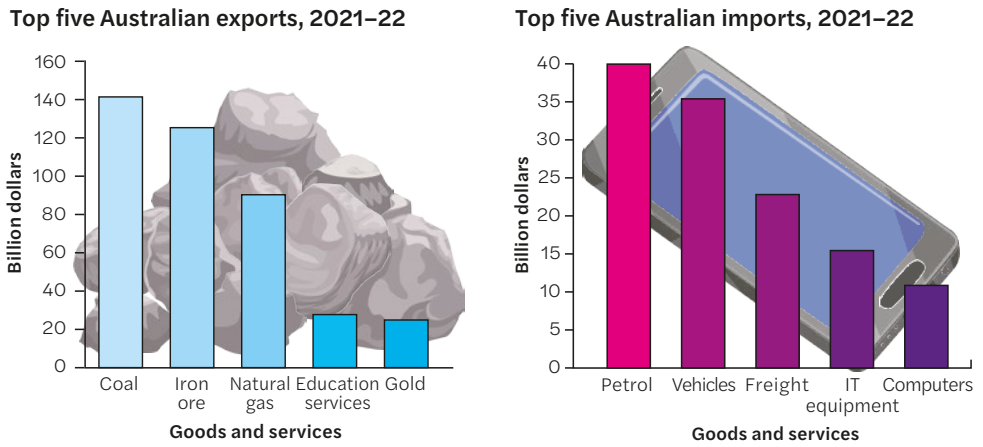
PQE, page 412; Interconnection, page 392

Who are Australia's biggest trading partners?

Trade is one of Australia's biggest economic contributors – the country earned $637 billion in 2022 from goods exports alone. As demand for goods increases globally, the value of Australia's goods grows. In 1990, trade (imports and exports) contributed 32 per cent to Australia's GDP; by 2022 it accounted for 46 per cent of GDP.

Trade partners

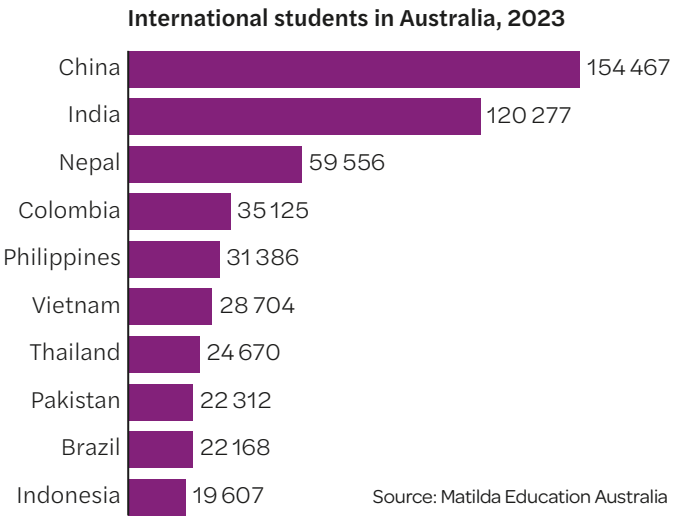
In Australia, our top five trading partners are China, Japan, the United States, South Korea and India. Australia is China's seventh largest trading partner. In 2016–17, our largest import was tourism and travel; Australians spent more than $28.6 billion overseas. Iron ore was our largest export and earned the country $66 billion.



▲ **Source 1:** Australia's top import and export goods and services in billions of dollars Source: DFAT

Education as an export

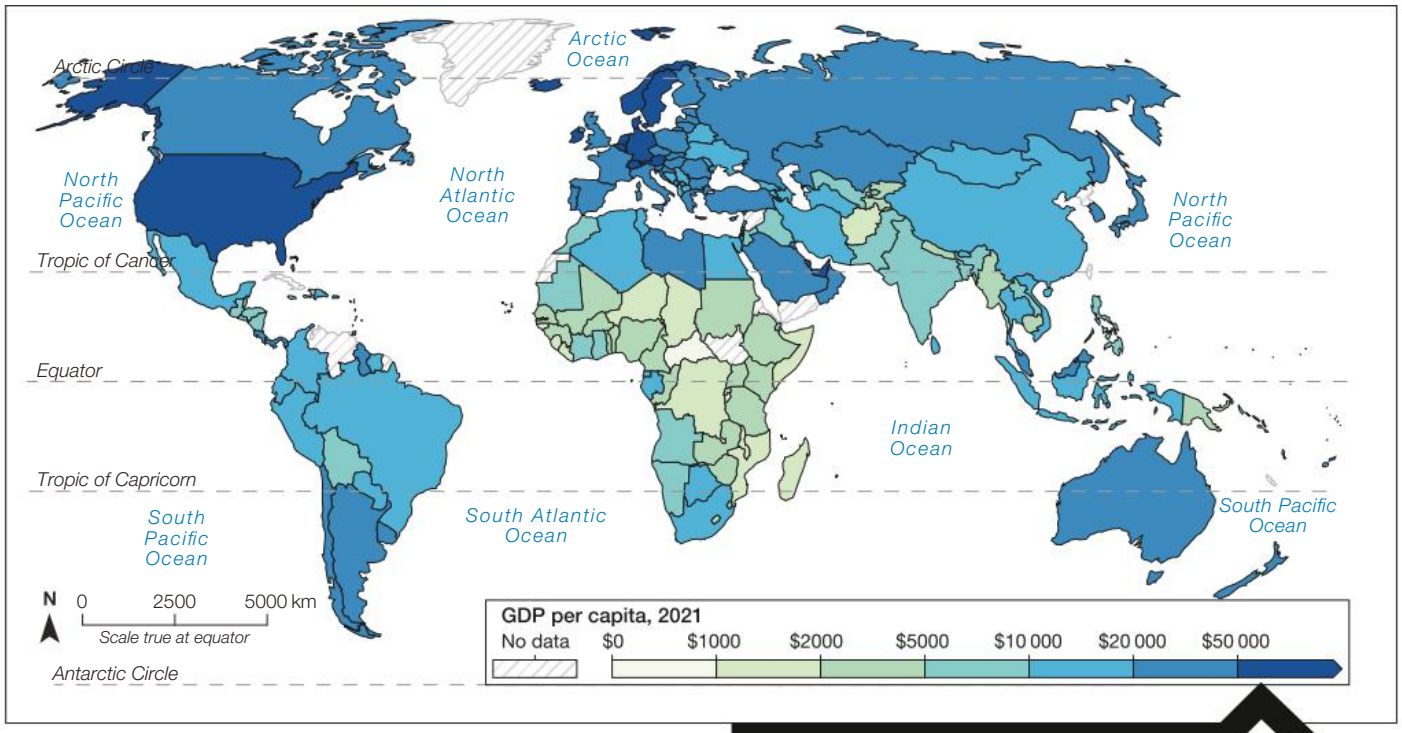
Education is said to be Australia's strongest export that 'isn't dug up'. Educating international students earned Australia $27 billion in 2022. In 2023 there were 725 582 international students studying in Australia.



Source: Matilda Education Australia

▲ **Source 2:** Top 10 source countries of international students in Australia in 2023. There were 31 per cent fewer students in 2022 due to disruption from the COVID-19 pandemic.

World GDP per capita, 2021



Source: Our World in Data

Source 3: Gross domestic product (GDP) for the world's countries in 2021. GDP per capita is a measure of the total value of goods produced and services provided in a country during one year divided by the size of the population.

Source 4: An enormous bucket wheel excavator operating at one of Australia's many open-cut coal mines. Coal is currently Australia's most valuable export and Australia is the largest exporter of coal in the world, accounting for 35 per cent of all coal exports. Japan is the largest importer of Australian coal.

Learning ladder 10.8

Perspectives of people and organisations

1. Source 1: What is the the one service in Australia's top five exports?
2. Source 3: Use PQE to describe the global pattern of GDP.
3. Source 2: Where do most of Australia's international students come from? What factors do you think influenced them to study in Australia?
4. Australia is the world's largest exporter of coal, but coal-fired electricity generation accounts for 30 per cent of global carbon dioxide emissions. What can the government do to overcome this issue?

Space

1. Source 3: Identify one country with a low GDP per capita, and one with a high GDP per capita.
2. Source 3: Describe where countries with a low GDP are located.
3. Source 3: Explain the types of countries that experience a high GDP. Use the terms 'economy' and 'trade' in your response.
4. Source 2: How did the COVID-19 pandemic influence international student numbers in Australia, and what are the economic and social impacts of this?

HOW TO

PQE, page 412; Space, page 388

Case study

Why is lithium a growing trade commodity?

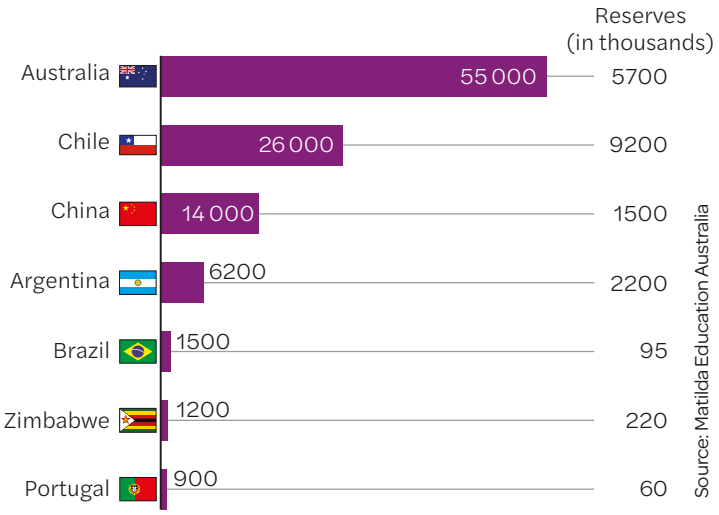
Lithium is an essential ingredient of lithium-ion batteries, which are used in electric vehicles. With global demand for electric vehicles rapidly rising, Australia is a key player in the electric-car market as the world's largest producer of lithium.

Demand for lithium

Over 90 per cent of lithium comes from just three countries, Australia (52 per cent), Chile (25 per cent) and China (13 per cent). In 2023, Australia's lithium exports are predicted to triple the previous year's exports and reach $18.5 billion, with China accounting for more than 90 per cent of these exports.

In 2010, lithium was mainly used for strengthening and increasing the temperatures that ceramics and glassware could tolerate, which is particularly important for cooktops and benchtops. However, by 2021, batteries accounted for over 74 per cent of lithium use. This change has largely been driven by the increasing popularity of electric vehicles. In 2021, the world produced over 540 000 tonnes of lithium and it is predicted that by 2030, the demand for lithium batteries will reach over 3 million tonnes.

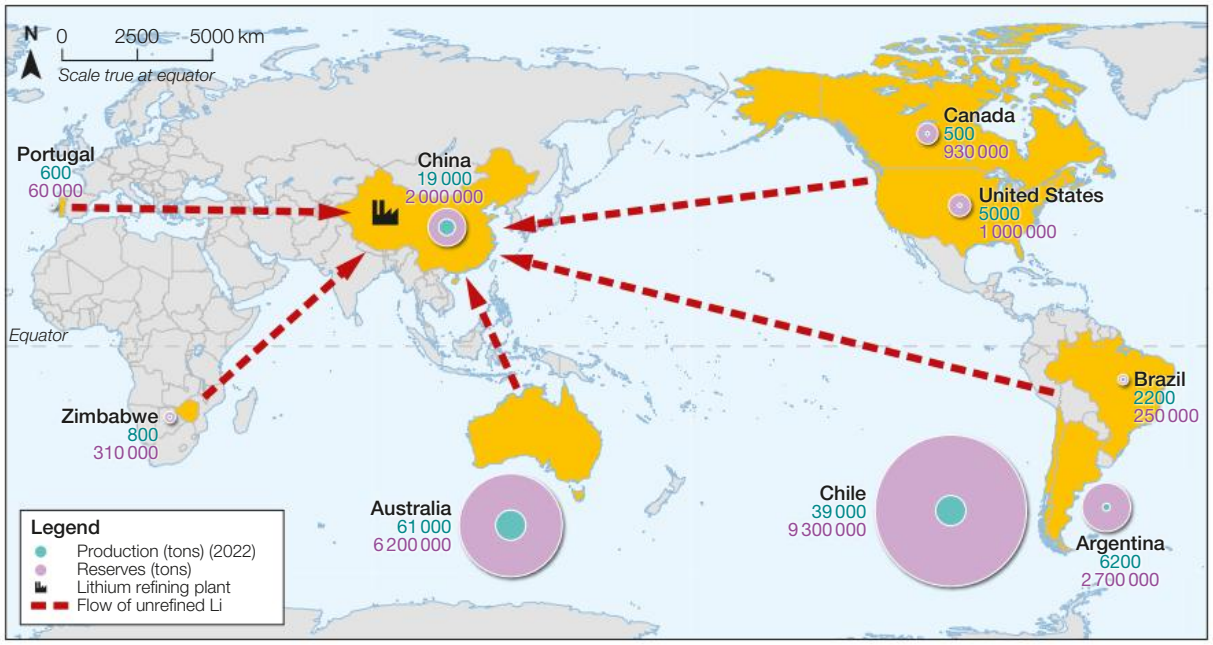
Lithium production and reserves (metric tonnes), 2021



Source 2: Countries with the greatest lithium mine production and reserves, measured in metric tonnes

Source 1: The Pilbara Minerals Pilgangoora Lithium Operations in Western Australia. This mine extracts lithium from the Pilgangoora ore body, which is one of the largest hard rock lithium deposits in the world and produces approximately 8 per cent of global lithium supply.

World trade flows of lithium (tons), 2022



Source: Matilda Education Australia

Source 3: Extracted lithium is exported to China from all over the world to be refined into a product that can be used in batteries.

Conversion to metric tonnes = tons × 0.907185

Battery manufacture

Global lithium-ion battery production capacity is projected to increase by 800 per cent by 2027. In 2022, China manufactured 77 per cent of batteries sold worldwide, and 86 per cent of all electric vehicles sold in Australia are sourced from China.

Australia faces a few major hurdles when it comes to manufacturing its own lithium-ion batteries and electric cars. First, batteries require processed lithium. Once processed, only 6 per cent of the raw lithium mined in Australia is actually useable; the rest is 'waste'. To produce batteries you need to build factories that can sort and process lithium. Another reason is as the demand grows, a lot of Australia's processed lithium is already promised and exported to other countries, making it difficult to keep supplies in Australia. A number of Australian companies are now being set up to produce our own batteries; however, there is a long way to go to be competitive in the rechargeable battery market.

Source 4: Employees work at the Tesla Gigafactory in Shanghai, east China. The factory has the capacity to build 750 000 electric vehicles powered by lithium-ion batteries each year.

Learning ladder 10.9

Processes that transform people, places and environments

1. Source 1: Outline why lithium has been increasing in demand and value over the past 10 years.
2. Describe the trade flows of lithium to China in 2022.
3. Sources 1 and 3: Explain how natural resources such as lithium connect people and place.
4. 'It would be more viable to invest in local lithium refining and battery production than simply exporting raw metals.' Analyse this statement with reference to local economy, demand, current trade relationships and access to technology.

Scale

1. Source 1: Is the Pilbara Minerals Pilgangoora Lithium Operations mine an example at a local, national or global scale?
2. What lithium products does Australia export and import from China?
3. Source 3: Explain why China's lithium-battery production is a global-scale enterprise.
4. Sources 2 and 3: Compare the production and reserves of lithium. Why do you think the scale of production in Australia is higher?

HOW TO Scale, page 398

What are the benefits and costs of global trade?

Global trade is a major contributor to reducing poverty and increasing wealth and wellbeing. The benefits of global trade can, however, come at a significant economic, environmental and social cost to people and countries.

Global trade

Global trade is the exchange of goods and services between countries. Consumer goods, raw materials, food, technology and services such as eduction are all bought and sold in the international marketplace. Global trade allows countries to export products and services to other countries and import products that may not be available domestically.

International trade is a part of global supply chains where one country supplies raw materials, processed goods or services to another country. For example, a smartphone designed in the United States might be assembled in China using silicone chips from Singapore and precious metals from Bolivia. Total global trade is the sum of all exports and imports. In 2019, global trade was valued at nearly $19 trillion.

Global trade for individuals

Online shopping has connected consumers to manufacturers all over the world. Customers now have access to a much wider range of products at cheaper prices. Consumers are no longer restricted to purchasing goods from local stores. Thanks to global supply chains, individuals can purchase goods from anywhere in the world. Between 2017 and 2022, the market for online shopping in Australia grew 20.2 per cent per year.

Suppliers of goods also receive individual benefit. Global trading has created employment for hundreds of millions of people, and improved the wellbeing and life expectancies of people who formerly lived in poverty. China has achieved great success in pulling 700 million people out of poverty since 1978. In a short time, China transformed itself from a farming-based economy to a manufacturing one.

Many goods supplied as part of the global supply chain are made in developing countries, where labour is cheaper. While this can be a positive outcome for millions of people in developing countries who gain employment, work conditions can be poor or even dangerous, and child labour is used in some countries. About 160 million children are involved in child labour, with 79 million of them involved in hazardous work such as in the shipbreaking industry in Bangladesh.

Global trade for businesses

Businesses can now link to buyers and other busnesses around the world. They can expand the target market for their product to include international customers, and access goods and services required by the business from a global market. This often includes sourcing labour from low-wage countries to reduce the cost of production. Interconnecting at a global scale helps businesses to reduce their expenses and increase their revenue to enhance their profitability.

Transnational corporations (TNCs) like Apple and Amazon are responsible for 80 per cent of global trade by producing and selling goods and services in more than one country. Global trading can become so complex that businesses lose control of the supply chain. In countries such as India and Bangladesh, activities may be outsourced to other factories with different quality control and work practices, making it difficult for businesses to maintain quality control over their product.

Global trade for countries

Global trading fosters closer ties between countries through the movement of goods, knowledge and technology. International trade allows countries to expand markets for their goods and services through exports, and access additional goods and services through imports. Countries like Australia have focused on industries that give them a competitive advantage and let go of industries such as car making, where it was less competitive. This is known as comparative advantage.

Critics of global trade argue that it favours wealthy countries, and that low-income countries are used as a source of cheap labour and raw materials. Larger, more powerful countries can control relationships with smaller trading partners by imposing **tariffs**, a type of tax or levy added to the cost of imported goods. The cost of imported goods are made artificially high. In 2020, China put tariffs on coal, barley, wine and lobsters from Australia, reducing our exports by $6.6 billion as a result.

Source 1: In low-income and middle-income countries, children work in dangerous environments, such as these shipyards in Bangladesh. Child labour is cheap – and children living in poverty need to work to help support their families.

Learning ladder 10.10

Perspectives of people and organisations

1. List one positive and one negative impact of global trading for individuals.
2. Describe variations in access to global trade for wealthy and developing countries.
3. What are the advantages and disadvantages of using low-wage nations for the production of goods?
4. Why do many countries use comparative advantage when engaging in global trading? Provide an example.

Scale

1. What does global trade involve?
2. How does internet shopping bring global advantages to the local environment?
3. Explain how tariffs operate at the national and global scale.
4. Source 1: How is this type of work important at a local scale but frowned on at a global scale?

HOW TO

Scale, page 398

Case study

What are the benefits of Fairtrade?

Fairtrade certification provides a safety net for small-scale farmers by ensuring they receive a fair price for their goods, helping to reduce poverty and inequality.

What is Fairtrade?

Fairtrade is an international not-for-profit organisation that supports farmers and workers in developing countries. Farms are assessed against strict international standards that focus on protecting the environment, treating workers fairly and producing goods ethically. Once approved, products from these farms can carry the Fairtrade logo, helping shoppers identify items that have been ethically sourced. Many Australian supermarkets, including Coles and Woolworths, now sell a wide range of Fairtrade products.

Fairtrade certification is designed to help small-scale producers who often struggle with low incomes and unfair trading systems. In many cases, farmers are forced to sell their crops for less than it costs to grow them. This contributes to poverty, inequality and poor working conditions. Fairtrade provides a safety net by ensuring that certified producers receive a minimum price for their goods.

The benefits

It is estimated that more than 2 million farmers and workers around the world benefit from the Fairtrade system. Fairtrade empowers farmers to take part in decision-making and have a stronger voice in global markets, and protects them from trade barriers and price changes. By receiving stable and fair payment, farmers can invest in better tools, machinery and farming techniques.

Fairtrade also promotes community development. Funds from Fairtrade sales have been used to build schools in remote villages and support the operation of community health centres. These facilities improve quality of life and provide long-term benefits such as education and healthcare, which are essential for breaking cycles of poverty.

Criticisms

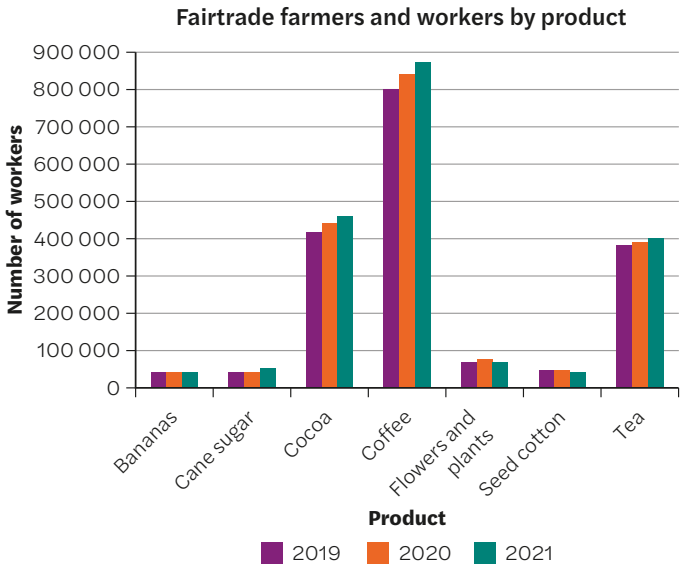
Some critics argue that Fairtrade prices are artificially high, which may encourage farmers to grow more than the market demands. This can lead to an oversupply of goods such as cocoa or coffee, decreasing their value and making it harder for non-Fairtrade farmers to compete.

Another criticism relates to the requirement for farmers to join cooperatives in order to become Fairtrade certified. A cooperative is a group of farmers

Source 2: Tea picker working on a Fairtrade tea estate in Malawi, Africa

Source 1: There are over 6000 Fairtrade products from bananas to coffee, tea, chocolate and flowers. Buying a Fairtrade product helps to eradicate poverty and inequality.

who make decisions together and share profits. While this can improve bargaining power and reduce costs, some farmers prefer to run their farms independently and have full control of their operations.



Source 3: Number of Fairtrade farmers and workers by product

Source: Matilda Education Australia

How is Fairtrade different from other ethical labels?

Where Fairtrade focuses on helping farmers earn a stable income and improve their communities, other ethical labels focus more on environmental sustainability. The Rainforest Alliance encourages farmers to protect forests, use shade-grown methods, and restore damaged land. Together, certifications like Fairtrade and Rainforest Alliance give consumers the power to support farming systems that are more ethical, sustainable, and fair.

Source 4: Coffee beans used in all McCafé coffee sold in Australia are sourced from Rainforest Alliance–certified farms in Brazil, Honduras, Kenya and Ethiopia.

Learning ladder 10.11

Sustainable management strategies

1. What does it mean for a product to be Fairtrade certified?
2. Describe one advantage and one disadvantage of Fairtrade for farmers.
3. Source 1: Explain why consumers might be encouraged to purchase Fairtrade products.
4. Do you think Fairtrade is an effective way to support farmers and the environment? Give reasons for your answer using evidence from the text.
5. Source 4: How can Fairtrade and other ethical certification programs improve the sustainability of environments?

Interconnection

1. Source 2: How is this tea picker connected to Fairtrade products sold in Coles and Woolworths?
2. Source 3: Describe the pattern of workers involved in the production of Fairtrade products.
3. What benefits do Fairtrade farmers receive and why are these important?
4. Source 4: What benefits do McDonald's and its customers gain by being connected to the Rainforest Alliance?
5. Weigh up the implications of Fairtrade certification for farmers. Is it really beneficial or does it support poor farming practices?

HOW TO

Interconnection, page 392

10.12

How does trade connect First Nations people to places?

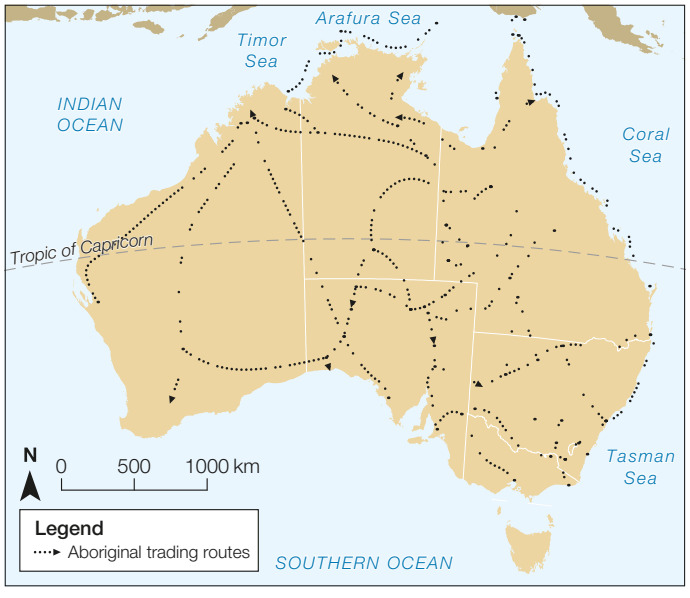
Trade and extensive trade networks have been present on the Australian continent and adjacent islands for millennia. First Nations Peoples have been trading within communities, between communities, and sometimes over vast distances across the continent, and internationally for many centuries.

Trade across the continent and the adjacent islands

To ensure that everyone had access to all the things required for a good life, extensive trade networks were established across the length and breadth of the Australian continent. These were supported at a local level, where individuals would learn specialist knowledge to produce specific and necessary items, including raw materials, preserved foods and medicines, clothing, weapons, instruments, sacred objects and materials, and tools made of wood, bone and stone.

In addition to the trading of items along these routes, people would also exchange knowledge, stories and lessons, start families, and engage in diplomatic relationships to solve collective problems and disputes. This meant that rather than being culturally static or unchanging, there were active cultural, technological, social, economic and diplomatic exchanges along these routes. These benefits of trade apply to all people and communities.

Map of the First Nations Peoples' trade routes



▲ **Source 1:** This is a map of the extensive trade routes across the Australian continent used by First Nations Peoples.

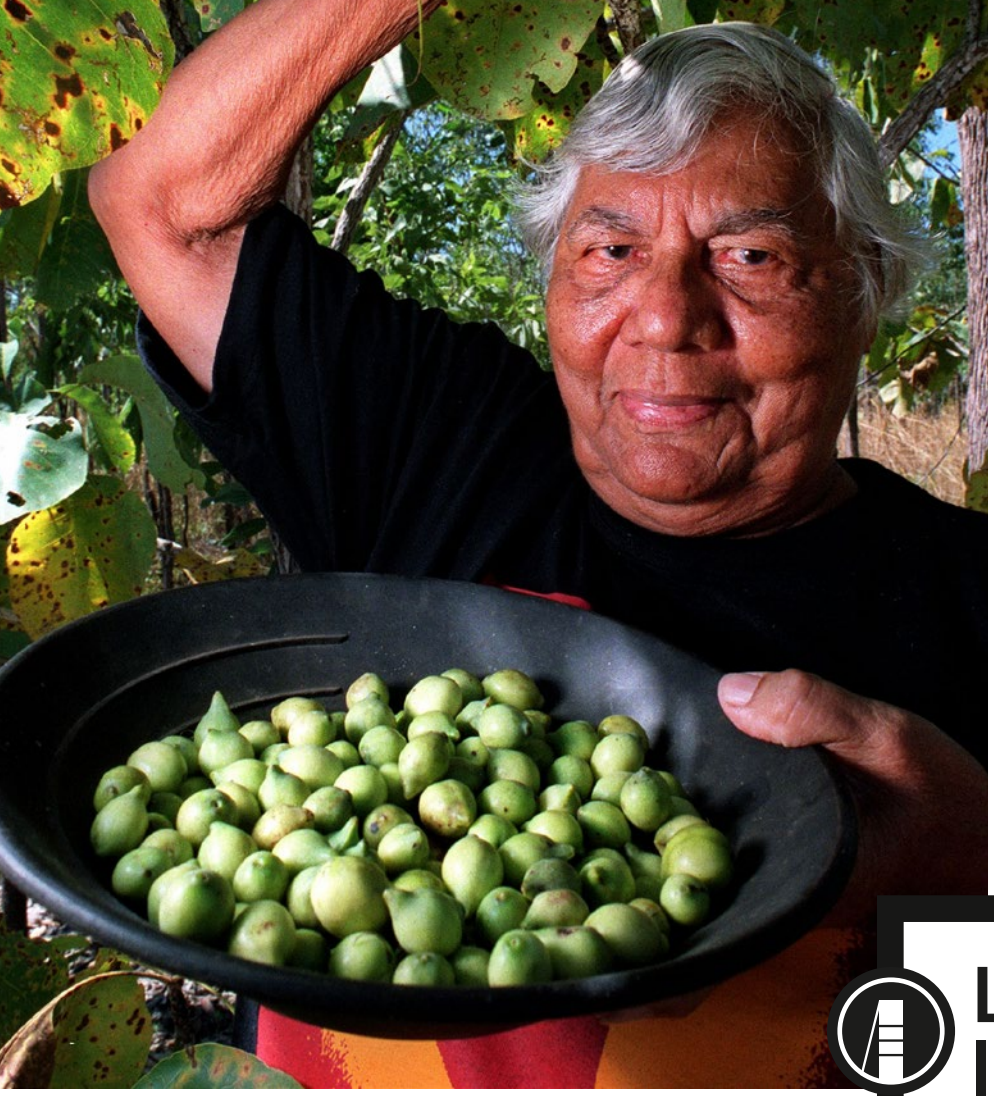
Source: Matilda Education Australia

Contemporary trade connections

In contemporary Australia, First Nations Peoples engage with local, national and international trade. Although this is in far greater values and amounts than anytime previously, this is still a long-held tradition that First Nations Peoples have been contributing to, and benefiting from, for millennia.

Trade continues to benefit First Nations people. A growing number of First Nations students are completing university qualifications, and the number of First Nations enterprises continues to increase. These enterprises include arts and cultural services, with the art market alone worth over $250 million in sales each year. The downside is that this industry is dominated by cheap, counterfeit and fraudulent artworks and only around 30 per cent are produced by First Nations artists.

Other First Nations enterprises include native food producers, specifically foods like the Kakadu plum, lemon myrtle and finger lime; fashion and textiles, including artists using native Australian fibres and dyes; and cultural tourism businesses that support caring for Country and sharing important First Nations knowledges. Together, these and many other businesses support the economic development of First Nations communities through employment, wealth creation, governance and self-determination.



Source 2: A farmer displays his collection of Kakadu plums. These are traditional bush foods that have been used and traded by First Nations Peoples for centuries due to their medicinal and nutritional benefits.

Source 3: A model walks the ganbu marra runway at Melbourne Fashion Week in 2024, showcasing a unique design by Marrithiyel and Deley artist and designer Paul McCann. McCann takes inspiration from his First Nations heritage to create stunning and original garments.

Growing First Nations trade connections

At a global scale there are businesses and organisations working to facilitate trade.

Source: Matilda Education Australia

Source 4: Businesses and organisations work to facilitate trade with their communities.

Learning ladder 10.12

First Nations Peoples' interaction with Country

1. What is one way First Nations Peoples interact with Country through trade?
2. Describe how First Nations people managed and exchanged resources across Australia through trade networks.
3. Explain how First Nations Peoples used their knowledge of the land and resources to ensure sustainable trade across the continent.
4. Analyse the benefits of First Nations Peoples' trade networks.

Scale

1. What trade transactions occur between First Nations Peoples and communities, past and present, at local and national scales.
2. Illustrate contemporary global trade connections by local First Nations Peoples' enterprises.
3. Explain how organisations and governments are promoting First Nations Peoples' trade connections and opportunities.

HOW TO Scale, page 398

How do clothing and fashion connect the world?

An extensive supply chain connects people and places across the world to satisfy the basic human need for clothing. Fashion is the latest clothing trend or seasonal style, and includes luxury brands to streetwear. 'Fast fashion' refers to a speedy process of making and selling new styles of cheap, mass-produced clothing continuously throughout the year. For example, Zara produces clothing, from design to sale in stores, across the globe in fewer than 25 days.

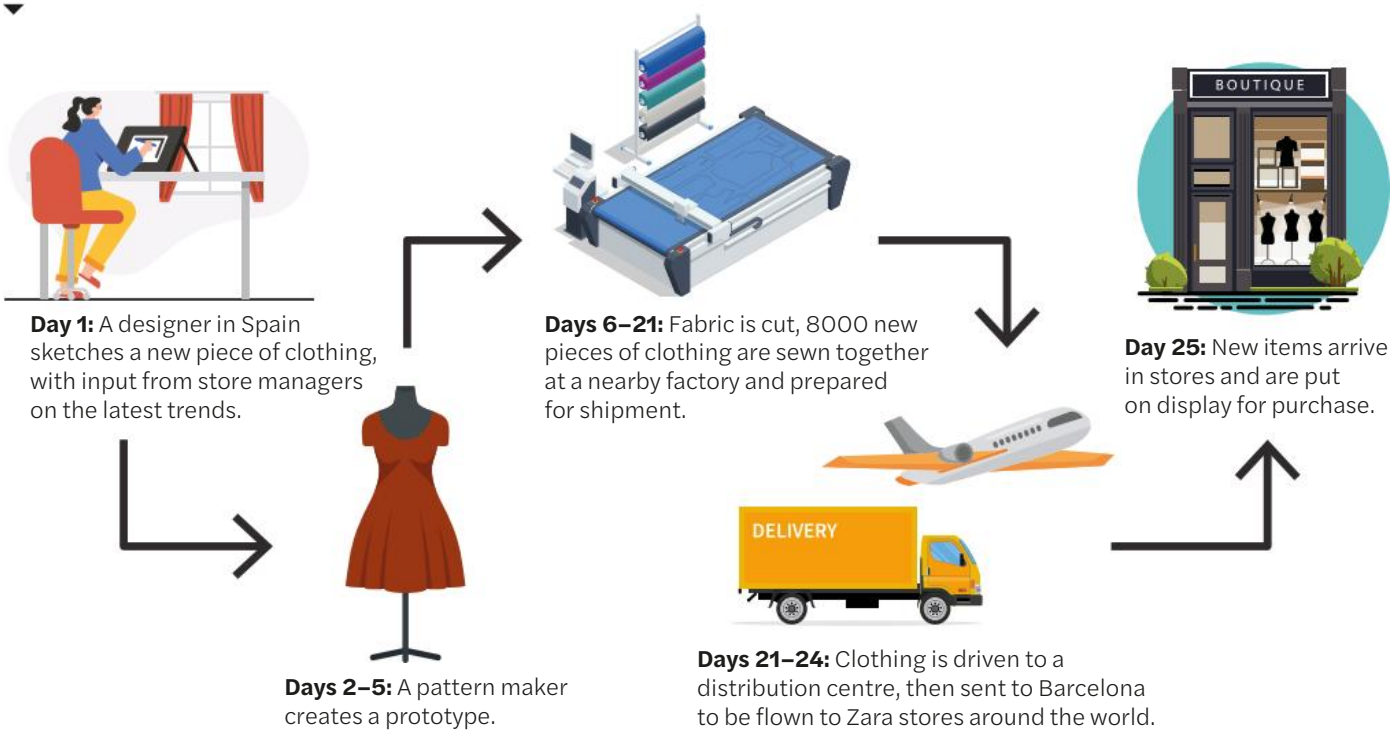
The supply chain

Approximately 100 billion new garments are produced each year by 75 million people working in industries that include fashion design, agriculture, textile and garment manufacturing, retailing, transport and end-of-life 'fashion waste' disposal. This is a linear supply chain in which raw materials become textiles and clothing that is worn until it is no longer wanted and is then disposed of.

