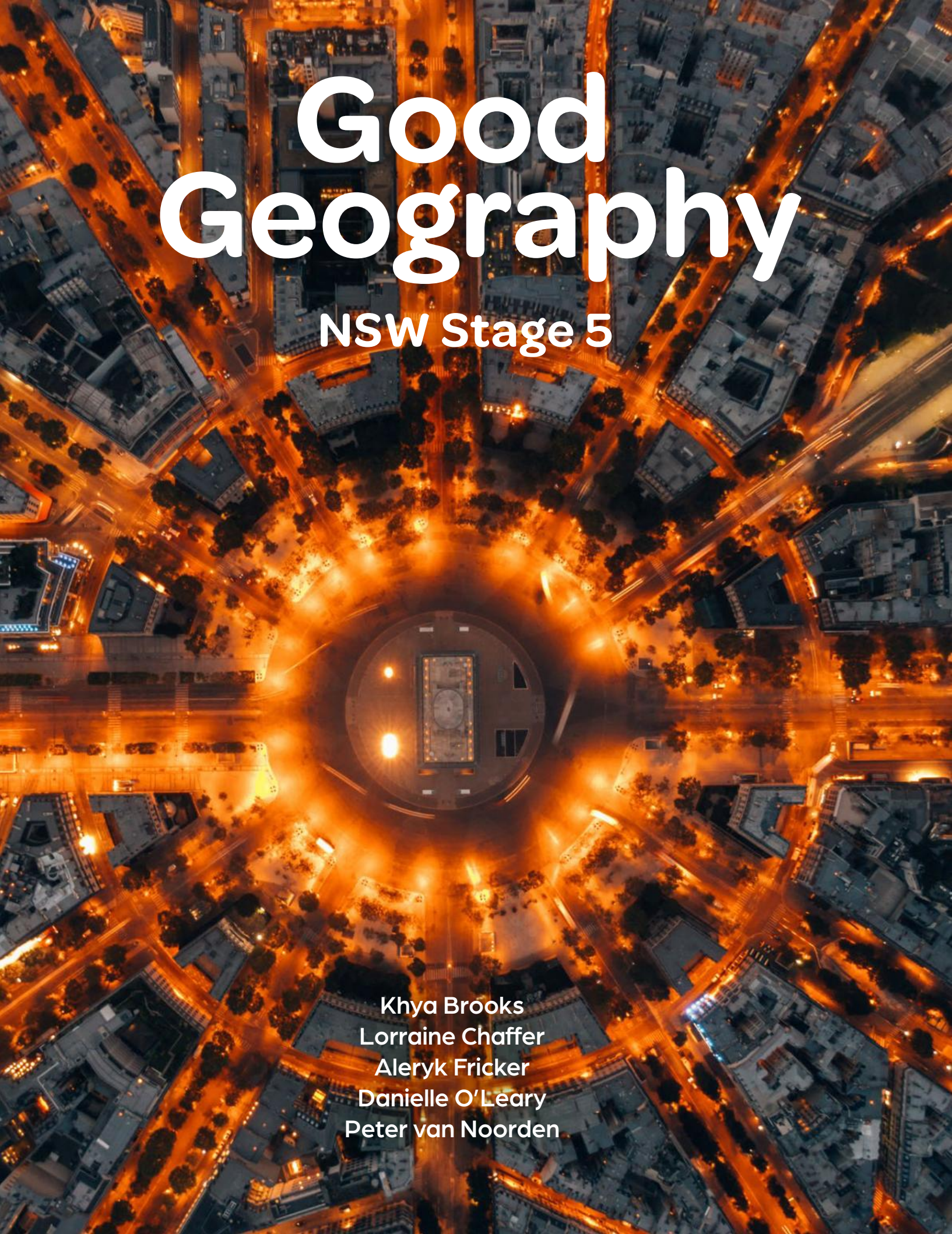

Good Geography

NSW Stage 5

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Good Geography

Stage 5

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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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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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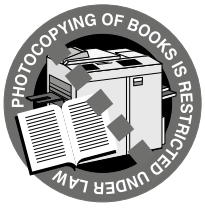

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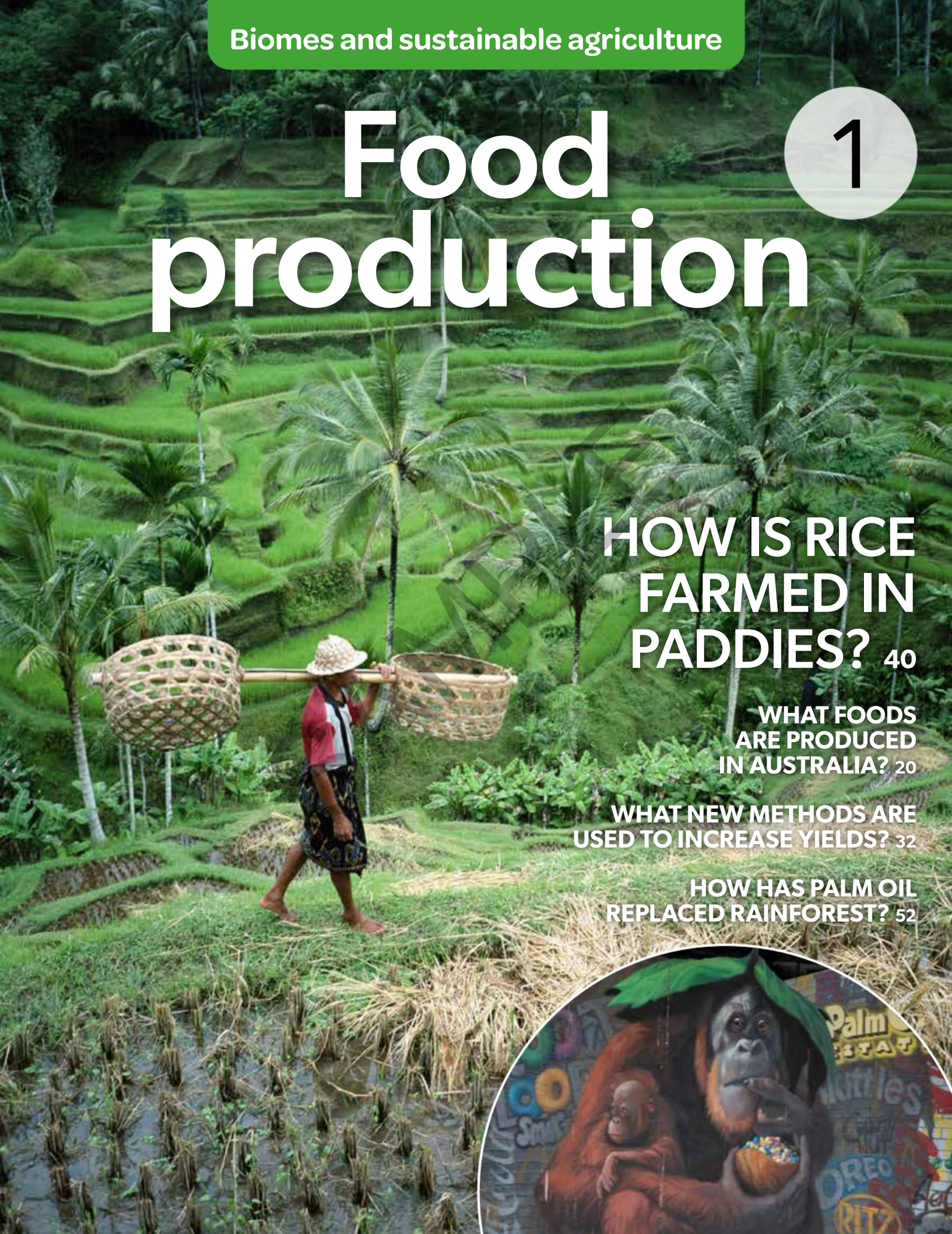


How can I understand food production?

Diverse land and aquatic biomes support a range of food production throughout the world. Introduced crops and grazing animals and new farming and production methods have led to improved human wellbeing, but also contributed to the degradation of important ecosystems.

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 toward 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 evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.

Source 1: Cattle grazing on cleared Amazon rainforest in Brazil. Between 1990 and 2018, cattle numbers in Brazil expanded by 56 percent. Brazil is is now the world's largest beef exporter, with 23% of the global beef trade. Seventy per cent of formerly forested land in the Amazon is now used for livestock pasture

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

What are biomes?

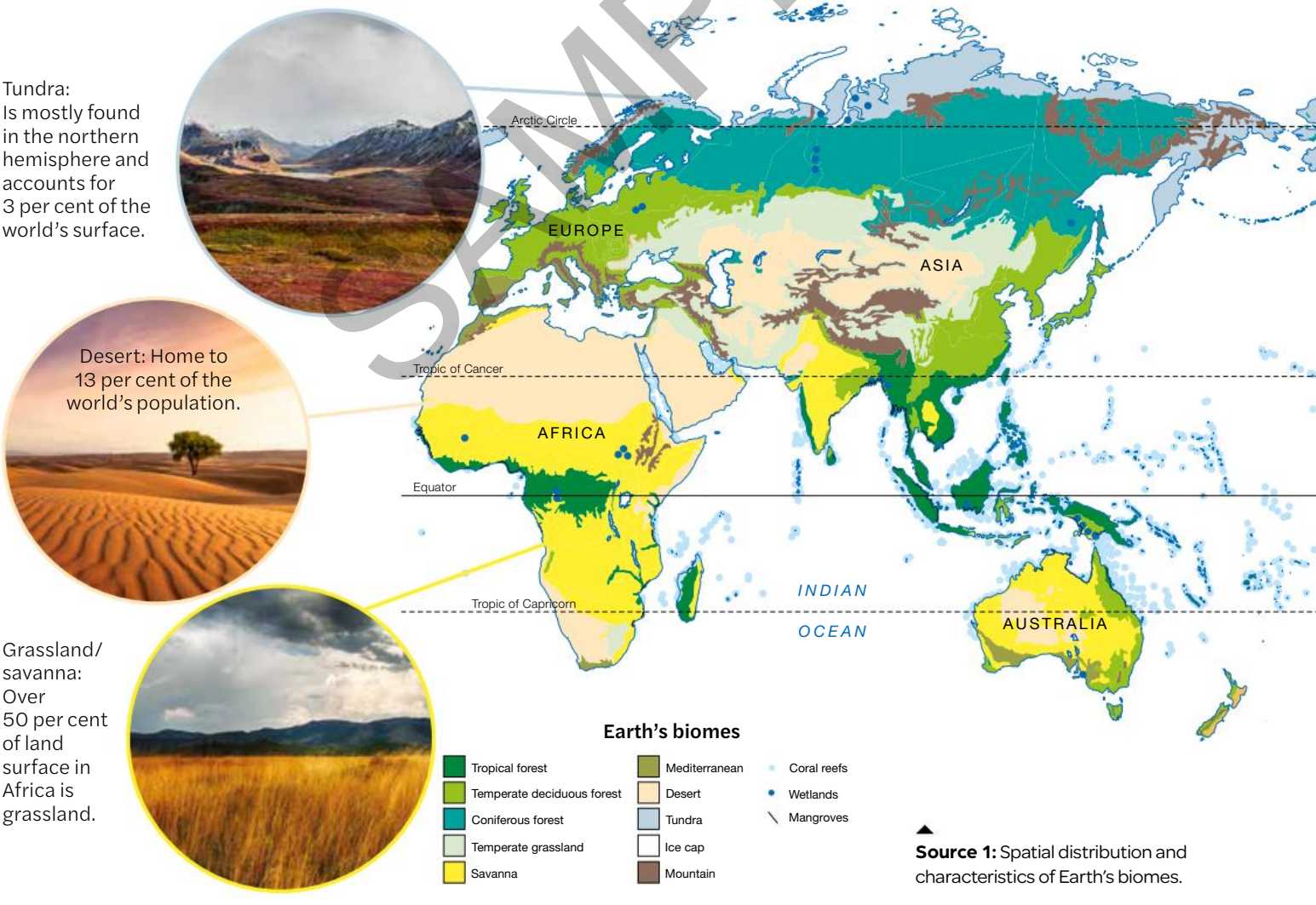
The biosphere comprises all living things on Earth. It is one component of Earth's four natural systems – the biosphere, lithosphere, atmosphere and hydrosphere. These systems work together to create the natural environment around us.

The world's biomes

To help us understand how the world works the biosphere can be investigated at a range of scales.

Biomes are identified at a global scale to show how climate influences living things. Temperature and rainfall are the main influences on terrestrial biomes as these factors determine the plants and animals that can live in different places and influence other features such as soils. Rainforests are found where the climate is hot and wet. Biomes are generally named according to climate or the dominant vegetation and appear as broad areas across continents. Source 1 is one example of a map showing the distribution of Earth's major biomes.

Ecosystems are examined when geographers want to study the way that the biosphere, lithosphere, atmosphere and hydrosphere interact at a specific place. There are many ecosystems within each biome. For example, places within the rainforest biome generally experience hot, wet and humid climates that support dense forests with thousands of species of plants and animals. Within the rainforest biome, the Amazon Rainforest in South America and the Congo Rainforest in Africa have very different ecosystems. The interactions between climate, soils, plants and animals are unique to each place. Source 2 shows the many interconnections of an ecosystem.



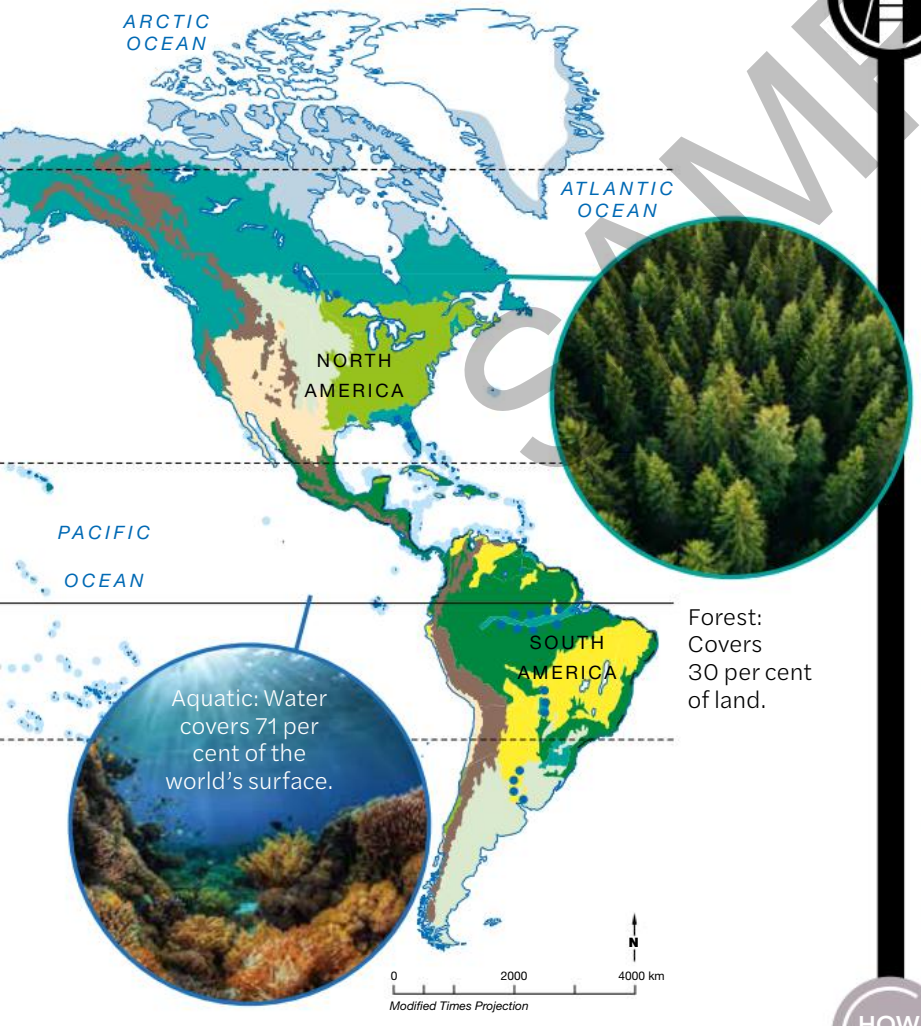
Source 1: Spatial distribution and characteristics of Earth's biomes.

Habitats provide individual organisms such as plants or animals with food, water and shelter. The habitat of the panda is the bamboo forest ecosystem within the mountain biome of China's Minshan Mountains. Ecosystems and biomes contain many habitats.

Where biomes are found

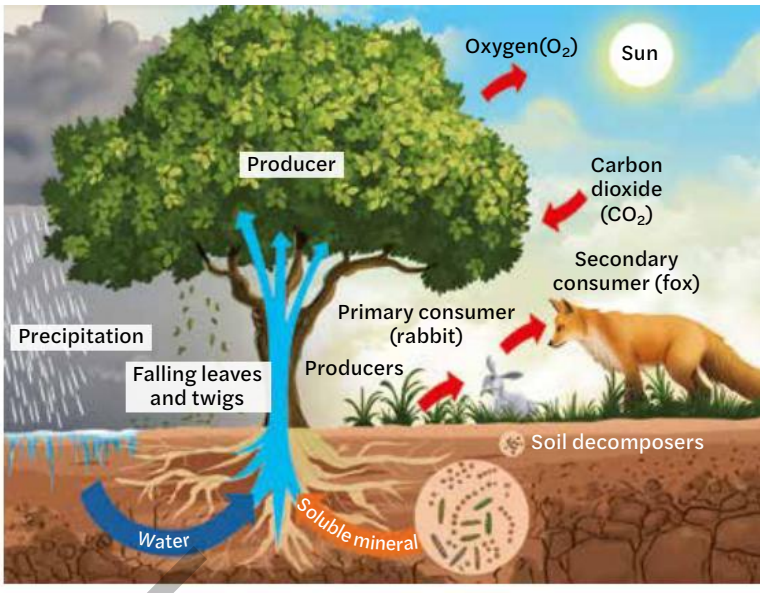
The spatial pattern of biomes is largely determined by climate. Variations in climate occur with changes in **latitude** and **altitude**. Temperature decreases from the equator (low latitude) to the poles (high latitude) and from sea level (low altitude) to the top of mountains (high altitude).

Precipitation also affects the location of biomes. At high altitudes and latitudes, precipitation is more likely to be snow than rain and the plants and animals in tundra and coniferous forests (boreal forest/taiga) biomes are adapted to those conditions. Places a long distance from the sea are drier and support biomes such as deserts and grasslands and unique species adapted to drought.



Source: Matilda Education Australia

Ecosystem: interaction of biotic and abiotic factors



▲ **Source 2:** Biomes contain many ecosystems.

Learning ladder 1.1

Characteristics of places and environments

1. Identify the main characteristics of two terrestrial biomes shown in Source 1.
2. Describe the location of rainforest and coniferous forest biomes in the world. In your answer refer to continents where these biomes are found.
3. Explain how latitude and altitude influence the location of biomes.
4. Analyse the difference between biomes and ecosystems and state how they are related.

Interconnection

1. Describe connections between living and nonliving parts of an ecosystem.
2. Explain how energy from the sun is linked to plants and animals in an ecosystem.
3. Source 2: Assess the effects of interconnections in this ecosystem and how they support food production.
4. Source 2: Assess how changes to interconnections in this ecosystem could impact food production.
5. Source 2: Predict how this ecosystem could be used to produce food in the future without destroying important interconnections.

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1.2

How does biome productivity influence food production?

Food production at a global scale is influenced by the productivity of biomes. The productivity of biomes is influenced by climate.

Biome productivity

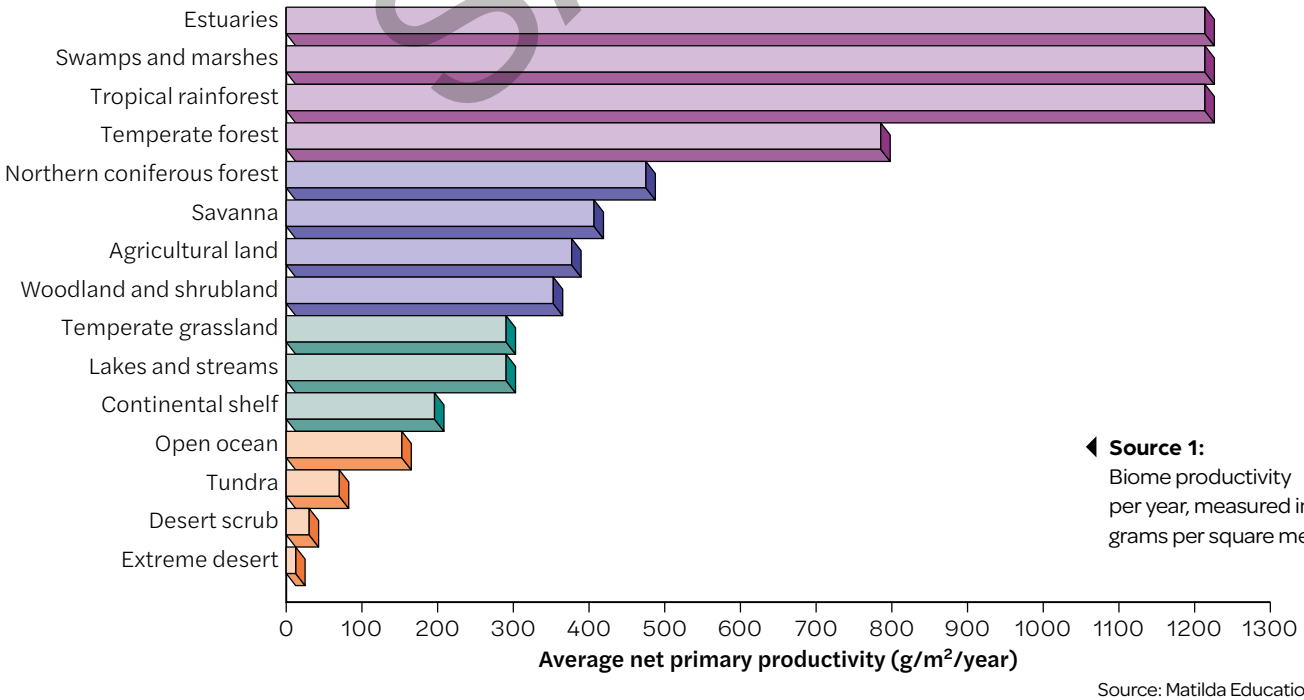
Primary productivity (PP or net PP) refers to the amount of biomass or living plant material produced through photosynthesis. High productivity can support large numbers of consumer species through food chains and food webs. The least productive biomes are those with extreme climates like deserts and tundra, where temperatures are hot or cold and precipitation low, resulting in limited plant growth. The most productive biomes typically have higher temperatures, plenty of water and lots of available soil nitrogen, such as tropical grasslands and forests. Comparing the climatic features of different biomes helps us understand differences in productivity. Potential impacts of climate change such as hotter, wetter and drier climates will impact productivity and the suitability of some biomes to produce food.

Biomes' capacity to produce food

The most productive biomes generally have the best climatic conditions that plants need to grow crops for human consumption or pasture and feed for livestock. Biomes are used for food and fibre production in many ways:

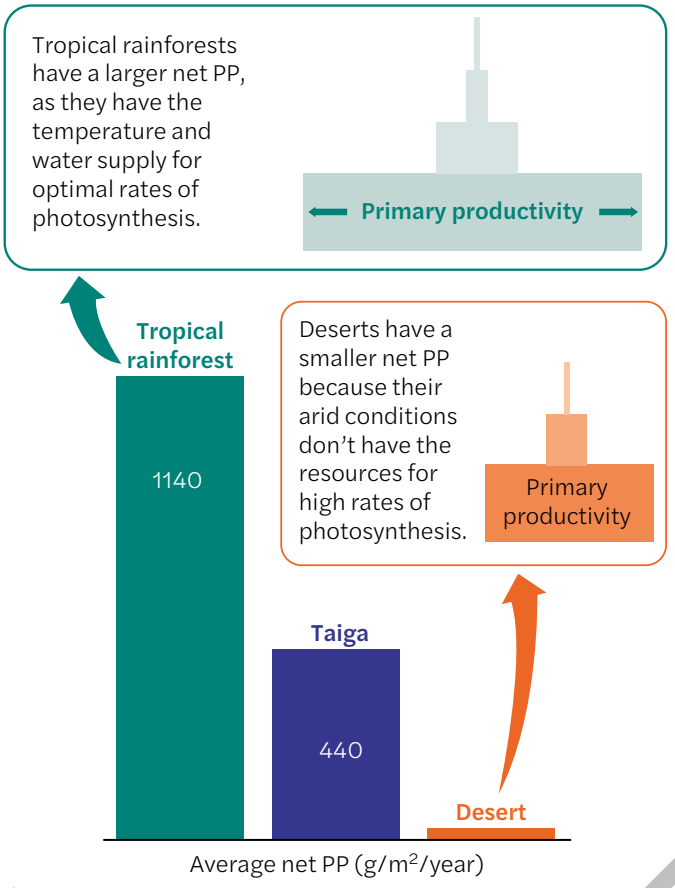
- harvesting resources such as nuts, fruits, seeds, wildlife and timber from productive forests
- using the primary biomass for grazing animals on grasslands and tundra biomes; the carrying capacity of grasslands is higher than tundra, producing more food
- replacing the natural biome with species suited to the climate such as replacing forests with banana crops
- modifying biomes to increase productivity such as using irrigation to supplement rainfall.

Biome productivity per year

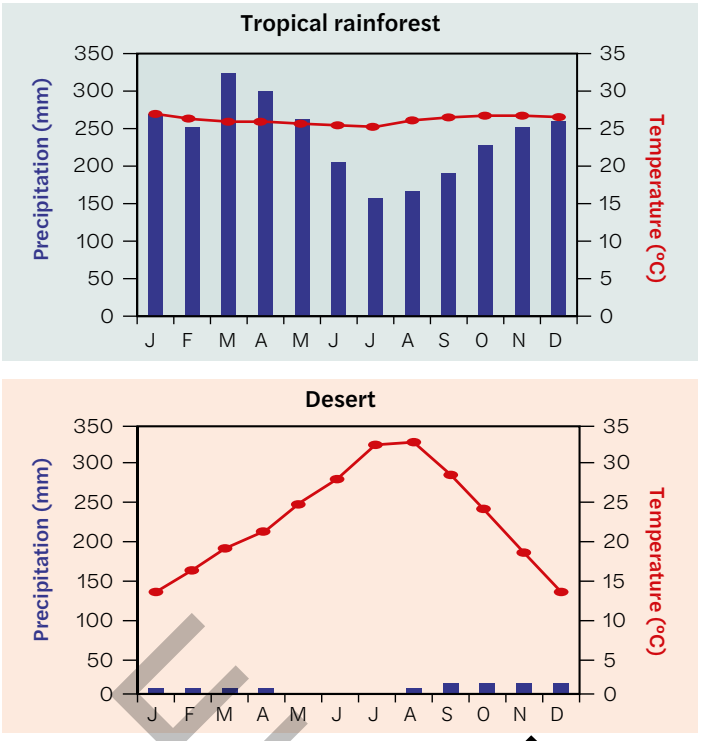


Source 1: Biome productivity per year, measured in grams per square metre.

Source: Matilda Education Australia



Source 2: Comparing productivity between rainforests and deserts

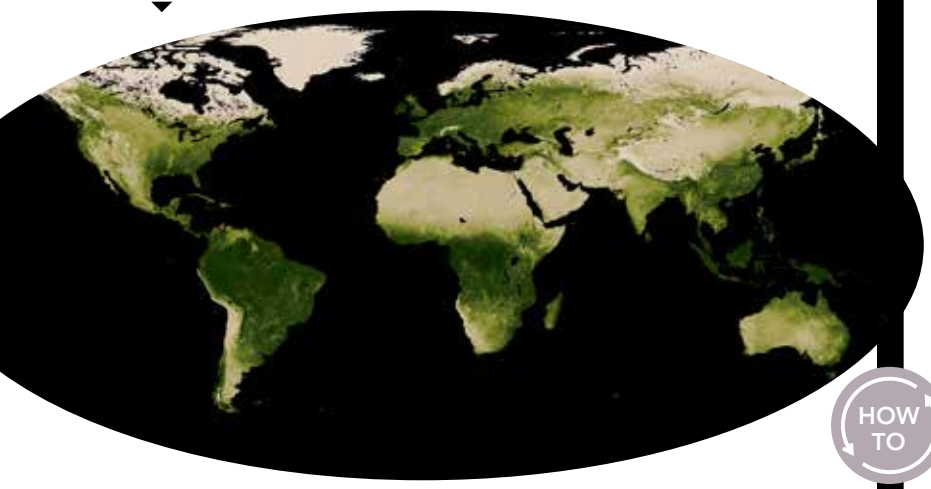


Source: Matilda Education Australia/BioNinja

Satellite monitoring reveals productivity

Biome productivity changes with the seasons. Satellites are used to monitor biome productivity by showing how 'green' different parts of the planet are and how greenness changes over time. In Source 3, dark green shows land areas with high productivity – plenty of leafy green vegetation – such as the Amazon Rainforest. Beige to white areas have little or no vegetation, including deserts and Arctic tundra areas. Areas with moderate amounts of vegetation such as grasslands are pale green.

Source 3: Visualising global primary productivity. The green areas show global vegetation.



Learning ladder 1.2

Processes that transform people, places and environments

1. Define 'primary productivity'.
2. How does climate affect primary productivity?
3. Source 1: Compare the productivity of three different terrestrial biomes.
4. Explain the relationship between biome productivity and food production.
5. Discuss the statement: 'With human intervention, biomes with low productivity have a capacity to produce more food.'

Interconnection

1. Source 3: Describe the link between latitude and the Earth's most productive ecosystems.
2. Source 1: How do seasons affect biome productivity? Give an example.
3. Source 2: Explain the relationship between climate and biome productivity.
4. Source 2: Analyse the relationship between primary productivity and food pyramid.
5. Assess the potential impact of climate change on biome productivity.

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1.3

How do biomes support food production?

Most food is produced within the biosphere, except where agriculture takes place in human structures that replace the natural environment, such as 'under glass' in the greenhouses of Iceland. Biomes provide the living (biotic) and non-living (abiotic) resources that are used to source or produce food.

Harvest and capture

For thousands of years humans practised **subsistence farming**, where food is hunted and gathered to maintain communities, with little surplus for trade or sale. Communities such as the Inuit in the Arctic tundra and the Pirahã in Brazil's Amazon rainforest continue these traditional practices.

The numbers of people harvesting and capturing food directly from biomes is declining due to increasing pressure from development, conservation, agricultural expansion and changing climates. The Hadza, who hunt wildlife using traditional methods such as bows and arrows and forage for food such as tubers, berries and fruit in the acacia forests of northern Tanzania are one of the last groups of true hunters and gatherers. Today, less than 300 live this way.

Small-scale (artisanal) fishing provides livelihoods and food security for nearly half a billion people globally – mostly in coastal villages in developing countries – and is responsible for nearly half of global seafood catches. Commercial fishing operations such as the wild Atlantic Salmon fisheries of Canada and Alaska supply the world markets with seafood. Since the 1980's the volume of fish 'captured' from the aquatic biomes has been between 86 million tonnes and 93 million tonnes per year.

▲ **Source 1:** Traditional Anangu owner sucks nectar from desert or honeysuckle grevillea flower near Uluru. Increasing recognition of Traditional Ecological Knowledge has increased the number of indigenous people practising traditional methods of food production and gathering 'bush foods' for personal and commercial use.

Grazing native pastures

In some parts of the world animals are herded between available pastures by nomadic or semi **nomadic** peoples such as the reindeer herders in Siberia and Scandinavia and the Masai people in Kenya who herd cattle. Nomadic grazing is practiced in climates with limited, or no arable land and in dry or cold biomes such as grasslands and tundra in Africa, the Middle East and Central Asia.

Commercial pastoralists graze livestock such as sheep, cattle and goats on natural vegetation (grasses, herbs and shrubs), usually on large, often unfenced properties. The **carrying capacity** (the number of animals per hectare) of the land is low so farms need to be large. Australia and Argentina have some of the largest cattle stations in the world on semi-arid country. This is known as **extensive farming**.

Biomes modified for agriculture

'Slash and burn' subsistence agriculture in rainforests and large-scale deforestation for cattle grazing are examples of biomes replaced or managed to support food production. Arable land is created by clearing natural vegetation and replacing it with a planted crop e.g., rice, wheat, and bananas. Most of the world's staple grain crops such as corn, oats, wheat and barley are cultivated on land that was originally grassland. Natural pastures are improved when replaced with non-native species, often with the use of irrigation and fertilisers to increase the carrying capacity of land.

Source 2: Reindeer herding in the tundra biome in Stora Sjofallet National Park, Lapland, Sweden. Reindeer are the only semi-domesticated animal which naturally belongs to the tundra biomes of the northern hemisphere. Reindeer herding takes place in nine countries – Norway, Finland, Sweden, Russia, Alaska, Mongolia, China, and Canada – by 30 reindeer-herding peoples herding 3.4 million reindeer.

Learning ladder 1.3

Characteristics of places and environments

1. Define the terms subsistence, commercial, nomadic and carrying capacity.
2. Source 3: Describe where reindeer herding takes place in Scandinavia.
3. Explain the ways in which biomes support the production of food.
4. How have humans altered biomes to increase the production of food?
5. Source 2: This farming activity is taking place in a national park. What changes have been made to the natural environment to accommodate farming? What impact does it have?

Environment

1. Source 2: Identify the environmental features of the biome shown in the photograph.
2. Explain why reindeer herders are nomadic.
3. Source 3: Compare the direction of the spring migration of reindeer in Norway and Sweden.
4. Predict how climate change could impact the capacity of the biomes in the photographs to support food production.

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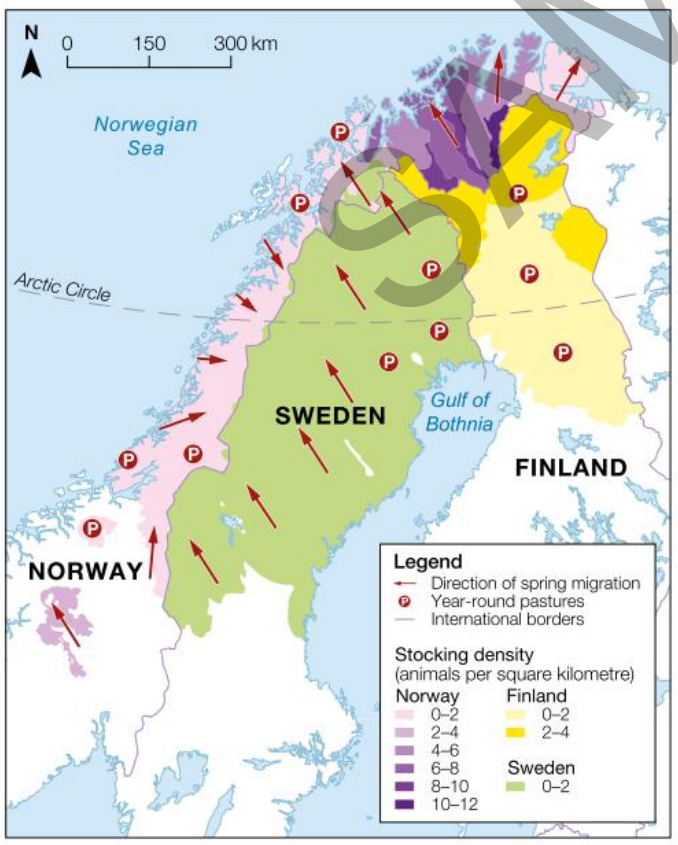
Migration of reindeer



Source: Tyler N.J.C., Hanssen-Bauer I. Førland E.J., Nellemann C.

Source 3: Seasonal migration of reindeer in Norway, Sweden and Finland.

1.4

Which environmental factors impact food production?

The spatial distribution of agriculture is determined by climate, water availability and suitable land, including its topography and soil. All plants require basic resources from the physical environment including light, temperature, water and nutrition.

Environmental factors

The natural environment determines where food will be produced and how productive and sustainable farming will be. All organisms require **biotic** and **abiotic** factors from the physical environment to survive and grow. Biotic factors are the living things in an ecosystem, such as plants, animals, and bacteria. Abiotic factors are the non-living components of the environment, such as sunlight, temperature, water, air, and soil.

Climate

Regions experiencing very high or low temperatures or low rainfall can only support limited agriculture. Crops have specific climatic requirements that set the limits of where they can grow.

Solar radiation

- Through the process of photosynthesis, plants use solar energy and water to convert carbon dioxide (CO_2) into food to develop leaves, stems and fruit, and in the process, store carbon.
- Sunlight varies seasonally and is a limiting factor in plant growth at latitudes which have months without sunlight

Temperature

- Minimum temperature is 6°C for crops to grow and at least 250–500 mm per annum of precipitation
- Temperature and precipitation influences types of crops grown. —e.g. hot, wet monsoon climate favours rice, while cooler, drier climates are better for wheat.

Precipitation

- Amount and regularity of rainfall affect crop growth and yields
- Low precipitation: dryland farming is where drought-resistant crops like millet and sorghum are grown.

Humidity

- Relative humidity of 40–60 per cent suitable for most crops
- When relative humidity is high pests and diseases are more common.

Source 1: All plants require basic resources from the physical environment to grow. These include abiotic factors including light, warmth, water, carbon dioxide and nutrition.

Monitoring climate and weather

The day to day weather is an important influence on food production, particularly the occurrence of weather extremes. Farmers rely on weather forecasts and long-term climate models to determine their weekly, monthly and seasonal routines. The Bureau of Meteorology makes agricultural observations for farming areas, indicating temperature, precipitation, evaporation, humidity, wind speed, sunshine hours, solar radiation and soil temperature. The Bureau also predicts frost, fogs, and thunderstorms which may affect crop yields. Farmers may decide to harvest a crop early if damaging storms delay planting if there is no possibility of rain and put in place measure to protect crops from frost.

▲ **Source 2:** Frosts damage crops when the temperature falls below zero. Farmers use a variety of measures to increase temperatures to reduce frosts, including covers, large fans and lighting large paraffin candles between rows as seen here in French vineyards.

▲ **Source 3:** Sheep grazier warnings from the Bureau of Meteorology alert graziers of wet weather followed by cold air that poses a risk of death to sheep. Freshly shorn and young sheep are most at risk in wet and cold conditions. Farmers move their flocks to the parts of the farm most protected from the forecasted winds.

Soil

Soil is the loose covering of fine rock particles that covers the Earth's surface. Soil is a renewable resource but can take more than 1000 years to form. The type of soil depends on the parent material (rock type), climate, organisms living in the soil, topography, and time. The proportion of clay, sand and silt affects the amount of water lost through infiltration, runoff and evaporation.

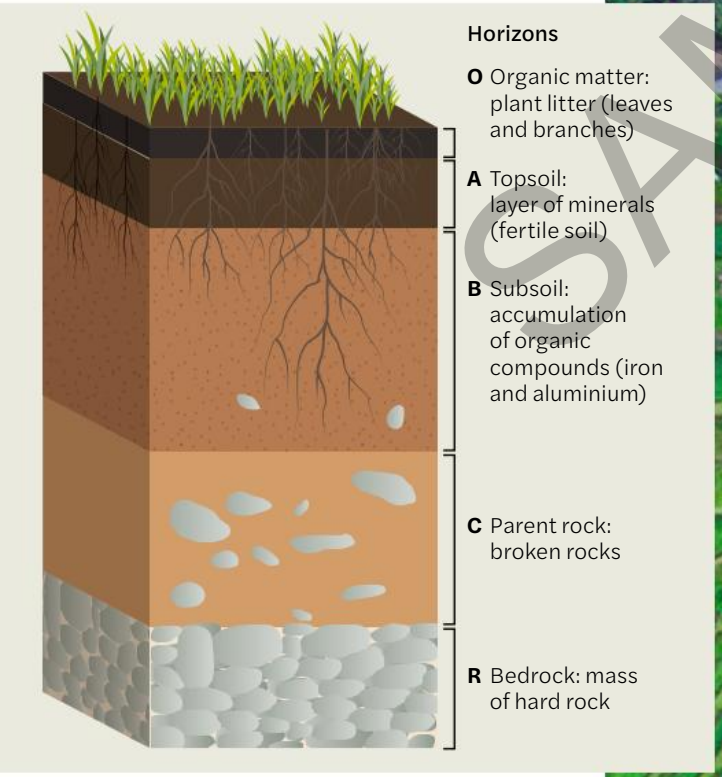
According to the United Nations Food and Agriculture Organisation (FAO) 'soil is the foundation for agriculture and the medium in which nearly all food producing plants grow'. FAO estimate that 95% of our food is directly or indirectly produced on soil.

Plants access water and nutrients via soil. Crops require nutrients from the soil depending on the type of crop and the stage in the crop-growing cycle. For example, nitrogen and phosphorus are required in the early stages of root and leaf development, and zinc and boron during the later flowering stage. A deficiency in nutrients limits food production. Soils that are too thin, salty, acidic, waterlogged, or frozen are unsuited to cropping.

A healthy soil is a living, dynamic ecosystem, teeming with microscopic and larger organisms that perform vital functions such as converting dead matter and minerals into plant nutrients (nutrient cycling); controlling disease, insects, and weeds; and improving water and nutrient holding capacity. Australian soils tend to be old, salty, acidic and nutritionally impoverished. They contain less organic matter compared with soils in the northern hemisphere. Australian soils are thin from millions of years of water and wind erosion. Arid areas are low in soil moisture and high in salt, which reduces plant growth and organic matter. The most fertile soils in Australia are of volcanic origin or alluvial soils deposited on river floodplains. This is where intensive crop and livestock production such as horticulture and dairying as are located.

Available land

Cultivating plants and raising livestock for food requires suitable land. Surprisingly, large areas of Earth's total land surface are suited to some type of agriculture. Of the 14.9 billion hectares of Earth not covered by oceans (70%) and the 29% considered uninhabitable,

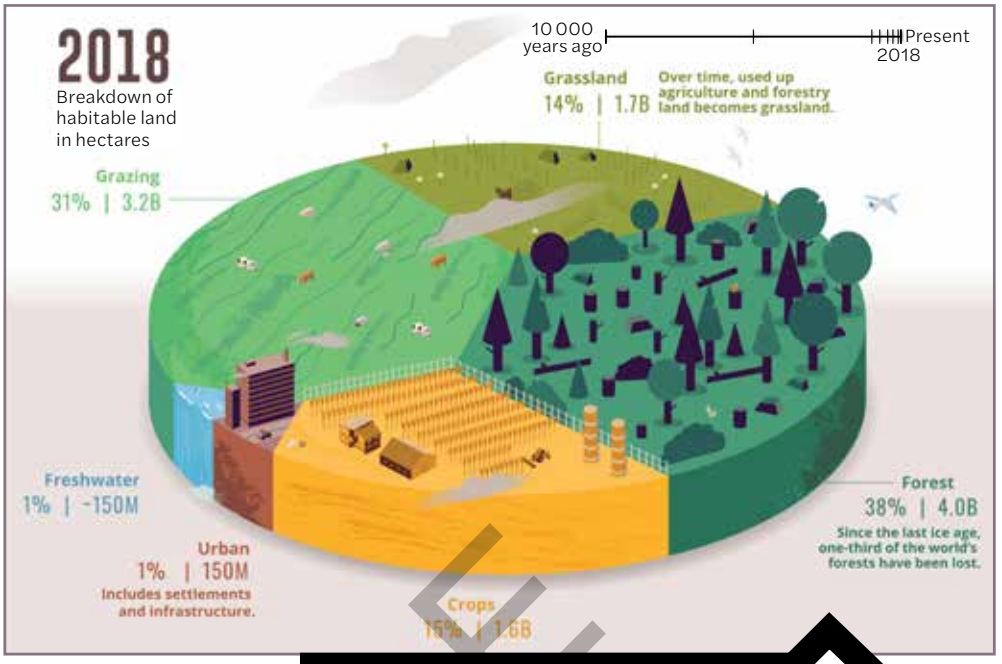


▲ **Source 4:** Soils are divided into horizons. Topsoil (A) and organic matter (O) are the most important soil horizon for plants. Organic matter provides protection from evaporation and aids drainage and supplies of nutrients through recycling.

including deserts, salt flats, exposed rocks, sand dunes and glaciers, agriculture is the main use of land. Grazing occupies the greatest proportion of landuse followed by cropping.

Landforms and gradient are important influences on food production. Flat land is the best best for growing crops because it maximises water retention and exposure to sunlight. Hilly land has shallower, less fertile soil, is difficult to cultivate and is prone to erosion from rainfall runoff. Steeper land is more appropriate for livestock such as sheep that can wander between hills and rocky outcrops to find pasture.

Land used for global food production



Source: Visual Captialist/Science Photo Library

▼ **Source 6:** Global land used for food production.

Source 5: Drone image of terraced rice fields in Ubud, Bali. Farmers have cut terraced steps into the hillsides to create more flat land for their rice paddies.

Learning ladder 1.4

Processes that transform people, places and environments

1. Source 1: Identify the environmental factor each icon represents. Write a sentence about the importance of each factor.
2. Source 2: Explain what the farmer is doing and why he is doing it.
3. Explain how weather and climate impact food production on a daily to yearly time scale and influence farm decision making.
4. Source 6: Calculate the hectares and percentage of Earth's habitable land used for food production. Predict the change you would expect to see in the percentage of Earth's land used for agriculture in the next 100 years.

Environment

1. What is the relationship between plants and soil?
2. Source 5: Describe how hilly topography influences livestock farming and crop production.
3. Source 4: Explain the processes behind the formation of soil and outline why it is so important in food production.
4. Source 3: Analyse the impact of weather and climate changes for farmers. Give an example to illustrate the implications.

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Case study

Why are volcanic soils so productive?

The US Geological Survey organisation states that 'volcanic materials ultimately break down and weathers to form some of the most fertile soils on Earth, cultivation of which has produced abundant food and fostered civilisations'.

Distribution of productive volcanic soils

Volcanic soils cover 1 per cent of Earth's surface but grow food for over 10 per cent of the world's population. Farmers are prepared to risk living near volcanoes because fertile volcanic soils increase crop yields and food supplies. Over time the physical and chemical weathering of volcanic rocks release nitrogen, potassium, phosphorus, and trace elements, which contribute to soil fertility.

Volcanic rocks chemically weather faster into fertile soils in tropical climates, where there is a combination of high temperatures and high precipitation such as in Indonesia compared to volcanoes located in cooler, drier environments like Iceland. On the tropical island of Hawaii, the formation of fertile soil and resulting growth of lush vegetation following an eruption can be as fast as a few hundred years.

The main concentration of volcanic soils however lies along the Pacific Ring of Fire where lava rises through volcanic vents and fissures in the Earth's crust. The ring includes countries such as Chile, Peru, Russia (Kamchatka Peninsula), Japan, the Philippines, Indonesia, Ecuador and New Zealand.

Mount Taranaki, New Zealand

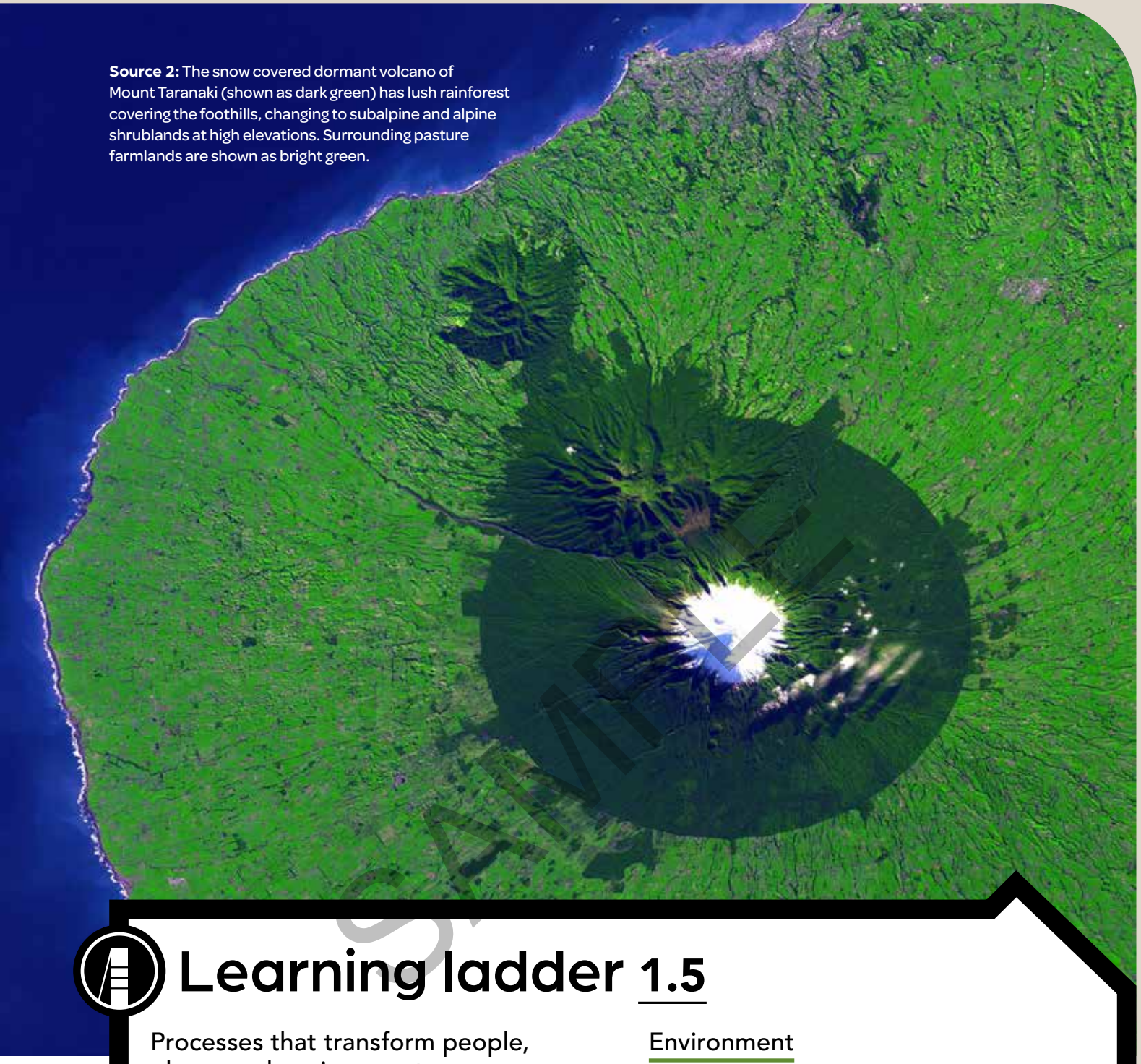
The plain surrounding Mount Taranaki was dubbed 'the garden of New Zealand' as early as 1840. It contains some of the deepest and richest soils in the world. Volcanic soils developed on Mount Taranaki ash are rich in the mineral andesite, making it highly workable and free draining. Streams and rivers radiating off the mountain are a reliable source of water. The fertile soil supports **intensive farming**, particularly dairying on the flatter land that surrounds Mount Taranaki. Today there is increasing pressure to diversify into grain crops such as wheat, maize and horticulture products such as fruit, vegetables and nuts that potentially offer higher returns than dairying and are less polluting on local rivers.

Source 1: Farming volcanic soils in three locations

Eyjafjallajokull, Iceland
- Annual temperature range: 0–13°C
- Annual precipitation: 850 mm
- Extensive sheep grazing and pasture crops

Mount Taranaki, New Zealand
- Annual temperature range: 11–22°C
- Annual precipitation: >2000 mm
- Intensive dairying, sheep, beef and horticulture

Mount Etna, Italy
- Annual temperature range: 20–21°C
- Annual precipitation: 800 mm
- Vineyards, citrus fruit, nuts



Source 2: The snow covered dormant volcano of Mount Taranaki (shown as dark green) has lush rainforest covering the foothills, changing to subalpine and alpine shrublands at high elevations. Surrounding pasture farmlands are shown as bright green.

Learning ladder 1.5

Processes that transform people, places and environments

1. What environmental factor is important in the formation of fertile soils around Mount Taranaki?
2. Describe the link between volcanoes and soil quality.
3. Explain why the global distribution of volcanic soils is concentrated around the Pacific Ring of Fire.
4. Source 1: Identify two advantages farmers in the Taranaki region (New Zealand) have over those farming volcanic soils in Iceland and Italy. Draw a conclusion about farm productivity in each place.
5. The New Zealand dairy industry has been criticised for the pollution of waterways. Investigate the issue and justify proposals to diversify food production on the land around Mount Taranaki.

Environment

1. Source 1: What are the similarities and differences between these environments?
2. Source 2: Explain the processes involved in the formation of volcanic soils shaped this environment.
3. Why are farmers willing to live near to geomorphic hazards such as volcanoes?
4. Source 2: The Taranaki region was originally one of the most densely forested areas of New Zealand. What impact do you think change has had in this region, and how does it continue to change?

Environment, page 414

HOW TO

Where is food produced on a global scale?

Due to increasing global population, technological advancement and increasing global trade, food is being produced on a bigger scale now than ever before.

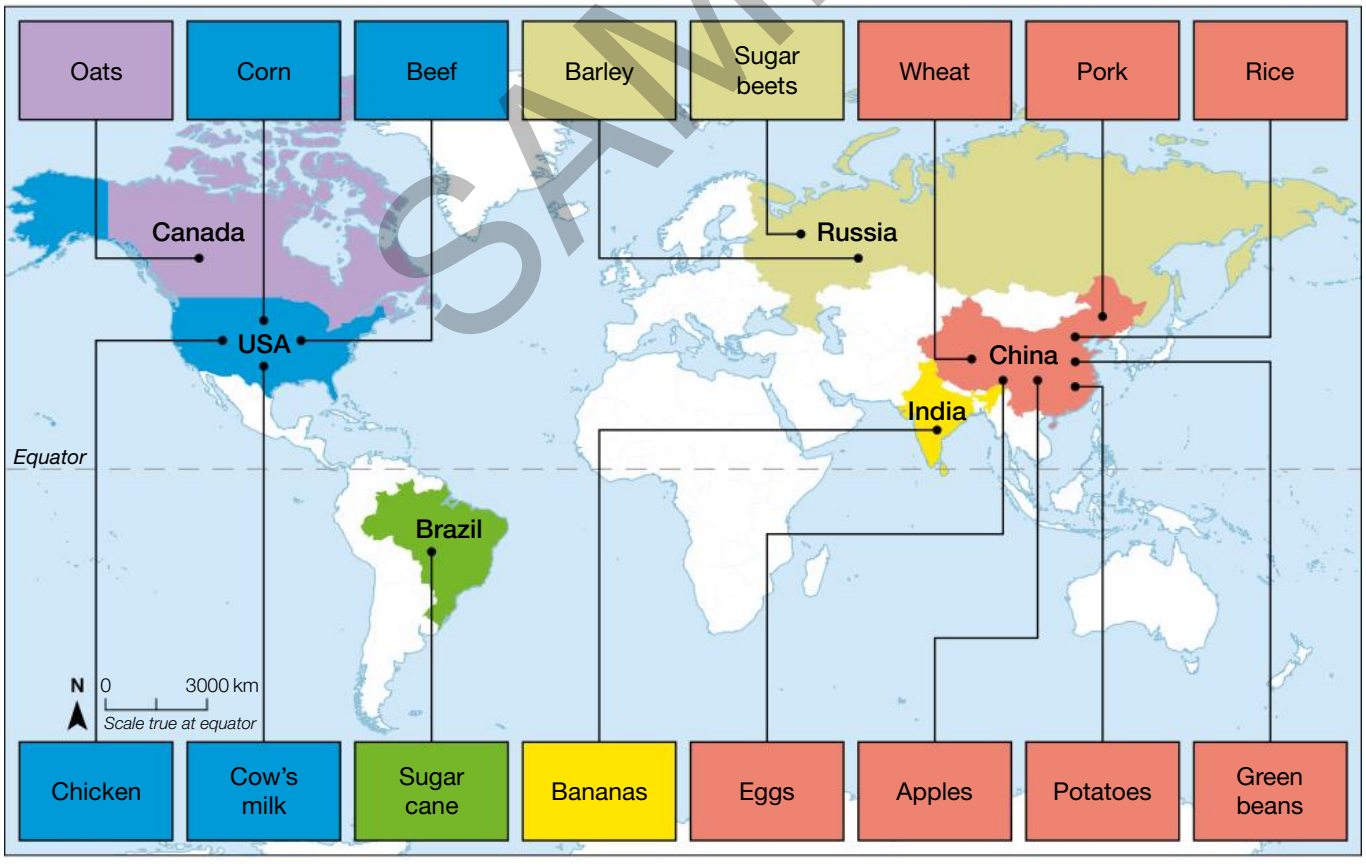
Global food production

Agriculture is one of the most important industries in the world, providing economic, social and nutritional needs for people everywhere. With the rise of **globalisation**, diets have become more similar and rely on the same staple crops. In fact, over two-thirds of agricultural products used in national diets around the world originated somewhere else and only four crops accounted for nearly half of the world's agricultural production in 2021; sugar cane (21 per cent), corn (12 per cent), rice (8 per cent) and wheat (8 per cent). Key global producers are mostly found in Asia, the Americas and in Europe.

Asia

Half of the world's agricultural production occurs in Asia. Due to diverse **agroecological** zones across Asia, many types of crops can be planted here. Culture also influences the crops grown, with east-Asian countries (such as Indonesia, Thailand and Vietnam) being large producers of rice and middle-Eastern countries (such as Pakistan, Turkey and Iran) being large producers of wheat. China is a global leader and with only 10 per cent of **arable** land, they produce 25 per cent of the world's grain and are the lead producer for over 30 **commodities**, including chicken, rice and potatoes.

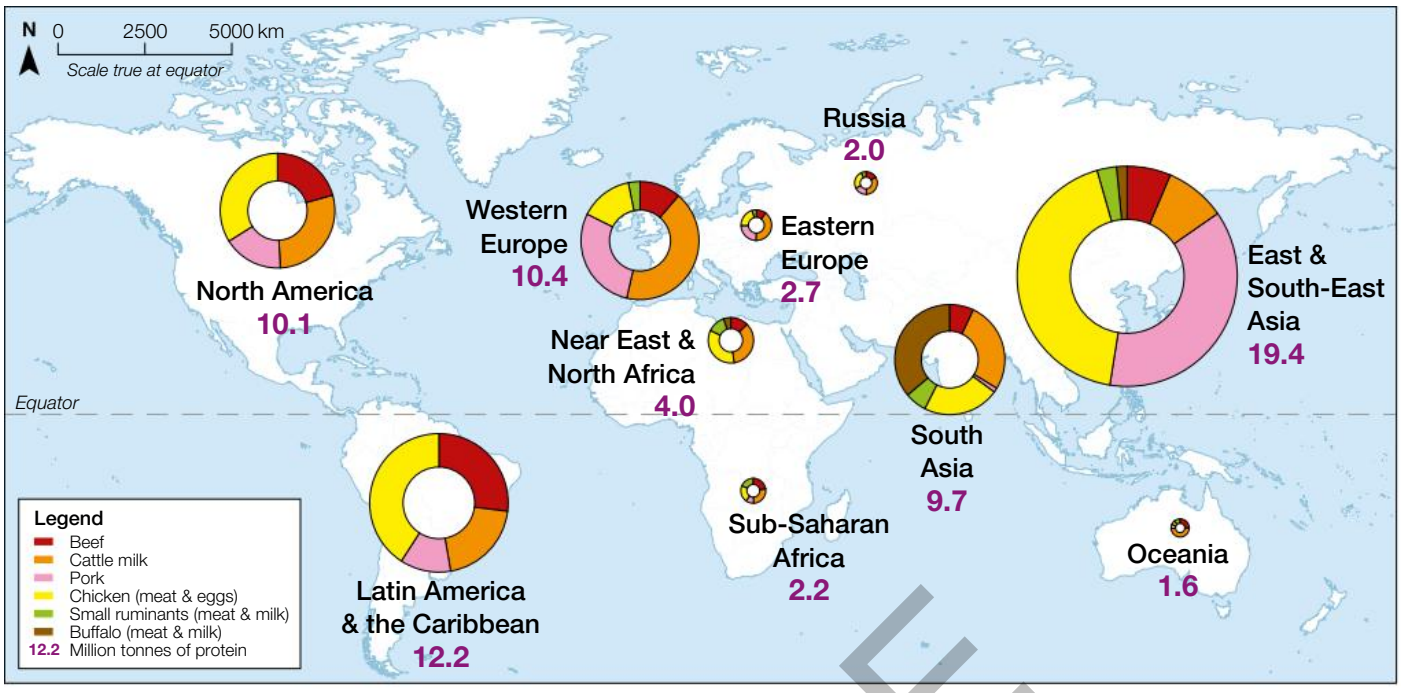
Largest producers of agricultural commodities



Source: University of the Potomac; illustration: Farm Journal

▲ **Source 1:** The world's leading producers of key commodities. The production of these crops is influenced by the climate, the soil, the technology and government investment in each country.

Global livestock per region, measured in million tons of protein



Source: Matilda Education Australia

▲ **Source 2:** Global livestock per region (milk and eggs expressed in protein terms)

Americas

Brazil and the United States are key agricultural producers in the Americas. Brazil has prioritised investing in the agricultural industry, resulting in one-third of their land being used for agriculture and them becoming leaders of soybean, coffee, oranges and sugarcane production. The United States is the world's largest producer of corn and leader of almond and blueberry output.

Europe

Northern parts of Europe are leaders of cool-climate crops, including grapes, barley and sugar beets. Russia is the world's largest producer of barley and sugar beets and cultivate over a third of the world's sunflower seeds. Southern European countries like Spain, are leaders in Mediterranean climate crops, such as olives and almonds.

Changes to global food production

Developing regions in Asia, Africa and South America have increased production capacity the most, with Asia and South America doubling production between 2000 and 2020. They are using government investments, technologies and subsidies to increase their agricultural production to support their growing populations, provide employment and increase export opportunities. Global challenges such as COVID-19, climate change and global conflict are causing further changes, i.e. sunflower oil prices have increased 25 per cent since Russia's invasion of Ukraine in 2022.

Learning ladder 1.6

Characteristics of places and environments

1. Source 1: In which commodities is China the world's leading producer?
2. Explain some of the factors contributing to the increase in food production on a global scale.
3. Source 1: Expalin how location impacts the types of food products produced on a global scale?
4. Source 2: Which continent has the greatest percentage of beef cattle in its total protein production? What impact does cattle grazing have on the environment?

Scale

1. Source 2: What pattern is shown for chicken meat and eggs at a global scale?
2. Explain the global production patterns of one food product.
3. Analyse how national changes in Ukraine have global impacts.
4. Assess how the production of one food product can have social, economic or environmental impacts on a global, national and local scale.

HOW TO

Scale, page 416

What value do biomes have for people and the environment?

Biomes contain all of the biodiversity on Earth that exists in ecosystems such as the tropical forests of South-East Asia and savanna grasslands of Africa. They provide people with the resources needed to support life and wellbeing, and play an important role in how the Earth functions, such as producing oxygen and food, and keeping the climate stable, the water clean and the soil productive. These benefits are often called ecosystem services. We value biomes for the economic, social, cultural and environmental benefits they provide. By recognising these values, people can understand the importance of using biomes sustainably.

Ecosystem services

Provisioning services are material goods that people get from the biomes such as water, food (fruits, vegetables, seeds and wildlife), timber and medicines. For example, antibiotics derived from fungi and bacteria, and drugs such as quinine to treat malaria, come from plants.

The world's crops and domesticated livestock have their origins in nature, and future foods and medicines may not have been discovered yet.

Regulating services are the processes that operate in nature to maintain air quality, regulate water supplies and purify water, control runoff and flooding, and decompose waste. For example, pollinators such as bees fertilise plants that produce seeds and fruit. Mangrove forests and seagrass ecosystems protect coasts from erosion.

Supporting services help to maintain the natural processes that life depends on, such as plants providing oxygen through photosynthesis, the water cycle recycling water through plants, and decaying vegetation contributing to the formation of soils. For example, forests are like water pumps returning water to the atmosphere where it is available to return to the forest; this cycle keeps the forest alive. Forests and aquatic biomes such as kelp forests sequester carbon from the atmosphere and help to maintain the climate.

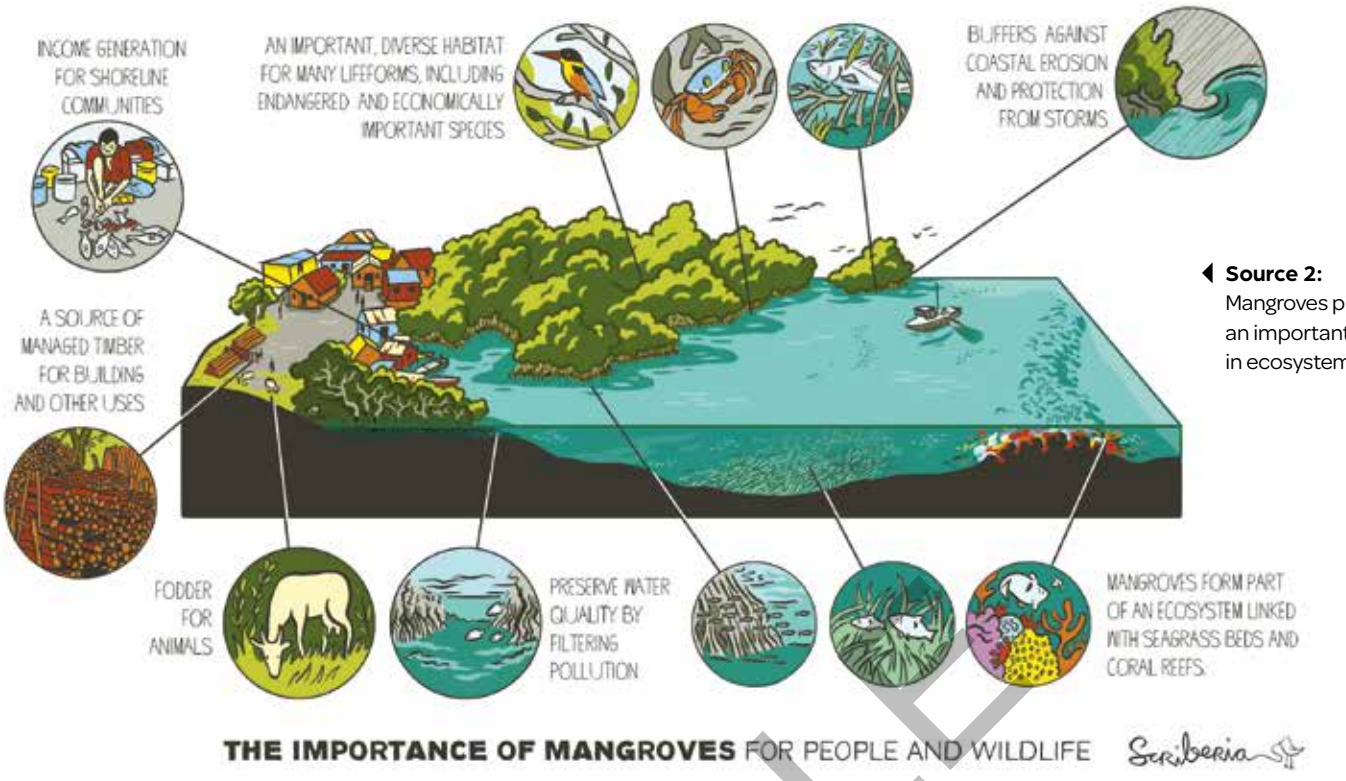
Cultural services are intangible benefits for people that include the enjoyment of nature, recreation, beauty and inspiration, and the spiritual and religious values people have for their natural environment.

First Nations Peoples have strong cultural relationships with nature, such as the totem animals of Aboriginal and Torres Strait Islander people in Australia.

Values

The services provided by nature have economic, social, cultural and environmental value. When products from nature are sold or traded, they have an economic value.

Source 1: Provisioning services are the products obtained from ecosystems, regulating services are the benefits obtained from the regulation of ecosystem processes, cultural services are the non-material benefits people obtain from ecosystems, and supporting services are services that are necessary for the production of all other ecosystem services.



Source 2: Mangroves play an important role in ecosystems.

When biomes are changed to create a dam or to grow a crop, the new land use has an economic value. The jobs created when natural places are used have an economic value for workers. The economic value of biomes helps modern societies to function – this also gives them a social value. Social values also come from the ways people use ecosystems for non-economic purposes such as relaxation and recreation, as an escape from the city or to enjoy its beauty (aesthetic value). Some businesses gain economic value by providing services such a tourism that help people enjoy nature. The regulating and supporting services of ecosystems make them valuable for the environment.

Perspectives on the value of biomes

For some people, the protection of biomes and ecosystems is important for the future of the planet and human wellbeing, particularly those concerned about the global loss of biodiversity and the increasing impact of climate change. Other people, however, see biomes as a resource to be exploited – timber to be harvested, wildlife to be hunted and fished, or forests to be replaced by an economically valuable crop such as palm oil or beef cattle. Over hundreds of years this perspective has resulted in the global loss of ecosystems and biodiversity. There are very few places in the world today untouched by human activities. In more recent years, the focus has been on sustainable development that balances the need to conserve the natural processes on Earth while meeting the needs of the human population.

Learning ladder 1.7

Characteristics of places and environments

1. Source 1: Identify four types of ecosystem services.
2. Define 'ecosystem services'.
3. Explain the importance of provisioning and cultural services for human wellbeing.
4. Source 2: Analyse the social, economic and cultural values of mangrove forests. Use examples in your answer.

Sustainability

1. What is ecologically sustainable development?
2. Identify three perspectives people may have about the value of biomes.
3. How do ecosystem services help sustain people and the Earth?
4. Examine the link between people's perspectives and the sustainability of biomes.
5. Assess the importance of maintaining ecosystem services for future sustainability.