A typical supply chain consists of several stages and can take several months to complete.

- **Design** usually occurs in large cities in developed countries where the headquarters of clothing and fashion retailers are located and where fashion trends often develop. Paris, Milan and New York are historical centres of fashion design.
- **Textiles, fibres and fabrics** are the raw materials used to make clothing, such as fibres or skins, and include fibres such as wool and cotton; animal skins to make leather; and artificial fibres such as polyester to make fabrics, trims, buttons and zippers. Textile mills are often located close to the source of raw materials such as northern England's sheep-raising regions and India's cotton farms.

Source 1: Supply chain of fast-fashion retailer Zara



Day 1: A designer in Spain sketches a new piece of clothing, with input from store managers on the latest trends.

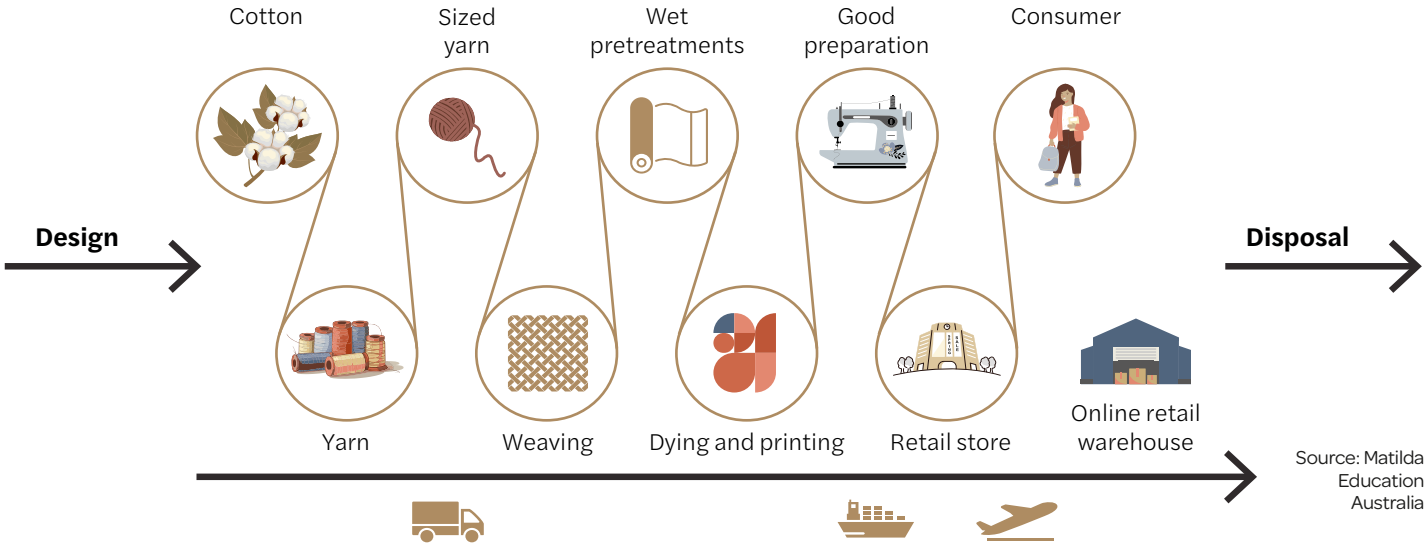
Days 2–5: A pattern maker creates a prototype.

Days 6–21: Fabric is cut, 8000 new pieces of clothing are sewn together at a nearby factory and prepared for shipment.

Days 21–24: Clothing is driven to a distribution centre, then sent to Barcelona to be flown to Zara stores around the world.

Day 25: New items arrive in stores and are put on display for purchase.

Source: Matilda Education Australia



Source: Matilda Education Australia

Source 2: Typical supply chain for the fashion industry

- **Garment manufacturing** creates clothing in factories located in low-cost locations in Asia, such as China and Bangladesh. Finished garments are transported long distances by sea or plane to retailers. Most nations produce some clothing locally, such as Spain, Italy and Australia; however, many businesses have moved overseas to reduce costs and increase profits.
- **Retailing** is the selling of clothing and fashion to the public, either instore or online. Big brands have 'flagship' stores or sell through retailers such as Kmart and David Jones. H&M and Uniqlo are fast-fashion retailers using stores and online retailing, whereas Shein sells only online.
- **End of life** is when we no longer want an item and dispose if it through the garbage system, donations to charities or resale. Most however ends up in landfill sites or is sent overseas.

All clothing has connections to other places and the people involved in the supply chain.

Source 3: Workers in garment factories in Bangladesh work long hours for low pay, sometimes in unpleasant or unsafe conditions.

Learning ladder 10.13

Processes that transform people, places and environments

1. Identify the key processes in a fashion supply chain.
2. What features of fast fashion make it different from typical clothing production?
3. Explain why the fashion supply chain is considered linear.
4. Why is most fashion produced in Asia and exported to the world?
5. Compare the retailing approaches of Zara and Shein.

Interconnection

1. Clothing consumers are linked to other places. What does this mean?
2. Describe one factor influencing the location of clothing manufacturing.
3. Create a world map to show all of the places named in the supply chain description. Colour code them according to their stage in the supply chain.
4. Suggest a link between fast fashion and the increased disposal of used clothing.
5. Assess the role of transport connections in the fashion supply chain.

HOW TO Interconnection, page 392

What are the impacts of clothing production?

The garment industry satisfies the human need for clothing and creates employment and a livelihood for millions of people worldwide. Negative environmental and social impacts, however, have given the industry a reputation for being highly unsustainable.

Overproduction, overconsumption and waste

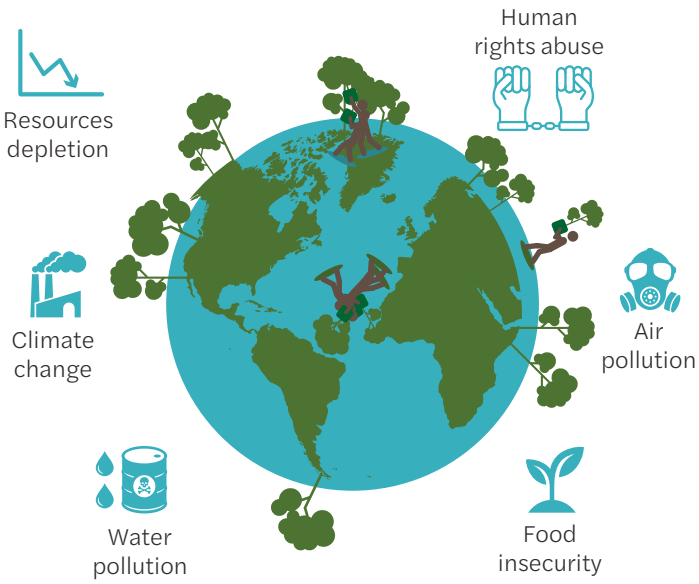
More clothes are being produced, consumed and wasted each year than ever before.

- Global garment production doubled between 2012 and 2022.
- Compared to 2019, 25 per cent more clothes were purchased in 2022, and 98 per cent of these were used for 50 per cent less time.
- On average, Australians consume 56 new items per person each year and only wear each item seven times.
- Each year, 92 million tonnes of clothing and textile waste is produced globally.
- Only 1 per cent of unwanted clothing is recycled into new garments – most goes to landfill.
- Wealthier countries export unwanted garments to poor countries as charity, but most of this is not useable clothing, leaving places such as Ghana and Chile with mountains of waste to deal with.

The fast-fashion industry has created a society that sees clothing as disposable and easily replaced with cheap, poor-quality and mostly synthetic garments not designed to last. The Ellen Macarthur Foundation, a charity committed to eliminating fashion waste and pollution, estimates that a garbage truck of textiles is burned or buried somewhere every second.

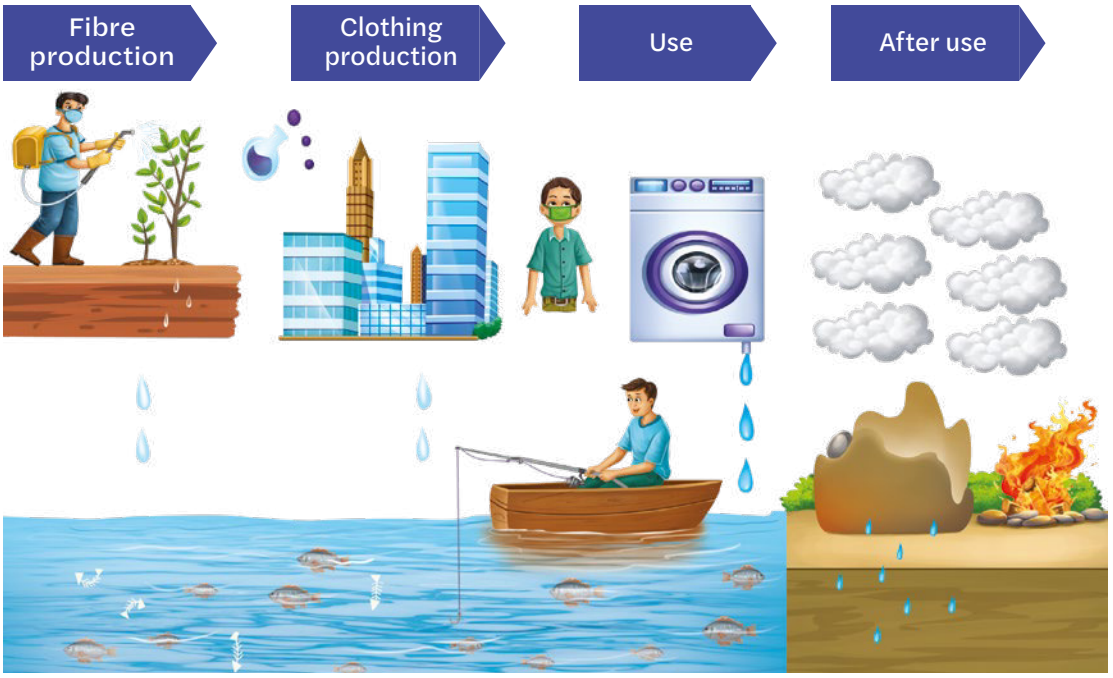
Environmental footprint

Large amounts of raw materials such as water and energy are used to produce clothes. Water is used for irrigation to produce fibres and in factories to dye fabrics and wash textiles. There is a high use of chemicals to produce synthetic textiles, dyes and fertilisers. Wastewater from farms and factories pollutes waterways. Garments in landfill sites leach chemicals into waterways; in countries dealing with dumped clothes, these are burned releasing toxic chemicals into the atmosphere where they are a health issue. The washing of synthetic materials releases microplastics into the environment that impact marine ecosystems and human health. Many factories are operated using energy from fossil fuels and release high levels of carbon dioxide into the atmosphere. The fashion industry is said to contribute up to 10 per cent of all global carbon emissions, a figure predicted to increase to 26 per cent by 2050.



Source 1: Negative impacts of the fashion industry

- Cotton requires a minimum of 10 000 litres of water to produce one kilogram of fibre, and competes with food production for limited water supplies.
- A cotton shirt requires approximately 2500 litres of water, and a pair of jeans around 7000–10 000 litres, from fibre production to the finished garment.
- Around 43 million tonnes of chemicals and 15 000 different chemicals are used across the fashion supply chain each year.
- The energy used in mills, factories and transport emits 1.2 billion tonnes of carbon dioxide.



Source 2: Environmental impacts of the clothing and fashion industry

Human impacts

For many workers in poorer countries, employment in the fashion industry has helped them out of poverty. However, they are mostly paid extremely low wages and forced to work long hours in poor and unsafe conditions. Throughout Asia, including China, Bangladesh, Vietnam, Indonesia, and some European countries, workers do not receive a living wage, the amount needed to cover the basic costs to live a decent life, which is considered a human right. They lack personal protective equipment such as masks and proper ventilation, and are exposed to chemicals that can have negative health effects and even cause cancer. Efforts to improve the working conditions of textile and garment workers globally has been and fragmented. Workers have taken to protesting for better pay and working conditions.

Source 3: Workers in Bangladesh protesting for better working conditions in 2020

Learning ladder 10.14

Processes that transform people, places and environments

1. Write statements to show your understanding of the terms 'overproduction' and 'overconsumption'.
2. What is the cause of the increased amount of global fashion waste?
3. Source 1: Use evidence to explain each of the negative impacts illustrated.
4. Source 2: Create a paragraph that explains the ideas expressed. Refer to each section of the illustration in your response.
5. Assess the role of fast fashion in contributing to the negative impacts of the clothing industry.

Sustainability

1. Identify facts about the clothing industry that support the argument that it is unsustainable.
2. How does the clothing industry fail to look after people and the planet?
3. Suggest ways to address three unsustainable features of the clothing industry.
4. Propose a campaign to educate the public about the impact of fashion waste on countries such as Ghana and Chile. Conduct additional research to assist with your campaign.

HOW TO

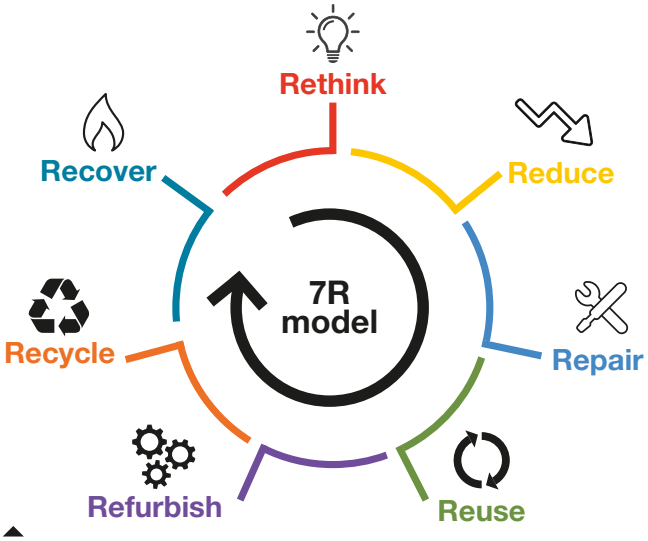
Sutainability, page 400

How can the clothing industry be made more sustainable?

To address the challenge of sustainability in the clothing industry, improvements can be made at every stage of the supply chain and with an industry–wide focus on the efficient use of natural resources, waste reduction and the fair treatment of workers.

Changes in the supply chain

The 7R model in Source 1 can be applied throughout the clothing supply chain to improve sustainability.



Source 1: The 7R model for sustainability

Production of raw materials

- Water-efficient agriculture such as drip irrigation and using climate-adapted species of plants and animals that require less water will reduce the water footprint.
- Organic production without the use of chemicals such as pesticides, herbicides and fertilisers will reduce the impact of waste water on the environment.
- Regenerative agriculture limits resource use and restores nature.

Designing fashion

- Design clothing for reuse or that can be easily disassembled, trims removed and all components reused will reduce waste.
- Design to re-create existing styles and fabrics and for longevity will mean clothing lasts for years, not months.
- Use natural fabrics and fibres that decompose in landfill sites and do not generate plastic microfibres.
- Incorporate recycled fibres into new products.

Textile and clothing manufacturing

- Reduce water use and carbon dioxide emissions by recycling using renewable energy sources.
- Establish factories closer to markets to reduce transportation costs and carbon dioxide emissions.
- Use just-in-time production to reduce stockpiles of unsold clothing.
- Use new technologies such as digital pattern layout and laser cutting to minimise waste.
- Pay workers a living wage and implement safe working conditions.

Retailing

- Reduce the inventory kept instore to reduce unsold ‘waste’.
- Recycle past purchases for resale and a discount off new clothing.
- Provide a welcoming customer experience that encourages instore shopping over online to reduce the return rate of unwanted clothes that add to costs, carbon dioxide emissions and landfill.
- Offer alternative models such as renting, subscriptions, repair and renovation services.
- Avoid the rapid turnover of new styles.

The consumers and 'end of life'

- Purchase clothes that last and are made of biodegradable/natural materials and keep them for longer.
- Consider sustainable options when disposing of unwanted or 'end of life' clothing.

In a whole-of-industry approach to sustainability, a closed loop or circular system is focused on the clothing produced today becoming the raw materials for future garment production to minimise waste and benefit the environment.

The fast-fashion dilemma

Many of the strategies that could improve the sustainability of the clothing industry go against the business model of fast fashion, where the aim is to produce more, sell cheaply and introduce new styles as often as possible to increase the profits of large corporations that control fashion labels. While access to cheap clothing benefits consumers, particularly those on low incomes, this needs to be weighed against the impacts of the industry. A change in perspective that convinces people to buy higher quality clothes that last longer, but fewer items, is the basis of the growing 'slow fashion' movement, a response to the impacts of fast fashion.

Positive change

There is growing demand for resale, rental and repair. Retailers such as H&M and Uniqlo are offering repairs services and recycling bins. The State of Fashion report in 2023 predicted the growth in revenue from resale at 11 times faster than global retail sales by 2025, and secondhand clothing is on track to reach 10 per cent of total fashion sales. Technology is improving processes that recycle natural and synthetic fibres from used clothing, and developing new biodegradable fabrics out of natural substances such as algae.

▲ **Source 3:** What does sustainable fashion look like?

Source 2: Swapping clothes and goods instead of buying new things can help reduce waste.

Learning ladder 10.15

Processes that transform people, places and environments

1. State three focus areas for more sustainable clothing production.
2. Describe two ways agriculture can reduce its impact on the sustainable production of clothes.
3. Why is reducing carbon dioxide emissions and water footprints important for the environment?
4. Explain how waste and wastewater impact the environment.
5. Assess the role of consumers in influencing the future of the clothing industry.

Sustainability

1. Source 3: Identify environmental, social and economic factors in the vision of sustainable clothing shown in this image.
2. Source 1:
   - **a** Identify stages in the fashion supply chain where each of the 7Rs could be used to enhance sustainability.
   - **b** Explain why there is no reference to waste in the model?
3. Why is fast fashion an obstacle to achieving sustainability?
4. Source 3: Explain the economic, social and environmental benefits of sustainable fashion.
5. Source 2: Create a campaign for a school fashion swap party. Include where, when and why.

HOW TO

Sutainability, page 400

How does the production of mobile phones connect the world?

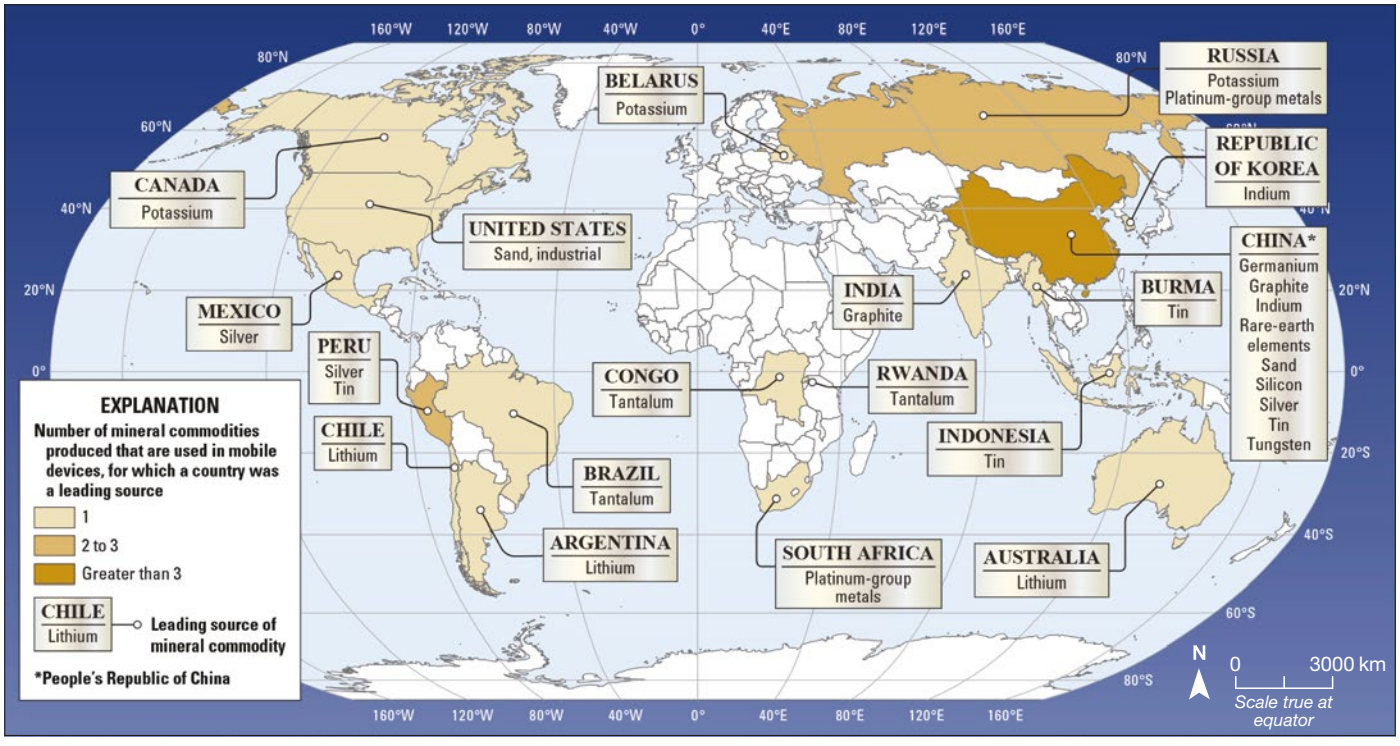
Today 60 per cent of the world's population own a mobile phone. To produce each mobile phone, hundreds of countries are connected in a global supply chain where goods (e.g. raw materials) and services (e.g. manufacturing and assembly) are traded.

Connection through the supply chain

Components in a typical mobile phone supply chain come from all across the world:

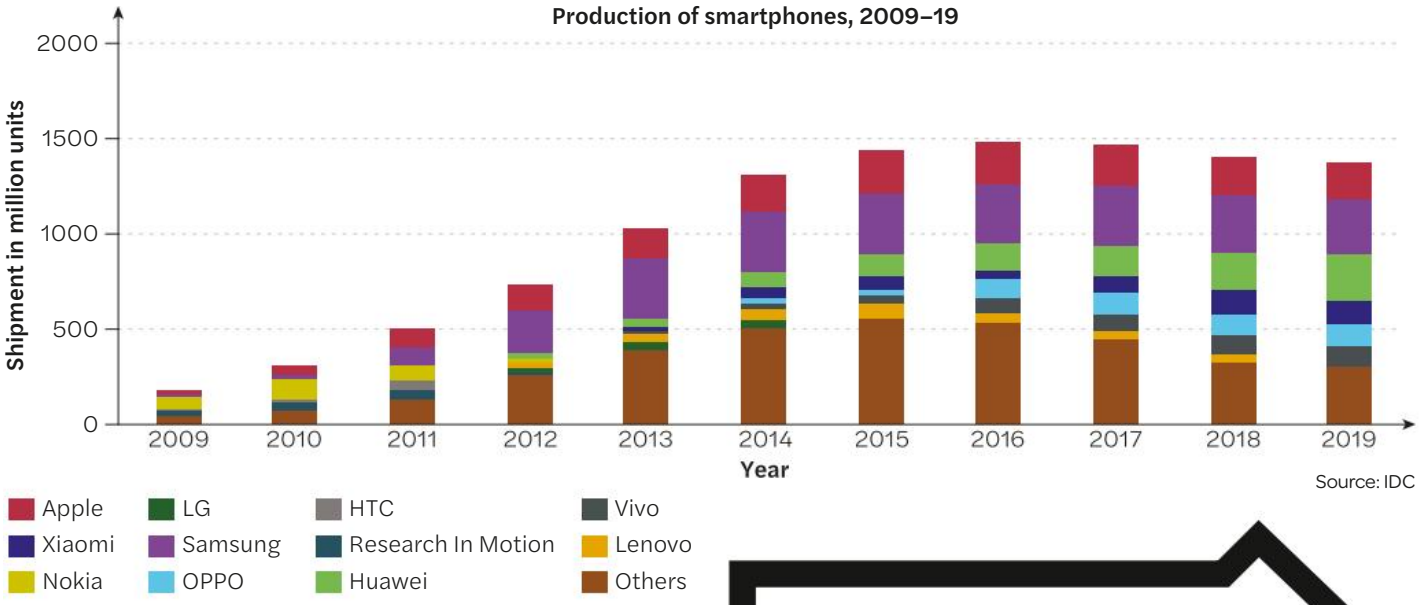
- **Extraction of raw materials:** Mobile phones contain various metals and minerals (see Source 1). These are mined in countries like China, the Democratic Republic of Congo and Australia.
- **Manufacturing of components:** Raw materials are exported to countries with strong technology sectors, such as South Korea, Japan and Taiwan. Here the materials are processed and manufactured into phone components; such as circuit boards, liquid crystal displays (LCD), speakers, batteries and cameras.
- **Assembly:** Individual components are imported to countries with low labour costs, such as China and Vietnam, to be assembled to make each mobile phone.
- **Design and marketing:** Major mobile phone companies often design their products, marketing and labelling from their headquarters.

Leading sources of mineral commodities used in mobile devices



Source: USGS

Source 1: An image displaying the different minerals used in smartphones and some of the main places these minerals are sourced around the world.



Source 2: A composite bar graph displaying the number of smartphones shipped by leading companies in the world each year.

These are usually located in major cities or technological hubs, such as Silicon Valley in California. In these headquarters, decisions about the supply chain are made and negotiations are made with various countries to establish the supply chain.

- **Distribution and retail:** The assembled phones are packaged and exported to various countries to be sold in retail stores. Major markets include the United States, Europe and, increasingly, India.

There are approximately 94 production lines and 400 steps to assemble a typical smartphone. Each stage of the supply chain impacts and connects various economies around the world, often becoming interdependent (reliant on one another). For example, if a raw material cannot be sourced or there is a delay in transporting it, other countries will be unable to manufacture components or assemble the phone. This will impact them economically and reduce employment opportunities.

Connection through consumption

Mobile phones enable global connectivity, linking people around the world instantaneously. They enable instant communication through phone calls, messaging and social media platforms like Instagram and TikTok. Mobile phones also connect to the internet, enabling people to access information, educational content and global news. Further, the development of apps has enabled people to engage in more global economic activities, such as banking, shopping and entertainment. This further connects people and places, promoting trade of goods and services between places.

Learning ladder 10.16

Processes that transform people, places and environments

1. Identify one place involved at each stage of the mobile phone supply chain.
2. Describe how the extraction of raw materials for mobile phones can impact the countries involved.
3. Source 2: Explain changes in the shipment of mobile phones since 2009.
4. Discuss how disruptions in the supply of raw materials can impact other countries involved in the manufacturing and assembly stages.
5. China is involved in many steps of the supply chain, from mining resources to manufacturing and assembling phones and their components. What are the global impacts of this regionalisation?

Interconnection

1. Draw a map or flowchart of the mobile phone supply chain to show how it connects places.
2. Identify how the extraction and exportation of raw materials connect different countries economically.
3. Explain how assembly countries depend on the component-manufacturing countries in the mobile phone supply chain.
4. Describe the impact on global markets if there is a delay in manufacturing components for mobile phones.
5. How does the widespread use of mobile phones for communication and economic activities illustrate the concept of global interconnection?

HOW TO
Interconnection, page 392

How do mobile phones impact people and places?

Mobile phones are designed to become outdated quickly or have a limited life span, a strategy employed by businesses called planned obsolescence. This encourages consumers to buy new products, in this case new mobile phones, more frequently. As a result, over 26 billion mobile phones have been sold worldwide since 2009, even though only 60 per cent of the 8 billion people in the world use them. This increases the demand for mined raw materials to produce more mobile phones, further depleting these resources and contributing to the growing issue of electronic waste. Approximately 54 million tonnes of e-waste are produced globally each year. This waste is chemically hazardous, polluting natural environments and water bodies.

Environmental impacts

Each mobile phone requires a significant amount of the Earth's finite metals and minerals (see Source 1). Mining these raw materials depletes the Earth's natural resources, and the construction of mines requires extensive deforestation, land degradation and habitat destruction. Further, excess waste produced during the mining process is released into natural environments. As seen in inner Mongolia (see Source 2), black sludge and toxic by-products from mines are dumped into local water bodies, contributing to soil and water contamination, toxic lakes and contaminated farmlands. In areas surrounding these mines, biodiversity has rapidly decreased, plants are not able to grow, and local communities have experienced increased respiratory illnesses and cancers. The infrastructure and machinery required to extract these minerals and transport them to other countries for manufacturing also emits large amounts of greenhouse gases, about 146 million tonnes of carbon dioxide each year, contributing to global warming (see Source 3).

Social and cultural impacts

The mobile phone supply chain spans many countries with different laws and regulations, resulting in uneven working conditions and workers' rights across the supply chain. Some countries have been found to implement unethical labour practices, including providing poor working conditions, unfair wages and in some cases, child and forced labour.

Source 1: The breakdown of minerals and metals used to produce a mobile phone

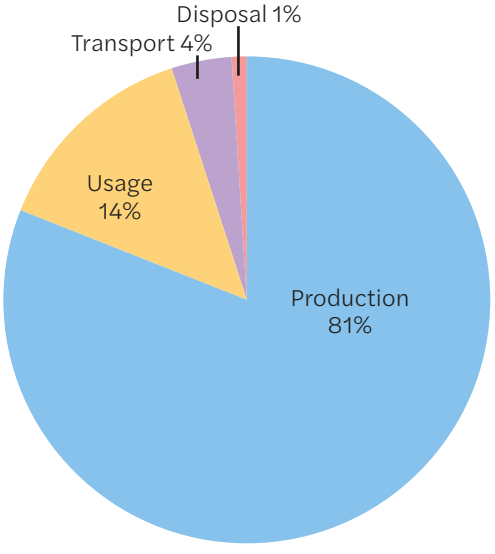
Source: The European Economic and Social Committee

Source 2: A photograph of polluted water being poured from a rare-earth smelting plant into a lake in inner Mongolia

In 2019, human rights lawyers launched a legal case against various technology companies alleging they provided unsafe working conditions that led to the death of children working in the Democratic Republic of Congo cobalt mines. And in 2017, 90 workers in a Taiwan mobile phone manufacturer were hospitalised due to toxic gas poisoning.

The complex nature of the supply chains also contributes to possible corruption by rebel groups or unethical corporations. This was seen with technology companies purchasing gold from an Italian refiner who had illegally procured it from 'wildcat miners' in 2019. These are groups that illegally mine materials without any regulations, who are responsible for excessive deforestation in the Amazon Rainforest and were found to have poisoned the Amazon River with mercury. Some mobile phone companies in the United States, European Union and China have implemented regulations on their supply chains to prevent profits from these industries being used to fund armed groups in the Democratic Republic of Congo.

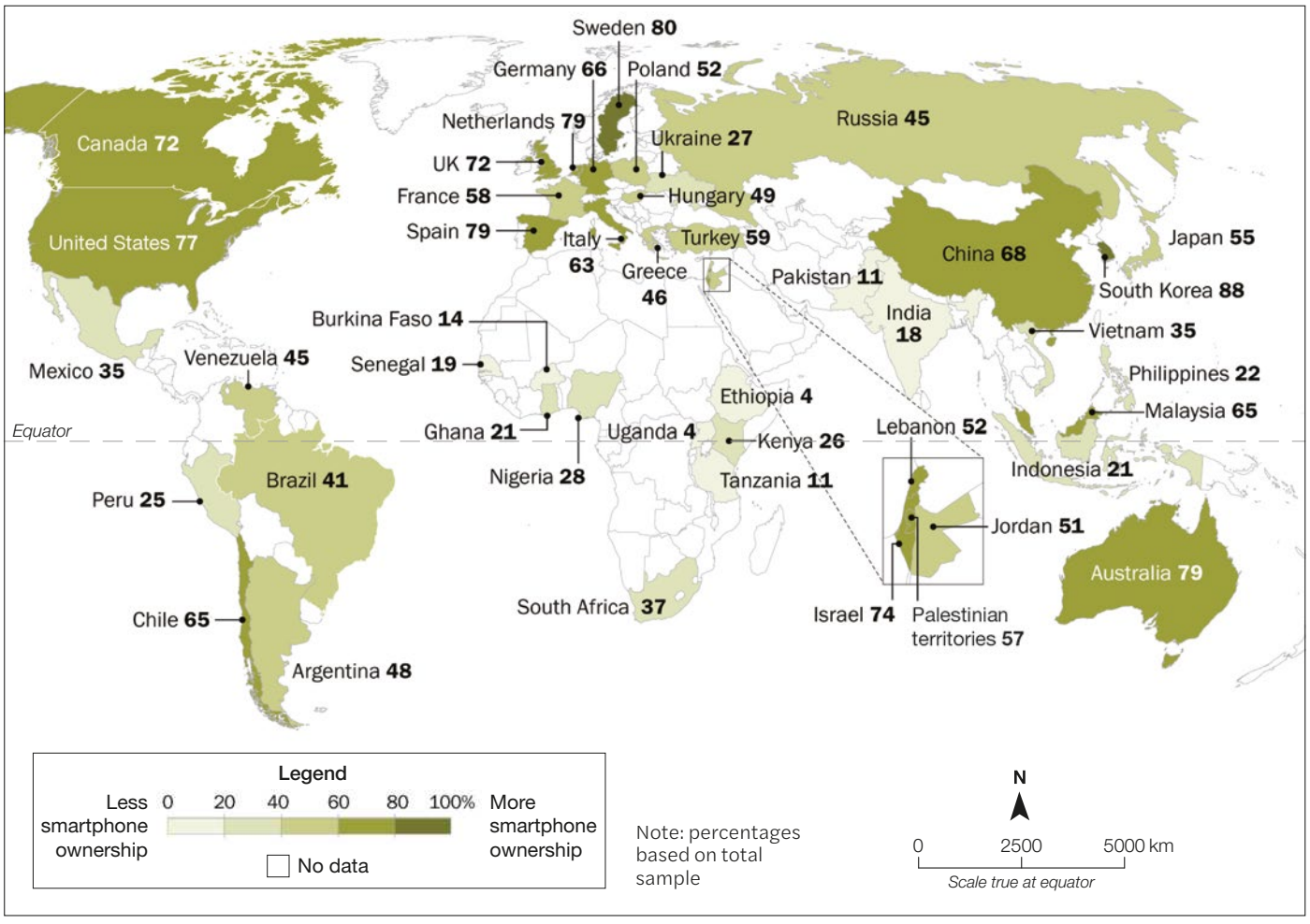
Greenhouse gas emissions from a mobile phone over 22 months



Source 3: A graph displaying the average greenhouse gas emissions from a device over 22 months

Source: The European Economic and Social Committee

Smartphones are more common in Europe, United States, less so in developing countries
Percentage of adults who report owning a smartphone



Source: Spring 2015 and 2016 Global Attitudes surveys

Source 4: A choropleth map of the percentage of a population with a smartphone. Darker green countries indicate a higher population with smartphones, with these tending to be more economically developed countries.