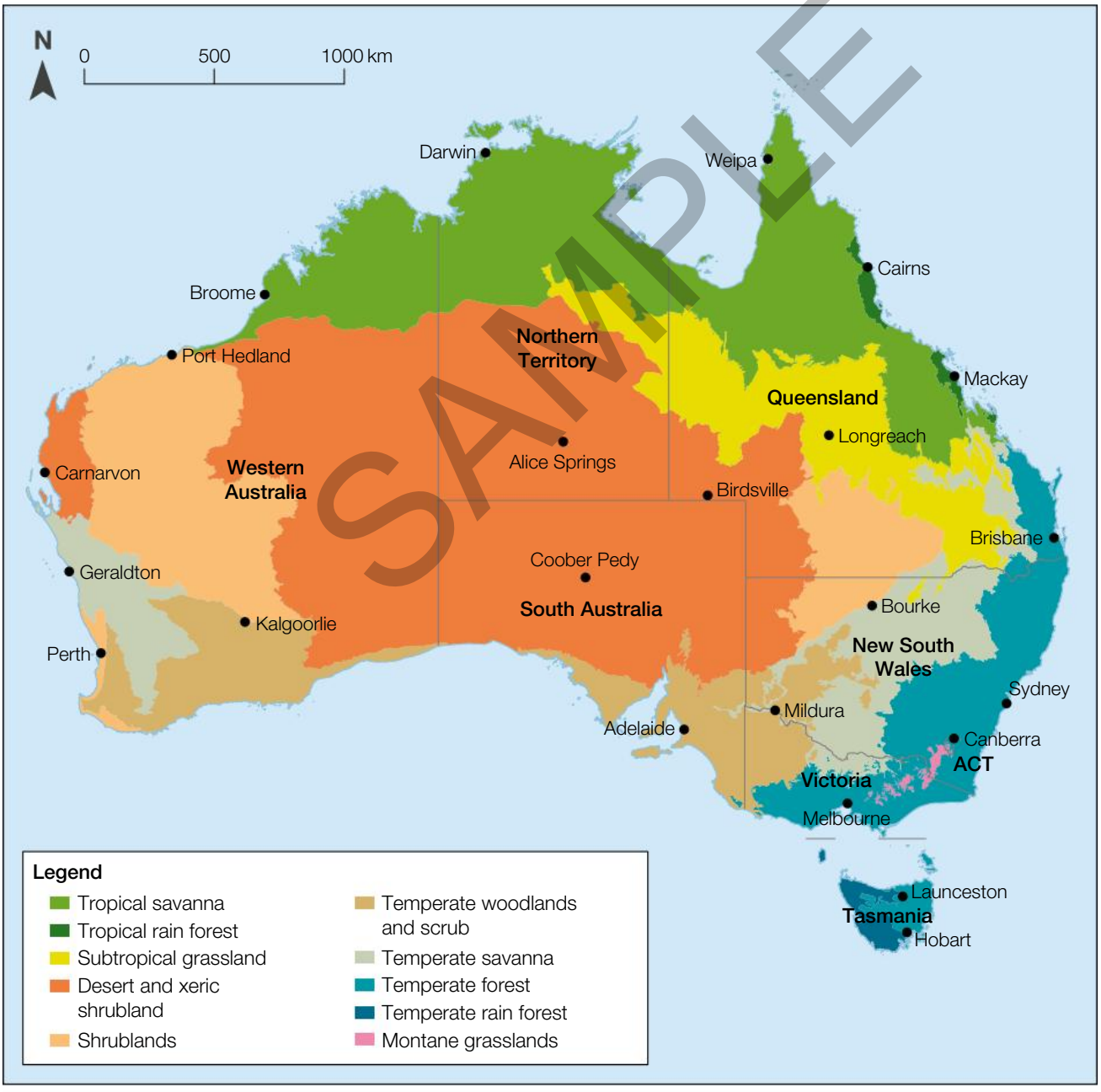
HOW TO Sustainability, page 418

1.8

What foods are produced in Australia?

Australia's wide variety of biomes, largely driven by climate and water availability, has resulted in a diverse agricultural industry that produces different food, industrial materials and fibres. Agriculture accounts for 55 per cent of Australia's land use. It is socially and economically important to Australia, making up 72 per cent of exports, worth approximately $76 billion in 2022, and creating over 239 000 jobs.

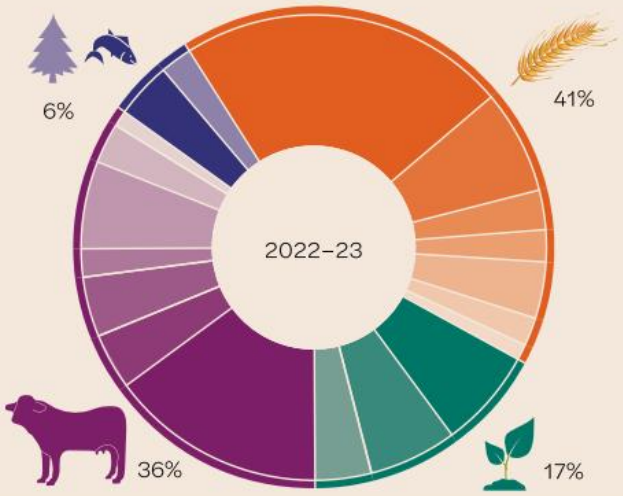
Biomes of Australia



Source: Matilda Education Australia, Wikipedia, Commonwealth of Australia 2019

▲ **Source 1:** Biomes vary on a regional scale within Australia.

Australia's agriculture, forestry and fishing sectors production

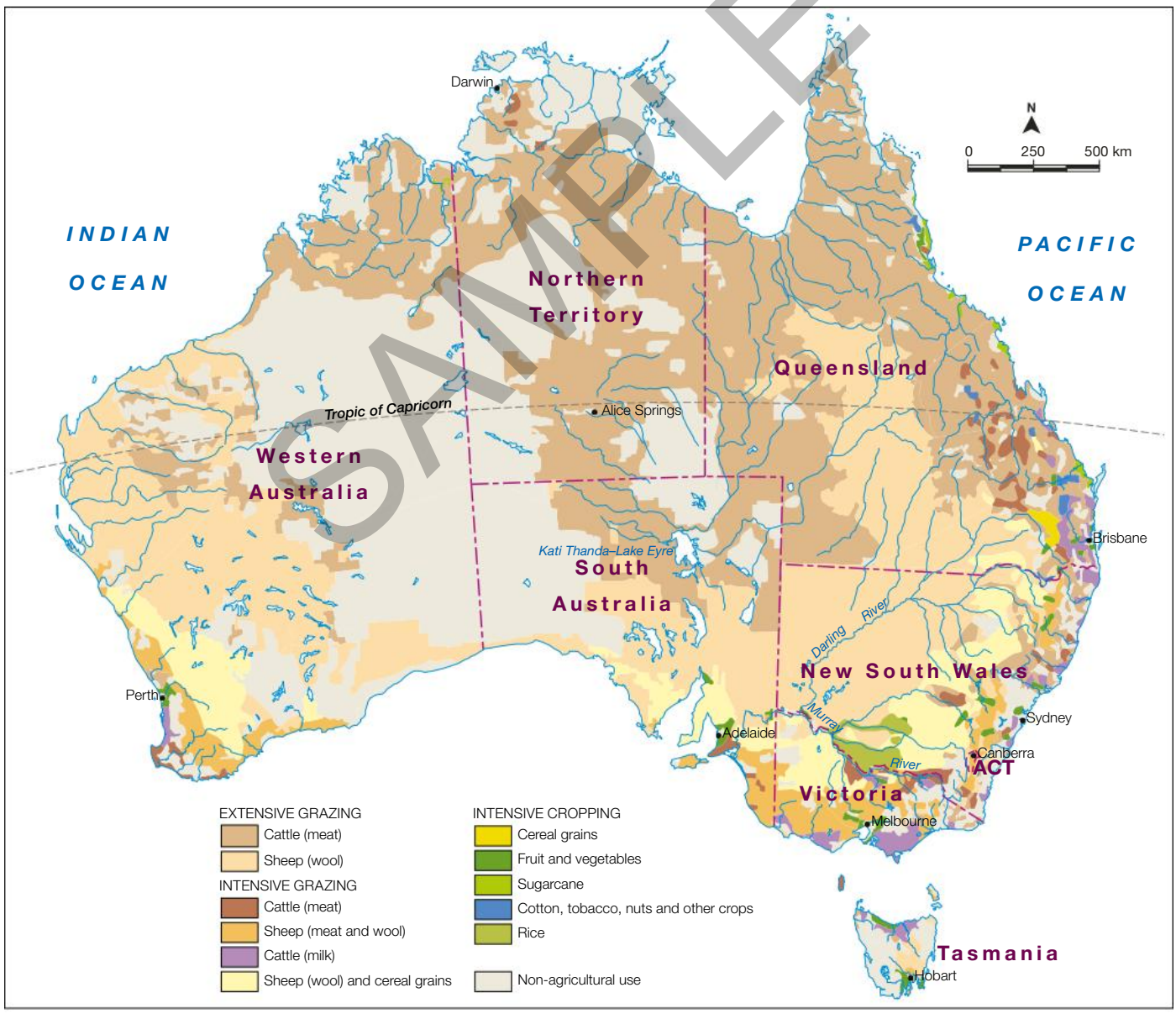


Cereal grains	23%	Cattle & calves	15%
Oilseeds	7%	Sheep & lambs	4%
Pulses	3%	Poultry	4%
Hay and pasture crops	2%	Pigs	2%
Cotton	4%	Milk	6%
Sugar cane	2%	Wool	3%
Wine grapes	1%	Other livestock products	1%
Fruit and nuts	7%	Fisheries	4%
Vegetables	6%	Forestry	2%
Other horticulture	4%		

Source 2: Australia's agricultural, fisheries and forestry sectors produce a wide range of crop and livestock products. The percentages shown here are the value of the product at the farm gate before they are processed.

Source : ABARES 2025

Australia's agricultural production zones



Source: Matilda Education Australia, Wikipedia, Commonwealth of Australia 2019

▲ **Source 3:** Australia's agricultural production zones

Wheat

The most widely grown crop in Australia is wheat, worth over $13.1 billion annually. It has a high **social value**, as it is used to make flour, stock feed, seeds and pasta. Many wheat varieties are drought-tolerant, meaning this crop is perfect to grow in the **temperate** to semi-arid climates that have low rainfall and high evaporation across southern Australia, such as in the wheatbelt of southern Western Australia and the Riverina in southern NSW. Farmers often have to rely on **irrigation** to help grow these crops due to the inconsistent rainfall. These environmental conditions are also great for other grains or cool-climate fruits, such as barley, oats, apples and pears.

Horticulture

Australia also produces a range of **horticultural** products such as fruits, flowers, vegetables, plantation crops and medicinal products. In northern Queensland and the Northern Territory, where there are tropical and sub-tropical climates with higher temperatures and precipitation, many tropical fruits and crops such as bananas, sugar cane, mangoes and papayas are grown. Meanwhile, in the cooler temperate and mediterranean climates of Southern Australian and Tasmania, cool-climate foods are produced. This includes fruit orchards such as cherries and apples, and famous high-quality wine regions produced from cool-climate grapes. Many famous wine regions are found through these climate regions of southern Australia, from Coonawarra, the Barossa Valley, the Yarra Valley and the Margaret River.

Dairying

Australia also produces a range of high quality dairy products; including 8.8 billion litres of milk a year, milk powders, butter and cheese. Dairy cows require cooler temperatures, as warmth and humidity affects their feed intake and reduces their production of milk. As a result, most dairy farms are found in the south-eastern seaboard of Australia in the cool-moderate pasturelands of Victoria, New South Wales and Tasmania.

Dairying in Australia is a type of intensive farming, where a large number of dairy cows graze on smaller farms with lush pasture.

Livestock grazing

Livestock grazing is common across Australia, due to its wide **pastoral**, temperate and tropical grasslands that are favourable for cattle and sheep. In addition to this, high **water scarcity** in Australia means many farmers choose livestock grazing over crop production because it requires less water. **Extensive farming** occurs in drier areas of Australia, where livestock graze widely on native vegetation. Sheep and cattle farming is prevalent across New South Wales, South Australia and the Northern Territory. Australia has become the world's second-largest beef exporter, with the beef industry producing around $8.4 billion a year.

Source 4: Extensive cattle farming occurs on large cattle stations in drier areas of Australia. The cattle need to be located and herded in a process known as mustering. On this Northern Territory cattle station, the mustering of cattle for sale, branding and health checks is conducted using helicopters, motor bikes and horses.

Source 5: Beef cattle farming in Queensland on lush green modified pasture after good rain. This is an example of intensive farming, where a large number of animals are raised in a smaller area.

Learning ladder 1.8

Characteristics of places and environments

1. List three ways in which food production is important to Australia.
2. Source 3: Explain the region of Australia where extensive grazing of livestock takes place.
3. Sources 4 and 5: Explain the difference between extensive and intensive agriculture.
4. Sources 4 and 5: Analyse the impacts of grazing livestock on the environment.

Space

1. Outline where one food product is produced in Australia and why?
2. Source 3: Explain the location of the wheat-sheep zone in Australia.
3. Sources 1 and 3: Use examples to explain how biomes influence where agriculture is produced in Australia.
4. Sources 1 and 3: If climate change expands Australia's deserts south and increases dryness, how will this affect food production in the future?
5. How can farmers overcome the impacts of climate change on Australia's biomes to continue producing food in the future?

HOW TO Space, page 406

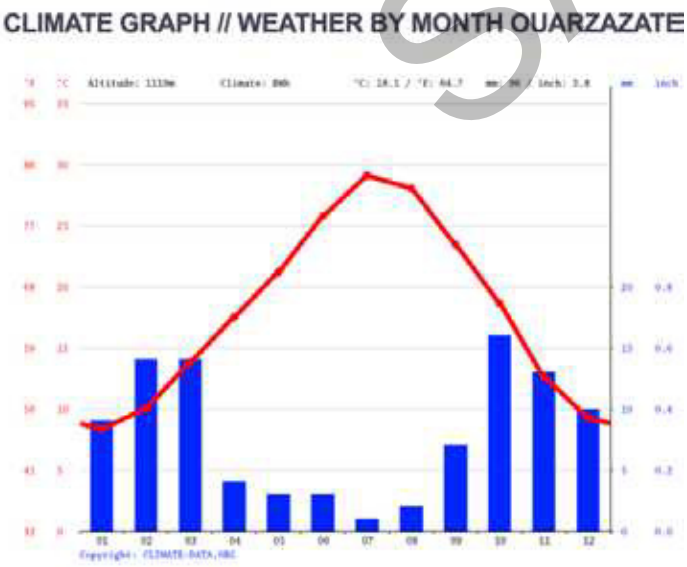
How is food produced in deserts?

Desert biomes are the driest places on Earth. They include a range of different environments including the sandy or rocky hot deserts found in the tropics around 30 degrees North and South of the Equator, and the cold deserts found in polar and mountain regions. Despite their aridity, these environments support a variety of farming activities ranging from the nomadic herding of cattle, sheep and goats that graze on natural vegetation and drink at permanent waterholes to small scale rainfed farms and large scale commercial irrigated plantations.

Characteristics of desert biomes

The defining features of desert biomes are low annual rainfall of 250 mmm or less per year and high rainfall variability. Low rainfall is due to high pressure systems (sinking air) and distance from the sea across Earth's mid latitudes. Coastal deserts occur where cold ocean currents reduce evaporation. Droughts are common and the environment has low primary productivity (NPP) because it is so dry. Rainfall is often in heavy isolated downpours that causes flash flooding. In hot deserts, daytime temperatures are extremely high while nights can get bitterly cold with temperatures falling below zero.

Very few plants grow to support wildlife. Xerophytic plants, such as cactus and woody shrubs like saltbush and acacia, along with grasses and flowering plants, can grow in these climatic conditions through adaptations. These include small leaves and thorns to reduce evaporation or deep roots to access groundwater.



Source 1: Climate graph and weather by month for Ouarzazate, Morocco (30º 56´ N 6º 54´W altitude 1153 m), is 273 kilometres from the coast at Essaouira in a dry desert basin between mountains.

Wildlife is nocturnal to escape the heat and able to survive on limited water and food, often relying on insects or reptiles. Seasonal rains promote the growth of grasses and flowering ephemeral plants. Soils range from sandy to rocky and have limited nutrient value, although this improves around rivers and oases.

Source 2: Small-scale subsistence farmer at Ait Ben Haddou near Ouarzazate

Source 3: A goat herder in Morocco.

The inhospitable environment in deserts means that population densities are low, except where permanent water supplies are available. Around oases where people have settled for thousands of years, large towns and farms have developed. Road infrastructure is often limited to major highways between urban centres or unsealed roads; however, these may be cut off by moving sand, flash-flooding during intense rainstorms or even landslides in arid mountainous areas. In poorer countries wildlife-drawn carts are used to transport farm produce and subsistence herders travel on foot.

Food production

The harsh climate and poor soils mean the capacity to produce food in arid lands is limited. Wildlife can graze on natural vegetation, but must regularly migrate to find new pastures. Where water is available, such as around rivers and oases, and where irrigation is possible, productivity increases. In many nations, including Morocco, desert produce is sold at local markets, although large-scale irrigation projects and plantations produce foods for export.

Food production in Morocco

Morocco is located in the north-west corner of Africa between latitudes 21°N and 36°N; it is bound by the Atlantic Ocean in the west and the Sahara Desert in the east and south. The Atlas Mountains divide the country into different biomes, all of which are arid or semi-arid – Mediterranean in the west (with a long dry season), Mediterranean–mountainous in central and northern Morocco, arid-steppe and arid-desert in the east and south.

Eighty per cent of crop land is in arid or semi-arid areas and only a small percentage of the country's lands are irrigated. Despite its aridity, Morocco produces large amounts of food for home consumption and export. Traditional agriculture is small-scale and produces rain-fed crops such as cereals, legumes and vegetables. About 45 per cent of Moroccans are small subsistent farmers. Irrigated areas support larger farms and produce 75 per cent of the country's farm exports. Plantation crops include olives, almonds, citrus, grapes and dates, while export crops –sugar beets, sugar cane, cotton and oilseeds – are all produced on a large scale.

West of the mountains orographic rainfall and snow melt feed the rivers and larger scale irrigated crop and livestock farming occurs. The mountains, valleys and plains to the east are arid because of the rain shadow effect of the mountains (Source 4).

Source 4: Annotated cross-section through the centre of Ouarzazate

Moving southwards, the climate becomes drier. In these arid regions nomadic herders have produced meat and livestock products such as milk and hides for centuries. Nomadism still exists today as herders move their stock between pastures and water sources; however, numbers are dwindling. Rain-fed and small irrigated farms are found in valleys, along intermittent rivers and at the base of mountains where aquifers are closer to the surface and form oases. Here, mixed farming involves intricate systems of irrigation, producing food such as dates, fruits, vegetables and spices in multi-layered forests, as well as livestock. Many communities still rely on ancient systems of delivering underground water known as Qanats.

Source 5: Arid lands farming near Marrakesh, Morocco. The farm is located beside a dry river bed and uses seasonal rain and wells for farming.

Source 6: A close up of the farm in Source 5

Challenges in Morocco

The greatest challenge to food production in Morocco is the changing climate. A lack of snow, and therefore summer snowmelt, along with increasingly low precipitation, means watercourses are running dry and oases are shrinking. Water withdrawn from aquifers for irrigation is not being replaced by infiltration and water levels are dropping. This is worsened by an influx of companies growing crops for export that use large pumps to access deeper water. Desert sands are moving in to take over date plantations and farmers are leaving oases to get jobs in large cities to the west. Desertification is threatening the survival of desert oases and the food they produce.

Learning ladder 1.9

Characteristics of places and environments

1. Outline three key characteristics of deserts that make food production difficult.
2. Source 2: Describe the types of food production that occur in arid biomes such as deserts.
3. Explain three causes of arid environments such as deserts.
4. Source 4 and Source 5: Analyse the challenges faced by Moroccan people to grow food east of the Atlas Mountains.
5. Predict the future of oasis agriculture due to climate change.

Representing and communicating information

1. Identify three geographical tools that help us learn about biomes and food production in Morocco.
2. Source 1
   - **a** Calculate the annual precipitation and annual temperature range at Ouarzazate.
   - **b** Explain why Ouarzazate fits the definition of a desert.
3. Source 3:
   - **a** Describe the location of Ouarzazate using geographical concepts and by referring to specific places.
   - **b** Explain why Ouarzazate has low rainfall.
   - **c** Assess the value of irrigation to Ouarzazate and other places in eastern Morocco.
4. Source 5 and Source 6
   - **a** Identify two types of photograph.
   - **b** Create a two photo sketches. Label natural and human features of the environment.
   - **c** Suggest three agricultural products produced on this farm.
   - **d** List the advantages and disadvantages of this type of photograph compared to Source 3.

HOW TO
Representing and communication information, page XXX

How does water impact food production?

Approximately 70 per cent of the world's freshwater extracted from rivers, lakes and aquifers is used for agriculture. The global demand for water for agriculture continues to grow, with a predicted increase of 19 per cent by 2050 just for irrigation.

Water for food production

Water for food production comes from three sources determined by what happens to water when it rains.

- Green water – is stored in the soil where it evaporates or is absorbed and transpired by plants; it makes up approximately 60 per cent of precipitation.
- Blue water – is surface run-off and percolation that flows into freshwater storages such as rivers, lakes, wetlands and groundwater; it represents the remaining proportion of precipitation and is stored or evaporated back into the atmosphere. Irrigation makes blue water available for food production.
- Grey water – waste water that has been used for another purpose and needs treatment for reuse in agriculture.

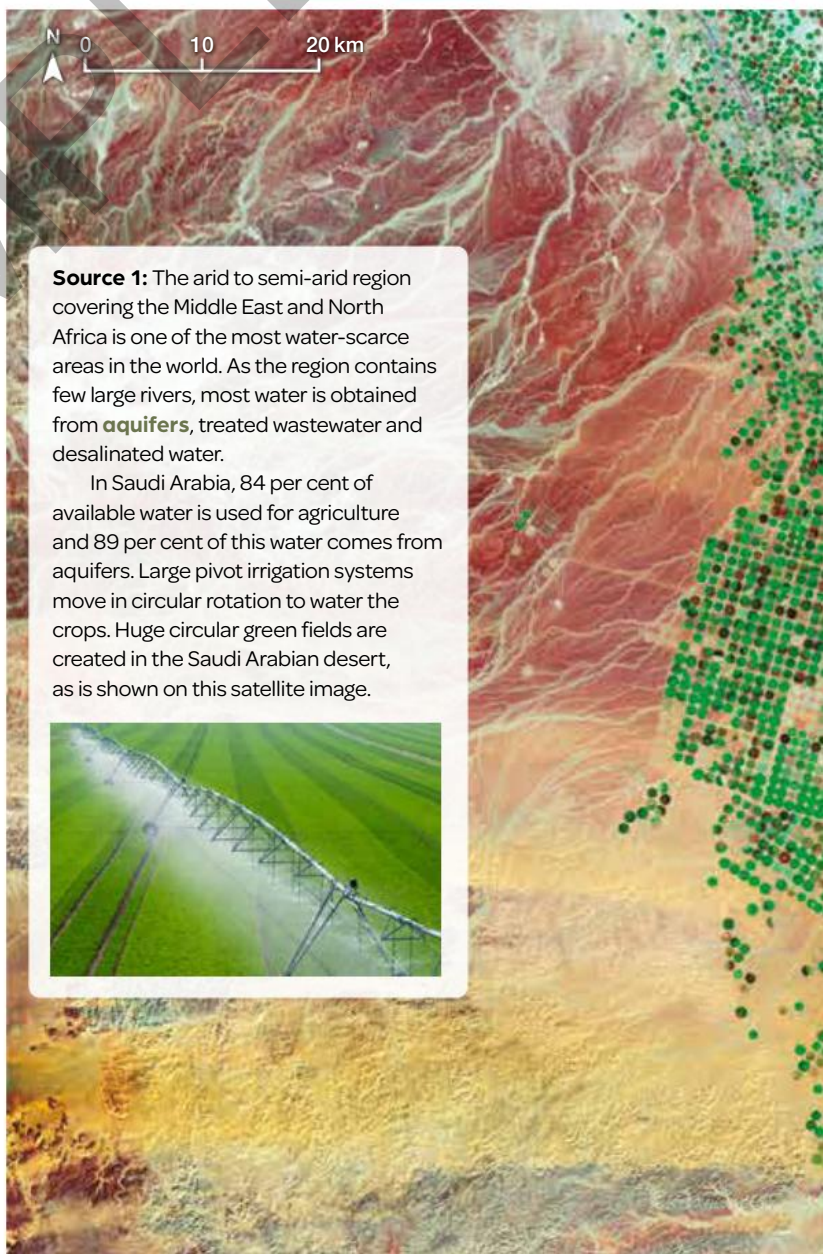
Rainfed agriculture, farming that relies on rainfall for water, uses green water. Farmers who use some irrigation to supplement natural rainfall are using blue and green water. In arid areas like Saudi Arabia (Source 1) mainly blue water makes food production possible. Grey water is becoming more important in countries facing water scarcity.

Increasing access and availability

About 80% of the land farmed around the world is rainfed and contributes nearly 60 per cent of global food production. These regions are vulnerable to natural variations in precipitation and fluctuations caused by climate change, increasing water and food scarcity.

Irrigation is the main method of increasing access to water, contributing to 40 per cent of global food production. Irrigation accounts for 80 per cent of Pakistan's and 70 per cent of China's food production. Pakistan, Bangladesh and South Korea irrigate more than half of their agricultural area.

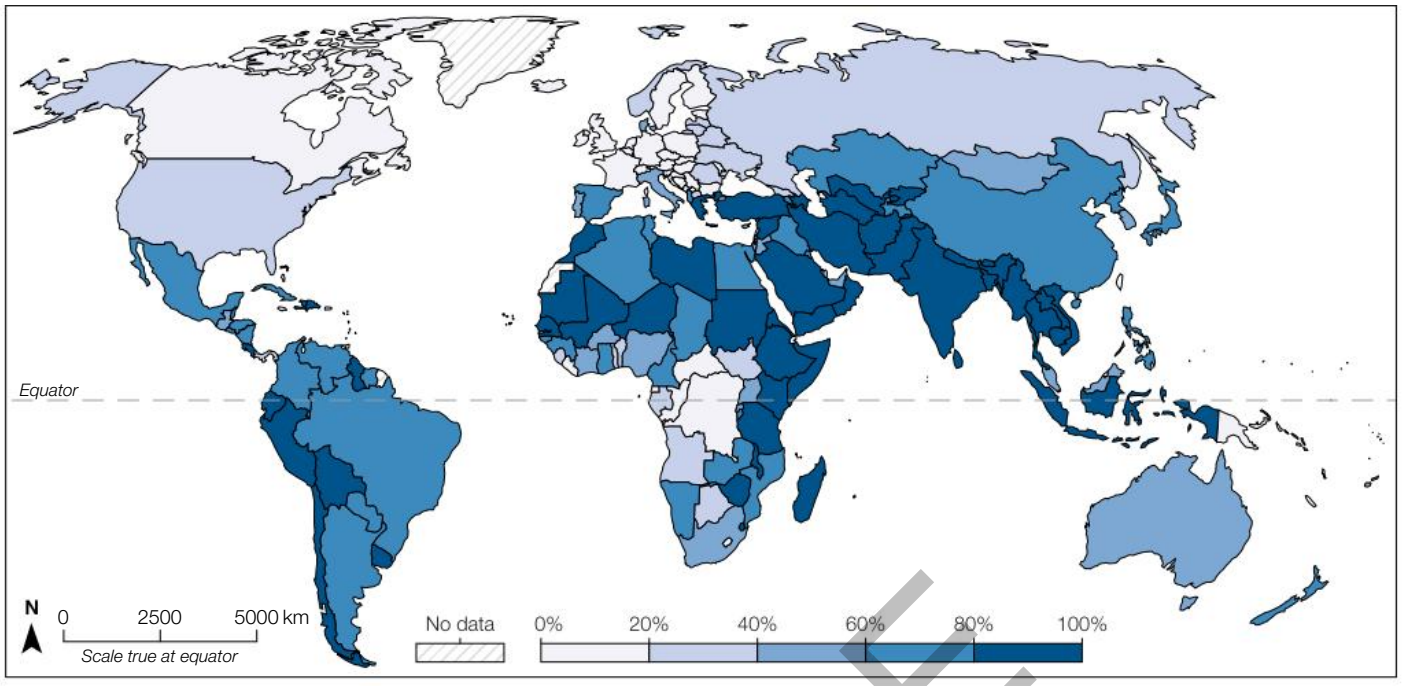
Irrigation involves construction of huge dams such as Tarbela Dam in Pakistan, the largest dam in the world. Generally, irrigated land is twice as productive as land growing rainfed crops. However, crop yield is affected by the degradation of irrigated land through waterlogging and **salinisation** of soils. Water can also be transferred in pipelines from wet catchments to water poor catchments, sometimes between countries, where it can be stored for irrigation.



Source 1: The arid to semi-arid region covering the Middle East and North Africa is one of the most water-scarce areas in the world. As the region contains few large rivers, most water is obtained from **aquifers**, treated wastewater and desalinated water.

In Saudi Arabia, 84 per cent of available water is used for agriculture and 89 per cent of this water comes from aquifers. Large pivot irrigation systems move in circular rotation to water the crops. Huge circular green fields are created in the Saudi Arabian desert, as is shown on this satellite image.

Global agricultural water withdrawals, 2021



Source: Our World in Data

▲ **Source 2:** Agricultural water as a share of total water withdrawals in 2021

Learning ladder 1.10

Processes that transform people, places and environments

1. Describe the impact of green and blue water on food production in the Middle East and North Africa.
2. Source 1: Explain how technological factors helped to form circular agricultural fields in Saudi Arabia?
3. What factors can positively or negatively impact regions that rely on rainfed agriculture?
4. Source 2: Use examples from the map to analyse the importance of irrigation for improving access to water for food production.

Change

1. How does precipitation become green, blue and grey water?
2. Explain the relative importance of blue, green and grey water to food production and how increasing demand for water may change this.
3. Source 1: Arid countries like Saudi Arabia are among those changing how they improve access to water for food production. Analyse the potential consequences of this.

HOW TO Change, page 412

Case study

How does water scarcity impact dairy farming?

The high cost of irrigation water caused by water scarcity is forcing dairy farmers off their farms in the Murray–Darling Basin region.

Dairy farming in the Murray–Darling Basin (MDB)

Dairy farming is concentrated in the southern regions of the Murray–Darling Basin (MDB). The MDB contains 1162 dairy farms that produce 20 per cent of Australia's national milk total. These farmers need water to produce pasture and fodder crops such as grasses, legumes or hay for the dairy cows to eat. Unlike coastal dairy farms, rain in the MDB is highly variable, and farmers need to use irrigation to grow the feed. Seventeen per cent of MDB irrigation water is supplied through irrigation pipes, canals and sprinklers to dairy farms.

Causes of water scarcity the the MDB

Water scarcity occurs when there is less available fresh water than is required. River flows in the MDB today are only 50 per cent of their 1900s volumes. This results in a high price for water. Water scarcity in the MDB and is caused by:

- droughts, including El Niño events, that decrease rainfall and increase evaporation
- climate change increasing the frequency and intensity of droughts
- high competition for water by communities and farms
- poor water infrastructure leading to water loss and high costs of water.

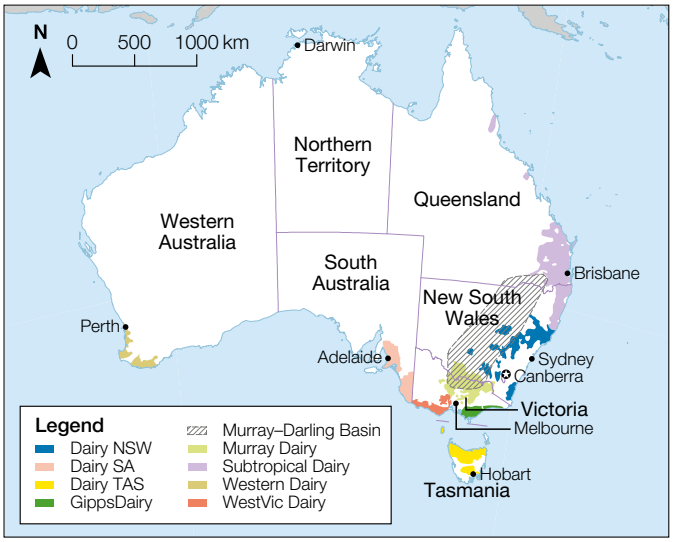
Impacts on dairy farming in the MBD

Water scarcity impacts dairy farmers by reducing the quality of their feed and grazing opportunities for cows, resulting in decreased cow health and milk production quality and quantity. This results in farmers having to spend money on feed, water or improving infrastructure to increase water access, impacting their profits and creating financial strain. This can result in farmers needing to reduce herd sizes to match the available water and food supplies, impacting the sustainability of farms.

Management of water scarcity

The Murray–Darling Basin Authority (MDBA) uses a water trading scheme to manage water in the MDB. This results in farmers being allocated 'water entitlements' that outline how much water they can use within the year. If they do not use as much as they are entitled, farmers can trade with other users and earn profit. If they use more than they are entitled, they have to buy 'temporary entitlements' which are often high in cost. This is meant to encourage farmers to invest in technologies and infrastructure so they reduce their water use. Unfortunately, 60 per cent of dairy farmers in the MDB use more water than their 'water allocation'.

Australian dairy farming areas



Source: Dairy Australia

▲ **Source 1:** Australia's dairy farming regions

Drought-stricken dairy farmers watch the river run by, unable to access it

Landline, 6 October 2019

Australia's dairy farmers are leaving the industry in droves as drought and sky-high prices for water take their toll. The Murray Valley region, stretching from northern Victoria to southern New South Wales, is one of the regions which has been hit the hardest.

An estimated 400 farmers have left there in the past year, milk production has halved to 1 billion litres, and saleyards are flooded with unwanted, surplus dairy cows – the less productive ones are destined for the meatworks.

"Truckloads and truckloads – hundreds a week – [are] getting killed out of the area," stock and station agent Nathan Everingham said.

Source 2: Landline, 6 October 2019 (ABC Rural: Cara Jeffery)

Learning ladder 1.11

Characteristics of places and environments

1. Identify one cause of water scarcity in the Murray Darling Basin.
2. Describe how water scarcity affects the quality and quantity of milk production in dairy farms.
3. Explain the social and economic impacts of water scarcity on dairy farmers in the Murray Darling Basin.
4. What challenges do dairy farmers face in managing their water allocations and trading water in the Murray Darling Basin?
5. Evaluate the viability of the dairy industry in the Murray Darling Basin.

Place

1. Source 1: Describe the location of the Murray Darling Basin.
2. Describe the impact of water scarcity on dairy farms in the MDB.
3. Source 2: What was the impact of water scarcity in the Murray Valley region in the drought of 2019?
4. How is dairy farming in the MDB different from coastal areas of Australia?
5. Develop a strategy to improve the water trading scheme. Write a letter or a campaign to present to the government explaining how your strategy will improve the scheme and better support farms in the MDB.

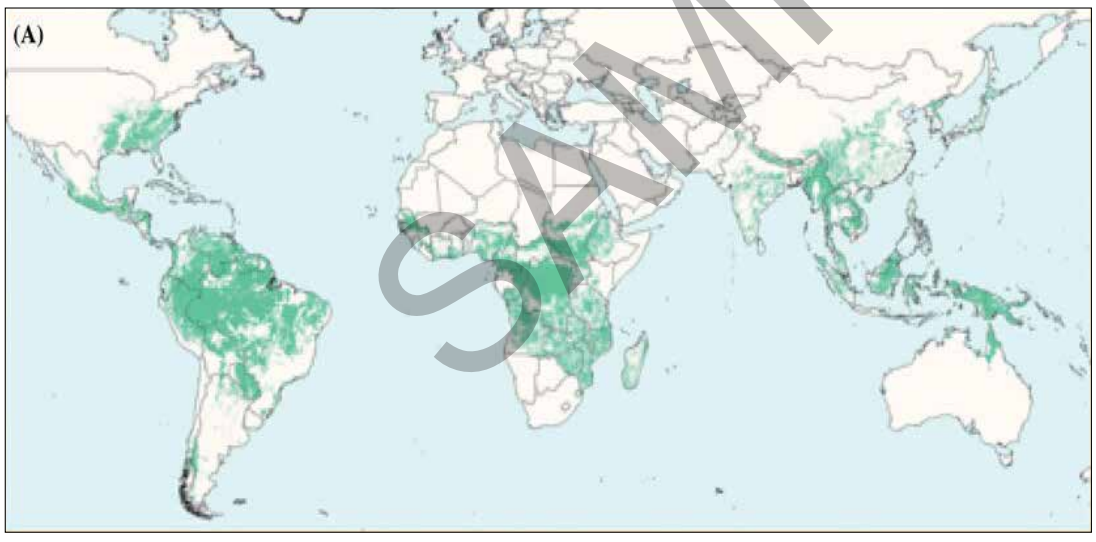
Place, page 408

HOW TO

What challenges impact the production of bamboo?

Bamboo is a fast-growing woody grass that is produced in a range of biomes, such as temporate and tropical forests. It is used as an industrial material, for construction and furniture, and is also a fibre for textiles, paper and crafts. Demand for bamboo has increased over the past decade, as it has been recognised as a versatile and sustainable material. It is increasingly being used to replace everyday plastics, such as straws and disposable cutlery. Growing it also has many environmental benefits, as bamboo **sequesters** large amounts of carbon from the atmosphere and, unlike most other farmed materials, it continues to store much of the carbon after it is harvested. Unlike regular trees, bamboo grows and regenerates quickly, reducing the need for deforestation. It can also stabilise soils and reduce erosion, and does not require much water for production.

Global distribution of bamboo forests



Source 1: Global map of the distribution of bamboo in forests around the world. Bamboo is naturally found in over 87 countries, most of which are in tropical and subtropical regions. Climate change can challenge bamboo farmers, by changing the regular climate patterns and influencing where bamboo can be grown.

Source: Matilda Education Australia/ Zhao et al

Challenges producing bamboo

Processing costs and profits

To harvest and process bamboo into fabrics is labour intensive and costly. The logging, storage and transport of bamboo can increase the price of bamboo, which reduces demand. This can lead to price volatility, and reduce the amount of money businesses are willing to pay for bamboo products. Consequently, bamboo farmer profits can be impacted.

Excessive rain or flooding

Bamboo is a drought-tolerant crop that does not require an extensive water supply. If soil has poor drainage, experiences flooding, is overwatered or experiences extensive rain, the bamboo roots will rot. This reduces crop yields and the quality of the bamboo. Excessive water-logged soils can lead to the growth of fungus, which further impacts the growth of the crop. Climate change is resulting in more intense and frequent storms, challenging bamboo farmers to create sustainable, affordable ways to drain their soils.

Fast growing

Bamboo grows up to 90 centimetres per day and can spread quickly. This requires bamboo farmers to harvest and cull bamboo regularly to manage its growth and spread. This is labour intensive, which can increase the costs associated with producing bamboo. Farmers can also experience legal and social consequences if their crop spreads into neighbouring native systems or farms, as it can decrease the space and nutrients for other crops and plant species, or threaten native habitats.

Monoculture

Bamboo plantations are a monoculture agricultural practice, where a single crop or plant species is grown over a large area for consecutive seasons. Monoculture farms can experience a variety of challenges including reduced soil fertility, ecological imbalances and vulnerability to pests and disease. As bamboo absorbs soil nutrients, the land becomes less fertile over time.

Pests and disease

As bamboo is a grass, young bamboo plants are vulnerable to being consumed by herbivores in their first five years. As the bamboo plant matures and the merging shoots associated with them grow, they become more vulnerable to over 400 insect species who feed on their wood-like biomass. Pesticide treatments are expensive and need to be professionally applied so as not to impact any species or neighbouring crops.

Source 2: Trucks transport bamboo in rural China. Harvesting, transporting and storing bamboo can be costly, impacting on the profit of farmers. These costs are even higher for farmers who are further away from bamboo processing facilities.

Source 3: Mealybugs secrete a 'honeydew' on bamboo that can cause an increase of other pests, such as ants, and black mould to grow. Farmers need to use costly pesticides to prevent pests from spreading through their crops.

Learning ladder 1.12

Processes that transform people, places and environments

1. What are the main biomes where bamboo is grown, and why is it suitable for these environments?
2. How has the increased demand for bamboo over the past decade influenced its production in different biomes?
3. What are some of the environmental benefits of growing bamboo compared to other farmed materials?
4. Explain how climate change could impact the cultivation of bamboo in both tropical rainforests and temperate forests.
5. How does the practice of growing bamboo as a monoculture affect the soil and surrounding ecosystem over time?

Sustainability

1. Why is bamboo considered a sustainable material?
2. What challenges do bamboo farmers face in maintaining sustainable production practices?
3. How does bamboo's ability to sequester carbon contribute to its sustainability?
4. Discuss the environmental impacts of using pesticides in bamboo farming.
5. Evaluate whether replacing traditional tree logging with bamboo farming would be more sustainable.

HOW TO Sustainability, page 418

How can we alter biomes to improve food production?

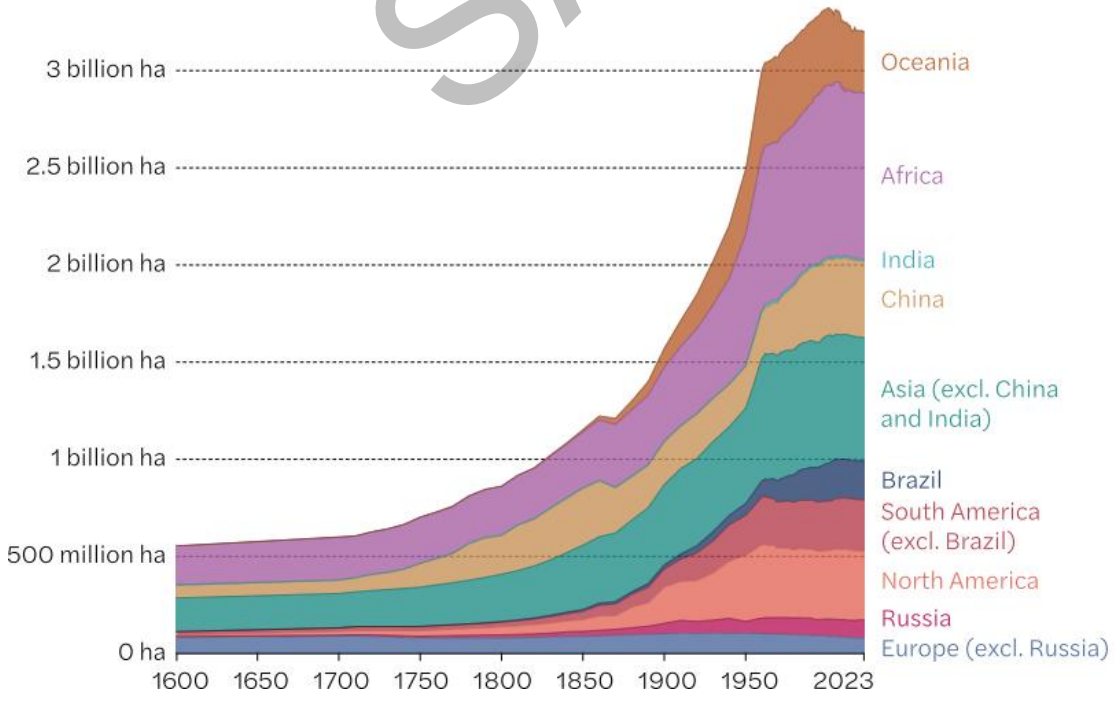
Farmers alter the environment to mitigate against challenges and to increase the quality and yield of their crops. These alterations can maximise food production by increasing the carrying capacity of farms; this is the maximum number of livestock and crops they can maintain sustainably with the resources (such as water) available. These alterations need to be effectively implemented, as they can also have social and environmental impacts.

Controlling climate

Farmers in biomes with temperature extremes, such as arid and sub-polar environments, or temperate forests and grasslands, which experience seasonal variations, can choose to alter the environment to support crop growth in varying temperatures and climatic conditions. These can include:

- **greenhouses:** structures that absorb and trap solar heat, enabling the structure to stay consistently warm and vegetation to grow through cool climatic conditions
- **hydroponics:** a method of growing plants without soil, using nutrient-rich water solutions to deliver essential minerals to the plant root. This enables precise control over water, nutrients and climate, leading to faster growth and higher yields. Some places also implement *aquaponics*, where fish are used in the water to provide the nutrients to plants, enabling the farming of both fish and crops
- **vertical farming:** a technique used in urban settings, as plants grow vertically on walls, enabling high-density food production in little space.

Grazing land use 1600–2023



Source: Our World in Data

Source 1:
A graph displaying the changes to biomes in different regions, to create agricultural land over time. This highlights the fast rate of change for land use.

Maintaining soil health

Farmers in biomes that experience large amounts of precipitation or excessive arid conditions, such as mountainous tropical biomes or savannas, can encounter high rates of soil erosion. This can reduce the nutrients in soils, as they are leached and run into local water sources. Strategies to overcome this include:

- **terracing:** an agricultural practice that involves creating stepped, flat areas on hilly or sloped terrain. These terraces reduce soil erosion, retain water, and make the land more suitable for farming by providing level surfaces for planting crops
- **fertilisers:** with core nutrients required to improve soil health, including phosphorus and nitrogen, which can increase the yield and quality of crops produced. However, the type and amount of fertilisers needs to be managed appropriately to reduce the chances of excessive nutrients running into and impacting local water sources
- **crop rotation:** rotating crops between paddocks by harvesting crops and then replanting them for a different season in a different paddock. This helps to maintain soil health, as soils are less likely to experience waterlogging from irrigation or soil degradation caused by mechanisation during harvesting over long periods of time
- **monoculture:** planting large areas with a single crop can alter the biomes biodiversity. Farmers do this to increase efficiency, as they are able to harvest larger amounts of crops with less labour intensity or output. This can increase the vulnerability of crops to disease and pests, which can spread through the singular crop and remove all viable products for farmers to sell.

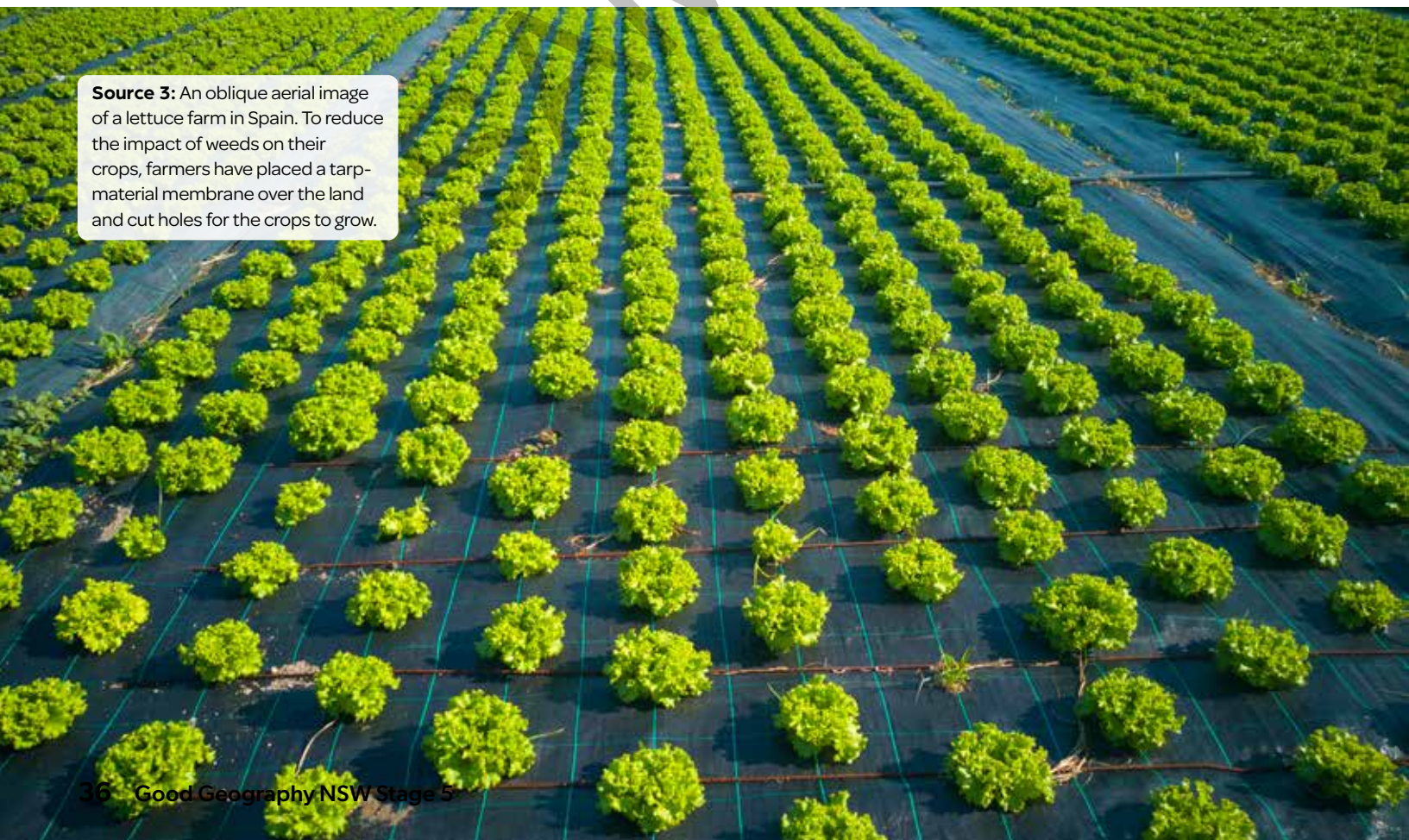
Source 2: An aerial photograph of rice terraces in China. Farmers develop terraces in mountainous regions to create flat spaces to grow crops. This reduces soil erosion, catches water for crop growth, and increases the amount of food produced.

Mitigating against challenges

Alterations can be made to all types of biomes to mitigate against challenges that can affect the carrying capacity of the land or the yield of crops.

- **Fencing:** Using fencing around agricultural properties can increase the carrying capacity of livestock, prevent overgrazing by sectioning off paddocks from livestock and protect the land. It also reduces herbivorous pests, such as rabbits, from consuming or degrading crops.
- **Pesticides:** Farmers can spray their crops with chemicals to remove or prevent pests and weeds from reducing their quality. This further protects soils from excessive weathering. The amount and type of pesticides must be managed to prevent them from damaging crops or running off into local water sources.
- **Artificial pollination:** Using manual or mechanical methods to pollinate crops can ensure successful crop production, even when natural pollinators (such as bees) are scarce.
- **Groundwater management and Irrigation:** Using sprinkler systems, or groundwater, to water crops can support the growth of crops during dry periods. This can lead to the depletion of natural water sources, and needs to be managed appropriately.

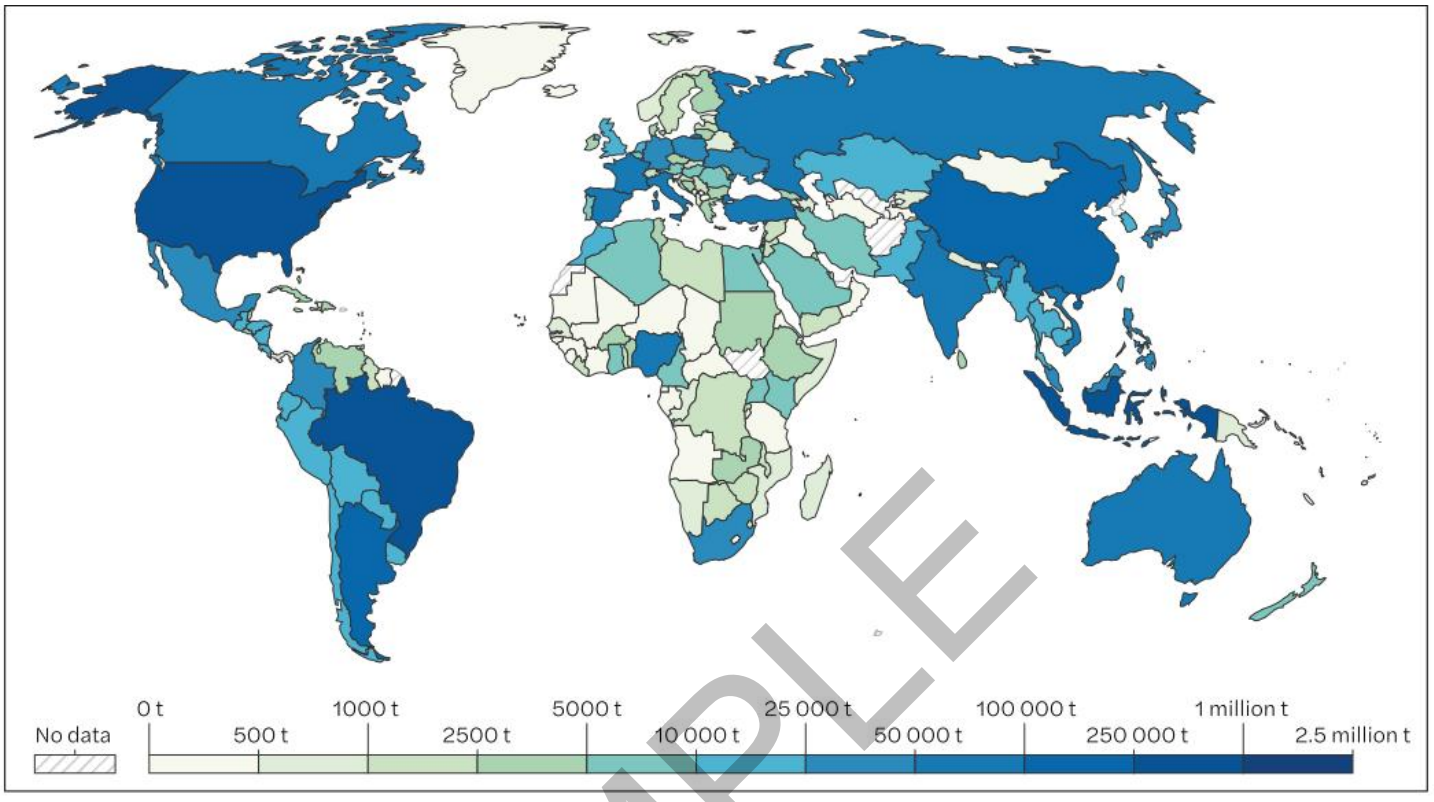
Source 4: A farmer spraying pesticides over tomato plants. This protects the quality and yield of their crops.



Source 3: An oblique aerial image of a lettuce farm in Spain. To reduce the impact of weeds on their crops, farmers have placed a tarp-material membrane over the land and cut holes for the crops to grow.

Global pesticide use, 2021

Total pesticide use measured in tonnes of pesticide consumption per year.



Source: Our World in Data

Source 5: A choropleth map displaying the total tonnes of pesticides used in 2021. This demonstrates the global extent of pesticide use in the world today.

Learning ladder 1.13

Perspectives of people and organisations

1. Describe vertical farming.
2. Why might farmers choose to use greenhouses or hydroponics in areas with extreme temperatures?
3. How might the use of fertilisers and pesticides be viewed differently by farmers compared to environmental organisations?
4. Discuss how vertical farming in urban areas might be seen as both an opportunity and a challenge by different stakeholders, such as city planners and local communities.
5. Analyse the varying perspectives of farmers and environmentalists on the impact of groundwater management and irrigation on local water resources.

Sustainability

1. How does crop rotation contribute to the sustainability of farming practices?
2. Source 1: How does the rapid increase of agricultural changes to biomes impact sustainability?
3. Explain the potential environmental impacts of artificial pollination and how these can be managed sustainably.
4. Explain how the use of hydroponics and vertical farming can support sustainable agriculture in urban environments.
5. Evaluate the sustainability of two alterations that can be made to biomes, and suggest alternatives that could reduce their environmental impact.

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1.14

How does irrigation increase yields?

Irrigation is the artificial application of water to the land. The prime role of irrigation is to increase food production by providing greater access to water.

Irrigation methods and benefits

Using irrigation to increase crop **yields** comes through changes to where and how food is produced:

- expanding arable land into areas previously limited by low rainfall, such as deserts
- increasing the productivity of existing farmland by overcoming seasonal water shortages and allowing multiple harvests in one year (double cropping)
- replacing low yielding **rainfed crop** varieties with high yielding, water demanding crops such as rice, vegetables and fruit
- using water resources more sustainably through low-waste water delivery systems.

Irrigation methods are selected to suit crops, the scale of farming operations and whether the farming is subsistence or commercial. Water is sourced from rivers, lakes, groundwater, and aquifers and delivered to crops and pasture through dirt channels, concrete canals, pipelines, controlled drip systems and sprinkler systems.

Yields and sustainability

Irrigation enables 20 per cent of the world's agricultural land to produce 40 per cent of its food and it expands the variety of foods grown. Irrigated crops are up to 2.5 times more productive than rainfed agriculture. Without irrigation some countries would remain dependant on the importation of staple foods such as cereals. Food self-sufficiency, a development target for many low-income countries, is improved through increased yields.

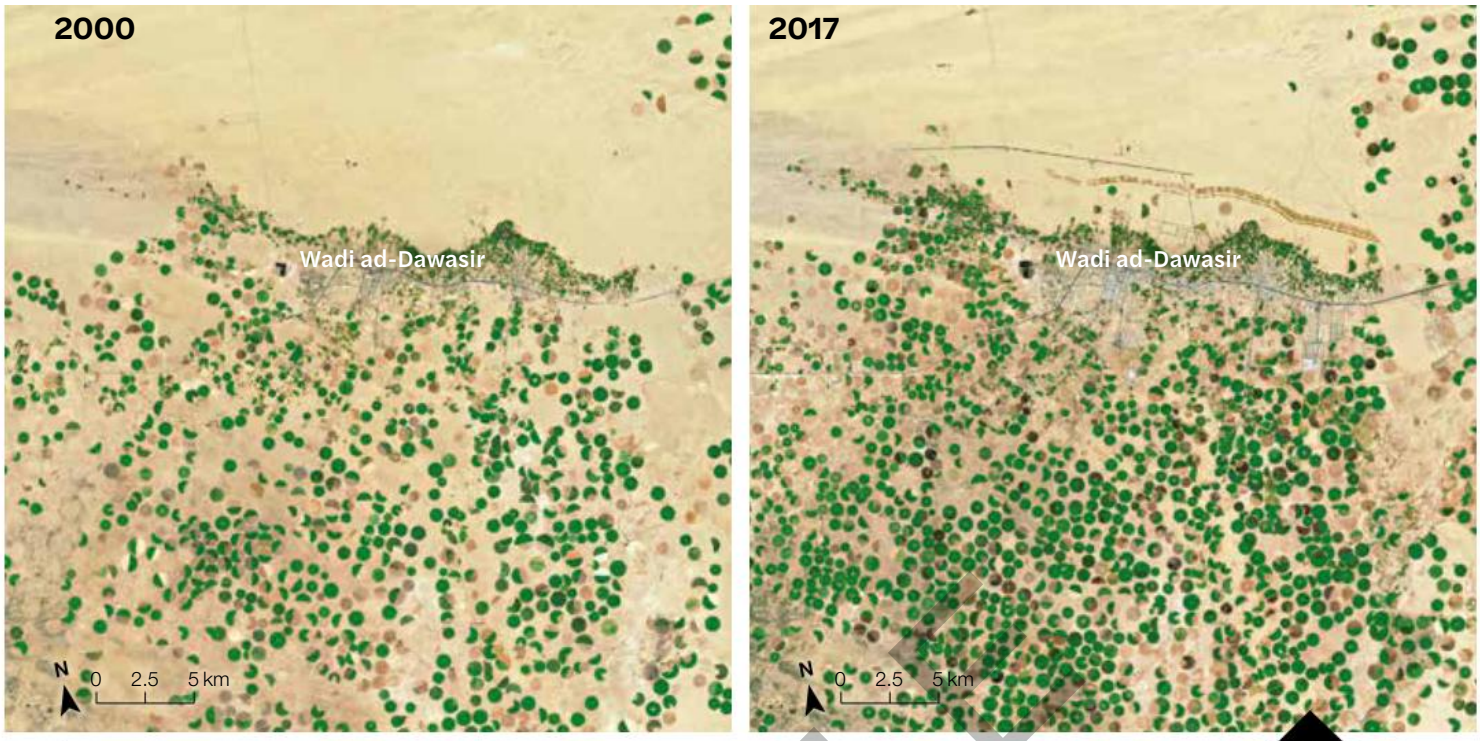
If not carefully controlled, the use of irrigation to increase crop yields and improve **food security** comes at an environmental cost. Water losses through leaking pipes, evaporation from open channels, **salinity** and waterlogging the soil are impacts being addressed by strategies to save water such as drip irrigation and computer-controlled delivery systems.

Saudi Arabia's desert irrigation

Large scale aquifer fed centre pivot irrigation systems in Saudi Arabia have increased food production and self-sufficiency. Since the 1980s Saudi deserts have transformed into a patchworks of green circles such as those at Wadi ad-Dawasir. The country has become self-sufficient in many foods and an exporter of products such as wheat, dates, dairy products, vegetables and flowers to global markets.

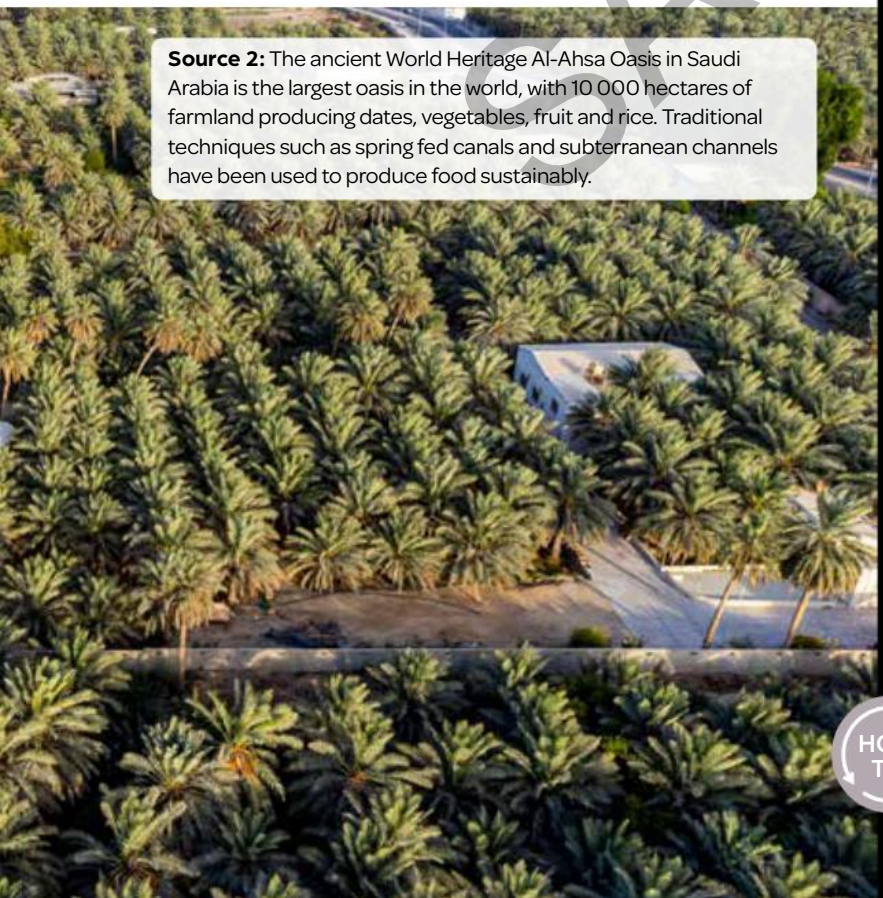
The unsustainable use of aquifers to feed large scale irrigation systems is a serious issue. When aquifers are pumped faster than they are recharged by precipitation, the resource becomes non-renewable and quickly depleted. To be sustainable, aquifers need to recharge, a process not possible in Saudi Arabia where natural rainfall is too low and extraction rates are too high. The Food and Agriculture Organisation predicts that Saudi Arabia's aquifer water resources may only last 25 years.

Expansion of centre-pivot irrigation around Wadi ad-Dawasir in Saudi Arabia, 2000 and 2017



Source: NASA Earth Observatory

Source 1: The expansion of centre-pivot irrigation around the town of Wadi ad-Dawasir in Saudi Arabia between 2000 and 2017 hides the issue of unsustainable groundwater extraction to produce crops such as wheat, alfalfa, and vegetables. Hydraulic pumps powered by powerful engines draw 'fossil' water from deep below the ground. Each pivot irrigates an area of more than 50 hectares. The water table here has dropped up to 6 metres per year since the 1980s. The water resource could be fully depleted within a few decades.



Source 2: The ancient World Heritage Al-Ahsa Oasis in Saudi Arabia is the largest oasis in the world, with 10 000 hectares of farmland producing dates, vegetables, fruit and rice. Traditional techniques such as spring fed canals and subterranean channels have been used to produce food sustainably.

Learning ladder 1.14

Sustainable management strategies

1. Describe three ways irrigation increases crop yields.
2. Outline the environmental impacts of irrigated agriculture.
3. Explain two strategies used to increase the sustainable use of irrigation water.
4. Source 1: Calculate the area of land irrigated using centre pivot irrigation in a 25 km^2 area in the bottom left corner of the 2017 satellite image.
5. Propose one method that could be used to recharge aquifers in Saudi Arabia and identify the challenges you would face in implementing your plan.

Sustainability

1. Describe three sustainability issues with irrigation.
2. Sources 1 and 2: Compare the methods used to extract groundwater in Wadi ad-Dawasir and Al-Ahsa World Heritage Oasis.
3. Explain the difference between sustainable and unsustainable aquifer storage and pumping.
4. Source 1: Analyse the sustainability of centre pivot irrigation based on climatic data and comments from international organisations.

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1.15

How will climate change impact food production?

Source 1: Warmer temperatures and increased rainfall create the perfect conditions for plagues of insects. In 2019–20 a desert locust plague in East Africa created food insecurity for twenty million people by destroying staple cereal crops, legumes and pastures. The plague was blamed on a changing climate creating exceptional breeding conditions and increased rainfall creating the vegetation growth they fed on. Increasing temperatures raise a locust's metabolic rate so it must eat more to survive.

Locusts multiply rapidly and reach densities of 80 million per square kilometre in three months. A swarm of 80 million can consume as much food as 35 000 people a day. Scientists predict that each degree increase in global warming will result in increased crop losses of 10–25 per cent from insect pests.

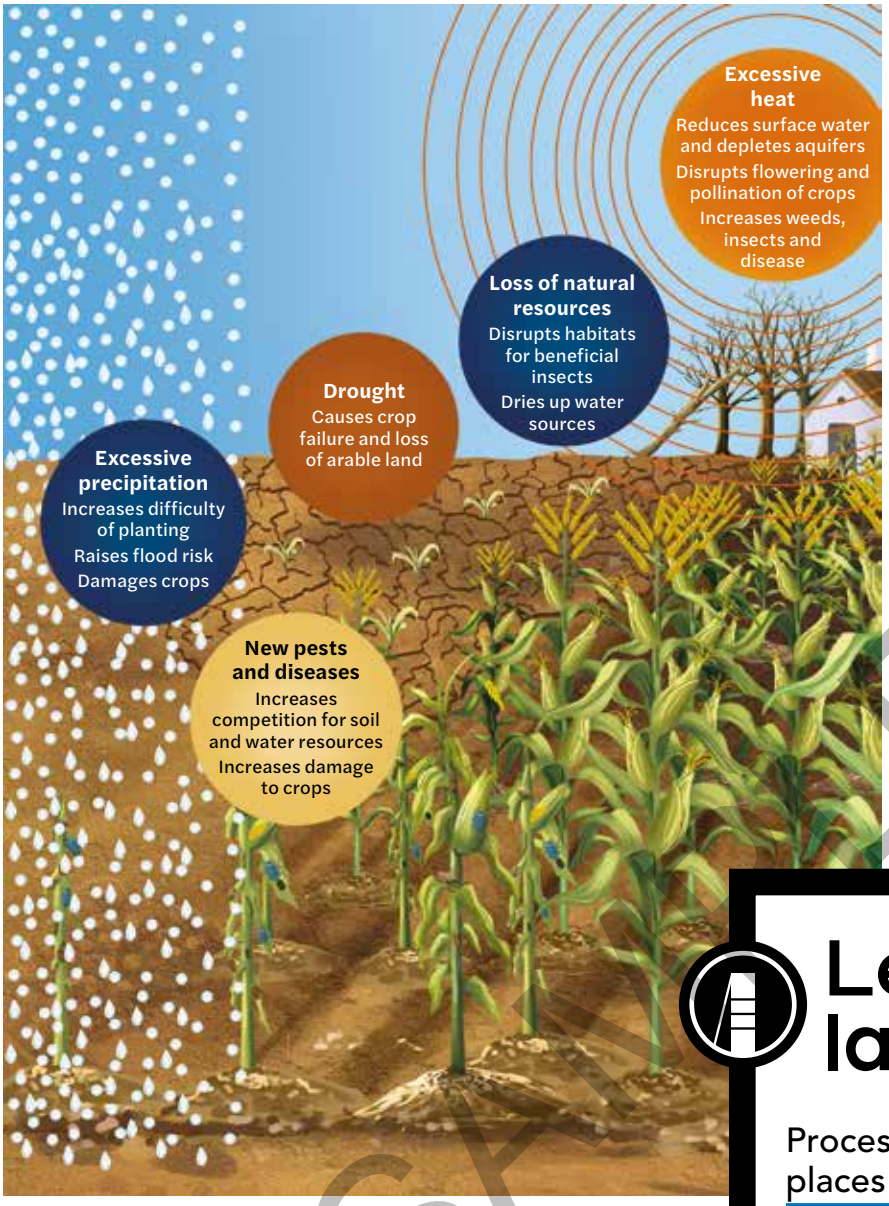
Climate affects every aspect of food production – what grows where, food quality and yield. The warming of Earth's atmosphere caused by increased greenhouse gas emissions will therefore impact on agricultural productivity and its distribution.

Atmospheric changes

Global warming will change food production through increased average temperatures, changes to rainfall and rainfall patterns, greater evaporation of soil and surface water, and more extreme weather events such as floods, drought, bushfires and heat waves. Food supply is threatened when changes in humidity, temperature and rainfall lead to outbreaks of disease and plagues of pests that destroy or consume crops. East Africa experienced a devastating plague of desert locusts in 2019–20 on top of several years of drought during which food production failed to meet demand. The resulting food crisis was attributed to changes in the atmosphere.

Spatial variations in impact

Climate and weather are becoming less predictable, making it difficult to accurately forecast the impacts of future climate change. It is agreed however that warming will not have the same effect on food production everywhere and there will be winners and losers. Some regions will benefit from increased temperatures such as higher latitudes in Europe where the growing season in many countries will be longer. It is expected that crop production in low latitude tropical countries throughout Asia and Africa will be reduced due to lower rainfall, extreme weather events, disease and insect plagues.



▲ **Source 2:** Impact of climate change on agriculture

Loss of productive land and fisheries

Rising sea levels will result in the loss of agricultural land to coastal erosion and saltwater intrusion. A warming atmosphere results in warmer oceans and increased melting of ice sheets and glaciers. This leads to rising sea levels that consume land that supports millions of people in low lying countries such as the island nations of Kiribati and the Maldives. When salt water intrudes into coastal groundwater, the water and land is too salty for crops. Climate change also threatens marine and freshwater fisheries on which millions of coastal populations in low income countries rely for food.

Vulnerable nations

In Bangladesh, agriculture is a leading sector of the economy facing increasing pressure from climatic events such as cyclones, drought, and flood, as well as the non-climatic challenges of population growth and urban growth. A loss of two percent in GDP each year is attributed to climate extremes, a figure expected to increase to 17 per cent by 2050.

Two-thirds of Bangladesh is less than 10 metres above sea level. By 2050 the country is predicted to experience a temperature increase of 1.5°C, an increase in precipitation of 4 per cent and a sea level rise of 27 centimetres. Arable land will be flooded, and rice production will fall. Climate change will bring more extreme weather events such as floods, droughts, and cyclones, which will further affect agricultural productivity. The areal extent, intensity and frequency of cyclones hitting Bangladesh are anticipated to increase.

Learning ladder 1.15

Processes that transform people, places and environments

1. Define the term 'geographic distribution'.
2. Describe how the geographic distribution of crops can be affected by climate change.
3. Source 2: List the impacts of climate change under the following headings: 'Changes in weather and climate' and 'Changes in land, sea and life'.
4. Explain how food production in low lying island nations is threatened by climate change?

Change

1. Identify the cause of climate change.
2. Source 1: Outline the changes that caused the East African locust plague.
3. Explain why there will be winners and losers in food production as a result of a changing climate.
4. Propose one strategy to reduce the vulnerability of coastal communities in Bangladesh to the impacts of climate change on food production.

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1.16

What factors affect rice production?

Rice has been cultivated for over 12 000 years across Asia. It is one of the most important foods produced in the world and is a staple crop in over 100 countries and central to the food security of over half the world's population.

Environmental factors

Traditionally, 'padi' or wet rice required temperatures ranging between from 20°C to 34°C and precipitation of over 1800 millimetres a year. This limited production to tropical locations where seasonal monsoon rainfall, supplemented by traditional irrigation methods, allowed one or two crops to be grown each year. Rice is a thirsty crop and today 85 per cent is grown using irrigation (wet rice) and in a wider range of climates with the help of new technologies. The remaining 15 per cent of production relies on natural precipitation (dry rice) and is limited to higher altitudes and drier inland locations.

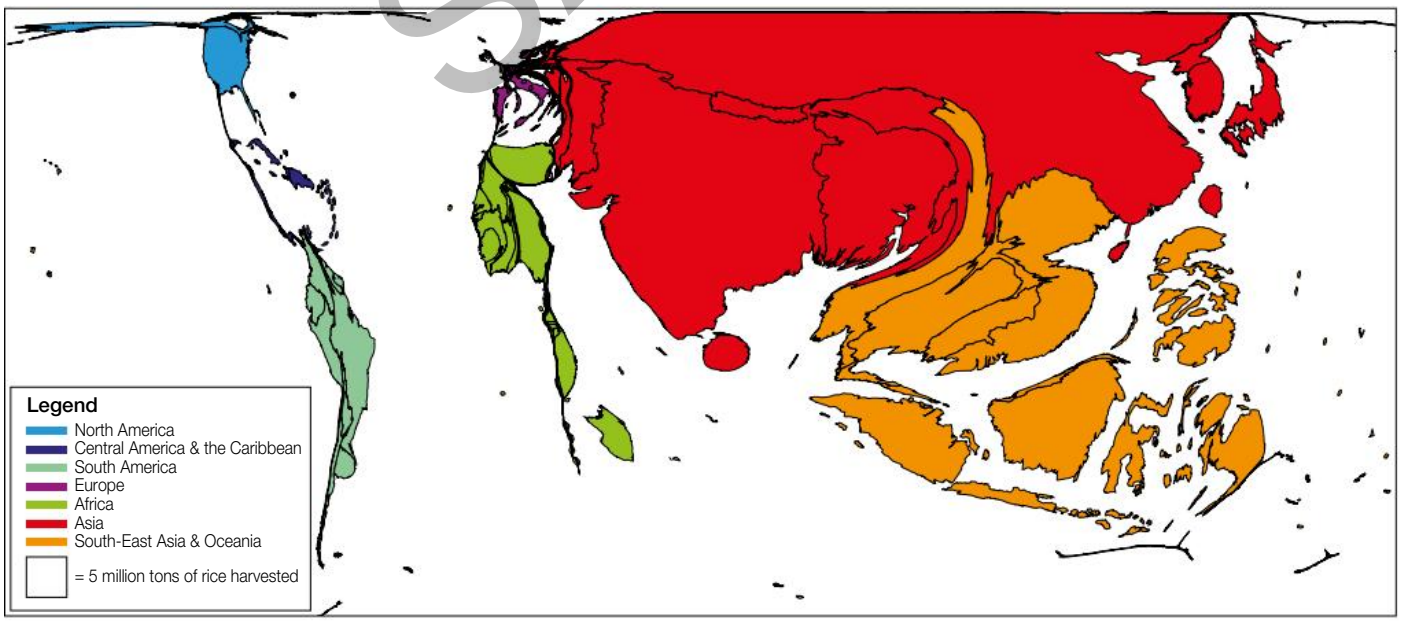
Padi rice growing requires flat land and fertile soils such as major river basin floodplains like the Ganges and Indus river deltas in India. This is where traditional rice farming is most productive. Terracing is used to create flat fields in hilly areas. Low walls known as bunds are used to create fields that can be flooded.

Culture and technology

In traditional rice farming, land is ploughed manually or using animals such as water buffalo. Seeds are raised in nurseries and replanted by hand when fields are ploughed and flooded. When ripe, the fields are drained, and the rice is harvested manually. The work is labour intensive and provides livelihoods for millions of people in low income countries where labour is plentiful and cheap. Simple machinery is used on many farms to assist with the planting.

Green Revolution technologies in the 1970s saw the introduction of high-yielding rice varieties that required the use of fertilisers, pesticides and irrigation. Yields increased dramatically but environmental issues such as water pollution and bioaccumulation of pesticides and chemicals such as arsenic through the food chains resulted.

Global annual rice production



▲ **Source 1:** In a cartogram countries are resized to represent their ranking in certain criteria. In this cartogram, countries have been resized according to annual rice production.

Source: Matilda Education Australia

Source 2: Traditional rice farming using terraced rice paddies. The terraces create flat rice fields with walls (bunds) around them. After ploughing, the paddies are flooded. Rice seedlings are planted in rows by hand, and rainfall and irrigation is used to keep the paddies flooded for four months. When the rice plants begin to turn yellow, the water level is lowered and the rice plants are harvested by hand.

In high income, commercially driven economies such as Australia, Canada and the USA, rice is grown on large farms using sophisticated machinery and modern technologies. Australian rice farmers have become the most productive in the world with the highest yields per hectare and are leaders in efficient water use. Technologies include large machinery, lasers to level fields for efficient water distribution, large spray irrigation systems, Geographic Information System (GIS) and remote sensing used for the management of environmental inputs.

Source 3: Mechanised rice harvesting in Australia

Learning ladder 1.16

Characteristics of places and environments

1. Source 2: Identify features of traditional rice farming in Asia.
2. Source 1: Describe the spatial pattern of rice production by continent shown in this cartogram.
3. Explain two environmental and two cultural factors that affect rice production.
4. Source 1: Discuss the advantages and disadvantages of using cartograms to represent the spatial distribution of crops such as rice.
5. 'Most rice farming in the world will continue to use traditional methods of cultivation into the future'. Propose arguments to refute this statement.

Change

1. How is the environment changed to produce rice?
2. Explain how the farming of rice has changed over time.
3. Analyse the role of technology in changing global rice production.
4. 'Rice is a thirsty crop'. Analyse the implications of this statement in relation to climate change.

HOW TO Change, page 412

Case study

Why is rice important in Bali?

Bali is a small island in Indonesia, located just 8°S of the equator. Rice is the dominant crop and a source of life and wealth.

Island environment

Rich volcanic soils, a tropical climate and access to abundant supplies of water for rain fed and irrigated rice farming ensure Bali produces high yields of rice. Steep land has been terraced to facilitate farming and although rainfall is seasonal, the country has 150 rivers flowing in mountain streams towards the coast, providing ample water for irrigation. Nightly thunderstorms deliver most precipitation during the wet season, leaving days of bright sunshine for crop growth and ripening.

Cultural ties to rice

To the Balinese Hindus, the crop is considered a gift from the gods. Before planting rice, holy water from volcanic Mount Batur is sprinkled on the irrigation canals. Offerings of food and flowers are placed in the fields by farmers to increase crop yields and protect the crop from pests and diseases. There are ceremonies for each stage of the yearly rice calendar during which farmers provide offerings that include the water opening (field flooding), rice field preparation, rice transplanting, growth, first plant appearance, flowering, and harvesting activities.

Source 1: Palm trees and vegetable plots around padi fields provide a diversity of food for farming communities.

Subak irrigation system

A unique feature of Balinese rice farming is the Subak irrigation system. Subak are areas of land connected by pathways that connect each rice field to a water temple or local water source. The complex system contains a network of irrigation channels, each subak occupying about 100 hectares and managed by up to 400 rice farmers. All people having land within the area of a particular subak are citizens of that subak.

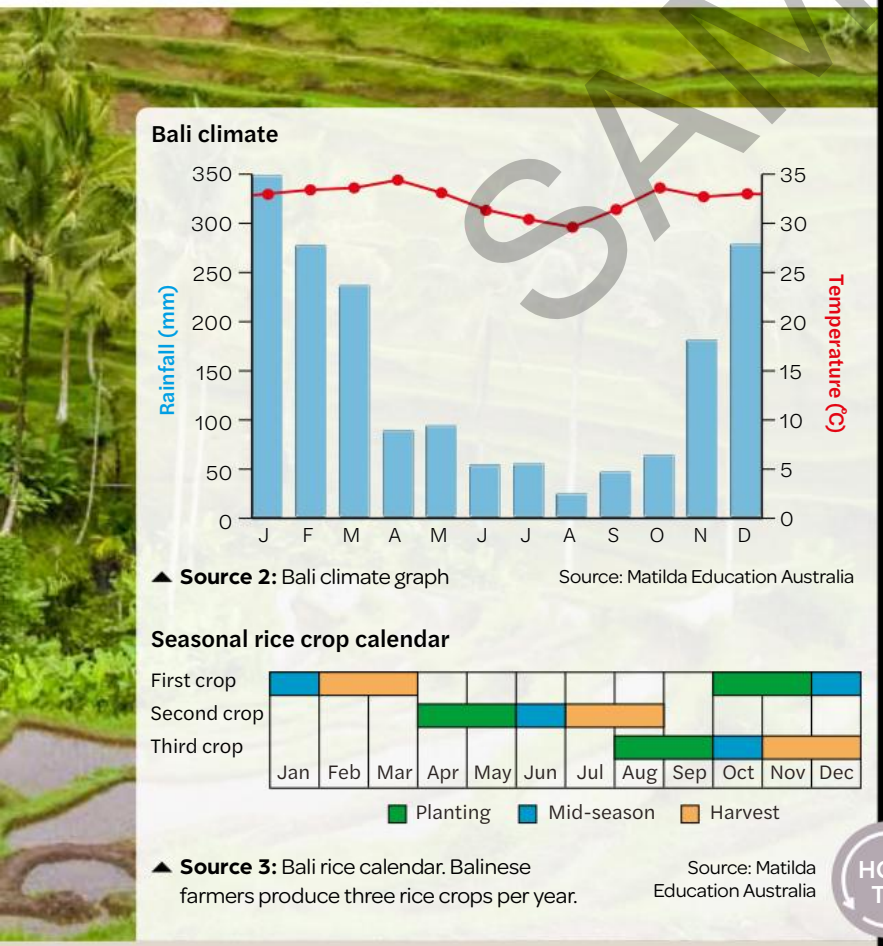
The subak is the primary unit of water management across Bali. Farmers work together in social units to maintain the system and share the water resources. The water flows by gravity down the terraced land, directed into fields using channels or a complex system of bamboo pipes. The purpose of the subak system is to optimize water sharing and land management, including the management of pests and resolution of conflicts. The water temples to which each subak leads are where water is stored. The water temples determine irrigation schedules and cropping patterns for each area. The temples are also holy places for prayer and giving thanks for the crop yield. The system was given World Heritage status as an example of an outstanding cultural landscape.

Rice production today

Today Bali continues to produce rice in the same way it has for thousands of years. The miracle rice that replaced traditional white rice and increased yields by 43 per cent continues as the preferred variety. To enhance sustainability farmers are being educated to:

- introduce a diversity of rice varieties to reduce the problems created by monocultures such as pests and weeds
- minimise the use of fertilisers and chemicals on which the miracle varieties depend.

One threat to rice cultivation in Bali is the conversion of farmland into tourist accommodation and urban developments. The current conversion rate is approximately 1000 hectares per year, which threatens future food security on the island.



Bali climate

▲ **Source 2:** Bali climate graph

Source: Matilda Education Australia

Seasonal rice crop calendar

▲ **Source 3:** Bali rice calendar. Balinese farmers produce three rice crops per year.

Source: Matilda Education Australia

Learning ladder 1.17

Characteristics of places and environments

1. Identify the characteristics of Bali that suit rice production.
2. Describe the connection between rice farming and Balinese culture.
3. Source 2: Explain the connection between seasonal rainfall distribution in Bali and the need for irrigation.
4. Why is world Heritage listing important for the future of the subak system of irrigation used in Bali.
5. Analyse threats to rice production in Bali and implications for future rice yields and food security.

Place

1. Where is Bali located?
2. Source 2 and 3: What natural features make Bali a good place for growing rice?
3. How do Balinese cultural beliefs and traditions shape the way rice is farmed?
4. How does the Subak irrigation system help farmers manage the land and water?
5. Sources 2 and 3: If climate change increases dryness and heat, how could this affect rice production in Bali?

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1.18

What economic factors affect food production?

In commercial agriculture the supply and demand for food products is controlled by conditions in the market such as demand, natural disasters and political conflicts along with government policies such as subsidies, tariffs and Free Trade Agreements.

Subsistence or commercial

Subsistence farmers in low-income countries who produce food for their own needs are not influenced by global economic factors. Farming takes place on small plots of land, using hand labour and few inputs resulting in low yields. Surpluses may be sold at local markets and farmers may have access to **microloans** to improve yields by purchasing high yielding seeds or fertilisers.

In contrast, commercial agriculture, whether large or small scale, is influenced by a complex mix of economic factors that influence decisions about what crops to grow, how they are grown, where they are sold and their market value. Access to finance enables farmers to purchase capital equipment and new technologies that increase productivity, often replacing the cost of human labour. Yields must be high for farms to be profitable.

Supply, demand and markets

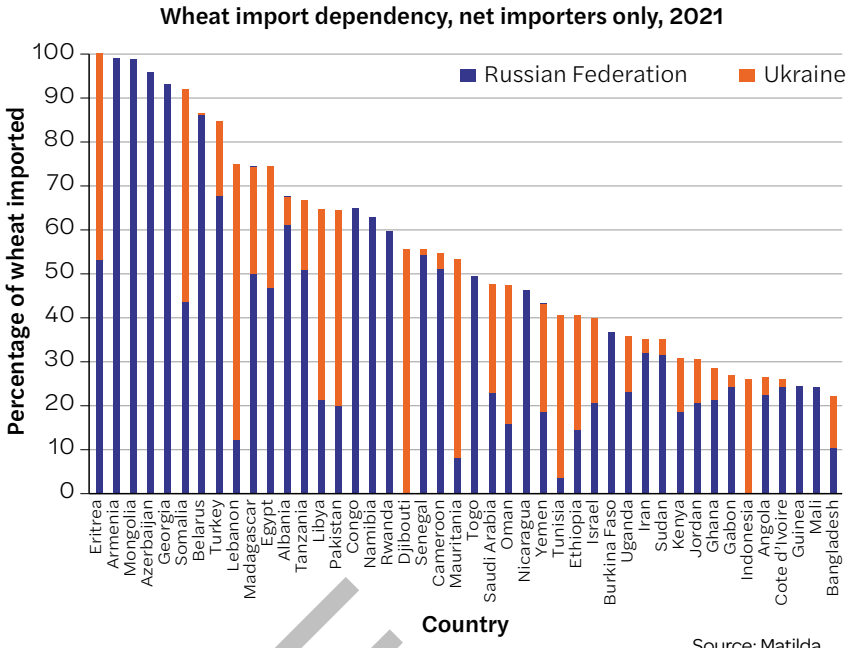
Demand is created by consumers who want a particular food crop or product. Demand comes from people purchasing food to eat as well as industries processing crops for food and non-food related products such as cheese, canned vegetables, and biofuels. The demand for food changes according to the tastes and preferences of consumers and affects the amount and type of crops produced. The increasing demand for meat protein in China has benefitted Australia. In April 2022 China was the largest single export destination for Australian beef (20 per cent of the market), lamb, mutton, and goat.

Source 1: The economic impact of the war between Russia and Ukraine that began in 2022 is felt around the world. More than 70 per cent of Madagascar's wheat exports come from Russia and Ukraine. Shortage of supply has driven up grain prices and combined with drought in southern Madagascar has led to critical food shortages leading to the malnutrition of hundreds of thousands of people.

Global commodity prices

Commodity crops are crops grown in large volume specifically for sale to large local and export markets. Farmers who grow commodity crops earn or lose money based on the price that buyers will pay. Farmers are competing in a global market where prices are affected by international influences such as natural disasters, political conflicts and the weakness or strength of a country's currency.

Australian farmers benefit when there is a decline in production in a region due to drought or war as this increases demand overseas for Australian producers, usually at higher prices. The Ukraine war disrupted grain and oilseed supply chains from Russia and Ukraine due to the war disrupting production plus economic sanctions against Russia from nations supporting Ukraine. This provided an opportunity for Australian farmers to meet some of the unmet global demand.



▲ **Source 2:** Some countries are heavily reliant on wheat imports from Russia and Ukraine.

Source: Matilda Education Australia

Government policy

Subsidies are paid by governments to farmers to continue producing crops often on the assumption that agricultural mass production benefits the economy by keeping food prices low. This policy often causes an oversupply of a few crops regardless of current market conditions because farmers are paid to grow these foods. Farmers in the European Union and the USA receive government subsidies to grow crops such as soybeans for stockfeed, corn for fuel and canola instead of wheat.

Tariffs are duties placed on imported goods. They are used to protect local growers from cheaper imported foods, however they can work against farmers trying to access overseas markets for their produce. China imposed tariffs of 80.5 per cent on Australian barley during a period of diplomatic tensions in 2020. The tariff wiped out any chance of Australia exporting barley to China, previously worth $1.2 billion a year.

Trade agreements are international treaties between two or more economies that reduce or eliminates barriers to trade and foreign investment. Australia negotiates **free trade agreements** (FTAs) that benefit Australian food producers, i.e. Japan can access tariff free or low tariff produce from Australia, including including oranges, cherries and grapes, dairy products, beef and seafood.

Learning ladder 1.18

Processes that transform people, places and environments

1. What is the difference between a subsidy and a tariff?
2. Compare the influence of economic factors on smallholder and commercial food producers.
3. Source 2: Explain how war can affect food production and food prices.
4. Source 1: Explain how economic factors have led to the situation shown here.
5. Analyse the importance of international demand, markets and events on food produced in Australia.

Interconnection

1. Give one example to show how Australian food production is interconnected to economic factors.
2. Source 2: Describe which country is most impacted by the loss of wheat imports from Ukraine.
3. Explain how government trade policies affect food production. Provide an example.
4. Analyse the impact of the Ukraine war on Australian producers of grain and oilseeds and consumers.

HOW TO
Interconnection, page 410

How important is growing food 'under glass'?

In countries where climatic conditions, such as extreme temperatures and water shortages, and the availability of suitable land limit agricultural production, 'covered' agriculture is a solution. Within this category, farming 'under glass' in climate-controlled greenhouses is the most productive system of food production for some crops, and is expanding rapidly across the globe.

The growth of 'under glass' agriculture

In 2020, the global value of production from greenhouses reached almost US$24 billion, the area of production was approximately 2 million hectares, and the expected growth rate was 9.3 per cent for 2021–26. The advantages of producing food in greenhouses include:

- year-round production through all weather and seasons
- 24/7 production using artificial light at night
- adjustable temperature, humidity and light levels can maximise plant growth and limit pests and diseases
- production is higher per hectare
- a clean protected environment produces quality food of high value
- the efficient use of resources such as water means less waste and reduced costs
- using natural sunlight reduces energy costs compared to artificial light
- allows local production where the food is needed
- can be adapted to climate change.

A disadvantage, particularly for poorer countries, is the high cost to establish greenhouse facilities using the best technology at a large scale. In places where greenhouses operate all day and night, light pollution can interfere with natural ecosystems and wildlife.

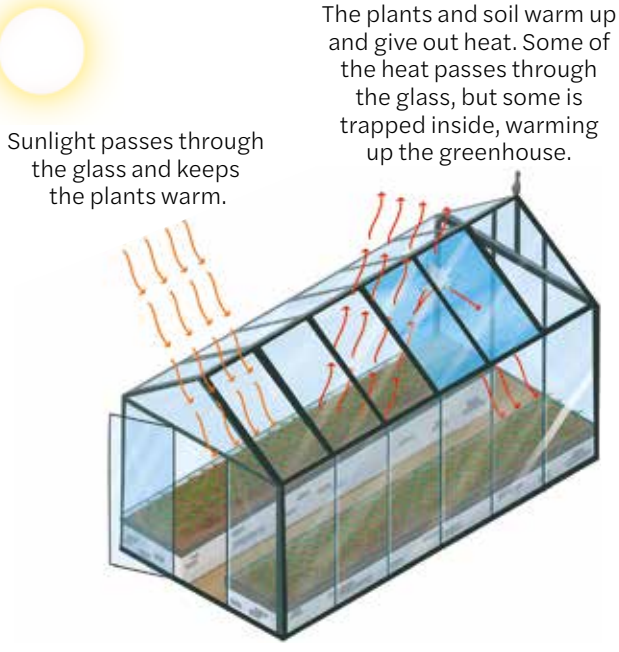
How do greenhouses work?

Greenhouses work by absorbing light from the sun, which the plants and surfaces inside convert to heat and release slowly, warming the air around them. Although traditionally constructed using glass (and called glasshouses), newer technologically and cheaper coverings such as polycarbonate, acrylic, ETFE (fluorine-based plastic) and fiberglass products are now used.

As demand grows, new technological developments continue to improve the greenhouse system of food production. Recent innovations include the use of:

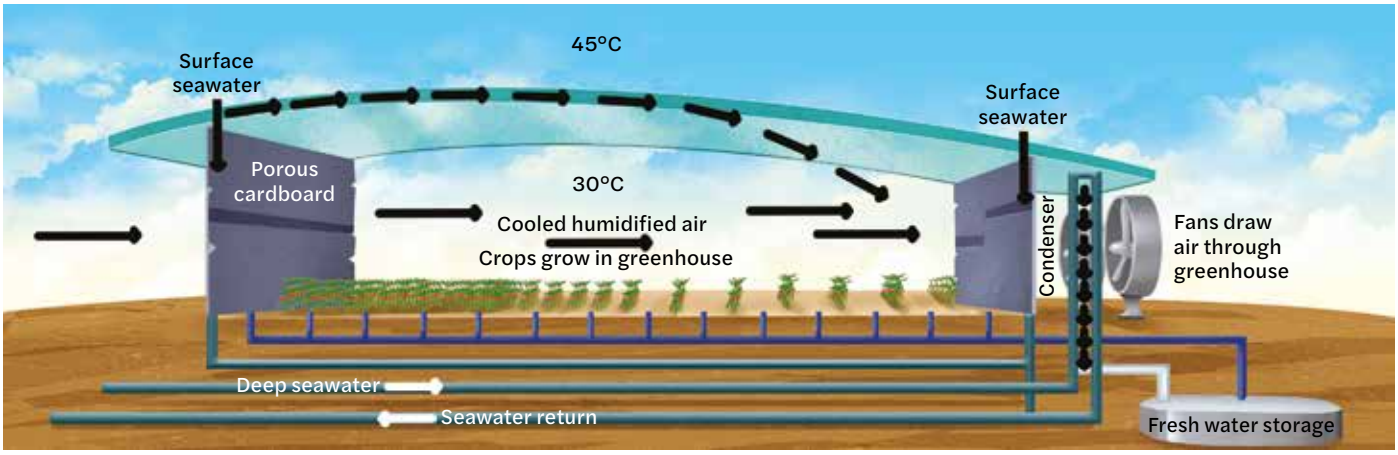
- robotics and AI
- precision irrigation
- automated climate control
- smart glass that reduces light emissions at night time
- computer monitoring and data analysis
- vertical farming in stacked layers to maximise space
- solar panels and smart films, which are being investigated to reduce energy costs and carbon footprints.

Controlled environment agriculture using greenhouses could be important for future food security, as climate changes increase.



Source 1: How a simple greenhouse works

How a seawater greenhouse works



Where is it already happening?

The Netherlands is the world's second-largest exporter of agricultural produce largely because of agricultural innovation and the use of technologically advanced greenhouses to control the environment. The Dutch landscape in Westland is dominated by greenhouses that may operate day and night. To stop light pollution from the extensive areas of greenhouses, in some places it is now a legal requirement to use blackout screens or curtains.

In Australia, Sundrop Farms at Port Augusta in South Australia use a seawater greenhouse system designed for semi-arid environments with low water availability and poor soils. Seawater and sunlight are the main natural resources, making operating costs up to 25 per cent less than a 'normal' greenhouse. The 20-hectare facility produces up to 100 000 kilograms of tomatoes a year.

Source 2: Greenhouse of chrysanthemum cuttings in the Netherlands

Source 3: Seawater is pumped via pipes into the greenhouse and is trickled over an evaporator. Air drawn into the greenhouse by fans is cooled by the seawater to increase humidity. At the other end, the cool air is drawn through a second evaporator full of seawater heated by the sun in ceiling pipes. The air then becomes hot and humid. When the hot humid air meets pipes containing cold seawater, fresh water condenses. This fresh water is stored on-site for irrigating the crops. At Sundrop, the control system, pumps and fans are solar-powered, evaporators filter out pollen and pests killed by the salt water, nutrients harvested from the salt water feed the crops, and the rest of the salt is made into gourmet salt crystals for sale.

Learning ladder 1.19

Processes that transform people, places and environments

1. Define 'farming under glass'.
2. Explain how greenhouses change environmental conditions so that food can be grown.
3. Explain why modern greenhouses are considered an innovative technology.
4. Analyse the advantages and disadvantages of using technological solutions to increase food production.
5. Propose a solution for poorer countries to increase food produced in covered farms.

Environment

1. Source 2: List the characteristics of the built environment shown in this photograph.
2. Source 1: Explain how greenhouses work.
3. Why would farmers implement greenhouses in their farms?
4. How would seawater greenhouses impact the environments around them?
5. Evaluate the impact of greenhouse agriculture on global food production.

HOW TO
Environment, page 414

How is the demand for sugar changing?

Sugar is a sweetener produced from sugar cane (in tropical environments) and sugar beet crops (in cooler temperate climates). These crops are harvested and processed to extract and refine crystallised sugar, which is then used as a sweetener in food and beverages worldwide. The large use of sugar in processed foods, such as lollies and sodas, has increased the demand for sugar across the world. These are foods associated with developed societies, such as the USA, Canada, Japan and Australia.

Increasing demand in Asia

Sugar consumption is increasing in Asia, and is expected to be responsible for 68 per cent of the increasing demand for sugar by 2030. This is predominantly due to the influence of westernisation, which is the spread of western culture through television and corporations into places such as Africa and Asia. These societies are then exposed to Americanised fast foods and sugary processed meals in popular culture, and through increasing transnational corporations, such as McDonalds. In China, the consumption of carbonated soft drinks increased by 165 per cent between 2000 and 2015. As Asia develops economically, individuals are using their higher incomes to consume these popularised foods. Many western traditions that promote sugar consumption are also increasing, such as Halloween. Asia has a large population, so even with slight increases in the consumption of sugar per person, it has global impacts on the demand for sugar.

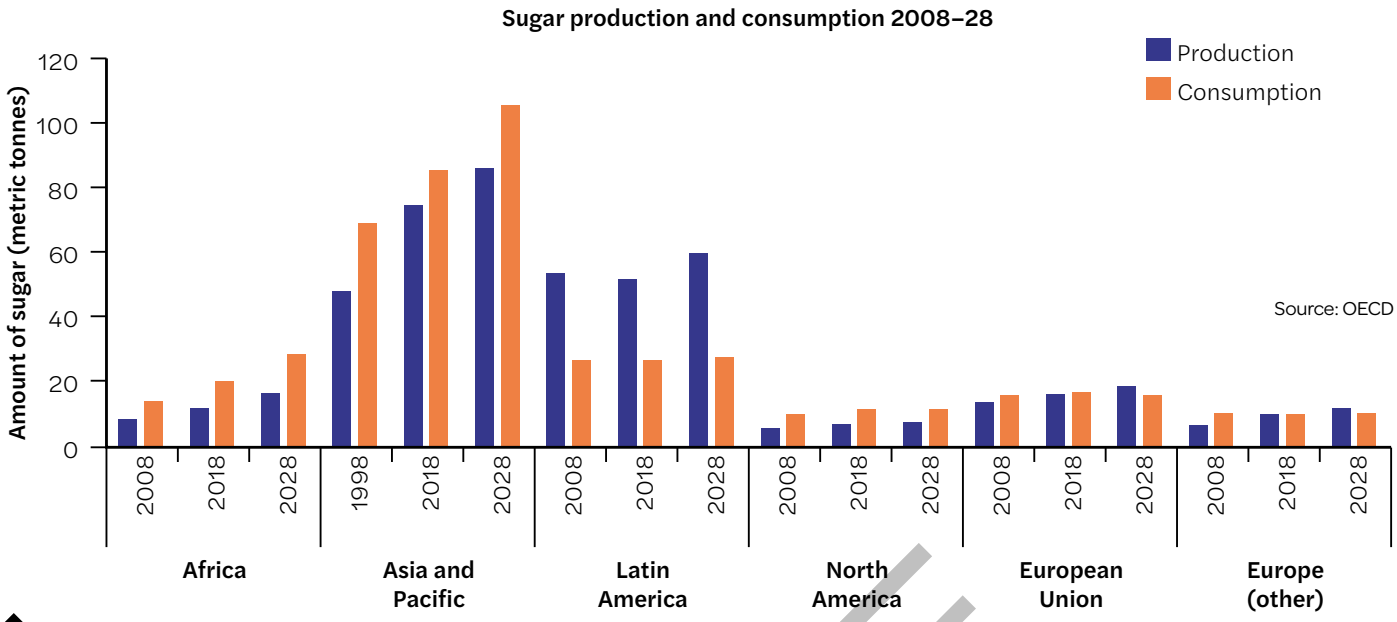
Decreasing demand in Australia

There is an increasing awareness of the health implications of too much sugar in diets, such as increasing diabetes and obesity. In Australia there is a growing 'sugar free' movement, where people are omitting sugars or opting for artificial sweeteners to improve their health. Many governments around the world, including Australia, are implementing sugar taxes. These are extra costs people must pay to purchase sugary products and food. The intention of these taxes is to reduce the demand for sugar, and improve the health of people. There are also rules and regulations attempting to achieve the same thing. This can be seen in school canteens, which are mandated to not sell sugar-sweetened drinks, to label sugary foods

Source 1: An infographic by the Rethink Sugary Drink campaign highlights the key health implications of sugar in Australia. These health challenges are leading to many social movements aimed at reducing the demand for sugar in Australia.

Source: www.rethinksugarydrink.org.au

Source 2: An aerial photograph of a sugarcane plantation being harvested. Growing awareness of the environmental impacts of sugarcane farming has led to a decrease of demand in Australia.



Source 3: Bar graph showing the patterns of production (purple) and consumption (orange) of sugar in different regions across the world in the past and projected into the future. Demand has increased the most in Africa and Asia, likely due to westernising diets.

as 'occasional', and to only sell products that have a health star rating of 3.5 or above. There are also social environmentalist movements that are boycotting sugar because of the environmental impacts of sugarcane plantations on ecosystems, such as the Great Barrier Reef. These social forces have decreased the demand for sugar in Australia.

Impact of changing demands

Many sugar plantations were established in the 20th century to provide enough sugar to meet the growing global demand. With the decreasing demand in many countries, this has led to an over-supply of sugar. This decreases the value of sugar, leading to many farmers having a reduced profit or even closing their plantations (Australia lost 11 per cent of sugarcane farms between 2006 and 2011). Other farmers, especially in Brazil, are now turning their sugar into ethanol, a biofuel.

Learning ladder 1.20

Perspectives of people and organisations

1. Describe one reason sugar consumption has increased in Asia.
2. Source 1: Why has Australia reduced their sugar consumption?
3. How has the increasing demand for sugar in Asia influenced global sugar production and supply?
4. How has westernisation contributed to the rise in sugar consumption in Asian countries like China?
5. Analyse how the interactions between transnational corporations and local cultures in Asia are transforming dietary habits and impacting the environment.

Change

1. Source 3: Describe the changes in sugar production.
2. Source 3: Explain the changing patterns of sugar consumption in the world now and into the future.
3. How does the decline in sugar demand in countries like Australia affect sugar farmers?
4. Discuss the environmental implications of the shift from sugar production to biofuel (ethanol) in countries like Brazil.
5. Predict the future demand of sugar, and the implications of these changes in the future.

HOW TO
Change, page 412

1.21

What are the environmental impacts of food production?

There are many changes made to the environment in order to produce food. These changes have significant consequences for ecosystems and natural resources.

Greenhouse gas emissions

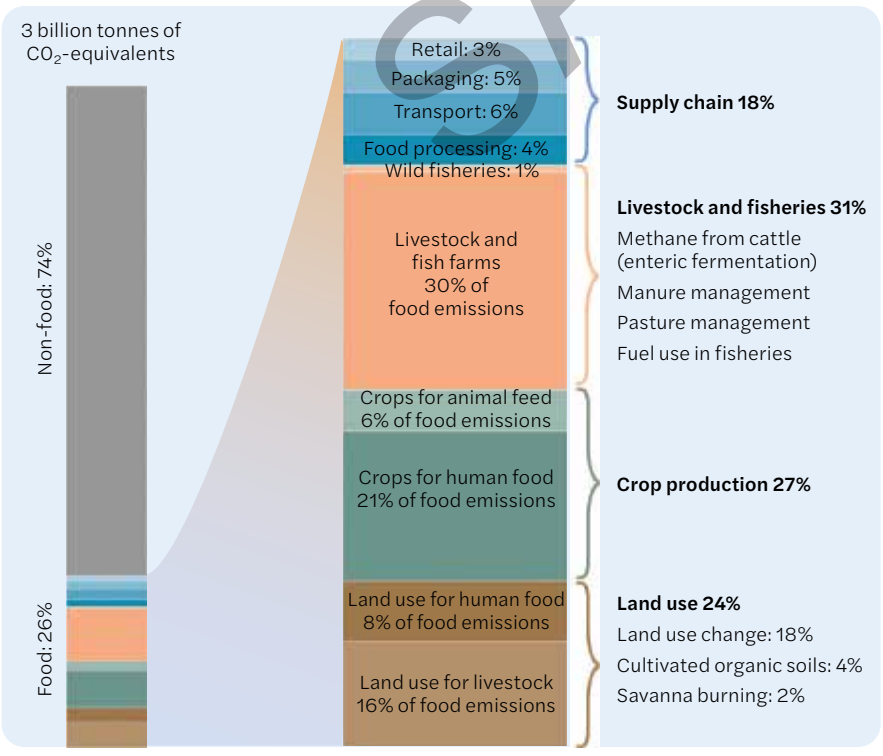
Agriculture is a significant contributor to greenhouse gas emissions globally. Every year 14.6 per cent of Australia's greenhouse gas emissions is driven by agriculture. This is because of the machinery used to harvest or clear land releasing carbon dioxide, synthetic fertilisers releasing nitrous oxides and livestock farming, especially cattle grazing, releasing methane. Although these greenhouse gases exist naturally in our atmosphere, too many of these particular gases can result in more heat being trapped in the atmosphere, leading to an increase of average temperature ranges. These emissions contribute to climate change, which is related to more frequent and intense weather events, rising sea levels and shifts in ecosystem processes.

Deforestation and soil degradation

As agriculture requires land, many forests and grasslands are removed to establish farms. This deforestation reduces biodiversity, creates habitat loss and fragmentation, reduces native vegetation and species and disrupts ecosystem processes.

Excessive tilling of land, the use of fertilisers and machinery and monoculture cropping degrades the quality of soils. This can result in compact and vulnerable soils, soil erosion, nutrient depletion, soil acidity and a loss of soil fertility. In the last two centuries, 50 per cent of Australia's forest cover has been cleared for agriculture. This makes it more difficult to produce agricultural products, reduces biodiversity and can impact food security.

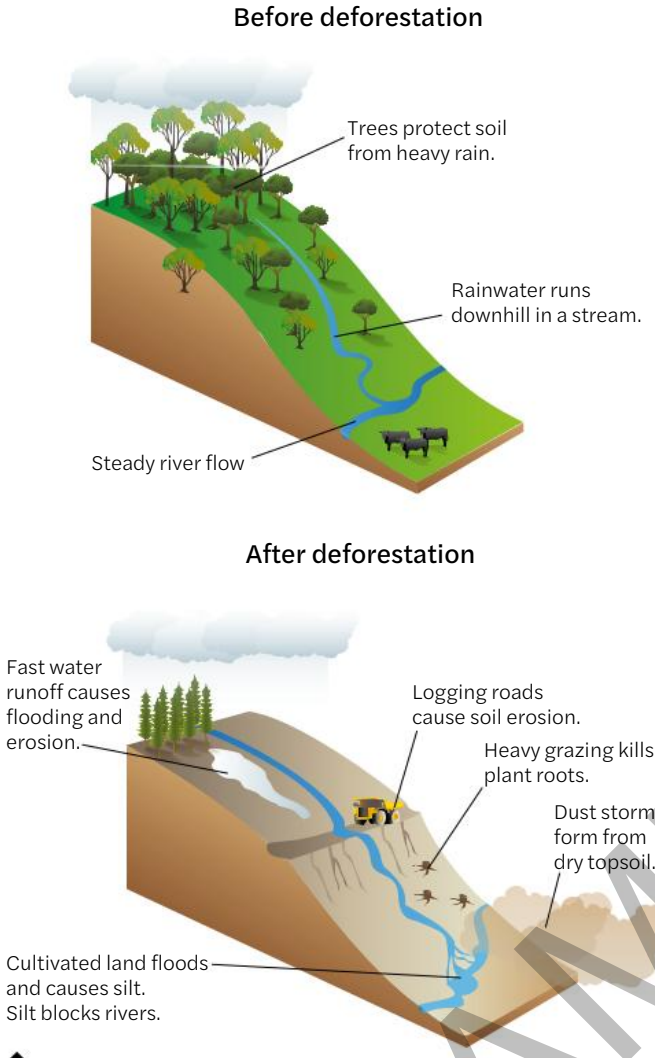
Global greenhouse gas emissions from food production



Source: Our World in Data

Source 1: Food production contributes to 26% of global greenhouse gas emissions; much greater than all transportation emissions.

Source 2: Increases in the use of pesticides and fertilisers has increased the threat of eutrophication in the Great Meander River's delta in Anatolia, Turkey.



Source 3: Before and after deforestation

Water pollution

Farmers use pesticides and fertilisers that contain nutrients such as nitrogen and phosphorous. When it rains, these nutrients runoff into local water sources, rivers and coasts. This can result in the pollution of local water sources, and in worst cases, eutrophication. This is when nutrients photosynthesise into algal blooms that sit on the surface of water. These algal blooms lead to oxygen depletion in the water and can block sunlight from reaching the primary producers at the bottom of coasts, wetlands, lakes and rivers. This impacts the food chain as it decreases producers and thus impacts the primary consumer populations. An extreme example of this is the eutrophication of the Coorong estuarine-lagoon in the Murray–Darling Basin; leading to the death of hundreds of thousands of fish.

Learning ladder 1.21

Processes that transform people, places and environments

1. Describe two environmental changes that occur to produce food.
2. Source 1: Describe how agriculture contributes to greenhouse gas emissions globally. Create a diagram to support your explanation.
3. Source 2: Explain how eutrophication, caused by agricultural runoff, affects aquatic ecosystems.
4. Source 3: Analyse the impacts of deforestation on the environment and biodiversity.
5. Assess how soil degradation impacts agricultural productivity and food security.

Sustainability

1. Identify one example of an unsustainable farming practice.
2. Source 2: Why is it important to reduce effects like eutrophication?
3. Explain the importance of understanding the impacts of agriculture for future sustainable management.
4. Source 1: Using information in this source, justify one sustainable strategy to reduce the environmental impacts of agriculture.

HOW TO Sustainability, page 418

How is food production threatening forests?

Deforestation is the conversion of forest to another land use. Most deforestation is occurring in tropical forests and over 80 per cent is linked to agriculture, particularly the production of beef, soybeans, palm oil and timber.

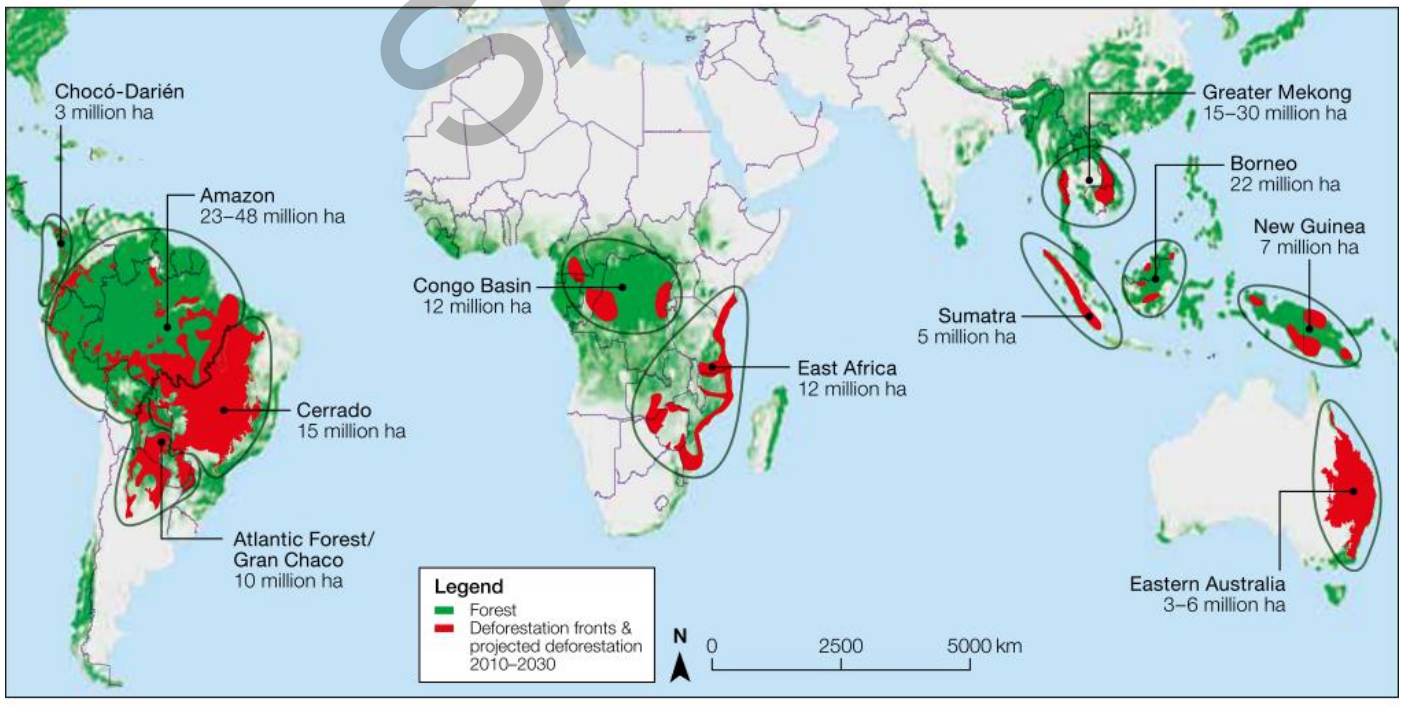
Deforestation drivers

Forests are cleared for three main types of agricultural production.

- **Livestock:** The large-scale clearing of forests to grow pastures for meat production, mainly beef cattle, is the largest driver of deforestation and responsible for 41 per cent of tropical forest loss. Most deforestation has occurred in South and Central American countries such as Brazil (24 per cent), Argentina and Paraguay. Global beef consumption reached a record high in 2021, a trend expected to continue as world population grows and incomes rise.
- **Large-scale cropping of food commodities:** Almost one-fifth of forests are cleared for the large-scale production of single commodities for sale internationally, mainly palm oil and oilseeds such as soybeans, sunflower, rapeseed, and sesame. Soybean production is indirectly linked to food through its use as livestock feed with only 6 per cent directly consumed in items such as milk and tofu. Other food commodities grown as monocultures on previously forested land include cocoa, coffee, rice, maize, sugar and cassava.
- **Small-scale cropping for food/subsistence use:** Landholders clear small pockets of forest to create enough land to grow crops such as vegetables, fruits and grains, and raise small livestock herds. Traditional slash and burn methods make up a small proportion of this. Subsistence agriculture is a key driver of forest loss in African countries; however, an increasing number of smallholders are now growing commodity crops including cacao (chocolate), palm oil and maize for domestic markets.

I've hyphenated large-scale here too_J

Global deforestation, in hectares



Source: Matilda Education Australia

▲ **Source 1:** Deforestation identified by The World Wide Fund for Nature

Source 2: Indonesian palm oil plantation has replaced lowland rainforest and swamp forest.

Source: Powered by Resource Watch /Global Forest Watch

Regional variations

There are significant regional differences in the spatial distribution and drivers of deforestation. The highest losses in 2010–20 were in South America and Africa, although South America experienced a fall between 2010 and 2020 compared with the previous decade. In 2023 forest loss in Brazil declined by one-third following a change of government policy. In South-East Asia food driven deforestation is mainly for palm oil plantations compared to North and South America, where the main driver is beef cattle grazing. A report by the Worldwide Fund for Nature (WWF) in 2021 identified 24 deforestation fronts across Latin America, Sub-Saharan Africa, South-East Asia and Oceania – the most significant of these and the main drivers of change are shown in Source 1.

Future food production

While clearing forests to grow food results in an increase in food production in the short term the consequences of deforestation put future food production in jeopardy. Climate change, loss of biodiversity and soil degradation (erosion, salinity, and loss of fertility) cause food insecurity by impacting the capacity of environments to maintain high yields for crops and livestock, making food production harder. It is well known that clearing tropical forests for crops is only productive for a few years before weeds take over and fertility is lost.

Learning ladder 1.22

Processes that transform people, places and environments

1. What is the key factor driving deforestation – environmental, social, economic or technological?
2. Source 1: Describe the spatial pattern of deforestation in Australia.
3. Explain how the livestock industry is impacting deforestation.
4. Source 2: Explain how you can distinguish the area cleared for plantations compared to the natural environment in this satellite image.
5. Predict the future of global food production should deforestation cease tomorrow.

Space

1. Describe how Earth's forest cover has changed between 2010 and 2020.
2. Source 1: Use PQE to determine where deforestation occurs in the world.
3. Source 2: Use the scale to calculate how much space has been changed to palm oil plantations in this satellite image.
4. How does food-driven deforestation vary across different parts of the world?

HOW TO

Space, page 406; PQE, page 430 <TBC>

1.23

Case study

How has palm oil replaced rainforest?

The rapid expansion of the highly productive and profitable palm oil industry, mainly in south-East Asia, has seen the rapid retreat of tropical rainforest and alarming declines in endangered species such as the orangutan.

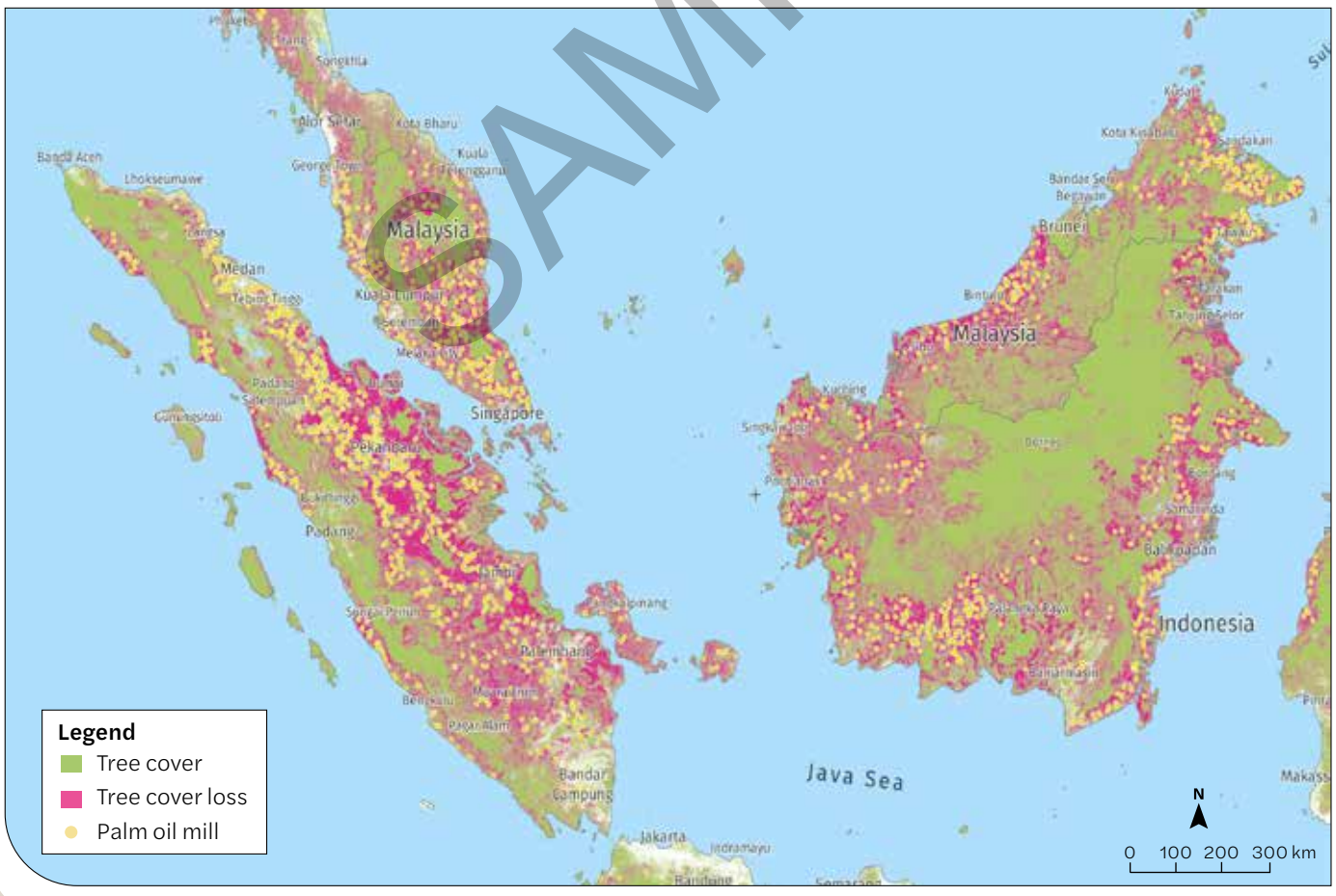
Why is palm oil popular?

Palm oil is a very efficient crop, producing more oil per land area than any other vegetable oil crop. Oil palm trees produce high grade oil that is mainly used for cooking, but is also found in many food products, cosmetics, detergents and even biofuel. Grown only in tropical regions, oil palms produce a much higher yield at a lower production cost than other oils. Palm oil is now an ingredient in half of packaged products found in supermarkets.

Why is palm oil threatening forests?

As demand for palm oil grows, land is cleared for oil palm plantations in the tropical areas of Asia, Africa and Latin America. The expansion of the palm oil industry has seen a dramatic decline in tropical forests and many endangered species and indigenous peoples that call the forests home.

Change in tree cover in Indonesia and Malaysia, 2016



Source: Global Forest Watch

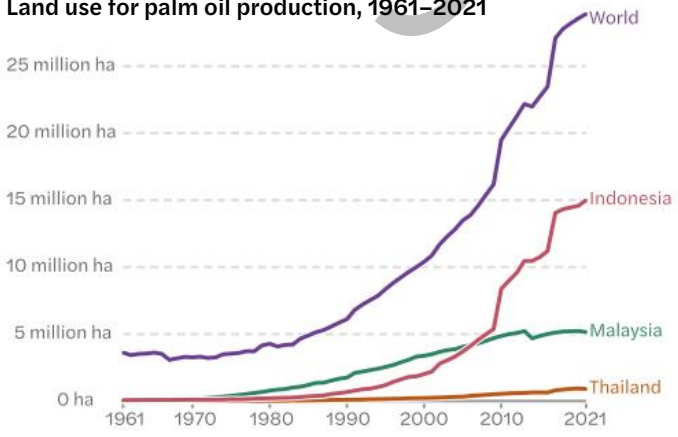
▲ **Source 1:** Change in tree cover in Indonesia and Malaysia in 2016

Source 2: Jenny McCracken street art mural, "Beneficiaries of the Palm Oil Estates" on display in Benalla.

Millions of hectares of rainforests cleared in South-East Asia have been replaced by oil palms for the production of palm oil. Conversion from natural forests to oil palm plantations destroys native foods and the habitats of endangered species such as orangutans. Approximately 80 per cent of orangutan habitat has been cleared for oil palms. In the last decade orangutan numbers have halved in the wild. Thousands of indigenous hunter-gatherers such as the Penan (Sarawak) and Oayaks (Borneo), who depend on the rainforest, have been forced off their land.

In recent years, large organisations like Nestlé have committed to sourcing sustainable palm oil that has been farmed, processed, distributed, and sold responsibly to reduce deforestation and exploitation of workers.

Land use for palm oil production, 1961–2021



Source: Our World in Data

▲ **Source 3:** Between 1980 and 2021, the amount of land used to grow oil palms increased from 4 million to 29 million hectares. The world devotes more than 330 million hectares for the production of oil crops. Palm oil accounts for 9 per cent of this land use, which is small when we consider that it produces 40 per cent of all global vegetable oil.

Learning ladder 1.23

Processes that transform people, places and environments

1. What change has occurred to the natural environment from the growth in palm oil use?
2. Source 1: Use the PQE tool to help you describe the loss of tree cover by 2016.
3. Source 2: What is this artwork saying about the issues arising from palm oil production?
4. Sources 1 and 3: Analyse the impact of palm oil production in Indonesia on wildlife and humans.
5. Given that palm oil is so high yielding compared to other vegetable oils, what action should we take to reduce its environmental impact?

Change

1. Source 3: How much did land use for palm oil production grow between 2000 and 2020?
2. Source 3: Use the PQE tool to describe the rate of change in land used for palm oil production in Indonesia, Malaysia and Thailand.
3. Source 1: Explain the reasons behind the changes shown in this source.
4. Source 1: What are the implications of the change shown here for orangutans? What action are major users of palm oil such as Nestlé taking?

HOW TO

Change, page 412; PQE, page 430

1.24

Why is land for food production under threat?

An increasing amount of arable land is being diverted to urban expansion, energy production (biofuels), mining and infrastructure projects. In addition, land is being 'grabbed' by resource and water poor wealthy nations to produce food for export.

Urban expansion

Peri–urban agriculture is the production of crops and livestock on the outskirts of cities, usually for local consumption in the city. This land is often referred to as the food bowl of a city because of the amount of food grown there. Historically these locations have faced the outward expansion or 'sprawl' of suburbs and the loss of productive farmland. Population growth and the increasing proportion of people living in urban places are driving this change.

Agricultural land is a disappearing resource in Greater Sydney where decades of residential and industrial development have displaced dairies, horticulture, orchards and intensive livestock farming. The NSW government continues to look to Western Sydney to accommodate Sydney's growing population and the commercial and industrial zones that create employment. The region supplies a large proportion of the livestock (chicken, beef and dairy), fresh vegetables, eggs, grapes and nuts consumed in Sydney and across NSW. Over the past 10 years Western Sydney has lost about 60 per cent of its farming land, a figure expected to grow as the region's population grows to 4.1 million (predicted by 2040) and demand for new dwellings escalates.

Biofuels

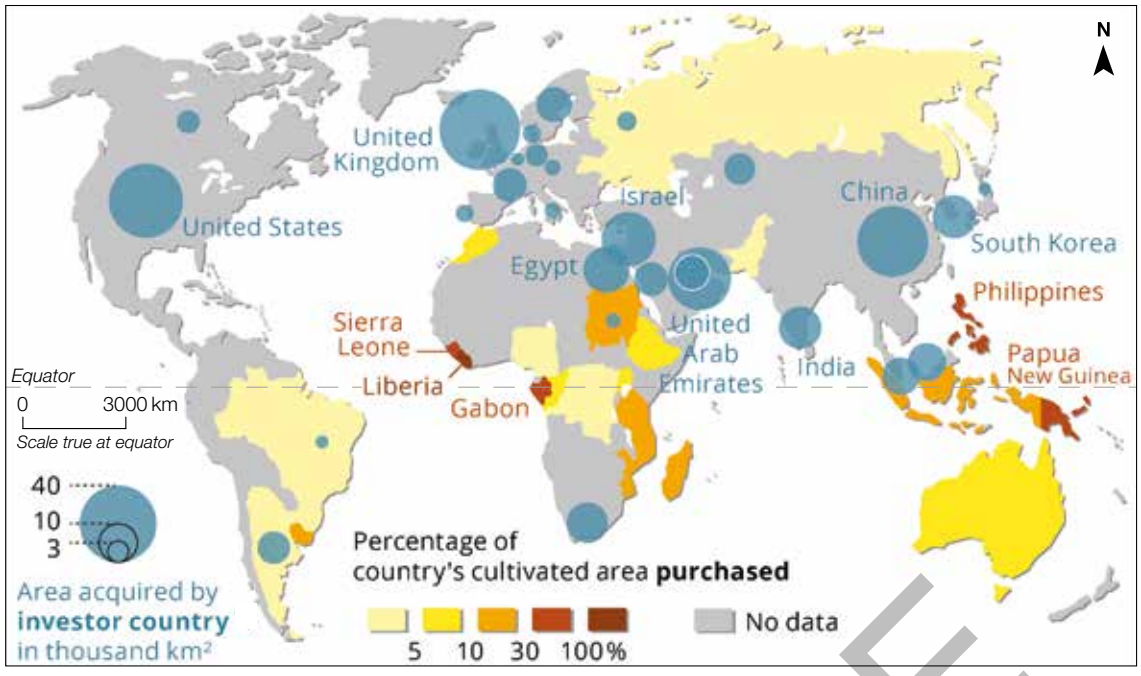
The increasing global demand for 'green' non-fossil biofuels such as ethanol and biodiesel can impact on food production in two ways:

- agricultural land is converted from food production to crops grown for fuel
- food crops are being diverted to produce fuels instead of being used as food.

In both cases a food crop is used to produce fuel using edible food such as sugar, wheat and maize or oilseeds such as sunflower and soybean. This situation is considered by many to be unethical at a time of global food insecurity and high food prices.

The food vs fuel debate has forced change to the industry. Increasingly biofuels nonedible feedstock that do not compete with food production are used. Examples include agricultural waste like sugarcane bagasse, rice husk, wheat straw, and forestry residues like small branches and bark. More recently non-food marine biomass from algae such as seaweeds and microalgae that have high growth rates and do not need arable or big land areas have become a source of biomass for the biofuel industry.

Land grabs



Source: European Environment Agency

Source 2: Land grabs occur when countries purchase or lease land for agriculture or other purposes, such as mining, in other countries. In Ukraine, large-scale agricultural projects were a part of foreign land deals that took over 3 million hectares (5.5 per cent of Ukraine's land). Peru has experienced the biggest land grabs since 2019, where over 16 million hectares were given away for mining. Current land grabs mostly focus on growing staples or biofuels, such as wheat, maize and rice.

Source 1: Urban sprawl in Western Sydney is shown here at St Clair. Land previously used to grow and raise food for consumption in Sydney is being replaced with residential, commercial and industrial land use. Western Sydney will supply 60 per cent of Greater Sydney's new dwellings in the period 2021–25.

Learning ladder 1.24

Processes that transform people, places and environments

1. Describe three activities that compete with agriculture for the use of arable land.
2. Source 1: Explain how urban growth impacts food production.
3. Explain why the biofuel industry is changing the source of biomass it uses.
4. Analyse the causes and impacts of change in Sydney's food bowl.
5. Source 2: Which countries have the highest percentage of their agricultural land sold or leased to another investor country or corporation? What are the advantages and disadvantages of these land grabs for the parties involved?

Scale

1. Give an example of competition for arable land at a local scale (farm level).
2. Source 1: Describe how competition for land has changed Sydney at a regional scale.
3. Source 2: Explain why land grabs are a global phenomenon.
4. Assess the impact of competition for land on food production at a range of scales.

HOW TO

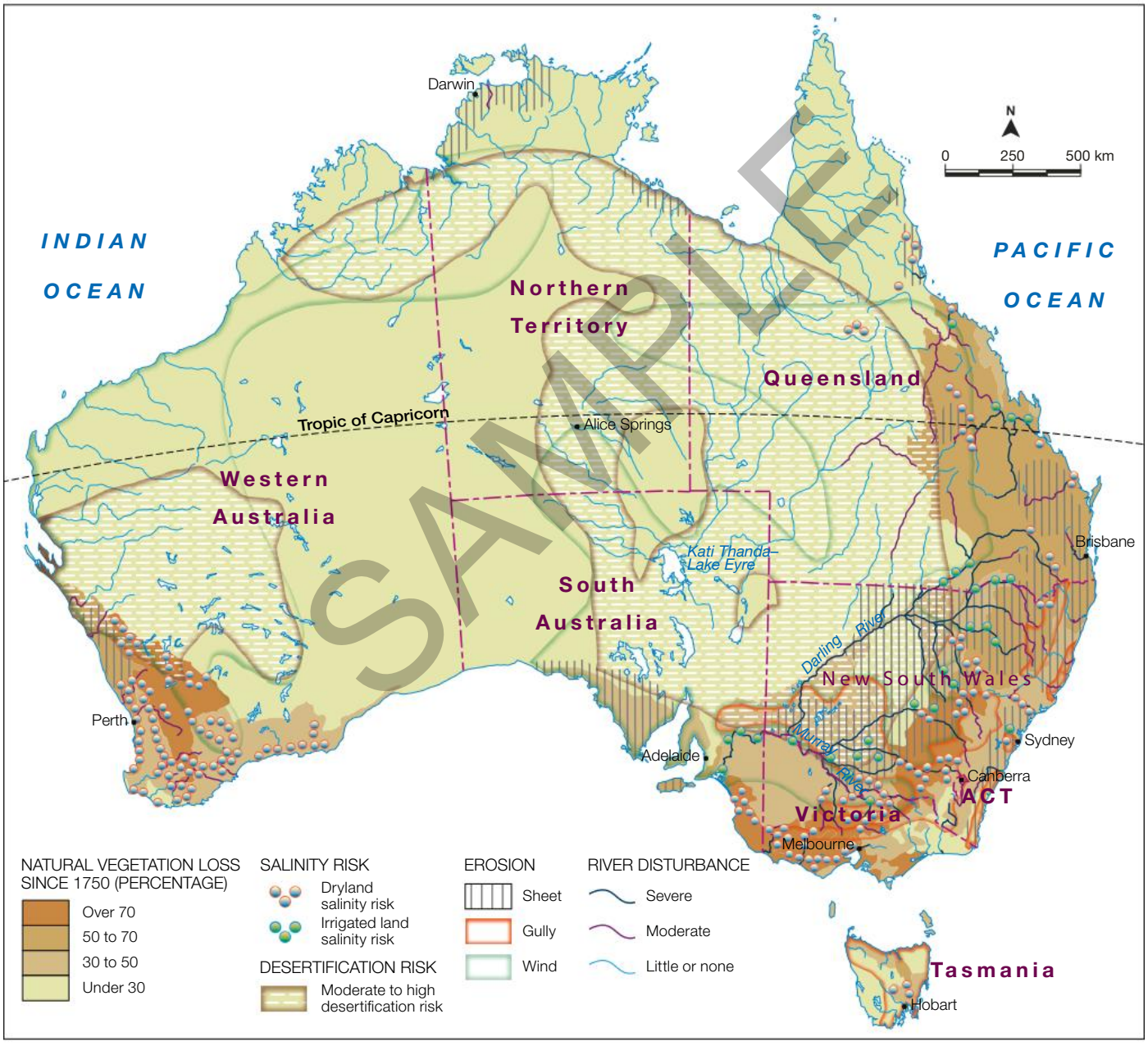
Scale, pages 416, 423

1.25

How is soil degradation affecting food production?

At a global scale over 22 per cent of agricultural land is affected by some form of land degradation and 2.3 per cent of agricultural land is considered fully degraded.

Australia land degradation



Source: Matilda Education Australia

▲ **Source 1:** About two thirds of Australia's agricultural land is degraded. The main causes of land degradation are water erosion, wind erosion, loss of vegetation, and salinity. Water erosion mainly occurs in eastern Australia, whereas wind erosion is a problem in the arid region of central Australia. Land degradation is the principal cause of desertification, a form of land degradation that transforms drylands (semi-arid or marginal lands) used to support agriculture into unproductive land, unable to support agriculture. An estimated 12 million hectares of land – an area that could produce the equivalent of 20 million tonnes of grain annually – are lost to desertification every year.

Natural and human processes

Land is degraded by natural processes such as insufficient or excess precipitation resulting in big erosion events such as dust storms and floods. A study in 2022 following flooding in Queensland's Lockyer Valley, a rich agricultural region, calculated that 550 000 cubic metres of soil was displaced from a single farm and 2.12 million cubic metres directly washed away throughout the valley.

Human causes of land degradation include deforestation and the planting of shallow rooted crops and pastures unable to hold the land in place. These processes are slow and insidious because the change they cause is only visible to the naked eye over time. Agricultural practices such as clearing steep slopes for grazing pastures increase the likelihood of land being eroded. The erosion of soil from riverbanks, a natural process, is accelerated by cattle grazing, a situation easily addressed by strategies that keep livestock way from rivers such as fencing and maintaining vegetation.

Soil degradation

Soil is the most critical component of the land used for agriculture. Soil degradation takes many forms.

Soil erosion – the loss of topsoil that provides the stability for plants and the nutrients and moisture needed for crops to grow. Water erosion includes splash erosion (raindrops dislodge soil particles) and erosion that transfers soil downslope through runoff in sheets, small channels (rills) and deep gullies. Wind erosion is visible as dust storms that lift millions of tonnes of soil into the atmosphere each year. Over 30 per cent of the world's cropland is losing topsoil faster than new soil is formed, drastically affecting food production.

Loss of fertility – nutrients and organic matter are depleted as a result of continuous cropping of the land, particularly **monoculture**. Without the addition of fertilisers, land becomes less productive and the chemical and physical properties of the soil change. These include changes to pH (acidification that determines whether plants can access nutrients), soil structure and drainage. Each of these changes reduces the productive capacity of soils, even minor declines in pH can harm crop and pasture growth.

Salinity – Some soils are naturally saline, but used wisely can support agriculture in semi-arid regions, such as the production of quinoa and grazing llamas in South America. Human induced salinity is caused by activities that raise the water table and bring salt to the root zone of plants such as land clearing and irrigation. Most food crops cannot tolerate high levels of salinity.

▲ **Source 2:** Uncontrolled stock access to the bed and banks of waterways can degrade soil, water and native vegetation.

Learning ladder 1.25

Processes that transform people, places and environments

1. Define land degradation.
2. Source 1: Describe the areas of Australia that have suffered a loss of more than half of its natural vegetation since 1750.
3. Explain how natural processes can degrade farming land.
4. Analyse the impact of loss of fertility on soils. What solutions have been used to improve fertility?
5. Source 2: Prepare a sketch of how this scene might look if the farmer took action to reduce soil degradation. Label your diagram.

Sustainability

1. Identify practices that contribute to the unsustainable use of land resources for agriculture.
2. How can naturally saline soils be sustainably farmed?
3. Source 2: Why is it important to manage livestock for the sustainability of the land?
4. Source 1: How does desertification occur and what sustainable management plans could be used to reduce it?

HOW TO

Sustainability, page 418

How do I use block diagrams to study soil degradation?

Block diagrams are used by geographers to provide a 3D view of an environment. They help us to understand the processes of change above and below the surface of the land and how these change over time. Block diagrams can also be used to plan and visualise the impact of management interventions.

Salinity

Salinity is the presence of salt on the land's surface, in soil or rocks, or dissolved in water in rivers and groundwater. Salinity is not new in Australia. It dates back 140 million years to when parts of Australia were covered by shallow seas. The seas dried up and salt was left behind. This salt is stored in underground water and rocks. Salinity has been called 'food's white death' because of the impact it has on farm productivity.

Human activities have contributed to soil degradation by causing salinity.

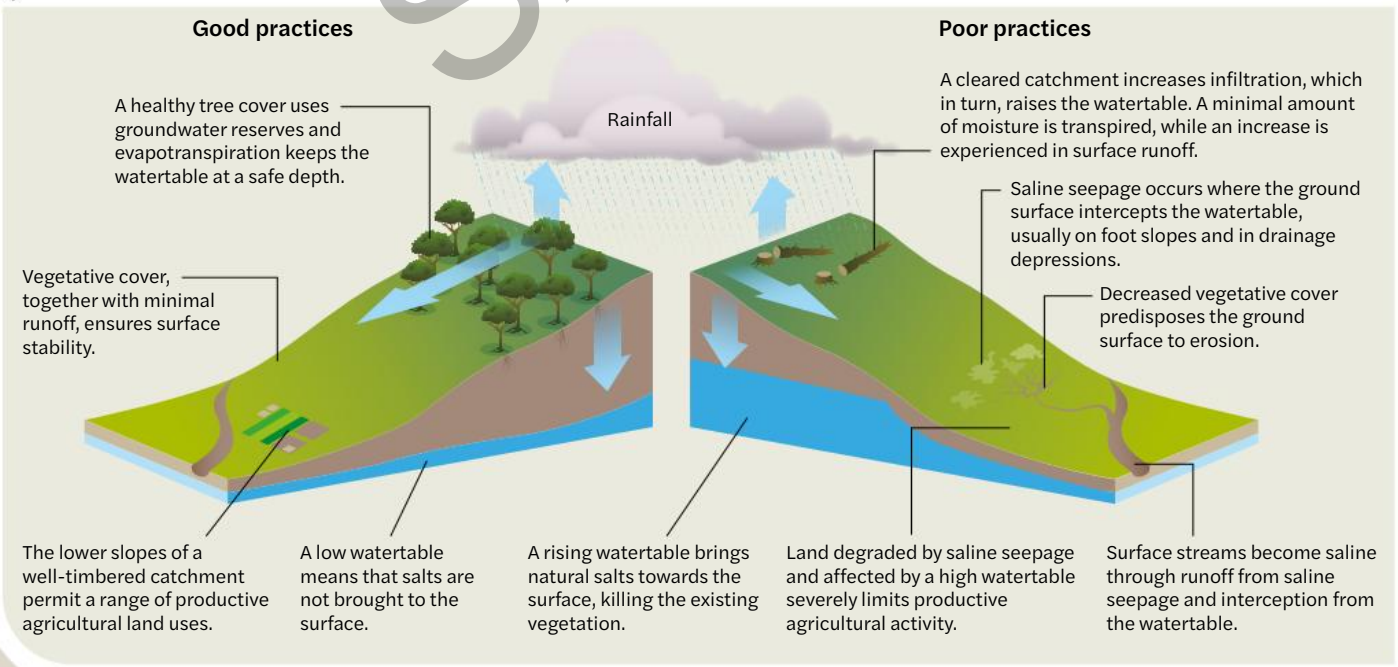
Dryland salinity in non-irrigated landscapes

Develops naturally when evaporation is greater than precipitation and when humans clear deep-rooted native vegetation and replace it with shallow-rooted crops and pastures. Both processes change cause the watertable to rise, bringing salt stored deep in the subsoil to the surface.