The use of mobile phones is also increasing people's dependency on digital connection, seen with the average smartphone user checking their device 47 times per day. This is changing social interactions as people engage in less face-to-face communication and become more dependent on immediate telecommunication responses. Mobile phones have also increased global connections through social media platforms, promoting more cross-cultural interactions and global communication. While increased connectivity can foster inclusivity and understanding among diverse groups, it can also lead to the spread of misinformation and reduce deep, meaningful personal interactions.

Positively, the consumption of mobile phones is supporting many countries with achieving their Sustainable Development Goals (SDGs). These are 17 goals established by the United Nations to provide people around the world with improved living conditions and human rights. Apps produced on smartphones are making it easier for governments and community organisations to implement strategies to achieve the SDGs. For example, the 250 000-plus education apps on smartphones have enabled 1.2 billion people to improve their education, including those who live remotely. Many non-government organisations (NGOs) have used mobile phones to provide humanitarian assistance, seen with AT&T's drone-based 'cells on wings', which improves connectivity during natural disasters and makes it easier and cheaper for people to call emergency services and access aid.

Source 5: In the district of Szibira, South Kivu, in the Democratic Republic of Congo, people struggle to earn a living by mining cassiterite and coltan, minerals used in mobile phones. Some countries along the mobile phone supply chain have less strict working regulations, leading to unfair wages, poor work conditions and forced labour.

Economic impacts

The mobile phone industry contributes significantly to economic growth, generating approximately AU$6.5 trillion globally each year. Over 12 million jobs are created worldwide across the supply chain in manufacturing, app development, telecommunications and retail. Mobile phones have also stimulated sectors like digital marketing and e-commerce, increasing access to employment in many fields and contributing to a more interconnected global economy.

However, the interconnected nature of the supply chain means shortages in manufacturing or raw materials in one place can cause economic impacts on other places. After the COVID-19 pandemic, many semiconductor manufacturing plants in China closed due to poor sales. This led to increased pressure for manufacturers in Taiwan to produce enough semiconductors and graphics cards for cars, phones and gaming consoles across the world. The slow supply of these components slowed down the mobile phone supply chain, impacting workers and companies in assembly plants, transportation networks and retail stores.

Learning ladder 10.17

Processes that form and transform places and environments

1. Describe one environmental impact of producing mobile phones.
2. Source 1: Referring to specific materials used in mobile phones, describe the environmental impacts when mobile phones end up as electronic waste.
3. Explain the relationship between planned obsolescence in mobile phones and the demand for raw materials.
4. Compare the social, economic and environmental impacts of mobile phone production on places.
5. Analyse how the entire life cycle of a mobile phone, from raw material extraction to disposal, transforms both local and global environments.

Change

1. Source 2: Describe the changes in one local environment due to the production of mobile phones.
2. Explain how impacts on the global production of mobile phones can affect local economies.
3. Source 5: Analyse the social impact of the mobile phone supply chain in the Democratic Republic of Congo.
4. Evaluate the impact of technological advancements in mobile phones on societal change, particularly in education and emergency response situations.
5. Design one strategy that can be employed in a mobile phone supply chain to improve its social, economic or environmental impact.

HOW TO Change, page 394

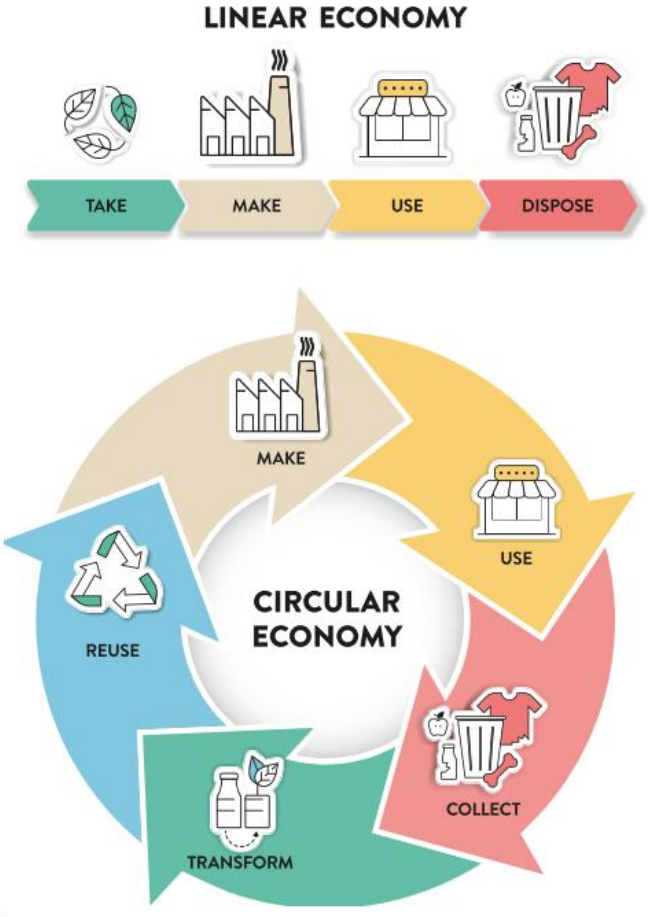
How can we improve the sustainability of mobile phone production?

Changing the way mobile phones are managed once they are no longer used can improve the sustainability of this industry. Currently only 17 per cent of retired mobile phones are recycled, with most people choosing to keep and stockpile old phones because they have security concerns about the data left on their devices or are unsure how or where to recycle them. More than 30 metals and minerals in phones are rare earth elements that are finite and depleting in quantities. As an example, the metal indium is vital for touchscreens and is also being increasingly used in solar panels. Over 1 kilogram of ore needs to be mined in order to extract a few milligrams of indium. As technology develops, this resource is being extracted at a faster rate every year, and is predicted to become depleted within the next 100 years.

How can a circular economy help?

Changing the production of mobile phones to be a circular economy can improve the reuse of these materials. A circular economy is one where manufacturers plan for products to be recyclable, repairable, reused or refurbished at the end of their life cycle. This is different from the current linear model, where products are made along a supply chain and end with the consumer throwing them away. They do this by:

- designing products to be fully recyclable
- providing upgrade and maintenance services to repair phones when needed, extending the life of phones
- increasing the durability of products so they have a longer life
- manufacturing products to be purposely reused later
- planning to redirect mobile phones and their materials back to the supply chain
- implementing infrastructure and initiatives for consumers to redirect mobile phones back to the manufacturer so the materials can be reused or for other technologies.



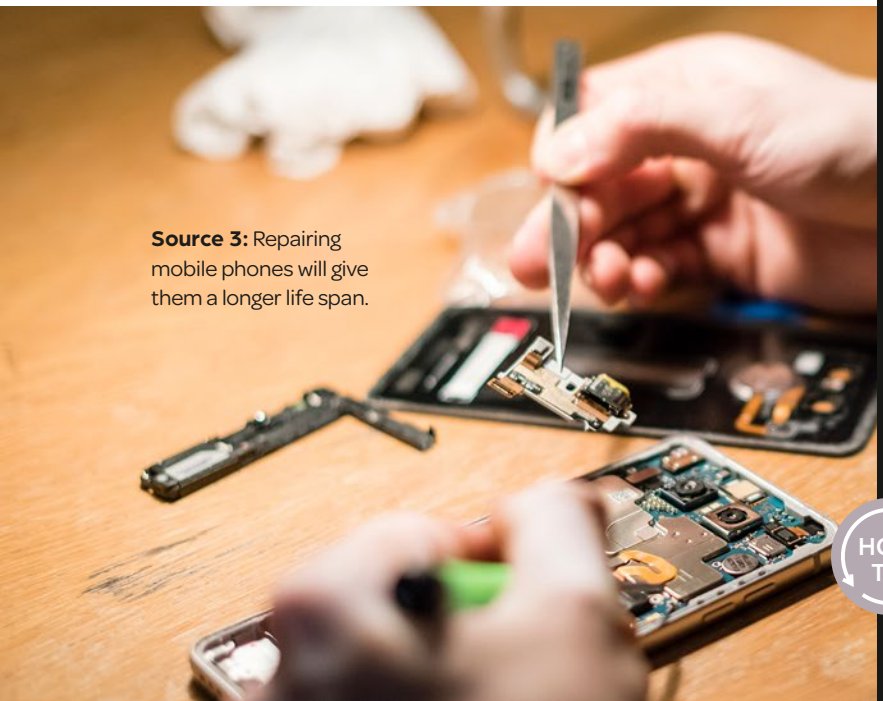
Source 1: This diagram shows the difference between a linear economy and circular economy model. A circular economy model focuses on collecting products, such as phones, and recycling back to the manufacturer so that resources can be extracted and reused.

Benefits

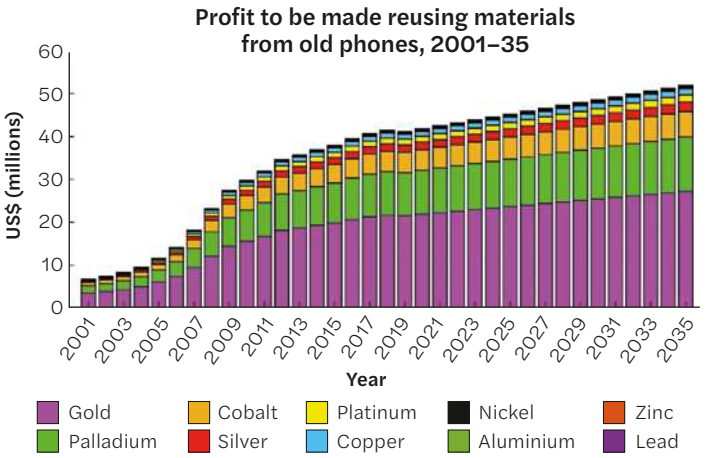
Achieving a circular economy can prevent rare resources used in phones from becoming over-mined, reduce the amount of e-waste ending in landfills, and decrease the environmental impacts of phone production. More jobs become available through the recycling and refurbishing of these products, and manufacturers can save money by extracting resources in countries where components are manufactured instead of paying for them to be mined and transported. More than 60 per cent of consumers have said they would be willing to change their phone manufacturing company if they knew another one had more sustainable production methods, indicating that businesses would benefit from implementing a circular economy.

Challenges and perspectives

The global nature of the mobile phone supply chain provides challenges for implementing a circular economy. It would require phone manufacturing companies to work with governments and communities to develop the infrastructure and processes to make it work. This would include developing processes for consumers around the world to deposit their phones in recycling centres, paying for the labour to have resources extracted from the technologies and then transporting those materials to assembly plants for reuse. This large-scale operation would be costly and difficult to manage, and would require investments and cooperation by governments and consumers. Businesses may find the global nature of this process too complex and expensive. Countries that rely on the mining industry for their exports would also be disadvantaged, as it would reduce demand for their products and impact local economies and employment.



Source 3: Repairing mobile phones will give them a longer life span.



▲ **Source 2:** This graph shows the potential profit to be made by reusing waste materials from old phones.

Source: Ozsut Bogar & Gungor, 2023

Learning ladder 10.18

Perspectives of people and organisations

1. Why might consumers choose to keep old mobile phones rather than recycle them?
2. What are the positive and negative perspectives phone manufacturers might have of implementing a circular economy?
3. How might the perspective of a mobile phone manufacturer differ from that of a consumer regarding the implementation of a circular economy?
4. Explain how the perspectives of countries reliant on mining might oppose the transition to a circular economy in mobile phone production.
5. Discuss the potential conflicts of interest between governments, manufacturers and local communities in establishing a circular economy for mobile phones.

Sustainability

1. Describe what a circular economy is.
2. How does increasing the durability and recyclability of mobile phones promote sustainability?
3. Explain the environmental benefits of transitioning from a linear to a circular economic model in mobile phone manufacturing.
4. Analyse how the circular economic model can influence social, economic and environmental sustainability.
5. Design a campaign targeting consumers that explains how they can improve sustainability in the mobile phone industry.

HOW TO

Sustainability, page 400

10.19

Thinking geographically

Interconnections and trade

Geographical concepts, inquiry and tools

Place, space, change, interconnection, different types of maps and a composite graph

Learning ladder: page 340

See **Geo How-To** for types of maps Page 406

Key inquiry question

How does the rise of lab-grown diamonds impact communities and environments in central and southern Africa?

In a written or oral report, use the knowledge and understanding developed in the activities below to answer the inquiry question. Include the following:

- the spatial patterns of where mined and lab-grown diamonds are produced
- the spatial patterns of where diamonds are consumed
- the environmental, sociocultural and economic impacts of changes to diamond production and consumption
- perspectives of the changes to diamond production and consumption by different stakeholders
- one sketch map or simple diagram.

Where possible, refer to the sources in this spread to support your judgements.

The rise of lab-grown diamonds

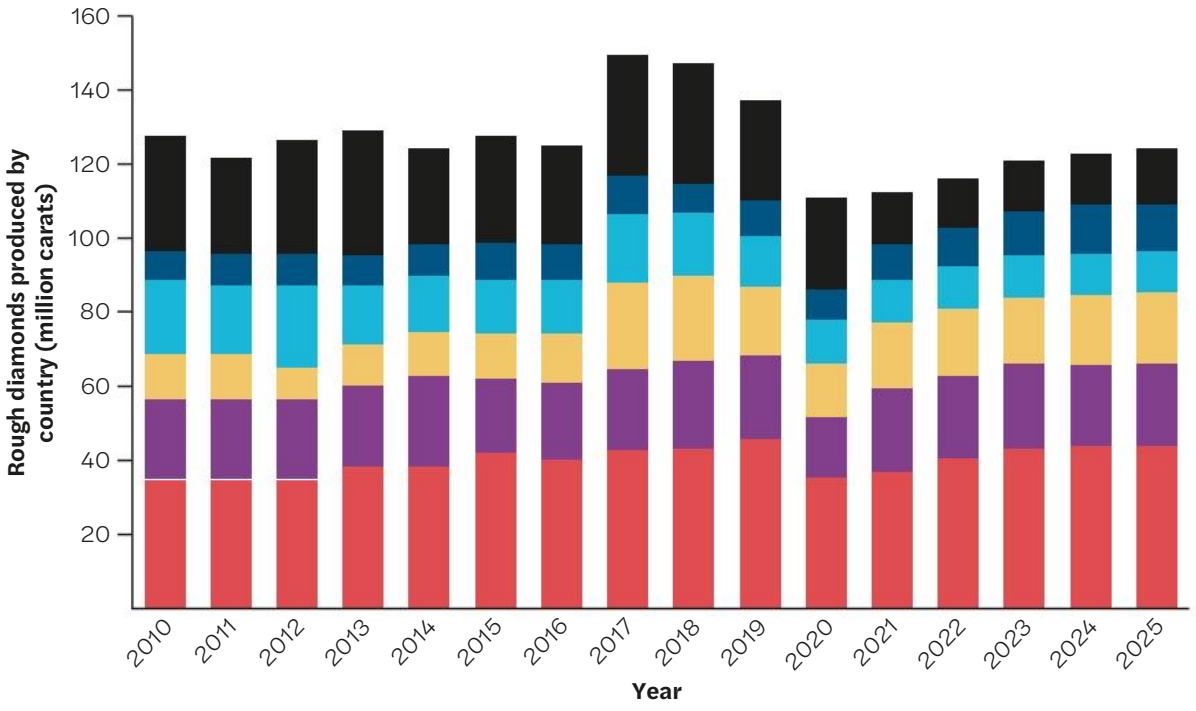
Natural diamonds are formed over millions of years deep within the Earth's mantle under extreme heat and pressure, while lab-grown diamonds are created in a laboratory where scientists replicate these conditions. Advances in lab-grown diamond technology have made production faster and cheaper, with costs dropping from $4000 per carat in 2008 to as low as $300 to $500 today. Many consumers, especially Millennials and Generation Z, prefer lab-grown diamonds due to their lower environmental impact and ethical advantages. For example, mined diamonds require shifting 250 tonnes of Earth per carat and produce around 57 kilograms of carbon emissions, while lab-grown diamonds, especially when produced using renewable energy, generate significantly fewer emissions. Mining also contributes to habitat destruction, water pollution and social issues like child labour. The shift towards lab-grown diamonds is reshaping the industry, leading to reduced demand for mined diamonds and forcing major producers, such as De Beers, to reduce prices and production. However, mined diamonds are still regarded as rarer and more valuable, with many people considering them more desirable than lab-grown diamonds.

Source 1 activities

1. Identify one benefit of lab-grown diamonds.
2. Describe one difference between natural and lab-grown diamonds.
3. Explain two different perspectives on the changes to diamond production.
4. Analyse the environmental and social impacts of changes to diamond production.
5. Predict the future changes to diamond production and consumption.

Source 1: The increasing consumption of lab-grown diamonds

Rough diamonds



Source 2: A composite bar graph showing the million carats of diamonds produced by countries between 2010 and 2025

Source: GlobalData

Source 2 activities

1 How many million carats of natural diamonds were produced by:
   - **a** Russia in 2020
   - **b** Botswana in 2022
   - **c** DRC and Angola combined in 2023
   - **d** African countries in 2012.

2 Describe the changes in the amount of diamonds produced in the DRC between 2010 and 2025.

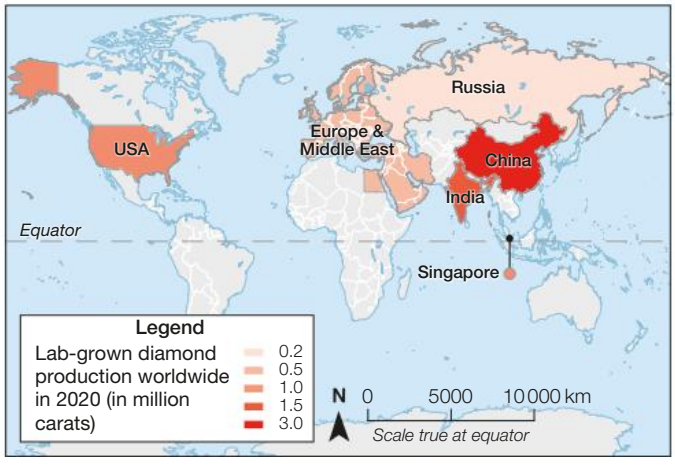
3 Explain the factors that could have contributed to the decrease of diamond production in 2020.

4 Which country reduced the million carats of diamonds they produced the most between 2015 and 2025?

5 Calculate the percentage of mined diamonds produced by:
   - **a** Russia in 2017
   - **b** 'Other' countries in 2018
   - **c** Botswana, DRC and Angola in 2021.

Where are lab-grown diamonds produced?

Locations where diamonds are grown in labs



Source: Matilda Education Australia

Source 3 activities

1 Identify which country produces the most-lab grown diamonds in the world.

2 Calculate the percentage of lab-grown diamonds produced by:
   - **a** the United States **b** India **c** China.

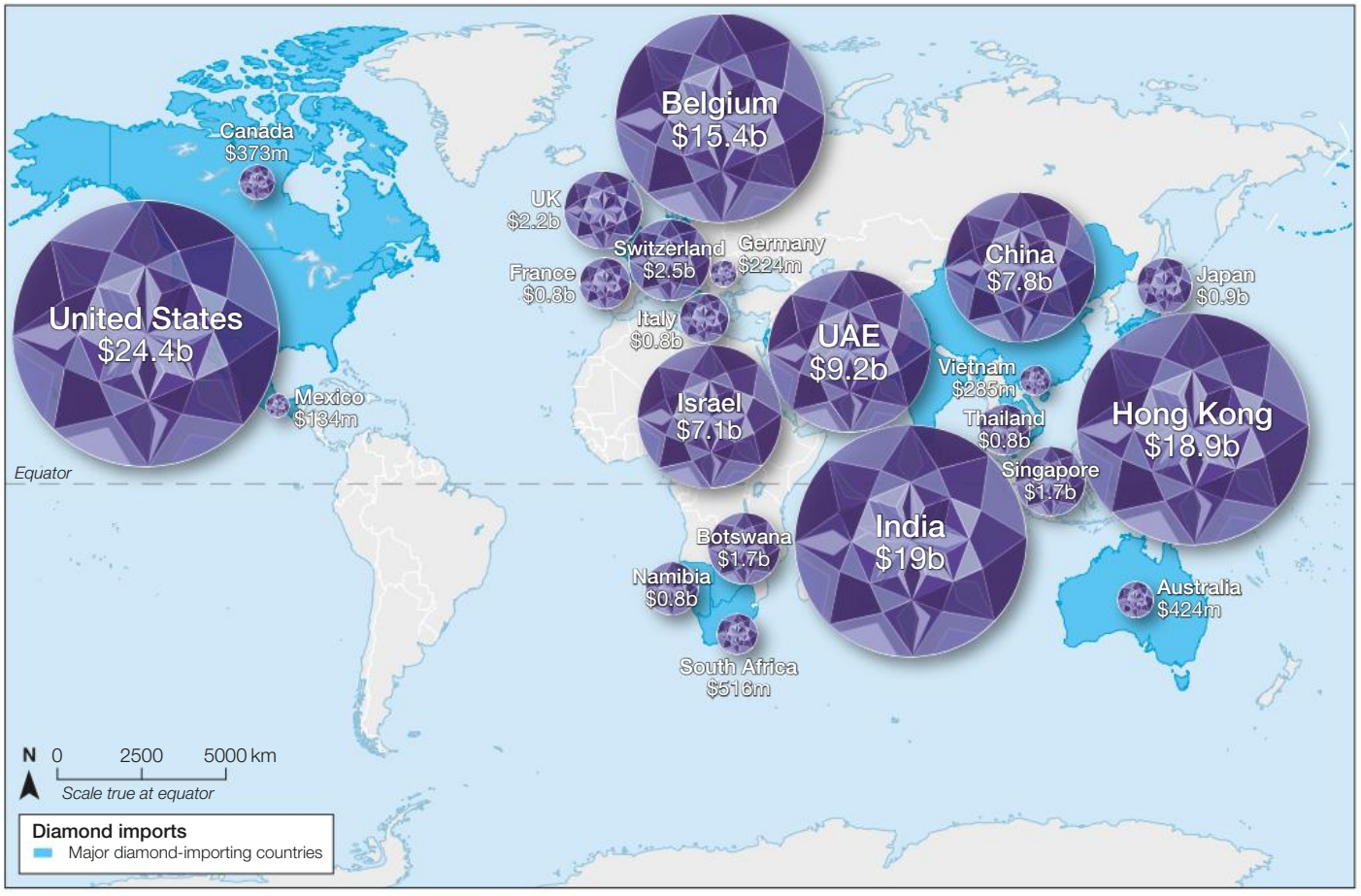
3 Compare Source 2 and 3. Explain the differences in the nature of the countries that mine diamonds and the countries that produce lab-grown diamonds.

4 Producing lab-grown diamonds requires extensive technologies. Predict the countries that could invest in this industry in the future.

Source 3: A map highlighting the places where lab-grown diamonds are produced

Diamond imports

Major diamond-importing countries



Source: Matilda Education Australia/World's Top Exports

▲ **Source 4:** A proportional map showing the global import of lab-grown and natural diamonds to different countries, highlighting the patterns of global demand for diamonds.

Global top five diamond importers, 2023

Country	Share of natural diamond global imports (%)	Share of lab-grown diamond global imports (%)
United States	18.8%	52%
India	21.7%	8%
Hong Kong	15.4%	17%
Belgium	9%	4%
United Arab Emirates	11.5%	13%

▲ **Source 5:** A table of the top five importers of natural and lab-grown diamonds global share of imports in 2023. Source: Tendata

Sources 4 and 5 activities

1 Which country is the largest importer of lab-grown diamonds?

2 How does India's import share of natural diamonds compare to its share of lab-grown diamonds?

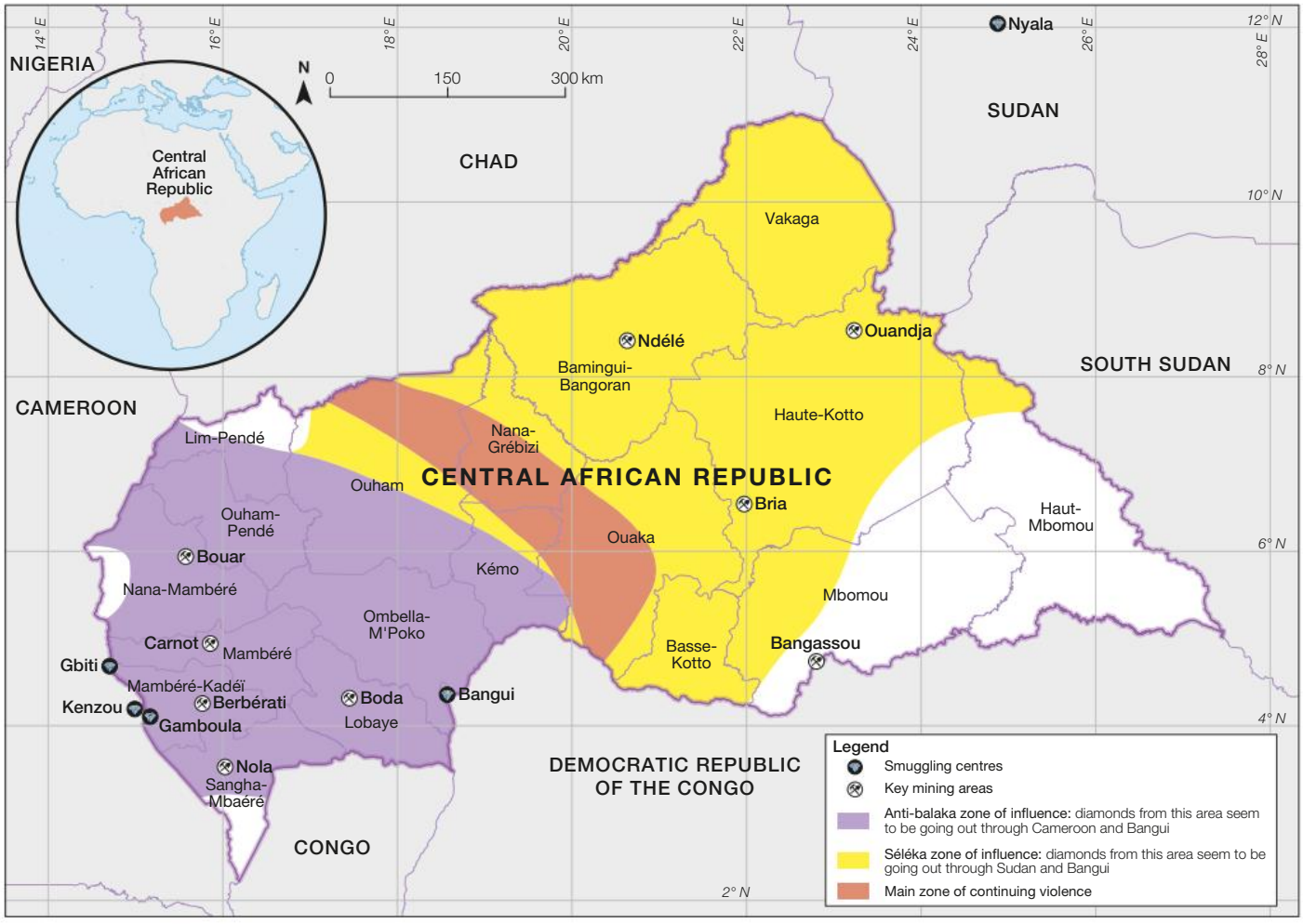
3 Which country has a higher share of lab-grown diamond imports than its natural diamond imports? What might explain this trend?

4 Create a composite bar graph to compare the percentage share of lab-grown diamond imports. An example composite bar graph is shown in Source 2.

5 Based on the trends shown in the table, predict how the global diamond import market might change by 2030.

Diamond mines across the Central African Republic

Diamond mining, Central African Republic



Source: Matilda Education Australia

Source 6: A map highlighting the location of diamond mines across the Central African Republic and the major two groups who manage the diamond production. The red area is a zone of conflict between the two groups.

Source 6 activities

1 What is the bearing of:
   - **a** Ouandja from Bria
   - **b** Ndélé from Bangassou
   - **c** Bouar to Gamboula
   - **d** Boda to Bria.

2 What is the approximate latitude and longitude of the following:
   - **a** Nola
   - **b** Bangassou
   - **c** Ouandja
   - **d** Bouar.

3 What is the approximate distance between the following:
   - **a** Gamboula and Bangui
   - **b** Ndélé and Ouandja
   - **c** Bouar and Bangassou
   - **d** Bria and Berbérati.

4 Describe the location with the highest density of mines in the Democratic Republic of Congo. Refer to latitude and longitude, direction and whether it is in the Anti-balaka or Séléka zone of influence.

5 How do the locations of diamond mines relate to the conflict zone between the Anti-Balaka and Séléka groups? Refer to directions and patterns from the map to explain.

Social implications of the diamond trade

Source 7: A photograph of a child working in the mining industry in the Democratic Republic of Congo. Thousands of children work illegally in the diamond mines here to pay for food or school fees.

Source 7 activities

1. What type of photograph is used?
   - **a** Aerial
   - **b** Satellite
   - **c** Ground level
2. Describe two things in the photograph that highlight the working conditions for miners in the Democratic Republic of Congo.
3. The photographer is facing north. Using the direction of shadows in the image, is it most likely morning or afternoon? Explain why.
4. This is a large-scale photograph, which allows it to show large amounts of detail. How are large-scale photographs helpful for geographers studying working conditions in diamond mines?

11

Geo How-To

Geography has its own set of concepts and skills to help us study our world and its characteristics, patterns and changes over time. Understanding geographic concepts will help you think like a geographer, and learning the skills to use maps, images, graphs and other sources of data will enable you to explore patterns and conduct fieldwork to answer important questions.

How to think like a geographer

Thinking like a geographer will help you develop an understanding of places and natural and human environments, and the interactions between people, places and environments.

Geographic concepts

Thinking geographically involves using the concepts of geography to look at the world in a particular way. As a geographer, you will analyse the world using seven geographical concepts. The concepts are geographic ideas that you can apply to the topics you study to deepen your understanding and help you create geographic questions that will guide your investigations.

Use the acronym **SPICESS** to help you remember the seven geographic concepts:

1. **S**pace
2. **P**lace
3. **I**nterconnection
4. **C**hange
5. **E**nvironment
6. **S**cale
7. **S**ustainability.

S Space

In a geographical context, *space* refers to the way that we use, *change* and distribute things on the Earth's surface. For example, this *space* is classified as a National Park. While tourists are allowed to visit this *space*, they must be respectful of the *environment* and remain on the designated pathways.

P Place

The concept of *place* allows humans to identify the location or position of something within a *space*. We can identify place through describing the relative or absolute location of that area. This *place* is called Huangguoshu Waterfall, and it is located in China.

Source 1: Huangguoshu Waterfall National Park in Guizhou province, China. This is one of the largest waterfalls in East Asia.

I Interconnection

Interconnection is the idea that two things or phenomena are related, interact or are linked in some way. For example, there is an *interconnection* between the abundance of trees and the movement of water through this environment. Without this water source, the trees would not be able to survive in such quantities.

C Change

Change refers to how a *place* is altered due to shifts in the environment or to meet the needs of humans. Change can be positive or negative, and can occur over short or long time periods. In this *place*, humans have *changed* the *environment* by adding boardwalks, handrails and access points so that tourists can view the waterfall.

E Environment

An *environment* can be defined by its **geographical characteristics**. Some environments are largely natural and are untouched by humans, such as coastlines, islands and forests. Other environments have undergone significant change and are largely unnatural, such as cities and other urban areas. Within environments we can observe processes, interconnections between **phenomena** and change over time. This image is an example of tourists visiting a natural environment.

S Scale

Scale usually refers to the size of something. Scale can be literal, such as a scale on a map using data to show you how big something is in real life. It can also be used as a word when describing a region. For example, patterns can exist on a local, regional, national or global *scale*. This image is an example of tourism on a local scale.

S Sustainability

Sustainability is the concept of maintaining and preserving resources and environments for future generations, by using sustainable, **renewable energy** for example. In this location, we can see a boardwalk has been added so tourists do not damage the environment by trampling vegetation. The area will be preserved for future visitors to enjoy.

Space

Source 1: Large-scale agricultural operations like soybean farms can be observed from the air using planes, drones and satellites. Aerial surveys of soybean fields help us understand the extent of crop cultivation, how the land is being used and farming practices. Understanding the spatial distribution of these crops is important for geographers and agricultural experts to develop strategies for sustainable farming, manage resources, and address environmental impacts such as deforestation and soil erosion.

In a geographical context, space does not refer to 'outer space'; instead, it refers to the ways in which we use, change and distribute things on Earth's surface.

1 I can identify spatial distribution

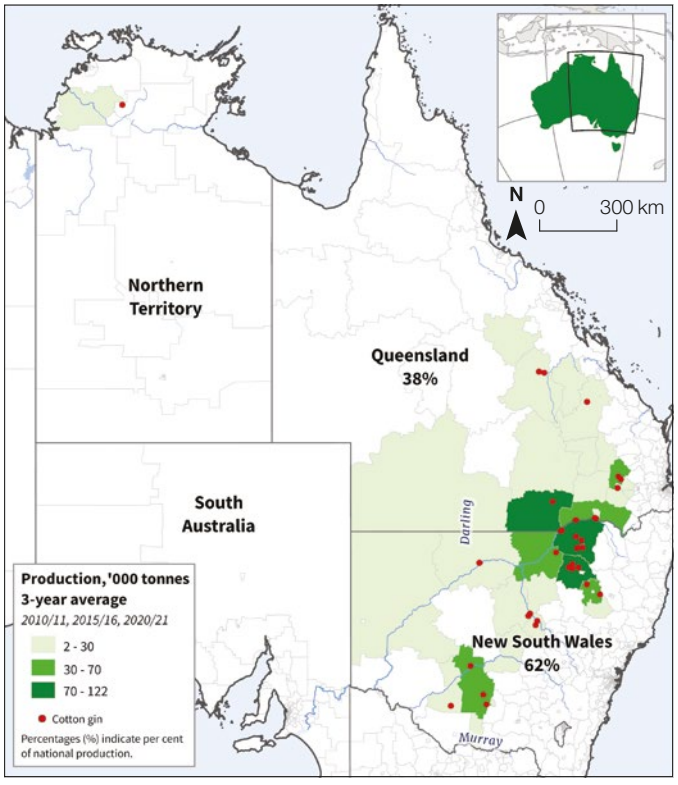
Geographical phenomena are events or features in the environment. Identifying spatial distribution means recognising how things or phenomena are arranged within a space or area. You may use terms such as **clustered** (grouped together), **linear** (in lines), **random** (all over the place with no clear pattern), **uniform** (equal in distribution), **uneven** (not the same as other places) or **even** (following a similar pattern to other places) to identify the way things are distributed. For example, Source 1 shows an **aerial view** of a soybean farm in Mato Grosso, located in central-western Brazil. The soybean plants are evenly lined up; they have a linear distribution.

2 I can describe spatial distribution

Once you have identified how things or phenomena are arranged in a space you can use PQE (see page 412) to describe this distribution.

- **(P) Pattern:** A pattern is a trend or something that repeats in the data. Look at the legend to understand what the colours or symbols mean. For example, cotton production in Australia is concentrated along the eastern regions, particularly in southern Queensland and northern New South Wales.
- **(Q) Quantification:** Quantification means using numbers to explain and give evidence for the pattern you see. For example, in just one northern New South Wales region more than 122 000 tonnes of cotton were produced over a three-year average.
- **(E) Exception:** An exception is something on the map or graph that doesn't follow the usual pattern. For example, up to 30 000 tonnes of cotton over a three-year average were produced in the Northern Territory.

Australia cotton production



Source: U.S. Department of Agriculture

Source 2: This choropleth map shows the distribution of cotton production in Australia using colours to represent different production levels (in thousands of tonnes over a three-year average). Legends provide information to help geographer interpret the symbols and colours used to represent phenomena.

3 I can explain spatial distribution

To explain why things are arranged in a certain way, we can use the **SHEEPT** framework (see page 414). SHEEPT stands for social, historical, economic, environmental, political and technological factors. SHEEPT helps us look at the same pattern from different points of view. For example, in Source 2, a *social* explanation for the distribution of cotton production is population density and labour availability. Productive areas such as northern New South Wales and southern Queensland are close to regional towns and communities, providing access to workers and services needed for agriculture. *Environmental* factors also influence the distribution of cotton. Cotton crops require warm climates and a lot of water to grow. Cotton crops are often grown near river systems like the Darling and Macquarie Rivers where irrigation can be used for large-scale farming. In contrast, central and western Australia are too hot and dry for cotton growth.

4 I can analyse the impact of spatial distributions

Analysing requires understanding the causes and effects distributions have on people and places and examining the significance of the relationships between them. In Mato Grosso, Brazil, farms use monoculture agricultural methods, where fields are used to grow one type of crop, such as soybeans (see Source 1). This practice can lead to a range of negative environmental impacts, including reduced soil health and loss of biodiversity, as well as increased vulnerability to pests and diseases. To ensure successful harvests, farmers can adopt strategies such as varying the species planted, crop rotation and sustainable management policies (see page 400).

5 I can assess changes to spatial distributions and their effects

Assessing means making a decision or figuring out how important, big or impactful something is. It is making a judgement. This helps you understand the value, results or effects of something by looking closely at it. For example, in Australia, cotton farming relies heavily on irrigation, especially in regions where rainfall is unpredictable. Droughts, altered rainfall patterns or water scarcity (see page 238) can affect the distribution of cotton production. If water resources become more limited farmers may struggle to irrigate their crops, leading to lower yields and crop failure, and ultimately forcing them to change crop species. On the other hand, regions with more reliable access to water might see an increase in cotton production, further shifting spatial distributions.

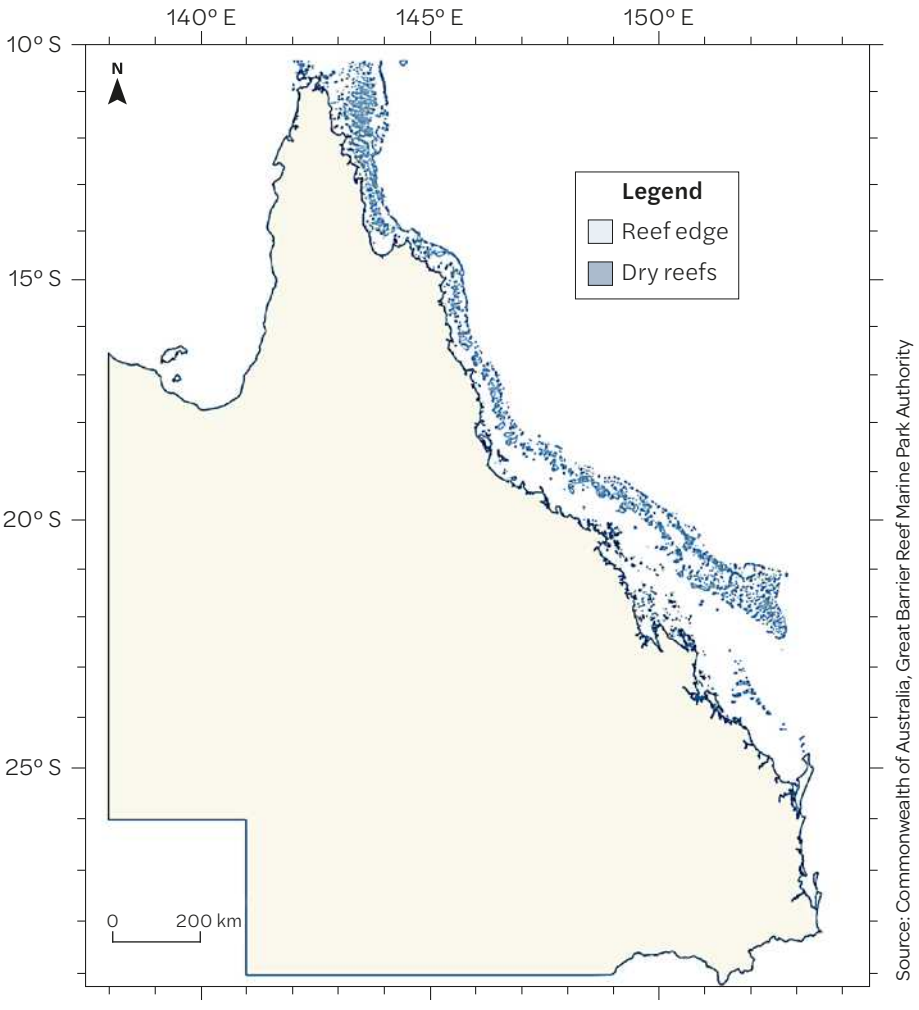
Place

In Geography, **place** refers to a specific location which has meaning to humans. Places have a range of physical (natural) and human (built) characteristics and can be described using their distinct features such as landforms, climate, culture and infrastructure. A place can be as small as your bedroom or as large as a country. Places are dynamic and constantly changing.

1 I can identify the location of a place

The concept of place helps us identify the location or position of features and characteristics within a space. We can describe a place using relative or absolute location. Relative location describes where a place is in relation to other places or using characteristics such as landscape features or political boundaries. For instance, the Great Barrier Reef is located off the north-eastern coast of Australia, near Queensland. Absolute location refers to a place's exact position on Earth. This may be a street address or coordinates such as latitude and longitude. For example, the absolute location of Whitsunday Island in the Great Barrier Reef is 20.2813° S and 148.8193° E.

Location of the Great Barrier Reef



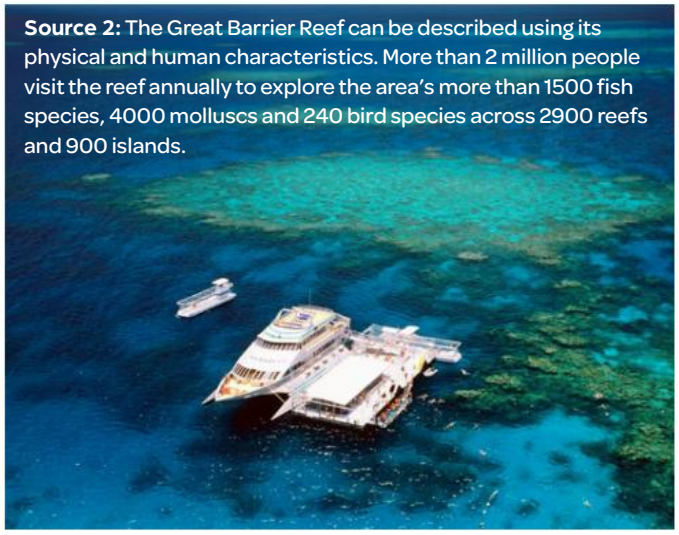
Source 1: Street addresses are useful for identifying locations on land, but they become less helpful when trying to pinpoint a place in remote areas, like the middle of a forest or the Pacific Ocean. To overcome this, geographers use latitude and longitude, a system of imaginary lines that wrap around the Earth, providing a precise way to describe any location on the globe (see page 404).

2 I can describe a place

To describe a place, you look at both physical and human characteristics. Physical features occur naturally, such as mountains, rivers or forests, while human features are built by people, such as buildings, roads or towns. For example, the Great Barrier Reef has a range of distinct natural features including aquatic animal and plant species, rock formations and islands. Human features like pontoons provide floating bases for snorkellers, divers and glass-bottom boat tours.

3 I can use geographic vocabulary to describe a place

You can extend upon the description of places using both qualitative terminology such as the physical appearance and quantitative terminology such as the size or age (see page 412). For example, the Great Barrier Reef stretches along 2300 kilometres and is home to more than 600 species of corals, making it the world's largest natural reef system.



Source 2: The Great Barrier Reef can be described using its physical and human characteristics. More than 2 million people visit the reef annually to explore the area's more than 1500 fish species, 4000 molluscs and 240 bird species across 2900 reefs and 900 islands.

4 I can explain how places are interconnected

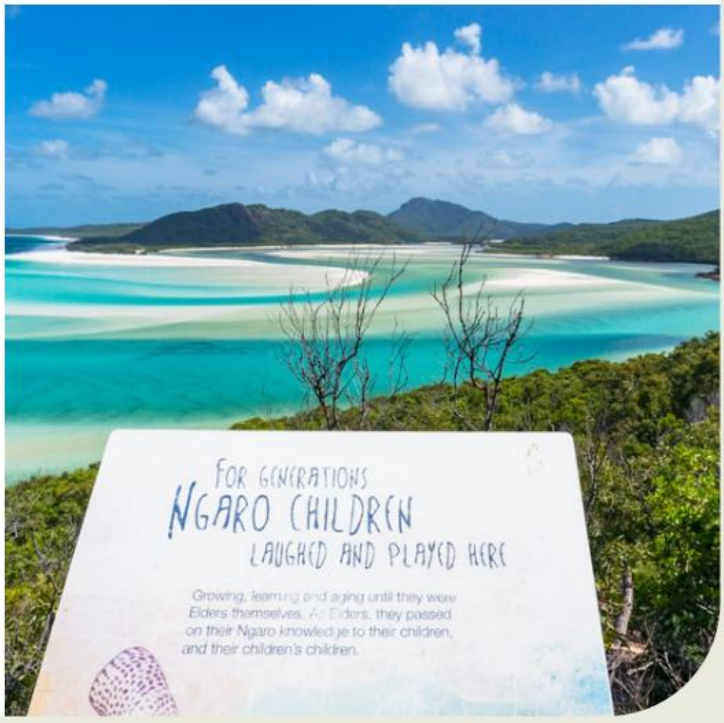
It is difficult to study one place in isolation. Places are connected through social, economic, environmental and political factors. The Great Barrier Reef in Australia is connected to a range of places on various scales (see page 398). Local communities depend on the reef for tourism, fishing and cultural activities. The reef is crucial for Australia's economy, bringing in $6.4 billion each year from activities such as tourism and supporting more than 64 000 jobs. The reef's health is linked to other surrounding environments. Pollution from nearby farms or rivers can impact the reef, and global climate change is leading to ocean warming and coral bleaching. Protecting the reef requires leaders to look beyond political boundaries with local, national and global policies being developed to ensure its long-term sustainability.

5 I can analyse the impact of places on people and environments

A location is considered a place when humans attach emotion or meaning to it. People have different experiences and feelings in places, creating what we know as 'sense of place'. Places impact human emotions; for example, you might feel a sense of security when visiting a relative's house or a sense of belonging at a local sporting club. This connection shapes a person's identity and can link them to their culture or ancestors.

Environmental factors, such as climate, landforms and ecosystems, determine the types of plants, animals and weather a place experiences. The Great Barrier Reef's warm, shallow waters provide an ideal environment for its diverse marine life. Human activities continue to shape this place through tourism, fishing and coastal development, which have both positive and negative impacts on the reef's ecosystems. These human actions, combined with natural processes, influence how the reef evolves over time.

Source 3: First Nations Peoples have lived around the Great Barrier Reef for more than 60 000 years, with sacred sites and cultural knowledge still preserved. Despite historical dispossession, more than 70 Aboriginal Traditional Owner groups maintain a strong connection to Sea Country, managing it through cultural practices and sustainable use of resources.



Interconnection

Geographical phenomena do not occur in isolation. Places, people and processes are interconnected through social, historical, economic, environmental or political factors. Interconnection is the idea that two things or phenomena are related, interact or are linked in some way. For example, the occurrence of drought is interconnected with a severe lack of rainfall and even the outcomes of climate change.

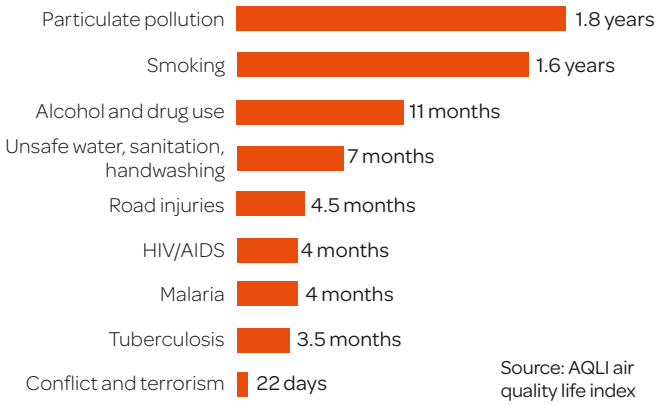
1 I can recognise an interconnection

Recognising and identifying interconnections is the first step to understanding how two or more things are connected. For example, there is an interconnection between increased pollution in the atmosphere and reduced community health.

2 I can describe interconnections

Describing interconnections between geographical phenomena involves providing more detail about the relationship. You may explore the movement of people or things, social connections or physical and human processes. For example, in Beijing, China, when air pollutants such as sulfur dioxide and nitrogen oxides react in the atmosphere, they cause increased occurrence of acid rain. Acid rain harms soil, plants and water bodies, affecting local ecosystems.

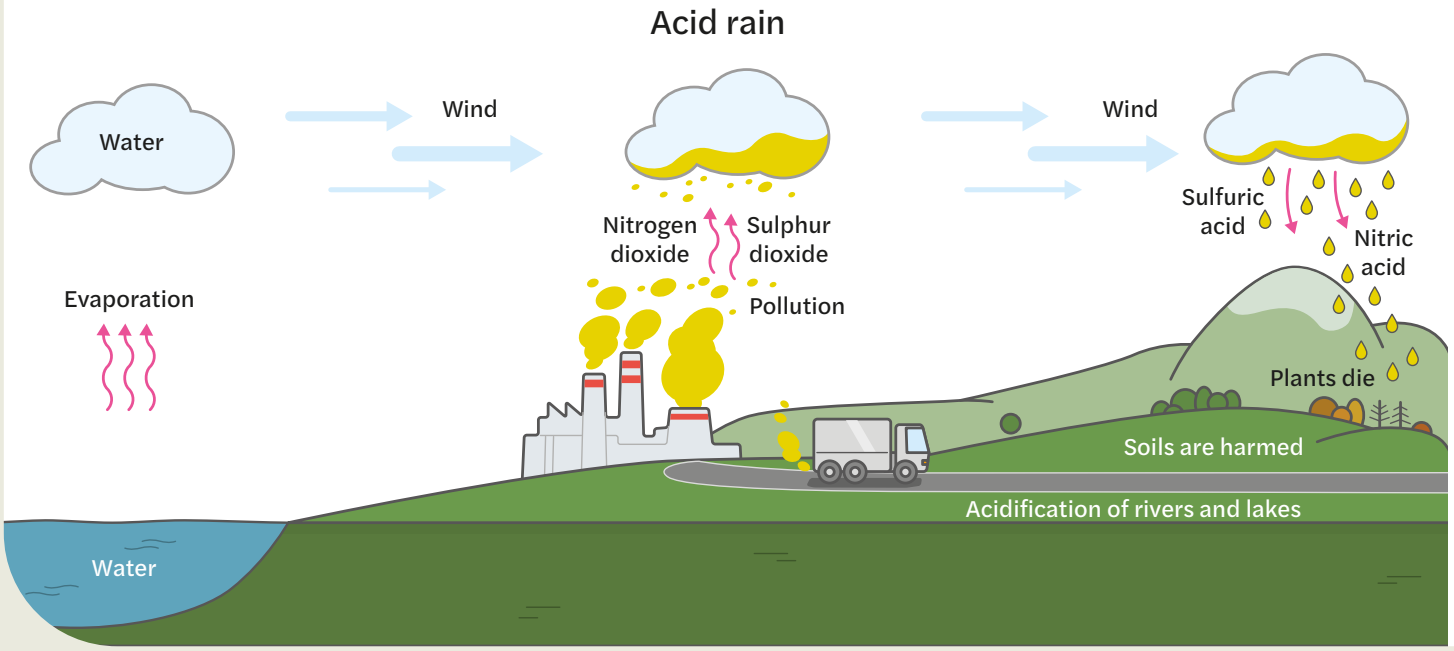
Air pollution is the greatest human health risk



Source: AQLI air quality life index

Source 1: There is a strong interconnection between increased pollution in the atmosphere and reduced human health and wellbeing. Long-term exposure to polluted air (quantified by the estimated number of pollution particles in the atmosphere, or 'particulates') shortens a person's average life expectancy by up to 1.8 years. This is higher than smoking (1.6 years) and drinking unsafe water (7 months).

Source 2: Flow diagrams or block diagrams are a good way to illustrate interconnections between phenomena by using arrows or labels to help visualise cause and effect.



3 I can explain the influence of interconnections

Explaining an interconnection means exploring the reasons why a relationship occurs between two phenomena. For example, in India, the interconnection between pollution and public health is a major issue. The local industry has grown quickly and as the population has increased, so has the number of cars on the road. This has led to higher levels of air pollution, especially in major cities like Delhi. Around 40 per cent of Delhi's pollution is caused by the burning of 'stubble', where the crop that remains after harvest is burned to clear land for the next planting season. This demonstrates the interconnection between human activities and the environment and public health.

4 I can assess the effects of interconnections

Interconnections can be complicated and have a wide range of effects on people and places. You make a judgement about those impacts. For example, the interconnection between increased air pollution and rising health problems in Delhi has serious social outcomes, such as increased pressure on hospitals and higher government healthcare costs. In late 2024, health services in Delhi reported a 50 per cent increase in patient visits due to respiratory illnesses linked to pollution. This illustrates how interconnected environmental changes can affect both the health of individuals and the way communities function.

5 I can assess the impact of changes to interconnections

To assess the impact of changes to interconnections, you need to first understand the concept of change (see page 394), and then assess how a change in one part of a geographical relationship affects other connected parts and determine how significant those relationships are. For example, if there is a sudden change in pollution in a city, it may impact the local air quality, public health or economy. These impacts may be positive or negative and happen over a short or long time. For example, the construction of a new major highway may improve travel times, but it could also increase the number of cars on the road, leading to higher rates of pollution in the long run. Assessing the impacts of change to interconnections helps geographers understand the wider implications of geographical relationships.

Source 3: Pollution in Delhi, India, reached hazardous levels in 2024, resulting in significantly reduced visibility to less than 100 metres. Authorities issued severe restrictions and health warnings for high-risk people such as the young and elderly to remain indoors.

Change

Change refers to how a place is altered due to shifts in the environment or to meet the needs of humans. Change can occur over large or small scales (see page 398), can have positive or negative impacts, and can occur over short or long time periods.

Source 1: Borneo is a south-east Asian island located just north of the equator (0.9619° N, 114.5548° E). Borneo is very mountainous and is characterised by dense rainforest. Borneo has a tropical climate, receiving more than 2000 millimetres of rain per year. Borneo is a very biodiverse place, meaning it has a wide variety of species living there, including 15 000 types of plants and more than 200 mammal species. Since 1960, deforestation has made way for oil palm plantations and other forms of agriculture. This has resulted in natural forest loss and the destruction of many natural habitats.

1 I can identify change

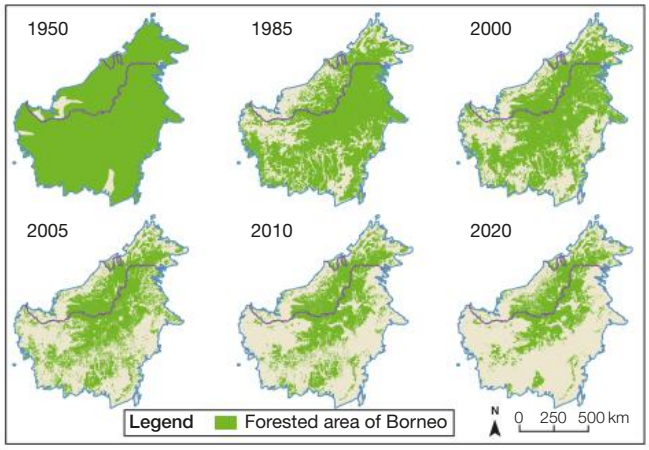
Change is occurring all the time. Change can be large, like the construction of a new city, or small, like a river rising by a few centimetres. Some changes are easier to notice than others. Some changes are predictable, like the seasons, and others are unexpected, like those caused by sudden earthquakes.

Identifying change requires geographers to focus on one region over a set time. Photographs are a good way of recording change. For example, Source 1 shows how the forest cover is reducing in Borneo, the world's third-largest island, because of deforestation.

2 I can describe change

Once you have identified change, you can describe it by recording what has occurred over short or long periods, whether the change is positive or negative, and whether it is driven by human or physical factors. Quantifying or providing numerical evidence for the change can also help to illustrate its extent. For example, in Borneo, deforestation has been taking place since the 1960s. This represents a long-term change largely driven by human activity, particularly logging and the expansion of oil palm plantations. Over the last century, more than 50 per cent of Borneo's forest cover has been lost, significantly impacting the island's biodiversity.

Deforestation in Borneo 1950–2020



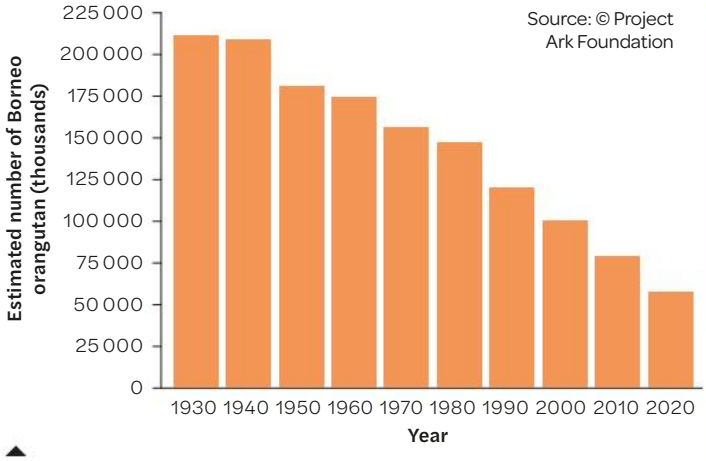
Source: Hugo Ahlenius/GRID Arendal, A UNEP Partner

▲ **Source 2:** Maps and graphs are another way to illustrate change over time. By quantifying change, geographers can better understand patterns, causes, consequences and interconnections. While the expansion of oil palm plantations has slowed since 2012, there is still more work to be done to protect the nation's natural resources.

3 I can explain the causes and effects of change

Explaining changes in places means looking at why and how a change has happened. Some changes occur naturally, like the changing seasons, which follow regular, predictable patterns. These natural changes usually happen slowly over a long period. On the other hand, human-caused changes tend to happen more quickly because they are often the result of planned actions, such as building cities, cutting down forests or burning fossil fuels. For example, in Borneo, deforestation is caused by activities like logging and planting oil palm crops. In the short term, deforestation may bring economic benefits, such as creating jobs and boosting local income. However, in the long term, the effects are mostly negative. Losing forests means animals such as orangutans lose their habitats; fertile soil can wash away, reducing farming productivity; and air pollution can increase.

Estimated Borneo orangutan population 1930–2020



▲ **Source 3:** It is estimated that over the past 20 years, more than 90 per cent of the habitat for the Borneo orangutan population has been lost. This significant habitat destruction, combined with poaching and illegal trade, has resulted in a dramatic decrease in the number of orangutans remaining on Borneo.

4 I can analyse the impact of change

Analysing the impacts of change requires you to not only understand why the change is occurring but also research what outcomes this may have on various people and environments over time. The impacts of change can also be interconnected. A change that occurs in one place can impact people in a completely different region. For example, it is estimated that deforestation and forest degradation contribute to as much as 20 per cent of human-caused carbon dioxide emissions globally. Deforestation in Borneo not only leads to the loss of local species and habitats but also affects the local and global climate. As trees are cut down, the carbon stored in the forests is released into the atmosphere, contributing to climate change.

5 I can assess how changes to processes shape places

Changes in social, economic, environmental or political processes can have both positive and negative impacts, shaping the characteristics of places over time. Assessing these changes means understanding how significant they are and how they affect people, environments and economies. You make a judgement about how significant the changes are. Human-caused changes often involve balancing economic gains with environmental health. For example, deforestation in Borneo disrupts local water cycles, affecting agriculture and clean water supply. Without trees to absorb water during monsoons, floods and droughts become more common. Tree removal also leads to soil erosion, reducing crop growth. These changes can impact local communities, economies and even global trade.

Environment

An environment is a place defined by its unique characteristics and features. Environments can be either natural, like forests or oceans, or built, such as cities or farmlands. They change over time due to various processes. These distinct characteristics help geographers identify, understand and manage different places around the world.

1 I can identify environments

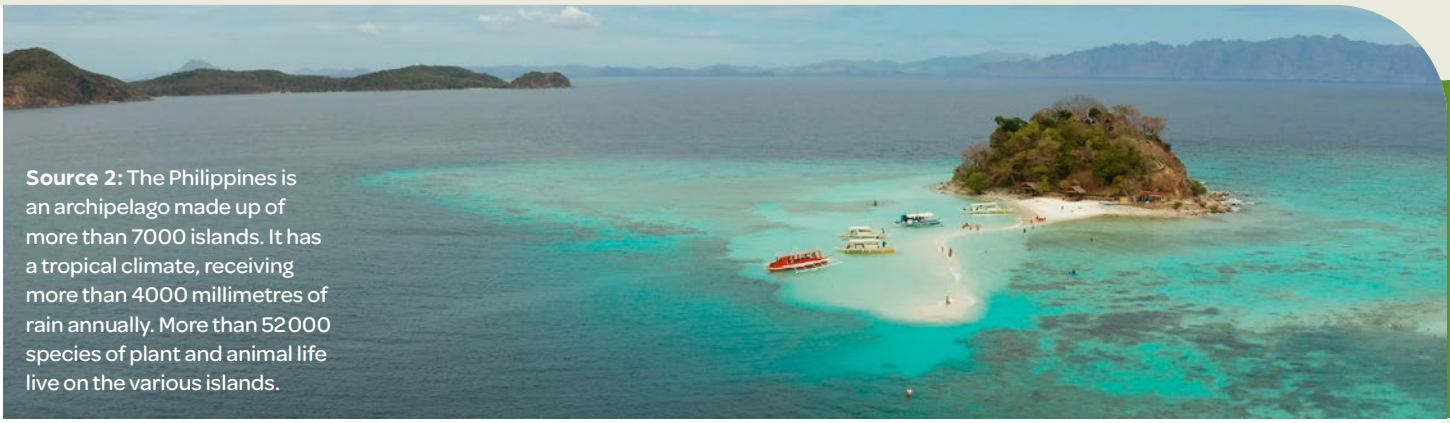
Identifying environments means being able to recognise different types of places around us. There are two main types of environments: aquatic and terrestrial. Aquatic environments are areas with water, such as oceans, creeks or lakes. Terrestrial environments are those found on land, such as forests or deserts.

Environments can be physical or human. Physical or natural environments exist without human intervention, like forests, oceans or wetlands, while human environments are places built by people, such as cities, farmland or highways.

2 I can summarise the characteristics of environments

We classify environments by looking at their distinct characteristics. For example, the Simpson Desert in Australia (see Source 1) is known for its dry, hot conditions with very little rainfall. In contrast, an island, like the tropical sandbar seen in Source 2, is a piece of land surrounded by water, with dense vegetation and a unique ecosystem. Recognising these characteristics helps us understand how environments are distinct from one another.

Source 1: The Simpson Desert is located in central Australia. It receives on average 125 millimetres of rain per year and the summer temperatures range from 20°C to around 35°C. Surprisingly, the desert is home to over 900 species of plants and animals.



Source 2: The Philippines is an archipelago made up of more than 7000 islands. It has a tropical climate, receiving more than 4000 millimetres of rain annually. More than 52000 species of plant and animal life live on the various islands.

3 I can explain physical processes

Explaining physical and human processes means understanding how and why both natural events and human activities change the environment. Physical processes are natural occurrences, like erosion, which occurs when wind or water gradually wears down rocks and soil, shaping the landscape over time. Human processes result from human decisions and activities. Examples of human processes include actions like deforestation, urbanisation and agriculture.

4 I can analyse processes that change places

Human and physical processes are factors in changing environments (see page 394). Physical processes, like changes in rainfall, can drastically change the landscape by reducing the ability for plants to grow and support animal life. Human processes, like deforestation, urbanisation or agriculture, can also change environments by removing tress, building urban structures or altering the natural landscapes to develop farmland. These physical and human processes are often interconnected (see page 392) and can have significant impacts on the environment, changing the characteristics of a place over time.

5 I can examine the impact of change on environments

Change can have both positive and negative impacts on environments and can happen in the short or long term. These changes can result from both physical and human processes. For example, a bushfire, which is a natural process, can have both destructive and beneficial effects on a forest environment. In the short term, a fire causes widespread destruction and habitat loss. However, in the long term, certain plants that are adapted to fire-prone environments can regenerate and reproduce after a bushfire, helping to restore the ecosystem. On the other hand, human actions, such as forest management and the acceleration of climate change, can influence the intensity of bushfires, making them more frequent and severe. By examining these impacts, we can better understand how physical and human processes are interconnected and how they affect the environment, informing management and actions.

Scale

Scale in geography refers to the size or level of processes, ranging from local to global. It helps explain how impacts vary and interact across different areas and over time.

1 I can recognise different scales

In Geography, we use two types of scale: **map scale** and **observational scale**. Map scale helps us measure things on a map, like distances or areas, as seen in Source 1. Observational scale is a broader concept and can be defined by **spatial** and temporal scales.

Spatial scale refers to the physical size or area of a phenomenon or process. For example:

- local scale: a specific area, like a town, school or neighbourhood
- regional scale: a larger area, like a state or province (e.g. New South Wales in Australia)
- national scale: the entire country, like Australia
- global scale: the whole world, considering worldwide processes like climate change.

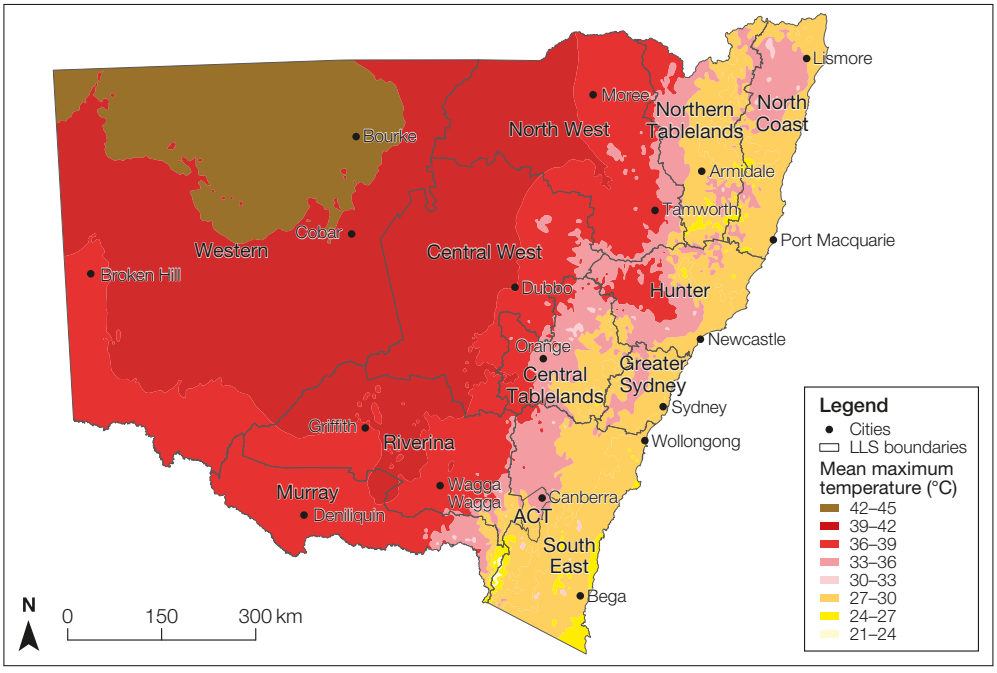
Temporal scale is about measuring time, such as changes over a period of days, years or centuries.

These two scales are linked. For example, over the last 10 years (temporal scale), urban blocks in the outer-east region of Victoria have become smaller to make room for more apartments and houses (spatial scale).

2 I can describe processes at a range of scales

At the local scale, processes are often easier to notice because they directly affect your community or environment. For example, natural events like floods, storms or bushfires can have immediate impacts on homes, businesses and local infrastructure. At the regional scale, processes can be interconnected across several local areas. For example, water shortages can affect a larger area and the people living there. National processes often have a broader impact across the entire country. For instance, a national policy on renewable energy can influence how regions develop and how industries operate. By using maps, graphs and data, we can better understand natural and human processes that occur at different scales and shape the world around us.

New South Wales maximum temperatures for 2019



Source 1: In 2019, New South Wales experienced above-average temperatures and below-average rainfall. On a local scale, this meant hotter weather that affected daily activities. Regionally, it led to drought conditions and an increased risk of bushfires, which, in turn, had local impacts on farming and productivity. Nationally, this prompted the government to create funding packages to support communities affected by drought and fires. A linear scale helps geographers understand the distance and scope of these patterns, providing a clearer picture of their impact across different scales.

Source: © State of New South Wales through the Department of Industry, Skills and Regional Development, 2019

3 I can explain how processes vary across scales

The same process can have different effects depending on the size and location of the area being studied. For example, population growth rates differ at global, national and local scales. Globally, population growth is slowing and is expected to peak and even start declining by around 2080. Countries like Germany are already experiencing a decline in population due to lower birth rates and longer life expectancy. On the other hand, in 2024, South Sudan had the highest population growth rate in the world at 4.65 per cent, with an average of 4.34 births per woman. Factors like access to education, employment opportunities, healthcare, technology, social norms, religion and government policies all influence these varying growth rates. Understanding these differences helps geographers explain how processes like population growth are shaped across scales.