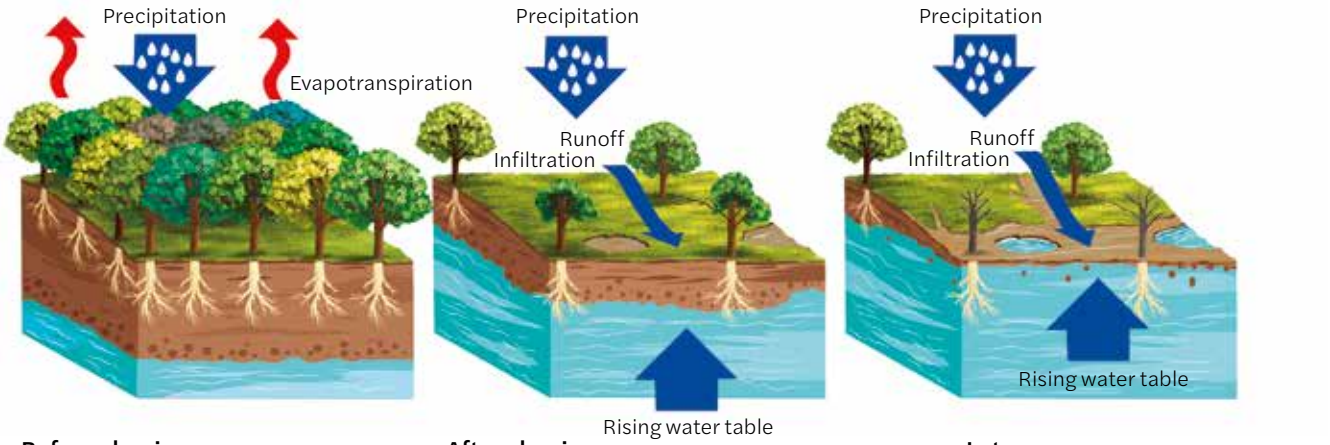
Irrigation salinity (wetland salinity)

Groundwater rises to the surface with the addition of irrigation water. It brings dissolved salts such as chloride, sodium, magnesium and calcium sulphates and bicarbonates. These salts kill kill most pastures and crops.

Source 1: Land management practices



Processes causing dryland salinity

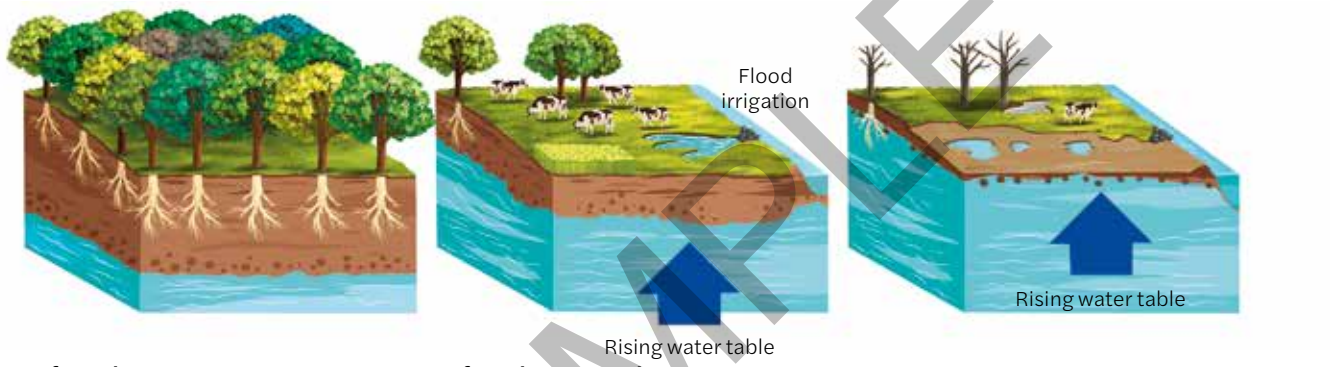


Before clearing
Most water is used where it falls. The system is in balance.

After clearing
Saline groundwater rises and is concentrated at the surface by evaporation. Vegetation growth is affected.

Later
Accumulation of salt at the surface kills protective plant cover. The land is open to erosion.

Processes causing irrigation salinity



Before clearing
The system is in balance. Most water is used where it falls.

After clearing and irrigating
Evaporation and irrigation raise the water table and concentrates saline groundwater at the surface.

Later
Protective plant cover is killed by the accumulation of salt at the surface. The land is open to erosion.

▲ **Source 2:** Processes of dryland and irrigation salinity

Learning ladder 1.26

Processes that transform people, places and environments

1. Identify the two types of soil salinity that impact food production.
2. Describe the process that is common to both types of soil salinity.
3. Explain the factors that make Australian soils vulnerable to salinisation.
4. Source 1: Outline the impact of good land management practices on soil degradation and farm productivity.
5. Create a block diagram to illustrate how one strategy to improve irrigation salinity would work.

Representing and communicating information

1. Source 2: How is movement of water shown?
2. Source 2: Describe the process of dryland salinity over time.
3. Source 2: Explain how irrigation causes salinity.
4. Suggest ways to improve the block diagram for irrigation salinity. Ask yourself if there are extra labels and/or arrows, above or below ground that would enhance your understanding. Recreate the block diagrams showing your additions.
5. Assess the effectiveness of block diagrams to communicate geographical information.

HOW TO

Block diagrams, page 436; representing and communicating geographical information, page XXX

Why visit a farm?

Fieldwork is a tool used by geographers to gather quantitative (statistical) data and qualitative (descriptive) information to answer inquiry questions.

Inquiry questions

In a study of food production there are many benefits to visiting a farm. The choice of farm will depend on what is close to your location and the inquiry questions you want answered:

- What types of food are produced in a local biome?
- How do farmers change biomes for food production?
- What problems arise from changes to biomes?
- What strategies could be implemented to enhance the sustainability of farms?

Pre–fieldwork activities

Before a farm visit, gather information about the location of the farm and the type of farming activity from secondary sources (the work of other people) and using spatial technologies. This activity will help guide the development of inquiry questions.

The following questions can guide the collection of information prior to your farm visit.

- Can I locate the farm using spatial technologies or a topographic map? (You could create your own sketch map of the location.)
- Has the farmer provided a map of the farm layout? Such a map could be used to record what each paddock or field is used for during your visit.
- What type of farm is it?
- What fieldwork instruments do I need?

At the farm

1 Using fieldwork equipment to gather quantitative data

It is important to understand how the physical environment supports the production of food and if farming activities have an impact on the physical environment. The types of equipment that could be used in a farm investigation are shown in Source 1.

2 Interviewing the farmer

These questions may apply to any farming activity or be specific to the farm you are visiting.

- What livestock or crops are produced?
- Who is produce sold to?
- How many people are employed to do the farming activities?
- Do you need to use chemicals on the farm to increase productivity?
- What technologies are used to benefit farm operations?
- What are your biggest challenges to producing food sustainably?

3 Making and recording observations

- Use fieldwork equipment to gather data (Source 1).
- Record observations using photographs and annotated diagrams of farm characteristics.
- Use spatial technology to record statistical data and photographs taken at different locations on the farm. This data can be mapped later using a GIS application. Alternatively record data on worksheets.
- Record data such as activities in different fields, water sources, degraded areas, direction of water flow, and weed infestations on a map of the farm.

Post farm visit

Collate your data and information from secondary sources and the farm visit and communicate your findings in a report or visual presentation. Make judgements about:

- The suitability of the farm for food production.
- Changes to the biosphere for food production.
- Existing or potential environmental issues caused by farming activities.
- The environmental sustainability of the farm.

Evaluate the success of fieldwork in answering your inquiry questions and communicate your findings in your report or visual presentation.

Activity	Equipment or technique	Conclusions to be drawn
Testing soil characteristics • texture • structure • pH • salinity • Infiltration rate • soil temperature • living soil (microbes and organisms)	• Collect 10 cm of topsoil (auger or spade) • Create and examine a ball or log (soil texture) • Observe clumping of soil particles (structure) • Time the infiltration rate of 100 mm of water (stopwatch, cylinder) • Test pH and salinity (soil test kit)	• Is the soil suited to pasture or crops? • Is pH between 4 and 7? • Is the soil a loam, sandy or mainly clay? • How well does water infiltrate the roots? • Is salinity an issue? • What do the colour and presence of organisms tell you?
Measuring gradient • slope of land • runoff rate	• Clinometer to measure the slope • Stopwatch and container of water to compare times 250 mm water take to flow 10 metres on different surfaces.	• Is the land vulnerable to erosion at different places on the farm?
Identifying weeds • identification • proportion	• Quadrat and weed identification chart to observe and identify weeds. Calculate the percentage of weeds at several locations.	• What weeds are present? • Are weeds an issue that need management?
Testing water quality • turbidity • pollutants • salinity	• Measure water clarity (turbidity tube) • Test Ph and ammonia (water test kit) • Test for salinity (refractometer)	• Are there issues with water quality that could affect farm productivity? • Has farming caused water quality issues?

Source 1: Gathering environmental data using fieldwork equipment and techniques

Testing soil characteristics – infiltration rates

Examining logs of soil

Testing amonia levels

Measuring gradient

Using a clinometer to measure angles

Identifying weeds

A quadrat is a square frame used in geography and ecology to study the distribution of an item in one isolated area. Estimates can then be made on distribution over a larger area.

Learning ladder 1.27

Representing and communicating information

1. Identify three examples of primary data that could be gathered during farm-based fieldwork.
2. Write a geographical inquiry question for a fieldwork visit to a dairy farm.
3. Describe two pre fieldwork activities you would undertake to prepare for a farm visit.
4. Identify the fieldwork equipment that would help measure water quality on a farm.

Environment

1. Source 5, page 60: Identify the food produced on this farm.
2. Source 5, page 60: Describe features of the natural environment that suit food production.
3. Source 5, page 60: Explain how the environment on this farm was changed to make food production possible.

HOW TO Fieldwork, page 442

Biomes and sustainable agriculture

Food security

2

HOW DOES AID HELP FOOD SECURITY? 84

How can I understand food security?

'Food security exists when all of the people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, in order to meet their dietary needs and food preferences for an active and healthy life,' Food and Agriculture Organisation (FAO). In 2023, nearly 30 per cent of the world's population faced moderate or severe food insecurity.

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 toward the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.
	Outcomes					Geographical tools and inquiry

Source 1: A Somali herder walks his cows through scrubland in 2023 in western Somalia. Ongoing drought in the region has led to crop failures and livestock deaths, leading to a food security crisis in Somalia and other nations in the Horn of Africa.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

What factors affect global food security?

Millions of people do not have regular access to safe and nutritious food and nearly one in three people don't have access to sufficient food supplies. These people live in a state of **food insecurity**, a situation that impacts individuals and the economic development of entire countries.

Patterns of food security

The Food and Agriculture Organisation (FAO) reported that 29.6 per cent of the world's population faced moderate or severe food insecurity, a total of 2.4 billion people in 2022. Of these 11.3 per cent suffered severe food insecurity. These figures followed a trend of increasing global food insecurity since 2019 due to several factors including population growth, poverty, conflict, natural hazards, poor agricultural development, a reliance on imports and increasing food prices.

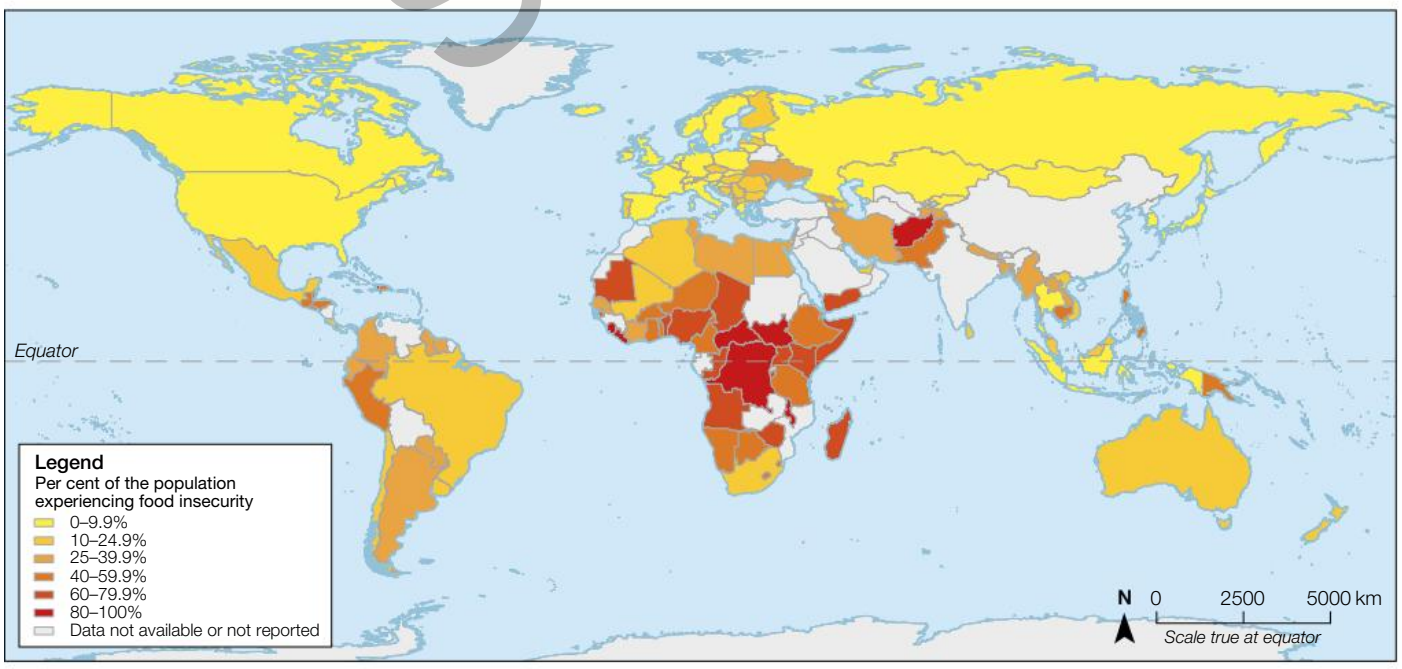
At all scales from international to local it is poor, politically unstable, female, rural and remote populations most affected by food insecurity. In nearly 60 per cent of countries women are more likely to suffer hunger and malnutrition because they eat last and eat the least. According to FAO, the majority of the world's food insecure people live in countries prone to natural hazards and climate change.

Factors affecting food security

Access: People can produce food and/or have the money to buy food locally or travel to places to buy food or receive food aid. The food must also be affordable to be accessible. Rising food prices limit poor people to cheaper, staple foods that lack variety needed for a balanced diet. Poverty is one of the biggest universal challenges to food security in rich and poor countries. Physical access to food is impacted by people' ability to travel to where food is sold.

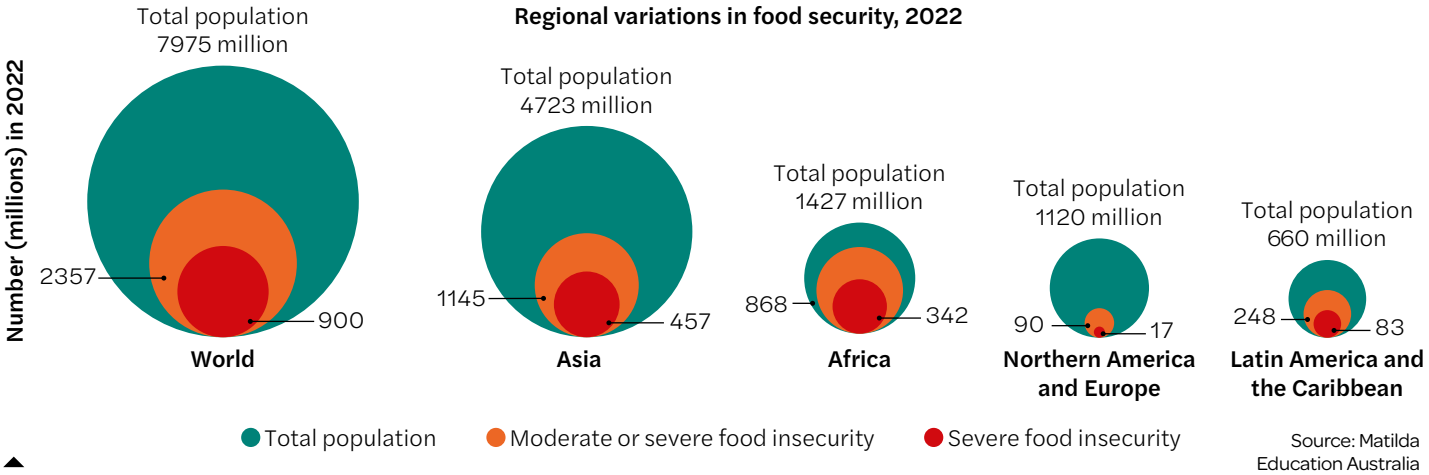
Availability: There is food for people to obtain. This includes quality food that is nutritious and meets the needs all groups, such as young children. Fires, volcanic eruptions, landslides, and floods physically damage crops and kill livestock while conflict takes farmland out of production, damages infrastructure such as dams and food storage facilities and interrupts supply chains, including imports from other nations and food aid. Remoteness hinders availability and access.

Global food security, 2021–23



Source: FAO

▲ **Source 1:** Global food security 2020–23.



Source: Matilda Education Australia

Source 2: Regional variations in food security. Not included in this graphic is Australia, which at a national scale is one the world's most food secure nations with very low levels of undernourishment. As a high income country, most (but not all) Australians can buy basic foods and receive adequate nutrition from a diversity of affordable, high quality foods grown in Australia and / or imported from overseas.

Quality and safety: Food must be used to meet nutritional needs and be safe to eat. Contaminated and unsafe food can impact people's health and put people at risk of disease.

Stability and resilience: ensures a steady and reliable supply of food to meet current needs and a reserve in case of emergencies that affect food production, imports, cost and quality. The COVID-19 pandemic increased global hunger by restricting people's physical access (restricted movement), economic access (job losses) and food availability (supply chains).

Source 3: Children, holding bowls and pots, queue to receive food aid in Idlib, Syria in 2019. Syrians, who sheltered in safe zones due to the civil war, have a hard time obtaining food.

Learning ladder 2.1

Processes that transform people, places and environments

1. Define the term 'food security'.
2. Sources 1 and 2: Describe the spatial distribution of food insecurity using geographic concepts such as hemisphere, continent, region.
3. Explain how two factors affect food availability differently.
4. How did COVID-19 impact access to food for different places?

Change

1. Identify how global food insecurity has changed since 2019.
2. Explain how a natural disaster can change a food secure community into one facing food insecurity.
3. How has change influenced food security for these children? Other than food aid, how can countries such as Syria improve their food security?
4. In Haiti, 90 per cent of crops were damaged by Hurricane Matthew in October 2016. Half of the Haitians employed in agriculture have been impacted by consecutive natural disasters that increased poverty and food insecurity and rely on food aid. What would need to change for Haiti to provide its people with food security in the future?

HOW TO
Change, page 412

2.2

What issues arise from food insecurity?

Food insecurity threatens the capacity of people to reach their potential with immediate and long-term consequences for individuals, families and nations. Issues arising from food insecurity include hunger, malnutrition, stunting and an incapacity to be productive citizens – an issue that can extend beyond the present generation.

Hunger, malnutrition and stunting

Hunger is also known as **undernourishment** – it means not consuming enough calories or nutrients to meet a person's needs for a normal, active and healthy life. The symptoms of hunger are discomfort and distress caused by the lack of food. In babies and young children undernourishment appears as listlessness and a frail, thin appearance. Persistent hunger can result in malnutrition, serious illness, wasting (a child's weight is extremely low for their height) and even death.

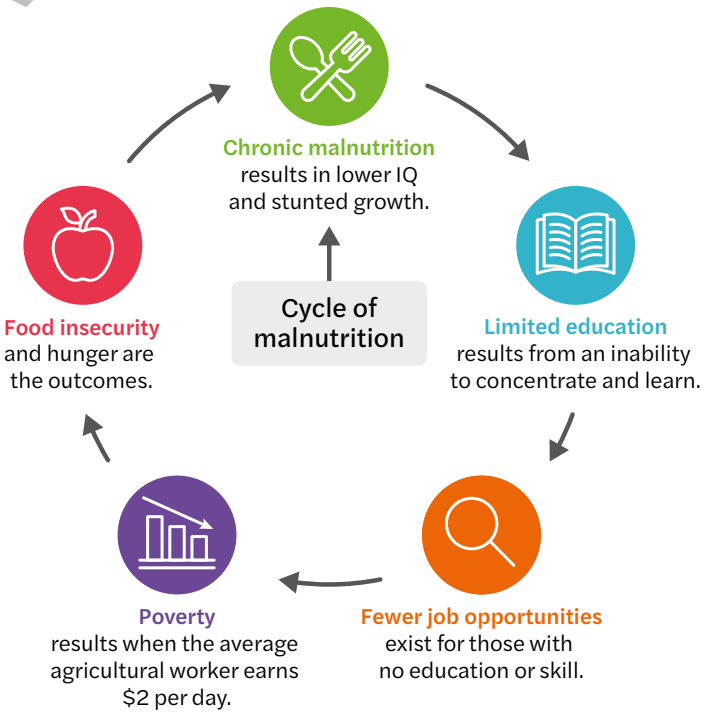
Malnutrition can also result in stunting, when a child is too short for their age because their physical growth was hindered at an essential period in their development. Stunting is a physical adaptation of the body to the calories available. Children who are stunted are four times more likely to die, suffer higher rates of disease and illness, have impaired cognitive development with IQ scores up to 11 points lower and earn 22 per cent less in employment than children who developed within a range considered normal. In 2023 food insecurity reached crisis levels in Somalia, with half of all children suffering malnutrition.

Cycles of malnutrition and poverty

Malnutrition can have consequences over a lifetime when long term food insecurity leads to the cycle of malnutrition. When a generation of young people suffer malnutrition and delayed development the future economic productivity of nations is threatened. Countries facing high levels of food insecurity such as Ethiopia and Yemen can lose as much as 16 per cent of their potential **gross domestic product** (GDP) from a generation of stunted children.

Food and Agriculture Organisation of the United Nations (FAO) data from 2021 stated that 149.2 million children under 5 years of age were affected by stunting with 90 per cent of those children coming from Africa and Asia. At a global scale progress has been made towards reducing food insecurity however it seems unlikely that the UN global nutrition targets on child stunting and wasting would be met by 2030.

A shortage of food and good nutrition within a household can lead to a cycle of intergenerational poverty and food insecurity that is difficult to escape. If a mother does not receive adequate nutrition stunting begins before a baby is born. Poor health in adulthood results in reduced job and educational performance, increased rates of disease and lower incomes, further reducing the capacity to access adequate nutritious food. Feeding stations target the malnutrition of children and maternal health.

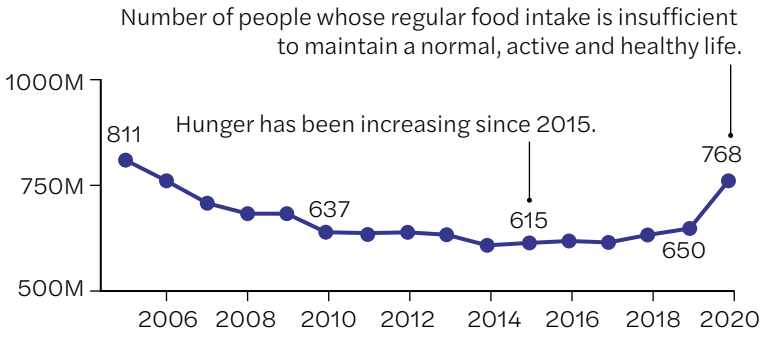


Source 1: Malnurition is not just an issue during childhood as it can have consequences that persist throughout a person's life, impacting their physical and cognitive development.

Famine and starvation

Many parts of the world are at risk of **famine**, an acute episode of extreme hunger that results in high mortality rates due to starvation or disease. It is estimated that globally, 80 million people are at a crisis-level of **food insecurity** that could result in famine without immediate action. Fortunately, the areas of the world threatened by famine today are far fewer than in the past as a result of coordinated international aid efforts that provide emergency food aid and better systems for monitoring extreme food shortages. When conflict and prolonged or consecutive hazard events or a combination block or hinder aid efforts, the threat of famine increases. Almost 80 per cent of Yemen's population in 2020 were in need of life-saving support when civil war pushed the country towards a famine.

Global rates of chronic hunger, 2005–20



Source: Matilda Education Australia

Source 3: Acute hunger is the short-term inability to access enough food to eat, usually requiring humanitarian aid. In 2020, 155 million people experienced acute hunger. An even bigger problem is chronic hunger. Hundreds of millions of people in the world suffer from chronic hunger, where people are unable to have enough food to eat for periods of at least six months. In 2018 the number of people in the world affected by chronic hunger increased during the COVID-19 pandemic.

Source 2: A child is weighed at a malnutrition weighing station.

Learning ladder 2.2

Perspectives of people and organisations

1. Define hunger, malnutrition, stunting and wasting.
2. Source 1: What are the main causes of malnutrition, and how does it affect people's lives?
3. Source 2: How do feeding centres help people, and what challenges do they face?
4. Source 3: Why did hunger decline after 2005, but increase again after 2018?
5. Why do some people believe food insecurity can be passed from one generation to the next? What might help break this cycle?

Interconnection

1. Identify two health issues linked to food security.
2. Explain the economic impacts of food insecurity on individuals, households and nations.
3. How does malnourishment lead to stunting in children?
4. Create a food security cycle to illustrate how adequate food and nutrition can have positive impacts on the future of household members.
5. How might failing to meet the UN global nutrition targets by 2030 affect the long-term wellbeing and economic development of food-insecure nations?

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Case study

Why is food so scarce in the Sahel drylands?

Although a **dryland** appears to be arid and barren like a desert, it is characterised by a fertile period of 1 to 179 days per year. Drylands account for approximately 40 per cent of the Earth's available land. The Sahel is a dryland region south of the Sahara Desert that stretches between Senegal and Eritrea. Over 41 per cent of people in Africa live in drylands.

Climate change

The Sahelian region is suffering the full force of **climate change**. Droughts are intensifying as temperatures are rising 50 per cent faster than the rest of the world. Climate change is also causing violent thunderstorms and flooding episodes such as dramatic flooding in Sudan in 2020 where hundreds died, 71 000 houses were destroyed and over 720 000 people left homeless.

Seventy per cent of people in the Sahel countries grow crops and raise livestock. Droughts and floods driven by climate change are destroying crops and the land is degrading and losing fertility. Farmers struggle to find drinking water and pasture for livestock.

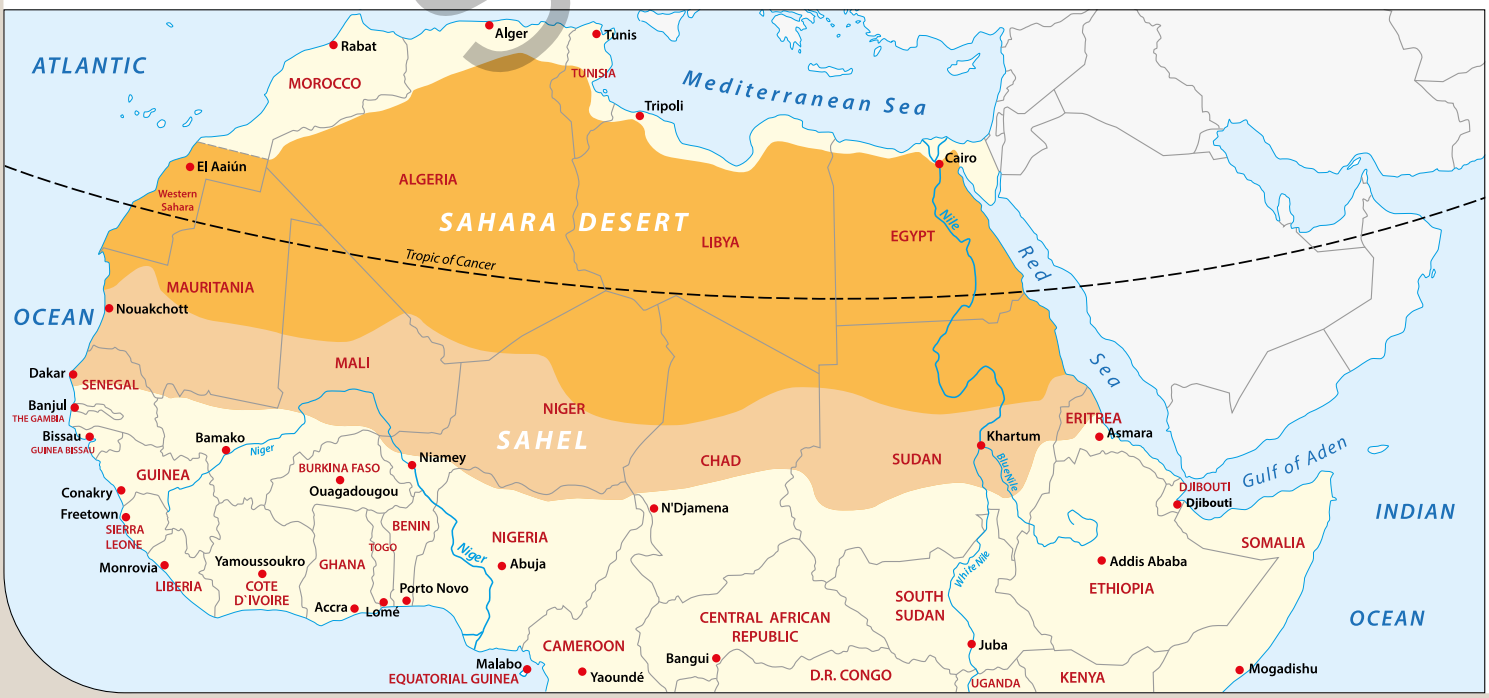
The economic impact on farmers is severe and the rest of the population who rely on agricultural production are plunged into food insecurity through food shortages and inflation of food prices due to scarcity. People unable to make a living are migrating to cities in the hope of an improved life.

Desertification

Desertification is a human-induced process in which the quality and fertility of the land is reduced by overcultivation, deforestation and unsustainable farming practices. Climate change has increased the rate of desertification in the Sahel drylands.

Extreme drought periods since 1968 caused a severe loss of croplands and livestock causing disastrous famines with over 100 000 deaths. As the human population of Africa continues to grow at a rate of

The Sahel region in northern Africa

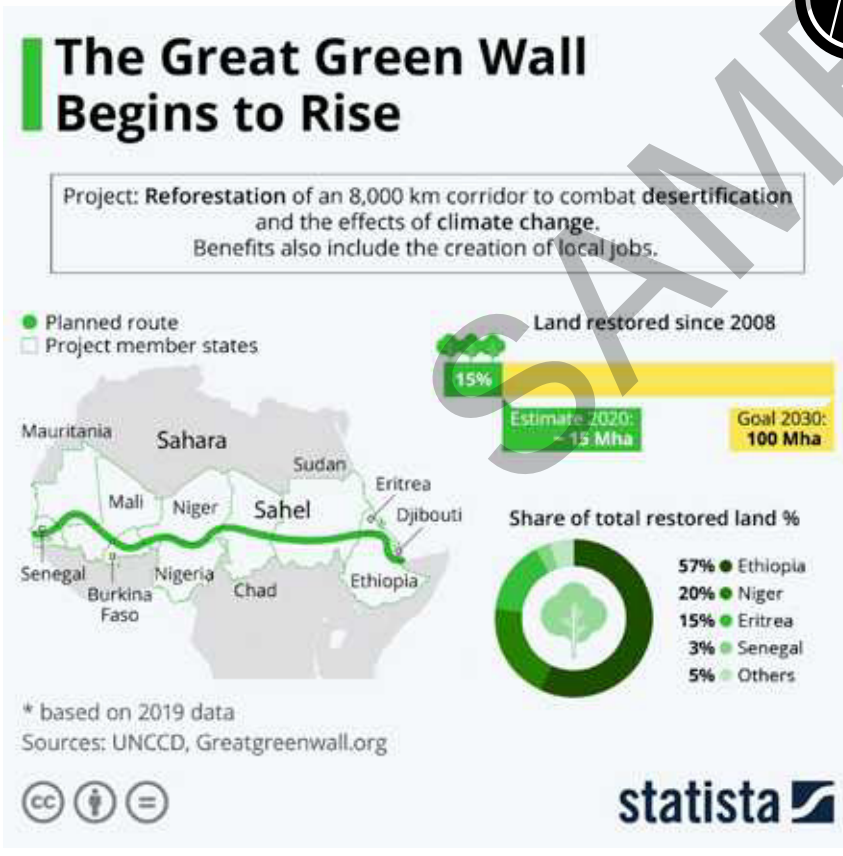


▼ **Source 1:** The Sahel region spans northern Africa.

Source: Matilda Education Australia

Source 2: A woman waters vegetables in a market garden established on formerly degraded land in Ouallam, Niger. The garden is shared by refugees, internally displaced people and locals.

around 3.1 per cent farmers continue to push the land to grow crops to feed their communities, actively increasing the rate of desertification. One solution has been the Great Green Wall, a reforestation project covering an 8000 kilometre corridor across the top of Africa.



▲ **Source 3:** The Great Green Wall (GGW) began in 2007 as a reforestation project to create a shield of trees to slow desertification. Today the project has expanded include strategies for sustainable land and water management such as climate-smart farming, forest conservation and using renewable energy sources.

Source: Statistica

Learning ladder 2.3

Processes that transform people, places and environments

1. Describe an environmental and economic factor impacting food security in the Sahel region of Africa.
2. Explain how climate change is impacting food security in the Sahel region.
3. Source 3: Explain why overgrazing is a major contributor to desertification in Africa.
4. Analyse how climate change is impacting farmers and the population that relies on their food production.
5. Source 2: What strategy is being used here to improve food security in the Sahel. Suggest a further strategy to stabilise food supply in this region.

Change

1. Describe how desertification changes the land.
2. How is climate change impacting incidences of desertification?
3. Source 2: Why are people forced to move from their homes and move to refugee camps or to cities in search of work?
4. Sources 1 and 2: Climate change will probably increase the amount of dry land and desertification. What will the environmental and social impacts of this be?

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Change, page 412

Case study

Why is there a food security crisis in Yemen?

Yemen relies on imported food, humanitarian aid and some locally produced food to feed its population. Food security will remain an issue for Yemen until it can reduce conflict in the country and sustainably grow more food locally.

Food insecurity

Yemen is one of the poorest nations in the Middle East and one of the world's most food insecure nations. In 2023 malnutrition was reaching emergency crisis level, with some locations on the brink of famine. For children under five years of age, 2.2 million suffered wasting and 45 per cent were stunted. The cause of the food crisis in Yemen is the intersection of multiple crises – political, economic, agricultural and environmental.

The political crisis

A violent civil war since 2015 increased already high food insecurity in Yemen. Over four million people displaced by the conflict live in camps for **internally displaced people**, where they rely on aid instead of producing or buying food. Some of the key events in the political crisis include:

- blockades of air and sea ports interrupted food and agricultural supply chains
- the destruction of infrastructure reduced physical access to food and markets
- conflict interrupted farming and caused an exodus of rural people to safer places
- the bombing, blockade and closure of the Port of Hodeida between 2015 and 2021 interrupted humanitarian aid, food imports and fuel supplies.

The economic crisis

Yemen depended on its oil and gas resources for revenue that was used to finance and subsidise the import of food, medicine and basic commodities. Declining crude oil prices and dwindling oil reserves in Yemen have reduced revenue and caused the cancellation of many development projects for infrastructure, water and agriculture needed to improve food security. High unemployment caused by political conflict has added to the food crisis.

The food production crisis

Yemen's agriculture was once dominated by small, subsistence farmers using traditional irrigation to produce drought resistant crops such as barley and sorghum. Yields were low; however, 60 per cent of households relied on farming as their main source of food or income. Money from oil made it easy to import food so farmers stopped growing crops that

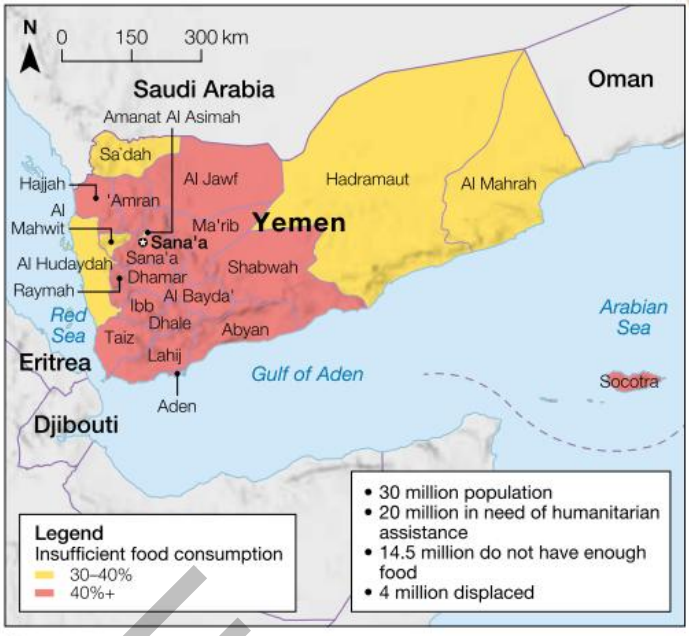
could not compete with cheap imports. They shifted crops like fruits and vegetables that required much more water from scarce underground aquifier reserves.

Limited agricultural production meant Yemen increasingly relied on expensive imported food. In 2022 Yemen was importing 85 per cent of its food requirements and with the food supply chain interrupted by conflict, local food producers struggled to fill the gap.

The environmental crisis

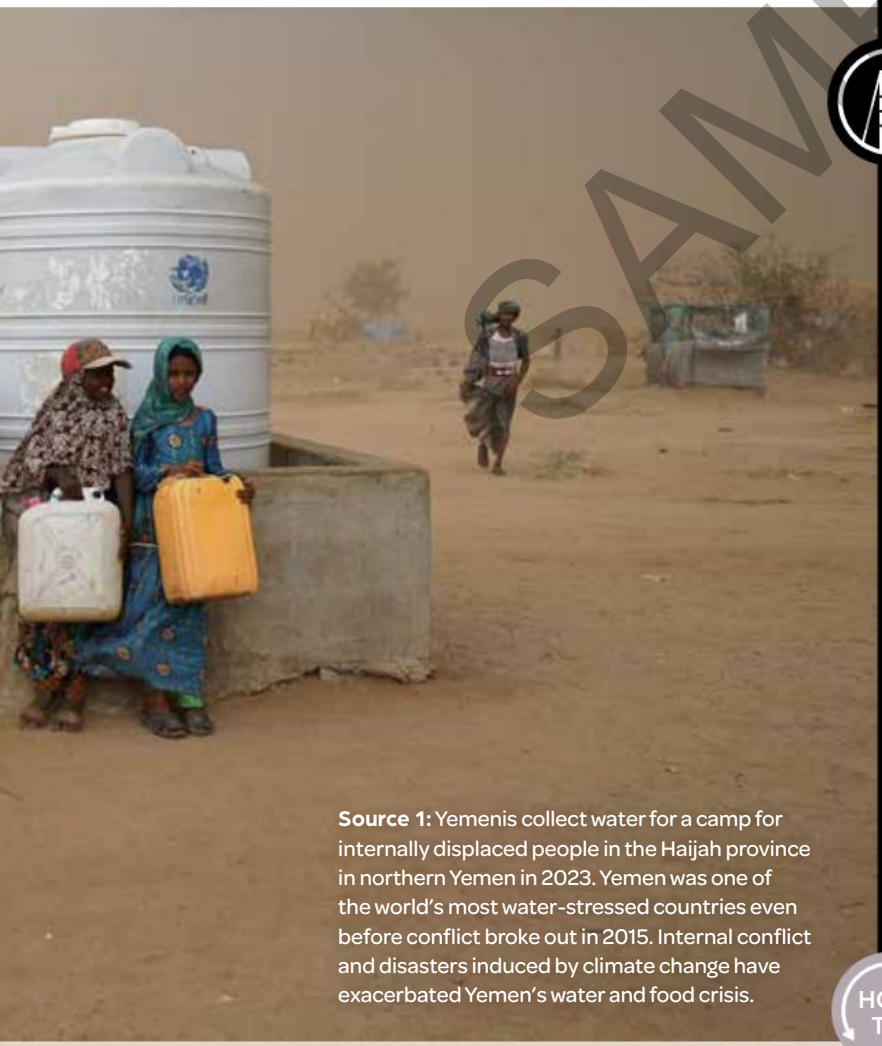
Climate change is affecting weather patterns around the world. Seven major floods, five cyclones and a landslide have hit Yemen since the conflict started, causing a further the loss of crops, livestock and infrastructure and worsening water security. Extreme weather events in 2022 included moderate-to-severe drought and unprecedented high temperatures. Crop growers were challenged by lack of rainfall and irrigation water that resulted in a 37 per cent reduction in the area sown to crops. Locusts are historically a major cause of crop losses in Yemen. The conflict has interrupted efforts to control the hatching of locusts.

Yemen food insecurity, 2023



Source: Matilda Education Australia

Source 2: In 2023 Yemen was listed among the five worst food crises in the world due to increasing numbers of people in Crisis or Emergency levels on the Food Security Classification. Households have food consumption gaps with high malnutrition and are in need of urgent support.



Source 1: Yemenis collect water for a camp for internally displaced people in the Haijah province in northern Yemen in 2023. Yemen was one of the world's most water-stressed countries even before conflict broke out in 2015. Internal conflict and disasters induced by climate change have exacerbated Yemen's water and food crisis.

Learning ladder 2.4

Processes that transform people, places and environments

1. What economic factors are impacting Yemen's food security?
2. Explain how the political crisis in Yemen is impacting its ability to feed its population.
3. Are economic, political or environmental factors impacting food security most in Yemen? Justify your answer.
4. Analyse the influence of climate change on current and future food production in Yemen.

Place

1. Source 1: Describe the physical characteristics of the region shown in the photograph.
2. Source 2: Describe the location of Yemen in the Middle East. Use geographical terminology in your response.
3. Explain the pattern of food consumption in Yemen.
4. Analyse the impact of four connected crises on food insecurity in Yemen.

HOW TO Place, page 408

How can a scatter plot help show relationships?

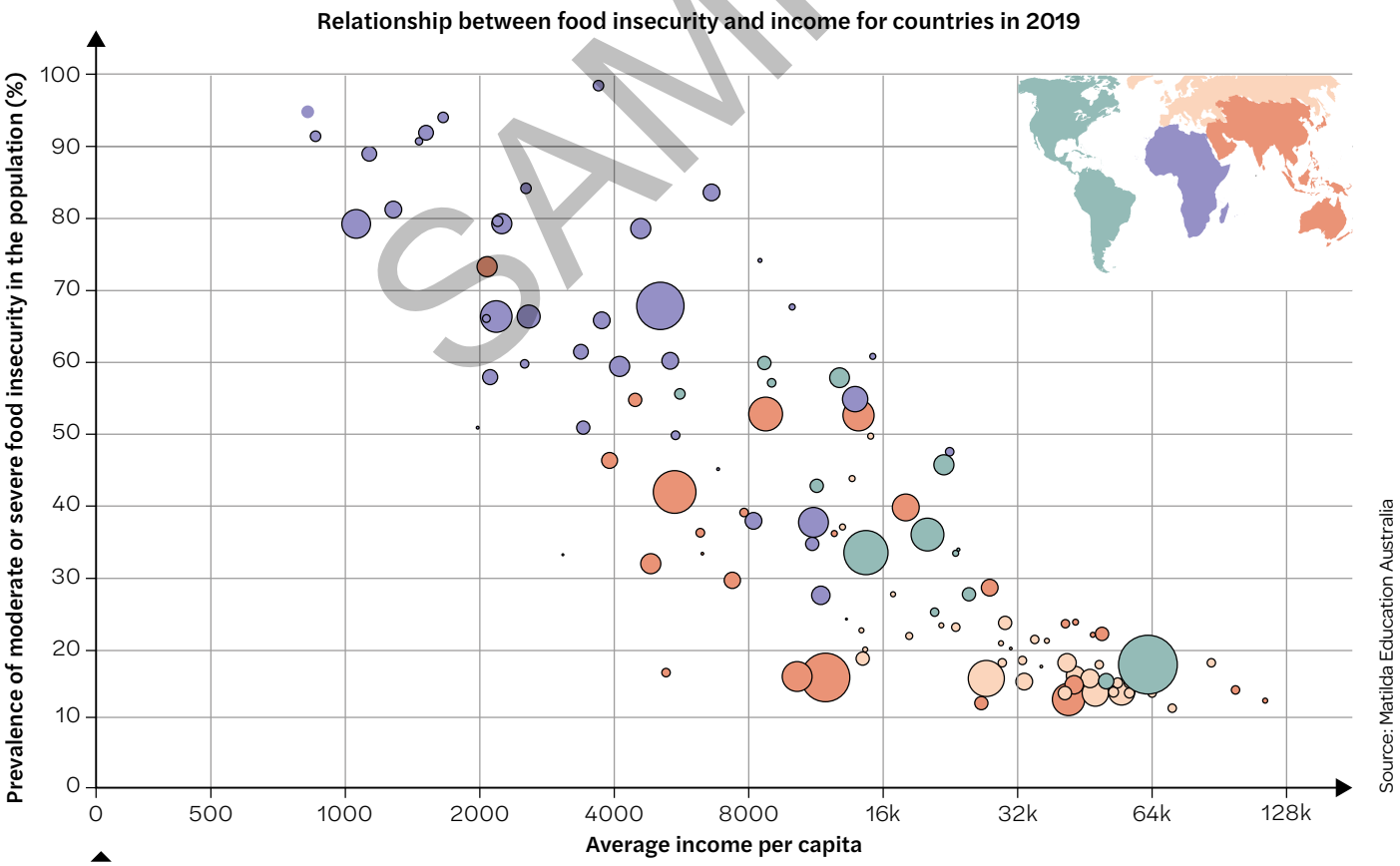
What are scatter plots?

A **scatter plot** is a type of graph that shows a relationship between two different variables, or pieces of data They do this by plotting one point of data along the *y*-axis (the vertical side) and a different point of data along the *x*-axis (the horizonal side). By plotting data for both variables, readers are able to determine if there is a relationship between the variables. An example is shown in Source 1, where the *y*-coordinate (the vertical axis) plots the percentage of severe food insecurity, whereas the *x*-coordinate (the horizontal axis) plots the average income per capita. All the data shown relates to the situation in countries of the world in 2019.

How can I determine a relationship?

You can determine relationships by looking at whether the data follows a direction and how tightly it follows it; the closer the data points the stronger the relationship. This is shown in Source 1, where the data moves in a downhill pattern. This is considered a negative relationship, showing that as the *x*-variable increases (income), the *y*-value decreases (food insecurity). This shows that there was a relationship between income and food security in countries of the world in 2019.

If the data shows an uphill pattern as you move left to right, this indicates a positive relationship between *x* and *y*. This means that as the *x*-coordinate increases,



Source 1: A scatter plot showing a negative relationship between the average annual income of a nation and the percentage of moderate to severe food insecurity. This graph shows that as income increases, the prevalence of food insecurity decreases. This tells us that there is a relationship between food security and income levels. The size of circles is representative of the population of each country.

the *y*-coordinate also increases. If there is no pattern and all of the plotted data is scattered, this indicates there is no relationship. These patterns are shown in Source 2. Scatter plots can also show complex patterns, such as when data curves, or can show outliers that don't follow the normal patterns.

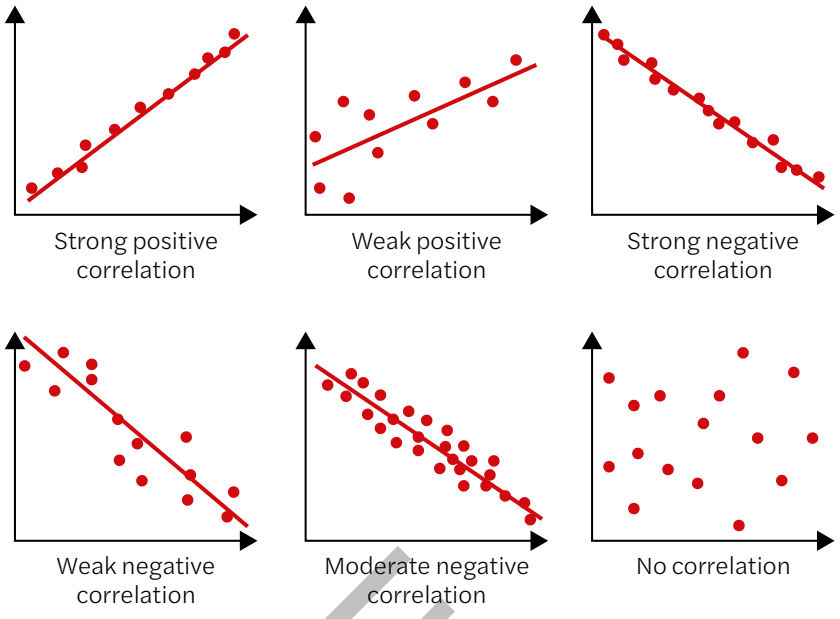
How are scatter plots used?

Scatter plots are very useful and an easy way to visually identify patterns. They can also be used to show more than two points of data, as shown in the Source 1. In this scatter plot, it not only shows us the negative relationship between income and food insecurity, it has also been used as a **bubble chart**. This is where the different size of circles shows us a different variable, in this case the size of each country's population. As there is no clear pattern of circle sizes on this graph, there appears to be no relationship between income, food security and population size.

An additional piece of information in Source 1 is that countries have been colour coded according to the world region they are in; for example purple circles represent countries in Africa and beige represents Europe. With this information we can see there is a relationship, as countries with high food insecurity and low incomes tend to be located in Africa and those with low food insecurity and high incomes are typically from Europe and the Americas.

Geographers, such as hydrologists and urban planners, can use scatter plots in many different ways to assess patterns and use this information to influence planning and management. However, it is important to remember that just because a scatter plot shows a relationship exists between two variables, this does not always mean there is a cause and effect relationship.

Different types of correlations shown on scatter plots



Source: Matilda Education Australia

Source 2: The types of correlations (relationships) that can be shown on a scatter plot

Learning ladder 2.5

Representing and communicating information

1. Describe what a scatter plot is and how it can be used.
2. Explain how a geographer could use a scatter plot.
3. Explain the relationships shown on Source 1 between income and food insecurity.
4. Using the data provided in the table opposite, create a scatter plot and explain the relationships it displays. It is encouraged for you to start your *x*-axis at 60 to help see the patterns more clearly.
5. Assess the validity and usefulness of scatter plots.

	y-axis	*x*-axis
Country	Food insecurity (%)	Life expectancy
Afghanistan	63	63
Australia	12	83
Bangladesh	32	74
Brazil	24	76
Cambodia	45	70
Canada	6	82
Chile	18	80
Ethiopia	56	69
Guinea	74	61
Japan	3	85
Mexico	26	75
Philippines	43	71
Spain	8	83
Tanzania	56	67
Zimbabwe	69	61

How can we improve food security?

Food security means a community or nation have their nutritional needs met. Food security increases resilience, promotes economic turnover, decreases conflict and it reduces mortality rates and other health conditions.

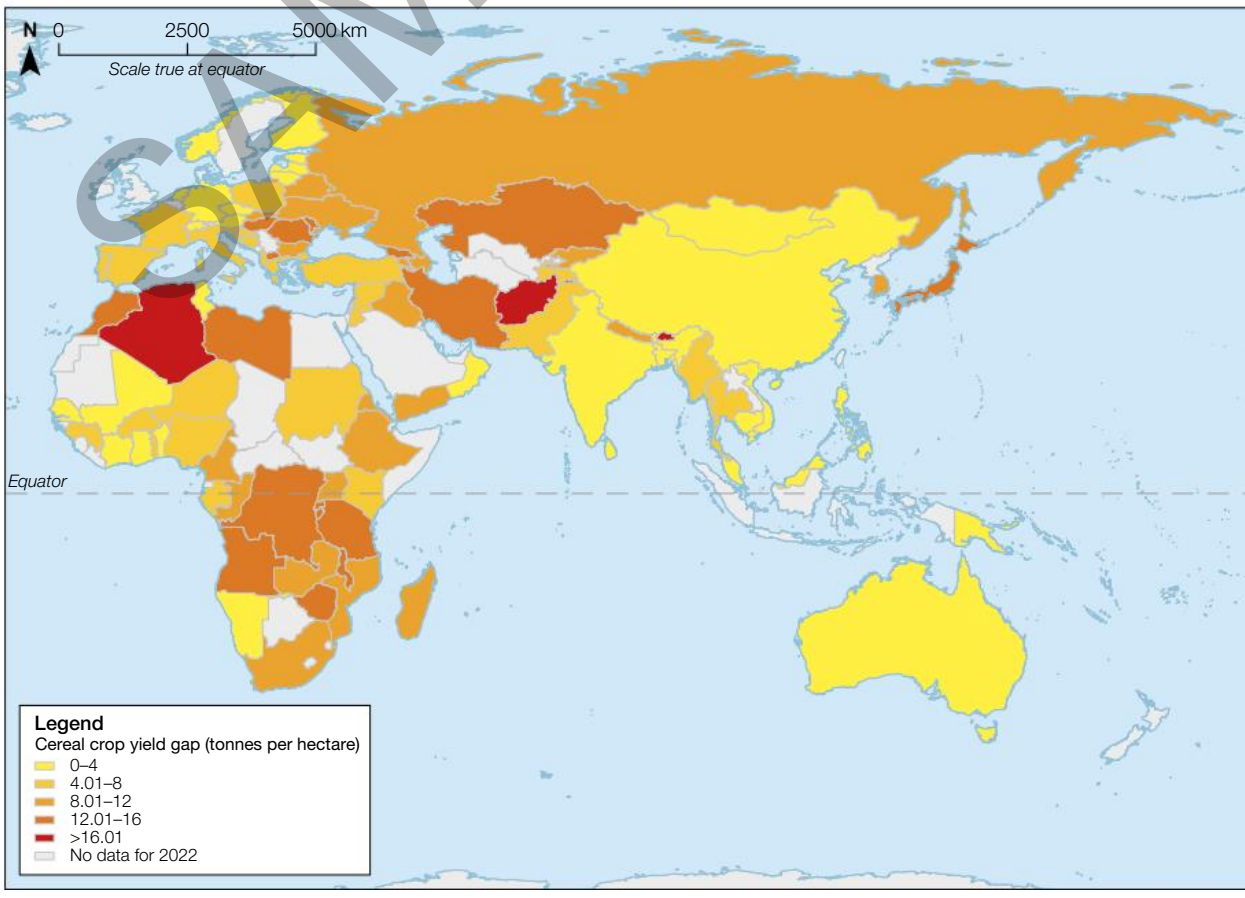
Close the yield gap

The yield gap is the difference between crops that are produced in a region and the amount that could have been produced if more sustainable and effective farming techniques had been used. Currently, the world's agricultural land only produces an average of 50 per cent of what it is capable of. By implementing technologies and practices that improve crop selection and diversification, improving pest control, decreasing water use and enhancing the quality and quantity of crops produced, the yield gap could be closed. This would enable farms to meet the food needs of a rapidly growing population and would prevent the need to clear approximately 120 million hectares of land for farms by 2050. International organisations and national governments can work collaboratively to share knowledge, technologies and resources around sustainable farming practices and provide incentives for farmers to implement them.

Implement food security reserves

Food security reserves are stored and maintained by governments and aid organisations. They help provide a stable food supply for communities during crises or drought. In Burkina Faso in Africa, crops are collected by the Aidons l'Afrique Ensemble (AAAE) organisation

Global yield gaps for cereal, 2022

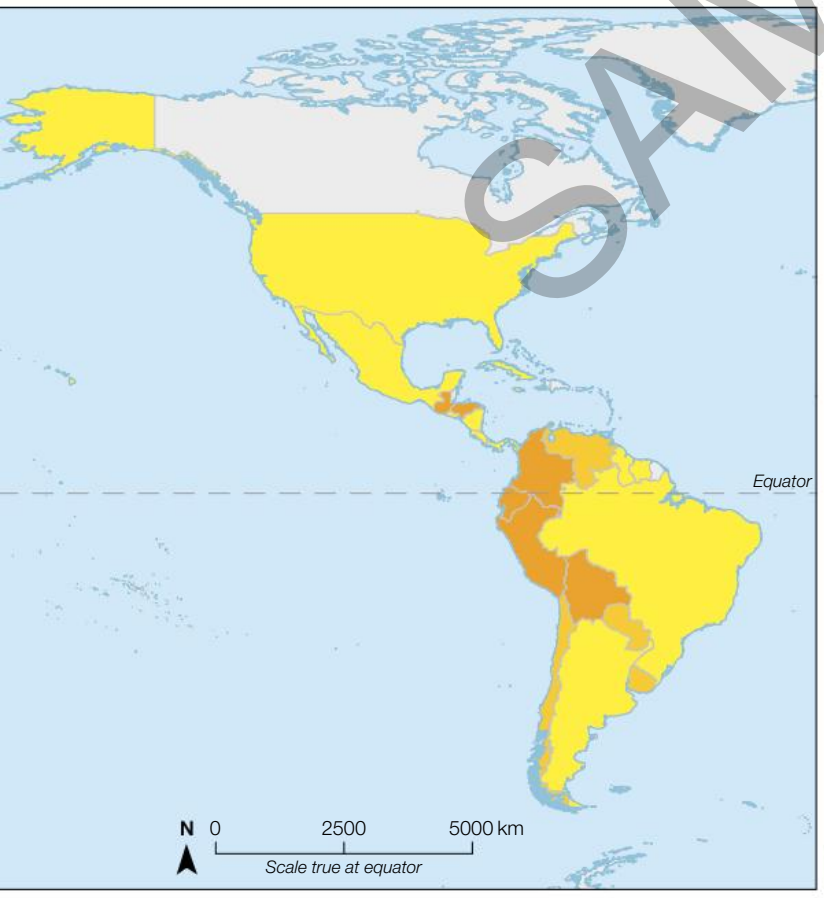


Source 1: Global food gaps, showing the possible yield that could be achieved for major cereal crops such as wheat and barley

after harvest in January to March. The AAAE then stores these crops, such as maize and sorghum, until the lean season of June to September when they sell them at low prices to vulnerable communities or donate them to families in most need. The lean season occurs when crops cannot be harvested, due to climate or environment, resulting in low availability and thus a rapid increase in prices. This allows families to access food, improves living conditions and prevents families from needing to migrate to search for food and work.

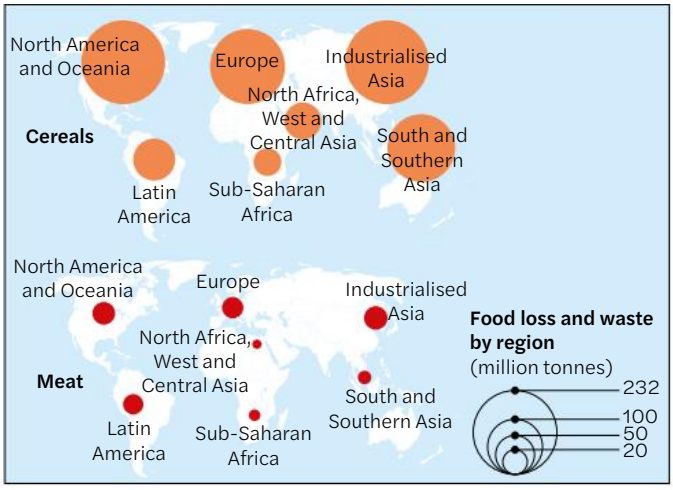
Reduce food waste

Food waste is a significant contributor to **food** insecurity. About one-third of the world's food ends up as waste. This occurs as a result of poor food storage post-harvest, over-selective customers, large food portions, and difficulties transporting food in a timely manner. The United Nations Sustainable Development Goals include an initiative to halve food waste by 2030, leading to nations such as Australia implementing the National Food Waste strategy. This aims to educate people about food waste, divert more food to food rescue, improve storage and transportation of crops and fund initiatives to minimise post-harvest losses.



Source: Matilda Education Australia

Proportional amounts of waste produced in food production



Source: Matilda Education Australia

Source 2: Proportional circle maps display the amount of waste produced by different regions. The larger the circle, the greater the waste in that location. About one-third of all food produced for human consumption is lost or wasted every year.

Learning ladder 2.6

Processes that transform people, places and environments

1. Describe the importance of food security and its impact on community resilience, economic turnover, conflict reduction and health outcomes.
2. Explain the concept of the yield gap.
3. Explain the role of food waste in contributing to food insecurity.
4. Analyse the social and economic benefits of improving food security for people and places.
5. Evaluate the purpose and effectiveness of food security reserves, providing examples of successful organisations or countries that have effectively managed these.

Scale

1. Describe two strategies to improve food security.
2. Source 1: Which regions have a high yield gaps compared to regions with low?
3. Source 2: Explain the global patterns of food waste.
4. Assess how international organisations can influence change on national and local scales.

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What new methods are used to increase yields?

Improving the yields of crops enables farmers to better meet the global demand for food, fuel and resources. Farmers have been using science and technology to improve their yields. This has had many positive social, economic and environmental impacts. It has resulted in increased yields, promoted the health of soils and reduced the need to expand agricultural land and resources.

Precision agriculture

Precision agriculture uses technology like drones and GPS systems to assess, plant, fertilise, use pesticides and harvest crops more precisely on farmland. Farmers use these technologies to collect and act on data about crop or animal performance, identify water-stressed areas, set specific irrigation systems, distribute pesticides, plan seed placement, assess soil health, and apply fertilisers. These targeted techniques reduce water, fertiliser, and pesticide waste whilst improving crop yields and quality. However, these technologies are expensive to establish and maintain.

Controlled Environment Agriculture

Controlled Environment Agriculture (CEA) involves growing crops indoors or in controlled environments to regulate temperature, humidity and nutrients and manage pests, disease and weather impacts. This results in higher yields as food resources are produced year-round. Examples include vertical farming, greenhouse farming and hydroponics.

Aquaponics is a sustainable version of CEA. It combines aquaculture (fish farming) with hydroponics (soilless plant gardening).

Source 1: A digital tablet with virtual reality can be used to analyse plant disease in sugarcane crops. This is an example of precision agriculture.

Source 2: Twenty-six per cent of canola grown in Australia has been genetically modified to be tolerant to different herbicides.

Fish that are being farmed, such as rainbow trout, produce waste in the aquaponics system and then microbes and worms convert this to fertiliser for the plants. The plants, such as tomatoes or watercress, then filter the water for the fish.

Genetic modification

Genetic modification of crops is a technology where scientists insert DNA into the genome of an organism and then grow these cells into a plant. The new aseeds of the plant will inherit the DNA. Scientists and farmers do this to create genetically modified crop species that are more tolerant of herbicides, resistant to insects or disease, more drought tolerant or increase the biomass production or ability to photosynthesise to improve a crops yield capacity.
Only four crops have been approved for genetic modification in Australia; canola, cotton, safflower and Indian mustard. As of 2021, 26 per cent of national canola was genetically modified.

Source 3: An example of an aquaponics system. This is where aquaculture (the farming of fish) and hydroponics (soiless plant farming) is combined.

Learning ladder 2.7

Sustainable management strategies

1. List three different strategies to improve yields.
2. In what ways can precision agriculture help reduce the environmental impact of farming?
3. Explain how aquaponics combines fish farming and plant cultivation to enhance crop yields sustainably?
4. Analyse the positive and negative impacts of using science and technology to improve yields.
5. Evaluate the effectiveness of using precision agriculture to improve crop yields and resource management.

Change

1. Describe one way farmers can change their agricultural practices to improve yields.
2. Explain how genetic modification technologies are changing farming practices.
3. Assess the sustainability of changes to farming practices.
4. Not all farmers can afford the technology to improve crop yields. Develop an initiative that will make these technologies more widely available.

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Case study

How can vertical farming increase yields?

Vertical farming often occurs indoors and involves growing and harvesting crops in vertically stacked layers. This agricultural method optimises space by allowing more crops to be grown in a smaller area and, being indoors, it enables year-round production.

Vertical farming in New York

New York City has over 19 million residents and has the highest population density of any United States city, at 10 194 people per square kilometre. As a result, the city is compact and filled with office buildings, apartments, restaurants and shops. For this reason, most fruit and vegetable produce is imported from areas hundreds or thousands of kilometres away. This not only increases the cost of the food, but transporting the produce increases CO_2 emissions that contribute to global warming. As a result many companies, such as Gotham Greens and Farm. One have developed vertical farms across New York and other cities that provide many benefits.

Water and resource efficiency

Vertical farms are more sustainable, as their climate control and technology enables water recycling, reduces water consumption, reduces fertiliser usage and solar and wind powered farms reduce energy use. Vertical farms in New York use 95 per cent less water, 90 per cent less transport and 90 per cent less electricity than traditional farms.

High-density crops

As crops are grown in multiple layers, vertical farms maximise their use of space to produce a higher crop density. The largest vertical farm in New York is less than 1 hectare, compared to the average size of

New York City vertical farms

Source 1: New York City vertical farms

Source: Matilda Education Australia

Source 2: Gotham Greens vertical farm in New York City

Source 3: Worker assessing the quality and quantity of crop yields in a vertical farm

traditional farms at 180 hectares. The indoor nature of the farms also ensures yields are free from pests, pathogens or extreme weather and enables control over environmental factors such as temperature, humidity and light. This optimises growing conditions and enables multiple harvests all year-round, increasing crop yields and quality.

Proximity

Approximately 70 per cent of the world's population are expected to live in cities by 2050, leading to the expanse of urban centres, the decrease of arable lands, more CO_2 emissions to transport food to cities and less farmers to support the food needs of a growing population. However, building vertical farms in urban areas increases their proximity to the consumer and decreases the time between harvest and consumption, leading to a high quality of produce that feeds the urban population faster. Most vertical farms in New York are a walking distance from the main five boroughs.

Are they the future?

Many other cities around the world now use vertical farming, such as Dubai, Tokyo and Paris. They provide a sustainable solution to reusing land, improving food security and also provide employment. However, their initial setup costs, energy requirements and complex technology need to be improved before it can be adopted on a wider scale. Nonetheless, vertical farming in large city areas is a growing industry due to decreased availability of agricultural land. In 2023 the vertical farming market had a value of $5.1 billion and this is expected to triple in size to $15.3 billion by 2028.

Learning ladder 2.8

Sustainable management strategies

1. How is vertical farming different from traditional farming methods.
2. Source 3: Outline how vertical farming can improve crop yields to support food security.
3. Source 2: Explain how vertical farming addresses the challenges faced by densely populated cities like New York City.
4. Analyse the social and environmental benefits of vertical farming compared to traditional farming practices.
5. Evaluate the potential of vertical farming as a sustainable and future-oriented solution for urban areas.

Place

1. Source 1: Describe the location of vertical farms in New York.
2. Source 3: Explain why vertical farms are suitable for urban places.
3. Explain the social benefits of vertical farms on the community and place of New York.
4. Evaluate the suitability for vertical farms to be implemented in large cities such as Sydney or Melbourne in Australia.

HOW TO

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2.9

How can sustainable practices help ensure food security?

Sustainability is the ability to use resources, such as land and food, whilst ensuring that development today does not negatively affect future generations. By using more sustainable practices we are able to reduce the demand for food, limit food waste, protect the environment from degradation and maintain ongoing food production.

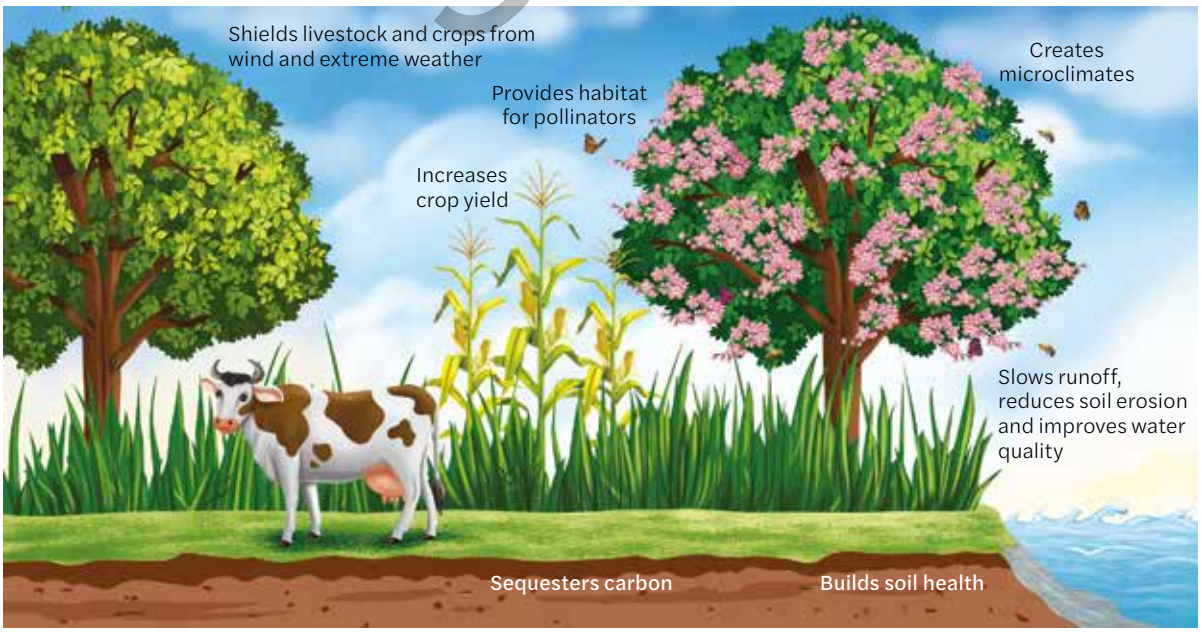
Sustainable agriculture

Sustainable agriculture promotes farming practices and technology that use less water through drip irrigation or rainwater harvesting to avoid water wastage, reduce land degradation and soil erosion by rotating crops between fields, preserving **biodiversity** by planting diverse resilient crops to overcome changes in climate or disease and use eco-friendly pesticides and fertilisers to avoid polluting local water systems. Through this, the environment on and around the farmland is more conserved, allowing the land to be used into the future to continue to grow crops and ensure food security.