4 I can analyse how scales interact to influence geographic processes

Processes can occur on multiple scales and can be influenced by the interaction of local, regional, national and global decisions and actions. For example, during the COVID-19 pandemic starting in late 2019, management strategies were implemented at various scales to reduce the virus's spread. At the global scale, international trade was limited and travel and tourism significantly decreased. National governments, including Australia's, imposed restrictions to protect public health, with local measures like lockdowns and social distancing put in place to reduce transmission. In Australia, the Prime Minister worked closely with state and territory leaders to coordinate efforts, such as the rollout of vaccines, rapid antigen tests and mask mandates. The global news and national policies had immediate local impacts, with shortages of products like toilet paper and cleaning supplies, while people adhered to lockdowns and quarantine measures. As vaccine uptake increased at the local level, restrictions were gradually lifted, and movement within Australia, as well as international travel, resumed.

5 I can assess how decisions are influenced by a range of scales

Decisions at different scales – global, national, regional and local – interact with and influence one another. For example, climate change policies are shaped by environmental, economic, social and cultural priorities at both local and national levels. While all countries share the global target of limiting temperature rise to below 1.5°C, the responsibility for reducing emissions varies due to different national emission levels and local impacts. You can make a judgement about the scale at which decisions are made. For example, rising sea levels, increased extreme weather events like wildfires and droughts, and reduced rainfall affect countries differently. This leads to debates over who should bear the responsibility for addressing climate change. Policies and strategies vary depending on the scale, both within countries and between them. In Australia, for instance, climate change policies are developed and implemented at various levels of government. The federal (national) government sets broad policies, while state (regional) and local (council) governments tailor strategies to meet their specific economic and environmental needs.

Source 2: In 2024, leaders from almost 200 nations gathered in Baku, Azerbaijan, for the 29th Conference of the Parties (COP29) to the United Nations Framework Convention on Climate Change, where they discussed progress made towards climate change management and emissions reduction targets. Decisions made on a national scale can have global impacts, especially with complex and large-scale processes such as climate change.

Sustainability

Acting sustainably ensures there will be adequate resources left for future generations. Sustainable practices help balance human activities and needs with the health of the environment (see page 396), ensuring that natural systems can continue to support life in the future.

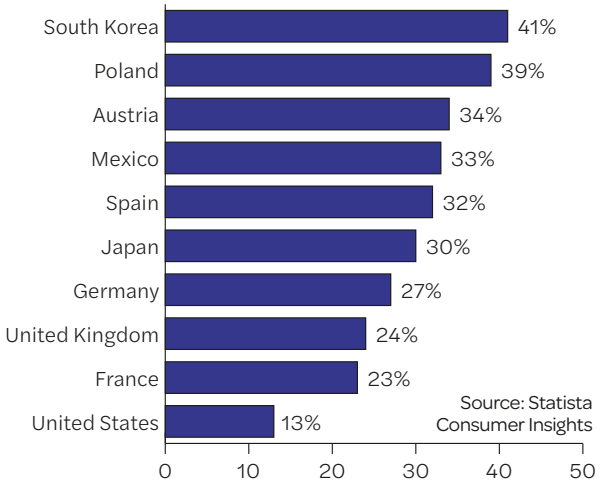
1 I can identify sustainability

Identifying sustainability means recognising and listing practices or strategies that help ensure the long-term health of an environment. This can include reducing the use of **non-renewable** or limited resources, like fossil fuels, and shifting to renewable energy sources (see page 194), such as solar or wind power. Conservation efforts to protect natural habitats and ecosystems also contribute to sustainability. Designing cities with green spaces, public transport and energy-efficient buildings promotes a sustainable urban environment. Encouraging communities to reduce waste by minimising plastic use, increasing recycling and supporting composting further enhances sustainability.

Public transport usage by country

Share of people who take public transport on their commute to work/school/university

764–7708 respondents (18–64 years old) who commute surveyed per country July 2022–June 2023



Source 1: Public transport is a more sustainable way to access services and facilities. By reducing the number of cars on the road, the amount of fossil fuels used and the rate of emissions is reduced, improving local environmental and air quality. Limited access or uneven distribution of public transport networks often means that some places rely more heavily on cars than others. In South Korea, more than 41 per cent of the population uses public transport to get to work or university, while in Australia, where public transport tends to be limited to highly urban places, only 4.5 per cent of people travel by train, bus or tram to get to work or university.

2 I can describe sustainability

Once you have identified what actions are sustainable, you can give more detail about what steps and choices help both present and the future generations. This is sometimes difficult to do as some organisations may use **greenwashing**, falsely claiming to be environmentally friendly to show a positive public image without making real, sustainable changes or choices. One strategy is colouring packaging green, a colour often associated with sustainable actions, to give the illusion of 'green' production or use. In contrast, true sustainable practices, such as **recycling**, involve the reuse of resources to decrease waste and preserve natural resources. Recycling helps reduce landfill and the need for the mining of raw materials.

3 I can explain the importance of sustainability

Often when we think about sustainability, we consider only the long-term preservation of the environment. However, in Geography we can discuss the concept of sustainability in multiple ways:

- environmental sustainability: preserving the environment for future generations
- economic sustainability: ensuring the economy keeps growing
- social sustainability: ensuring all people can thrive in the community and have equal access to opportunity
- cultural sustainability: ensuring cultural traditions and values are respected, supported and passed on to future generations.

Balancing environmental, economic, social and cultural sustainability is difficult. To explain the importance of sustainability, you need to consider *why* a particular practice is beneficial and understand its effects on different people and places. For example, political debates often focus on how to prioritise the economic benefits of industries like resource mining, such as job creation and trade, while also addressing the environmental consequences and the long-term sustainability of natural landscapes.

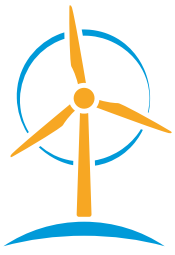
4 I can analyse the long-term impacts of sustainable and unsustainable practices

Sustainable practices are essential for ensuring the long-term wellbeing of economies, communities, and environments. However, transitioning to more sustainable practices can be challenging, especially when immediate benefits are not always visible.
If unsustainable practices such as continued reliance on fossil fuels persist, it is predicted that global temperatures could rise by more than 0.3°C by 2200. Although this may seem like a small increase, the rapid pace of global warming from human actions can have huge impacts. For example, extreme weather events such as more frequent and intense wildfires, similar to those in Los Angeles in January 2025, could become regular occurrences. Additionally, melting sea ice and glaciers will contribute to rising sea levels, threatening low-lying coastal cities and islands. Rising pollution levels can also harm public health, leading to respiratory issues due to smog and contaminated water sources. While changing long-established societal habits and practices is difficult, particularly given economic reliance on unsustainable industries, these changes are crucial for ensuring the long-term health of both people and the planet.

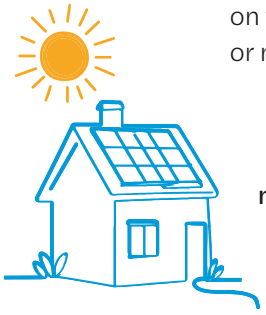
5 I can evaluate strategies to improve sustainability

You may evaluate the success of a sustainability strategy by exploring the steps taken to ensure long-term environmental, economic, social or cultural wellbeing. You may weigh up the arguments for and against the strategy and research evidence to make a judgement on whether the strategy will have long-term positive or negative impacts on people and place.

Source 2: While the closure of coal-fired power plants may lead to job losses, the shift toward renewable energy is expected to generate thousands of new jobs and create significant opportunities in emerging industries.

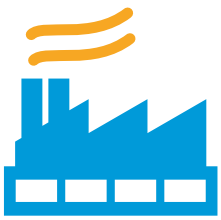


90 GW
renewable energy and transmission
200 000
JOBS



2.5 million
retrofits and new buildings
940 000
JOBS

20 000
electric buses and new green transport
140 000
JOBS



Clean
manufacturing and mining
230 000
JOBS

27 MHA
land regeneration
200 000
JOBS

90%
waste recycled
80 000
JOBS

+10 000 new jobs in training, education and research

How to use geographic tools

Mapping with BOLTSS (NA)

Geographers use specialist tools to assist in geographical inquiry. Developing skills in understanding and using these tools helps us display and analyse data effectively.

B Border

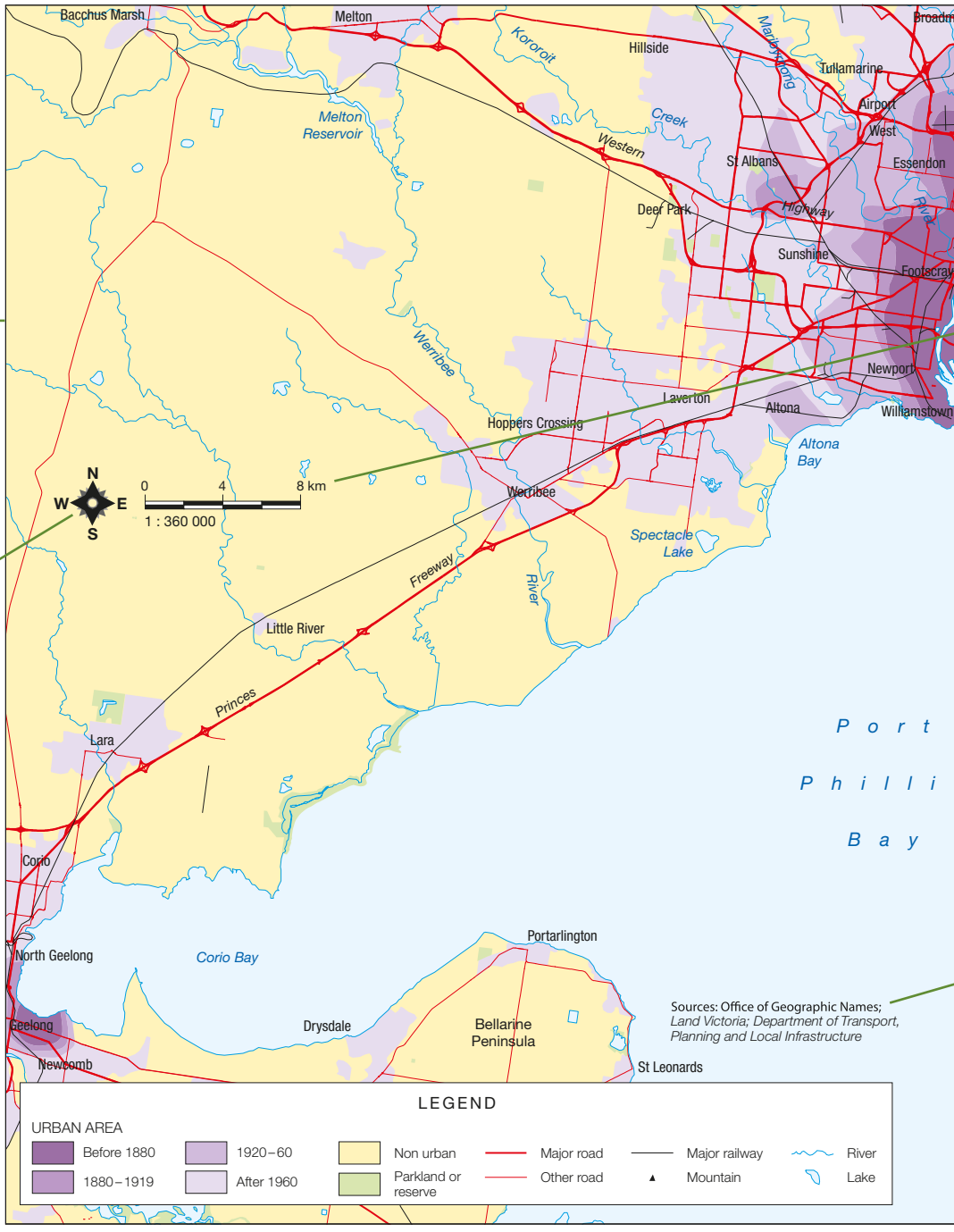
Borders are important, because they show the edges of the mapping field. A border provides a clear area for you to construct your map, and makes it look clear and neat.

O Orientation

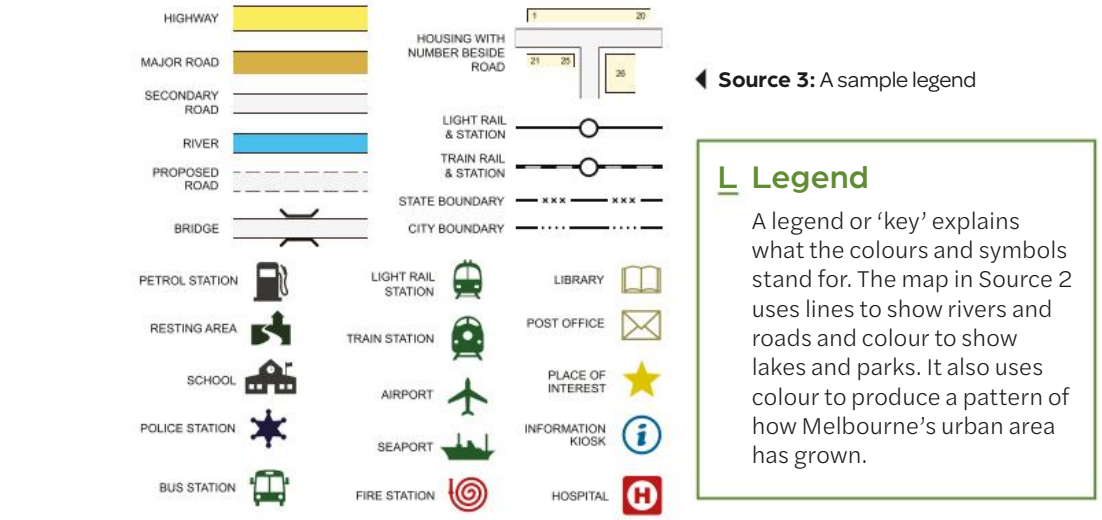
Orientation refers to the compass direction. The four cardinal points on a compass are north, east, south and west. The points in between, such as north-east, give more accurate directions.

▲ **Source 1:** Cardinal points of the compass

Urban growth in Melbourne



▲ **Source 2:** Urban growth in Melbourne



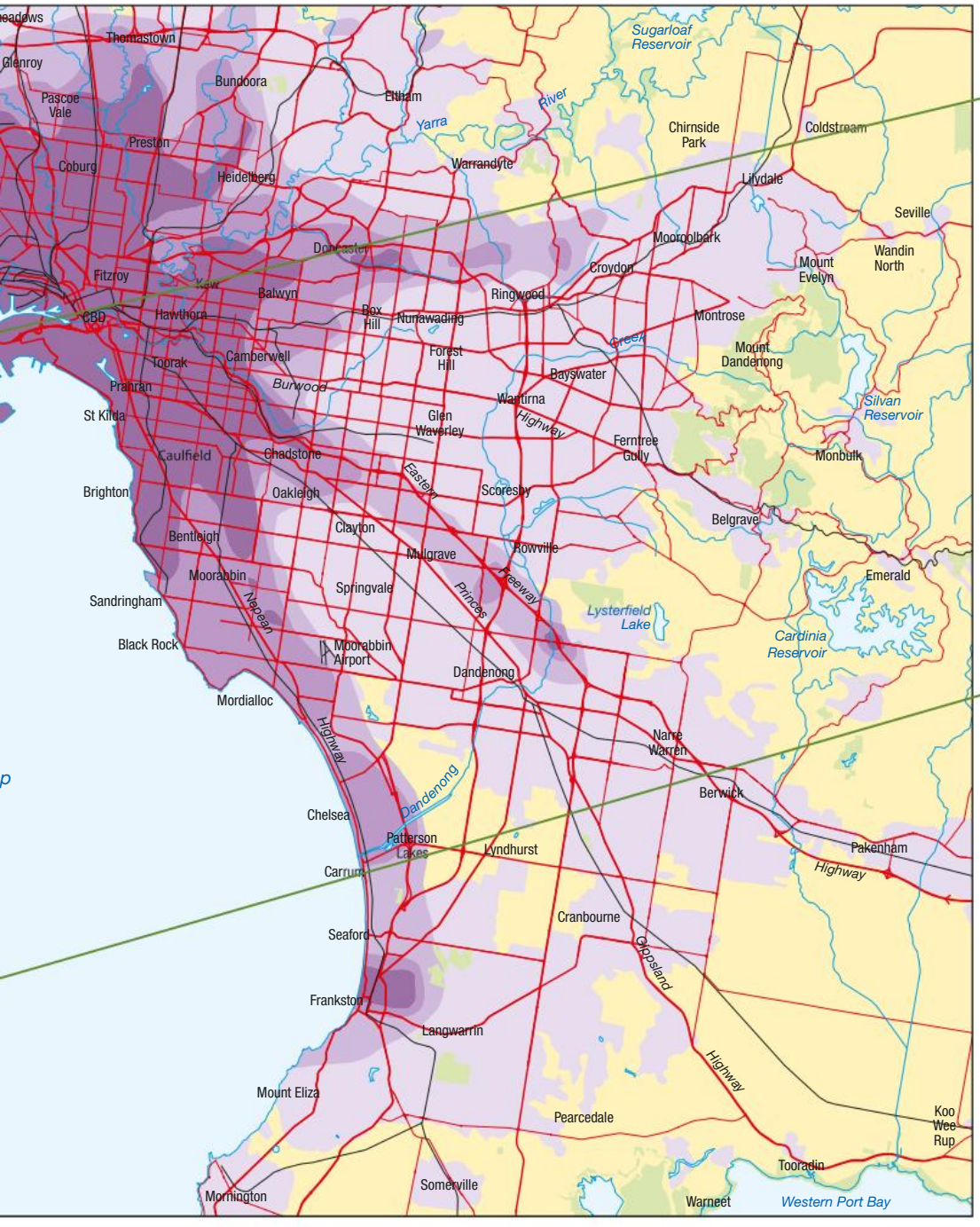
Source 3: A sample legend

L Legend

A legend or 'key' explains what the colours and symbols stand for. The map in Source 2 uses lines to show rivers and roads and colour to show lakes and parks. It also uses colour to produce a pattern of how Melbourne's urban area has grown.

T Title

A title tells us what the map shows, and gives us some understanding about it. Make sure you always add the date and the time to your sketch maps – this will allow you to monitor change over time in a location. The title of this map is 'Urban growth in Melbourne'.



S Scale

The scale gives us information about how big something is in real life. Scale can be expressed in three ways:

1. **Scale statement** describes the scale: 1 centimetre on the map represents 2 kilometres on the ground.
2. **Representative fraction** uses units to show scale: 1:100 000 means 1 centimetre on the map represents 100 000 centimetres on the ground.
3. **Linear scale**

S Source

It is important to let the reader know where you obtained the information for your map – which is known as your source. The source can also indicate whether the map is trustworthy.

(NA) Neatness and Accuracy

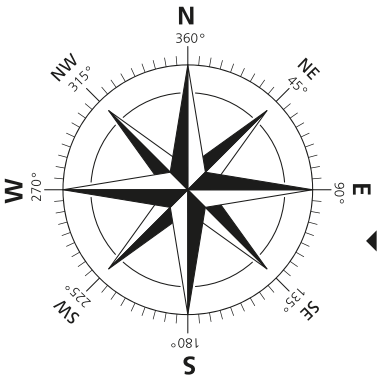
When we read a map, we rely on it being neat and easy to read – but we also expect that the data has been displayed accurately. When you construct a map, it is important to correctly show the patterns and distributions you see in the data.

Source: Matilda Education Australia

Mapping skills

Direction

Geographers use compass points to give accurate directions because these points do not change. No matter where you are, the hand on a magnetic compass will always point towards the Magnetic North Pole.



Source 4: Cardinal and intercardinal points of the compass

The four cardinal points on a compass are north, east, south and west. The points in between, such as north-east and north-north-east, give more accurate directions. A bearing is the angle measured in degrees clockwise from north to a direction line: a bearing of 90° is due east and a bearing of 180° is due south. Bearings give you 360 points of direction. They are used where highly accurate direction is important, such as in air, sea and land navigation.

On the map of Australia in Source 6, the compass reading for Halls Creek (C4) is east of Broome. Port Hedland (B3) is located south-west of Broome.

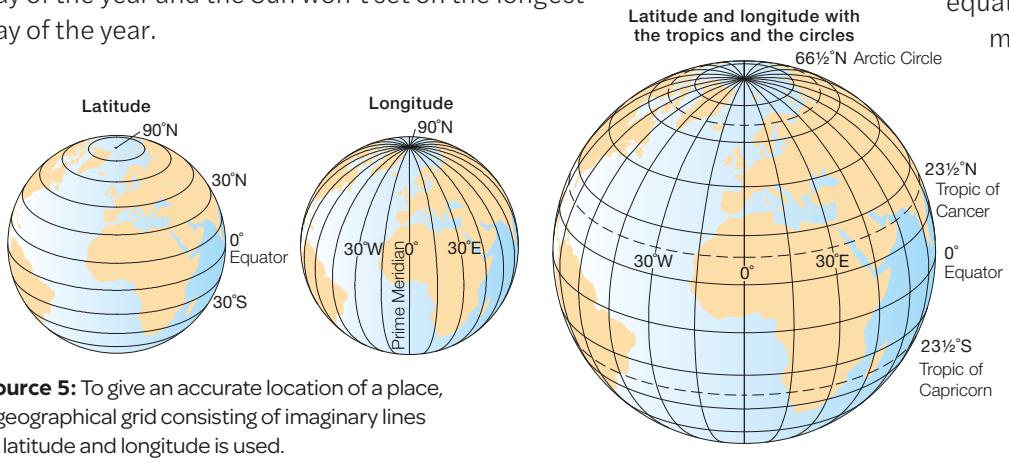
Latitude and longitude

We can use latitude and longitude to pinpoint any place in the world with great accuracy. This grid system is used in maps for long-distance navigation.

Parallels of **latitude** are imaginary lines drawn around the Earth from east to west. Lines of latitude are parallel to one another and are measured in degrees north and south of the equator (0° latitude). The Tropic of Cancer (23.5°N) is the most northerly and the Tropic of Capricorn (23.5°S) is the most southerly parallel of latitude at which the Sun can be directly overhead. The Arctic Circle in the **northern hemisphere** and the Antarctic Circle in the southern hemisphere mark the point that the Sun will not rise in winter on the shortest day of the year and the Sun won't set on the longest day of the year.

Meridians of longitude are imaginary lines that run from the North Pole to the South Pole. Degrees of longitude increase to the east and west of the prime meridian (0°), which runs through Greenwich, near London. The International Date Line (180°) marks the division point of the Western and Eastern Hemispheres.

We can locate any place in the world at the point where latitude and longitude intersect. Latitude is stated before longitude. For example, in Source 6, Tanami, NT, is located 20° south of the equator and 130° east of the prime meridian. For more accuracy, each degree can be further divided into 60 minutes (') and each minute into 60 seconds ("). The location of Darwin is 12°27'26"S 130°50'12"E, expressed in degrees, minutes and seconds.



Source 5: To give an accurate location of a place, a geographical grid consisting of imaginary lines of latitude and longitude is used.

Political map of Australia

Source: Mapgraphics

Source 6: This political map contains three different ways to locate places – lines of latitude and longitude, an alphanumeric grid and a direction arrow.

Scale

Scale is important in geography as it allows us to make maps and other images, and shrink them down to a size where we can see patterns, distributions and changes over time.

Scale is the ratio between the distance shown on the map and the real distance. To calculate the real distance between Sydney (F2) and Canberra (E2) in Source 6, mark the distance between the cities on the edge of a piece of paper, then place the edge of the paper under the linear scale. You will find the distance is about 250 kilometres.

In Source 6, the scale is shown in three different ways:

- the linear scale is like a ruler for you to measure distances on the map
- the scale statement uses words to say one centimetre on the map represents 230 kilometres on the ground
- as a representative fraction – 1:23 000 000 (1 cm = 23 000 000 cm).

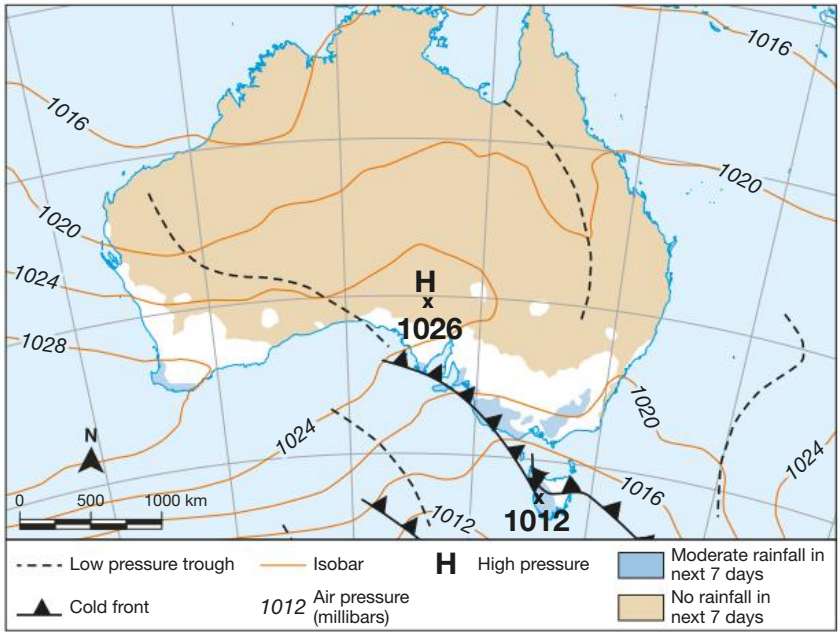
Source 7: This car model is a scaled-down version of the real car. This is a 1:64 scale model of a VW Beetle car. One centimetre length of the model represents 64 centimetres of the real car.

Types of maps

Weather maps

Weather maps show conditions in the atmosphere.

Weather map – Australia, 23 August 2017



Source: Mapgraphics/Bureau of Meteorology

The curved lines you see on a weather map are called isobars, and they join areas of the same barometric pressure. Air circulates around high pressure in a clockwise direction and low pressure in an anticlockwise direction, so isobars also indicate the direction of the wind. When isobars are close together, this indicates strong winds. When they are far apart, winds are light.

A cold front line marks the forward boundary of a cold air mass and the triangles point in the direction the cold front is moving. Clouds and rain are expected with a cold front.

Source 8: A weather map, also known as a synoptic chart, showing Australia on 23 August 2017

Choropleth maps

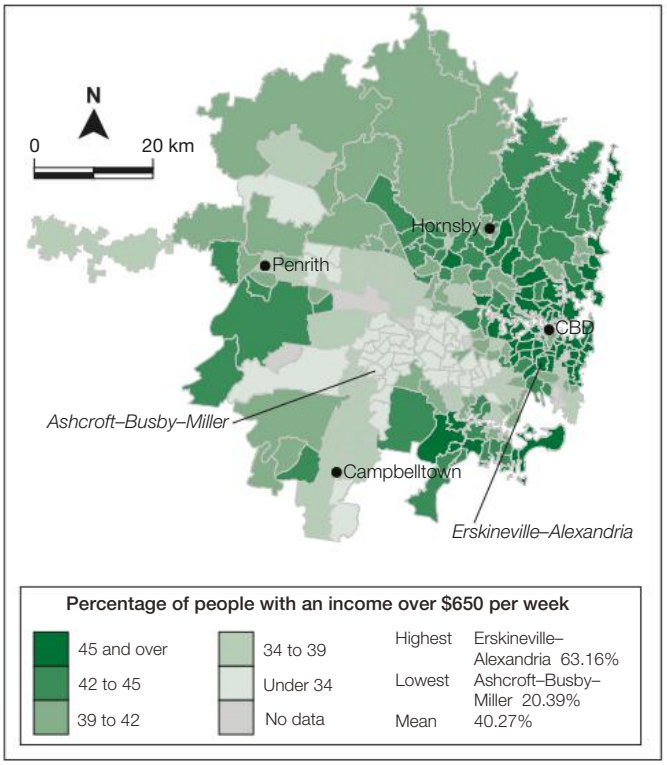
Choropleth maps use colour to show the spatial distribution of data.

To enable the viewer to quickly make sense of a pattern, choropleth maps use different shades of the same colour to reflect a pattern. Darker shades show 'the most' of something and lighter shades show 'the least'.

This choropleth map shows the percentage of people with an income of more than $650 per week in the Local Government Areas (LGAs) of Sydney. The pattern shows that a higher percentage of people earning more than $650 per week live north and directly south of the Central Business District (CBD). A lower percentage of people earning more than $650 per week are located in the LGAs to the west of the CBD.

The graded colour scheme on choropleth maps enables us to see exceptions to the general pattern: the LGAs south and west of Penrith have 42–45 per cent of their working population earning more than $650 per week; higher than the surrounding area.

Income distribution – Sydney



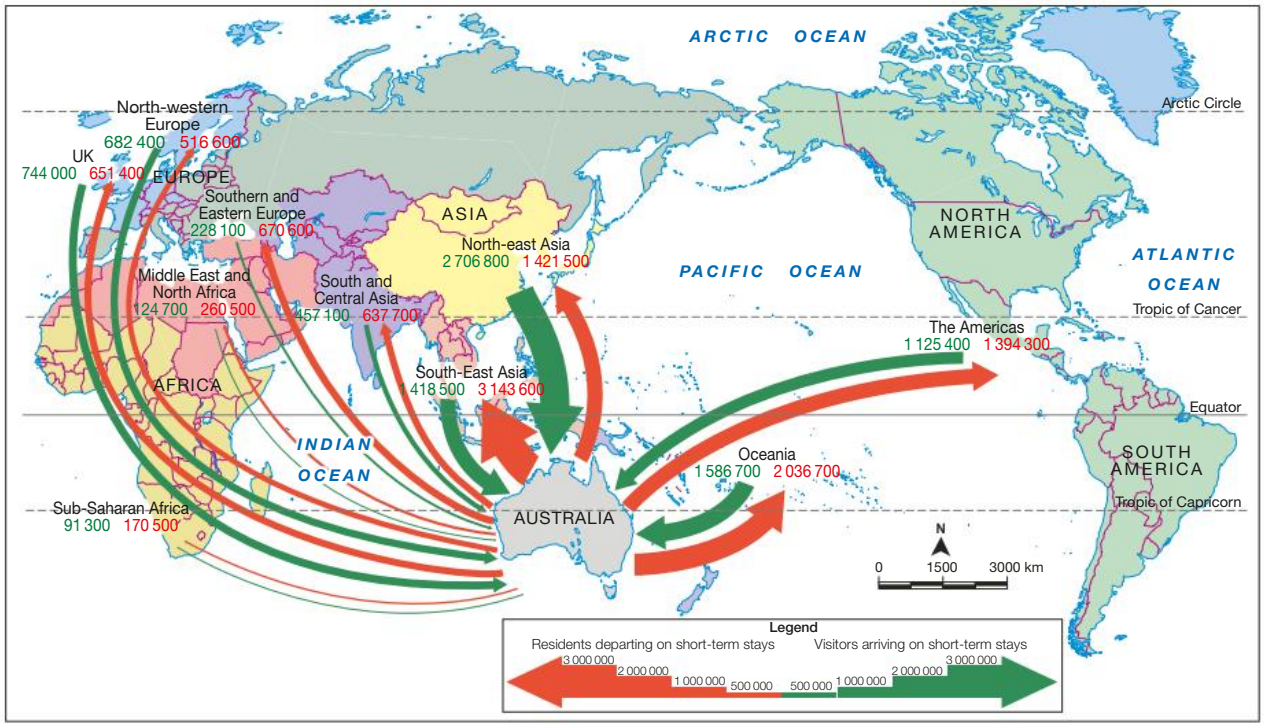
Source: Mapgraphics

Source 9: Choropleth map showing the distribution of income in Sydney's LGAs

Flow maps

In flow maps, arrows show the direction of movement and thickness shows the size of movement.

Australian tourism – international arrivals and departures



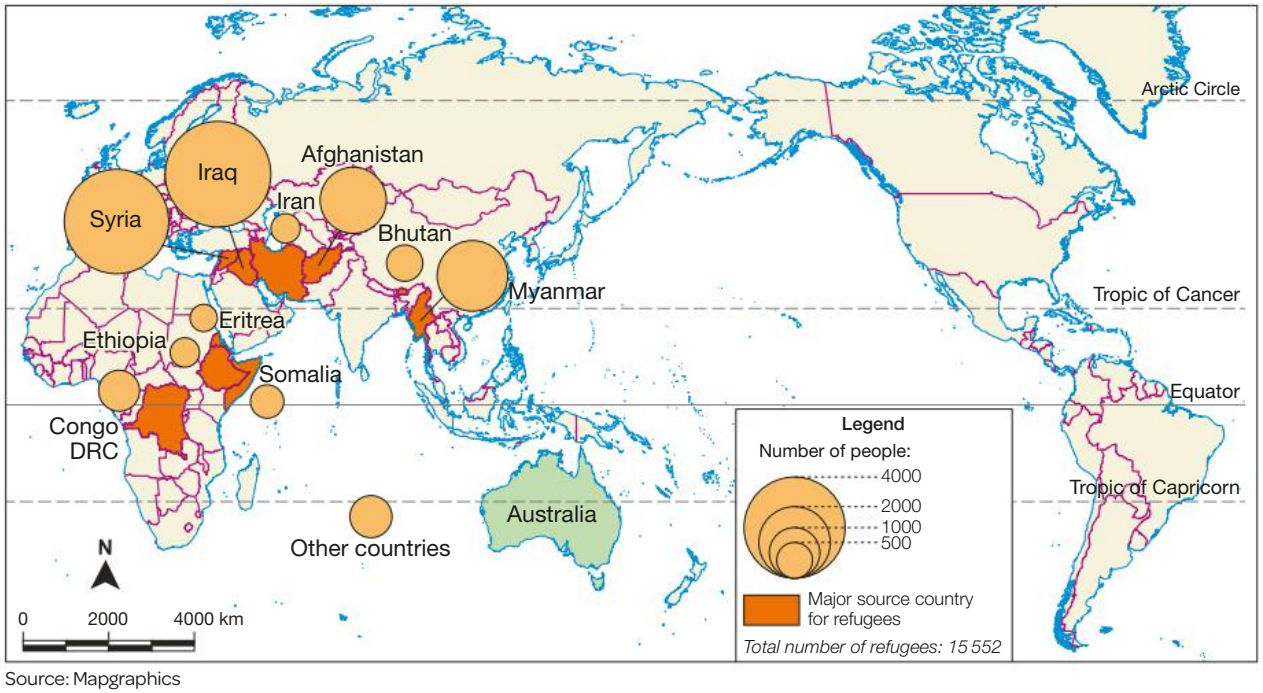
Source: Mapgraphics

Source 10: Flow map showing Australia's international tourist arrivals and departures

Proportional symbol maps

A proportional symbol map uses map symbols (such as circles) that vary in size to represent the data value. The larger the symbol, the greater the value.