Agroforestry

Agroforestry is the practise of combining the local environment and trees with farming. For example, animals can graze under fruit, legume or timber trees. The animals are provided with fodder and shelter, whilst their manure enriches the soil. This not only provides multiple income sources for farmers, but when implemented correctly it increases animal welfare, the biodiversity of native animals and improves dairy and meat production for farmers.

Crops can also be paired with trees. This is particularly done in coffee producing countries such as Ethiopia, Indonesia and Colombia, who use fruit, timber and legume trees to shade their coffee crops. This has proven to increase biodiversity and pollination and reduce pests. The trees also help to stabilise soil, enrich the soil through litter fall, and **sequester** (capture and store) a large amounts of carbon above ground in the vegetation and below ground in the roots.



Source 1: Agroforestry can improve sustainable farming practices, with good outcomes for the farmer and the environment.

Source 2: Agroforestry system with coffee bushes being shaded by taller trees on the western slope of the Andes Mountains in Ecuador, South America

Sustainable use of ugly food

As a result of strict cosmetic standards of food, approximately 20 per cent of harvested produce gets discarded before reaching the shops because of its size, colour or look. This unnecessarily contributes to food waste. Recently there has been a trend of supermarkets and businesses selling boxes of 'ugly' fruit and vegetables to consumers at a smaller price; sometimes as low as 50 per cent. This is sustainable, as it reduces the amount of food wasted and promotes the affordability of food for more people. Companies are now also being established to reuse these unsightly produce in food donations, in other products such as soups and juices and for food composting.

Source 3: A pile of 'ugly' vegetables that would not meet the cosmetic standard required for supermarkets. Many of these types of fruits and vegetables end up as waste.

Learning ladder 2.9

Sustainable management strategies

1. Describe how sustainable agriculture can be used to improve food security.
2. Outline the methods and practices used in sustainable agriculture to conserve water, reduce land degradation, prevent soil erosion, and preserve biodiversity.
3. How would agroforestry provide environmental, economic and social benefits?
4. Explain how cultural changes to the way we see food can improve food security, referring to ugly food.
5. Assess the capacity for all farmers in Australia to implement sustainable agriculture. What would be the advantages and limitations?

Sustainability

1. Describe two ways farming practices can become more sustainable.
2. Source 1: Explain why agroforestry is sustainable.
3. Assess how the use of ugly foods can promote long term sustainability for food security.
4. Source 2: Analyse with further research why coffee growers obtain benefits from agroforestry.

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How can we reduce food waste?

Each year 30 per cent of food produced globally does not get consumed because it is lost or wasted somewhere along the food supply chain. It is estimated that as much as one-fifth of garbage sent to landfill consists of food waste.

The food supply chain

Most food is part of a supply chain that transfers food from the farm where it is grown (food production) to the plate when it is eaten (food consumption). Along this supply chain food may be transported, stored, processed, and sold by a retailer or prepared by a restaurant before it is consumed. Waste occurs at every stage and in every country that produces food.

Food loss

This type of waste occurs at the beginning stages of the food supply chain, usually after harvesting crops or selling livestock. It also happens during transport to the next stage in the supply chain if food is spoiled on the journey. Food loss is mostly unintentional. Factors causing food losses include:

- extreme weather events such as storms that destroy crops before they can be harvested.
- pests and diseases that eat the food or make it inedible
- poor facilities such as the refrigeration needed to reduce spoilage and covered storage to keep food dry
- overproduction means not all food leaves a farm because there is no market for it
- competition from cheap imported food means some food is not harvested.

Food loss is the main cause of waste in developing countries where food security is poor. Strategies to address this type of waste include government programs to improve transport and storage facilities such as silos and refrigeration as well as access to technologies that improve information for farmers on impending weather events and on changing markets. A review of government policies that allow cheap imports of locally produced foods has the potential to reduce food losses at the farm level. The main benefits of reducing food loss is improved food security in poorer nations.

Source 1: Potatoes and onions rotting on a farm are considered lost food.

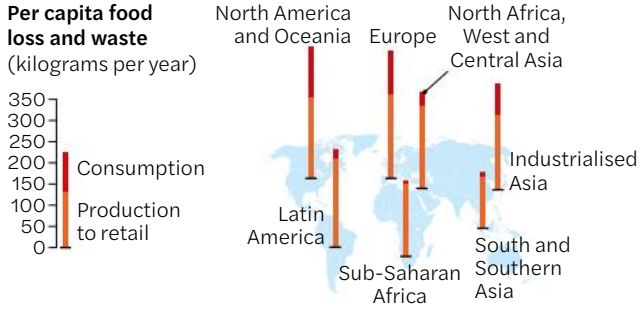
Food waste

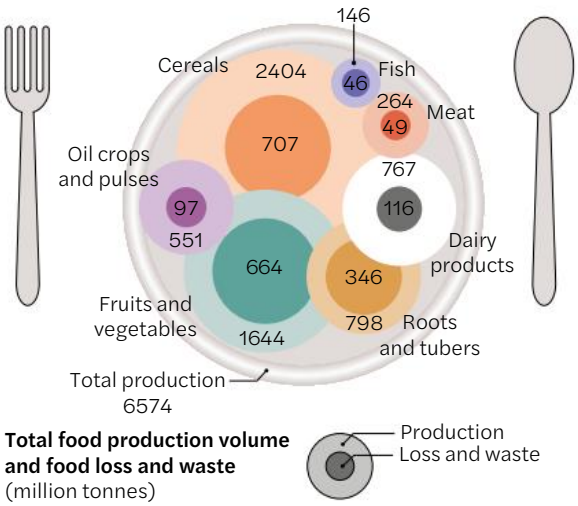
The United Nations Environment Program report revealed that about 931 million tonnes of food waste was generated worldwide in 2019; 61 per cent from households, 26 per cent from food service and 13 per cent from retail.

Food waste refers to edible food that is thrown away or remains unused because it is spoiled, it has passed an expiration date, there is too much of it or it does not match what consumers want. Food waste occurs in the latter stages of the food supply chain. For example, food is wasted at a restaurant or processing plant where only a certain size or grade is accepted or is thrown out by a retailer for fear it is no longer safe to consume. Households, food retailers and restaurants make a conscious decision about what they will use or consume.

Food waste occurs more in wealthier countries like Australia, where the average household wastes 136 kilograms of food per person every year. People and organisations have the luxury of choice and expect to see shelves full of fresh or processed food products.

Source 2: Food waste by region and food type





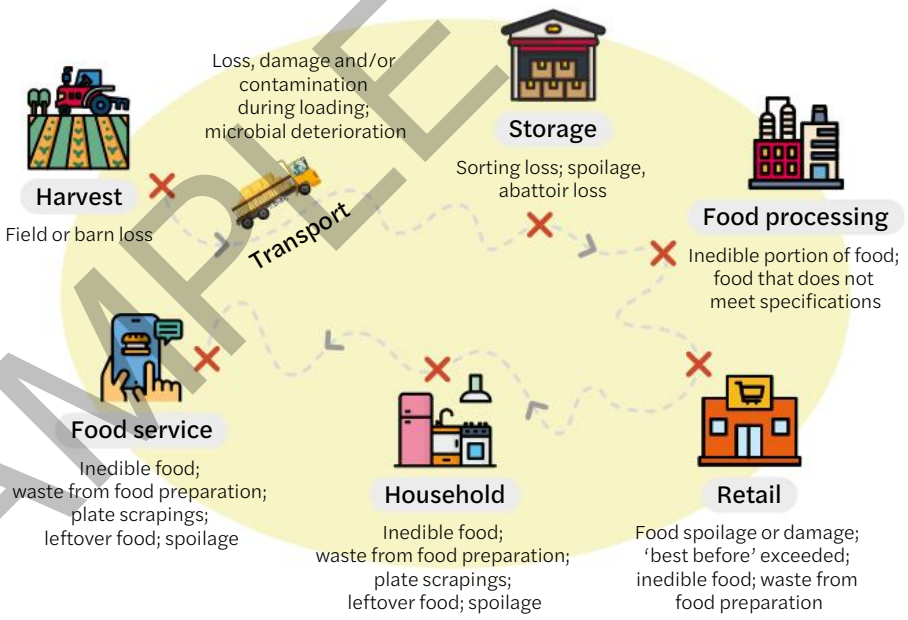
Source: Riccardo Pravettoni

They buy more than can be consumed, throw away good food that is past its expiration date or food that has deteriorated and become cosmetically imperfect, but is still edible.

Efforts to reduce food waste include:

- the donation of excess food to food banks and charities
- encouraging retailers to sell fresh foods in small unpackaged quantities to avoid householder waste caused by buying in bulk
- educating people about the value of food for its nutrition rather than its appearance, the true meaning of expiration dates and using all parts of fresh food items as ingredients in cooking (known as top-to-tail cooking).

Source 3: The food chain stages and reasons for food loss and waste.



Learning ladder 2.10

Sustainable management strategies

1. Source 3: Briefly define a 'food supply chain'.
2. Source 1: Is this 'food loss' or 'food waste'? Explain.
3. Describe one strategy used to reduce food loss that could improve food security in developing nations.
4. Explain the role of education as a strategy to reduce food waste in wealthier countries.
5. Rank three strategies in the order you believe would be most effective in reducing food waste in Australia. Justify your answer.

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Sustainability

1. Why is food waste a sustainability issue?
2. Create a diagram to illustrate the key features of a sustainable food supply chain.
3. Source 2: Explain why the current food production system is considered unsustainable at a global scale.
4. Discuss the statement 'Most food waste is a result of choice'.
5. Propose one action that could be taken by each group – individuals, businesses and governments – that would reduce food loss and waste.

What role does humanitarian aid play in food security?

Humanitarian aid is the provision of resources such as food and services to countries or communities that require assistance in times of crises, emergencies and prolonged conflicts. Aid is funded and managed by national governments, international organisations and **non-government organisations**; with over $41 billion raised in 2022 for global food programs.

Short-term aid

Some provisions of aid to address food security are short-term and aim to provide immediate relief and meet urgent food needs following a disaster, economic challenge or conflict. This can include providing immediate food provisions, such as ready-to-eat meals or food parcels, establishing temporary food kitchens or establishing a food voucher system for vulnerable communities to enable them to access nutritious food easily. It can also include the immediate repairing of food storage facilities, infrastructure or developing communal kitchens to support vulnerable communities share resources and temporarily support one another through a crisis.

These strategies were employed in 2019 by the World Food Programme (WFP) to support communities in Mozambique, Zimbabwe and Malawi after Cyclone Idai caused flooding, disrupted food chains and destroyed crops. The WFP provided food rations of cereals and oil to communities, provided transport to distribute aid and food efficiently and set up emergency feeding centres to provide cooked meals to communities.

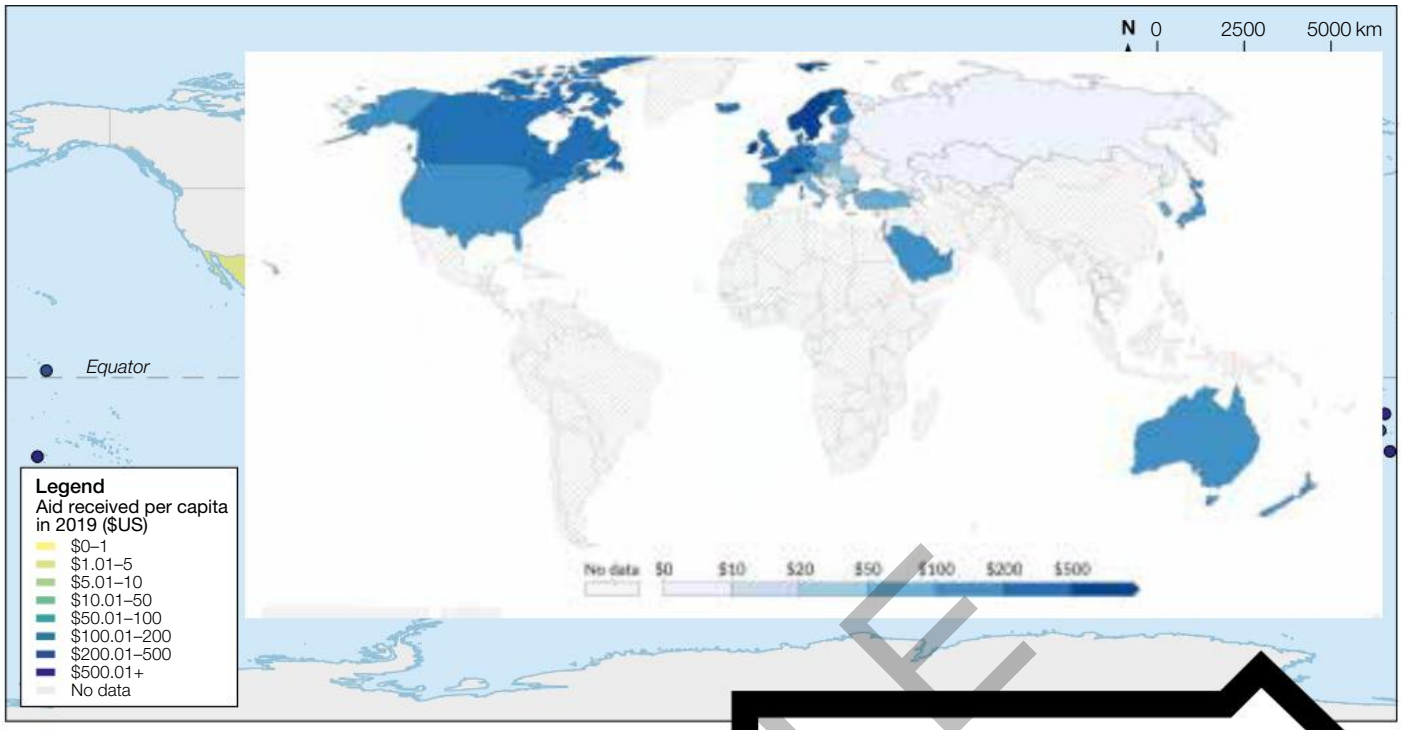
Long-term aid

Humanitarian aid is even more effective when it has long-term goal of promoting self-sufficiency in communities and addressing the factors that cause food insecurity. This can include distributing seeds, tools, technologies and fertilisers to communities to support them in establishing sustainable agricultural activities. It can also include providing training to increase crop yields, educating communities on nutritional needs and hygienic food practices to improve the quality of food and reduce disease.

Through these aid provisions, food supplies are more sustainable over time and it also increases local businesses, provides employment opportunities, improves the local economy and improves social practices to promote the consumption of safe, nutritious food. This can be seen with the example of the CARE international organisation, who have implemented education programs for farmers in Malawi to support them in using minimal tilling practices to reduce soil degradation, and established seed banks for farmers to purchase and trade drought-resistant seed varieties to improve crop diversity and yields in their farms.

Source 2: Internally displaced people with wheat sacks during a food distribution at a camp near Gode, Ethiopia in 2023. The last five rainy seasons since the end of 2020 have failed, triggering the worst drought in four decades in Ethiopia, Somalia and Kenya.

Global humanitarian aid given in 2023 ($US)



Source: Matilda Education Australia

Source 1: The amount of humanitarian aid given by countries in 2023

Humanitarian aid is significant in helping vulnerable groups through food crises. However, overreliance on aid can hinder self-sufficiency and impact local markets. Therefore, humanitarian aid needs to focus on strengthening food practices, improving resilience and promoting sustainability for long-term food security.

Learning ladder 2.11

Perspectives of people and organisations

1. Outline the role of humanitarian aid in times of emergency or crisis.
2. Source 2: How does humanitarian aid contribute to food security for vulnerable individuals and communities in Ethiopia?
3. How did the World Food Programme (WFP) provide aid after Cyclone Idai in 2019?
4. Source 1: Identify the countries likely to contribute to global food aid and explain why.
5. Contrast the perspectives of governments, non-government organisations and vulnerable communities on food aid programs.

Space

1. Source 2: Where is humanitarian aid being provided in Ethiopia, and why is it needed there?
2. Source 1: Explain the spatial distribution of humanitarian aid in 2019. Where is most aid sent, and what patterns do you notice?
3. How does the location of countries providing aid compare to the location of countries receiving aid? What does this tell us about global food security?

HOW TO Space, p. 406

2.12

Case study

How has aid improved food security in Afghanistan?

Tens of millions of Afghans are forced to skip meals or even go days without eating. The food insecurity crisis has been helped with emergency food aid from the World Food Programme.

The World Food Programme in Afghanistan

Afghanistan has experienced decades of political and economic instability, prolonged conflict and increasing environmental challenges, such as drought and land degradation. These worsening factors, alongside new Taliban-imposed restrictions on women working, have impacted employment, poverty and decreased agricultural productivity in the country. As a result, 74 per cent of people experienced malnutrition and nearly 90 per cent of Afghan families were unable to access or afford food in 2022. This has led to more than three times the humanitarian aid needed from international organisations such as the World Food Programme (WFP). The WFP, funded by over 60 governments, has worked in Afghanistan to improve nutritional outcomes and overcome food insecurity.

What do they do?

Emergency food programs

The WFP implements lifesaving food programs, providing millions of people in Afghanistan with emergency food support and nutrition. This requires the WFP to fund, produce, manage and distribute over one million metric tonnes of food in areas across Afghanistan, including remote mountainous regions. They have also implemented annual food voucher programs to help families afford staple food products and created school food programs, providing 708 000 primary students daily snacks each year. When implementing these programs, the WFP use local bakeries, delis, warehouses, retailers and transportation companies to produce and distribute their food. This has put $672 million into local economies and created over 8500 jobs a year.

Education and Training

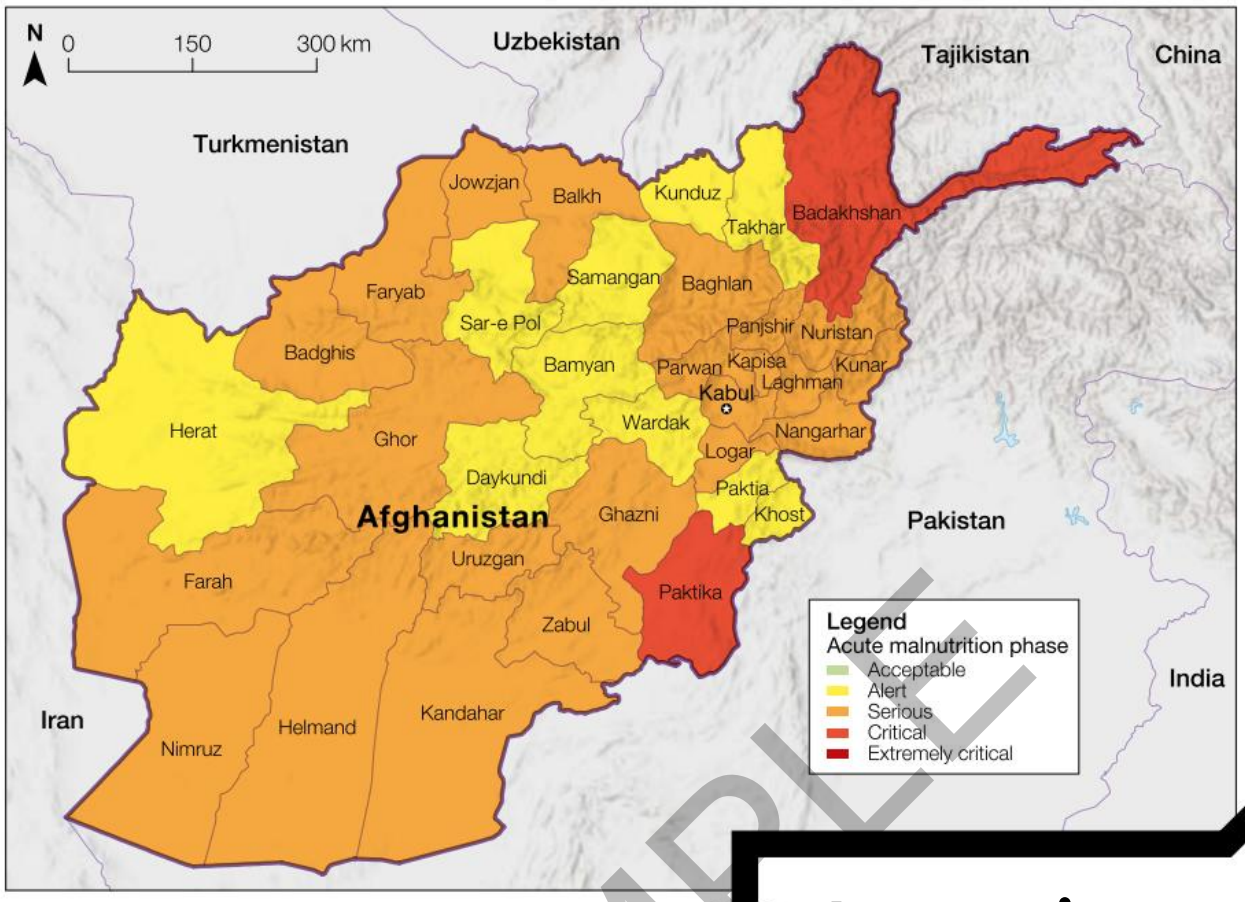
The WFP has also implemented education and training programs across Afghanistan, teaching farmers about sustainable farming practices to improve productivity and providing them with drought tolerant seed species to provide food and an income through the ongoing droughts. This led to over 13 474 farmers receiving increased income and support in 2022.

Is it effective?

Each year the number of people requiring aid in Afghanistan increases by about 30 per cent, requiring more funding from the WFP. Raising these funds has been made more difficult by many countries

Source 1: Afghans in Kabul receive humanitarian aid from the World Food Programme, November 2021

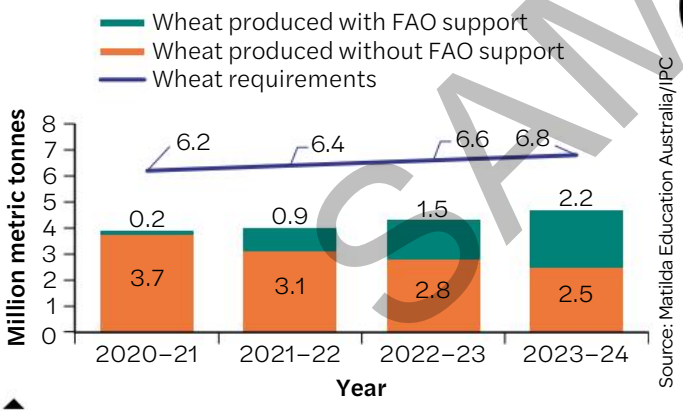
Malnutrition in Afghanistan, 2022



Source 2: A map of malnutrition patterns across Afghanistan in 2022

Source: Matilda Education Australia/IPC

Wheat production in Afghanistan, 2020–24



Source: Matilda Education Australia/IPC

Source 3: A graph displaying the amount of wheat produced in Afghanistan to address food security. The orange indicates wheat that was produced by farmers independently, whereas the green indicates farmers required support from the Food and Agricultural Organisation (FAO). This indicates a growing reliance of farmers on aid programs.

reducing aid in response to the policies of the Taliban administration. This, in addition to challenges such as the remoteness of communities across Afghanistan, increasing droughts and ongoing conflict makes it harder to distribute aid across the country. Irrespective of this, the WFP has helped up to 28 million people in Afghanistan each year, and continues to make substantial progress toward food relief for communities across the country.

Learning ladder 2.12

Processes that transform people, places and environments

1. Outline the primary challenges faced by Afghanistan that have led to high levels of food insecurity.
2. Source 2: Conduct PQE on this map.
3. Explain how WFP emergency food programs have supported communities in Afghanistan.
4. Source 3: Referring to trends on this graph, what are the impacts of food aid in Afghanistan on wheat production?
5. What impact has the WFP's work had on the nutritional outcomes and overall food security of Afghan communities?

Change

1. Source 1: What changes are faced by this family?
2. Explain why Afghanistan's food insecurity is increasing rapidly.
3. How will improving food security provide economic and social benefits?

HOW TO
Change, page 412

How can food aid support First Nations communities?

First Nations Peoples in remote communities suffer a food insecurity rate of 43 per cent, contributing to the higher rates of cardiovascular and chronic disease.

What causes this disproportionate food insecurity?

Many socio-economic factors contribute to the higher rates of food insecurity for First Nations Peoples in Australia. These communities are three times more likely to be unemployed, and as a result are 2.5 times more likely to be in the lower income brackets compared to non-Aboriginal Australians. This results in higher rates of financial stress, making it more challenging to afford nutritious food.

These challenges are made even more difficult for Aboriginal communities in remote areas, where long distances between towns make it difficult for stores to stock high quality fresh fruit and vegetables, with up to 55 per cent of remote communities not accessing fresh food for extended periods of time. Further, the high transportation rates to remote communities and the low competition amongst stores make food prices excessively high. This results in remote stores often relying on frozen and pre-packaged food, such as noodles, which are less nutritious. The combination of higher unemployment and higher food prices mean many remote Aboriginal families are forced to spend a larger percentage of their income on food, increasing food insecurity.

Source 1: Aboriginal community members enjoying fresh fruit and vegetables.

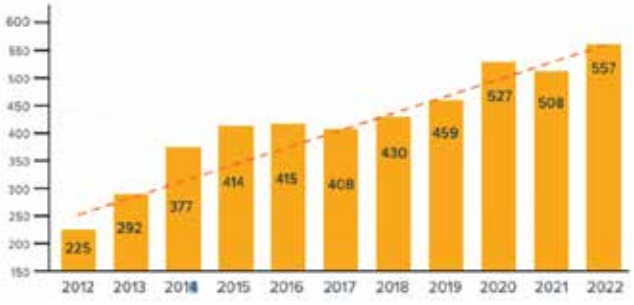
How can aid help food insecurity?

Outback Stores

Outback Stores are a not-for-profit and federally funded grocery store chain. This organisation has established 47 retail stores in remote communities and financially support struggling stores. They establish consistent food supplies and transport networks, enabling them to provide more regular and affordable fresh fruit in stores. This has resulted in 36 per cent more fruit and vegetables being consumed by these remote communities (Source 2).

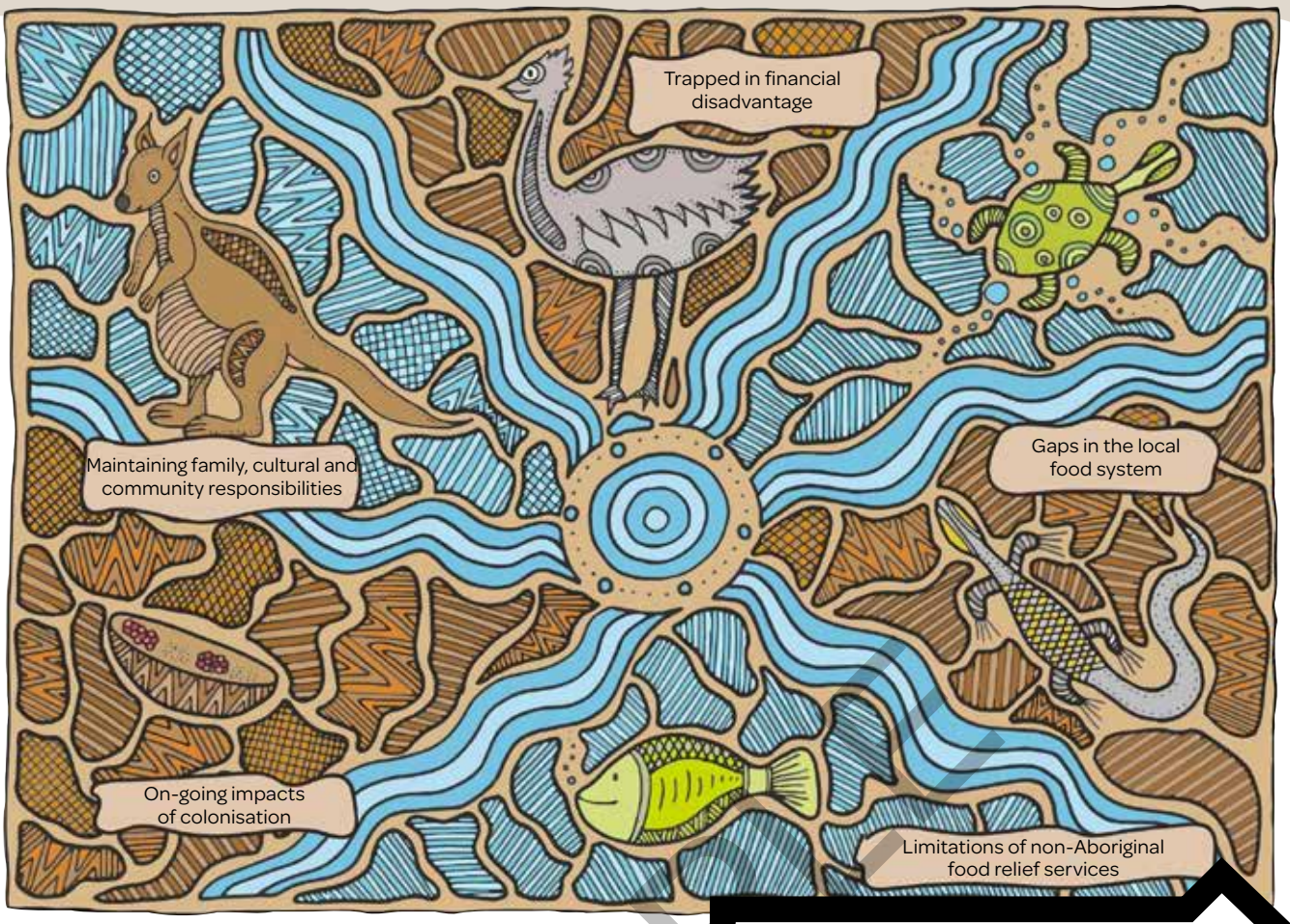
Outback Stores also promote food awareness campaigns to promote healthier eating, contributing to 144 788 less litres of sugary drinks being consumed in these communities. They also reduce the financial pressure in communities by donating any profits to local communities and providing over 313 jobs a year. This has resulted in over $48 million in real wages being provided to these communities since 2006. However, rising costs of food, natural disasters and difficulty finding transport drivers have impacted the effectiveness of food prices in some stores, with some locals arguing prices are still too high with 'baby formula and a single pack of diapers [costing] $50 each'.

Total volume of fruit and vegetables sold in Outback Stores



Source: Matilda Education Australia

▲ **Source 2:** The total volume of fruit and vegetables sold in Outback Stores, a not-for-profit government initiative to improve fresh food access in remote Aboriginal communities.



Source 3: This artwork completed by Gunditjmara artist Shakara Montalto uses an Aboriginal lens to explain the issue of food security for Aboriginal Australians. The browns and orange patterns represent the land, and the strong connection Aboriginal people have to Country (traditional lands), and the blue swirls and circles represent the rivers and water ways that sweep throughout Australia. The artwork depicts bush tucker including the Kangaroo, Emu, Turtle, Goanna and Fish.

Tharawal Aboriginal Corporation

The Tharawal Aboriginal Corporation, located in Airds NSW, run a series of community events aimed at improving food security for local Aboriginal families. One initiative they fund and manage is the 'Good Tucker All Round program', which provides a subsidised fruit and vegetable box to be delivered weekly to disadvantaged Aboriginal families. In addition to this, The Tharawal Aboriginal Corporation has established a Koori community garden for Aboriginal community members to come together and learn how to grow nutritious foods. Fresh vegetables are grown in the garden and used in the Community Kitchen as part of healthy, tasty meals that are made and shared together. The Corporation is funded by the government, who promised an additional $520 000 to them in 2022. This funding is substantial in supporting the corporation in delivering services to local disadvantaged Aboriginal communities. However, the reliance on government funding can impact on the long-term planning and sustainability of these initiatives.

Learning ladder 2.13

Characteristics of places and environments

1. Outline two reasons why Aboriginal communities in remote regions experience increased food insecurity.
2. Describe how the physical environment and location of remote communities contribute to their higher rates of food insecurity.
3. Explain the difference of food insecurity in Australia between First Nations and non-First Nations communities.
3. What are the social and economic benefits to Outback Stores in remote communities?

Environment

1. Source 1: Describe the environment these Aboriginal community members live in.
2. How does the Tharawal Aboriginal Corporation use the local environment to improve food security?
3. Source 2: What environmental and economic challenges make food security difficult in remote Aboriginal communities?

HOW TO
Environment, page 414

How can fair trade help food security?

Fair trade means to create more equitable and ethical trading relationships around the world. The primary focus is to ensure that producers in **low income countries**, such as farmers or artisans, receive fair prices for their products and have better working conditions without being exploited by wealthier countries and companies with high bargaining power.

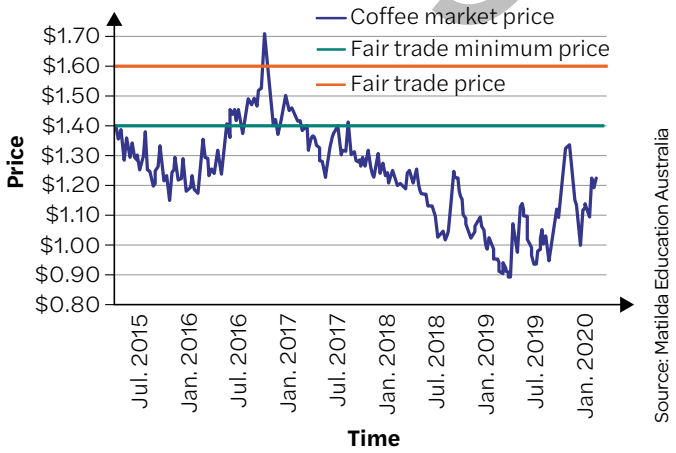
How does fair trade work?

Fair trade organisations like Fairtrade International support farmers and artisans around the world by setting fair market prices for products to protect farmers from price drops in the global market. Fare trade organisations:

- establish a guaranteed minimum price for their farmers, reducing their vulnerability
- work with cooperatives to ensure profits are split fairly amongst farmers
- set ethical labour standards and minimum wages
- promote sustainable practices.

Products sold through these organisations are labelled as 'fair trade'. Manufacturers who buy these products pay an additional premium that is given to the producers and invested back into their communities. This label then helps customers know that they are purchasing sustainable and ethical products.

Coffee fair trade pricing, 2015–20 $US



Source 1: A graph demonstrating the importance of fair trade minimum prices (FTMP) for fair trade coffee between 2016 and 2020. FTMP are the lowest figures paid to fair trade farmers. This ensures vulnerable farmers are protected against market price drops, as shown with the value of coffee in this time being well below the minimum price paid to coffee farmers.

Source 2: Fair trade banana farmer in the Dominican Republic, the leading producer of organic bananas worldwide. Around 70 per cent of Dominican bananas are certified Fairtrade. The Dominican Republic has a significant number of small producers. The industry's workforce is mainly composed of migrant workers from neighbouring Haiti. Many men from Haiti migrate to work in the Dominican Republic without family and send remittances back home to support their families.

Why do we need it?

Without fair trade, small scale producers in low income countries can be exploited. This was the case with cocoa farmers in West African countries such as Ghana and Côte d'Ivoire in the past. Large chocolate companies were paying low prices for their cocoa. This resulted in low wages, encouraged the use of child labour to meet demands and resulted in environmental degradation and poor working conditions. With the implementation of fair trade, cocoa farmers are now receiving approximately 85 per cent more income today, and the premium paid for their fair trade cocoa beans has been used to fund schools, infrastructure and sustainable farming technologies in many West African communities.

How does it help food security?

Fair trade is crucial for global food security. Fair trade ensures farmers and artisans receive fair prices for their products, which promotes improved wages and working conditions, provides stability for farmers and allows them to have more money to invest in sustainable practices to improve their agricultural productivity. This is further improved by the education, training and support provided by fair trade organisations. Farmers are also able to access information on ways to diversify their crops and overcome ecological challenges such as drought and floods. This not only improves the social, economic and environmental wellbeing of low income communities, but it improves the amount of food available for communities and their capacity to afford it. This is fundamental in overcoming global food insecurity.

Learning ladder 2.14

Sustainable management strategies

1. Describe the primary goal of fair trade.
2. Explain how fair trade protects farmers.
3. Explain why fair trade is necessary for small-scale producers in low-income countries.
4. Assess the impact of fair trade on cocoa farmers in West African countries.
5. Source 2: Evaluate the role of fair trade in addressing food security in both the Dominican Republic and Haiti.

Sustainability

1. Outline one way fair trade is sustainable.
2. Source 1: Describe how fair trade minimum prices protect farmers and improve food security.
3. Explain how fair trade promotes sustainable practices.
4. Why is this person prepared to pay a premium price for fair trade certified coffee when he could source cheaper options?

HOW TO Sustainability, page 418

What forms of traditional agriculture are still used today?

Traditional agriculture involves small-scale farming, where farmers use manual labour and simple tools to carry out tasks. Indigenous peoples around the world have used sustainable traditional forms of agriculture over thousands of years.

Traditional agriculture in Australia

First Nations communities have developed and implemented farming practices over thousands of years. These practices reflect a deep understanding of the land and local ecosystems and prioritise sustainability and **stewardship**. This is because Aboriginal Peoples saw their role as caretakers of the land, who aimed to preserve the health of **Country**. Their farming practices hold immense cultural significance and have been embedded and passed down through generations in cultural rituals, ceremonies and stories. Today farmers and land management industries are recognising the importance and effectiveness of using the long history of traditional knowledge and farming practices to develop more sustainable agricultural approaches.

Traditional agriculture strategies

Traditional agricultural practices have promoted biodiversity. Detailed seasonal calendars and a knowledge of the environmental conditions required to grow different native seeds have meant that Aboriginal Peoples can more effectively plan the ideal location to plant and harvest native crops. Communities historically would also save and exchange seeds, to promote a diversity of crops across seasons and locations.

These communities would also use their knowledge to assess the soil, moisture levels and distribution of species in an environment before implementing 'firestick farming' – setting 'cool' fires to reduce the dry vegetation that contributed to extreme fires. Firestick farming also promoted the growth of some vegetation and grasses, fertilised soils and prevented some perennial species from smothering other staple foods, such as murnong. This shaped the land by increasing the diversity of native grasses and plants across grasslands and this would produce new food for animals. Firestick farming is now widely recognised and used today as a sustainable land management technique, with over 80 cultural burns in savannas across northern Australia each year.

Traditional aquaculture: eel farming

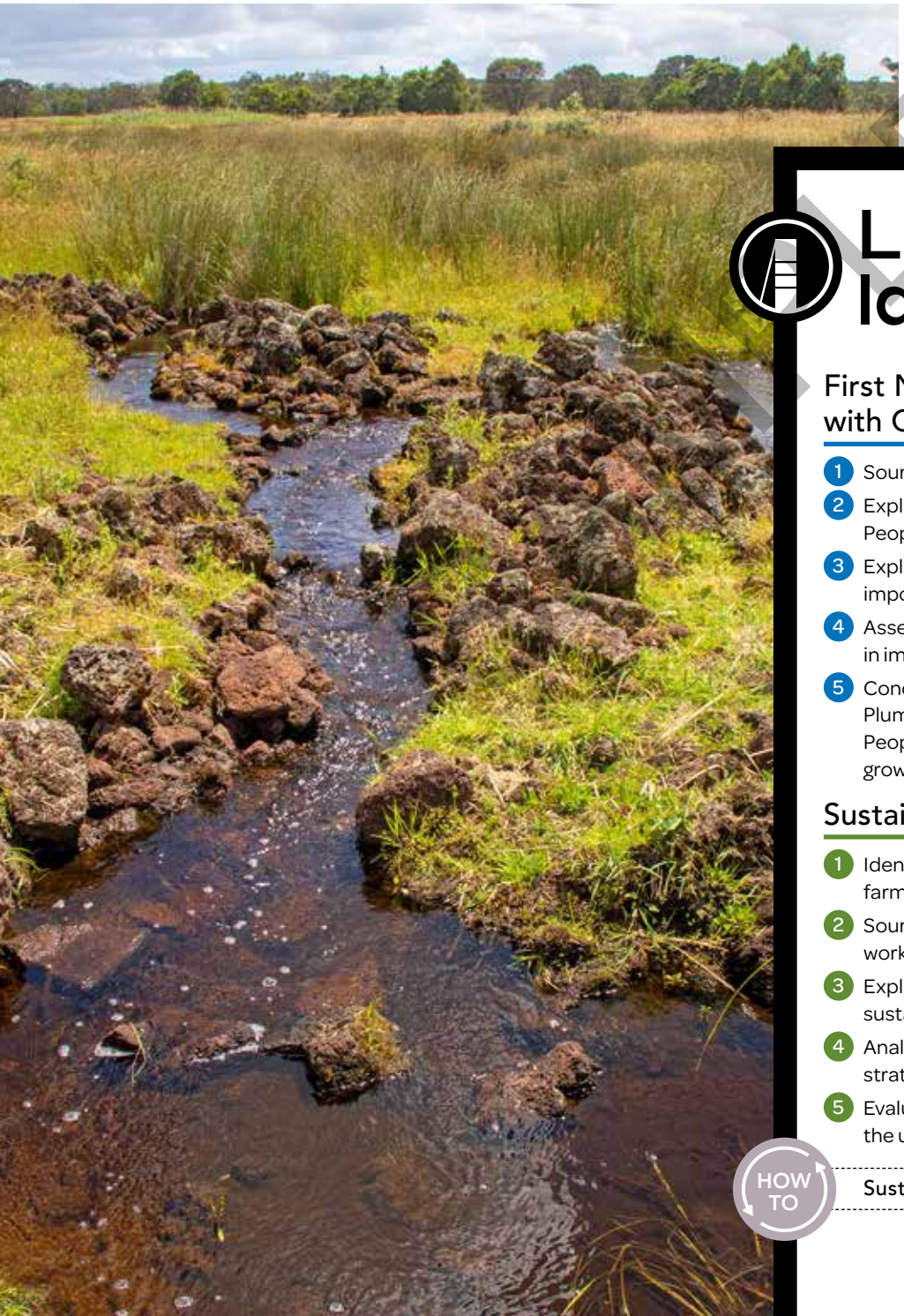
Aboriginal Peoples built some of the world's oldest traditional **aquaculture** systems. Aquaculture is farming and breeding of water species, such as fish, eels and shellfish. Over the last 6000 years, the Gunditjmara people in south-western Victoria built over 75 square kilometres of weirs and dams around the lakes to create ponds, channels, stone-walled traps and woven baskets that could be used to breed and trap short-finned eels to eat and trade.

These highly complex systems promote sustainability, as many of the baskets used to catch eels have small pockets for young eels to swim through, ensuring they are not fished until they are an edible size. In the areas there are also traditional smoking trees, which were used to preserve the eels for trade. These aquaculture systems are estimated to have been so efficient that they were feeding up to 10 000 people.

The Budj Bim Cultural Landscape is a World Heritage Site due to its historical and cultural significance to the Gunditjmara people. A restoration project has led to the eel traps being reused productively today.

Source 1: The tubers of the murnong are an Australian bush food.

Source 2: Eel channels built by the Gunditjmara people in the Budj Bim Cultural Landscape. These eel channels were part of a complex aquaculture system used by First Nations Peoples to feed over 10 000 people and trade with other First Nations groups.



▲ **Source 3:** An Aboriginal craftswoman in Arnhem Land splitting pandanus for weaving. This is one way First Nations Peoples have used to harvest native vegetation for use in culture and traditions.

Learning ladder 2.15

First Nations Peoples' interaction with Country

1. Source 3: Describe why pandanus was harvested.
2. Explain one farming strategy used by First Nations Peoples.
3. Explain how the use of traditional farming is important to First Nations Peoples.
4. Assess the importance of First Nations knowledge in improving food production in Australia.
5. Conduct research into the farming of native Kakadu Plums. Use your research to justify why First Nations Peoples should lead the development of this growing industry.

Sustainability

1. Identify one example of a sustainable First Nations farming strategy.
2. Source 2: Describe how the eel channels and nets worked.
3. Explain how First Nations knowledge can increase sustainability of modern farming.
4. Analyse the sustainability of First Nations farming strategies.
5. Evaluate the impact of different worldviews on the use of Aboriginal farming methods in the future.

HOW TO Sustainability, page 418

What sustainable food practices are used by First Nations Peoples?

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 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, mined, or have resources taken 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**.

Source 1: These River Red Gums growing along the river help keep the soil in place and prevent erosion of the riverbank.

Caring for Country

Given that Country has not been considered a commodity by First Nations people, the way that Country is considered and experienced is different compared to non-Indigenous contexts. For many First Nations people, caring for Country is central to health and wellbeing, and supports the same cultural continuity that has ensured that people have thrived across the continent and adjacent islands for tens of thousands of years.

Caring for Country means recognising that humans are a part of our ecology and closely connected to the health and maintenance of the local and regional biomes.

It is also recognising that our capacity to thrive is closely linked to how well we are able to care for Country, which in turn cares for us by providing everything we require to live well. This focus on our relationship with Country answers the question of *why* Country should be cared for, and the application of complex science answers the question of *how* Country should be cared for.

Managing water in the landscape

Part of caring for Country is to ensure that all the flora and fauna have enough water. In New South Wales, the extensive riverine systems have supported the arid and semi-arid biomes west of the Great Dividing Range where annual rainfall is significantly low.

One of the ways that the First Nations people managed water in the landscape was to build earthen weirs through vast lengths of the rivers. These weirs would be built out from the riverbanks. They would be secured by promoting the growth of river gums (*Eucalyptus camaldulensis*) to hold the soil in place as well as attract birds and marsupials, which were important food sources. The water flow would be forced into a pronounced zigzag pattern and would be slowed. Slower moving water would have more time to infiltrate the riverbank soil, ensuring that more water stayed in the system instead of flowing away. This would allow more of the surrounding environment to be sustained, especially during the hot summer period when rain was infrequent. Most of these weirs were destroyed to make way for the river trading ships in the colonial period.

Sustainable harvesting

In contemporary agriculture, the plants grown are often destroyed as part of the harvesting process, especially grains, sugar and root vegetables. This requires farmers to preserve seed for the following year's crop and increases risks associated with rainfall and soil degradation when the plants are growing as seedlings. The result is that crops can fail due to poor rainfall, and the soil requires a large amount of fertiliser to replenish the nutrients.

One way that First Nations people reduced these risks was the way that the Murnong (*Microseris ianceolata*) was harvested. The plant would usually form with multiple tubers under the ground, and during harvesting the plant would be gently lifted from the earth and only one tuber would be removed. The plant would then be replanted to continue to grow. This would ensure that the plant and soil health would be maintained and the cycle would be able to continue with greatly reduced risk for the next harvesting season.

Source 2: Only one tuber would be removed at a time during harvesting, so the plant would not be destroyed. First Nations Peoples have used these kinds of sustainable harvesting techniques for tens of thousands of years.

Learning ladder 2.16

First Nations Peoples' interactions with Country

1. Why would only taking one Murnong tuber support food security?
2. How did the planting of River Gums support food production?
3. How does being connected to Country support sustainable outcomes?
4. How were the rivers adapted to respond to seasonal changes in the weather?
5. What are some of the ways that caring for Country could enhance contemporary agricultural processes?

Sustainability

1. What was one way that water was kept for longer in the river systems?
2. How is the Murnong harvested sustainably?
3. What are some of the negative effects on the soil when crops are destroyed during harvesting?
4. What are some of the advantages for ensuring that water remains in the environment for longer?
5. What knowledge do First Nations people require to know how to care for Country?

HOW TO Sustainability, page 418

Thinking geographically

Biomes and sustainable agriculture

Learning ladder: page 64

Geographical concepts, inquiry and tools

Place, change, environment, sustainability, tools, inquiry

Key inquiry question

How is climate change impacting food production in Argentina?

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 Argentina
- the spatial patterns of biomes and food production in Argentina
- the environmental impacts of food production in Argentina
- the environmental, social and economic factors influencing the future supply of food in Argentina
- one sketch map or simple diagram.

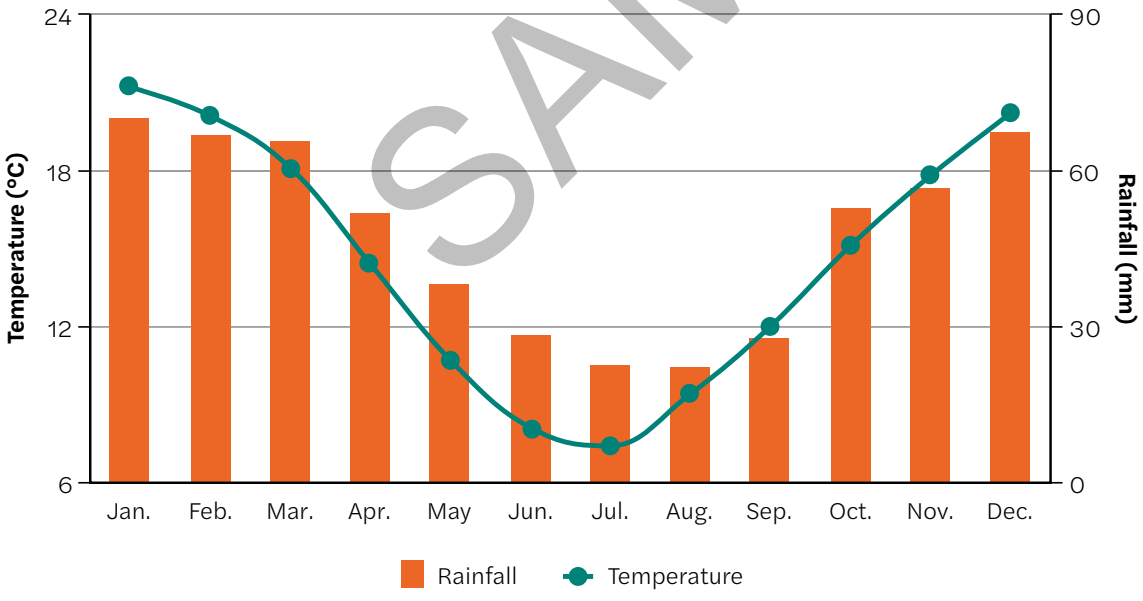
Where possible, refer to the sources in this spread to support your judgments.

Rainfall in Argentina

HOW TO

See **Geo How-To** for climate graph, page 439

Climate graph of Argentina, 1991–2019



Source 1: Climate graph of Argentina

Source: Matilda Education Australia

Source 1 activities

1 What is the average temperature and precipitation in the following months for Argentina?
   - **a** February
   - **b** May
   - **c** July
   - **d** October

2 How much total rainfall does Argentina experience in December, January and February?

3 In which months does Argentina experience winter?

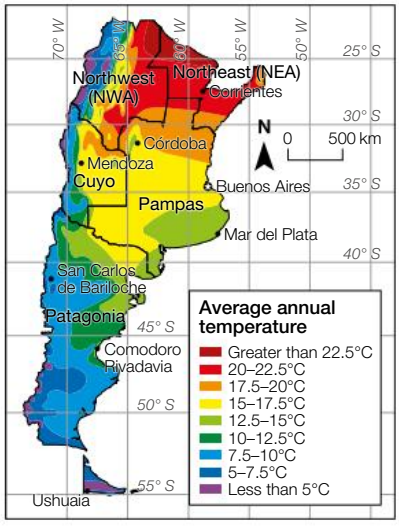
4 What is the temperature range experienced in Argentina across the year?

5 What is the average annual rainfall experienced by Argentina?

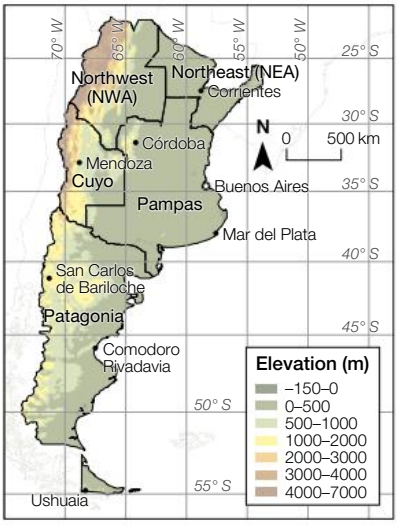
The geographical features of Argentina

Title xxx xxxxxxx xxxx xxx xxxxxxx xxxx xxx xxx

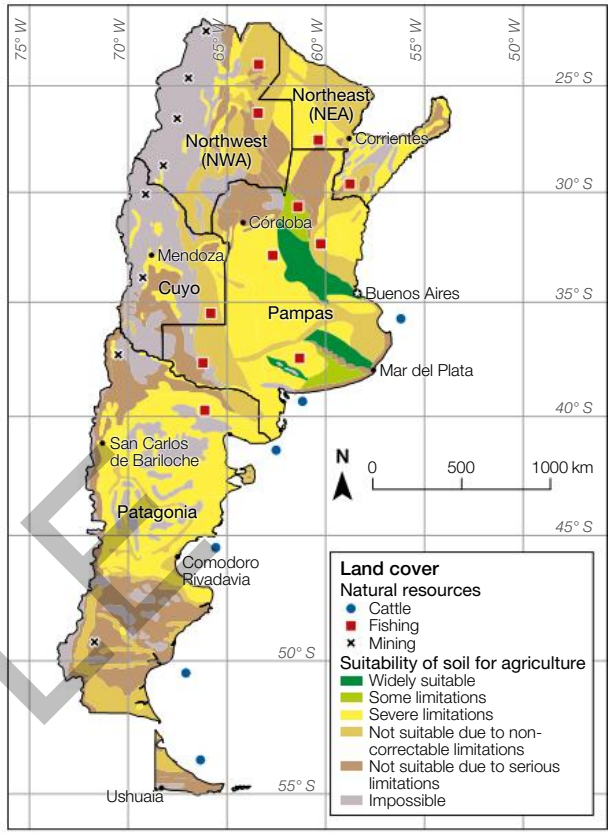
Source: Matilda Education Australia



▲ **Source 2:** Argentina climate zones



▲ **Source 3:** Argentina relief



▲ **Source 4:** Argentina land cover

Sources 2–4 activities

1 Source 2: What is the distance of Argentina along the 50°S latitude?

2 Source 3: Which area of Argentina has the highest elevation: Cuyo, Patagonia or Pampas?

3 Sources 2 and 3: How does elevation influence climate in Argentina?

4 Source 4: What is the main land cover at the following locations?
- **a** 35°S, 60°W
- **b** 25°S, 60°W
- **c** 45°S, 70°W

5 Source 3: What is the relief experienced in Argentina along the 30°S latitude?

HOW TO See **Geo How-To** for map scales, page 423, and latitude and longitude, page 422

Planting and harvesting crops in Argentina

Source 5 activities

1 In which two months is barley planted?

2 How many months does harvesting occur for rapeseed?

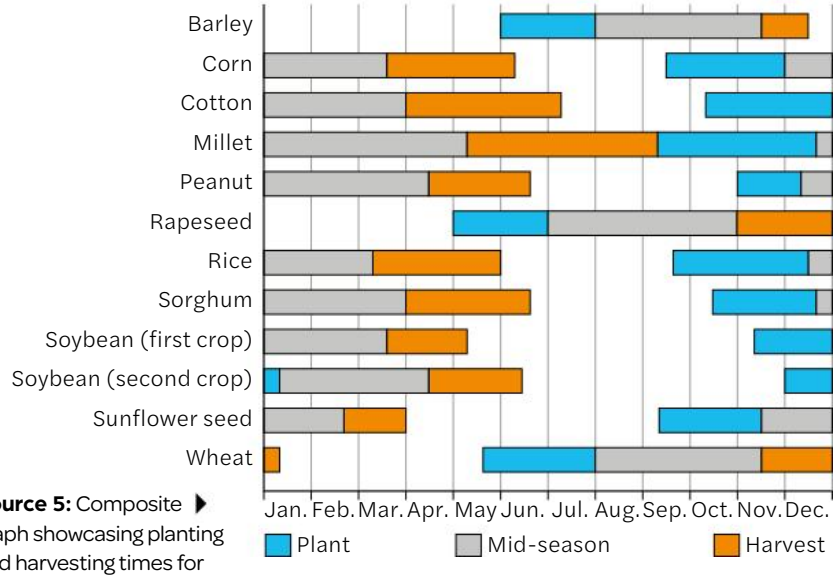
3 How many months are between planting and harvesting for the following crops?
- **a** cotton
- **b** millet
- **c** rice
- **d** wheat

4 Which of these crops requires the least amount of time for planting and harvesting labour?

5 What season does planting tend to start for crops in Argentina?

6 What are the advantages and disadvantages for a farmer planting and harvesting the following crops?
- **a** barley
- **b** millet
- **c** wheat

Planting and harvesting times for crops in Argentina



Source 5: Composite graph showcasing planting and harvesting times for crops in Argentina

Source: USDA

Resource distribution across Argentina

Source 6 activities

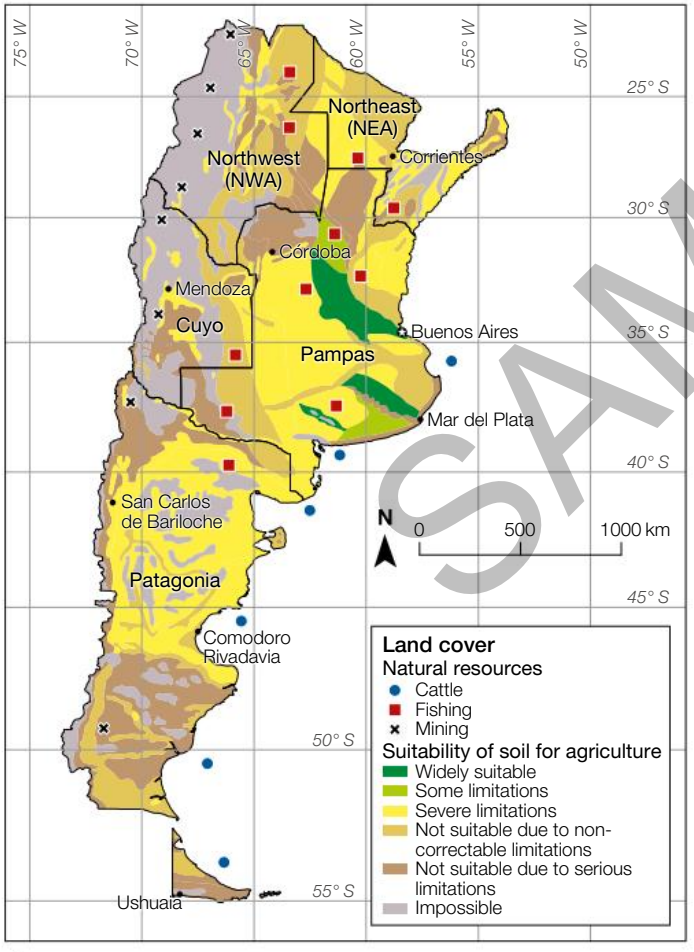
1 In which area reference is the most southern part of Argentina found?

2 Which area reference has the highest number of agricultural activities?

3 Find one grid reference for each of the following agricultural activities:
   a fishing
   b cattle
   c mining

4 Sources 2, 3 and 6: Explain how climate and elevation have influenced the location of agricultural activities in Argentina.

Agricultural and natural resource distribution across Argentina



Source 6: Map of agricultural and natural resource distribution across Argentina

Matilda Education Australia

Human alterations to maximise food production / environmental impacts of food production

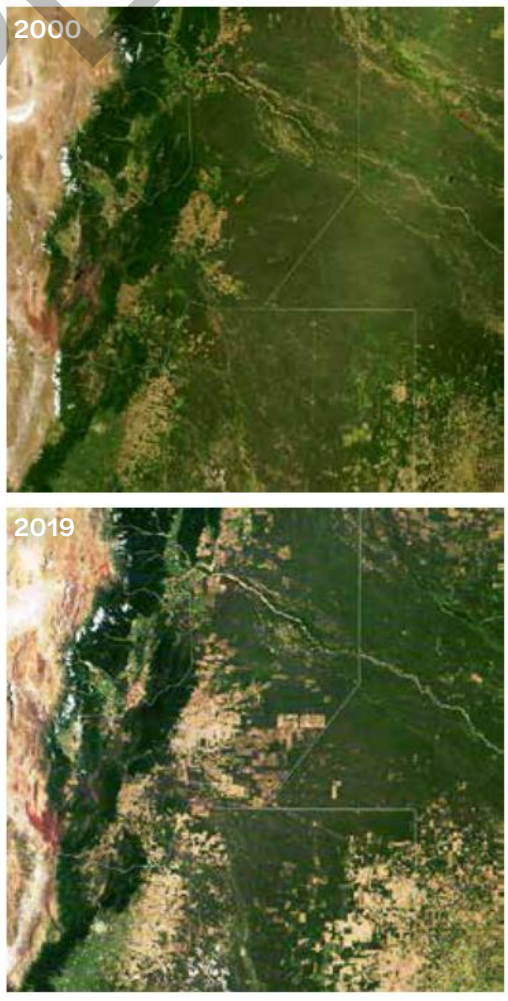
Source 7 activities

1 Sources 2, 3 and 7: Gran Chaco is in the central northern part of Argentina. Explain how elevation and climate influence this forest.

2 Describe the change in the environment of Gran Chaco between 2000 and 2019.

3 Calculate the approximate percentage of deforestation at this location between 2000 and 2019.

4 The Gran Chaco is approximately 650 000 square kilometres. Calculate the percentage of the forest that was cleared in the following time periods:
   a 142 000 square kilometres were cleared between 1985 and 2013: _____ %
   b 29 000 square kilometres were cleared between 2010 and 2018: _____ %



Source 7: Satellite images of Gran Chaco forest in 2000 (top) and 2019 (bottom), highlighting deforestation to develop soybean fields and pastures for grazing livestock

Risk of increasing temperatures

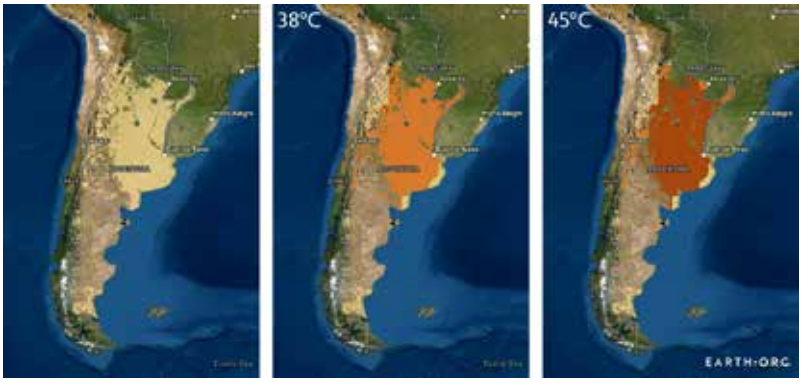
Source 8 activities

1 Explain the areas of Argentina most vulnerable to changes in temperature.

2 Explain the areas of Argentina most vulnerable to changes in precipitation.

3 Sources 6 and 8: Explain which agricultural activities are most likely to be impacted by climate change in the future. What are the implications of this?

4 Explain why the most cropland is found where it is in Argentina, using geographical terms and referencing all three maps.



Source: Earth.org

▲ **Source 8:** A map highlighting the areas of Argentina most at risk to increasing temperatures

Yellow areas show where crops of any type are grown. With a 4°C rise, orange areas show cropland that could experience heat spikes over 38°C, which is 85.6 per cent of total cropland. Brown areas show cropland exposed to peak temperatures greater than 45°C, which is 76.5 per cent of total cropland.

Food insecurity in Argentina

	Moderate food insecurity (% of population)			Severe food insecurity (% of population)		
	2014–16	2017–19	2019–21	2014–16	2017–19	2019–21
World	21.8	24.8	28.1	7.7	8.9	10.7
Latin America and Caribbean	27.6	32.0	37.3	7.9	9.7	12.3
Mesoamerica	29.3	27.8	32.1	6.4	6.8	7.5
South America	23.4	30.6	36.6	6.0	8.4	12.1
Argentina	19.2	35.8	37.0	5.8	12.9	13.0

Source: Data adapted from World Bank Data

▲ **Source 9:** Percentage of global populations with moderate or severe food insecurity 2014–21

Sources 9–10 activities

1 What percentage of people experienced severe food insecurity in Argentina in 2019–21?

2 Calculate the percentage increase of people experiencing moderate food insecurity in Argentina between 2014 and 2021.

3 Between which years did the rate of moderate food insecurity increase the most in Argentina?

4 The population in Argentina between 2019 and 2021 was approximately 42 500 000. Calculate how many people experienced:
   a moderate food insecurity
   b severe food insecurity.

5 Compare the changes in food insecurity in Argentina with the rest of South America.

6 Describe the factors contributing to food insecurity in Argentina.

7 Explain the relationship between food insecurity and increases in obesity and overweight people in Argentina.

8 Analyse how climate change will impact food security in Argentina in the future.

Food insecurity is increasing rapidly in Argentina. In 2021, one in three people reduced the quantity and quality of the food they ate or skipped a meal, while one in eight were unable to eat on one or more days. There are many reasons for this, including nearly 43% of the 46 million people living below the poverty line and the increasing cost of healthy foods. The industrialisation of agriculture has meant farmers prioritise exporting crops to increase their incomes, resulting in 66% of agriculture products being exported each year. This, alongside increasing inflation, the deterioration of agricultural ecosystems and Argentina's high vulnerability to climate change is increasing the challenge of food security. Many families cannot afford to eat healthy foods, resulting in some of the highest levels of overweight and obesity in South America. Nearly 13% of children under five are overweight and more than one in four adults (28.3%) are obese, compared to the regional average of 8.2% and 23% respectively. The growing costs of healthy foods will continue to exacerbate this issue.

www.thenewhumanitarian.org/analysis/2023/02/09/Argentina-food-hunger-poverty-hyperinflation

▲ **Source 10:** Text describing the increased food security issue in Argentina

Changing settlement patterns

3

WHY ARE PEOPLE PULLED TO CITIES? 124

WHAT IS IT LIKE LIVING IN REMOTE PLACES? 142

HOW IS MIGRATION CHANGING AUSTRALIA? 112

WHY DO URBAN SLUMS DEVELOP? 140

How can I understand changing settlements?

More than half the world's population now lives in urban areas, as large numbers of people move from rural areas to cities seeking job opportunities, higher pay, and better access to health care and education. Urbanisation leads to the growth of megacities, or to many cities spreading into one to form a conurbation.

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 toward 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 evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.

Source 1: In the nineteenth century, London became the world's largest city, as people poured into the city for work in the new factories as part of the Industrial Revolution. Today, the largest and fastest growing cities are in the world's less economically developed countries (LEDCs), particularly in Asia.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

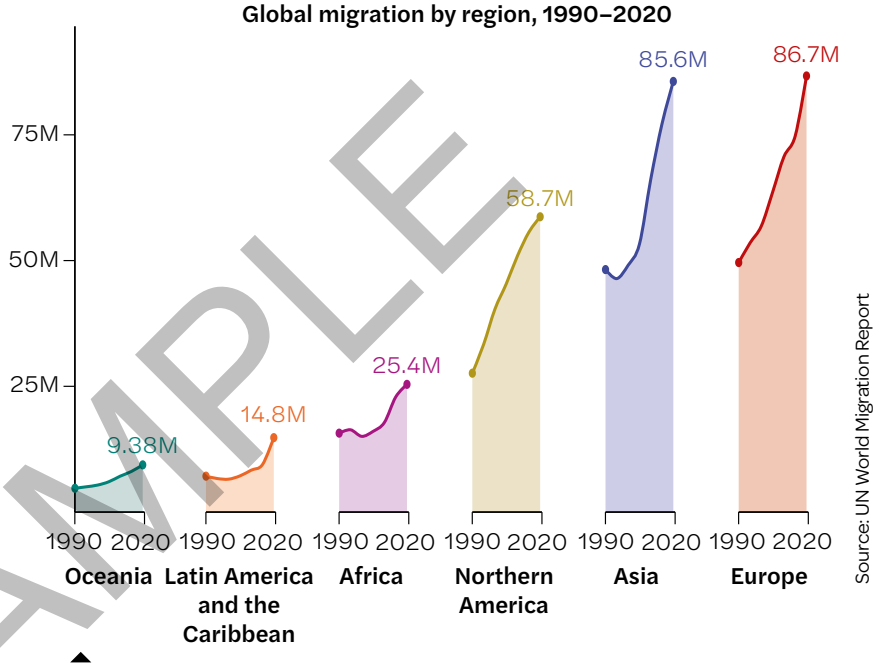
What factors influence migration at a global scale?

Migration is the movement of people from one location to another. It is estimated that in 2020 there were 281 million people living in a country where they were not born – about 3.6 per cent of global population.

Patterns and trends

The number of migrants as a proportion of the global population has increased along with the total number from in all regions of the world. In 2020, more than 40 per cent of international migrants were born in six countries: India, China, Bangladesh, Pakistan, the Philippines and Afghanistan. The second largest source of migrants was Mexico, followed by Russia. Rates of migration have increased over the past 50 years, especially between countries and within specific regions, such as Asia, and for the purpose of work. Migrant workers, also known as economic migrants, are the largest proportion of international migrants at 169 million, with internally displaced persons (71.2 million) and refugees and asylum seekers (40.7 million) the second and third largest groups.

Global migration by region, 1990–2020



Source 1: Increasing numbers of migrants globally by region

International migration, 1970–2020

Year	Number of international migrants	Migrants as percentage of global population
1970	84 460 125	2.3
1975	90 368 010	2.2
1980	101 983 149	2.3
1985	113 206 691	2.3
1990	152 986 157	2.9
1995	161 289 976	2.8
2000	173 230 585	2.8
2005	191 446 828	2.9
2010	220 983 187	3.2
2015	247 858 644	3.4
2020	280 598 105	3.6

Factors influencing migration

Migrants fall into several categories:

- permanent or temporary
- international (between countries) or internal (between states, regions, rural and urban places)
- voluntary or forced.

Within each category, people move because of economic, social, environmental and political factors that 'push' people away from their homes or 'pull' them to other locations. Safety, financial security, family, government policy or political conflict, and natural hazards are the biggest influences on international migration.