Refugee arrivals to Australia, 2016



Source: Mapgraphics

Source 11: Proportional symbol map showing the number of refugees coming to Australia in 2016

Topographic maps

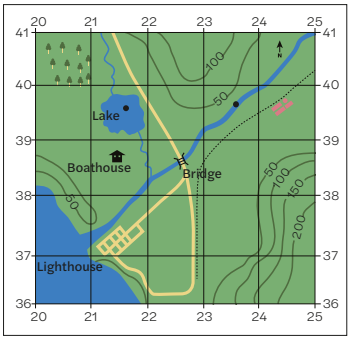
Topography is the study of land surface. Topographic maps show the different human and natural features on the ground, such as towns, roads, railways, forests, lakes and rivers. Topographic maps use contour lines to show different heights, helping you identify the shape of the land and features such as hills, valleys and ridges. A grid over the topographic map allows you to find relative and absolute locations.

Contour lines

Contour lines are imaginary lines on a map that join points of the same height above sea level.

When contour lines are close together, the land is steeper and when they are spaced further apart, the land is flatter. On the contour map in Source 14, the town of Tully is located in a flat valley between steep mountain ranges that surround it. The contour lines in the valley are widely spaced. The contour interval is the difference in height between the contour lines. For example, the contour interval used in Source 12 is 50 metres.

A sample topographic map

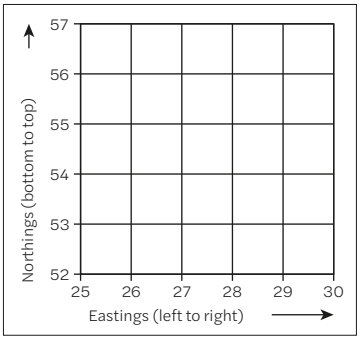


Source 12: This simple maps shows contour lines and grid references.

Grid referencing

It is not always easy to describe a specific point on a map using directional terms. Instead, you can use the grid references, also called the area reference (AR), to show the exact or **absolute location** of that place.

For example, you may want to highlight the exact position of the boathouse using the map in Source 12. If you spent time explaining where this was, you would be describing the relative location of that place. You might say, 'It is north-north-east of the lighthouse and west of the bridge'.



▲ **Source 13:** An example of grid references

To read an area reference, we first look at the numbers (or letters) associated with the vertical lines, reading from left to right – these are called 'eastings'. We then look at the numbers associated with the horizontal lines, reading from the bottom of the map to the top – these are called 'northings'.

For our example, the boathouse is located at the four-figure grid reference AR2138. This reference takes us to the bottom left-hand corner of the grid square that the boathouse is located in. The lake is located at AR2139 and the bridge is located at AR2238.

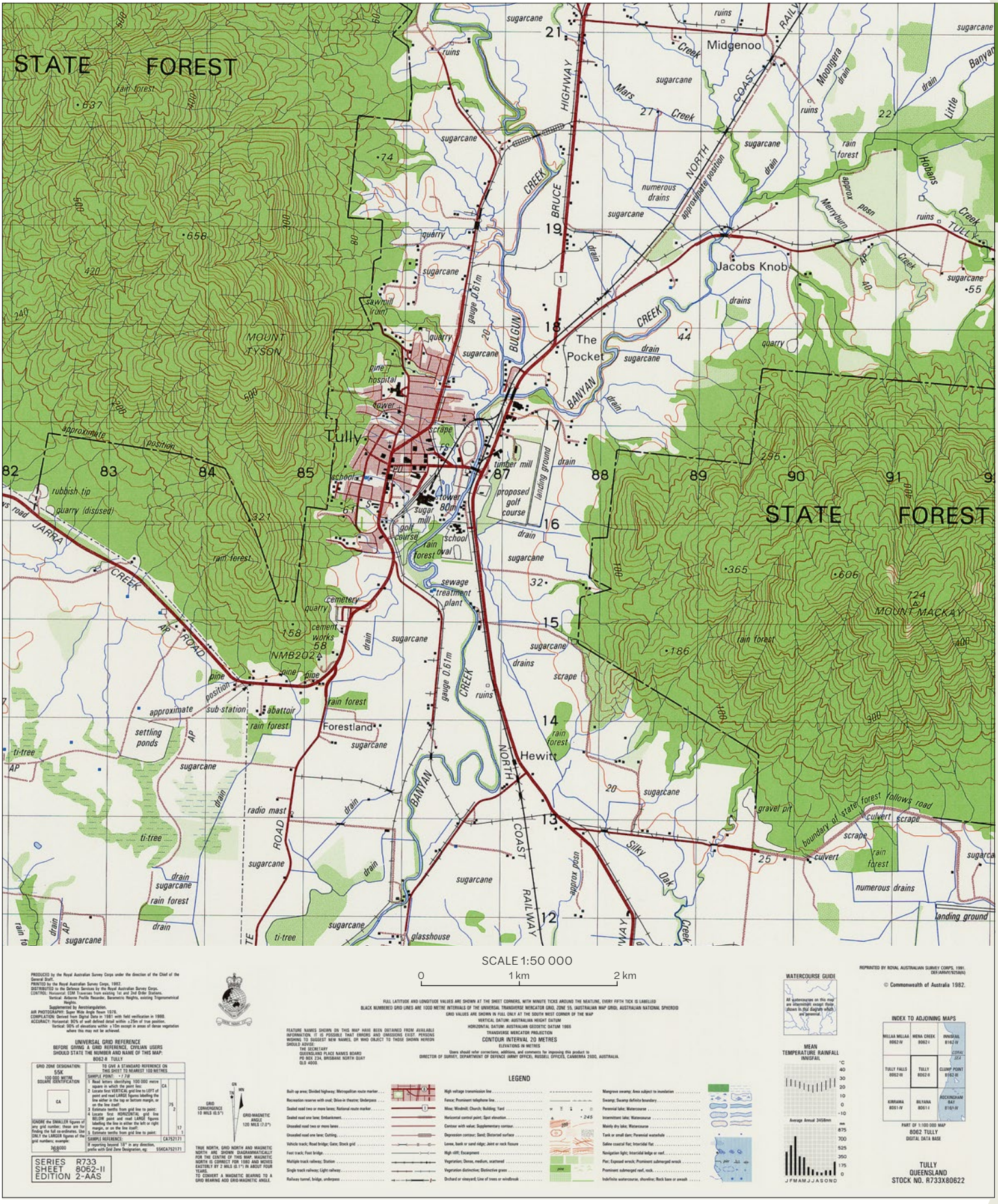
Gradient

Contour lines and spot heights, such as those shown at the top of mountains, can be used to calculate gradient and local relief. Gradient and local relief are important influences on land use.

The formula used to calculate gradient is Vertical Rise (VR; the change in height between two points – use the contour lines) divided by Horizontal Run (HR; the horizontal distance between two points – use the scale map). Make sure that they are using the same unit of measurement.

For example, if the VR is 100 and the HR is 1000 the gradient is 100/1000 or 1/10. This means that for every 1 metre you travel across the land you have walked uphill by 1 metre.

Tully 1:50 000 topographic map

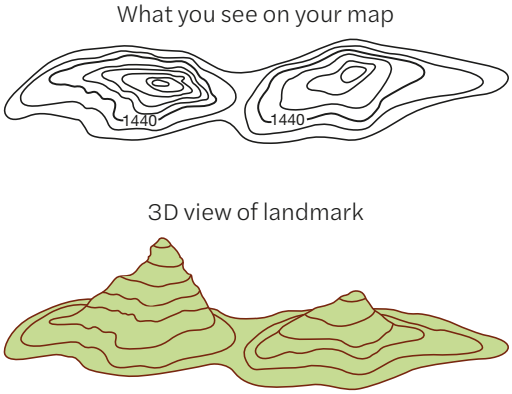


▲ **Source 14:** Tully 1:50 000 topographic map

Cross-sections

A cross-section shows the shape of a geographical landscape or landform from the side, as if it had been sliced by a knife. This type of drawing can be helpful in visualising landforms from different perspectives.

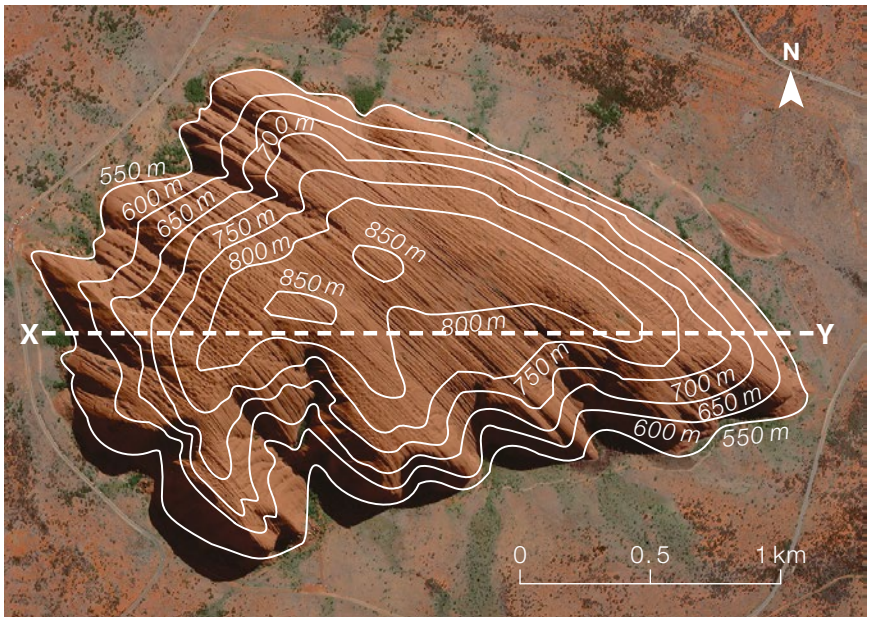
When drawing a cross-section by hand, we finish with a two-dimensional (2D) side-on view of the terrain; however, computer programs can create three-dimensional (3D) representations to enhance our understanding, as shown in Source 15.

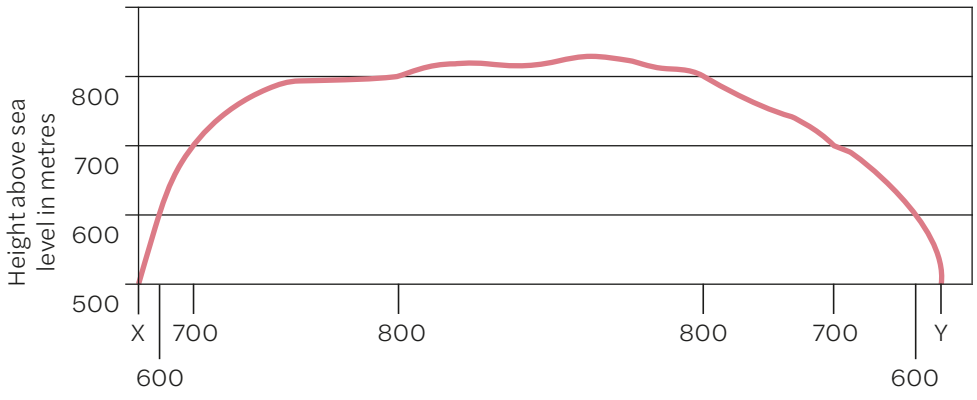


Source 15: The difference between what you see on a cross-section versus the 3D view of a landmark

Contour lines are used to construct a cross-section. The overlay on the aerial photograph of Uluru in Source 16 is a contour map. The contour lines are the numbered lines that join places of equal height. Close contour lines indicate a steep slope and widely spaced contours mean a gentle slope.

Source 16: An aerial photo of Uluru with contour lines overlaid



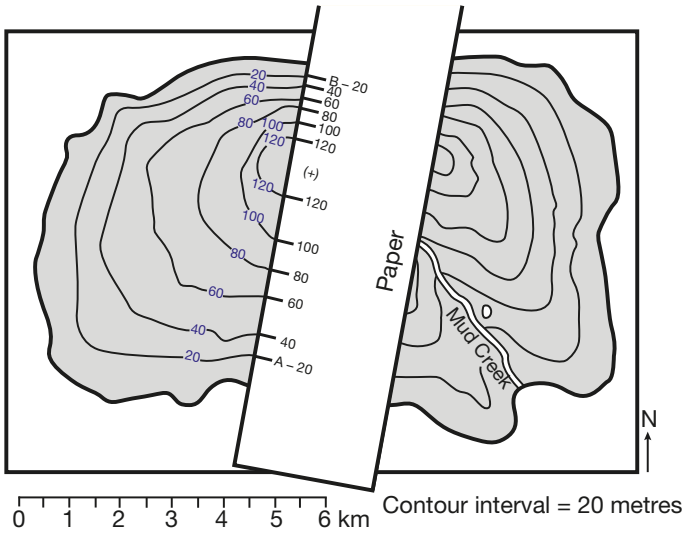


Source 17: A simple cross-section of Uluru. X and Y are matched to the transect line in Source 16.

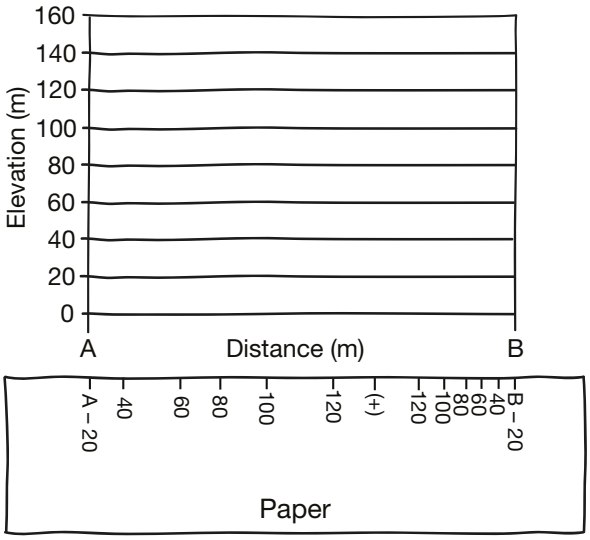
Source: Contour map from Matilda Education Australia, Geoscience Australia

How to draw a cross-section

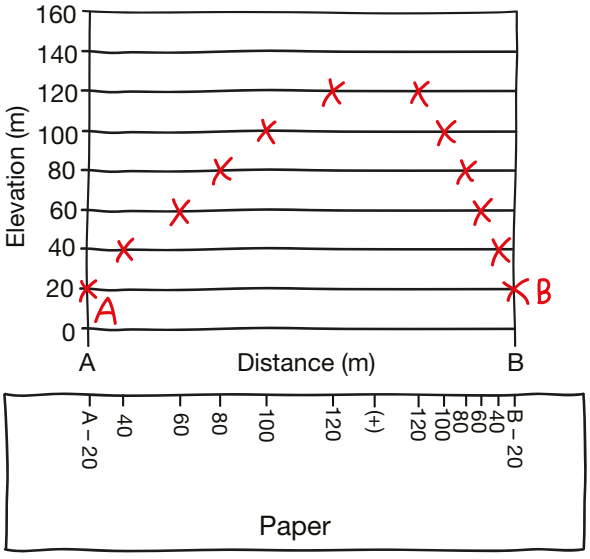
a Place a straight edge along the line between points A and B. Mark each contour line at the point it touches the edge of the paper and record the height.



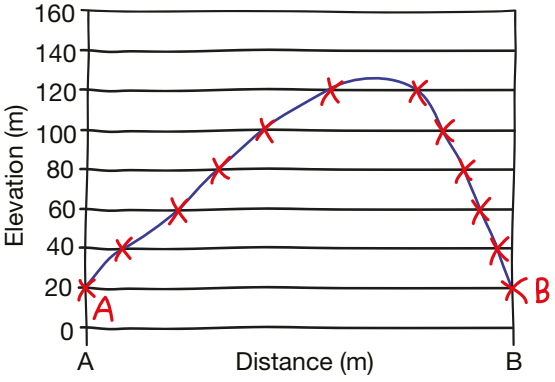
b Draw a vertical scale like the one below. You need to decide on a scale depending on the range of elevations presented on the contour map.
For example, for the Uluru cross-section in Source 17, 1 centimetre represents 100 metres.



c Place the marked edge of the paper underneath the vertical scale and mark the appropriate height directly above with a dot.



d Join the dots with a smooth line to create your 2D image



PQE

In geography, we use maps and graphs to understand what is happening in the world around us. In many cases, these maps and graphs provide us with information about patterns and the location or distribution of specific items.

The formula PQE helps us to describe these patterns and their distribution. P stands for pattern, Q stands for quantify (or 'how many') and E stands for exception.

P Pattern

A pattern is a trend in the data. When you look for a pattern, you need to read the legend and interpret what the colours or symbols mean.

On a graph or map, you might notice data points are clustered in one spot, or you might see the opposite, that they are distributed unevenly. You can then use compass points or the names of places to describe where the data clusters appear. For example, when observing the map in Source 18, we can see that people in the western United States prefer mint chocolate chip and Oreo cookies and cream flavours, while the eastern side prefers vanilla and chocolate.

Descriptive words you can use include: *clustered, even, uneven, highly distributed, north, south, east, west, increase, decrease* and *fluctuate.*

Q Quantify

When we quantify our pattern, we need to use numerical data to provide evidence of what we see.

You could obtain data by using the legend, by using the scale to measure or by conducting a count. You need to ensure that the data you provide relates directly to the pattern you recorded earlier.

For example, we noticed that more states in the western United States prefer mint chocolate chip and Oreo cookies and cream ice cream, while more eastern states prefer vanilla and chocolate. To quantify, we could count the number of states that like these ice-cream flavours. Six states in the west prefer mint chocolate chip and four prefer Oreo cookies and cream.

E Exception

An exception is a piece of data on the map or graph that doesn't 'fit in' with the general pattern.

When you spot an exception on a map or graph, it is good to quantify it to provide a comparison to your original pattern description. For example, we noticed that the western United States prefers mint chocolate chip and Oreo cookies and cream flavours, while the eastern states prefer vanilla and chocolate. To quantify this, six states on the west coast prefer mint chocolate chip and four prefer Oreo cookies and cream. However, Wisconsin, which is on the east side of the United States, has also voted mint chocolate chip as its favourite flavour – which is an exception to our original pattern.

What is the difference between qualifying data and quantifying data?

PQE helps us describe patterns and distributions. When we describe, we 'say what we see'. In a PQE analysis, we do not explain or give a reason why we see patterns, this is done in a SHEEPT analysis (page 414).

To quantify means to use percentages, counts, ratios or data from the legend to provide more details about the different patterns you are writing about. To qualify a statement means you use general descriptive words such as 'large', 'many', 'small scale', 'enormous', 'broad' or 'tiny' to describe a pattern or change.

By using quantifiable data, we can more easily see key differences between locations or even monitor change over time. Imagine that your PQE analysis stated: 'There are a lot of people who like ice-cream in the United States'. Does this sentence allow you to create a detailed visual of what is happening around the country? Or does this quantified statement provide more detail: 'Six states in the west prefer mint chocolate chip and four prefer Oreo cookies and cream'?

How do I start my PQE sentences?

When writing a PQE analysis, start sentences with the following key terms:

Pattern:
Overall...

For example:

Overall, the west side of the United States prefers mint chocolate chip and OREO cookies and cream ice cream, while the east side prefers vanilla and chocolate.

Quantify:
To quantify...

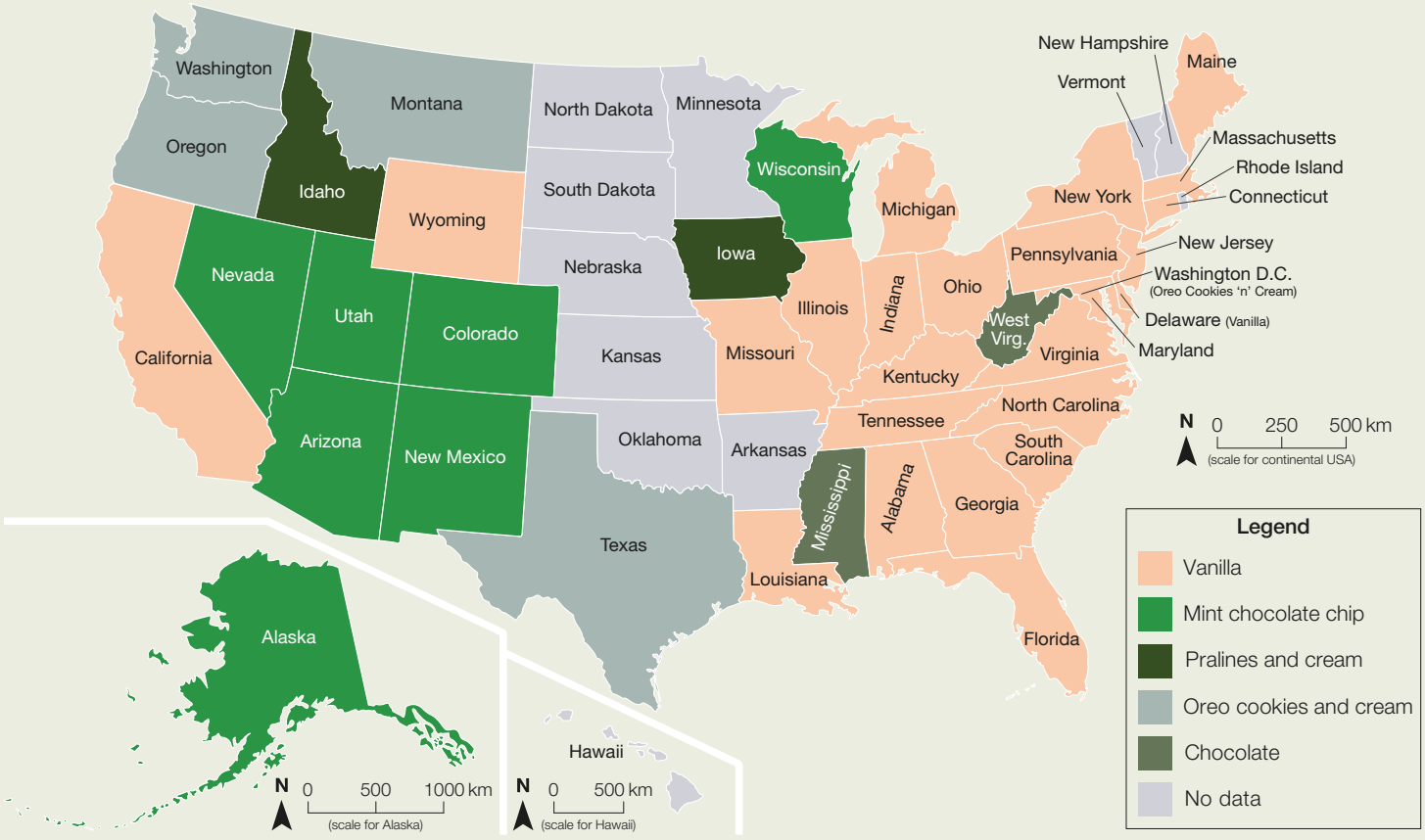
For example:

To quantify, six states on the west coast prefer mint chocolate chip and four western states prefer OREO cookies and cream.

Exception:
However...

For example:

However, the state of Wisconsin, which is on the east side of the United States, has also voted mint chocolate chip as their favourite flavour, which is an exception to the pattern.

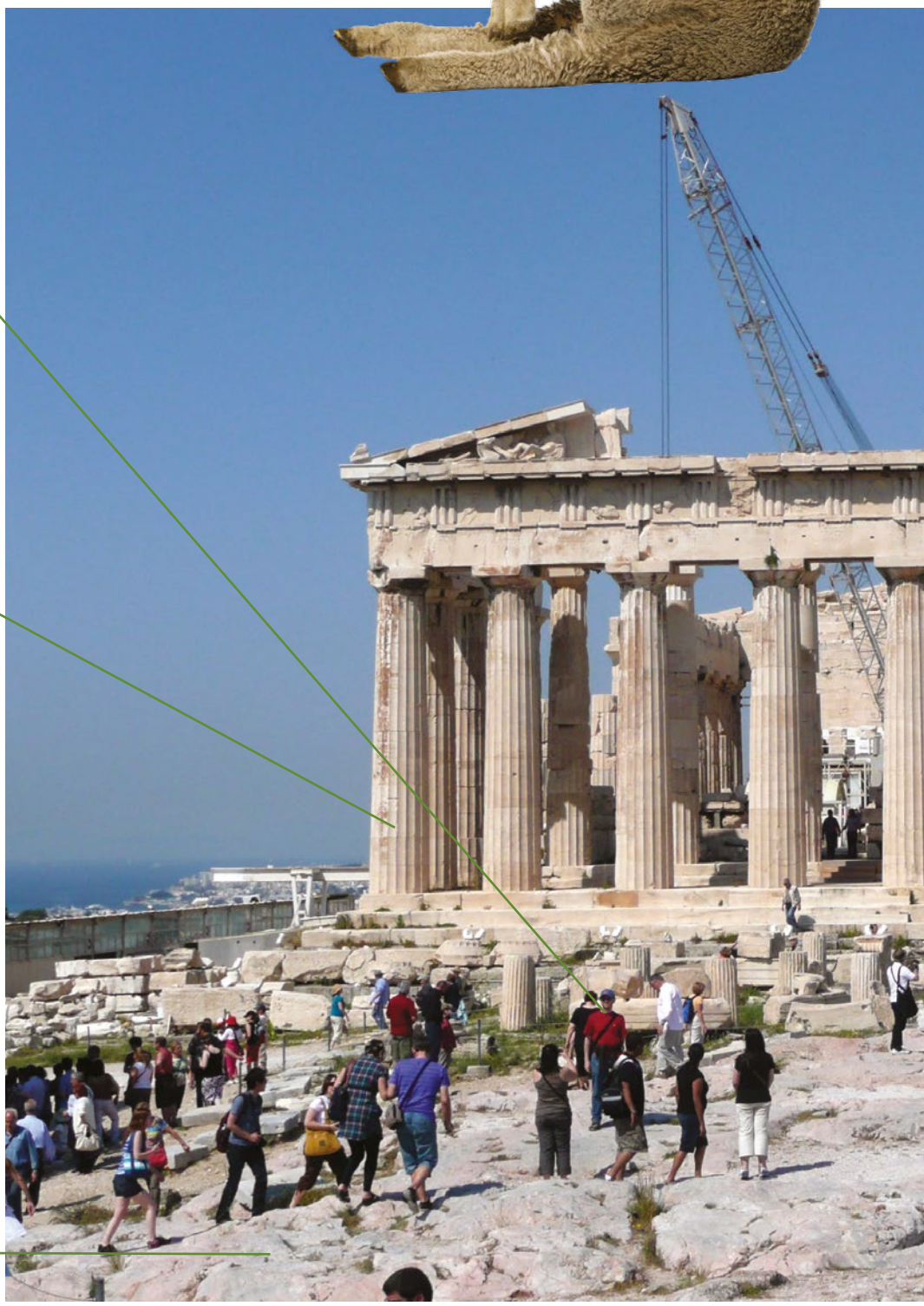


Source: Base map from iStock/Vectorius 2016, data from Baskin Robbins

Source 18: This map of the United States shows the favourite Baskin-Robbins ice-cream flavours.

SHEEPT

SHEEPT is an acronym that helps you remember the reasons why a spatial pattern occurs. This acronym stands for: Social, Historical, Economic, Environmental, Political and Technological.



S Social

Social factors are anything to do with people. Social factors include population, culture, language and religion.

H Historical

Historical factors are anything to do with our past. Historical events, buildings, people and changes to climate all influence what we see in our world today.

E Economic

Economic factors are those relating to money. In geography, how much people earn, how much things cost and how much money is spent can provide us with information about a *place*. Tourism is a huge economic factor for many regions.

E Environmental

Environmental factors are those relating to the natural or human environments on Earth. Humans can manipulate the environment to suit their needs.

Source 19: The Parthenon in Athens attracts tourists wanting to find out about ancient Greek culture, history and democracy.

How do I write a SHEEPT analysis?

SHEEPT is usually used to explain why patterns or distributions may occur in a particular region. It can also be used to expand our thinking when annotating images or considering new geographical content. When completing a SHEEPT analysis, you do not need to use each of the terms directly. Below is an example of how we can write a SHEEPT analysis for an image. The highlighted terms indicate the use of a SHEEPT term. Can you identify all the SHEEPT terms used?

Source 19 is an image of the Parthenon in Athens. This is a historical site that was once used as the city treasury in ancient Greece; however, today is it largely a tourist site. Tourism is important for Greece's economy and many locals are employed in the industry as tour guides or restaurant workers. Many tourists enjoy visiting Greece as it is well known for its warm, sunny weather; beautiful beaches; and rocky cliff faces. When tourists travel to historical or other sites in Greece, they are expected to follow local laws and customs. Because of the age of this historical site, it is constantly renovated with large machinery and monitored by officials to ensure tourists and locals are safe when exploring the grounds.

P Political

Political factors are those to do with the government or leading groups, and these factors usually involve laws and policies.

T Technological

Technological factors relate to the different types of technology used. It could relate to transport or building technologies or even spatial technologies.

Sketches and annotating

Field sketches are an excellent way to record data when you are investigating an inquiry question.

Sketches allow you to annotate movement, patterns or any interconnections you see. Field sketching is not a test of your artistic skills – the idea is to record a simplified version of what you can see.

T Title

1

Provide a heading for your sketch that tells readers what it is and where it is located. You might wish to record both the absolute and relative locations.

O Orientation

2

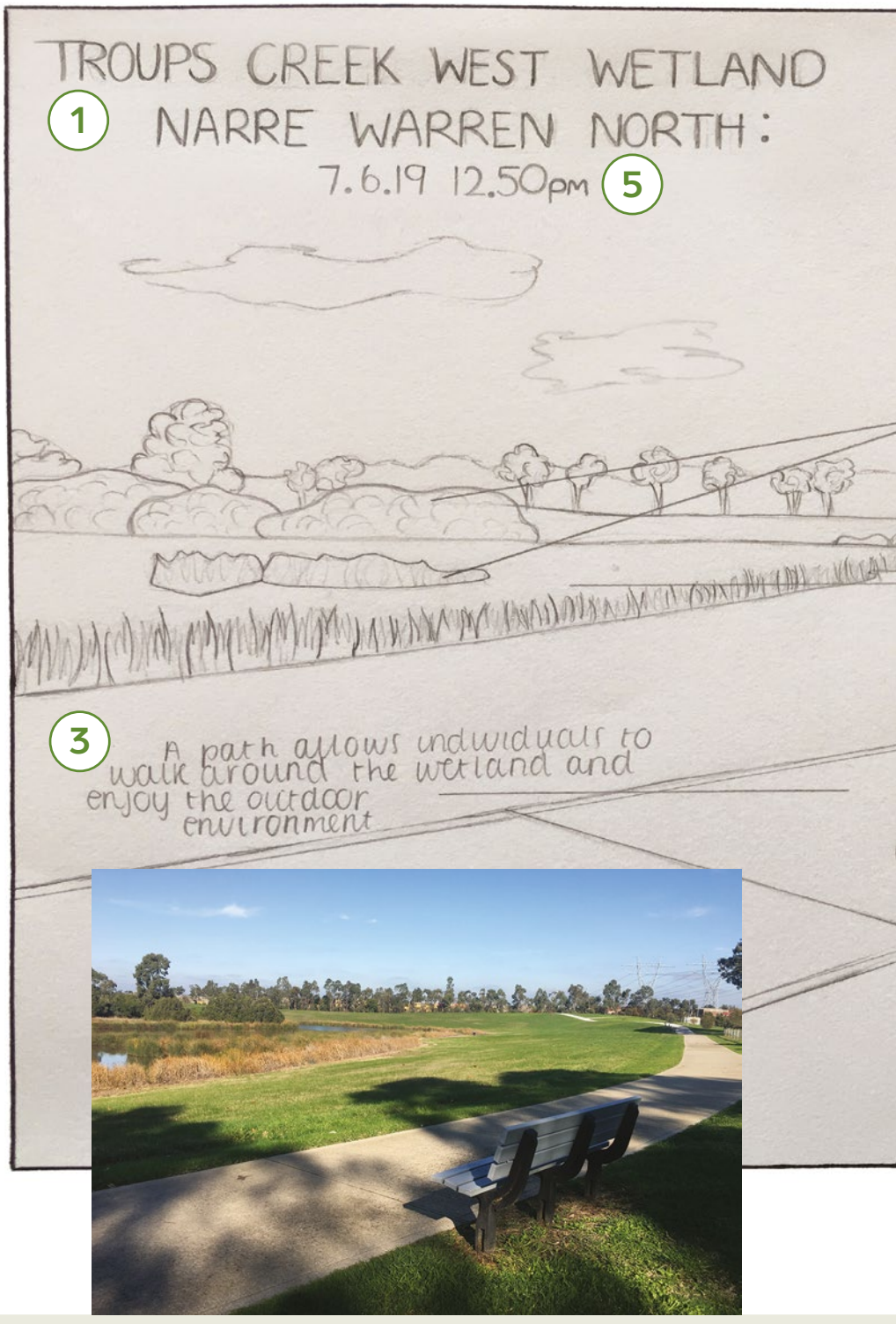
An orientation shows the direction that you were facing when you made your sketch. You need to use a compass so you can record a correct orientation.

A Annotations

3

Annotations (or notes) are the most important thing to complete when drawing a field sketch.

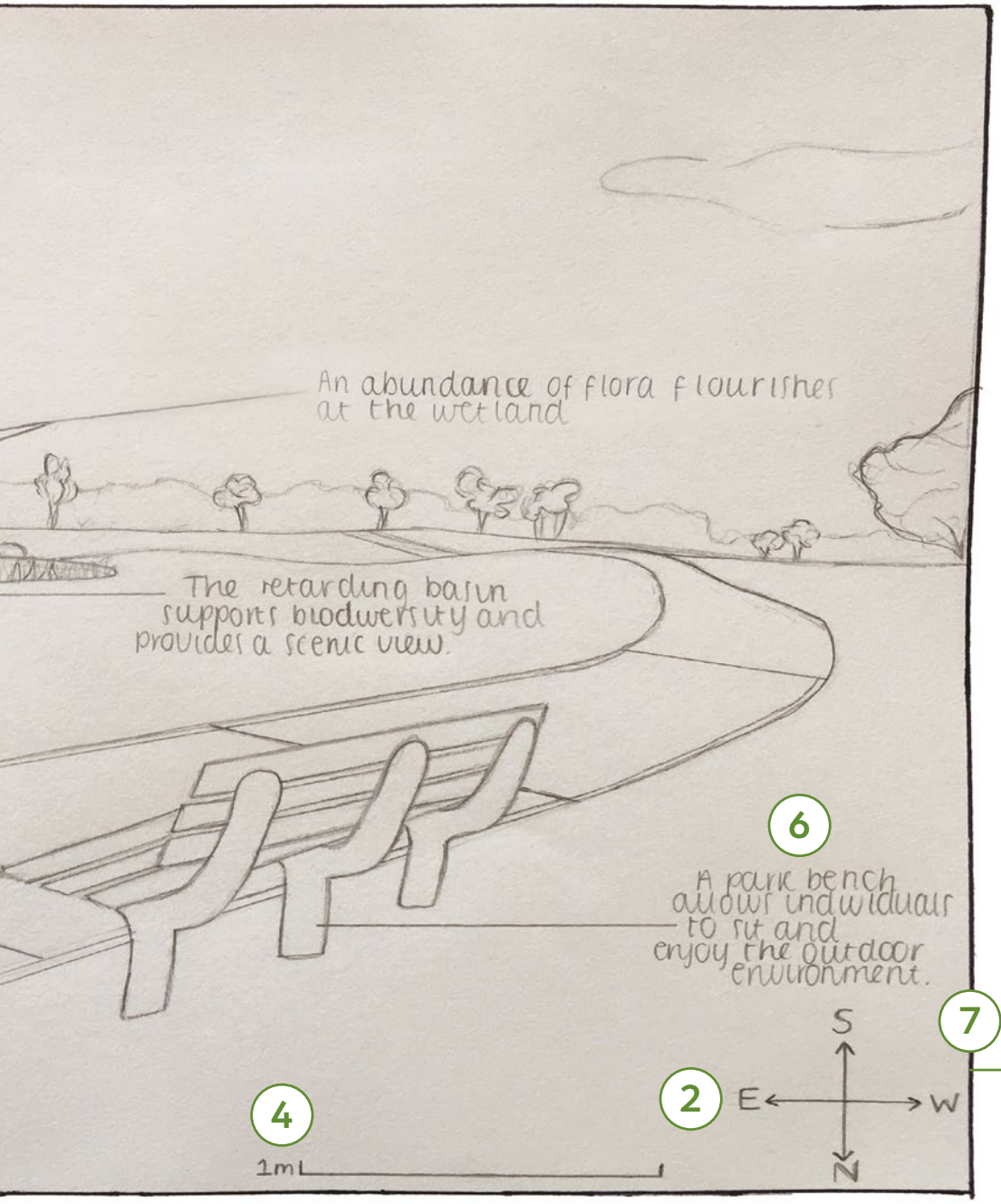
Annotations allow you to record details about what you see, and explain how elements of your drawing relate back to the inquiry question. Make sure that the lines to your annotations are made with a ruler – and that they do not overlap.



When you are making a field sketch, you need to remember TOASTIE!

TOASTIE will help you remember the key skills when making a field sketch.

It stands for Title, Orientation, Annotations, Scale, Time, Information and Edge.



Source 20: An annotated sketch

S Scale 4

Most sketches are not made to scale. However, all geographical maps and sketches require a scale to give the reader some indication of size.

To estimate a scale, use a ruler or pace out the area you have sketched. Then measure how large the same area is on your drawing.

For example, you might estimate that the path you have drawn is 1 metre wide, and when you measure your drawing of the path it is 1 centimetre wide. So your rough estimated scale is 1 cm = 1 m.

T Time 5

By recording the time your sketch was completed, you can analyse how the environment changes over the course of a day, a month or even years.

I Information 6

The annotations on your sketch need to be longer than one word. Annotations should be at least one sentence, and they should inform the reader and help them to identify patterns.

E Edge 7

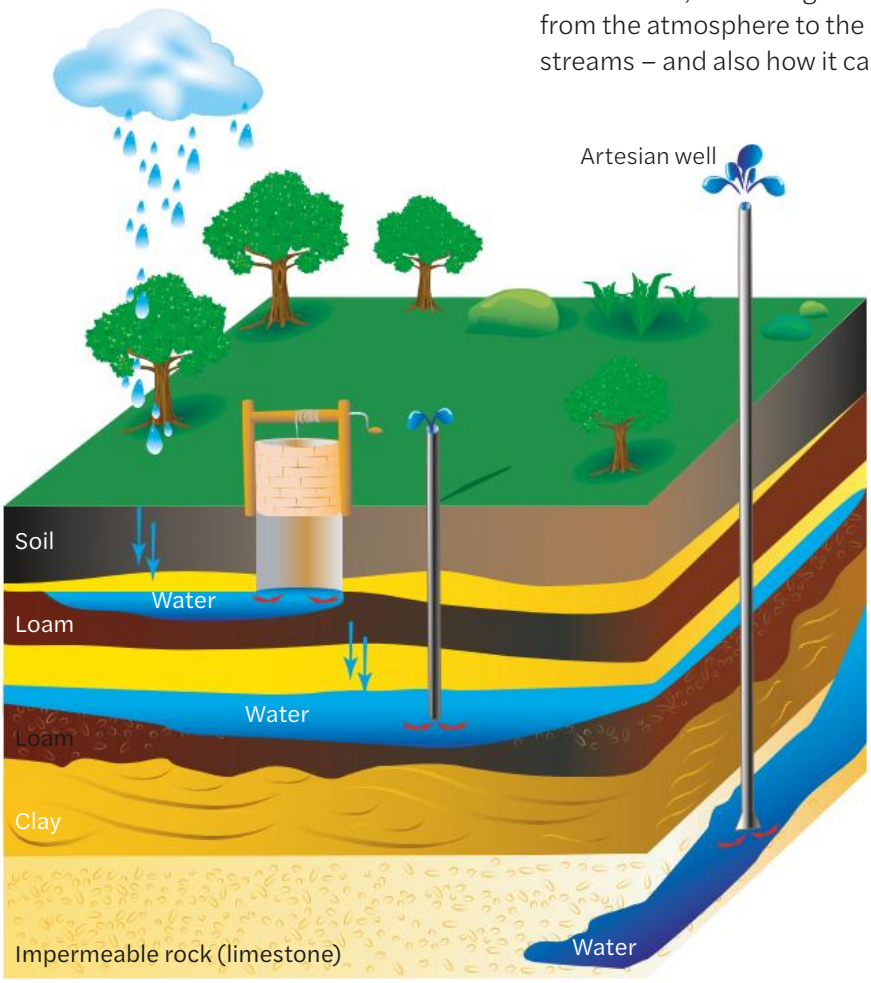
Always include a border so it is clear where your sketch starts and ends.

Visual communication

Block diagrams

Block diagrams give a three-dimensional (3D) view of the land and can show what is happening above and below ground.

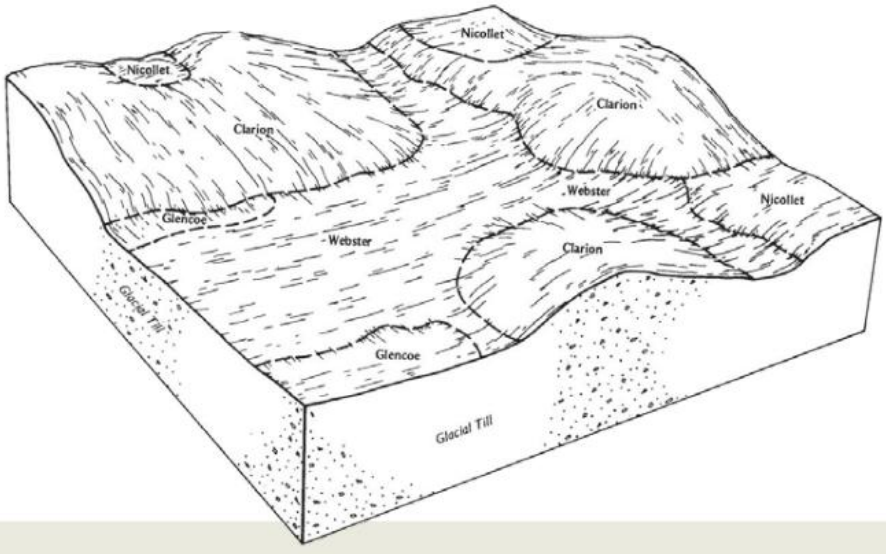
For instance, block diagrams can help us visualise how water can move from the atmosphere to the surface of Earth through rivers, oceans and streams – and also how it can move under the ground.



When you create a block diagram, make sure you draw a 3D object that has an equal amount of drawing room both above and below the surface of Earth.

Labels and annotations are important on a block diagram, as they help your audience to interpret your drawing.

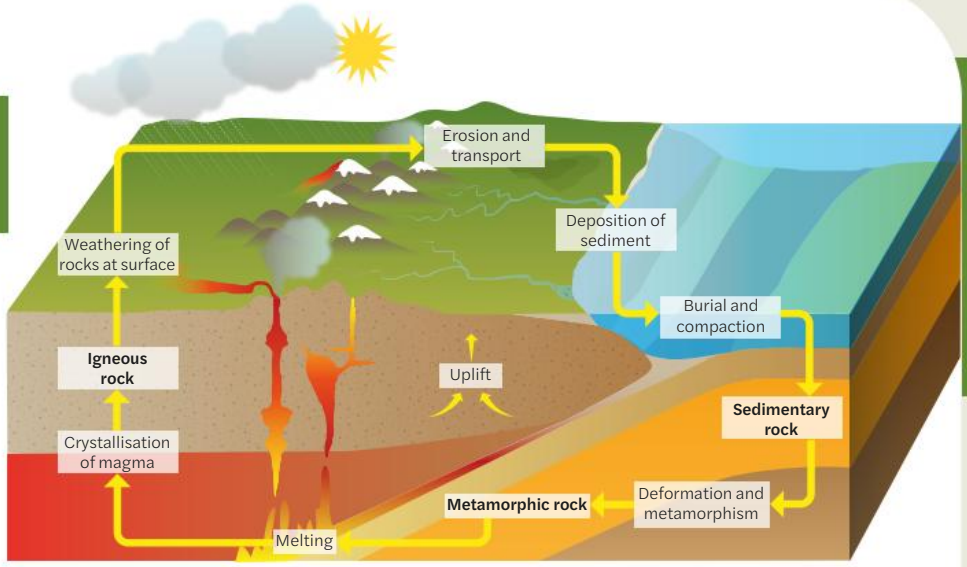
Source 21: A block diagram



Source 22: Sketch of a block diagram

Flow diagrams

Flow diagrams are helpful to show processes or to show how different parts of the environment are interconnected. Arrows show the movement between stages or how different items are connected.



Source 23: A flow diagram

Photo essays

A **photo essay** is a way of presenting information visually. It is ideal for showing characteristics of a place or a process.

A photo essay usually includes a series of photos with specific annotations or captions. The captions provide brief background information about the key features of the image, or the meaning behind the selected image.

Source 24: A photo essay

Preparing sandbags for the flood

Heavy rainfall could create a problem

Floodwaters are rising

The massive clean-up

Graphing

Simple graphs

Graphing is an important way of displaying geographic information. It shows us patterns and changes over time.

When you are creating a graph, the word to remember is SALTS. **SALTS** is an acronym based on the first letters of five key things about graphs: Scale, Axis, Legend, Title and Source.

S Scale

The scale of your graph will depend on the data you are trying to visualise. To find out the axis scale you need for a graph, first find out the 'range' of the numbers, which means finding the lowest value and the highest value, then fill in the numbers in between so you can mark your data points easily.

A Axis

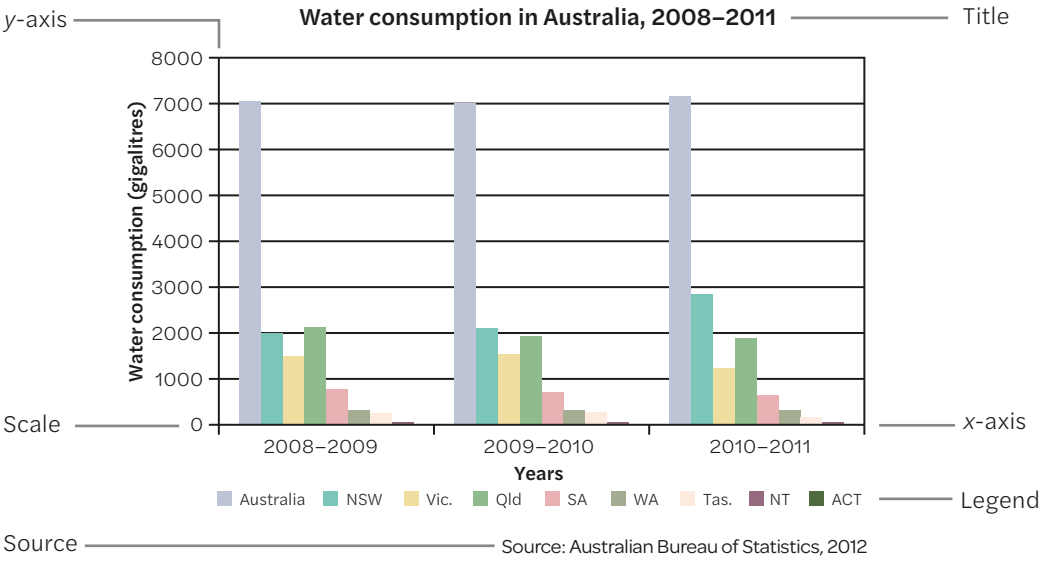
Each graph has an *x*-axis and a *y*-axis. The *x*-axis is the horizontal axis and the *y*-axis is the vertical axis. Make sure you label each axis.

L Legend

A graph often uses colours to represent data. A legend shows the audience what these colours mean and how to read the data.

T Title

A title lets your audience know what your graph is showing.



S Source

When you graph information, it is important to acknowledge where you obtained the data. Maybe you collected it yourself or maybe you sourced it from a website. By stating the source of your information, the reader knows how reliable it is.

Source 25: A bar graph featuring SALTS

Climate graphs

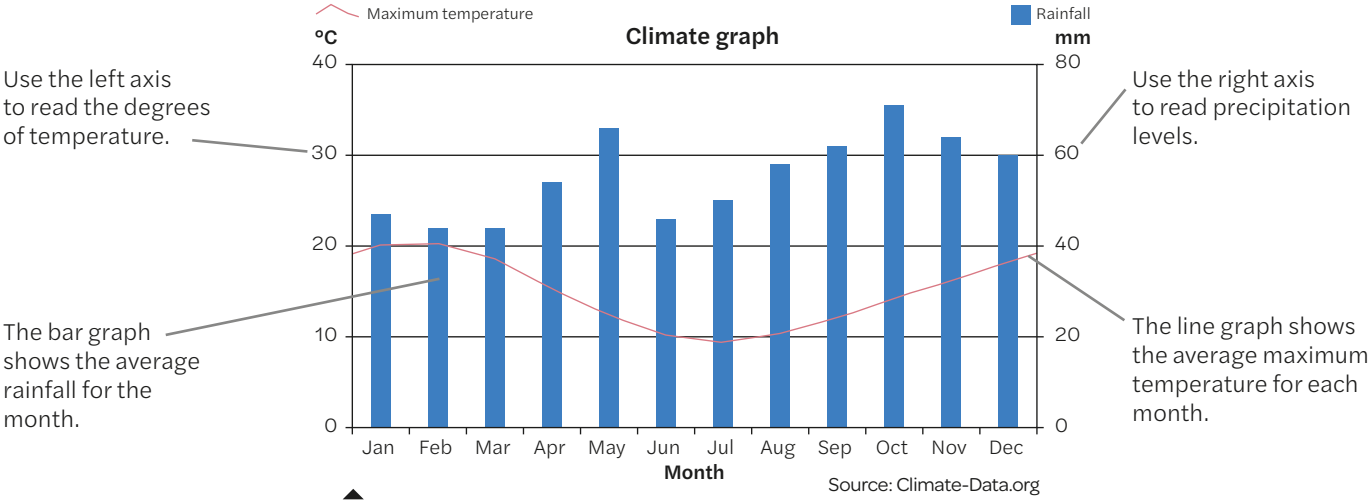
A **climate graph** shows two types of data on one graph. It shows both the average temperature and rainfall that a region usually receives over a year.

How do I read climate graphs?

This climate graph shows:

- maximum temperature (in degrees Celsius) on the left *y*-axis
- rainfall (in millimetres) on the right *y*-axis
- the months of the year on the *x*-axis
- the red line (or maximum temperature) varying throughout the year, peaking December to March and decreasing from April to July in the Southern Hemisphere
- the amount of precipitation varying, shown with the blue bars. In Australia, it tends to be highest in spring from August to November – with the exception of another peak in May.

The best way to describe the patterns we can see in a climate graph is by using two PQE analyses – one for temperature and one for precipitation.



Source 26: A climate graph

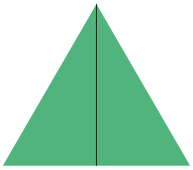
What is the difference between weather and climate?

Look outside your window and describe today's temperature and the amount of rainfall there has been. Is it cloudy? Has there been a thunderstorm or is the sun shining? What you have just described is the weather. Weather changes daily and is usually predictable up to 10 days in advance. Apps on your smartphone and the last five minutes of the television news show you these predictions of daily weather.

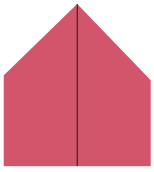
Now close your eyes and describe the climate of Australia. Do you imagine Australia being hot and dry? Just because we can describe Australia as hot and dry, does not mean it is like this everywhere, all year round. Unlike the weather, climate helps us describe the yearly (annual) average temperature and level of precipitation (rainfall and snow) in a region or country.

Climate graphs help us visualise the climate of a region or country. Climate change describes how the average temperature and precipitation levels of a location are changing over time.

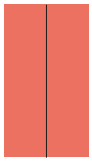
Population profiles



Shape: Triangle
Growth: Fast



Shape: Extended triangle
Growth: Medium



Shape: Column
Growth: Slow

Shape: Reduced pentagon
Growth: Shrinking

Source 27: Various population profiles. The shape of the profile tells you about the population.

Population profiles are graphs that show the percentage of females and males in particular age groups in a population.

Population profiles can be made on a local, national or global scale. On a population profile, female data is normally shown on the right side and male data on the left. The length of each bar represents the number or percentage of males or females in that age group. Source 28 shows the percentage. To calculate the number, use the total population of the place.

The shape of the profile tells us a lot about the population

Population profiles come in different shapes: triangles, columns, pentagons and so on. The shape tells you about the population. If the shape is:

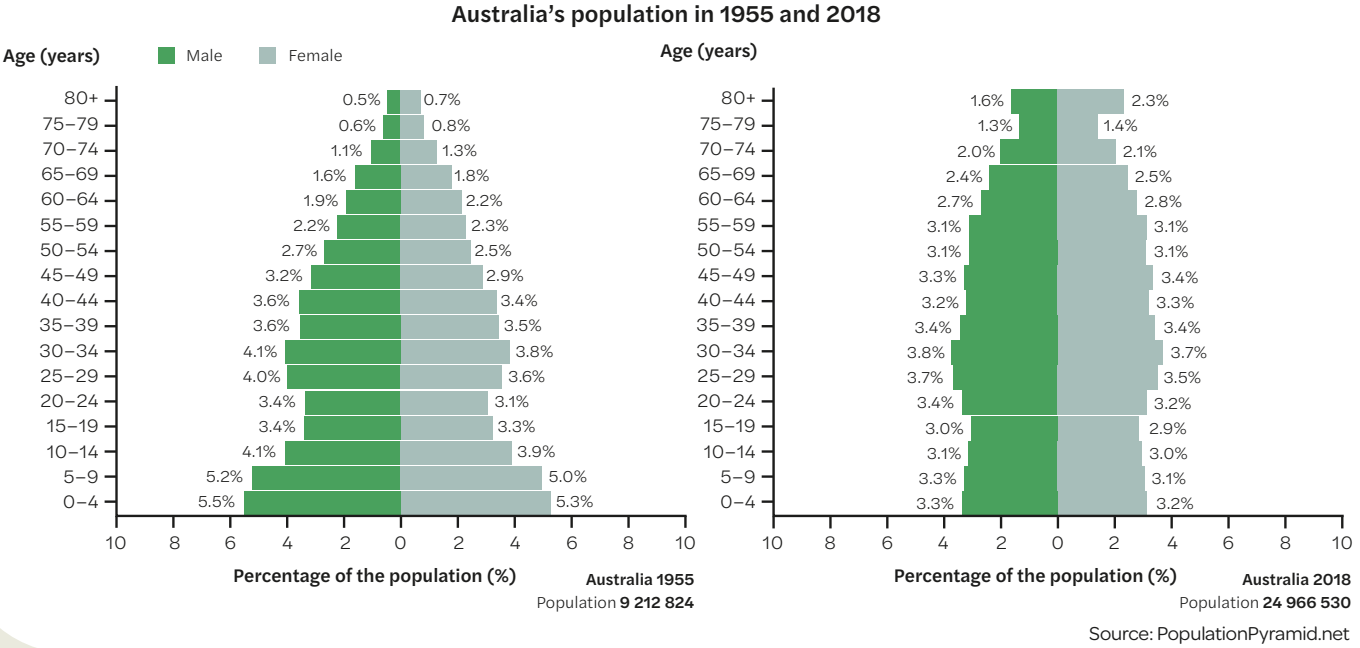
- a triangle: growing population, with more young people than old people
- a box: slow or stable growth, with equal numbers of old and young people
- an upside-down pyramid: aging or declining population, with more old people than young people.

How do I interpret a population profile?

The population profiles in Source 28 show Australia's population in 1955 and 2018. In 1955, many people were in the age range 0–14. Approximately 5.5 per cent of the population were males aged 0–4 years old, and 5.3 per cent were females aged 0–4 years old. We also had many working-age people. For example, 4.1 per cent of the population were males aged 30–34, and 3.8 per cent were females aged 30–34.

In 2018, the percentage of younger people in the population is significantly lower and there are more people in the older age ranges. The total population also grew to 25 million people.

Source 28: Population profiles showing Australia's population in 1955 (left) and 2018 (right)



Source: PopulationPyramid.net

Satellite images

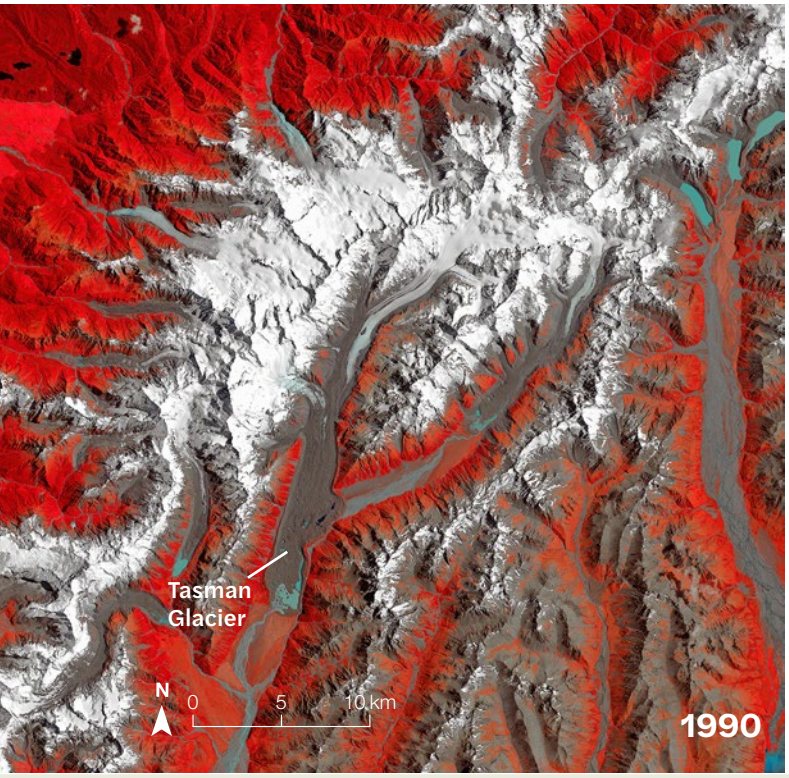
Satellite images are pictures of Earth taken from space. Satellites orbit the Earth and record images of the Earth's surface. We can use this data to see an event, such as a volcanic eruption, or to observe a change in land cover or other spatial patterns over time. Satellite images taken in daylight provide the most information.

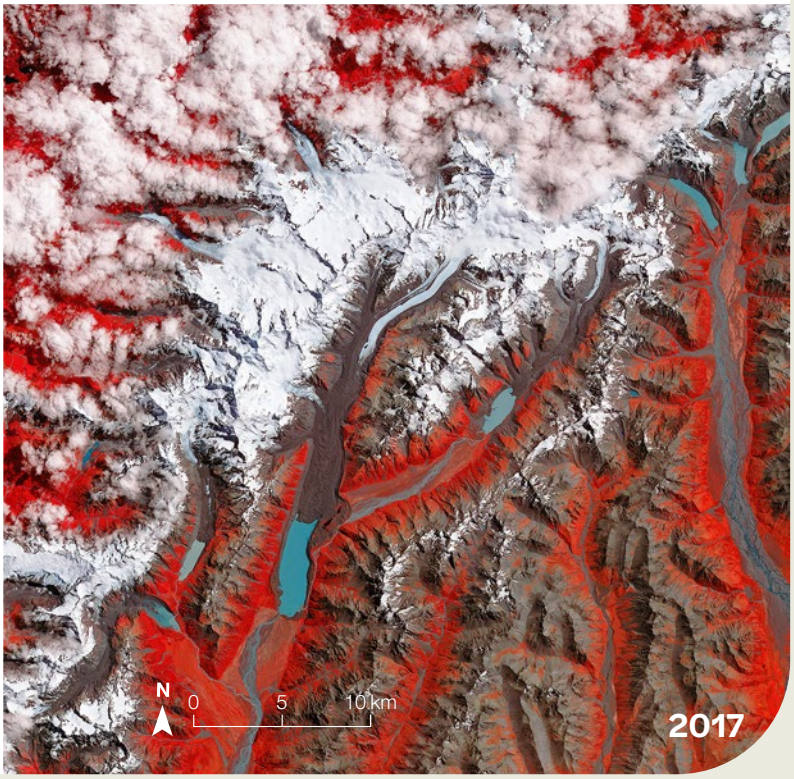
How can I use colour to interpret satellite images?

When you are trying to interpret a satellite image, look for colours and shapes. Colour will normally give you some idea about land cover. For example, in naturally coloured satellite images green usually indicates vegetation, blue is the colour of water and brown is usually desert or barren land. False-colour satellite images substitute colours to make patterns clearer to see. For example, Source 30 substitutes red for green to show vegetation.

White can indicate snow or clouds, so here you need look at shapes. Clouds tend to look fluffy and, depending on the time of day, can cast a shadow onto the ground. Snow is usually on the tops of mountains, and you can see where it is melting or following the slopes. Looking for shapes is also helpful when you are trying to identify rivers or reservoirs, which can be seen as blue lines.

Source 29: Satellite images taken at night provide different information than those taken during the day. This photo of Italy shows the extent of the urban areas through the lights at night.





Source 30: New Zealand's Tasman Glacier satellite images taken on 30 December 1990, and 29 January, 2017. In these false-colour images, white is snow and ice, red is vegetation, blue is water and brown is soil (including sediment-covered glaciers). It can be clearly seen that the Tasman Glacier is quickly retreating, replaced by a glacial lake shown as bright blue.

How to conduct fieldwork

Fieldwork is an important part of geography. It is one of the ways that geographers *learn by doing*, and it is a tool for discovering new things, learning about patterns and relationships, answering questions and exploring the world.

Conducting fieldwork

When conducting fieldwork, geographers collect data. There are two main kinds of data:

- **quantitative data**
- **qualitative data**.

Quantitative data is recorded in numbers; for example, the height of a building, the number of plants on a sand dune, the number of people in a population or the flow rate of a river.

Qualitative data tends to be more observational. You might write down descriptions of a place, conduct a field sketch or take photos as evidence to answer your inquiry question.

Both aspects of data collection are important, and you should try to collect both quantitative data and qualitative data in your fieldwork.

The steps you will follow to conduct your fieldwork study are:

Step 1: Inquiry question and hypothesis

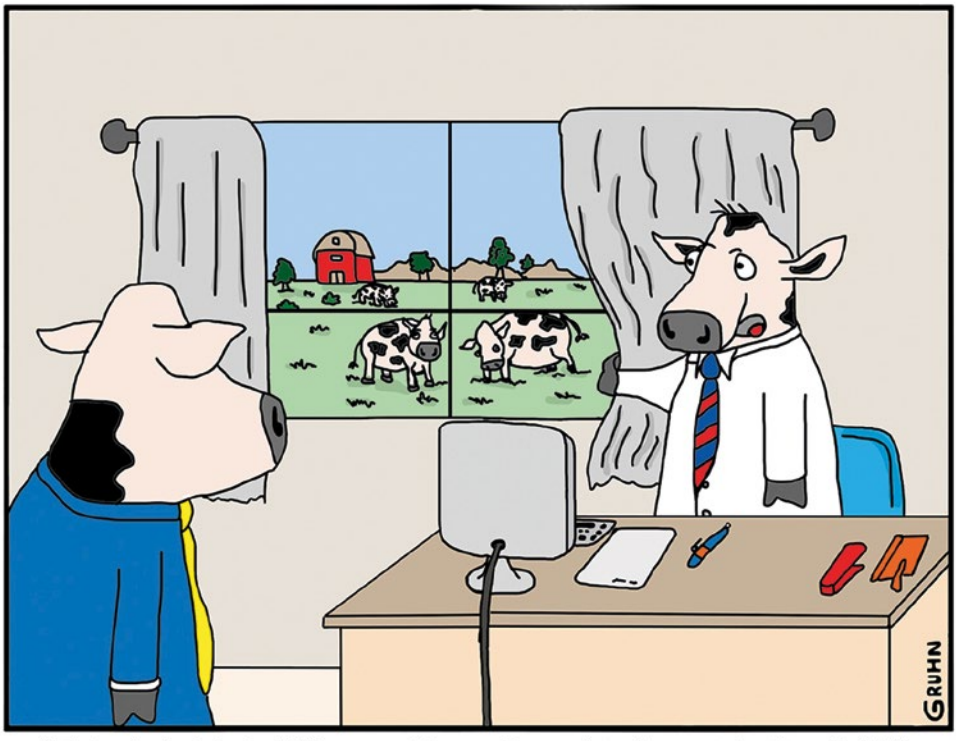
Step 2: Data collection

Step 3: Data analysis.

Before you begin your own fieldwork task, we will explore each of these steps.

1 Inquiry question

An **inquiry question** is an overarching idea that you or your class wants to investigate. A good inquiry question is one that is measurable and quantifiable. You need to be able to collect a defined range of data and answer the question within the limitations you are presented with. For example, will you have to conduct your fieldwork at school? Will you be able to survey members of the public?



"This desk job is killing me Jim. I need to be out in the field."

Source: CartoonStock.com

After developing an inquiry question, you should make the aim of your fieldwork clear. What is it you are hoping to find out using different fieldwork methods? An example aim: To identify features of a local creek to determine the quality of the water.

You could also write a **hypothesis**. A hypothesis is an 'educated guess' about the answer to the inquiry question. It's making a statement about what you think might happen. It is important not to let your thoughts about possible findings from your research influence your data collection and analysis.

2 Data collection

Before you begin any fieldwork study, you need to develop a list of **primary research methods** and **secondary research methods**. You also need to agree, as a class, on your data collection methods.

Primary research methods are things that you will do in the field to find evidence to answer your inquiry question, and to prove or disprove your hypothesis.

Secondary methods are ways that you can collect data back in the classroom to help you answer the question; for example, research using websites, books or other publications.

You can record your methods in a table like the one in Source 1.

3 Data analysis

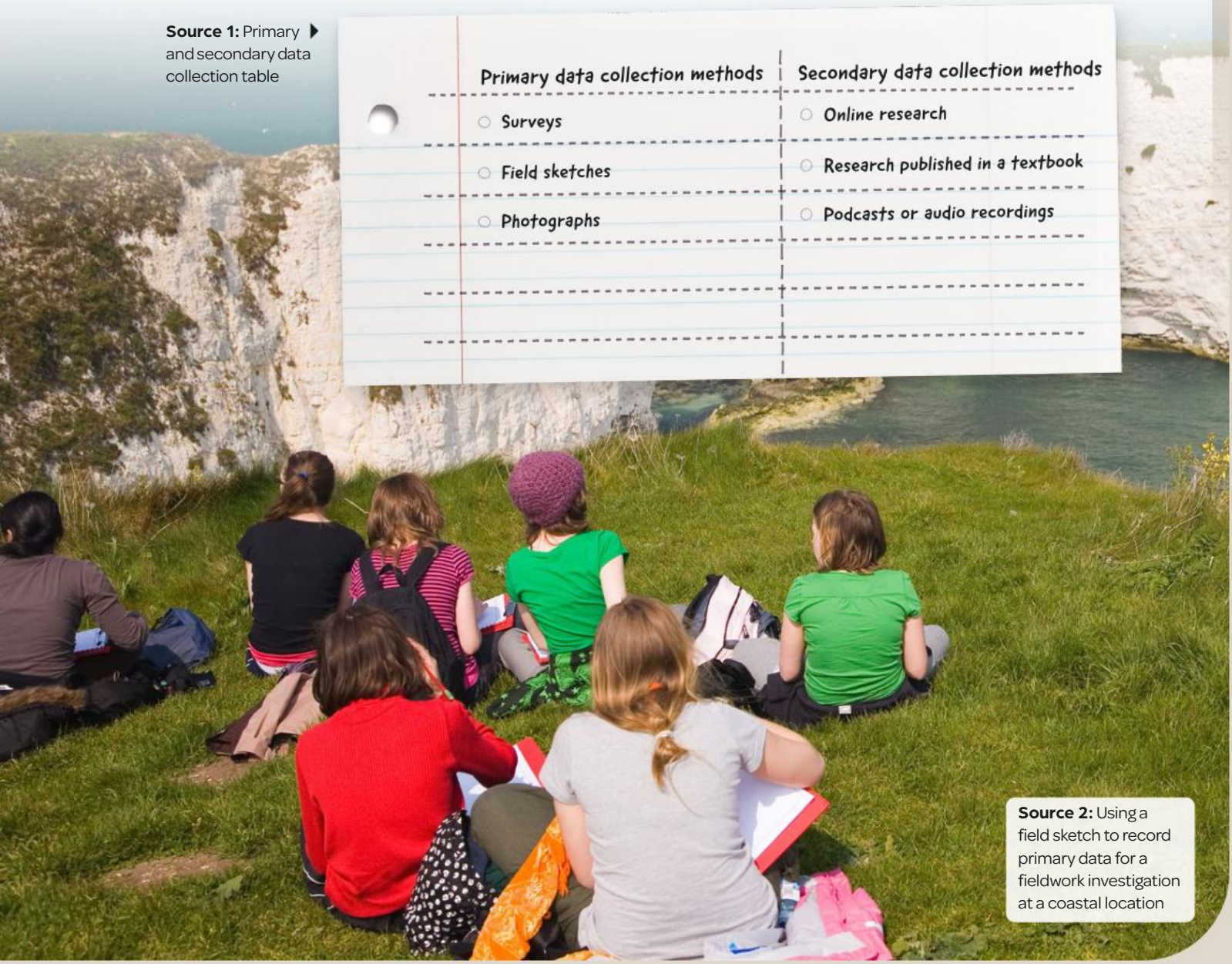
Once you have collected data in the field using primary and secondary methods, you need to communicate your findings.

You can communicate your research via a report, or display it as a visual poster or presentation. When you communicate findings, you need to ensure you highlight any patterns, interconnections or significant data that allow you to answer the inquiry question – and to prove or disprove your hypothesis.

In your study of geography, you will explore water as a resource – its economic, cultural and aesthetic value. You will also look at what makes a *place* liveable. Now you are going to conduct your own research in your local area to answer an inquiry question and write a mini fieldwork report.