Source 2: The changing state of international migration, 1970–2020

Voluntary migration

People choose to relocate for work, family reunion or study purposes. This is generally a safe, legal and orderly process and is consistent between countries at a global scale. Many people who move for work are temporary migrants, issued special visas to work in targeted industries in selected places. For example, the populations of the UAE and Singapore comprise large numbers of temporary foreign workers needed in construction and maritime industries or in domestic services. Australia brings workers from Pacific island nations to work in the agricultural sector, especially at harvest time. In these examples, jobs are unable to be filled by residents of host nations because of their high proportion of skilled workers. Other temporary immigrants are high-paid workers for large organisations contracted to work from international destinations.

Most migrant workers are from poorer Asian and African countries who work abroad to send money home to their families. Other people choose to migrate permanently with the intention of becoming citizens of their destination country. The intention of temporary migrants is to return to their home country, whereas the intention of permanent migrants is not to return home, except perhaps as a visitor.

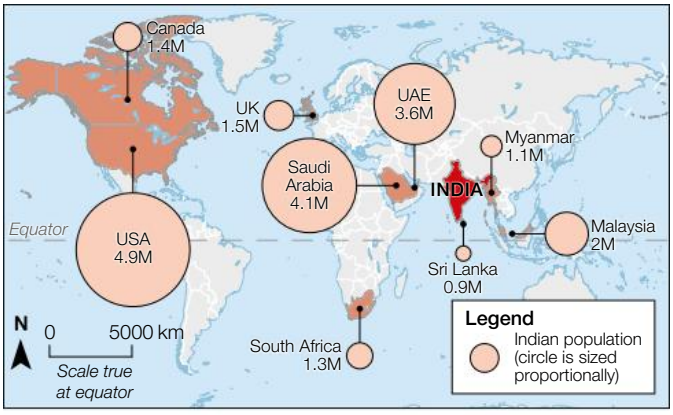
Forced migration

Where conflict, persecution and natural disasters force people to leave the safety of their homes the process is irregular and often very dangerous. This forced migration includes asylum seekers (awaiting refugee status), people determined by the UN to be genuine refugees and internally displaced people (IDP). It also includes people returned home involuntarily because they arrived illegally in a place. Refugees who do not want to return to their home country for fear of persecution seek a new life as permanent residents in another nation. However, those refugees and internally displaced persons who move because of conflict and disasters often return to their homes when it is safe to do so. Countries and places where conflict has driven forced migration include Afghanistan, Ethiopia, the Sudan, the Syrian Arab Republic, Yemen and Gaza. Many of the migrants from these areas of conflicts are living in cities or refugee camps in neighbouring nations.

Global diaspora

Diaspora is the collective name for people living outside of their country or origin. Indians make up the world's largest diaspora, a statistic that continues to grow rapidly and outpace other migrant sources.

Indian diaspora, 2022



Source: UN DESA 2021

▲ **Source 3:** Indian diaspora, 2022

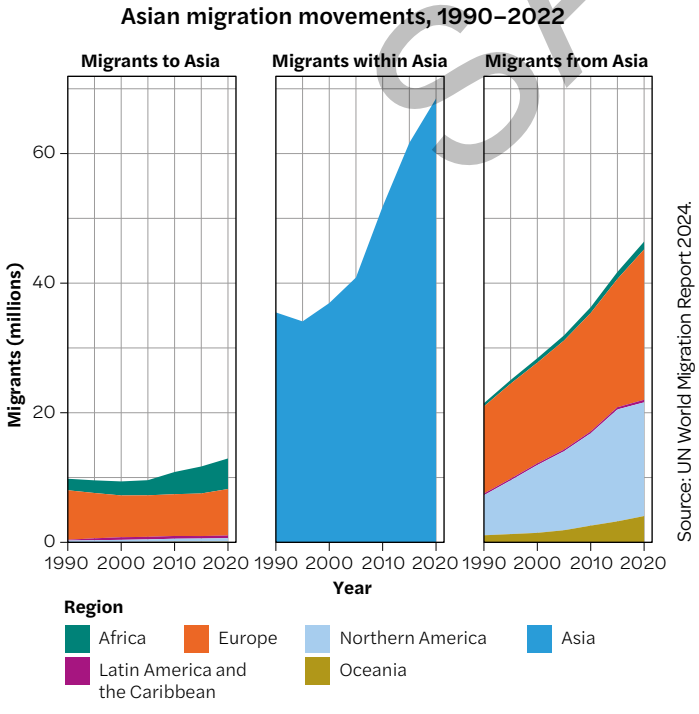
The main pull factors for Indian migrants are economic opportunities, education and historical/family ties. The United States is the largest country of destination globally with over 50 million permanent or temporary resident migrants. Germany is the second top destination with over 9 million migrants.

Focus on Asia

Asia was the origin of over 40 per cent of the world's international migrants (around 115 million) in 2020. Of these, over 50 per cent (69 million) were residing in other Asian countries, although numbers migrating to northern America and Europe are increasing. Migration can be attributed to many influences:

- **Environmental migration** is caused by natural disasters including typhoons, floods and storms, tsunamis and earthquakes. These impact millions of people each year, particularly in South-East Asia, and were the source of 31 per cent of disaster displacements in the entire Asia-Pacific region in 2020 and 2021. In southern and mainland Asia, heatwaves, floods and droughts have become more common. In 2022 floods in Pakistan displaced over eight million people. Climate change is expected to increase environmental migration in flood-prone countries as sea levels rise and hazards increase in number and intensity.
- **Economic migration** is caused by workers attracted to countries where incomes and job vacancies are higher than at home. Thailand, Malaysia and Singapore, and gulf states such as the United Arab Emirates and Saudi Arabia are major destinations for Asian workers. India, the Philippines and Vietnam have large emigrant worker populations and are among the highest recipients of international remittances (money sent home from workers abroad). In 2022 remittances to the Philippines represented 9.4 per cent of the country's GDP.

- **Political instability** and conflict result in internally displaced and refugee populations. The most significant in Asia is Afghanistan with most of its refugees hosted in neighbouring countries, particularly Pakistan, the Islamic Republic of Iran and Bangladesh. Pakistan hosted 1.7 million, mostly Afghan, refugees in 2022.
- **Political persecution, violence and discrimination** forces migration. The most well known of these are the Rohingya people from Myanmar. Bangladesh hosts the largest population of displaced Rohingya and also the largest refugee camp.
- **Demographic change**, such as rapid population growth that makes economic progress difficult in poorer nations, or declining population caused by fewer births and ageing populations in wealthier countries, leads to labour shortages. Japan and South Korea are now looking to migration to fill the demand left by declining populations.
- **Education** influences a large proportion of young temporary migrants from Asia, particularly China and India. China is also a destination for international students from other Asian nations including the Republic of Korea, Thailand, Pakistan and India, and other countries are increasingly targeting international students. Japan set a goal to attract 400 000 foreign students by 2033 and sending 500 000 Japanese students to study abroad.



Source 4: Migration movements to, within and from Asia

Migration corridors

Migration corridors occur where there are regular and large movements of people between two countries. The largest corridors are from developing countries to larger and wealthier economies, and the migrants moving along these corridors are a mix of voluntary, forced, permanent and temporary. The Mexico–USA border is the largest migration corridor in the world. Other significant corridors are a result of conflict and include refugees fleeing from Syria to Turkey; people returning to their homelands or families in the Russian Federation from Ukraine, or in the reverse direction; and Ukrainians fleeing to safety in Poland. Migration corridors result in extremely large populations of migrants in destination countries or awaiting processing in refugee camps. For many, the routes involve treacherous journeys such as across the Mediterranean Sea from Syria to Turkey, or through the desert and across rivers from South America into Mexico then to the United States, resulting in large losses of life.

The Mexico–USA border

In 2023, the number of migrants crossing into the United States from Mexico hit a record high. For many decades the United States has been the destination for economic migrants from Mexico with tens of thousands illegally crossing the 1950-kilometre-long border each year. Although the border is patrolled and monitored by the US Border Control team as well as Mexican authorities and there are dedicated customs entry points into the United States for legal movements, it is estimated that up to 10 000 people a week risk their lives to cross the border to the southern states of California, Texas, New Mexico and Arizona. Incomes in the United States are significantly higher than in Mexico, particularly in agricultural areas that suffer the greatest poverty. Other push factors include poor medical facilities, low education rates and literacy rates, low life expectancy, and high rates of unemployment. Most Mexicans believe they will earn more money, have better access to health and education, and a better quality of life by moving to the United States.

Mexico accounted for 37 per cent of the total migration via the Mexico–USA migration corridor in 2021, with the remaining 63 per cent coming from the Northern Triangle countries of Central America comprising Honduras, Guatemala and El Salvador. Many South American migrants are genuine asylum seekers who will travel over 2400 kilometres through Mexico to get to the border or spend months in Mexico awaiting appointments seeking asylum into the United States.

Source 6: A US Border Patrol boat picks up families, as other migrants wait for an opening in the razor wire barrier to cross into the United States

People smugglers often take advantage of desperate migrants, charging tens of thousands of dollars to get into the United States illegally. Mexico is also a route into the United States for Asian and African migrants; however, a 2025 crackdown by the US government is targeting all arrivals through Mexico.

Migration routes from Mexico into the United States

Source: Matilda Eduction Australia and Pew Research Center

▲ **Source 5:** Migration routes through Mexico to the United States and changing origins of migrants

Learning ladder 3.1

Processes that transform people, places and environments

1. Define permanent, temporary, forced and voluntary migration.
2. Source 3: Use the PQE method to describe the spatial patterns of the Indian diaspora.
3. Source 6: Analyse what is happening in this scene. Refer to type of migration and influences on the movement of people shown in the photograph.
4. Create a table with four columns, one each for economic, social, environmental and political factors that influence international migration. Complete the table with information and examples from the text.

Change

1. Source 2: Identify the five-year period in which the proportion of global migrants in the world population underwent the greatest change.
2. Source 1: Explain the increase in the number of international migrants in Europe between 1990 and 2020.
3. Sources 3 and 4: Analyse the patterns of Asian migration with particular reference to India.
4. Sources 5 and 6: Assess the importance of Mexico as a migration corridor into the United States.
5. Research the changing flow of remittances to the top 10 receiving countries. Analyse the patterns, making specific reference to Asian countries.

HOW TO
Change, page 412; PQE, page 430

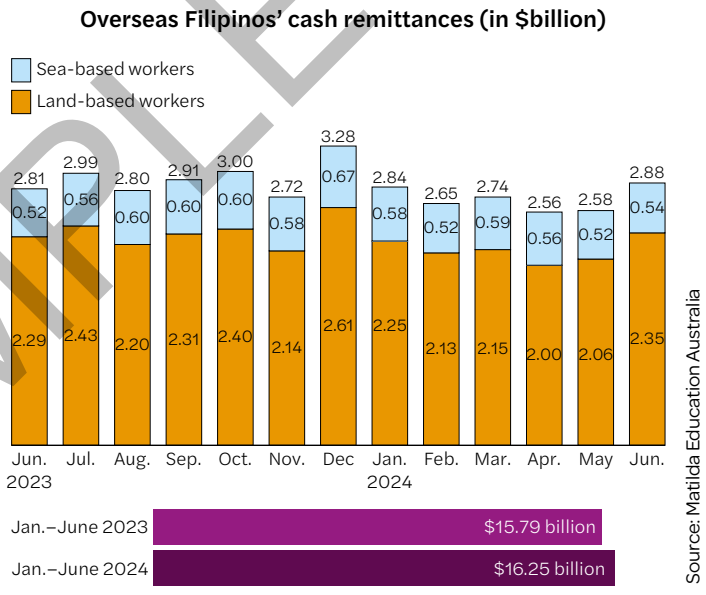
3.2

What are the consequences of international migration?

When millions of people move around the world, there are consequences for the individuals, the destination countries and countries of origin. Perspective on the value and impacts of migration vary. For example, in the United States, many believe that migrant workers from Mexico keep wages low and this impacts what Americans are paid, while others think that there is a benefit to the economy from migrants working for low wages and allowing businesses to function.

Consequences for individuals

People move because they are seeking economic or social change in their lives. Many migrants successfully transition to better lives in a new location. However, many migrants are also vulnerable to exploitation and harsh conditions and may not benefit personally for many years, if ever, from change. Migrant workers and refugees can suffer at the hands of people smugglers and third parties who exploit them for large sums of money. Foreign workers in low-paying industries undertake dangerous types of work and are often housed in substandard accommodation, while refugees risk dangerous journeys such as across the Mediterranean Sea from Syria to Turkey, during which lives are lost. Families are traumatised from these experiences and many struggle to be accepted in destination countries. When they are integrated into communities it may take years for professional qualifications to be accepted and to get work in their area of training.



▲ **Source 1:** Remittances to source countries like the Philippines can boost economic development, and benefit future citizens.

Destination countries

Migrants offer many benefits to their destination countries. These are some examples:

- Workers in essential service such as construction, agriculture and hospitality allow economies to function and grow.
- Skilled and unskilled jobs vacancies can be filled.
- Diversity of people from different cultures enriches societies with new foods, languages, music, festivals and businesses.
- Migrants may bring financial resources that are invested into new business ventures.
- Permanent migrants of child-bearing age can increase the birth rate and prevent population decline.

There are also perceived challenges for countries that accept migrants:

- Increasing populations in already overpopulated cities can affect affordability.
- Pressure on services and facilities increases, particularly in the welfare and housing sectors.
- Funding is needed for border control, customs and refugee processing facilities.
- Racial tensions may increase due to historical cultural differences.

Source 2: Benefits and challenges of international migration

Countries of origin

Migration also has benefits for the countries of origin of migrants.

- Remittances assist economic development and, in many cases, exceed the development assistance provided by other countries.
- Population pressure in large cities where services and facilities struggle can be reduced.
- Returning migrants bring new skills or qualifications or innovative ideas that assist economic development.
- Countries can invest in improving the wellbeing of remaining populations.

However, migration can also cause challenges for the countries of origin of migrants.

- Brain drain – highly qualified people leave the country, many of whom never return.
- This can lead to shortages of educated or key workers.
- Rural depopulation can lead to loss of farmers and reduced agricultural production.
- Larger numbers of men emigrate as workers, leaving women, the old and the very young, which creates gender imbalance.
- Certain villages, such as Santa Ines, Mexico, have lost two-thirds of their inhabitants.
- Large refugee camps have environmental impacts such as deforestation caused by the use of wood for fuel and shelter, overgrazing by stock arriving with the refugees, water shortages due to increased demand and pollution due to a lack of sanitation.
- Countries can become over-reliant on remittances that can reduce the necessity of people to work, causing lower economic growth.

Learning ladder 3.2

Processes that transform people, places and environments

1. Identify four ways that migrants could be personally impacted by their migration experience.
2. Source 1:
   - **a** Describe the range of foreign workers illustrated in the infographic.
   - **b** Explain how the remittances sent to families at home in the Philippines could change the wellbeing of family members.
3. Source 1: Explain how remittances can be an economic advantage for a country with a large emigrant population.
4. Analyse potential social consequences of large numbers of males leaving countries to work overseas.
5. Assess the environmental changes caused by large refugee camps and recommend solutions to one negative change you identify.

Scale

1. Describe the social benefits of migration at a local level.
2. Mind map how migration affects places at local, national, and global scales. Colour code to identify changes to countries of origin and destination countries.
3. Source 2: Rank the images in order of most positive change to most negative change for destination countries at a national scale.
4. At which scale do origin countries experience the most challenges when workers migrate, and why?

HOW TO

Scale, pages 416, 423; PQE, page 430

3.3

How is international migration changing Australia?

More than 30 per cent of Australia's population were born overseas and more than 50 per cent have at least one parent born outside Australia. Migration includes skilled workers, family reunions, refugees and students, with the majority coming from Asia–Pacific.

Growth through migration

Without migration, Australia's current population would be lower than 15 million; waves of migration have played a major role in the current total of almost 26.5 million in 2023. Today, Australia is one of the most culturally diverse nations in the world, with more than three hundred different languages spoken, and migration is a cornerstone of this diversity and growth.

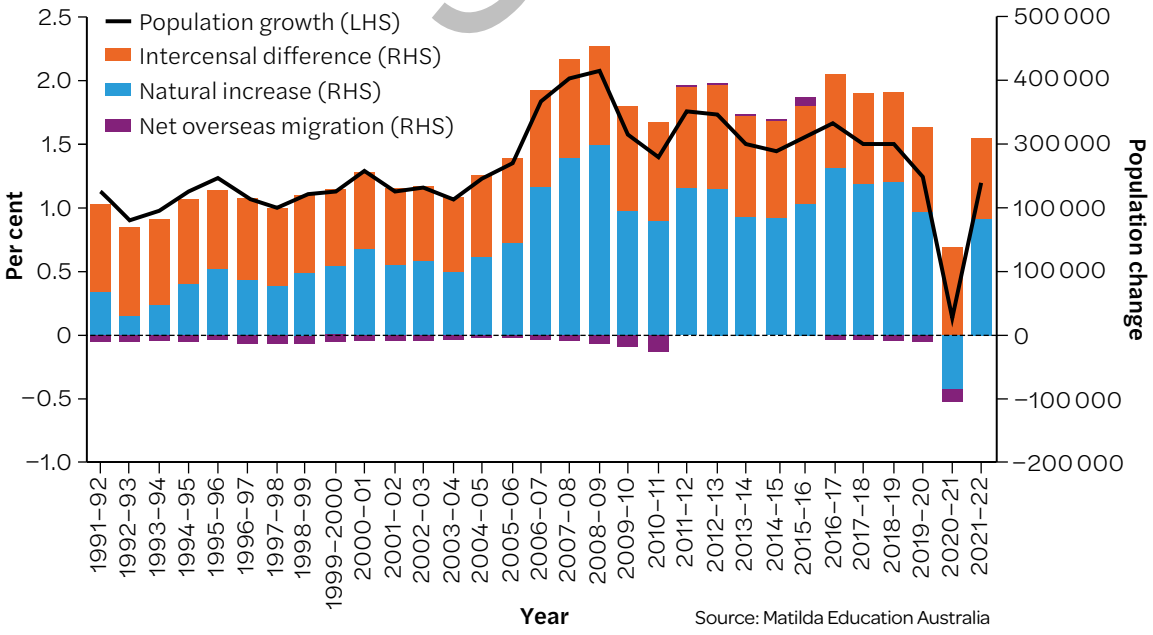
In the post-World War II period, most new migrants to Australia came from the British Isles and from Europe, but this trend has shifted over the past few decades, with the fastest growing populations of migrants coming from China, India, New Zealand, Philippines and Vietnam.

Australia's migration program

Migration to Australia takes place through a variety of pathways, but the Australian Government's Migration Program is the main avenue for immigration to Australia and is used to increase the national population and promote economic growth. To do this, migration targets are annually adjusted to meet the needs of Australian society. The Migration Program has two streams:

- The skill stream (72 per cent of the 2023–24 program), which attracts migrants who can contribute to identified skill shortages in the economy. The Department of Immigration publishes lists of skilled occupations, including doctors, nurses and engineers, that Australia requires and people from overseas can apply for them. They can either apply as individuals or can attract visa sponsorship by employers or governments.

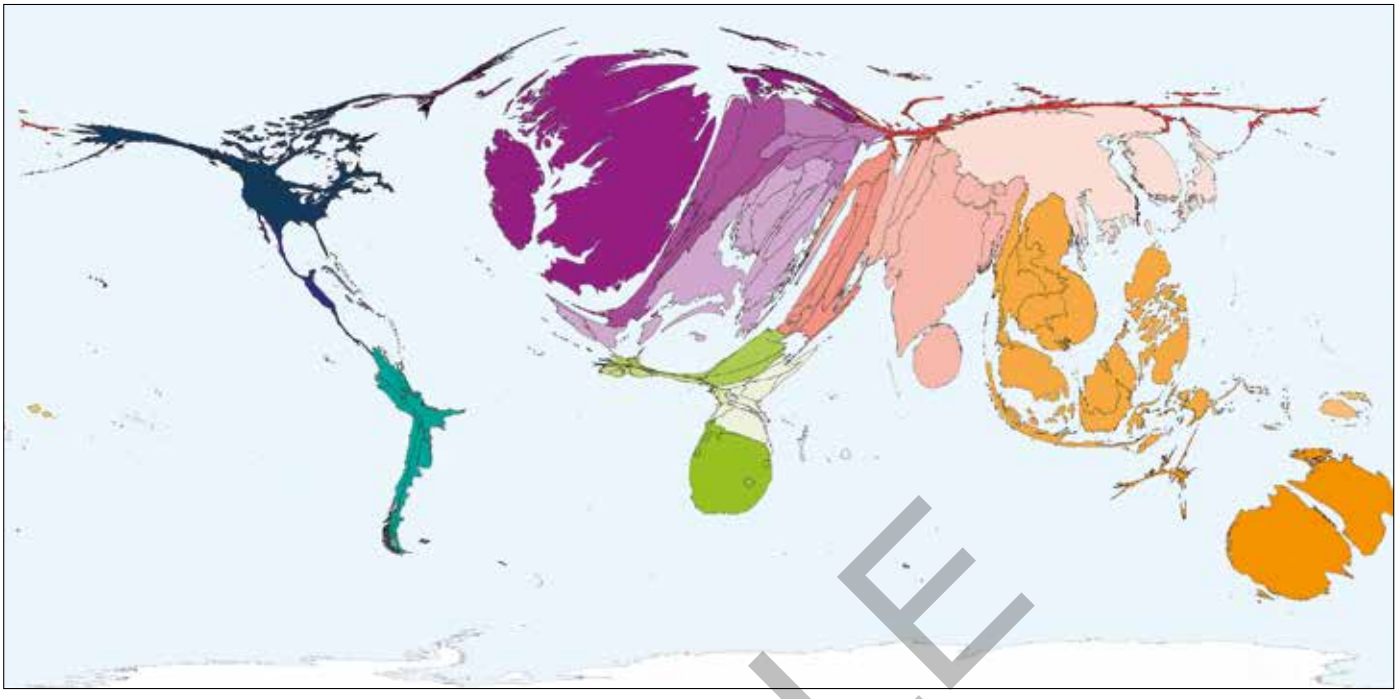
Components of population change, Australia, 1991–92 to 2021–22



Source: Matilda Education Australia

Source 1: This graph of Australia's recent population change shows the country's reliance on the intake of overseas migrants and the impact of the Covid pandemic in 2020–21 on Australia's population when migration was stalled.

Migration to Australia, 1990–2017



Source: World Mapper

- The family stream (28 per cent of the 2023–24 program), which reunites immediate family members who are permanent residents or Australian citizens, such as the spouses who are foreign nationals, or the siblings of Hazara migrants from Afghanistan.

In addition to this, the Humanitarian Program allows Australia to fulfill its international obligations to assist in the resettlement of refugees and to provide support in response to regional and global humanitarian disasters and conflict.

Source 2: Migration to Australia, 1990–2017. The relative thickness or thinness of a country represents the proportion of migrants from that country.

Source 3: Thomas Deng, Garang Kuol and Awer Mabil all were part of the Australian soccer squad in 2022. They are the first trio of South Sudanese refugees to represent Australia. Deng, Kuol and Mabil all arrived in Australia as refugees. Awer Mabil spent the first ten years of his life in a refugee camp in Kenya and Thomas Deng also spent his early years in Kenya before arriving in Adelaide. Garang Kuol and his family were forced to flee to Egypt and eventually settled in Shepparton.

Where do migrants settle in Australia?

Every state and territory of Australia has a proportion of its population born overseas, yet the distribution of migrants tends to follow a more clustered pattern, with the majority living in the eastern states and in large cities of over 100 000 people. In recent years, the Migration Program has looked to provide incentives to shift this settlement pattern and attract new migrants into regional areas to support economic growth and the provision of services.

In 2011, 82 per cent of the migrant population lives in capital cities, compared to 66 per cent of all Australians, with the highest proportions of migrants in Sydney, Melbourne and Perth. Following World War II, waves of migrants increasingly concentrated in New South Wales and Victoria; from 1947 to 1991 migrant populations in Australia's large cities doubled to 80 per cent. Within cities themselves, migrants tended to concentrate into suburbs like Carlton (Italians) and Oakleigh (Greeks) in Melbourne, Fairfield (Vietnamese) in Sydney, and Burns Beach (South Africans) in Perth. Today, the majority of new arrivals continue to settle in eastern states and capital cities; by 2011, three-quarters of all new migrants to Australia settled in New South Wales, Victoria and Queensland.

Increasing components of migration programs	Impact on settlement patterns
Skilled migration intake 	• Professionals settle in cities and more expensive suburbs that reflect higher incomes rather than ethnicity • States target skilled migrants to fill specific shortages in agriculture, technology, manufacturing and mining • Migration stimulates economic growth in cities, states and regions
Asian migrants 	• Concentrate into cities (e.g. high percentage of Indians in Melbourne and Sydney) • Often choose city apartment living in middle or inner suburbs • Concentrate in suburbs with high populations from previous waves of migration
International students and working holidays 	• Majority in large cities where universities and casual employment are concentrated • Regional centres with universities (e.g. Bathurst and Townsville) • Regional centres benefit from seasonal workers (e.g. tourist resorts and farming districts)
Humanitarian intake 	• Predominantly in large cities where support is available • Lower socioeconomic groups live in outer suburbs (e.g. Blacktown in Sydney) • Regional centres targeted (e.g. Tamworth and Geelong) • Benefits states with falling populations (e.g. Tasmania)
Regional settlement program 	• Benefits towns in regional Australia, particularly in farming and mining areas (e.g. the Kimberley and Ballarat) • Satisfies skills shortages in regional locations • Increases populations, stimulates local and state economies and generates employment • Makes regional and rural areas sustainable by slowing population loss

Source 4: Refugees from Myanmar work at the Luv-a-Duck factory in Nhill. They've created new lives for themselves and strengthened the rural economy.

Case study: Nhill

In regional western Victoria, roughly halfway between Melbourne and Adelaide, lies the town of Nhill. With a population of around two thousand and, like many regional towns, a gradually aging population (with a median age of 47) due to rural-to-urban migration patterns that see many younger people leave to seek employment and tertiary education in cities.

The principal employer in town, the Luv-a-Duck factory that prepares duck meat for distribution across Australia, had been struggling to find workers and in 2010 began working with a small group of Karen refugees; over time this community has now grown to more than 200 with the support of the Victorian Government's Capacity Building and Participation Program and the entire Nhill community. The Karen – a persecuted minority group from Myanmar – have overcome immense cultural differences and language barriers to thrive in regional Victoria, breathing life into the local economy and serving as a model example of how international migration can support the challenges created by internal migration.

Learning ladder 3.3

Perspectives of people and organisations

1. Why do some people want to migrate to Australia?
2. How does migration affect the population of Australia's largest cities?
3. Why do most international migrants settle in cities on Australia's east coast?
4. How does the Australian Government manage the number and types of migrants coming into the country?
5. How has the Karen community in Nhill helped the town? What challenges did they face?

Sustainability

1. What might be some of the impacts of international migration on the Australian economy?
2. Suggest why the Australian government will review both numbers and in-demand skills annually in terms of granting visas.
3. Source 4: How is international migration important to the wellbeing of rural communities like Nhill?
4. Discuss how international migration might contribute to the need for better environmental management in urban areas like Melbourne and Sydney in terms of traffic and housing.

Sustainability, page 418

Case study

Where are Sydney's migrant communities?

More than 250 different languages are spoken across Sydney, and each community vibrates with its own hubs, services and activities. New arrivals to Sydney from Asia–Pacific, Africa and the Middle East continue to grow faster than those from Europe.

Chinatown

The 2021 census registered more than 238 000 Sydney residents born in China, along with those of Chinese descent born in Australia, Malaysia, Indonesia, East Timor, and other countries, making them the largest of Sydney's migrant communities. Different Chinatown districts have been present in Sydney since the arrival of the Chinese during the Gold Rush of the 1850s, but the current Chinatown at Haymarket is both the largest and the oldest. It includes the Chinese Garden of Friendship, widely available Mandarin and Cantonese-speaking services and shops with traditional foods and medicines.

Bankstown

Sydney is also home to one of the largest Lebanese **diasporas** in the world, the majority of whom arrived prior to 1991. Lebanese migrants represent the diverse cultures of Lebanon itself, including Sunni & Shia Muslims, Maronite & Orthodox Christians, Druze, and Armenians. Numbering almost 90 000, they are well-established and can be found across the city, particularly in and around Bankstown, Canterbury and Parramatta. The Lakemba Mosque, Australia's largest mosque, has significant ties to the Lebanese community, along with many other services.

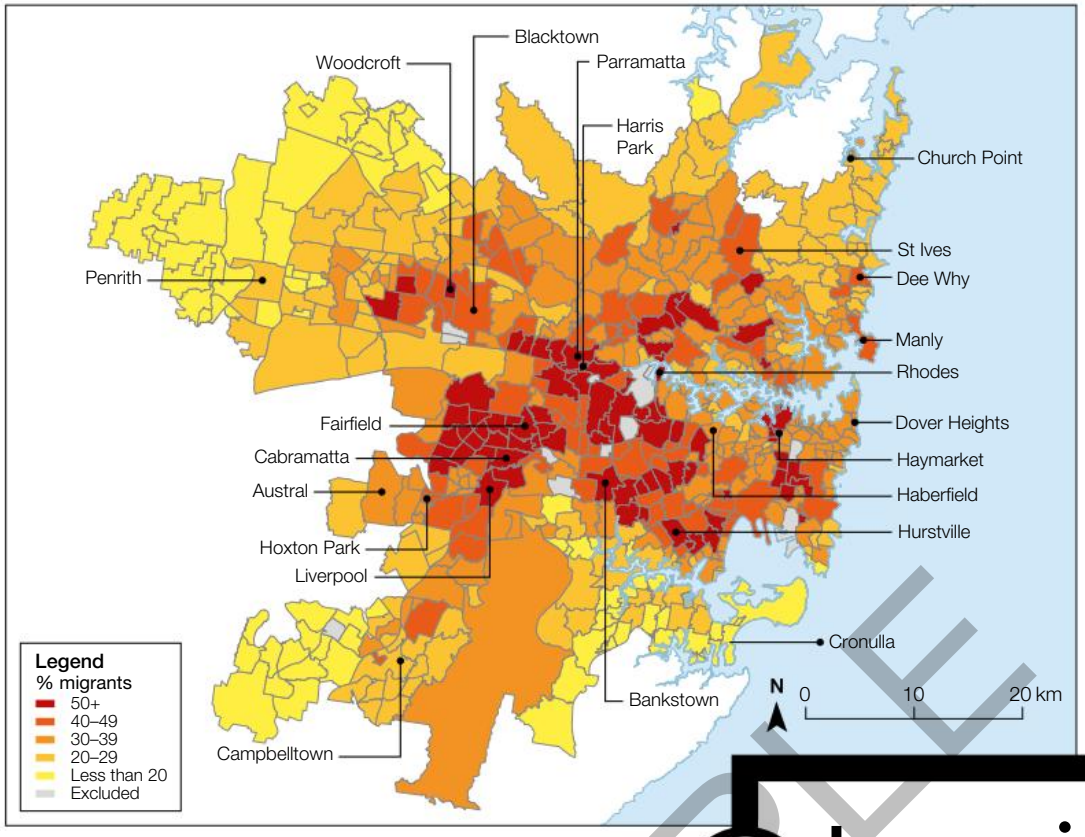
Fairfield

More than 60 per cent of all Iraqi-Australians live in New South Wales, particularly in and around Fairfield, along with many Syrians and Iranians. Fairfield City Council has welcomed thousands of humanitarian arrivals from war-torn Iraq and Syria. The area has established religious and community services in place. New arrivals gravitate to Fairfield due to family links and the large existing Iraqi and Syrian communities.

Blacktown

Among Australia's most diverse communities is Blacktown, where more than half of the population are born outside Australia, including Filipinos, South Asians and Pasifika communities. The largest migrant group in Blacktown are from the Philippines. Australia's largest Sudanese and South Sudanese-communities live in Blacktown. The suburb's highly multicultural community include residents who hail from more than 140 different countries.

Percentage of migrants in Sydney by suburb, 2011



Source 1: Percentage of migrants by suburb in Sydney 2011. The pattern of migrant concentrations in different Sydney suburbs in 2011 remains a key population feature of the city in 2025 although in some places concentrations have significantly increased. In 2021 58 per cent of the population in the Green Square, an inner city urban renewal project were born overseas with Chinese ancestry the largest component.

Source: Matilda Education Australia

Source 2: People kneeling in prayer at Australia's largest mosque at Lakemba in Sydney. Lakemba Mosque was started by Lebanese migrants as a community prayer hall to teach the basics of Islam.

Learning ladder 3.4

Processes that transform people, places and environments

1. Describe a social and historical factor influencing the location of migrants in Sydney.
2. Explain the advantages for Iraqi and Syrian migrants who arrive in Fairfield.
3. Source 2: Explain why religion and language may be a source of comfort for newly arrived migrants in Australia.
4. Analyse the facilities and services that local areas such as Bankstown may need to support its culturally-diverse communities?

Change

1. Describe how have migration patterns to Sydney changed over the past few decades.
2. Provide an explanation as to why the areas listed have the highest percentage of migrants.
3. Suggest factors that have likely contributed to the increasing diversity of Western Sydney.
4. Suggest how local governments can support communities in fostering heritage and identity.

HOW TO Change, page 412

Where do people migrate within Australia?

Internal migration is, in many ways, part of the Australian way of life. Very few people will live their entire lives in the same home; work, study, lifestyle and family all play significant roles in population movement within Australia. The impacts of this movement are a key factor in the rapidly changing infrastructure, services and urbanisation of our major cities.

Mobile population

Internal migration is a common phenomenon in Australia, as people move between states (interstate migration), between regions, cities and rural areas (intrastate migration) and even from suburb to suburb (intercity migration). According to the Australian Bureau of Statistics, almost half of all Australians move house every five years. Such movement can include:

- Seachange and treechange migration as retirees and young families seek a change from urban areas, leaving crowded Sydney suburbs and heading to the Central Coast.
- The pursuit of higher education as young adults leave rural areas, like Shepparton, to attend universities in larger urban areas, like the University of Melbourne.
- First Nations Peoples in remote communities who migrate temporarily to visit extended family, or urban Aboriginal peoples moving to their traditional lands, such as returning to the Tiwi Islands from Darwin.

Economic migration

Work is perhaps the primary driver of movement within Australia, creating distinct patterns of migration, including:

- The pull of larger urban areas, notably Sydney and Melbourne that offer the greatest number and variety of employment opportunities.
- New outer-urban suburbs in larger cities tend to grow quickly due to the availability of more affordable housing, i.e. Tarneit in Melbourne's south-west and the Area 20 precinct of north-west Sydney.
- Resource-rich locations in remote areas of the country, such as the Pilbara in Western Australia and Bowen Basin in Queensland tend to attract a mobile workforce. With services and facilities often limited, most workers tend to live in cities such as Perth, Darwin, Cairns or Brisbane, and undertake fly-in-fly-out (FIFO) or drive-in-drive-out (DIDO) arrangements.

Source 1: Since 2000, the western Sydney suburb of Kellyville has undergone suburbanisation. On the rural-urban fringe of Sydney, Kellyville has transformed from farmland to a suburb of nearly 30 000 people. The western suburbs of Syney continue to expand and the new suburb of North Kellyville has already added a further 20 000 residents to the region.

Kellyville is an example of economic migration, where families are buying freestanding homes for the same price as apartments in Sydney.

1 Economic
People move to large cities for employment. The CBD offers the largest employment opportunities, stimulating a demand for more inner-city housing.

2 Economic
People move to outer suburbs where housing is more affordable. Many commute to work. Outer suburbs are often a family lifestyle choice.

3 Economic
Workers are moving to WA and Qld where a resources boom is creating employment in mining and associated industries.

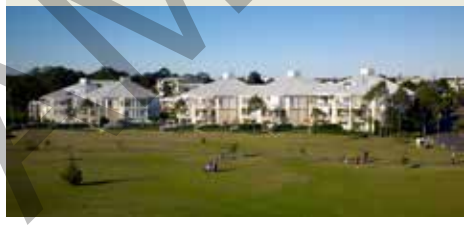
4 Lifestyle
Many mining workers are choosing to move to cities in mining states and live away from the mines using FIFO work arrangements.

5 Lifestyle
Attractive locations with a pleasant climate and proximity to cities attract retirees, families and young people.

6 Lifestyle
Inner-city apartment living attracts workers looking to live close to work, cultural and social venues.

7 Environmental
Droughts, floods, cyclones and bushfires force Australians from farms and devastated communities. Congestion drives people from cities while lack of rural facilities drives them to cities.

8 Lifestage
Families may chose proximity to schools and recreational facilities. Older people might downsize to apartments or move to the coast, while students go off to university after school.



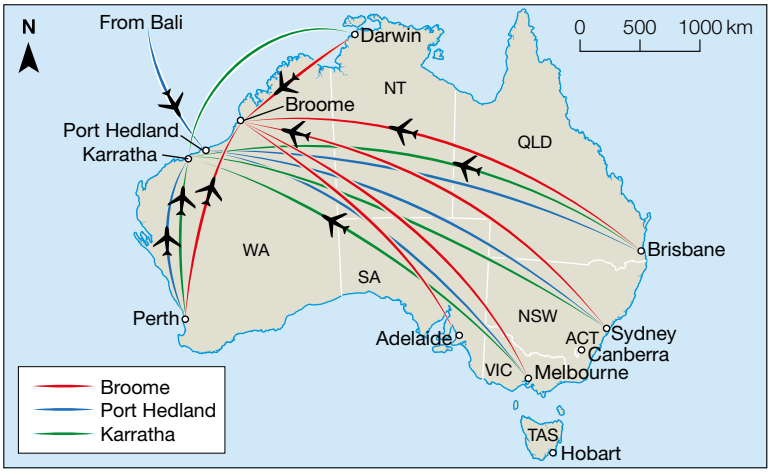
9 Cultural
Aboriginal and Torres Strait Islander Peoples migrate temporarily to visit extended family members or to reconnect with their culture, but most move to larger towns for jobs, education and services.

▲ **Source 2:** There are many reasons why people might migrate within Australia.

FIFO workforce

Infrastructure projects, primary industries and resource extraction require tens of thousands of workers across Australia, particularly in construction, mining and transport. Although some migrants choose to live in local communities like Port Hedland, Newman and Karratha, fly-in-fly-out (FIFO) workers form a significant proportion of the workforce. More than 50 000 people work this way around Australia, spending time in mining camps, local towns and project sites, before returning to their place of residence. FIFO workers often form the majority of construction and infrastructure projects, including rail, road, buildings and power infrastructure.

FIFO movement to Western Australia



Source: Matilda Education Australia

▲ **Source 3:** FIFO workers come from as far as the eastern capital cities to work on large mining and construction projects in the Pilbara region.

Source 4: The COVID-19 pandemic of 2020–21 fuelled a large migration of CBD residents to coastal areas like Terrigal, Gosford and Bateau Bay on the New South Wales' Central Coast.

The lockdowns and encouragement to work at home saw house prices and populations of coastal towns close to major cities quickly increase. With greater flexibility continuing in the workplace, decentralisation of populations to country and coastal locations continues today.

Migrants stay close to cities

Lifestyle changes have seen growing numbers of Australians move to quieter regions like Victoria's Surf Coast, New South Wales' Blue Mountains, South Australia's Barossa Valley and Queensland's Sunshine Coast.

Although some people are drawn to leave urban areas in favour of country towns, beaches and natural environments, the vast majority of internal migration in Australia is rural to urban. Population density in Australia's urban areas continues to rise, particularly in inner-urban suburbs as workers, students and empty-nesters move closer to central business districts, seeking the inner-city lifestyle. As prices soar in such areas, more housing is developed on the city fringes, leading to further urban sprawl.

According to the National Sea Change Taskforce, 'the total population in coastal areas outside capital cities will increase to around 13.2 million people by the year 2050. That's a population increase which is equivalent to another 12 or 13 Gold Coasts around coastal Australia'. This further contributes to urban sprawl, as urban corridors emerge, such as Perth-Mandurah and Brisbane-Gold Coast, as well as potentially unsustainable growth as local and state governments struggle to provide schools, public transport and infrastructure to support ever-emerging residential developments. In addition to this, the risk of environmental degradation continues to rise as fragile coastal environments are put under increasing pressure.

Interstate migration

The number of interstate moves rose to a record high of 485 000 over the year to March 2022 during the COVID-19 pandemic. Queensland has long been the most popular destination as migrants are drawn to the warmer climate, coastal lifestyle and employment opportunities. In the post-pandemic period, other states and territories have made significant efforts to entice internal migrants to support growing economic demand, notably Western Australia and the Northern Territory. Rising house prices in many regions has also accelerated such movement, with both New South Wales and Victoria seeing negative net internal migration figures; in simple terms, more Australians left those states than moved into them.

Source 6: ▶
Internal migration in Australia 2011–16. Since 2016 there have been trends of increased migration from Victoria to Queensland and from NSW to other states.

Learning ladder 3.5

Sustainable management strategies

1. What infrastructure do new suburbs need in addition to housing?
2. Suggest how population growth in new areas can put pressure on the environment.
3. Explain how the growth of Australia's coastal communities can increase erosion and affect marine wildlife.
4. Suggest three ways that local governments could balance the need for more housing and communities with protecting the environment.
5. Source 4: Which groups of internal migrants are attracted to coastal areas close to major cities? What additional services are needed in coastal towns to cater for the increased population?

Interconnection

1. What *pull factors* influence internal migration in Australia?
2. Source 3: Who are FIFO workers? Describe their interconnections between where they live and work.
3. Source 6: Calculate the net migration into Queensland from 2011 to 2016.
4. Source 6: Compare the population growth areas of New South Wales and South Australia
5. Predict the trends of interstate migration in NSW in the next 10 years. Use two reasons to justify your prediction.

Interconnection, page 410

HOW TO

Case study

How is internal migration affecting China?

The Chinese government controls where its people work through the *hukou* system. Workers must obtain a permit to work outside their home village.

Internal migration in China

The largest **internal migration** in human history is occurring in China. Its people are migrating from inland **rural** villages to work in large coastal manufacturing cities such as Dongguan in Guangdong province. In 2023, China had approximately 297.53 million migrant workers, accounting for about 38 per cent of the total workforce.

Under China's *hukou* system everyone must be registered in their home town or village to be able to access education, housing and welfare. Individuals are categorised as either rural or **urban**, and they are required to work within their designated area. China allowed people to move to other provinces to work in 1984 to provide the cheap labour required for China's booming manufacturing industries.

Under the *hukou* system, people moving from rural areas to cities must buy a work permit. Most permits only allow for temporary work of up to 12 months. There is great demand for these permits and they can be difficult to obtain.

Different living standards

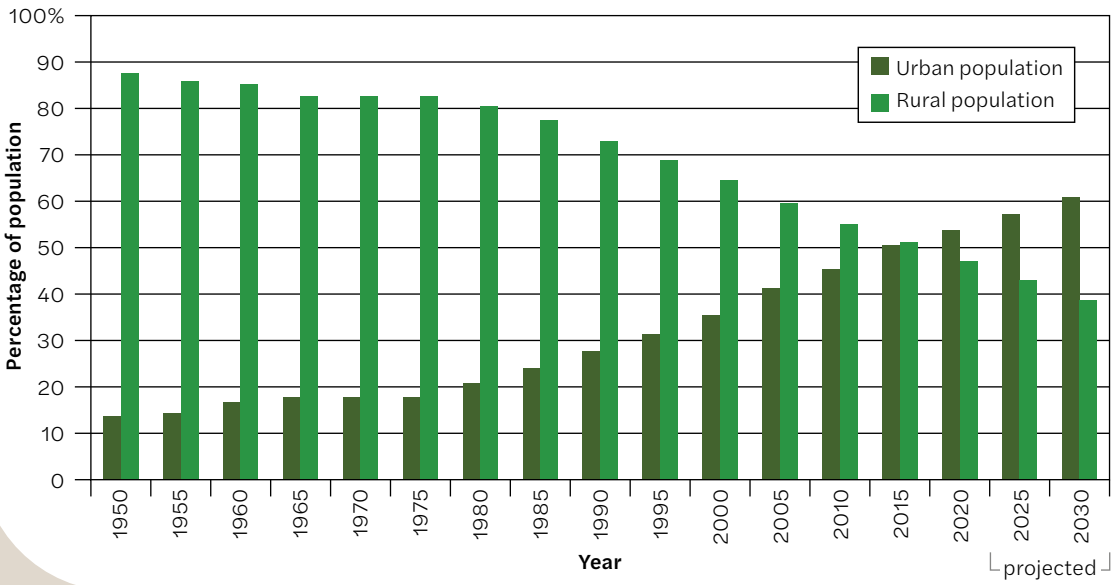
Differences in living standards are so great between rural and urban areas in China that **migration** is a very attractive prospect for rural workers. Rural incomes are less than 40 per cent of urban ones. Farmers move to the large industrial centres where they can earn far more money than they could growing crops or tending cattle.

Problems for migrant families

Migrant workers often leave their children behind so they can work in urban areas to earn a better income. Good quality housing is difficult to find and rents are expensive. Migrants also struggle to get access to services such as education and health.

Migrants can spend many years away from their family. More than one-third of children in rural China are left behind in their villages under the care of their grandparents or other relatives.

China's urban population growth, 1950–2030



Source 1: China's urban population growth 1950–2030

Source: QBS

Source 3: Smartphone assembly line in Dongguan, Guangdong province. China produces 60 per cent of all mobile phones and about half of them are manufactured in Guangdong province.

China's population by province, 2019

Source 2: China's population 23 May 2019. Guangdong province, in the south, accounts for 27 per cent of China's temporary migrants.

Source: iStock/Rainer Lesniewski

Learning ladder 3.6

Processes that transform people, places and environments

1. What is the social impact of China's hukou system?
2. Source 1: Use PQE to describe the pattern of rural to urban migration between 1950 and 2030.
3. What problems are faced by migrant families in China?
4. Why are temporary work permits in great demand in China when migrants suffer much hardship?

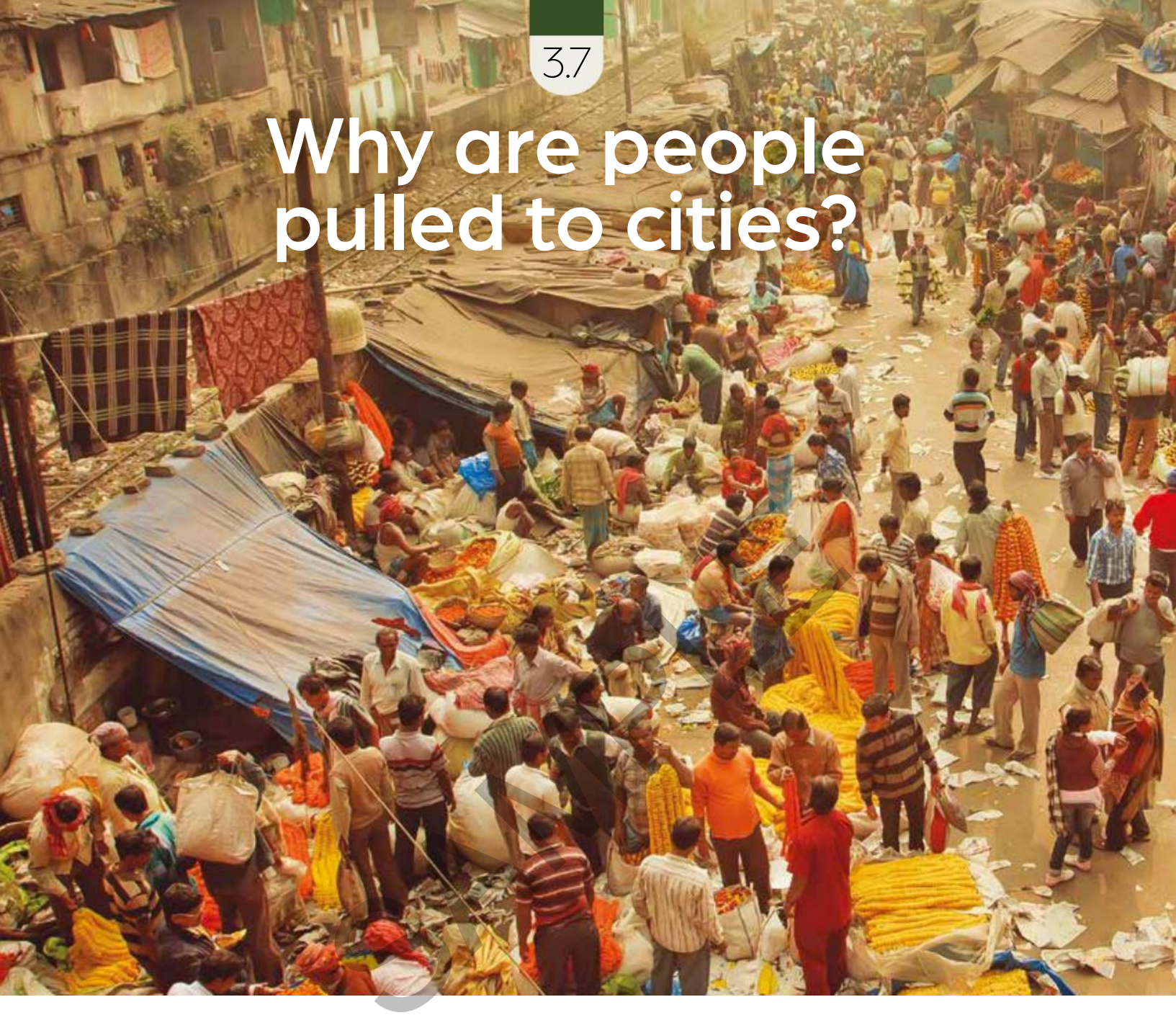
Change

1. What percentage of China's workforce is made up of migrant workers?
2. Source 1: Describe the changes to China's urban population since 1950, and what changes could take place up to 2030.
3. Source 2: What is the population of Guangdong province? How has its population been impacted by internal migration?
4. What might the implications of rural to urban migration be for rural areas? How can these be overcome?

HOW TO
Change, page 412

3.7

Why are people pulled to cities?



Over the last 150 years, there has been a clear pattern of **migration** from rural to urban areas. This urbanisation of the world's population is driven by people seeking better jobs and services.

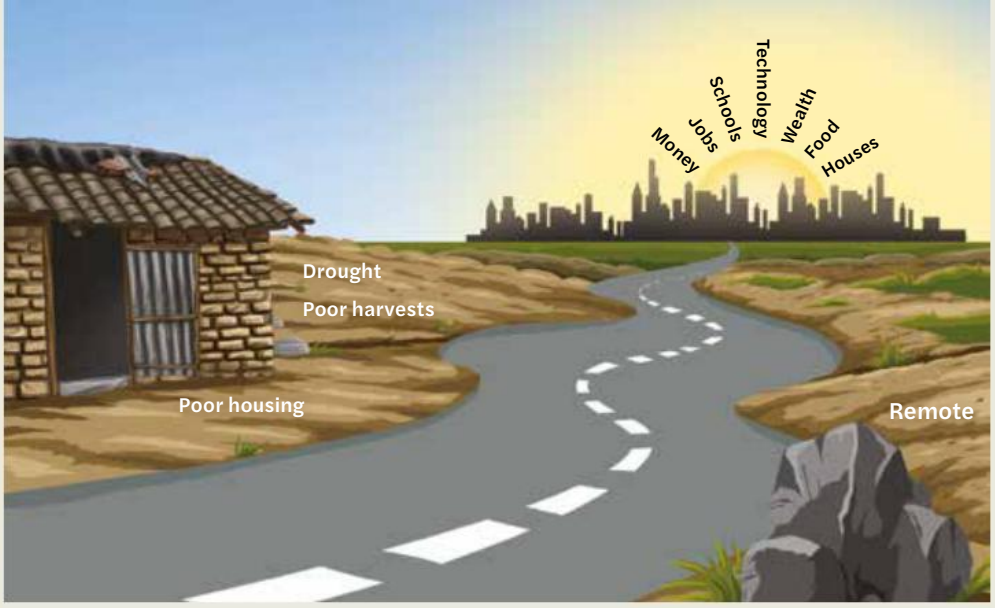
Push and pull factors

There are a number of factors pushing people from rural areas and pulling people towards urban areas. Push factors can include droughts, floods, famine, lack of employment opportunities, and even **civil war**. Many young people today also see farming the land as a difficult, unglamorous and unrewarding career.

Pull factors encouraging people to move to cities include the chance of better jobs with higher salaries; greater access to education, goods and services; and a higher living standard.

Urbanisation

The push factors from rural areas and the pull factors to urban areas have seen millions of people migrate to cities in a process called **urbanisation**. Rapid urbanisation can lead to issues such as overcrowding and shortages in jobs, housing and services. Many new arrivals in cities in **less economically developed countries (LEDC)** cities are forced to live in tightly packed **slum** communities.



Push factors

- Few services
- Lack of job opportunities
- Poor transport links
- Natural disasters
- Wars
- Shortage of food

Pull factors

- Access to services
- Better job opportunities
- More entertainment facilities
- Better transport links
- Improved living conditions
- Hope for a better way of life
- Family links

▲ **Source 2:** The perceived advantages of urban life versus some perceived disadvantages of rural life

▲ **Source 1:** The crowded streets of Kolkata in India. Rural to urban migration in India has seen cities like Kolkata become some of the most densely populated areas in the world. More than 24 000 people live in each square kilometre of the city. One-third of the city's population lives in slums and shantytowns, which house up to 28 000 people per square kilometre.

In 2023 India overtook China as the world's most poplulous nation, with a population of 1.43 billion people. Two-thirds of India's population still live in rural areas, however, urbanisation is rapidly changing the spatial distribution of India's population. The push force of unemployment in rural areas and the pull force of higher incomes in urban areas has resulted in the movement of millions of people to urban areas, placing great pressure on cities to cater for the increase.

Learning ladder 3.7

Perspectives of people and organisations

1. Describe why rural people might want to move to a city.
2. Source 2: How do people view life in cities compared to life in rural areas?
3. Why do some people see urbanisation as a good thing, while others see it as a problem?
4. Source 3: How has urbanisation changed life for rural migrants and city residents in Kolkata?

Interconnection

1. Source 2: Describe the interconnection between migration and better job opportunities.
2. How might push and pull factors differ for people living in more or less economically developed countries?
3. What are the implications of large numbers of rural migrants arriving in large cities in less economically developed countries?
4. Write a short narrative of a person who is wanting to move from a rural to an urban area in an LEDC. In the narrative, highlight the push and pull factors for the place they want to leave and the location they want to move to and how the change of place will impact them physically, emotionally and financially.

HOW TO Interconnections, page 410

3.8

Where are the world's urbanised areas?

More than half of the world's population now lives in urban areas, mainly along coastal regions in the northern hemisphere. Urbanisation has seen cities in Asia grow rapidly.

What is an urban area?

An urban area is a densely populated human settlement. In Australia, urban areas are defined as centres of 1000 or more people, with a **population density** of at least 200 people per square kilometre. Urban areas such as cities and towns contain commercial and residential buildings, and **infrastructure** such as transport, power, water and sewage treatment.

Urbanisation refers to the growth of urban areas as more people move from **rural** areas to cities. Projections show 68 per cent of all people will live in urban areas by 2050.

Where are urban areas?

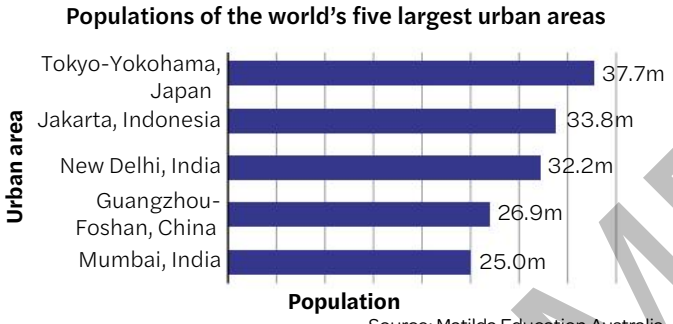
The world's urban areas are generally located close to coastlines and transport routes. They are found in areas of high rainfall and on flat land. Desert, mountain, forest and polar environments have some of the lowest population densities on Earth.

In addition, the **northern hemisphere** contains most of the world's largest urban areas and cities. Europe and the USA are two regions that have been highly urban for a long time and that feature **more economically developed countries (MEDC)** of the world.

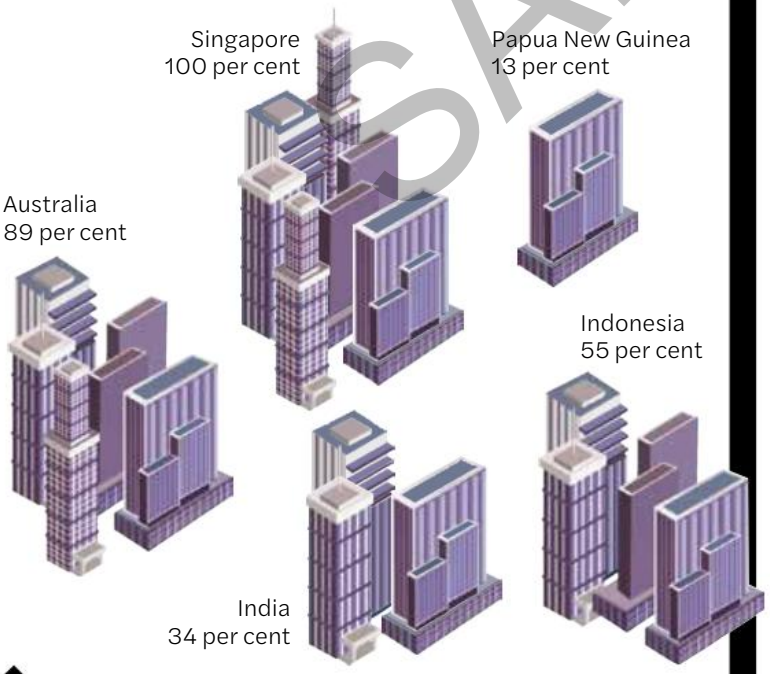
The Asian countries of China, India, Indonesia and Singapore are examples of countries where urbanisation has been recent and rapid. The largest cities in the **southern hemisphere** are found along the coasts of South America.

Source 1: Gardens by the Bay in Singapore. Singapore is one of 11 countries in the world that are 100 per cent urbanised. With only about 720 square kilometres of land, Singapore has increased its land area by 23 per cent by reclaiming land from the sea and has relied on high-rise apartments to house its population.

Source 2: This composite satellite image shows the Earth at night. It highlights the city lights of the world's urban areas. The northern hemisphere is far more urbanised than the southern hemisphere.



▲ **Source 3:** The world's five largest urban areas are all in Asia.



▲ **Source 4:** In 1950, only 30 per cent of the world's population lived in urban areas. Urbanisation occurred mainly in developed countries such as Australia. Today 55 per cent of people live in urban areas; however, some countries, such as Papua New Guinea, remain largely rural.

Learning ladder 3.8

Characteristics of places and environments

1. What is an urban area?
2. Describe the regions of the world where urbanisation is taking place.
3. Source 1: How has the environment of Singapore changed through urbanisation?
4. What impact is urbanisation having in Asia?

Space

1. Source 2: Which hemisphere is the most urbanised? How can you tell from this image?
2. Source 2: Use PQE to describe the world's spatial distribution of urban areas.
3. Sources 1 and 3: What impacts do you think urbanisation has had on the environment in Singapore?
4. Discuss why most urbanised areas are located along coastlines. You may wish to use the SHEEPT factors to broaden your thinking.
5. Conduct research to create a list of the top 10 fastest-growing cities on Earth. Outline the implications of rapid change in at least one of these cities.

HOW TO

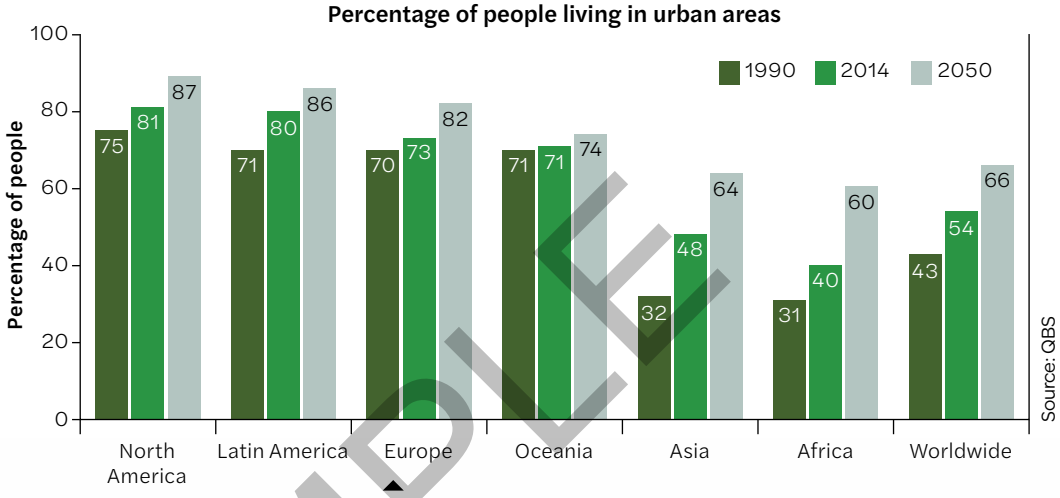
PQE, page 430; SHEEPT, page 432, space, page 406

What is the impact of urbanisation?

Rural to urban migration has seen large numbers of people move from farming areas to cities. Today, 55 per cent of all people in the world live in urban areas.

The lure of the city

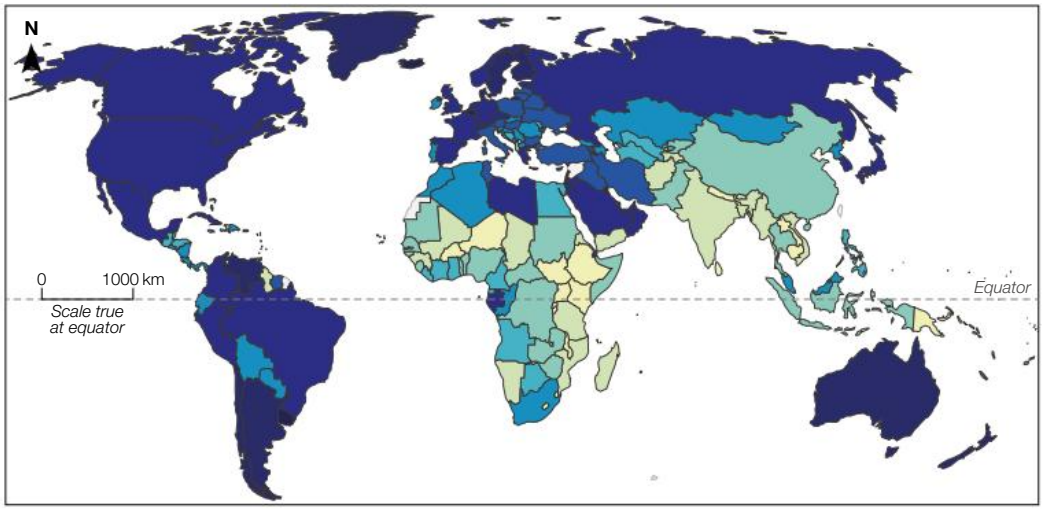
The promise of job opportunities and better services pulls people from rural areas to cities. In 1900, just 16 per cent of people lived in urban areas. By 2050, this percentage is likely to grow to two-thirds of the population, as more African and Asian rural dwellers move to cities.



Source 2: Percentage of people living in urban areas

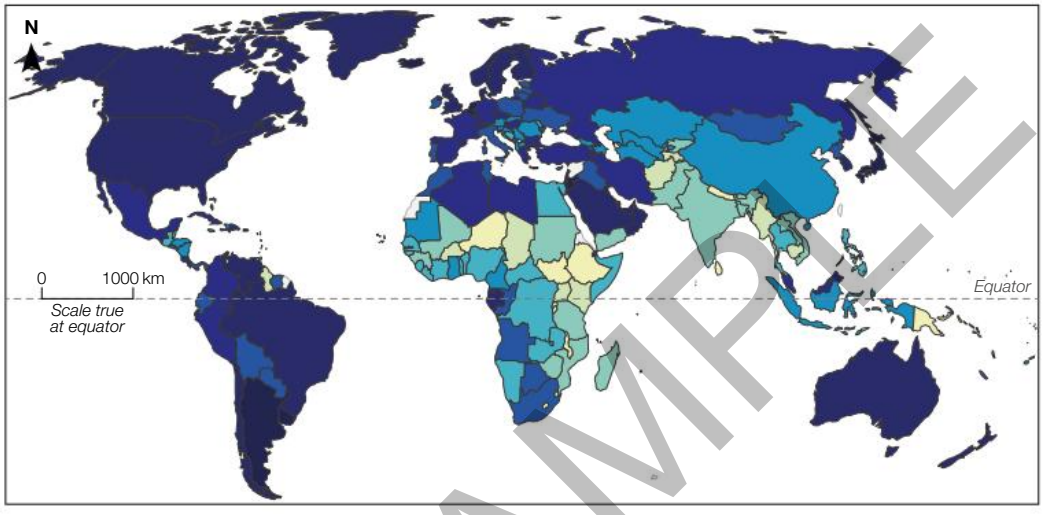
Source 1: Seoul was the destination for most rural migrants in South Korea. Between 1960 and 1970 many farmers left for opportunities in the city. In 1960, just 28 per cent of all South Koreans lived in cities. By 1970, 41 per cent lived in cities. Today, South Korea's urban population is 82 per cent and it has quickly grown from one of the poorest to one of the wealthiest nations in the world.

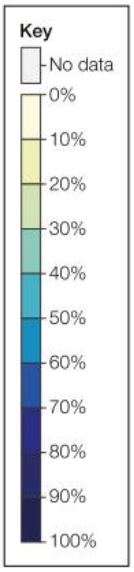
Global patterns of urbanisation, 1990



Source 3: Global patterns of urbanisation, 1990

Global patterns of urbanisation, 2020





Source 4: Global patterns of urbanisation, 2020. This map shows that many countries, particularly in Asia and Africa, are becoming more urbanised.

Source: Our World in Data (CC BY 4.0)

Learning ladder 3.9

Characteristics of places and environments

1. Why are people from rural areas drawn to cities?
2. Source 1: Describe how urbanisation has transformed Seoul.
3. Source 4: Which regions of the world had the highest percentages of urbanisation in 2020?
4. Create a comparison table highlighting the pros and cons of living in an urban or rural environment (consider the SHEEPT factors).
5. Source 2: Which regions of the world will experience the greatest urbanisation by 2050? What are some of the implications of these changes for the regions involved?

Change

1. Source 2: Identify which regions have the largest predicted increase in urbanisation from 1990 to 2050.
2. Source 2: Using PQE, explain the pattern of change in urban areas between 1990 and 2014.
3. Consider what you know about each of the world regions you identified in step 1. Why would these places have such large changes over time?
4. Source 4: Using SHEEPT, explain why we have seen increased urbanisation occur over time on a global scale. You may wish to reference specific regions to quantify your response.
5. Source 2: Where is the greatest and least urbanisation set to occur between 2014 and 2050? What are the implications for the regions involved?

Change, page 412; PQE, page 430
SHEEPT, page 432

HOW TO

Case study

How is urbanisation changing Indonesia?

Just 50 years ago, Indonesia was mainly a rural society, with just 17 per cent of Indonesians living in urban areas. Rapid urbanisation has seen massive growth in Indonesian cities, which has led to problems such as housing shortages, congestion and pollution.

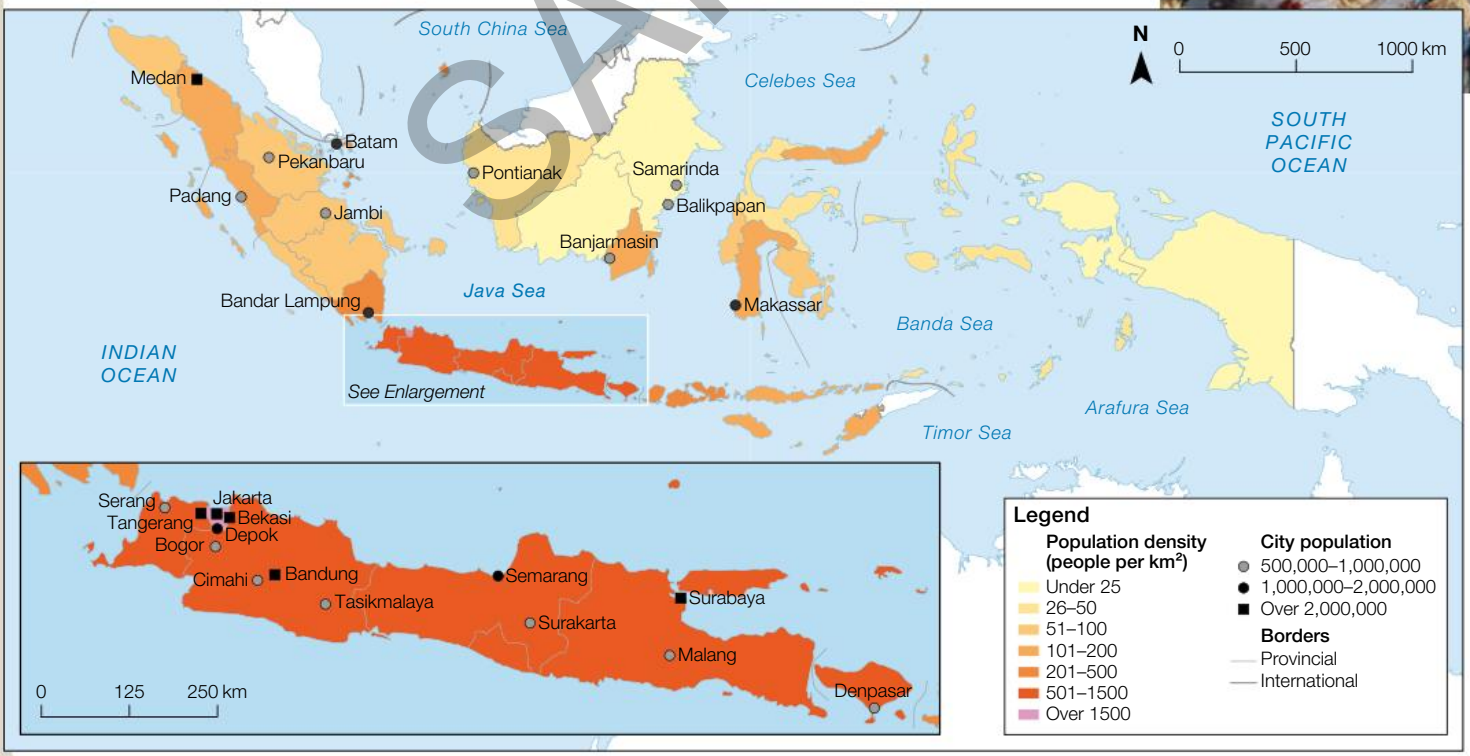
Indonesia's growing cities

Indonesia is the world's fourth most populous country and 60 per cent of Indonesia's 268 million people live on the island of Java. Indonesia has quickly transformed from a rural society to an urban one. In 2018, 55 per cent of all Indonesians lived in urban areas.