Source 1: Primary and secondary data collection table

Primary data collection methods	Secondary data collection methods
Surveys	Online research
Field sketches	Research published in a textbook
Photographs	Podcasts or audio recordings



Source 2: Using a field sketch to record primary data for a fieldwork investigation at a coastal location

How do you use water in your local community?

Domestic water use accounts for only 12 per cent of Australia's total water use – yet Australia has one of the highest rates of water consumption per person in the world. The average daily water use is 340 litres per person, or 900 litres per household. Average water consumption ranges from 100 litres per person in some coastal areas, to over 800 litres per person in the **arid** inland areas.

1 Inquiry question

Source 3: Exploring the edge of the lake

Inquiry question

How is water used in the local community?

Hypothesis

Water is used in a range of ways for both natural and human environments.

Source 4: Recreation in the local pool

2 Data collection

Some primary research methods you could use to collect data are listed below.

- Walk around your local environment and take photos as evidence of water use. Create a photo essay of these water uses, and add short labels to explain each use.
- Create a survey for your classmates or family to identify which type of domestic water use they think contributes most to our daily water consumption per person. Multiple-choice questions work best, as you can then create bar graphs to display your data. Questions you could ask include the following:

> ? Which domestic water use do you think contributes most to our daily water consumption per person?
>
> ☐ Toilets ☐ Sinks ☐ Hoses
>
> ☐ Shower ☐ Other:

> ? How is water used in the local community?
>
> ☐ Pools ☐ Dams ☐ Lakes
>
> ☐ Fountains

- Using appropriate techniques, complete a field sketch of water use, movement or value in your local community.

3 Data analysis

Once you have collected the data, you need to present and analyse your results. Use the steps listed in 'In the field' to help you complete your fieldwork analysis.

In the field

Inquiry question

1 Describe the key differences between primary and secondary research methods.

2 List the primary and secondary methods you will use to investigate the inquiry question.

Data collection

3 Outline the characteristics and history of your local region in four or five sentences.

4 Name two primary fieldwork techniques you used to complete your fieldwork.

5 Name two secondary resources you used in the lead up to the fieldwork.

6 Answer this inquiry question: 'How is water used in the local community?' Consider:
- How many different uses were present in your local area?
- Do you think that water is used wisely in these places?
- Which domestic water use do you think consumes the most water?

Data analysis

7 Which domestic water use was the most reported?

8 Why do you think this is?

9 Were you surprised by these results? Why or why not?

10 Was the hypothesis supported by the evidence? Why or why not?

11 Record five key pieces of evidence that support your answer – these could be data, photos, sketches or surveys.

Evaluation of methods

12 Which methods were the most successful for collecting data to answer the inquiry question? Why?

13 Which methods were the least successful for collecting data to answer the inquiry question? Why?

How liveable is your place?

Every community has elements that can be improved to increase the overall liveability of that place. For example, Source 5 shows an empty housing development piled with bricks and overgrown with weeds. As geographers, we can help town planners develop ideas about how to redesign places such as these – and make more useable spaces for the community.

1 Inquiry question

Source 5: An empty lot, ready for building to begin

Inquiry question

How can liveability be improved in the local community?

Aim

To identify the facilities valued by different groups of people to determine how to improve liveability

Hypothesis

Different groups will value different facilities in the community.

Source 6: Differing levels of liveability

Source 7: Students checking survey and map materials

2 Data collection

Some suggested primary methods you could use to collect data are listed below.

- Walk around your local community and take photos of places where infrastructure could be improved to increase liveability. Create a photo essay of these examples, adding short annotations or labels to explain how they are being used or how they could be improved.
- Create a survey for your classmates or family to identify which areas in the community require improvement. Multiple-choice questions work best, as you can then create bar graphs to display your data. Questions you could ask include the following:

Which aspects of the community do you value?

☐ Hospitals ☐ Schools ☐ Housing estates

☐ Shopping centres ☐ Parklands ☐ Other:

Which aspects of the community need to be improved?

☐ Hospitals ☐ Schools ☐ Housing estates

☐ Shopping centres ☐ Parklands ☐ Other:

- Using appropriate techniques, complete a field sketch of a location that could be altered to improve the liveability of your local area. Annotate the changes that you suggest for this place.

3 Data analysis

Once you have collected the data, you need to present and analyse your results. Use the structure listed in 'In the field' to help you complete your fieldwork analysis.

In the field

Inquiry question

1 Describe the key differences between primary and secondary methods.

2 List the primary and secondary methods you will use to investigate the inquiry question.

Data collection

3 Outline the characteristics and history of your local region in four or five sentences.

4 Name two primary fieldwork techniques you used to complete this fieldwork.

5 Name two secondary resources you used in the lead up to the fieldwork.

6 Answer the inquiry question: 'How can liveability be improved in the local community?' Consider:
- What is the definition of liveability?
- What facilities make your local region or area liveable?
- What facilities could be improved? Why?
- Brainstorm different groups of people within your local community, and suggest what facilities they might value. Give some reasons to back up your ideas.

Data analysis

7 Which facilities do people think make a place more liveable?

8 Are there particular areas in your community that require improvement? Describe these places.

9 Why do you think this is?

10 Were you surprised by these results? Why or why not?

11 Was the hypothesis correct or supported by the evidence? Why or why not?

12 Record five key pieces of evidence that support your answer – these could be data, photos, sketches or surveys.

Evaluation of methods

13 Which methods were the most successful for collecting data to answer the inquiry question? Why?

14 Which methods were the least successful for collecting data to answer the inquiry question? Why?

15 Based on your research, redesign an area in your local region to improve the liveability for the local community.

Source 8: Geography student conducting a field survey

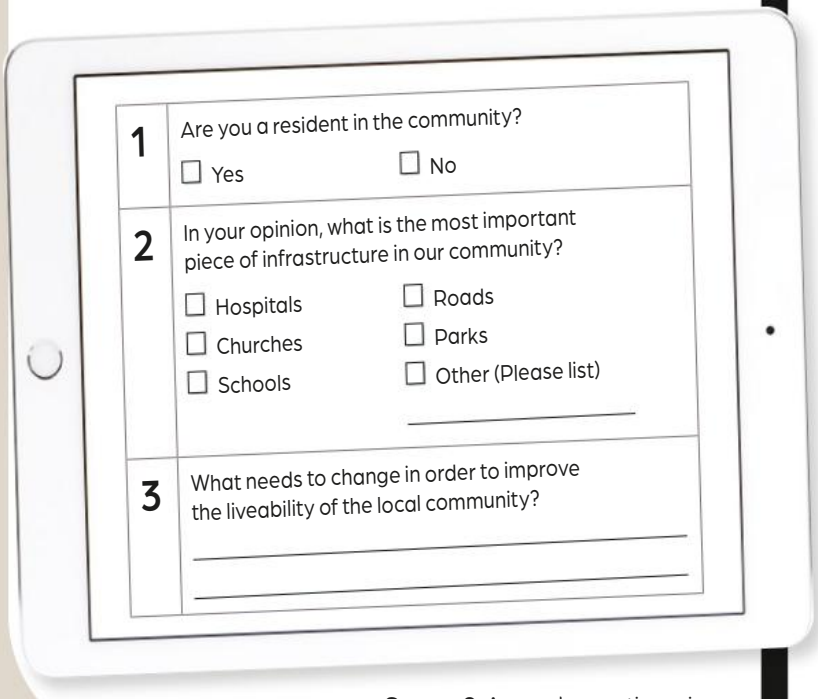
How do geographers use surveys?

In geography, surveys are useful ways to collect data in the field. Surveys could be in the form of a questionnaire, where you ask questions about a topic to better understand people's views.

You can also do a vehicle survey, where you tally the number of vehicles that pass in a particular amount of time. Surveys provide you with a sample of what is occurring in a natural or human *environment*.

Surveys can be written by hand or prepared on software such as Survey Monkey or Google Forms.

Some sample questions for a questionnaire about liveability follow.



▲ **Source 9:** A sample questionnaire

In the field

1. Are surveys a primary or secondary data collection method?
2. There are three main stages to fieldwork: defining the inquiry question, data collection and data analysis. In which stage would a survey be a useful tool?
3. Write a survey question that would gather quantitative data about water use.
4. Write a survey question that would gather qualitative data about water use.
5. Why are multiple-choice questions often used in surveys?
6. Follow these steps to design a survey on a topic you are passionate about:
   - **a** Write an objective for your survey. Think about who will be reading the data and what decisions will be made based on the data you collect. Make sure your objective is short and clear.
   - **b** Write a title for your survey.
   - **c** Write two or three sentences to introduce and explain your survey to the people who will be completing it. Decide whether your survey will be anonymous or not.
   - **d** Choose how you will create your survey: on paper, on your computer using Word or Excel, or using an online platform such as Survey Monkey or Google Forms.
   - **e** Using the method you chose in Part d, write 10 survey questions. Keep your questions short and specific. Try to use multiple-choice questions to make data analysis easier.
   - **f** Swap your survey with someone else in your class. Proofread and evaluate each other's surveys. Give appropriate feedback to your classmate about how they can make their survey more effective.
   - **g** With your teacher's permission, conduct your survey in your class, school or community.

Glossary

A

abrasion the process of scraping or wearing something away

absolute location precise point on the Earth's surface, typically defined by coordinates such as latitude and longitude or a specific address

active (volcano) a volcano that is erupting or likely to erupt in the future

aerial view perspective of a landscape from the air, typically viewed from above

aesthetic value appreciation of how a place looks and its perceived beauty, uniqueness or connection to a person

aid agencies organisations that provide help to people in need, especially during emergencies like natural disasters or in areas where there is poverty

air mass large body of air that is all the same temperature and humidity, and at the same level of pressure

air pollution the release of harmful particles or materials in the atmosphere

aquifer underground layer of water-bearing rock where groundwater can be extracted

archipelago a group or chain of islands that are close together in a body of water, such as a sea or ocean

arid receiving little or no rain

avalanche sudden and rapid downslope movement of a large mass of snow, ice and debris on a mountain

B

backwash water returning to the sea from the beach

basalt a type of dark, solid rock that comes from cooled lava; found in places like volcanic islands or areas near volcanoes

beach nourishment replenishment of a beach by sand from another source

beach stretch of coastline made up of sand, pebbles or other materials, located between the ocean and the land

bioaccumulation gradual build-up of chemicals, toxins or plastics in organisms, typically moving up the food chain

biodiversity variety and abundance of species within an ecosystem

block diagram three-dimensional diagram that shows how a system or feature works

block mountains mountains, often with steep sides, formed when large blocks of the Earth's surface are pushed up by faults (cracks in the Earth's surface)

blowout a depression or hollow formed in a sandy area, typically due to the erosion of sand by strong winds. It often occurs in desert or coastal environments where wind removes loose sand, creating a dip or crater-like feature

bore a large wave that is formed when the tide comes into a narrow area, such as a river or a bay, creating a strong surge of water

breaking wave a wave that is forced to spill forward as the bottom of the wave orbit comes into contact with the sea floor and slows down

breakwater a rock wall built parallel to the beach and located in the water, designed to direct the force of the waves at the wall and not at the beach and sand dunes behind it

bushfires fires that occur in natural vegetation, such as bushland or forests

butte an isolated hill with vertical sides and a small flat top; smaller than a mesa

C

calderas circular volcanic craters formed by the collapse of a volcano after an eruption

carrying capacity the amount of material that can be held in a contained area such as a river

catchment an area where water is collected by the natural landscape

chemical weathering when rocks are broken down by a chemical change

civil war a conflict between groups within the same country, often due to political, economic or social tensions

climate change a change in climate patterns, often refers to an increase in global temperatures apparent from the late 20th century onwards. Also referred to as global warming

climate graph a graph showing average rainfall and temperature for an area over a period of time

climate the average weather in a certain place, over a period of time

clustered grouped or bunched together in a specific space

coastal flooding inundation of coastal areas caused by storm surges, excessive rainfall or rising sea levels

community a group of people connected in some way and with a distinct identity

community of place a community based on a connection to a specific place or region

condensation a process by which a gas (for example, water vapour) is changed to a liquid (for example, water drops)

Connection to Country the deep spiritual, physical, social and cultural relationship between Indigenous Australians and the land

constructive wave a small and infrequent wave that deposits sand on the beach rather than scouring it away; responsible for creating depositional landforms such as beaches, sand dunes, sand bars, spits and tombolos

continent one of Earth's seven main continuous expanses of land; e.g. Asia

contour lines lines on a map that join points of the same height above or below sea level

conurbation a process whereby whole cities merge together into a continuous urban area

convectional rainfall rain that occurs when land heats the air above it, forcing the air to rise

converging margin an area on Earth where tectonic plates collide

Country For many First Nations people, 'Country' refers to the lands, waterways and skyscapes of a particular geographical location. These locations are associated with identity and belonging and cover all parts of the continent of Australia and the adjacent islands. Country encompasses both the physical environment and also cultural connections, stories, lore, law and traditions related to caring for Country and its resources for future generations.

crest the top of a wave; where it peaks

culturally sensitive tourism travelling in a way that considers the sustainability of social traditions and practices and is respectful of people and place

cumulonimbus cloud dense, vertical cloud, formed from water vapour carried by powerful upward air currents; associated with heavy rain and storms

D

dam barrier constructed to hold back water

deforestation the clearing of a forest to make room for a different land use such as farming

delta triangular region of sediment at the mouth of a river

demonstration a protest by a group of people in support of a cause

deposit drop or place in an area, such as the deposition of sediment by a river

deposition formation over time of a layer of soil or rock

desalination process of removing salt from seawater

desert area that receives less than 250 millimetres of rain every year

desertification the process whereby land along the edge of a desert becomes damaged by drought and through overuse by humans, and is replaced by desert

destructive wave a large and powerful wave that constantly crashes onto the coastline, wearing away cliffs and digging out areas of beach

developed countries countries with strong economies, good healthcare, education systems and a high standard of living for most people, usually also featuring advanced technology and infrastructure

dew point temperature below which water begins to condense and dew (tiny droplets of water) is formed

direct action using protests, strikes, petitions and other forms of protest to achieve demands

diverging margin where tectonic plates move apart

dome mountain a mountain that forms when magma is injected between two layers of sedimentary rock, causing the top layer to bulge upwards

domestic tourism travelling within a country that a person lives

dormant (volcano) an inactive volcano that may erupt in the future

drainage basin area of land where precipitation collects and drains into a river, bay or other body of water

dredge to clear or deepen an ocean or river bed by scooping up material with a machine known as a dredger

drought a long period of time when there is little or no rain, causing water shortages that can harm crops, animals and people

dune a mound or ridge of sand or loose sediment piled up by the wind, especially on beaches or in deserts

E

earthquake the sudden shaking of the ground as a result of movement in the Earth's crust

economic value the worth of something in terms of the money or the benefits it provides, such as natural resources, goods, or services that contribute to a country's economy

economy how money is made and used in a country or region, including the production and consumption of goods and services

ecosystem a community of plants, animals and other organisms in their physical environment

ecotourism ways to experience the natural world and learn how to protect, sustain and conserve the environment for future generations

effusive eruptions volcanic eruptions where lava steadily flows out of the volcano with less explosive activity

Elders highly respected members of First Nations communities who hold and share cultural knowledge, including lore, law, story, song, dance and other highly specialised and complex knowledge and wisdom, and have important responsibilities to guide younger generations

El Niño Southern Oscillation (ENSO) a weather pattern that occurs when the ocean water in the Pacific Ocean becomes warmer than usual, leading to big changes in weather such as heavy rains or droughts in different parts of the world

embers small burning pieces of wood or coal from a fire that can be carried through the air and reignite flames

environmental resource any material from the environment that is useful or valuable to society; these can be renewable, non-renewable or perpetual resources

epicentre the central point of a difficult or unpleasant situation, such as an earthquake or a pandemic

equator a line separating the Earth halfway between the poles, dividing the Earth into northern and southern hemispheres

erosion removal and relocation of soil or rock by water, wind or ice

evaporation process by which a liquid (for example, water) is changed to a gas (for example, water vapour)

even balanced arrangement across a space

exception something that does not follow or fit within the overall pattern

explosive eruption either where magma full of bubbling gas explodes as it reaches the surface (a Plinian eruption) or magma reacts with water to create a steam-blast (a phreatic eruption)

export selling and shipping of goods and services to another country as part of trade

extinct (volcano) a volcano that is unlikely to ever erupt again

F

fairtrade a way of doing business that makes sure producers in developing countries get a fair price for their products, and helps improve their living and working conditions

fieldwork practical, hands-on geographical investigation conducted in the real world to collect primary data

fissures narrow cracks in the Earth's surface caused by volcanic activity, tectonic movements, or the drying and shrinking of the earth

flash floods rapidly occurring floods caused by sudden, intense rainfall, often leading to severe water build-up in a short time

flood large amounts of water overflowing onto dry land

floodplain area of ground next to a river that floods when the river waters rise

flow diagram visual representation that illustrates a process and the connections between its steps

flow landslide the movement of earth, rock or debris down a slope because of excessive rainfall or an earthquake

fold mountain a mountain that forms when two tectonic plates collide and rock is folded upwards

folding the bending of tectonic plates which form mountains

forced migration movement of people against their will due to conflict, persecution or natural disasters

fossil fuel fuel made from the decomposed remains of things that lived millions of years ago (for example, coal, oil)

fresh water any naturally occurring water that is not salt water, including water in ice sheets, ice caps, glaciers, icebergs, ponds, lakes, rivers, streams and groundwater

frontal rainfall rain that occurs when a mass of cold air pushes up warm air

fronts where two different air masses meet often causing changes in weather

frostbite damage to body tissues caused by exposure to extreme cold, typically affecting the nose, fingers or toes

G

geographical characteristic naturally occurring feature of a place, such as its landforms and ecosystems

geomorphic hazard a danger that originates at or near Earth's surface, such as a volcanic eruption, an earthquake or a landslide

geomorphic processes erosion, weathering and deposition which shape landscapes and landforms

geothermal energy thermal energy generated and stored in the earth

glacier mass or river of ice that slowly moves down a mountain or valley, carving a u-shaped valley as it goes

global positioning system (GPS) a satellite navigation system used to determine the position of an object or person on the ground

global trade the exchange of goods and services between countries around the world; involves importing (bringing goods in) and exporting (sending goods out)

gorge narrow valley between hills or mountains, usually with steep rocky walls and a stream running through it

graben dropped blocks along a fault line in the formation of block mountains

green belt undeveloped areas around cities set aside for open space

green wedge undeveloped areas within cities that have been set aside for open space

greenwashing companies use misleading marketing to appear environmentally friendly while not actually following sustainable practices

Gross Domestic Product (GDP) the total value of all goods produced and all services provided in a country over a year

groundswell wave a steep and fast wave formed by a strong wind storm in the open ocean that creates long wavelength waves that move quickly into shallow water before breaking

groundwater water that is located under the Earth's surface in rock or soil

groyne a wall that extends out from a beach into the sea, designed to trap the sand moving along the beach and also direct waves away from the shore, reducing erosion

H

headland narrow, high land jutting out into the sea, formed of harder rock that resists erosion

headwater source of a river or stream

hierarchy a system in which people or things are arranged in order of rank or importance. In geography, it can refer to how places are ranked or organised based on factors like size, population or importance.

high-income country country with an average annual income of US$12 376 or more per person

horst uplifted blocks along a fault line in the formation of block mountains

hot spot a location on the where tectonic plates move over very hot parts of Earth's mantle and rocks melt to generate magma for volcanic activity

humanitarian organisation organisation that provides aid or assistance to people in need; for example, Red Cross

hydroelectric electricity generated by the movement of water

hydroelectricity electricity that is produced by water-powered generators

hypocentre the point underground where an earthquake starts

hypothermia life-threatening medical condition resulting from having an abnormally low body temperature

hypothesis an educated guess or idea about how something works, based on facts or observations; it can be tested through experiments or further investigation

I

ice cap covering of ice over the ground in a large area, especially in the polar egions

ice sheet layer of ice covering a large area of land for a long period of time

ice shelf floating platform of thick ice attached to a land mass

iceberg large floating mass of ice that has detached (or calved) from a glacier or ice sheet and is floating in open ocean

import bring goods and services into a country from another through trade

Indian Ocean Dipole (IOD) a climate phenomenon where the sea surface temperatures in the western and eastern parts of the Indian Ocean become unusually different from each other; this affects weather patterns, including rainfall and storms in nearby areas

infant mortality death of children who are one year old or younger

infiltration process where water (rain, hail or snow) soaks into the soil

infrastructure physical and organisational requirement needed for the operation of a society; for example, roads, water supplies

inquiry question an open-ended question to prompt an investigation

inselberg an isolated steep-sided mountain, uncovered as the softer land around it is eroded away

inter-plate earthquakes earthquakes that occur at plate boundaries

internal migration migration of people within the boundaries of a country or region

internally displaced person person forced to flee their home and shelter elsewhere within their country's borders

international migration migration of people from one country to another

international tourism travelling to different countries to visit places of interest or enjoy vacations; this helps share cultures and brings money to local economies

internet a global network of computers that allows people to access information, communicate and share content with each other from almost anywhere in the world

intra-plate earthquakes earthquakes that occur within a tectonic plate rather than at a plate boundary

inundation flooding of an area

irrigation watering of crops and pastures from a water source other than precipitation (for example, with water from a river or lake)

isobars lines on a weather map that show areas with same air pressure

K

karst landscape formed by the erosion of rock, often limestone, creating features like caves, sinkholes and underground rivers

L

lahar a fast-moving mudflow of volcanic ash and rock that flows down the slopes of a volcano either during an eruption or following heavy rains after an eruption

landform a natural feature of Earth's surface such as a mountain, valley, sand dune or cliff

landscape all the visible features of an area of land, including landforms; different types of landscapes include coastal, desert, riverine, mountain and polar

landslide the mass movement of soil, rock and debris down a slope

latitude a measurement in terms of something's distance north or south of the Earth's equator

lava the name given to magma when it reaches Earth's surface

less economically developed country (LEDC) low-income country experiencing severe barriers to development; also referred to as developing country

levee a wall built next to a river to stop it from overflowing

life expectancy the average number of years a person is predicted to live

linear arranged in a straight line

liveability a measure of the qualities and characteristics of a place where people live

liveable easy or pleasant to live in

lobby an attempt by individuals or groups to influence the decisions of government and public opinion on issues such as deforestation, pollution and the impact of introduced species

lock a device used for raising and lowering boats between different levels on waterways, such as a weir

longshore drift the movement of sand in a zigzag fashion along the beach until it meets an obstacle such as a headland or groyne

low-income country country with an average annual income of US$1045 or less per person

M

magma liquid rock from the mantle beneath Earth's crust that rises through volcanic vents to Earth's surface

malnutrition lack of proper nutrition from one's diet, leading to health problems

mantle the solid layer under Earth's crust in which parts can melt into magma and move to the surface through volcanoes

manufacturing process of making products

map scale tool that shows how distances on a map compare to real-world distances

marketing action to promote the selling of a product or service

mass wasting the movement of rocks downhill due to gravity, such as rock falls and landslides

meander bend or curve in a river or road

mechanical weathering a process whereby rocks are broken into pieces by changes in temperature, being split open by expanding roots or ice

megacity a highly urban city with 10 million or more people

mesa a broad, isolated flat-topped landform found in desert areas; the eroded remains of a wide plateau

meteorologist scientist who studies and forecasts weather and atmospheric conditions

middle-income country country with an average annual income of US$1046–$12 375 per person

monsoon seasonal wind, occurring in the Asia and Pacific regions, that brings large amounts of rain

more economically developed country (MEDC) a country with a strong economy, in which most people have access to good education, health care and employment opportunities

mountain a large **landform** that sits above the surrounding land, usually in the form of a peak; steeper than a hill

mountain range a series of peaks and high land linked in a line

multi-faith embracing and respecting multiple religious faiths

N

natural disaster natural event, such as a landslide, which causes widespread damage and loss of life

natural hazard natural process, such as a landslide, which could cause damage, injury or loss of life

nomadic choosing to move from place to place over time to find better conditions, rather than living in one location

non-renewable resource resource that cannot be regenerated or replenished within a human timescale once it is used up (for example, coal, oil)

northern hemisphere the half of the Earth that is located north of the equator

O

oasis place in a desert where groundwater has come to the surface creating a green or fertile area

observational scale a way of estimating the size, extent or duration of something based on what is perceived

offset method of indirectly reducing carbon emissions by compensating through activities such as tree planting or investing in renewable energy projects

orographic rainfall rain that occurs when warm, moist air is lifted over a mountain

overtourism excessive numbers of tourists visiting a place, leading to negative environmental, social and economic impacts

P

paddy field planted with rice that grows in water

pandemic a disease that spreads in multiple countries around the world at the same time, usually affecting a large number of people

pattern repeated sequence of events, features, or phenomena that can be observed in data or the environment

per capita a term used to indicate the average amount of something per person in a group or population, such as income, consumption or resources

perpetual resource natural resource with an unlimited supply (for example, wind, sun)

phenomenon something that is observed to exist or happen

photo essay series of photographs used to present information visually

phreatic eruption an explosion of steam, water and gas from a volcano, caused when groundwater comes in contact with hot lava or magma below the surface

physical weathering the breakdown of rocks by wind, water and temperature changes

place a location that is given meaning through human experiences, emotions and connections

plate tectonics movement of the Earth's crust caused by shifting tectonic plates, which can lead to continental drift, earthquakes and volcanic activity

plateau a large flat area of land that is high above sea level

plunge pool deep basin at the foot of a waterfall created by the action of the falling water

polar the regions at the Earth's North and South Poles, characterised by extremely cold temperatures due to low solar energy and prolonged periods of darkness in winter

population density a measure of how many people live in a particular region or area

population profile a pyramid-shaped graph that shows the distribution of age and gender within a population

precipitation water that falls from the atmosphere to the ground as rain, snow, hail or sleet

primary dune a mound of sand at the rear of a beach

primary research methods collecting firsthand data, such as through fieldwork, surveys, experiments or interviews

production the process of making goods or services, often in factories or farms, to be sold or used

prognostic charts weather maps that predict atmospheric conditions and future weather patterns

pyroclastic flow a huge avalanche of hot gas and tephra that can move at speeds of up to 700 kilometres per hour and heat to temperatures of 1000°C, destroying everything in its path

pyrocumulonimbus clouds thunderstorm clouds formed by intense fires, which are able to produce lightning and ignite new fires

Q

qualitative data non-numerical data based on qualities or characteristics

quantification using numerical data in descriptions or explanations

quantitative data numerical data based on measurements or counts

R

rain gauge device that measures the amount of rain that falls in an area

random occurring by chance or accidentally

recycle convert into reusable materials

reef a long line of jagged rock, coral or sand sitting just above or below the surface of the ocean

refraction a change in the direction of a wave as it approaches land

refugee a person threatened by conflict or a natural disaster who is forced to flee their home to seek safety, food and shelter in another country

remoteness the state of being far away from other places, often making it harder to access or connect with those areas

renewable energy energy that comes from natural sources like the sun, wind or water, which can be continuously replenished

renewable resource a natural resource that can regenerate or replenish within a human timescale (for example, trees)

reservoir human-made or natural water storage area that collects and retains water

reverse osmosis process in which a solvent is pushed through a membrane into another solution

rift valley a valley with a wide, flat floor caused by dropped blocks known as graben from the formation of block mountains

Ring of Fire a region around the Pacific Ocean known for its high level of volcanic and earthquake activity; shaped like a ring and includes Japan, Indonesia and the west coasts of the Americas

riverine floods excessive rainfall leading to rivers overflowing their banks and inundating surrounding areas

rock cycle the continuous process of rock formation, transformation and recycling

run-off water that flows over the surface of the land and into rivers and lakes

rural-to-urban migration a form of migration where large numbers of rural dwellers move to urban areas with the promise of better job opportunities and services

rural–urban fringe region on the edges of cities that is close to rural areas or towns

S

safe water water that is safe to drink and free from contamination

salt pan shallow region where salt water has evaporated, leaving a layer of salt on the ground

SALTS acronym for Scale, Axis, Legend, Title and Source

sand bars ridges of sand built up by waves and currents over time

sand dunes hills of sand formed over time by the wind

satellite image image of Earth taken from space

saturated zone area deep below the soil where all the spaces between soil and rock particles are filled with groundwater

sea change decision to move to a coastal location for a better lifestyle

sea level the average height of the ocean's surface, used as a reference point for measuring the elevation of land or other water bodies

sea wall a wall that runs parallel to the shore at the back of a beach, designed to stop erosion by waves and storms and protect the paths, roads and houses built along the shore

secondary research methods gathering information and data from existing sources collected by others, such as books, reports or databases

sedimentary rock formed over a long period by sediment deposits

sedimentary rock a rock that forms when layers of sediment are pressed together by the weight of overlying rock

seismic wave a wave generated from the sudden release of energy in or beneath Earth's crust during an earthquake

semi-desert region that is dry but receives more regular rainfall than a desert

settlements places where people establish communities and live

SHEEPT acronym for Social, Historical, Environmental, Economic, Political and Technological factors

sketch simple drawing made to record data when in the field

skilled worker a worker with specialist training or qualifications

slum a highly populated residential area with densely packed, poor-quality housing with few services, often inhabited by people living in poverty and with few choices of where to live

southern hemisphere the half of the Earth that is located south of the equator

Southern Oscillation Index (SOI) measures changes in air pressure between the central and eastern tropical Pacific Ocean and the western Pacific Ocean; used to help predict weather patterns like El Niño and La Niña, which influence global weather

spatial scale the size or extent of a space, sometimes described using local, regional, national or global levels

spatial technology computer systems that interact with real-world locations in some way

spheroidal weathering the rounding of rocks caused by chemical weathering where rocks disintegrate along the edges and corners are rounded by water coming from more than one direction

SPICESS the 7 geographical concepts — Space, Place, Interconnection, Change, Environment, Sustainability and Scale — used to understand and examine geographic issues and relationships

spit a narrow bar of deposited sand linked to the coast

spot fires small fires started by embers from a larger fire, often igniting ahead of the main fire

spring groundwater from an aquifer that makes its way to the Earth's surface

stack a pillar of rock separated from cliffs or created from a collapsed arch

storm surges a quick rise in sea level because of strong winds during a storm, which can lead to coastal flooding

stratovolcano a volcano characterised by tall, steep sides, which is made of layers of hardened lava and ash from repeated eruptions

stream gauging station location where the speed, height or volume of a body of water can be measured

strike-slip faulting a type of fault in the Earth's crust where two plates move horizontally past each other

subduction the process whereby a continental plate meets an oceanic plate, and the oceanic crust bends and moves down toward the upper mantle where the edge of the plate melts into magma that feeds volcanoes along the converging margin

suburb a medium-density region of housing that surrounds the central business district of a city

supply chains the connections between suppliers, manufacturers, distributors and purchasers that enable the production and delivery of goods and services

sustainability protecting and maintaining environments, communities and economies for future generations

sustainable able to be maintained at a certain level, such as energy or air quality

swash water and suspended materials such as sand flowing onto the beach

swell a collection of waves formed by winds that can travel for long distances through the ocean; measured from the crest to the trough

synoptic charts maps used to identify weather patterns and atmospheric conditions, such as air pressure, wind and rainfall

T

tailings waste leftover after mining valuable minerals

tariffs taxes on imports or exports to support local industries or raise domestic revenue

tectonic plate massive slab of solid rock that moves extremely slowly across the surface of the Earth

temporal distance the time it takes to move between two locations

temporal scale the time-period over which phenomena occur

tephra solid material ejected from a volcano during an eruption, such as volcanic bombs and ash

terra nullius a Latin term meaning 'nobody's land', historically used to describe land seen as uninhabited or without recognised ownership

terrace flat area on the side of a hill, used for agriculture

TOASTIE acronym for Title, Orientation, Annotations, Scale, Time, Information and Edge

tombolo a landform that forms when waves deposit a bar of sand to link an island to the coast

tourism the business of providing services for tourists such as accommodation, transport, tours and other activities

trade the buying, selling, importing and exporting of goods and services between individuals, businesses or nations

training walls walls built on either side of a river mouth to stop sand from blocking it

transform margin where the edges of tectonic plates slide past one another; the plates can become stuck and then break free with a sudden movement, triggering an earthquake

transnational corporations (TNCs) companies that operate across multiple countries, managing production and services on a global scale

transpiration water vapour leaving plants through their leaves

tree change decision to move to a rural location for a better lifestyle

tropical used to describe the climate in the areas of the world between the Tropic of Cancer and the Tropic of Capricorn

tropical cyclone a spinning column of air that forms when a low-pressure system develops over warm tropical oceans (above 26.5°C). Cyclones are characterised by strong winds and heavy rainfall; also known as hurricanes or typhoons in different parts of the world

trough the bottom of a wave

tsunami a huge ocean wave generated by an offshore earthquake, volcano or landslide

turbidity the cloudiness or haziness of a liquid (often water) caused by particles, like dirt or algae floating in it, often making the water look murky

turbine machine for producing power where a wheel or rotor, usually fitted with vanes or blades, is made to revolve by a fast-moving flow of water, steam or other fluid

U

uneven a distribution that is not uniform and has irregular patterns

uniform an even distribution that follows a consistent and clear pattern

urban based in or relating to a city or large town

urbanisation an increase in the proportion of people living in urban areas

urbanised living in or based in cities

V

valley low area of land between hills or mountains

virtual water total amount of water needed to produce a crop or product

volcanic bomb large rocks launched high into the air during an explosive volcanic eruption

volcano a vent in Earth's crust from which lava, gas and ash can pour during a volcanic eruption

W

wadi a dry watercourse in a deep gorge that divides a plateau

water balance the flow of water in and out of a system

water cycle the natural process by which water circulates between the Earth's oceans, atmosphere and land, involving precipitation, drainage in streams and rivers, and return to the atmosphere by evaporation and transpiration

water poor lacking in natural water resources

water resource natural body of water that can be used for different purposes

water rich having a large amount of natural water resources

water scarcity not having enough natural water to meet the needs of a community or region

water table the level below the Earth's surface where water is found

water vapour water in its gas state; when liquid water evaporates, it becomes water vapour

waterfall cascade of water falling from a height

wave when the surface of water moves up and down as energy created by wind (or earthquakes and volcanic eruptions) moves through the water; the wind forces the water to rise and gravity pulls it back down again

wave-cut platforms flat areas of rock at the base of cliffs created by waves constantly crashing against the shore over time, wearing away the rock

weathering a process where rock is worn away, broken down or dissolved into smaller and smaller pieces by water, heat and cold; chemical weathering is a chemical change in a rock, while mechanical weathering involves rocks being broken into pieces

weir a small dam used as a water supply

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World political map

1	Abkhazia	10	Austria	20	Bosnia and Herzegovina	28	Comoros	38	El Salvador	48	Guinea-Bissau	57	Kuwait
2	Adjara (Geor.)	11	Azerbaijan	21	British Virgin Islands (UK)	29	Côte d'Ivoire	39	Equatorial Guinea	49	Haiti	58	Lebanon
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70	Montenegro	80	Réunion (Fr.)	89	São Tomé and Príncipe	97	South Ossetia	106	Vatican	Ch.	Chile	PNG	Papua New Guinea
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