In 1950, only Indonesia's capital city, Jakarta, had more than one million people. In 2023 Jakarta's population was estimated at 11 million, making it Indonesia's only megacity. Today Indonesia is home to 19 cities with populations over one million.

Indonesia's city populations are growing at a rate of 4.1 per cent per year – faster than any other Asian country. By 2045, it is estimated that over 70 per cent of Indonesia's population will be living in cities.

Population density in Indonesia



Source 1: Population density in Indonesia

Source: Matilda Education Australia, Statistics Indonesia

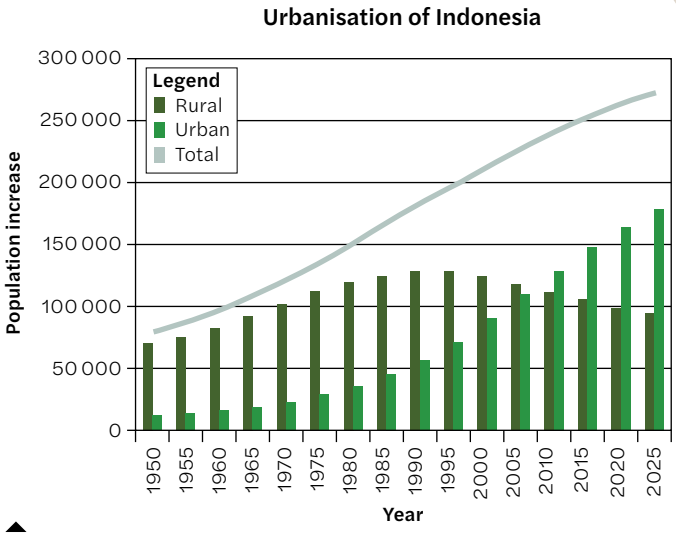
Source 2: A heavily polluted river runs through a Jakarta slum. Twenty-six per cent of all Indonesians live in slums.

Rural to urban migration in Indonesia

The Indonesian government has placed few restrictions on rural to urban migration. Most internal migration in Indonesia consists of the rural poor moving into cities for better wages, education and healthcare access. Most rural migrants are young people seeking stable jobs and a more modern life in Indonesia's large cities.

Almost 80 per cent of Indonesia's 140 million farmers are now aged 45 or older. Officials worry that future food supplies might be affected as the rural population continues to age.

The infrastructure in Indonesia's cities is not keeping pace with growing populations. New arrivals to cities will often live in poor housing in city slums, battle traffic jams and suffer high levels of air and water pollution.



Source 3: Urbanisation of Indonesia

Source: Indonesia Statistical Bureau (BPS) Proyeksi Penduduk, 2005

Learning ladder 3.10

Processes that transform people, places and environments

1. Give an example of a social factor that pulls people to Indonesian cities.
2. Explain why rural to urban migration is occurring in Indonesia.
3. Source 2: What is the cause and effect of rapid urbanisation shown here. Why do people live here?
4. Source 1: Describe the areas of Indonesia least impacted by urbanisation. Why might this be the case?

Environment

1. Source 1: Which region of Indonesia is the most urbanised? Refer to population density and specific cites in your response.
2. Source 2: Describe the built environment shown here.
3. Source 3: When did there become more urban dwellers than rural dwellers in Indonesia?
4. Source 3: What impact on the built environment does this graph suggest? How are governments currently coping with large numbers of arrivals to cities in Indonesia?
5. Source 3: Based on the trends shown here, what action will governments in Indonesia need to take to plan for those living in rural and urban areas?

HOW TO

Environment, page 414

3.11

What settlements do people live in?

People around the world live in vastly different settlements, from densely-populated **megacities** with sprawling suburbs to semi-rural and rural communities. Such settlements often begin where fresh water, arable soil and gentle topography are available, often in close proximity to coastal areas. The abundance of natural resources and temperate climates can also play a key role as settlements grow and civilisations expand.

Urban and rural settlements

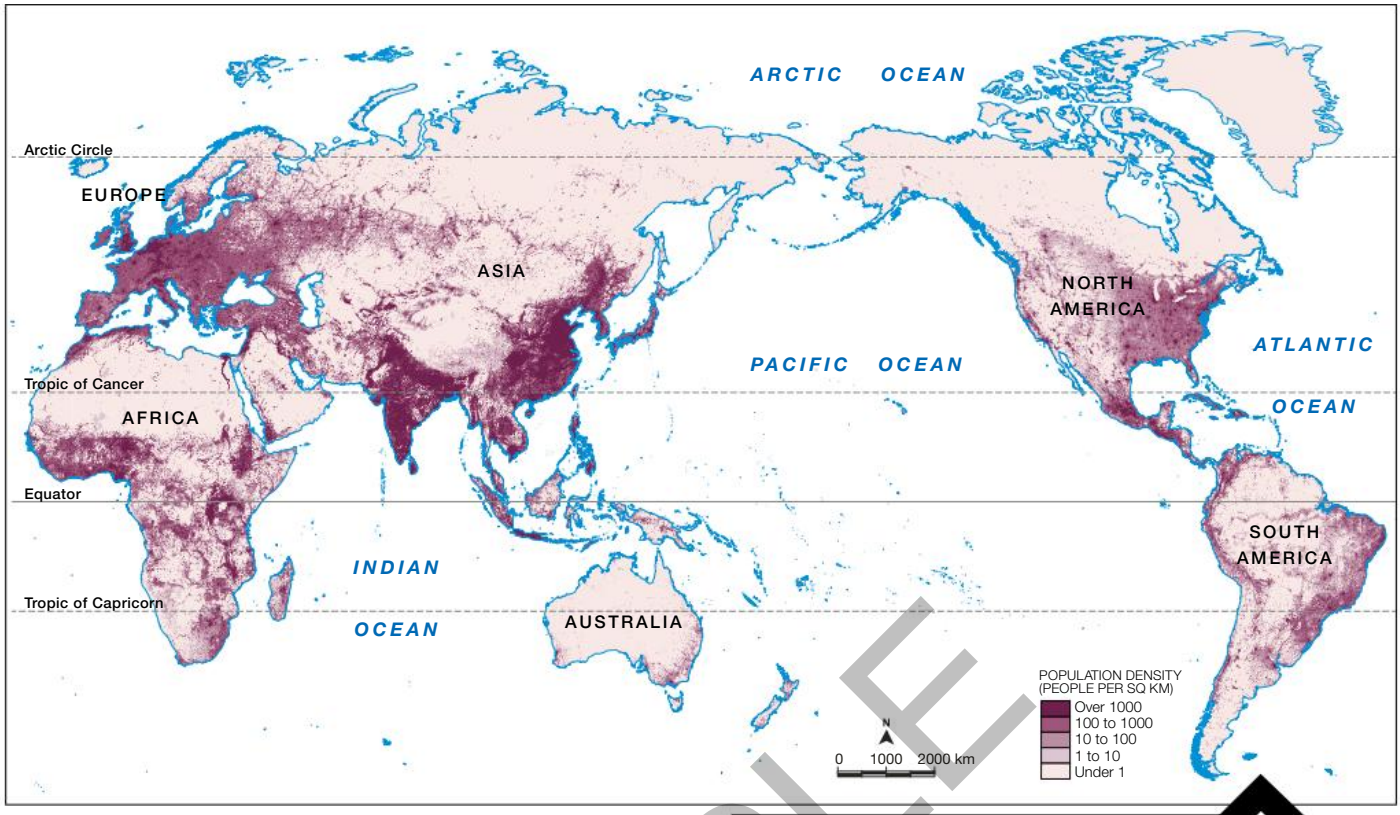
Within urban environments, people might dwell in towering high-density apartments, townhouses or even houses themselves. Suburbs connect through transport infrastructure and in Australia are carefully zoned into residential, commercial and industrial areas, in addition to other land uses. Zoning helps to improve both the liveability of residential areas and the efficiency of business and manufacturing. In many parts of the world, unplanned slums can emerge, often lacking access to existing power, water and sewerage systems.

In rural areas, low-density housing is the norm, and communities are often linked to agriculture or other forms of primary industry, including mining, forestry or fishing.

▲ **Source 1:** Aerial view of the rural community of Burrawang in New South Wales Southern Highlands.

Source 2: Villa 31, a prominent slum in Buenos Aires, Argentina, is home to more than 50 000 people. The slum is located in Retiro, one of Buenos Aires' wealthier neighbourhoods. These informal settlements consist of small houses or shacks made of tin, wood and scrap materials. Narrow unpaved alleys connect the different parts. There is no sewerage and limited access to water. Electric power is sometimes supplied using illegal connections.

Global population density



Source: Matilda Education Australia

▲ **Source 3:** Global population density

Learning Ladder 3.11

Characteristics of places and environments

1. Source 3: Identify the regions of the world with higher rates of population density.
2. Why do urban settlements tend to grow faster than rural ones? Provide examples.
3. What natural features and characteristics tend to influence human settlement?
4. How might human settlements have a negative impact on the environment?
5. Debate: "As cities grow larger, the benefits for people outweigh any environmental negatives".

Environment

1. List five different types of dwellings.
2. How would life in a tall apartment differ from life on a farm?
3. Source 2: What is a slum? Why might they develop in urban areas?
4. Why is zoning used for settlements as they develop and expand?

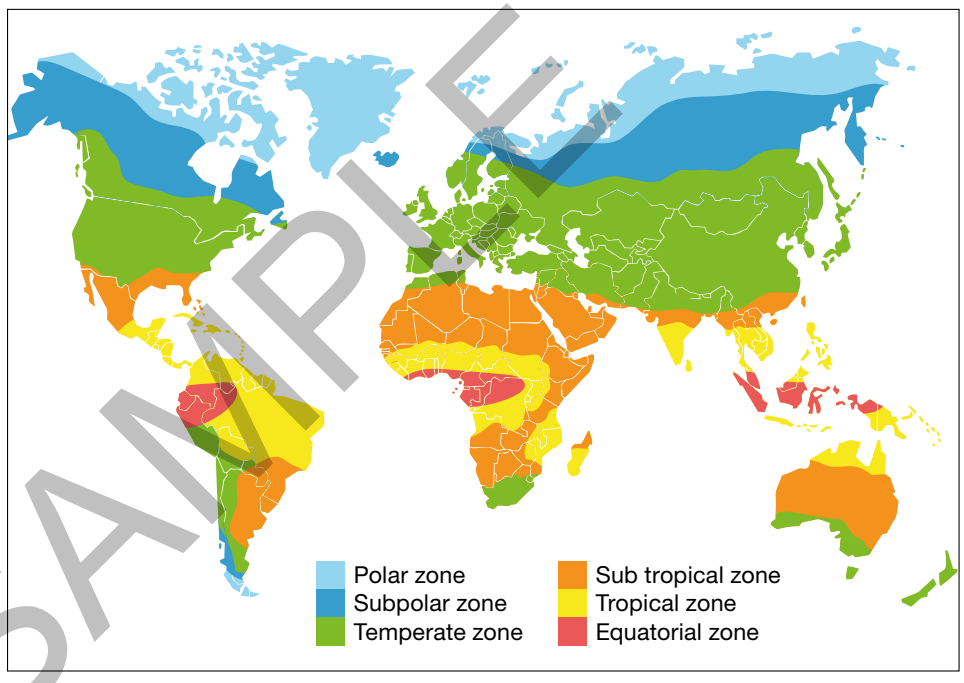
HOW TO Environment, page 414

What are the differences in settlement patterns between Australia and Canada?

Settlement patterns vary between countries for reasons such as climate, topography, population density and land use. Australia and Canada show different settlement patterns because of differences in their physical environments and land use.

Australia has an area of 7 741 220 square kilometres and a population of 26.6 million. It is the world's sixth-largest country. Canada, the world's second-largest country, extends across 9 984 670 square kilometres and has a population of 40.1 million. Both are very large countries with low population densities, with Australia averaging 3.4 people per square kilometre, and Canada averaging four people per square kilometre. However, the distribution of population is uneven in each country, concentrated into large urban settlements with large areas of unoccupied land. Source 1 shows the location of Australia and Canada and the global climate zones. The uneven distribution of settlements in Australia and Canada can be seen in Sources 2 and 4.

World climate zones



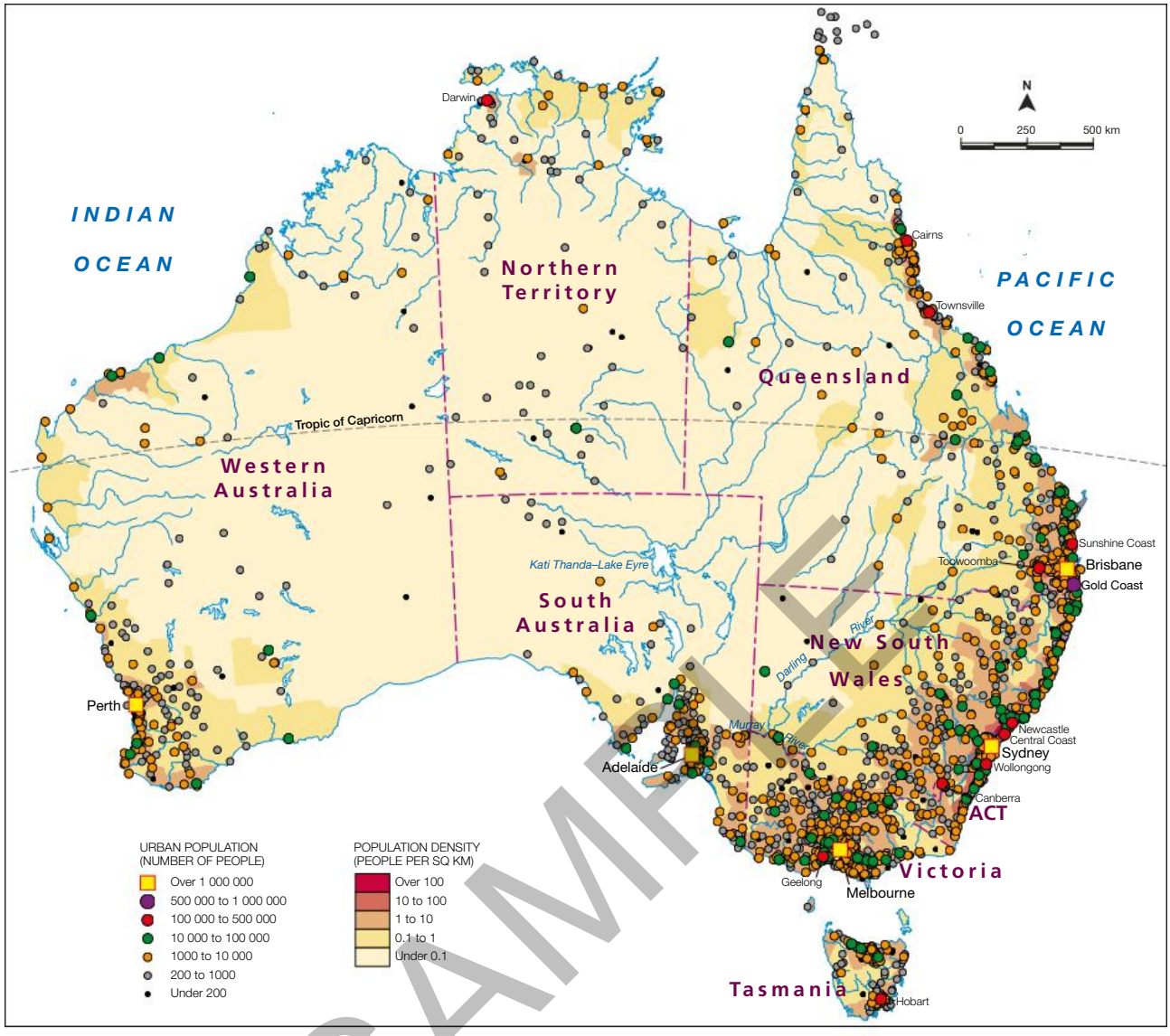
Source: Adobe/Siberian Art

Source 1: The location of Australia and Canada in relation to world climate zones.

Physical influences on settlement: Australia

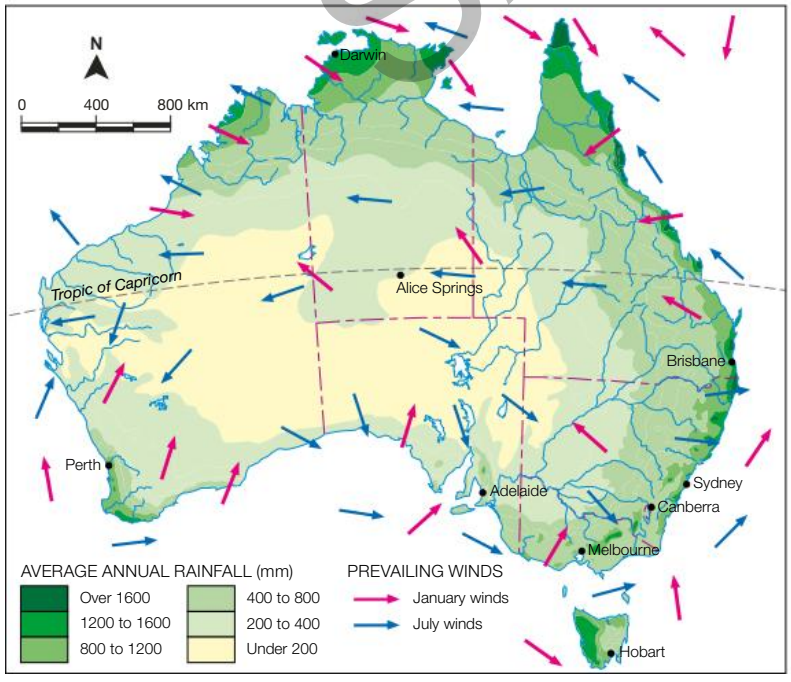
Australia is a large island that extends from 10 degrees to 43 degrees South of the equator. This latitudinal extent means that there are large variations in temperature between the north, where the climate is tropical (hot), and the temperate south where it is cooler. Three climate zones for Australia are shown in Source 1. The shape of the Australian continent means large areas of the inland are a long distance from the ocean and experience very dry conditions. This effect is known as 'continentality'. In Western Australia this dryness extends to the coast because of the influence of cold ocean currents on evaporation rates and precipitation. Rainfall is high in the east and south-east due to the orographic effect of the Great Dividing Range. In the north the rainfall is seasonal, with distinct hot and wet, and hot and dry, monsoon seasons. Source 3 illustrates how rainfall across most of Australia declines further inland from the coast, resulting in large areas being classified as desert, receiving less than 250 millimetres of rainfall each year. Australia is the world's driest inhabited continent, where a lack of water reduces the capacity of the land to support people and agriculture. Moving inland from the coast, agriculture changes from intensive to extensive crop growing and livestock raising. The wettest areas support rain-fed and irrigated crop growing. The settlement pattern seen in Source 2 is a response to these influences.

Australia population density and distribution



Source: Macmillan Global Atlas

Australia annual rainfall



Source: Macmillan Global Atlas

Source 2: Distribution of settlements and population density in Australia

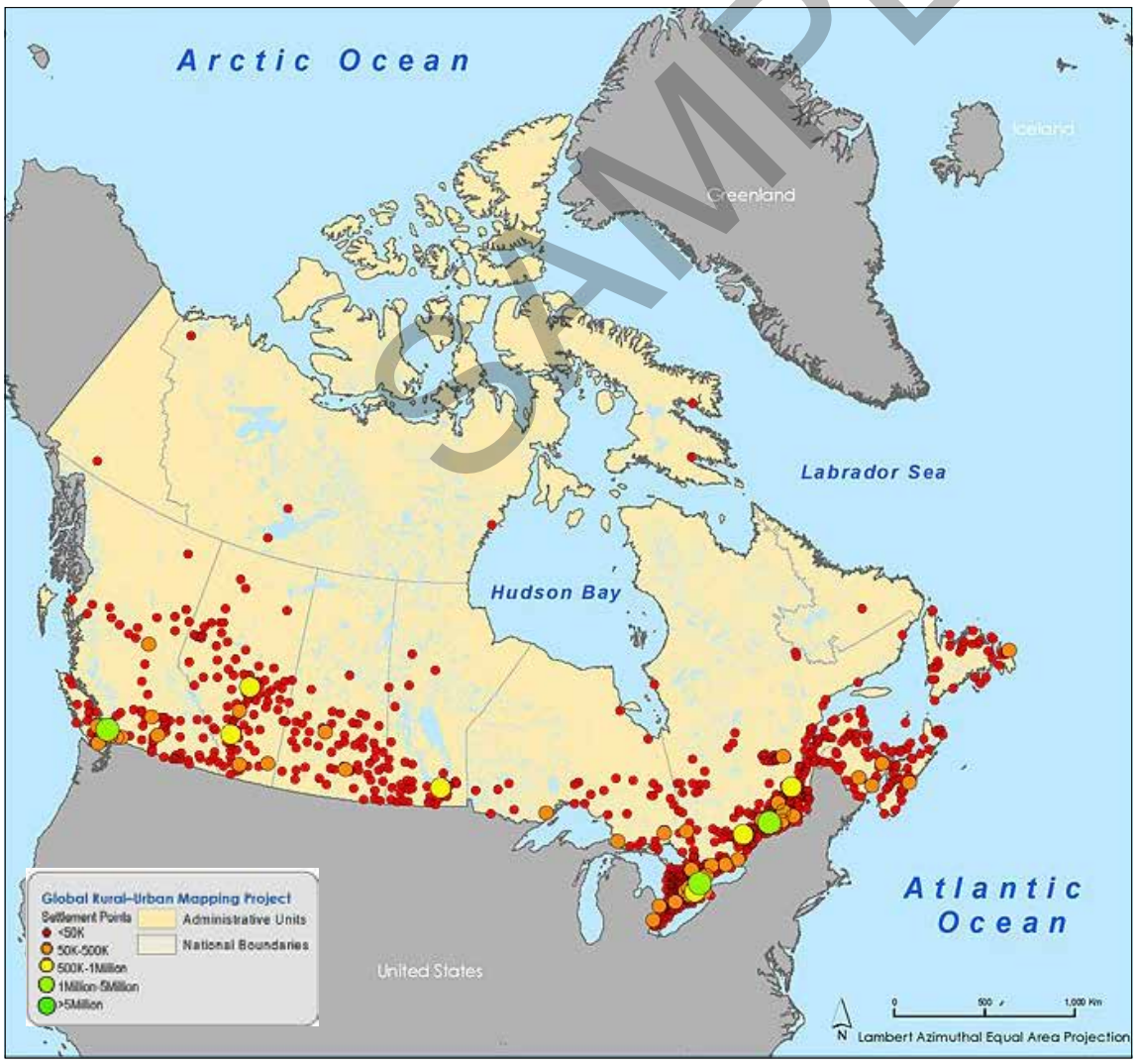
Source 3: Australia's rainfall distribution

Physical influences on settlement: Canada

Canada also has a large latitudinal extent from 42 degrees North to over 83 degrees North; however, the variation in temperatures ranges from temperate in the south to polar in the north, a large frozen wasteland for most of the year, and almost uninhabitable (Source 5). Settlements are concentrated in the temperate region along the border with the USA and in the south-east where the largest settlements developed along waterways that extended westward from the coast. Ottawa, the capital, Quebec and Montreal are large cities in this region. Canada has more fresh water than other country in the world, with 9 per cent of the land covered in water. It has over two million lakes such as the Great Lakes on the border with the USA. The St Lawrence Seaway in the east connects the Atlantic Ocean to the Great lakes.

The Rocky Mountains in the west are a source of precipitation and rivers that flow inland and to the coast. Rivers such as the Bow River flow eastwards from the Rocky Mountains through the prairies. Here, agriculture supports large inland towns such as Calgary (Source 5) and Edmonton. Large areas of Canada remain covered in forest and only 6.8 per cent of the land is used for agriculture. Much of this is in the prairies, large flat plains formed by glaciation in the last ice age, where livestock are grazed and grains such as wheat and maize are grown. This compares to 52.9 per cent of Australia that is agricultural land. Australia is a flat country due to a lack of mountain-forming processes, being on a tectonic plate. Temperatures have the greatest influence on Canada's settlement pattern, and precipitation and water availability on Australian settlements. Both countries have large areas considered remote – they are a long distance from services and facilities and often lack transport connections.

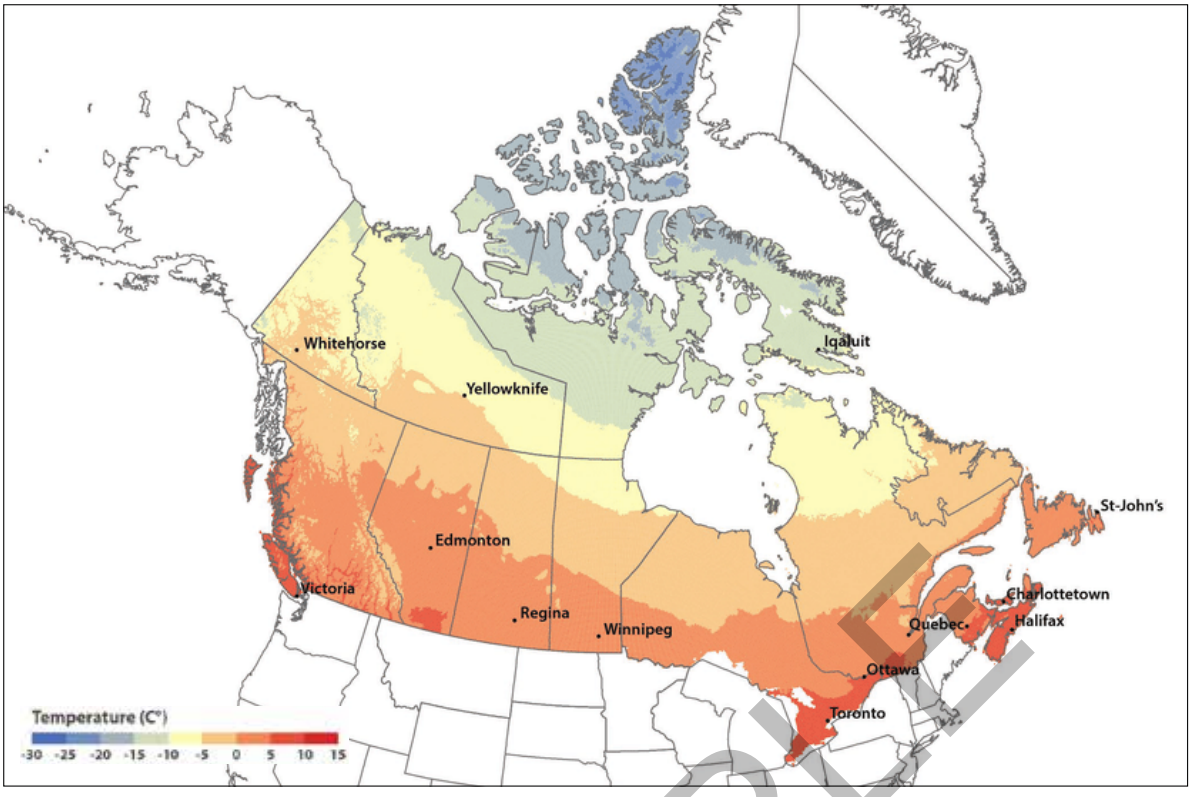
Distribution of settlements in Canada



Source 4: Distribution of settlements in Canada

Source: CIESN

Canada's average temperatures



Source 5: Canada's temperature variations

Source: Matilda Education Australia

Concentration in large cities: Australia

In 2024 more than two-thirds of Australia's population lived in its eight capital cities with an average population density of 300 people per square kilometre. In Australia, capital cities:

- are the largest city in each state and dominate the settlement pattern
- are coastal cities and ports dating to the colonisation of Australia by the British from where settlement expanded outwards
- absorb most of Australia's population growth because migrants, the main source of Australia's population growth, arrive and stay in capital cities, reinforcing the pattern of concentration
- have developed large metropolitan regions of towns and satellite cities around them.

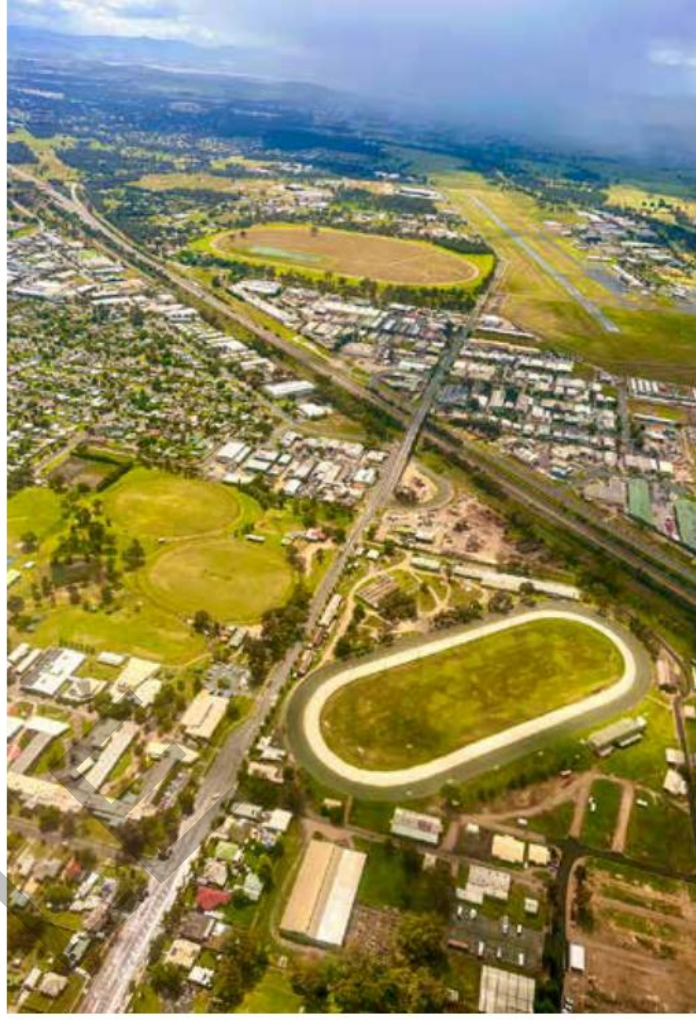
In south-east Queensland, for example, an urban region extends 240 kilometres from Noosa (north) past Brisbane to the Gold Coast and NSW border (south). In NSW, the urban corridor containing Sydney, Wollongong and Newcastle extends over 300 kilometres and contains Australia's highest population densities. In 2024, the Greater Metropolitan area of Melbourne became the largest city in Australia.

Australia has a small number of inland and coastal cities known as regional centres, which developed for specialised purposes such as manufacturing, ports and commerce. Examples include Newcastle (NSW), Cairns (Queensland) and Geelong (Victoria). Inland cities serve large rural hinterlands, such as Bendigo (Victoria), Mount Gambier (South Australia), Dubbo (NSW) and Toowoomba (Queensland). The growth of inland regional centres, such as Wagga Wagga, is often at the expense of small rural towns. Growing regional centres absorb people from surrounding smaller settlements, attracted by access to facilities, services and employment. During the COVID-19 pandemic, there was an exodus of people from large cities into regional centres, which has boosted their populations.

Concentration in large cities: Canada

Canada exhibits a similar concentration of population and settlements. Its largest cities date back to colonisation by the French and British and the development of port cities such as Montreal, Toronto and Vancouver. Over 80 per cent of Canada's population live in only 10 per cent of the country, with the most densely settled areas and largest cities in Canada developed on the best agricultural land. Many of Canada's large inland cities are larger than those in Australia, but like Australia there are large urban corridors such as Quebec to Windsor in the east; Vancouver to Victoria in the west; and between Edmondton and Calgary in the interior.

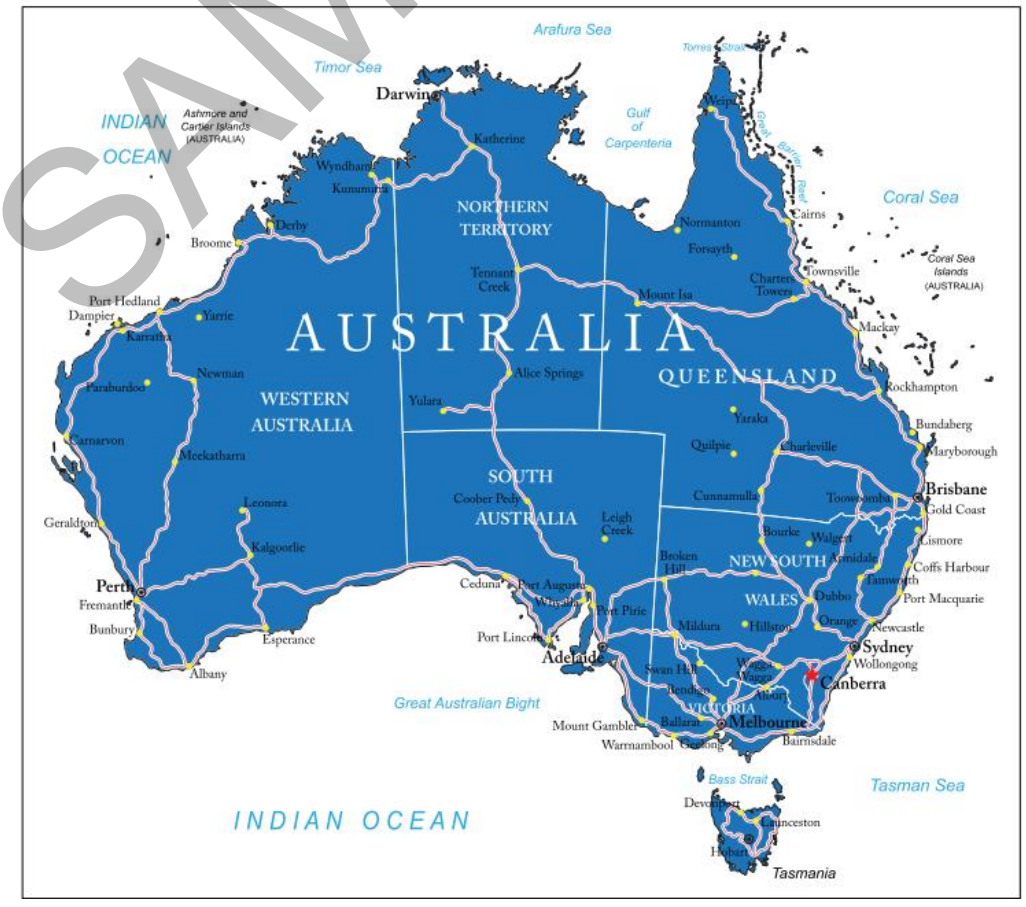
Source 6: Calgary is a large inland city situated on the Bow River that flows eastwards from the Rocky Mountains in Canada. The city is known as 'Cowtown' because of the rich grazing land surrounding the settlement. Albury-Wodonga is a large urban region on the NSW–Victorian border serving a large agricultural region.



The influence of transport connections

Sources 6 and 7 show the network of major roads in Canada and Australia. The relationship between transport and settlement patterns can be clearly seen when compared to Sources 2 and 4.

Australia's road network.



Source 7: Australia's road network

Source: Adobe Stock/bogdanserban

Canada's highways

Source: Adobe/lesniewski

Source 8: Canada's highway system

Learning ladder 3.12

Characteristics of places and environments

1. Identify two similarities between Australia and Canada.
2. Source 1: Describe the different climate zones in Canada and Australia.
3. Sources 2 and 4: Explain why parts of Australia and Canada are sparsely settled.
4. Analyse the influence of agricultural land on settlement patterns in Australia and Canada.
5. Sources 7 and 8: Assess the role of road networks in reinforcing settlement patterns.

HOW TO Space, page 406

Space

1. Outline the average population density of Australia and Canada.
2. Explain the spatial distribution of settlements in Canada. Refer to physical and human factors.
3. Sources 2 and 4: Compare the spatial distribution of settlements in Australia to Canada.
4. Analyse the reasons behind the similarities and differences between the distribution of settlements in Australia and Canada.
5. How would warming temperatures affect distribution patterns between Canada and Australia differently in the future?

3.13

What are the opportunities and challenges of megacities?

Urbanisation is leading to the development of more megacities – cities with 10 million people or more. Most megacities are found in Asia, where fast-growing cities are causing headaches for planners.

Where are megacities?

Megacities are cities with populations above 10 million. In 2011, there were 22 megacities in the world, and according to the United Nations there will be 43 by 2030. One in eight people lived in one of the world's 33 megacities in 2023..

Nearly 60 per cent of all megacities are found in Asia, including the five largest. Tokyo in Japan is the world's largest city, with 37 million people; if it were a country, the city would be the 31st largest in the world. New York City is the largest city in the United States, yet it is only 48th most populous in the world. Australia is the only habitable continent without a megacity.

Challenges of megacities

Megacities experience high population density, presenting a variety of challenges. Governments and organisations find it difficult to provide services and resources, or build and maintain infrastructure to support large populations. This can lead to a large number of homeless people, a lack of employment opportunities, limited water and electricity services, high traffic congestion and poor air quality. For example, New Delhi in India has 34 million people and is increasing in population by 700 000 each year. Since 2005, the government built 43 000 new homes for the poor, but in that same time the population rose by 10 million people. This has led to communities developing informal settlements, called slums, that lack clean water or toilets. This is a challenge experienced by many megacities in the world, including Sao Paulo in Brazil, Cape Town in South Africa and Lagos in Nigeria.

Source 1: Predicted population growth of the top 10 megacities, 2020 and 2035

City	2001	2025
Tokyo	37 m	39 m
New Delhi	23 m	33 m
Shanghai	20 m	28 m
Mumbai	20 m	27 m
Mexico City	20 m	25 m
New York	20 m	24 m
Sao Paulo	20 m	23 m
Beijing	16 m	23 m
Dhaka	15 m	23 m
Kolkata	14 m	19 m

Source: Source: United Nations

Source 2: Tokyo is currently the world's largest megacity, but the United Nations predicts that it will be overtaken by New Delhi in 2028.

Megacities of the world

Source: Matilda Education/United Nations

▲ **Source 3:** Megacities of the world – including three of the biggest: Tokyo, New Delhi, Shanghai and Jakarta.

Opportunities of megacities

Having high-density populations can make it easier for governments to centralise their services, allowing more people to access them. This includes developing effective public transport that can limit the need for cars; as seen in Tokyo and New York. Services such as education are also easier to provide, as children are close to schools and there are enough people to be employed as teachers and administration. During the COVID-19 pandemic, although the high density of populations in megacities enabled the disease to spread quickly, it was also easier for health organisations to provide vaccinations to large groups of people quickly.

▲ **Source 4:** A crowded street in Dhaka, the world's most densely populated megacity.

Learning ladder 3.13

Characteristics of a range of places and environments

1. What is a megacity?
2. Use PQE to explain the spatial distribution of megacities in the world.
3. Source 4: Explain the term 'density' with reference to the population of Dhaka.
4. Source 2: Contrast the foreground and background in this photograph. How has urbanisation changed the environment?
5. Discuss ways governments can capitalise on the opportunities of megacities, while reducing the challenges.

Place

1. Source 1: Where are megacities located on the North American continent?
2. Source 1: Rank the megacities according to the largest population increases from 2001 to 2025.
3. Source 2: Which natural landforms made this an ideal place for a large city?
4. In 2023 Australia had a total population of 25.7 million people. The largest city is Melbourne with 4.9 million people. Contrast Australia to our closest neighbour, Asia.
5. How do the challenges and opportunities of megacities influence their character?

HOW TO

Place, page 408; PQE, page 430

Case study

What are the challenges of living in the megacity of Mumbai?

Mumbai is a megacity with more than 25 million people. Traditional and innovative solutions for housing, traffic congestion, waste management, and healthcare are required to deal with the the pressures of a rapidly growing population.

Informal settlements

Although the proportion of the urban population living in slums (or **informal settlements**) in the developing world declined from 39 per cent in 2000 to around 24 per cent in 2023, the global number of slum dwellers could reach a billion by the middle of this century. In megacities like Mumbai, this challenge is often starkly evident and highlights the increasing inequality between rich and poor. In 2000 Mumbai slum residents protested against an airport expansion that would see 85 000 families lose their homes.

Urban planning and the investment of millions of dollars in new infrastructure will be needed to prevent the creation of new informal settlements and to lift millions out of poverty.

Informal settlement of Dharavi

In the Mumbai suburb of Dharavi, seen in the movie *Slumdog Millionaire*, some 5000 businesses and 15 000 single-room factories produce an estimated annual revenue of over US$700 million, despite lacking the mainstream resources and support of established brands and multinationals. In recognition of its unique recycling and upcycling industries, King Charles himself once referred to the suburb as 'a role model in sustainability'.

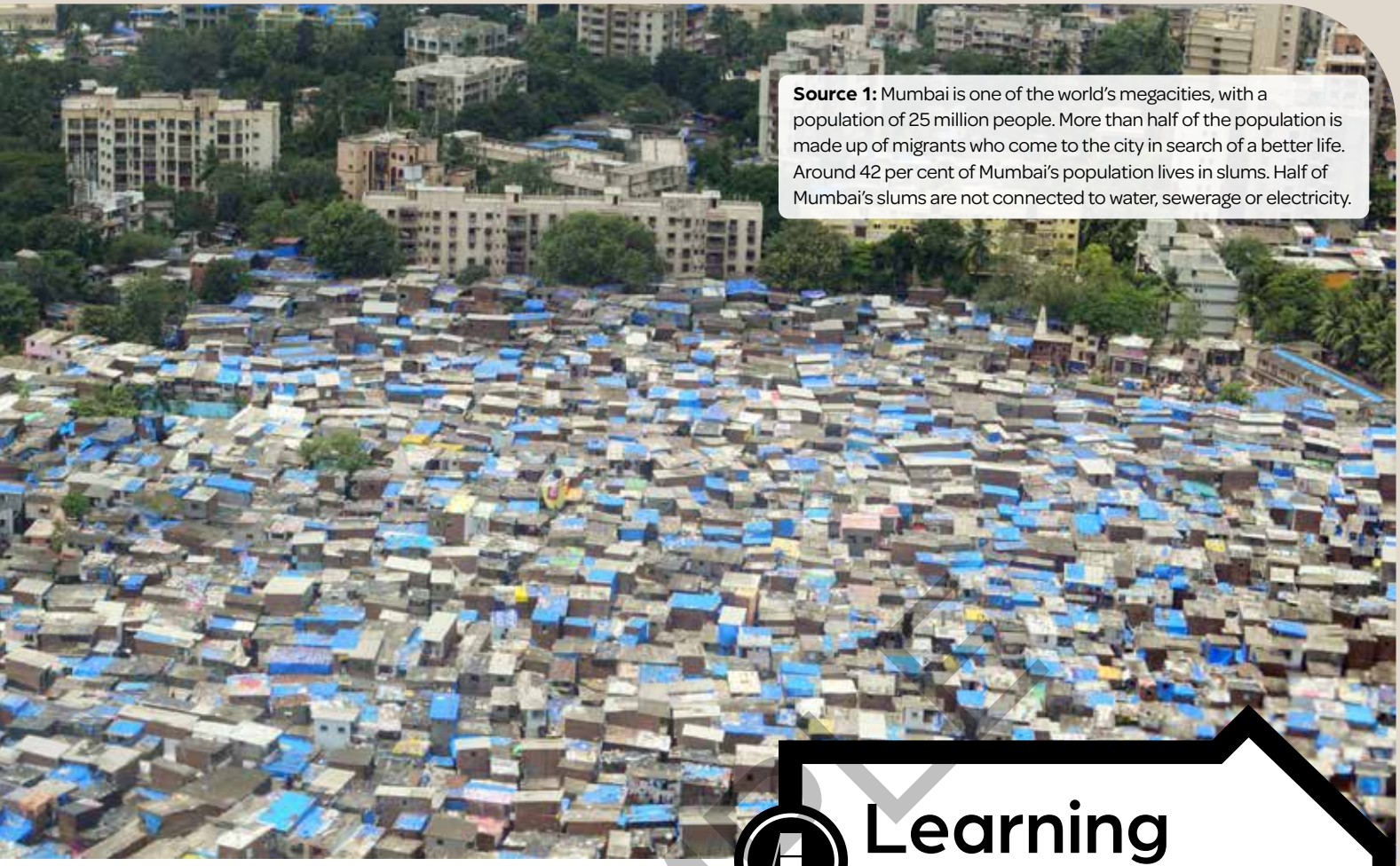
Suburbs like Dharavi have often emerged over time in a vacuum resulting from rural-urban migration and a lack of housing infrastructure, basic facilities and urban planning; the population in the slum is estimated to exceed more than one million people, with a population density in excess of 275 000 people per square kilometre, the highest in the world.

As demand far exceeds supply, informal settlements spread and, in the case of Dharavi, informal economies emerge, creating employment through street vending, recycling and the production of materials such as clay bricks and pots. Shops, schools, health clinics, ATMs and gyms can all be found in Dharavi, as well as electricity. Despite this, life can be both unpredictable and unstable; the dilemma for authorities is how to preserve the economy and livelihoods at the heart of Dharavi while also improving living conditions and providing services.

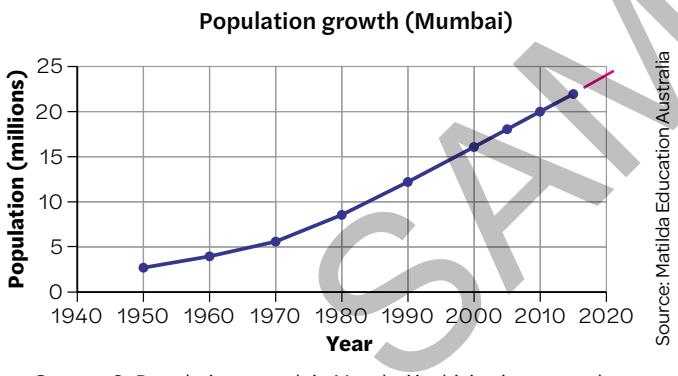
Strategies to improve lives

In informal settlements around the world such as Dharavi, governments continue to look for solutions to help people improve living conditions:

- Slum clearance and redevelopment – a drastic solution involving significant public expenditure in providing housing and/or changing the land use to drive slum dwellers away. In 2023, Gautam Adani, one of India's richest men, flagged an ambitious plan to revitalise the area through investment in one of the largest urban renewal schemes in the world.
- Upgrading infrastructure – providing sanitation, water, electricity, waste disposal and paved streets improve living conditions in informal settlements.
- Urban planning – zoning to minimise or mitigate the establishment and growth of slums is ideal, but a significant challenge in established urban areas.
- Legal tenure – providing opportunities for slum dwellers to own their home.
- Microcredit – facilitating small loans, through charitable groups like Kiva, to provide locals with a means to improve their own lives.



Source 1: Mumbai is one of the world's megacities, with a population of 25 million people. More than half of the population is made up of migrants who come to the city in search of a better life. Around 42 per cent of Mumbai's population lives in slums. Half of Mumbai's slums are not connected to water, sewerage or electricity.



Source: Matilda Education Australia

▲ **Source 2:** Population growth in Mumbai is driving issues such as housing, traffic congestion and waste management.

▲ **Source 3:** Thriving businesses have emerged in Dharavi, creating employment for people living in informal settlements.

Learning ladder 3.14

Characteristics of places and environments

1. What issues are facing Mumbai as the population quickly grows?
2. Source 1: Describe how Mumbai differs from most Australian cities.
3. How does the growth of informal settlements, such as Dharavi, affect the environment?
4. Consider the strategies listed in this spread and rank them in terms of which are more likely to improve the lives of Dharavi's residents.

Place

1. Using Google Earth or an atlas, describe the relative location of Dharavi.
2. With reference to the text and sources, identify five geographic characteristics of Dharavi.
3. How might the characteristics of Dharavi be influenced by its population density and its informal nature?
4. Why do you think recycling is so prevalent in Dharavi? What factors contribute to this?

HOW TO

Place, page 408

3.15

What is it like living in remote places?

Source 3: The Navajo are native to Monument Valley, a remote region on the Utah/Arizona border of the United States. They live in small settlements on or near their traditional lands.

2007 was a milestone year for humanity; the point where, for the first time, more people lived in cities than outside them. However, beyond the growing waves of rural–urban migration, many people still live in semi-rural and rural areas, including quite remote places.

Remote places are often defined as such by their physical distance from other locations, such as the island of Tristan da Cunha in the middle of the Atlantic Ocean, thousands of kilometres away from land, or far-flung scientific outposts in places like South Georgia Island or Svalbard. Other locations are remote based on their accessibility in terms of landforms and landscapes, such as the dense tropical heart of the Amazon Rainforest, the snowy taiga of the Russian Far North or the scorching heat of Australia's Gibson Desert.

Life in a remote place is a stark contrast to an urban environment, population density is generally extremely low and the people that live there are more likely to live a lifestyle of subsistence and grow, hunt, harvest or trade their own food. Access to education and healthcare, including immunisations and maternal support, can be very limited in remote locations, as can access to infrastructure prevalent in urban areas, including internet access, electricity and sewerage systems. Outside goods and services that can be sourced tend to be very expensive, leading to ongoing challenges; in 2017 the life expectancy for Indigenous Australians in remote areas was 65.9 for men and 69.6 for women, compared to a national average of 80.7 and 83.7 for urban Australians (Australian Bureau of Statistics).

Earth's most remote settlement – Tristan da Cunha

Source: xxxxxx xxx xxxxxx xx xxxx xxxxxx xxx xxxxxx xx

▲ **Source 1:** The isolated UK Overseas Territory of Tristan da Cunha is the world's most remote human settlement. It is inhabited by less than 300 people.

The vast majority of the people who live in remote areas around the world are indigenous – such as the Pintupi (Australia), the Awá-Guajá (Brazil) and the Nenets (Russia) – and draw on traditional knowledge, wisdom and customs to survive in landscapes where others cannot, even as climate change and species loss continue to threaten these often unique biomes. Such peoples often hold strong cultural and spiritual ties to their lands, like in Pilbara Country in northwestern Australia. The pursuit of natural resources and minerals from local and multinational companies can further threaten the way of life of people in many remote parts of the world.

Source 2: Each spring and autumn, the Nenet herd their reindeer up to 1000 kilometres between their winter pastures in the taiga forests of Russia and their summer pastures well above the Arctic Circle. Herders establish temporary settlements during these long migrations.

Learning ladder 3.15

First Nations Peoples' interaction with Country

1. List different types of remote places where indigenous peoples around the world live.
2. Sources 2 and 3: Describe how some indigenous peoples have adapted to their environment.
3. How might an indigenous connection to Country be linked to the location itself?
4. What challenges do people, especially Indigenous Peoples, face living in remote areas?
5. Why should governments recognise the traditional owners of lands before considering development or resource extraction?

Place

1. Source 1: Locate Tristan da Cunha and describe its relative distance from nearby locations.
2. Select one of the locations mentioned in this spread and describe its physical and human characteristics.
3. Select one of the indigenous peoples mentioned in this spread, how is their lifestyle and culture linked to the place in which they live?
4. What are the major differences between life in a remote place and life in an urban area?
5. Evaluate the advantages and disadvantages of living in a remote place.

Place, page 408

HOW TO

What is the importance of living in Barkindji Country?

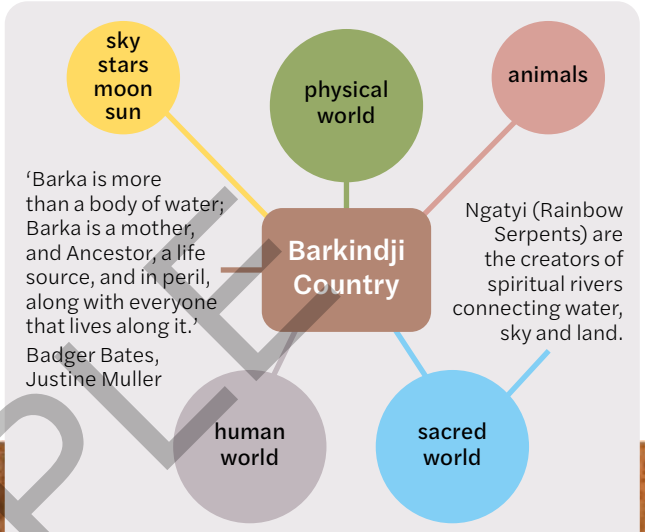
Remote Aboriginal communities struggle to be supported despite having genuine needs of cultural wellbeing and nourishment from kinship and spiritual connections to Country.

Barkindji Country

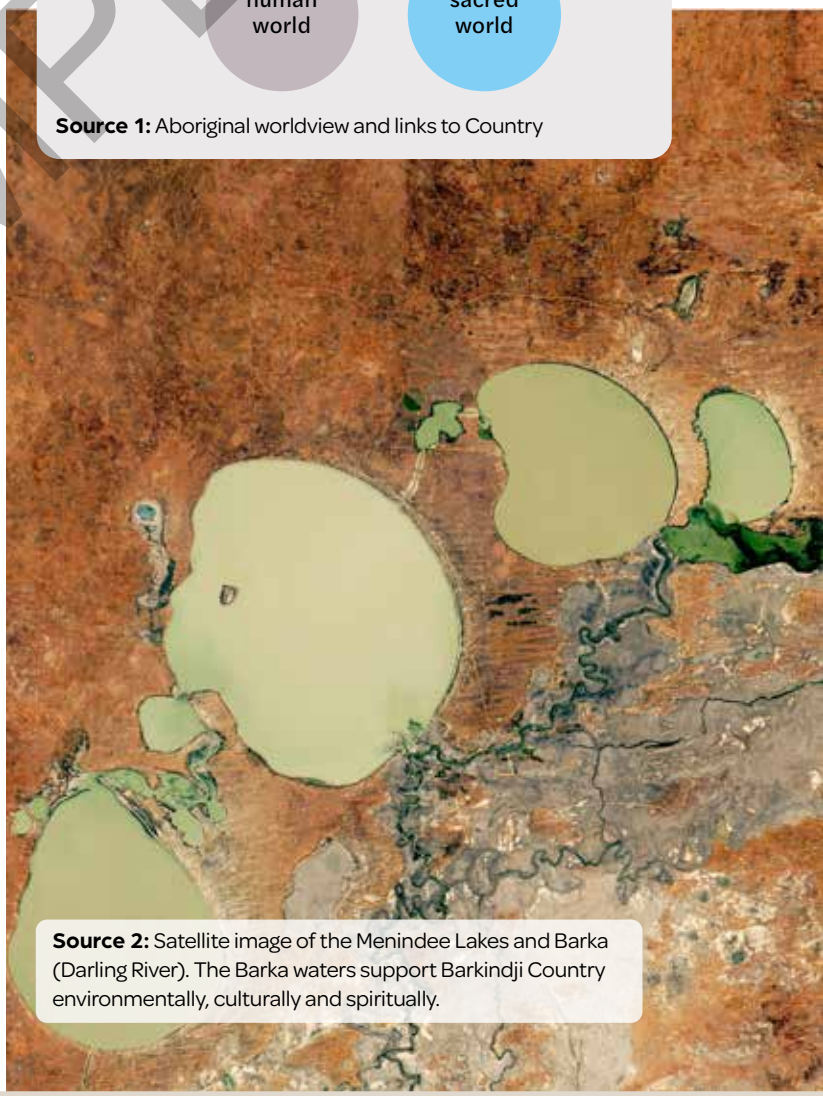
Wilcannia is one of the small NSW towns located in far west New South Wales. It is situated on Barka (Darling River), 195 kilometres east of Broken Hill. For many people, this town with a population of only 452, is not the first choice for liveability – but for the Barkindji Peoples this place is home. This place holds stories of the surrounding Ngiyampaa, Mutthi Mutthi peoples who with the Paakantyi/Barkindji Aboriginal people have lived on these remote NSW lands for millennia.

The waterways and Country hold stories within the unique landscapes, including spiritual connections which unites these communities. These long-held connections to Country are marked by the world's oldest ritual burial sites, and 20 000-year-old human footprints at Mungo lakes. The site where Mungo man and Mungo woman are located tell both a geographical story of a once inland lake, and First Nations people's long connection to water of the past. In more recent times, a new story of how such a site became known globally as a World Heritage listed site with UNESCO has also begun to be told. Mungo lake is now dry, however, for many centuries the waters came and went, and this allowed the local communities to move up rivers to other parts of Country where water was more plentiful.

Between 1836 and 1890 the colonial practices of overstocking land with cattle and sheep caused the Darling River and Willandra Creek water supplies to often dry up. This made the liveability of this Country unattractive to many non-Indigenous people, but Aboriginal communities continued to stay because this was their place, their stories, and the place of their Dreamings. Nagatyi (the Rainbow Serpent) connects this Country in far western NSW to stories and communities across the Australian continent.

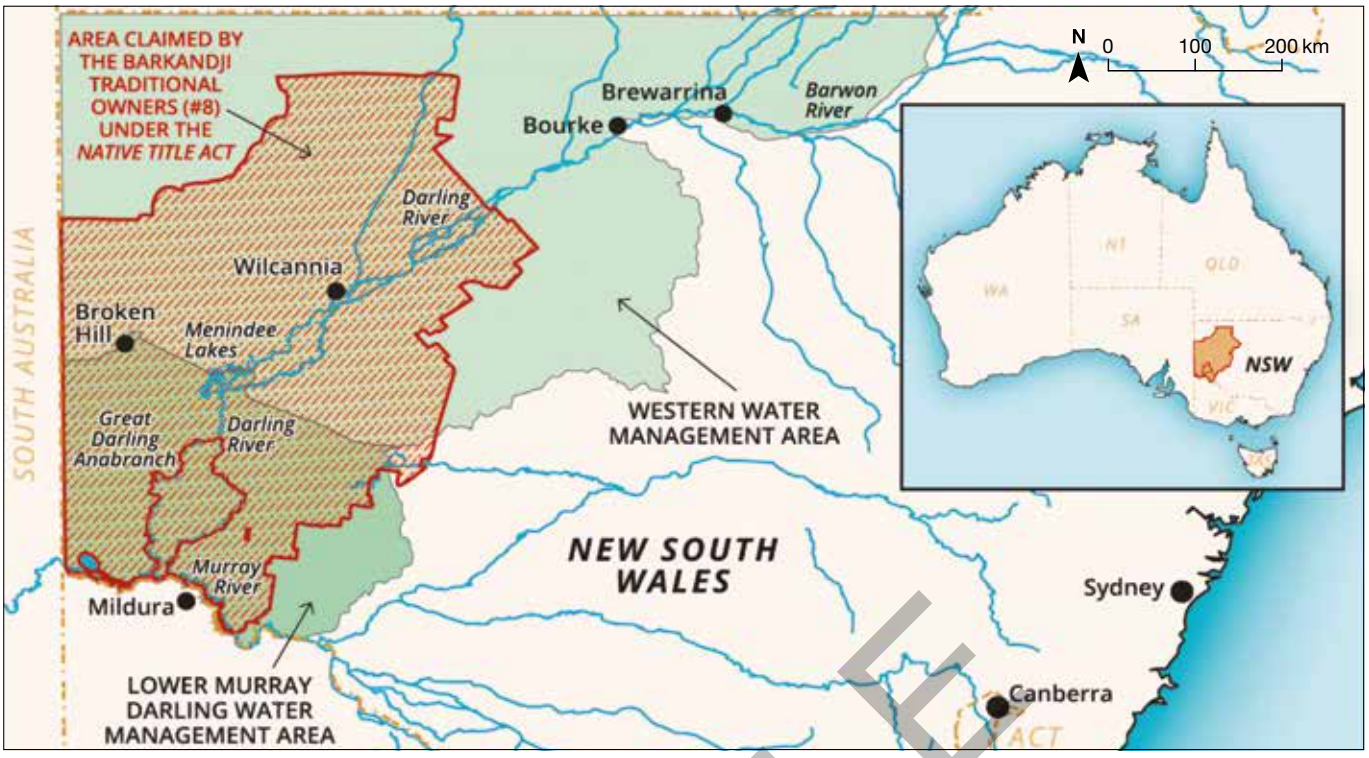


Source 1: Aboriginal worldview and links to Country



Source 2: Satellite image of the Menindee Lakes and Barka (Darling River). The Barka waters support Barkindji Country environmentally, culturally and spiritually.

Lands of the Barkandji people



Source: LD Hartwig, S Jackson, N Osborne.

▲ **Source 3:** Map of western NSW showing the Barkandji (Barkindji) Traditional Owners native title claim area and the water management

Learning ladder 3.16

First Nations Peoples' interaction with Country

1. Source 2: Why is Barka important to the Barkindji people?
2. Why is Wilcannia liveable for the Paakantyi/Barkindji people?
3. Source 1: What do you think Paakantyi/Barkindji Aboriginal people's connections to land are based on the diagram and your own new understandings?
4. Analyse the challenges to liveability in the region following colonisation by Europeans.

Interconnection

1. Source 3: Which towns does the Barka (Darling River) connect?
2. Source 2: Explain the interconnection between Barka and fertile land in the satellite image.
3. Source 1: Explain the interconnections of Country to Barkindji people.
4. What impact do spiritual connections to the land have for First Nations Peoples in their views on the liveability of settlements?

HOW TO Interconnection, page 410

3.17

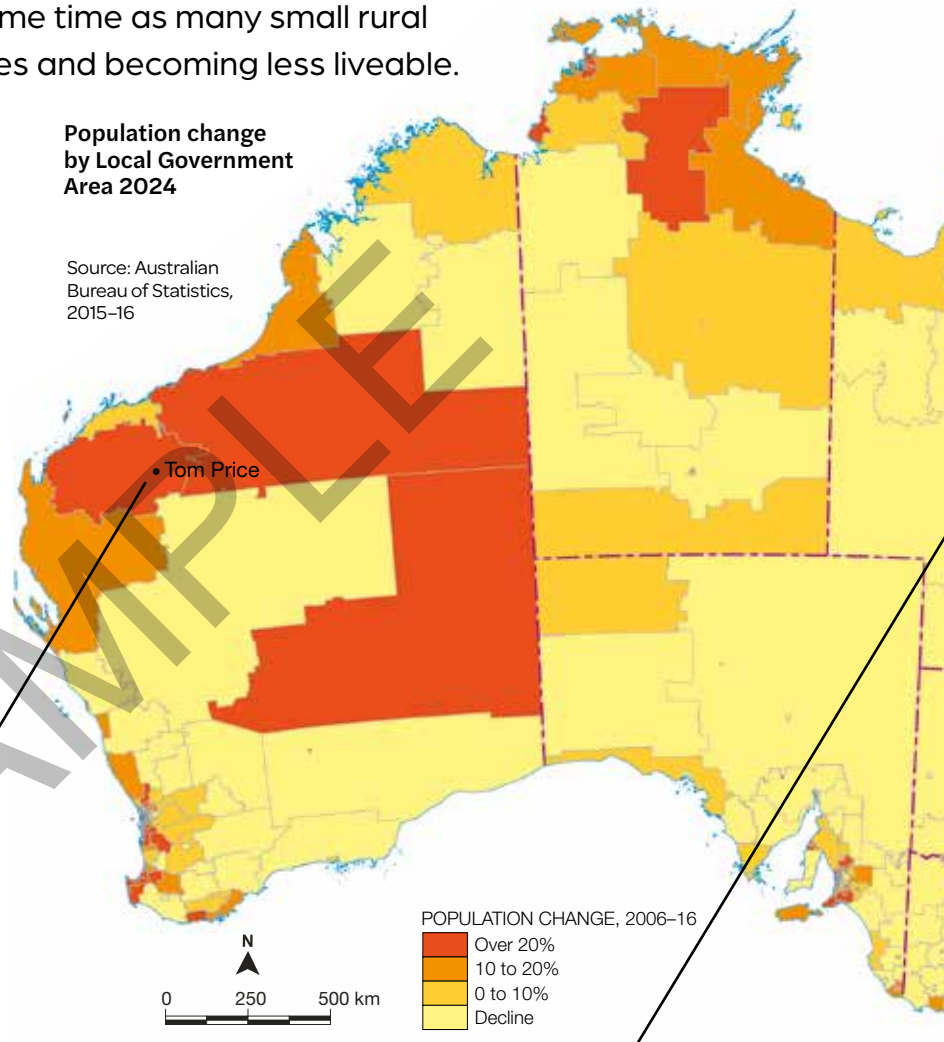
How do places change over time?

Growth areas on the **rural–urban fringe** of major cities are attracting thousands of new residents – at the same time as many small rural towns are losing population and services and becoming less liveable.

A simple way to measure the **liveability** of a place is to calculate whether it is growing or declining. Fast growing areas show there is demand – people want to live there. The fastest growing places in Australia are new housing estates on the edges of capital cities.

Growth and decline can also be linked to work opportunities, such as the rapid increase and decrease of populations in mining towns like Tom Price, in Western Australia. Small rural towns more than 100 kilometres from capital cities represent many of Australia's declining populations. Tough farming conditions have forced many farmers off the land; in turn, this forces shops, schools and hospitals in nearby country towns to close.

Source 1: Percentage of population growth by region, 2006–2016

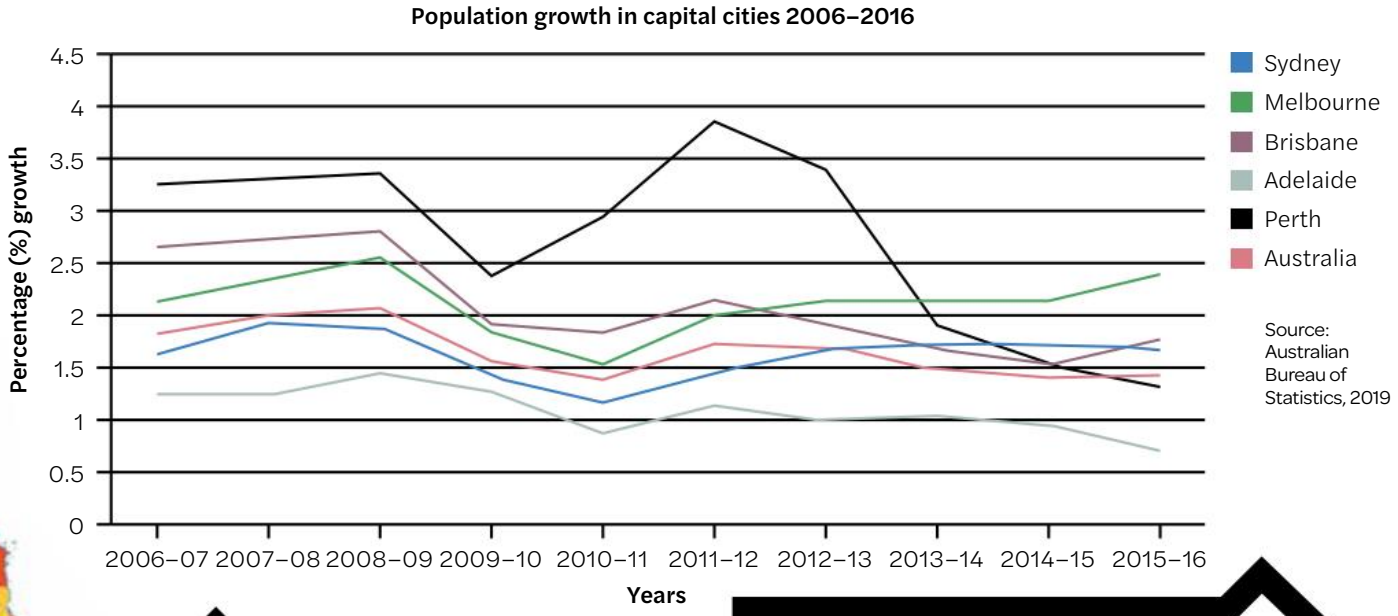


Tom Price

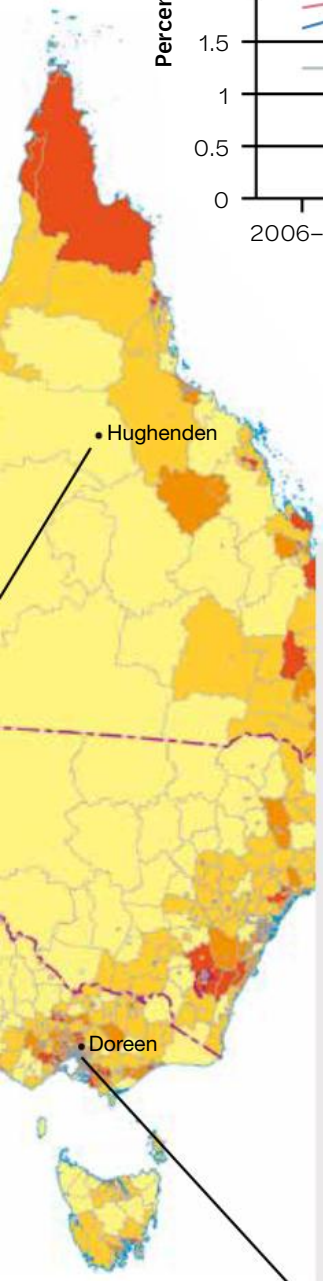
The mining industry has driven growth in places such as Tom Price, a town in Western Australia. The population of Tom Price grew by 85 per cent during the 2006–11 mining boom. Then, as the mining boom ended, the population declined by 50 per cent between 2011 and 2016. In 2023 the Estimated Resident Population was 3,233.

Hughenden, Queensland

Hughenden is a small town in outback Queensland. It has lost half its population in the last 50 years. Hughenden is a service centre for the surrounding agricultural areas, but businesses have closed as people have left the town – and one of the businesses to close was the Grand Hotel. The town is hopeful that a recent discovery of dinosaur bones will bring tourists to the area.



Source 2: Population growth in Australian capital cities, 2006–16



Learning ladder 3.17

Processes that transform people, places and environments

1. Source 1: Which key factor is driving change at Tom Price – environnmental, social, economic or technological?
2. Why are places with growing populations more liveable and those with declining populations less liveable?
3. Source 1: Where are the fastest growing places in Australia and why are people attracted to these places?
4. What impact is declining populations having on remote rural communities such as Hughenden?

Change

1. Source 2: Which capital city had the greatest change in population due to internal migration and natural increase?
2. Source 1: Describe the changes that took place between 2011 and 2016 in Doreen.
3. Source 1: Explain why population changes in Tom Price occurred between 2006 and 2016.
4. Source 1: What are the environmental and social implications of the quickly expanding suburb of Doreen?
5. Source 2: What impact do you think the steep increase and decrease of the population would have on the city of Perth? What actions might be taken to cater for the change?

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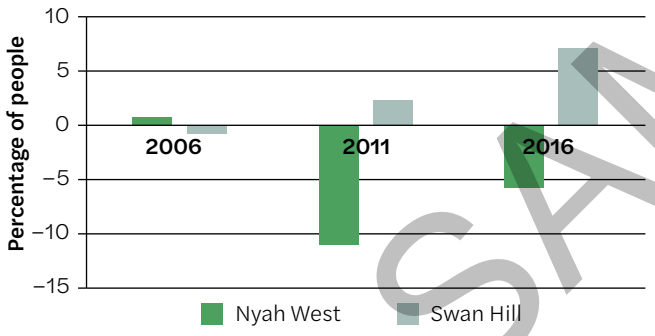
Case study

What is the impact of Nyah West's declining population?

Nyah West is a small town in north-western Victoria, near the New South Wales border. It was established in 1915 when the railway was extended from Swan Hill, and it has since supported the surrounding irrigated farms that produce wine, dried fruit, vegetables and wool.

Many farmers sold up and moved away after a long drought and falling prices for dried fruit. Like many small rural towns in Australia, Nyah West is losing its people to larger cities such as Melbourne and to the nearby 'sponge city' of Swan Hill, which soaks up the populations of smaller surrounding towns as they lose their services. Nyah West lost several government services and all of its banks in the 1980s and 1990s. These are all now available in the growing town of Swan Hill, just 20 minutes away.

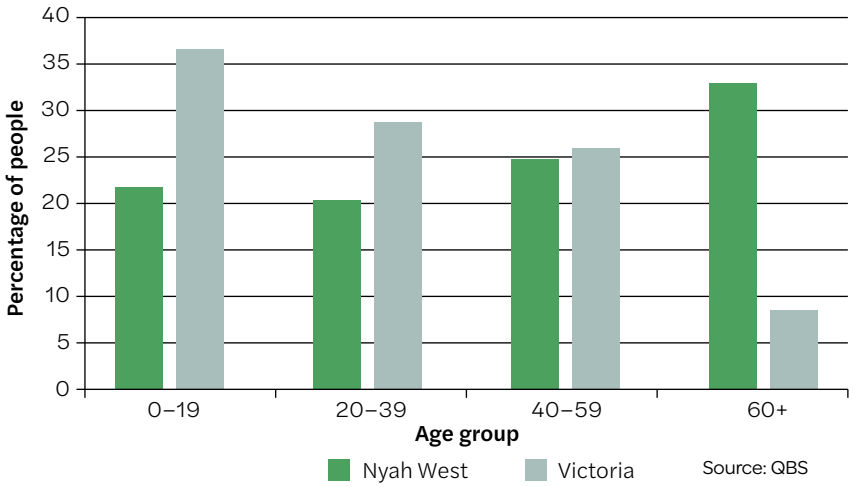
Population change in Nyah West and Swan Hill, 2006–21



Source 1: Population change in Nyah West and Swan Hill, 2006–21

Source: QBS

Age groups living in Nyah West and Victoria in 2021



Source: QBS

▲ **Source 2:** Age groups living in Nyah West and Victoria, 2021

Source 3: Swan Hill offers a wide range of services for its residents and the local region.

▲ **Source 4:** Vacant shops line the main street of Nyah West, a declining town in Victoria's Mallee region. Only three of the 20 shops in the main street are still open. Once it had three more cafes, three supermarkets, two hairdressers, a baker, a gunsmith, a bank, three doctors and a nursing hospital. The primary school is still there, but has only half of the 100 pupils it once had.

Learning ladder 3.18

Processes that transform people, places and environments

1. Source 1: What changes took place in Nyah West between 2006 and 2021?
2. Source 4: What evidence of a declining population is there on the main street of Nyah West? How does this make a place less liveable?
3. Source 3: What features of Swan Hill make it a liveable city?
4. Source 1: Compare the population change in Nyah West and Swan Hill between 2006 and 2021 and suggest why this pattern has occurred.

Interconnection

1. Source 4: Is there an interconnection between closed shops and a declining population?
2. Source 2: One impact of population decline in Nyah West is its ageing population. Use the data to explain this pattern and suggest the services Nyah West might need to support this population.
3. Source 3: How far do Nyah West residents go now to access services they once had in their town? What alternatives do they have?

HOW TO

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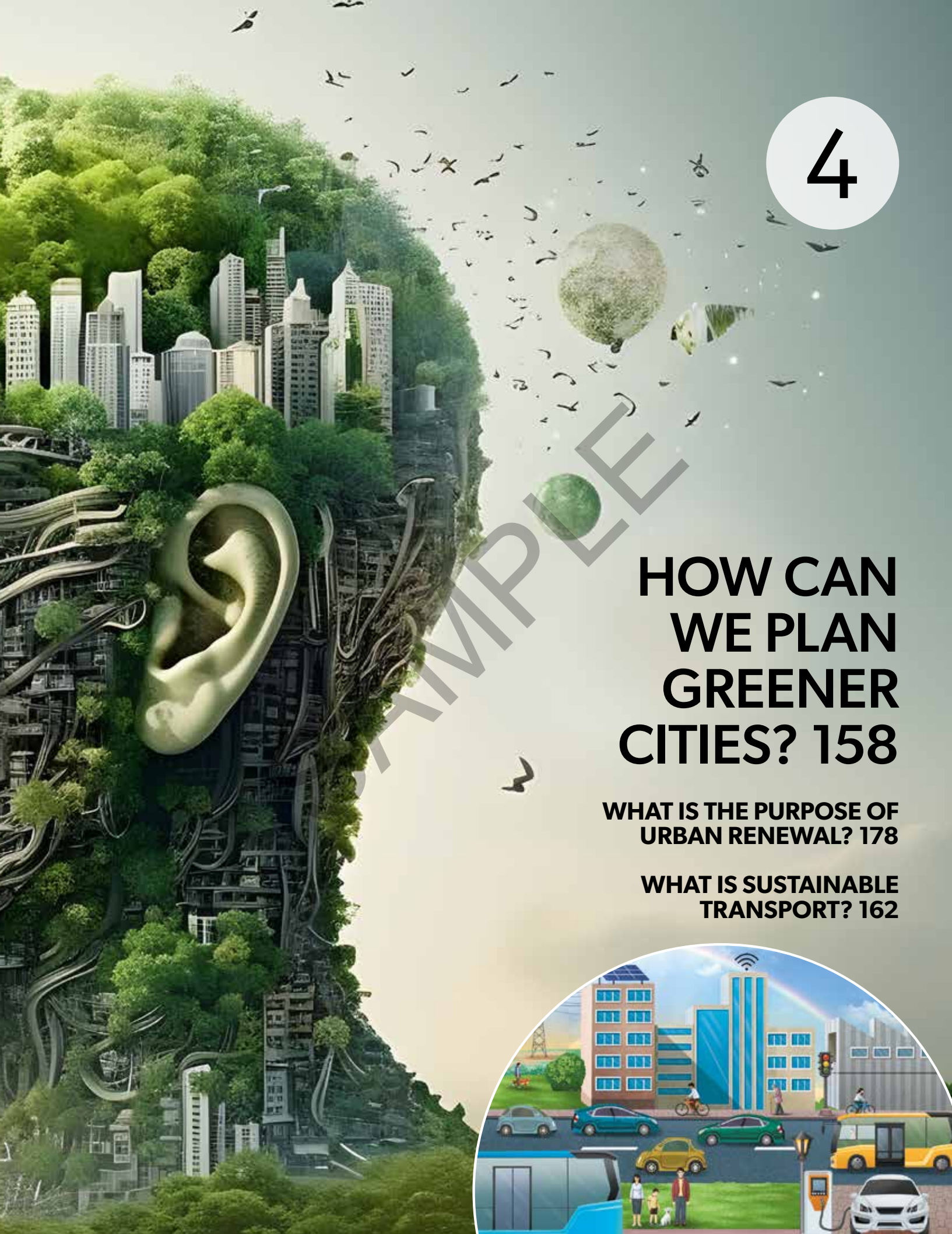
Sustainable urban planning



4

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4.0

How can I understand sustainable urban planning?

As the populations of Australia's urban areas continue to rise, issues such as housing shortages, traffic congestion and pollution are creating problems for urban planners to solve. Future urban planning requires strategies that promote sustainability such as urban renewal, higher density housing and energy saving and greening measures.

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 toward the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.
	Outcomes					Geographical tools and inquiry

Source 1: CopenHill in Copenhagen, Denmark, is an an energy plant that runs on rubbish rather than fossil fuels.

I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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 inter-connections.	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.	4
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 geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical 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 social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
I can describe a place.	I can describe spatial distribution.	I can summarise the characteristics of environments.	I can describe inter-connections.	I can describe processes at a range of scales.	I can describe sustainability.	I can describe change.	1
Place	**Space**	**Environ-ment**	**Inter-connection**	**Scale**	**Sustain-ability**	**Change**	Steps in skill progression

Geographical concepts

4.1

How do we plan for urbanisation?

Governments need to plan far into the future to successfully manage Australia's growing urban populations. Redevelopment of underused areas and encouragement of people to move to regional areas help authorities deal with rapid urbanisation.

Population growth

Australia is one of the world's most highly urbanised countries, with three in every 10 people living in Sydney or Melbourne. In 2023, Australia's population reached 26.5 million and Melbourne overtook Sydney as Australia's largest city with a population of 4.9 million people.

Australian cities have low population densities compared to cities in other countries. Montreal in Canada has the same population as Sydney, but covers only a third of the area. Cities in Australia contain unused or poorly used space that could be redeveloped for housing through urban renewal.

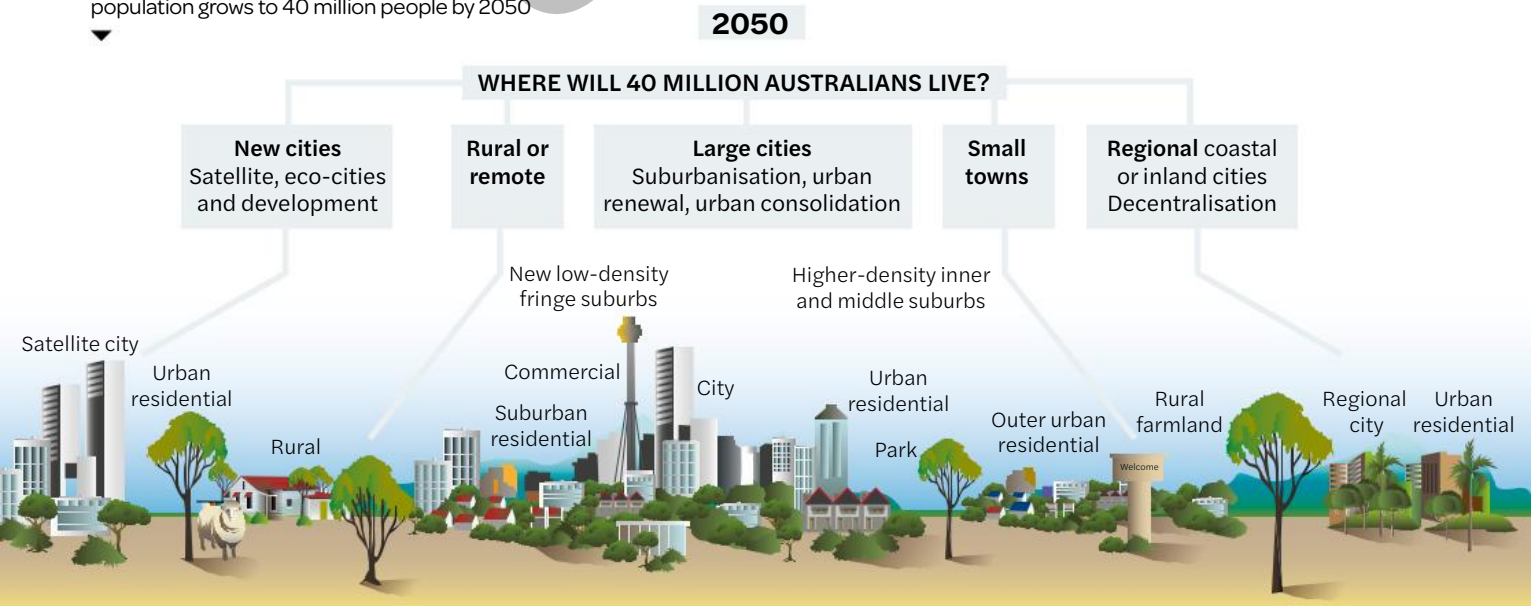
By 2050 it is projected that Australia will have a population of 40 million people. Nearly all of the growth will come from international migration and more than 70 per cent of this growth is likely to be in the major cities. Melbourne and Sydney will each have populations of eight million and Brisbane and Perth will each have populations of more than four million.

Planning for urban growth growth

When planning for future urban growth, urban planners and governments consider four key trends:

- **suburbanisation** – where land on the city's outer edge is made available for housing. The suburbs grow outwards as new houses and services are constructed. Expanding cities through suburbanisation replaces natural environments or land previously used for farming.
- **decentralisation** – when people move from an urban area to a rural or coastal area to escape urban problems such as expensive housing, traffic and pollution. The decentralisation of the population helps take pressure off the urban centre.
- **urban renewal** – when people move back into inner city areas that have been improved through urban renewal to attract people who enjoy the advantages of being near the city centre.
- development of **satellite cities** – creation of new towns and cities, as well as eco-cities, for living hubs connected to nearby large cities by transport.

Source 1: Living options for Australians as the population grows to 40 million people by 2050



Source 2: Tengah is a new eco-town being developed on a brownfield site of an old brickworks and military training barracks in Singapore. The town will provide 42 000 new homes with substantial green spaces, centralised cooling and automated trash collection. Tengah will become Singapore's first car-free town and will feature a 100m-wide, 5km-long forest corridor linking it to the surrounding green network.

Finding suitable urban sites

Urban planners define three different types of sites that can be researched for potential urban development:

- **greenfield** – agricultural or open land site located in the urban fringe that supports standard suburbanisation as low-density single houses on large blocks of land or new medium density eco-city satellite developments that are ecologically sustainable and connected to major cities
- **brownfield** – redeveloping commercial and industrial buildings or sites for higher-density housing. This uses existing infrastructure and facilities, such as old factories or a new development on an old site.
- **greyfield** – redeveloping existing commercial strips for medium-to-high-density housing, usually in conjunction with new transport hubs. Urban villages are created, including facilities such as shops and employment.

Learning ladder 4.1

Processes that transform people, places and environments

1. Define the term 'suburbanisation'.
2. What are the four key trends that governments need to consider when planning for large population growth in an urban area?
3. Source 1: Compare the benefits and challenges of two living options for Australia as the population climbs.
4. Analyse the benefits and drawbacks of suburbanisation, decentralisation and urban renewal.

Change

1. How is Australia's population projected to change between 2023 and 2050?
2. What changes occur through urban renewal?
3. What change occurs in a greyfield site? Why do you think the change occurs?
4. Source 2: What dramatic change is proposed in Tengah in Singapore? What key factors are driving this change?

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4.2

How can we design sustainable cities?

Sustainable cities aim to satisfy the economic and social needs of residents with the smallest ecological footprint. This involves creating compact and walkable cities, reducing natural resource use and waste and making communities safe, healthy and attractive places to live.

Sustainable cities

Cities can reduce their ecological footprint through creating more public green spaces, reducing waste, greater use of renewable energy and smart planning of infrastructure to make facilities easy to access. Some key trademarks of sustainable cities include:

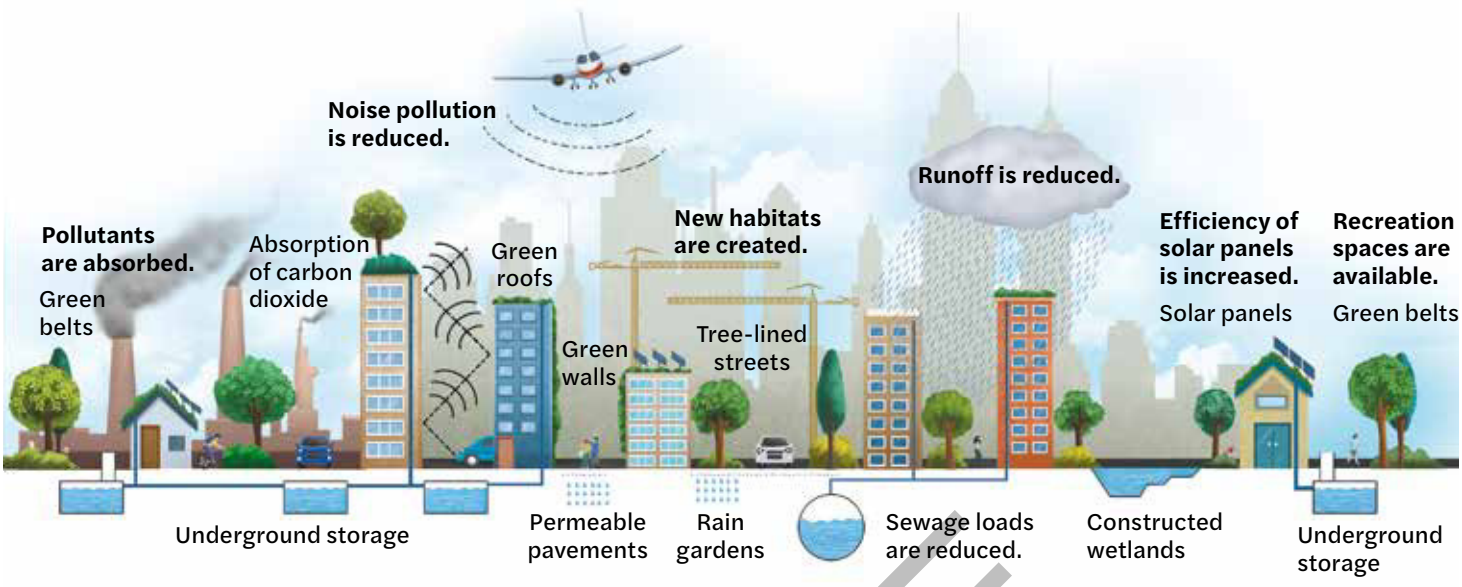
- Greening of buildings through vertical gardens and access to larger public green spaces
- Walkable and bikeable neighbourhoods
- Greater use of electrified public transportation
- Vehicle charging stations for electric vehicles
- Homes and public buildings are energy and water efficient
- Renewable resources are used instead of non-renewable resources
- Waste is seen as a resource and is recycled
- Food is sourced locally or grown organically in rooftop gardens

Sustainability at a variety of scales

The responsibility for achieving sustainability rests with organisations, businesses and individuals, while governments set targets, develop management plans and enforce regulations. Strategies are implemented at a variety of scales:

- **households and small businesses:** water tanks, recycling waste and using energy-efficient appliances.
- **public places:** planting trees, using energy efficient street lighting and building cycle paths to create liveable, cleaner communities.
- **suburbs:** building energy- and water-efficient urban renewal projects and housing estates to reduce the demand for natural resources
- **city:** installing public transport networks to reduce CO_2 emissions and improve access.

Source 1: Singapore is often referred to as 'garden city' with almost 50 per cent of land in urban areas given over to parkland. Plants are also prominent on building facades, interiors and rooftops. Green spaces reduce the heat island effect when an urban area absorbs and reflects solar radiation, increasing temperatures. Access to green spaces is also important for the physical and mental health of residents. Singapore has plans to plant a futher million trees to create green spaces that are within easy reach of all residential areas.



Source 2: Greening of cities includes the introduction of vegetation on roofs and vertical gardens on buildings and green belts of public space. Vegetation absorbs carbon dioxide emissions and improves the living conditions for people.

Learning ladder 4.2

Sustainable management strategies

1. Identify the three challenges for sustainable cities.
2. Explain how sustainability can be addressed at a variety of scales.
3. How has Singapore gained a reputation as the garden city?
4. Source 2: Outline the multiple benefits of greening cities.

Place

1. Using an atlas, state the location of Singapore.
2. Source 1: Describe the human and physical characteristics shown in this photograph.
3. Explain Singapore's approach to greening cities.
4. Select a suburb, town or city you live in or one located nearby and answer these questions.
   - **a** Do people walk, cycle or use public transport more than they use cars?
   - **b** Are there enough safe open spaces for people to enjoy? Are they easily accessible?
   - **c** Are renewable sources of energy used?

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Place, page 408

Case study

Why is Oslo the world's most sustainable city?

In the 2022 Sustainable Cities Index, Oslo, the capital city of Norway, was a clear number one. With around one and a half million residents, the city serves as a role model for many other cities around the world in terms of taking an active approach to sustainability.

Climate budgeting

Oslo's success is built on a system called climate budgeting; rather than make massive investments or sudden change, the local government conducts an annual review of areas where the city can reduce carbon emissions further. To date, this has included cemeteries, parking, schools, waste management, vehicles, zoning, public transport, and more. The idea behind climate budgeting is that small, constant changes work better to support sustainable objectives in a way that complements local communities. All these small steps help Oslo to work towards their goal of reducing carbon emissions by 95 per cent of their 1990 levels by 2030.

One of the cornerstones of Oslo's success has been the growing level of public awareness; as its citizens become more aware of the issues relating to climate change, they have a better understanding of the need for change and the parts that individuals can play in it.

Sectors with higher emissions	Actions and solutions
Private cars and vans	Increasing tolls and parking prices for non-electric vehicles. Creating zones where non-electric vehicles cannot enter.
Waste and energy supply	Oil-fired furnaces are now banned. Clean energy sources, notably hydroelectricity, are now increasingly used.
Construction machinery	Public works now use electric machinery. All municipal construction projects must be zero-emission by 2025.
Agriculture	School and office lunches shifting towards pescatarian or vegetarian, rather than meat-based meals.

▲ **Source 1:** A key part of climate budgeting is a multi-pronged approach to emissions reduction.

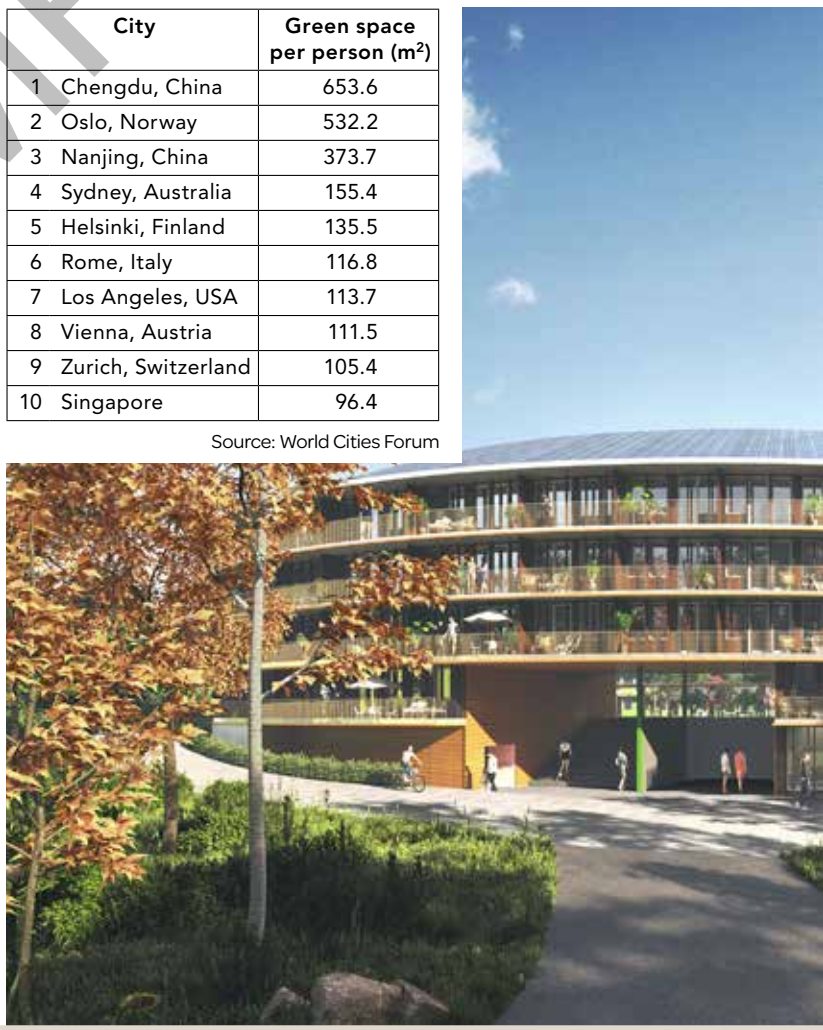
Green spaces

Re-greening is a priority, with a goal of planting an additional 100 000 trees across the city by 2030, and replacing many lawn areas – including cemeteries – with flower beds, attracting bees and other wildlife into the city. Today 47 per cent of Oslo is green space.

▼ **Source 2:** World's 10 greenest cities

	City	Green space per person (m^2)
1	Chengdu, China	653.6
2	Oslo, Norway	532.2
3	Nanjing, China	373.7
4	Sydney, Australia	155.4
5	Helsinki, Finland	135.5
6	Rome, Italy	116.8
7	Los Angeles, USA	113.7
8	Vienna, Austria	111.5
9	Zurich, Switzerland	105.4
10	Singapore	96.4

Source: World Cities Forum

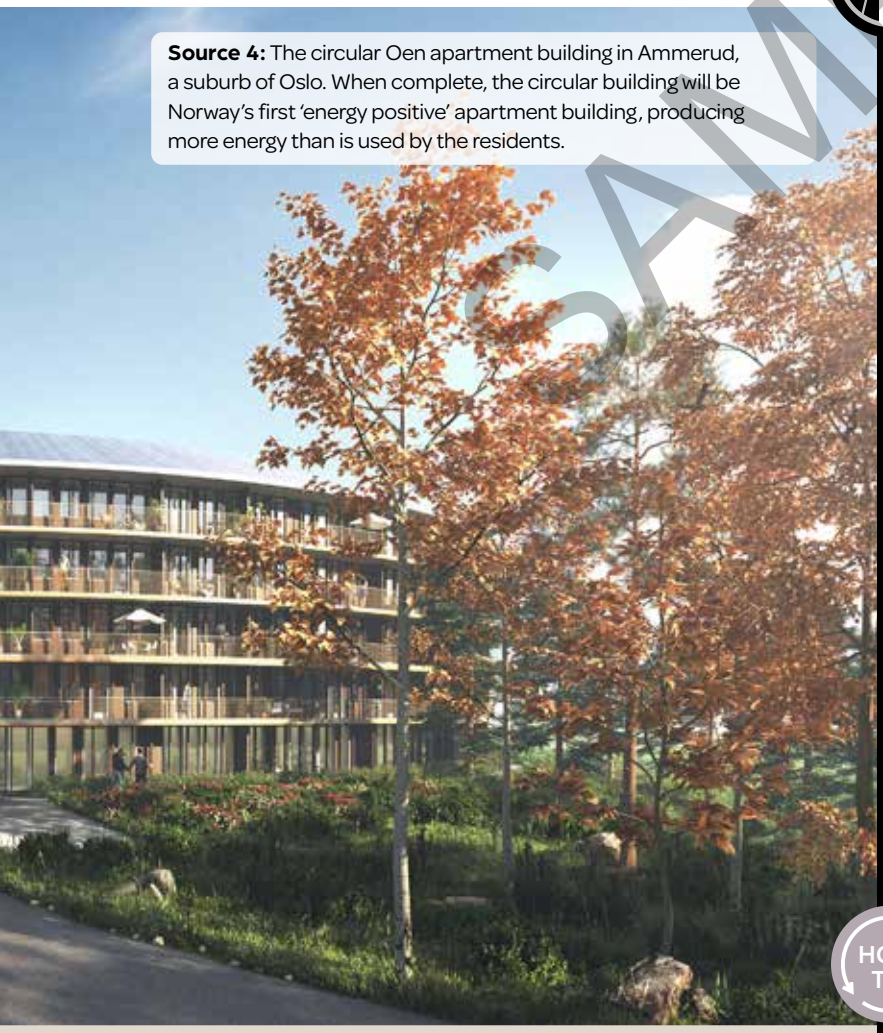


Transport

From 2009 to 2019, carbon emissions dropped by almost 20 per cent and purchases of electric vehicles surged. The city's entire fleet of buses is now entirely electric and the number of people in Oslo travelling by public transport, bicycle, and on foot is also increasing.

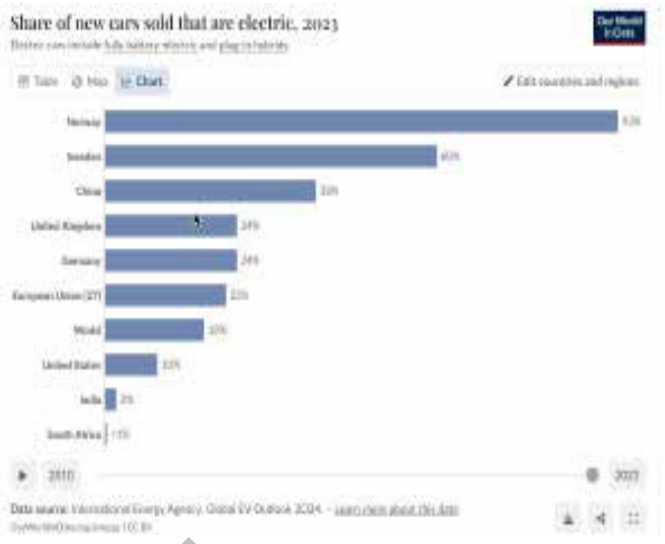
Oslo is now the electric vehicle capital of the world, with the highest proportion of electric cars and the most number of public charging stations per head of population. Heavy-duty vehicles run on biogas, produced locally from food waste and sewage.

Source 3: Charging stations in Oslo



Source 4: The circular Oen apartment building in Ammerud, a suburb of Oslo. When complete, the circular building will be Norway's first 'energy positive' apartment building, producing more energy than is used by the residents.

Global share of electric vehicles in new car sales, 2023



Source 5: Countries with the highest percentage of electric vehicles in new car sales 2018

Source: Our World in Data.

Learning ladder 4.3

Perspectives of people and organisations

1. Define 'climate budgeting'.
2. What incentives are there in place to encourage the use of public transport in Oslo?
3. In what ways do Oslo's sustainable changes affect its residents?
4. 'Oslo is prioritising the environment over economic growth.' To what extent do you agree?
5. Source 1: What restrictions have authorities placed on Oslo's population. What are the advantages and disadvantages of these restrictions from the perspective of the people?

Sustainability

1. List three sustainable practices used in Oslo.
2. Why is the city of Oslo re-greening?
3. Source 3: Explain why electric vehicles are increasingly popular in Oslo and what the benefits of this are for the environment.
4. Discuss why climate budgeting is an effective approach to sustainable environmental management.

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What is the future of sustainable transport?

Sustainable transport refers to the use of low emission, energy efficient forms of public and personal transportation to help lower carbon dioxide levels, reduce congestion and improve access to transportation for all.

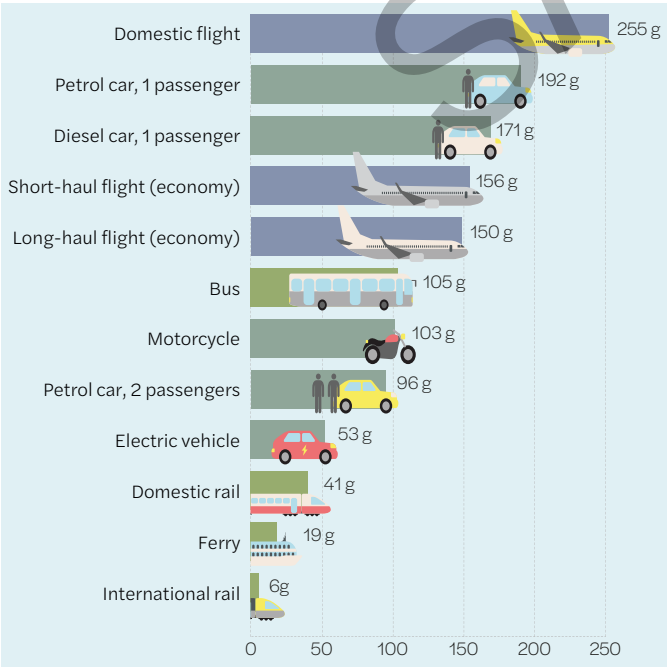
Carbon emissions from transport

Transport accounts for around 25 per cent of global carbon dioxide (CO_2) emissions. For short distances, walking or cycling have the lowest carbon output. Using trains for transportation instead of a car for medium-legth distances will reduce carbon emissions by 80 per cent.

Electric vehicles are the best choice to reduce emissions for private vehicles. They emit one-third of the amount of carbon dioxide that petrol or diesel powered cars send into the atmosphere. Powering an electric car from renewable electricity such as solar power, gives the greatest benefits.

Shorter aeroplane flights emit the greatest amount carbon dioxide emissions per passenger per kilometres travelled.

Carbon cost of transportation
(emissions per kilometre travelled)



Source: Alamy

▲ **Source 1:** CO_2 emissions from transport per passenger.

Sustainable transport options

Individual choice

From the perspective of an individual traveller, there are decisions you can make to reduce your transport carbon footprint:

- Walk, run or cycle wherever possible to also reduce pollution and improve health.
- Use trains or boats for longer trips.
- Car-sharing not only reduces CO_2 emissions, but also relieves congestion and pollution.
- Use electric rather than petrol or diesel cars.

Action of governments and organisations

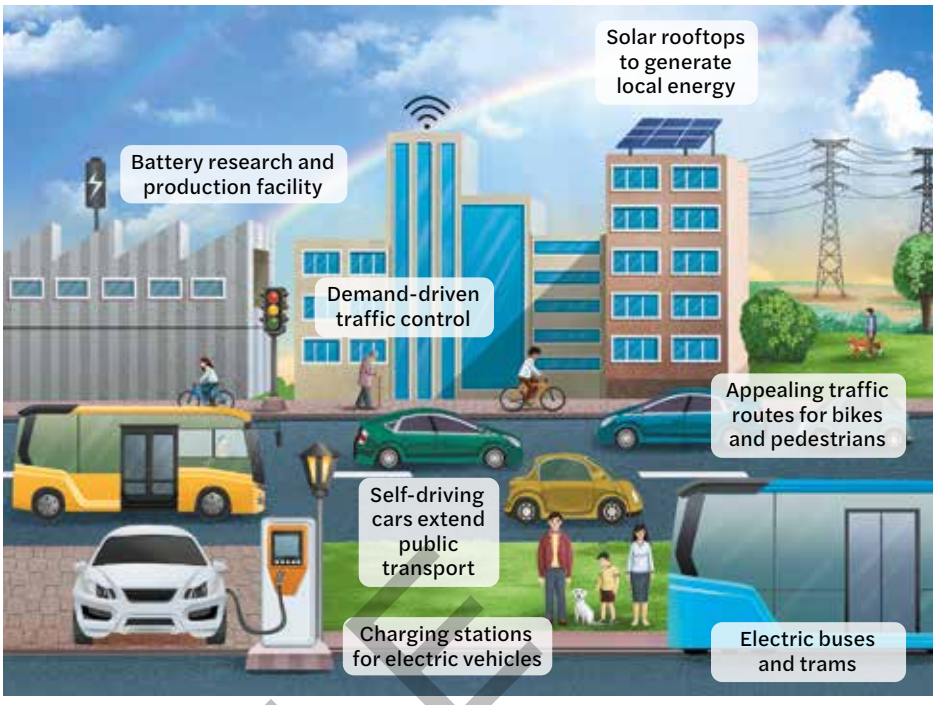
In the United Nations' 2030 Agenda for Sustainable Development, sustainable transport is seen as a key driver of growth and equity. Given that almost a quarter of global energy consumption and carbon dioxide emissions come from transport, it is essential that governments and councils prioritise transitions towards sustainable transport for their populations. In developing economies, providing equitable access to sustainable transport is also a challenge to ensure social harmony and opportunities for all.

Many of the most visibly proactive proponents of green public transport options are found in established economies like Finland, Germany and Canada, but balancing economic growth with both equality and sustainability is a global challenge. Moving towards sustainable transport in the future requires a range of initiatives and a global leader can be found in the Colombian capital of Bogotá, whose solutions have included:

- building 84 kilometres of bike lanes (ciclovias) and prioritising cycling as a form of transport
- repurposing 44 000 square kilometres of street space into pedestrian walkways and thoroughfares for foot traffic

- purchasing almost 1500 electric buses for public transport
- reducing tolls and restrictions for cars that carry more than two people, thus encouraging carpooling
- improving road safety by reducing speed limits and introducing a Kids First program to support children walking or cycling to school
- encouraging the use of e-bikes for the delivery of goods, particularly in high-density urban areas
- clean air initiatives that prioritise road repair, revegetating adjacent areas, restricting and fining defective or high-emission vehicles to reduce pollution
- bikesharing, with reduced rates for low-income earners, as well as hundreds of public bicycle repair stations.

Source 2: Bogotá has constucted special bike lanes on key thoroughfares and prioritised cycling as a form of transport.



Source 3: Sustainable transport options.

Learning ladder 4.4

Sustainable management strategies

1. List three issues that vehicles and transport create in urban areas.
2. What are three of the initiatives used in Bogotá to promote sustainable transport?
3. How might the initiatives in Bogotá support people from lower-income or marginalised communities?
4. To what extent can initiatives like those in Bogotá be implemented in a city like Sydney?

Interconnection

1. Describe the interconnection between transport and pollution.
2. How can sustainable transport improve social equity?
3. Source 2: Explain how the initiatives in this source contribute to reduced emissions.
4. Source 1: Use this source to create a radical new plan for sustainable transport in a major Australian city.

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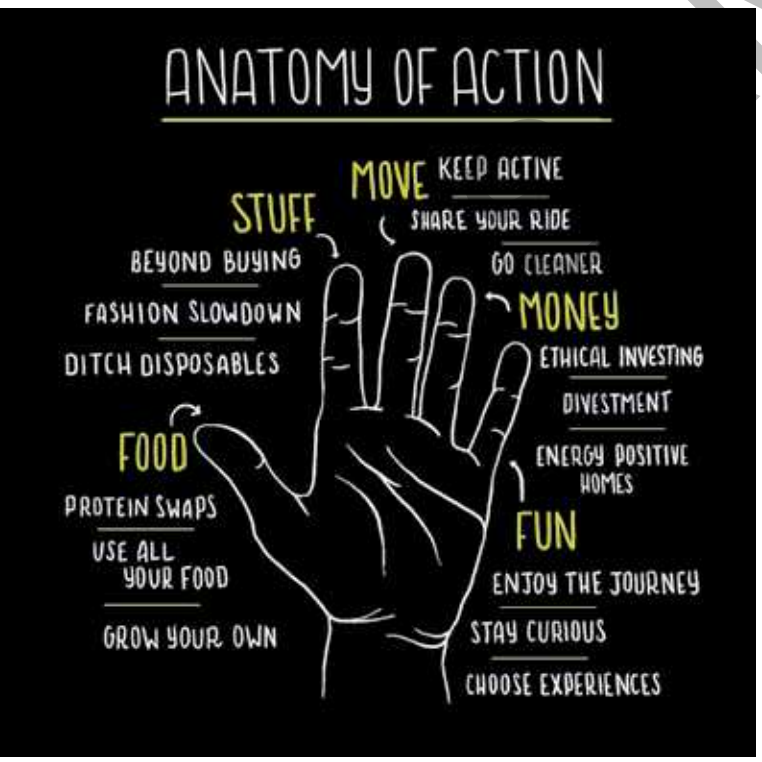
4.5

How can individuals enhance sustainability?

Making conscious changes to one's life can play a large role in supporting sustainability in a variety of senses, ranging from reduced emissions to improved wellbeing and a sense of being and belonging.

Individual action

There is a continuing view that climate change – and initiatives to combat it – is the challenge of governments and multinational corporations. The reality is that all individuals can play a role in enhancing sustainability. The United Nations has identified sustainable living as an increasing necessity for our planet; one that requires us to understand how our lifestyle choices impact the world around us. Given that the world's population may well reach 10 billion by 2050, it is important to note that global resources will be stretched even thinner and, as disposable incomes increase, so too does demand for goods and services.



Source 1: The Anatomy of Action is a United Nations-led initiative to promote sustainable living at an individual level, encouraging people to make a conscious effort towards action.

Promoting sustainability for individuals is done by the United Nations in a variety of ways, including the Anatomy of Action (Source 1), but a more detailed example is their Sustainable Lifestyles: Options & Opportunities publication, which focuses on six key domains, as shown in Source 3.

Source 2: Local farmers markets, such as this one at Mullimbimby in northern New South Wales, give individuals the chance to buy locally, purchase seasonal produce and support local farmers.

Domain	Effective actions	Secondary actions
Food	• Reduce food wastage. • Shift to plant-rich diets.	• Support local farmers. • Purchase seasonal produce.
Mobility	• Increase walking, cycling or public transport. • Reduce the need to travel.	• Ensure vehicles are efficient. • Don't let vehicles idle.
Consumer Goods	• Consider hiring or borrowing, rather than buying. • Reduce use of plastics and textiles.	• Increase recycling. • Buy locally.
Housing	• Reduce housing energy needs. • Use more sustainable furnishings.	• Use less water in the home. • Consume fewer resources in the home.
Leisure	• Reduce carbon footprint. • Encourage sustainable tourism.	• Buy locally. • Use recyclable or reusable goods.

Source 3: The six key domains for individual sustainability action as mappped out by the United Nations in the publication, *Sustainable Lifestyles: Options & Opportunities*.

Learning ladder 4.5

Perspectives of people and organisations

1. Source 1: What is the Anatomy of Action?
2. Sources 2 and 3: Which actions listed in Source 3 can be supported by the activity shown in Source 2?
3. Source 3: Select two actions that would be challenging for you to implement and describe why.
4. Using examples, explain how individual actions can reduce one's carbon footprint.

Sustainability

1. List three changes you could make within your own home to improve sustainability.
2. Why does the United Nations promote connections with local produce, providers and communities?
3. What are the benefits to individuals and the environment of becoming more sustainable?
4. How might living in a fast-growing urban area make it challenging to live a more sustainable life?

HOW TO Sustainability, page 418

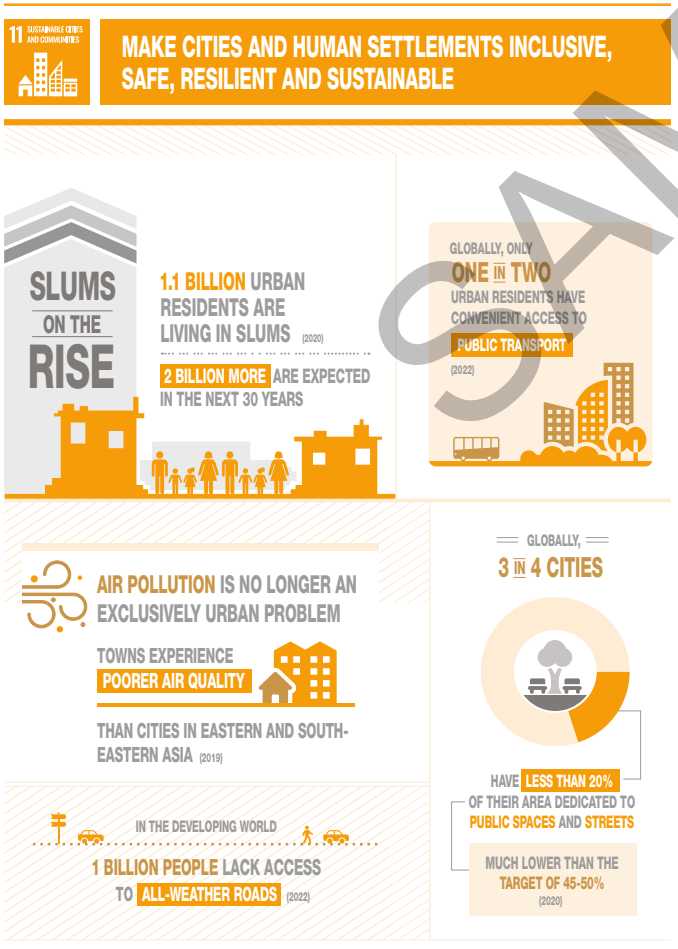
4.6

How can communities become more inclusive?

One of the core components of improving individual sustainability is the concept of community, whether it be the relationship between local producers and consumers, the climate budgeting of the local council, or the provision of sustainable transport.

Taking action

Goal 11 of the United Nations' Sustainable Development Goals identifies the need for cities to be more inclusive, safe and resilient. Doing so requires planners at all levels to consider how best to support their communities. Around the world, many different strategies for creating more inclusive communities can be found, providing opportunities for improving equity and equality among their residents, regardless of gender, socioeconomic status or mobility.



▲ **Source 1:** Goal 11 of the Sustainable Development Goals has identified a range of current challenges to inclusivity.

Providing effective social housing

Access to affordable housing is a genuine issue in many cities around the world. In the United Arab Emirates, a range of government housing initiatives are available for its citizens to ensure that all have access to adequate housing, including free land, housing assistance and interest-free loans; priority is given to low-income earners, orphans, widows, the elderly and those with special needs.

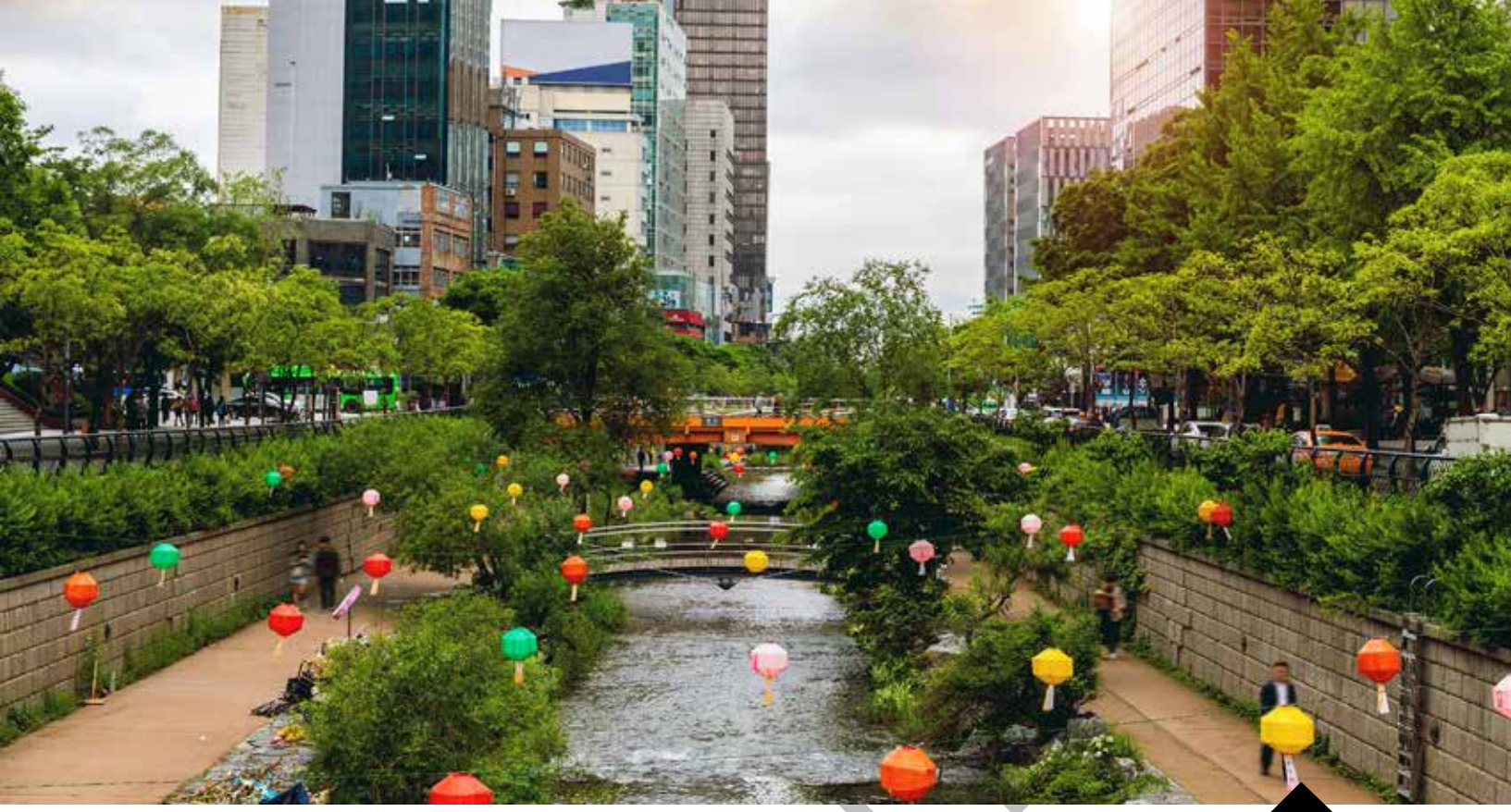
Improving gender equality

Urban areas in many parts of the world are often designed by men and for traditional gendered roles within different societies. Reviewing these designs can go a long way towards inclusion for all genders, whether it be in terms of services and facilities, or even public safety.

Women in Pakistan face sexual harassment in the form of staring, whistling or touching on buses. In the Pakistani city of Peshawar, a quarter of seats on buses are now reserved for women. The buses are also equipped with CCTV cameras, guards and have well-lit stations, making female passengers feel safer. In just two years, patronage by women on buses in Peshawar jumped from 2 per cent to 30 per cent of all travellers.

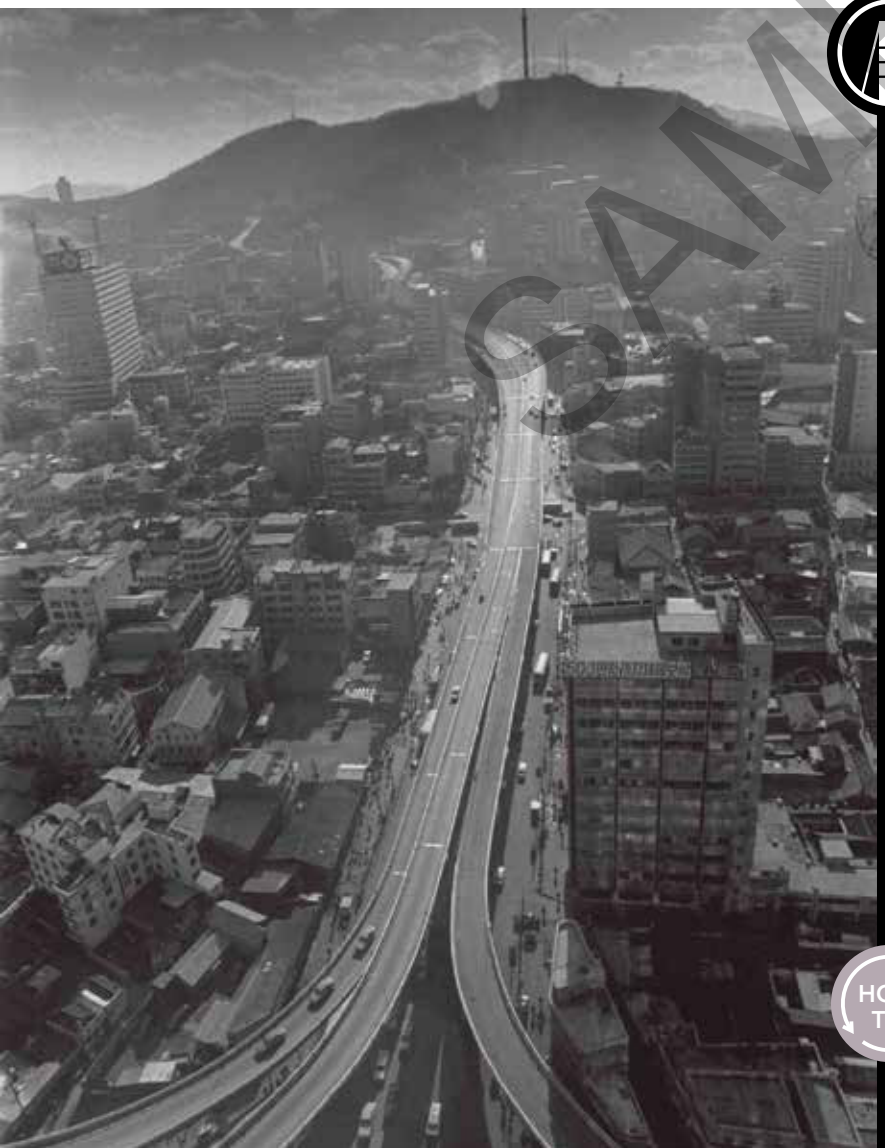
Reducing air pollution

Seoul, a city of around ten million, has grappled for decades with the side effects of its rapid urban and economic growth, especially air pollution, traffic congestion and an urban-heat island effect. The original Cheonggyecheon Stream that ran through the city was concreted over in the 1950s and replaced by an expressway (Source 3), but in 2003 the expressway was removed and a process of restoration began. Not only has air pollution improved, the stream itself has now become an important public green space, an oasis of calm in a busy city (Source 2).



▲ **Source 2:** The Cheonggyecheon Stream in modern Seoul

▼ **Source 3:** The Cheonggye Expressway (1972) in Seoul



Learning ladder 4.6

Characteristics of places and environments

1. What benefits come from making public transport affordable and safe?
2. Describe how Pakistan improved inclusivity for women.
3. Using examples, explain how cities can improve gender equality through urban design.
4. Source 1: Analyse the statistics relating to public spaces and streets. Why do you think cities are struggling to reach the targets set by the United Nations?

Environment

1. Source 3: Identify this urban environment.
2. Source 3: Describe the built characteristics of Seoul in 1972.
3. Source 3: Explain how and why the Cheonggye Expressway was built.
4. Source 2: Analyse the changes made to this urban site and the environmental and social improvements of the change.

HOW TO Environment, page 414

How does decentralisation reduce urbanisation pressure?

Decentralisation is one technique used by governments to provide businesses and individuals with incentives to move to regional centres with the aim of relieving population pressures in major cities.

Decentralisation

Governments in Australia have responded to fast population growth and sprawling capital cities by developing **decentralisation** policies to strengthen the economies of regional centres. Decentralisation aims to slow major city growth by encouraging people to move to regional centres.

Businesses are given financial benefits to move from capital cities to regional centres. Governments also establish or relocate departments and authorities to towns and cities outside of capital cities. The largest relocation of a government body in Victoria's history occurred in 2009 when the Transport Accident Commission was moved from Melbourne to Geelong, creating 650 jobs.

Source 1: The Transport Accident Commission (TAC) building in Geelong. The relocation of the TAC to Geelong from Melbourne created 650 ongoing jobs along with the 800 jobs created in the construction a new purpose-built headquarters. The relocation of the TAC also led to many of the workers purchasing or renting homes in Geelong and using local shops and services to drive economic growth in the region.

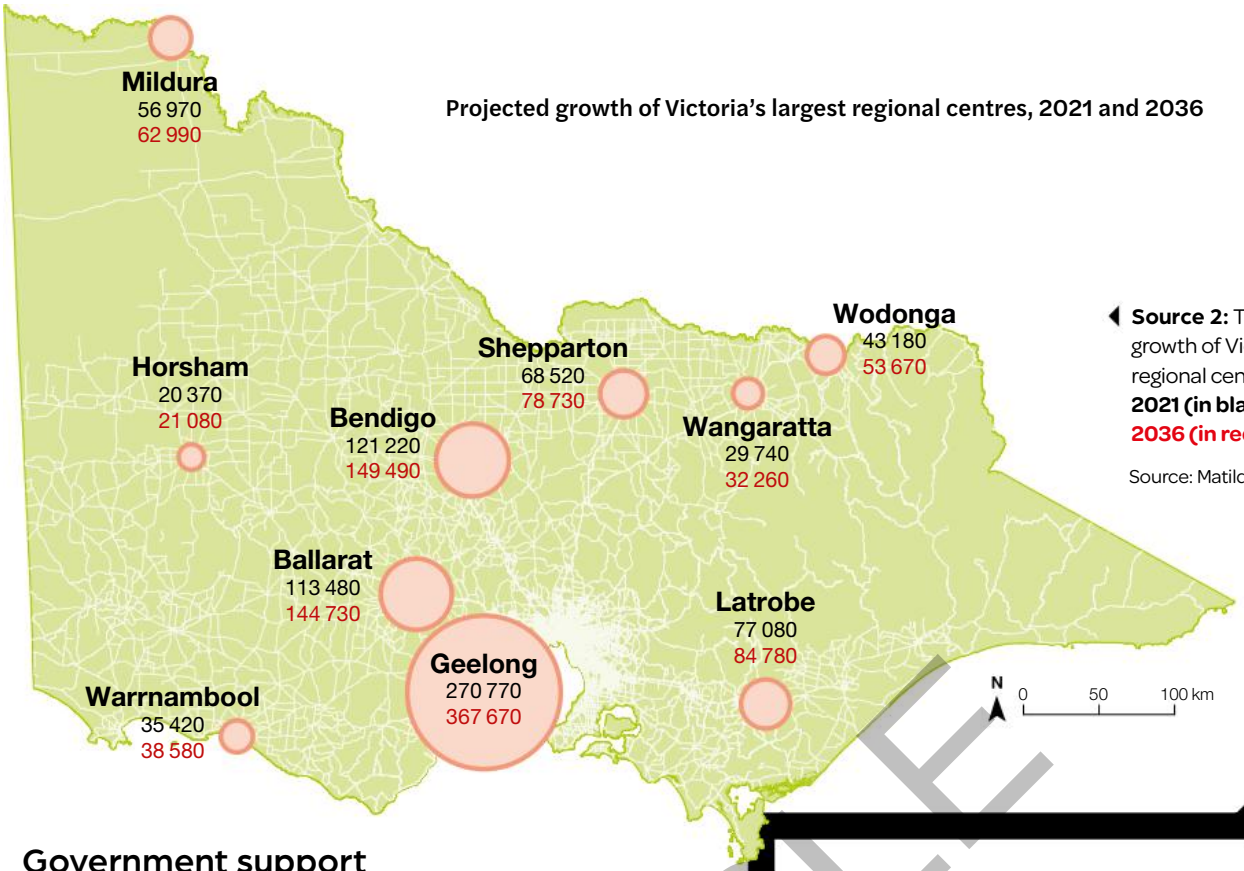
The decentralisation of populations away from capital cities was boosted in 2020–21 when the coronavirus pandemic forced people to work from home. With no tie to an office in a capital city, thousands of workers chose to move to regional areas for the opportunity to live in a more affordable or lifestyle driven location. Businesses learned to work remotely, using online video calls to meet with co-workers and customers. These flexible work arrangements have continued in the post coronavirus period, with many businesses downsizing their office requirements in capital cities. In August 2023, city office vacancy rates hit a 30 year high, with 12.8 per cent of offices empty.

Growth of regional centres

The populations of many regional cities have experienced rapid growth in the past decade. Growing populations increase the demand for schools, hospitals, businesses, shopping centres and other infrastructure.

The New South Wales' government is predicting that regional populations could grow by one million people by 2038. Areas forecast to add the most people are the Central Coast and Hunter regions which are estimated to have populations of 750 000 people and 406 000 respectively.

Victoria's 10 largest regional cities are growing rapidly and their populations are set to grow by nearly 200 000 people between 2021 and 2036 – a growth rate of 23.6 per cent. These centres have asked for billions of dollars in government investment for infrastructure and services to support further growth and employment.



Source 2: The projected growth of Victoria's 10 largest regional centres between **2021 (in black)** and **2036 (in red)**.

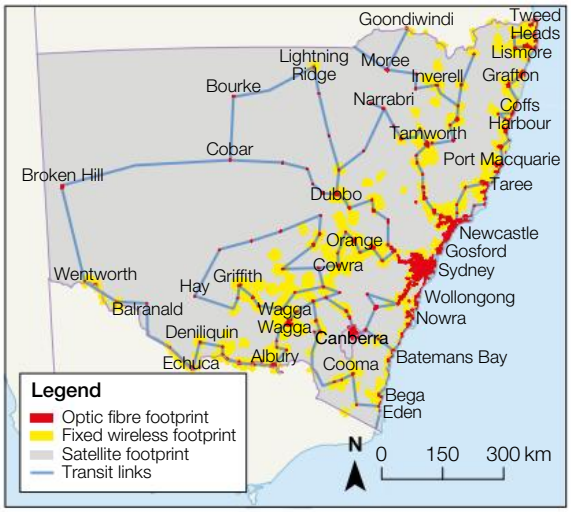
Source: Matilda Education Australia

Government support

To stimulate regional growth through decentralisation, governments need to support regional areas in a number of ways including:

- linking regional cities with capital cities through improved road and rail services to enable fast and affordable business and personal transport links
- providing reliable digital connections to enhance the Australian Government's National Broadband Network (NBN) rollout
- taxation exemptions for businesses to relocate to a regional area
- skill training and support programs in regional centres.

NBN network in New South Wales



Source 3: NBN network in New South Wales

Source: Matilda Education Australia

Learning ladder 4.7

Processes that transform people, places and environments

1. Define the term 'decentralisation'.
2. Source 2: Which Victorian regional centres are expected to grow the most from 2021 to 2036?
3. Why do governments have plans for the decentralisation of their major city populations?
4. How did the COVID pandemic impact the decentralisation of populations in Australia?
5. Evaluate the list of government support for decentralisation. Which type of support do you think is the most important for individuals and businesses considering a move to a regional centre and why?

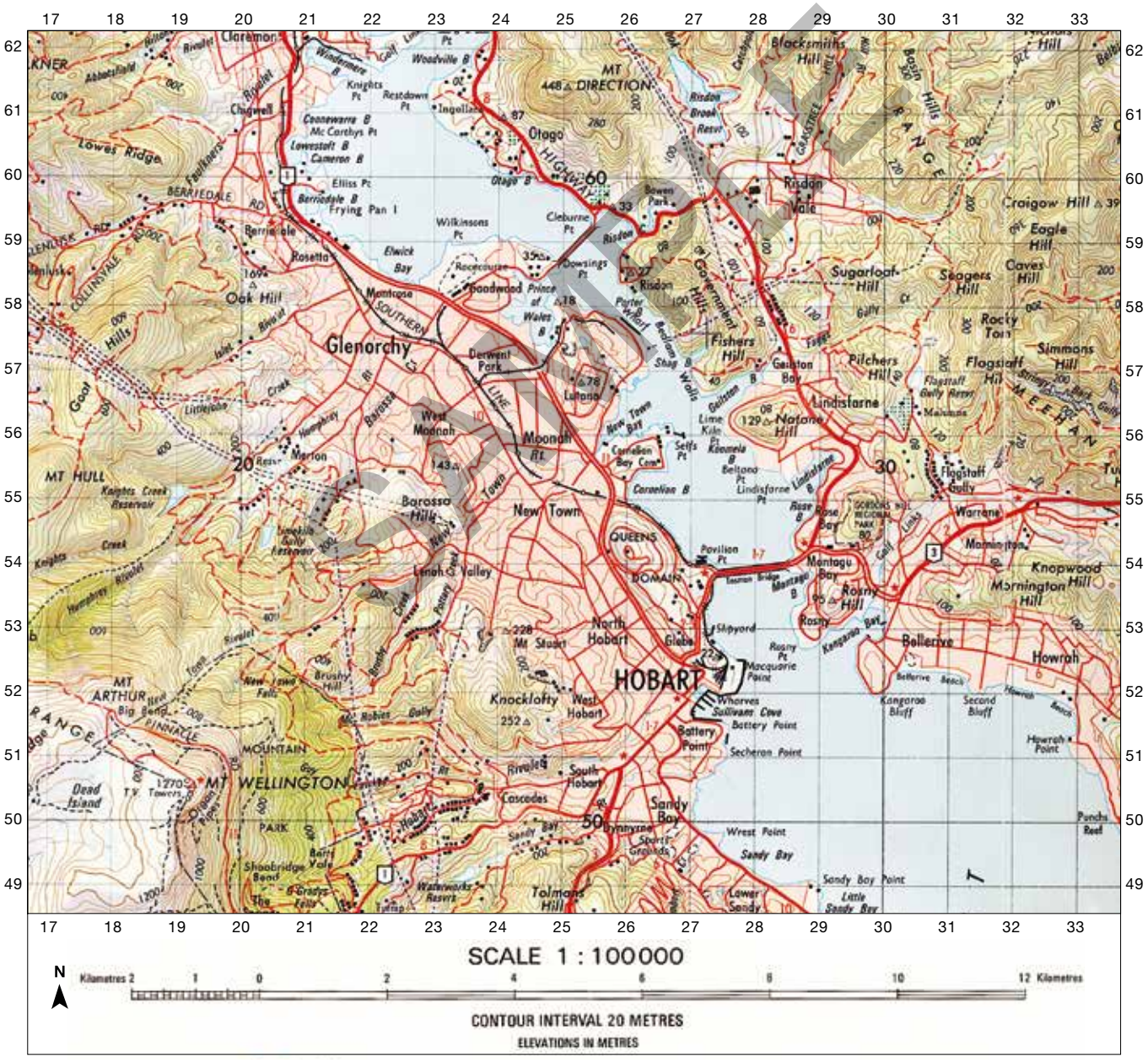
Scale

1. How does decentralisation affect businesses at the local scale (local, regional, national)?
2. What are the economic impacts of decentralisation on regional towns and the national economy?
3. Source 3: Explain how investments in technology at a state scale can influence local places?
4. How can governments help to make decentralisation successful at local and regional scales?

HOW TO
Scale, pages 416, 423

How do I use topographic maps to study urban places?

Topographic map of Hobart



Topographic maps are used by geographers and urban planners to study urban areas. Topographic maps indicate built up areas and show places and infrastructure such as roads and rail. They also indicate steep areas through contours lines where expansion of urban areas is difficult.

How do you identify urban areas on topographic maps?

Topographic maps show a range of settlement types ranging from a single house to a big city. Urban areas are shown by shaded areas (usually pink) to indicate the built up area. Other urban features shown on a topographic map include a range of road and rail types, buildings and airports.

On the topographic map of Hobart in Source 1, the urban area is shaded in pink. Places are named, with the size of type indicating the size of the settlements (i.e. Hobart is in larger type than other places named on the map). Other key locations in the urban environment are also named, such as Tasman Bridge at AR2753.

▲ **Source 1:** Topographic map of Hobart. In 2023, Hobart's population reached 265 000, which represents 46 per cent of Tasmania's total population of 579 000. Hobart is Australia's 13th largest city. It is smaller than regional cities such as Newcastle and Wollongong. In many ways, Tasmania can be compared to rural Australia with its very low population growth, ageing population and migration of young adults to mainland cities. The sustainability of very small towns is likewise threatened by declining populations.

How can you identify potential areas of urban growth?

Urban development is attracted to areas of flat land, where it is easier to construct buildings and provide infrastructure such as roads. Topographic maps show the shape of the land using contour lines. Flatter land is shown where contour lines are further apart and steeper land is indicated by close contour lines.

The urban area of Hobart and its suburbs in Source 1 is found on flatter land next to the Derwent River, with its growth restricted by steep land such as Mount Wellington to the west of Hobart.

Learning ladder 4.8

Representing & communicating information

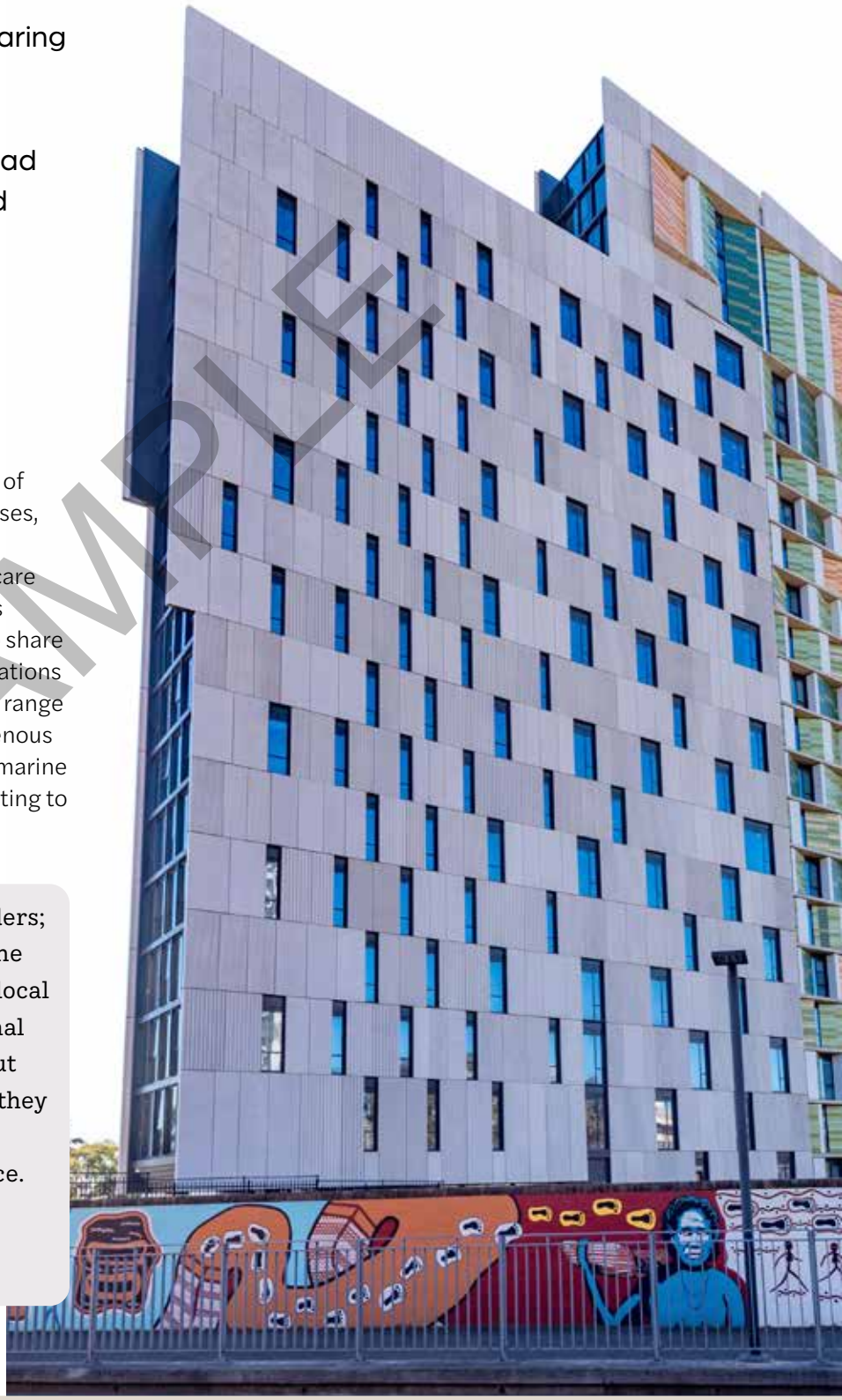
Refer to Source 1, topographic map of Hobart, for the following questions.

1. **1** Name a feature in AR 2753.
   b Give an AR for Battery Point.
   c Name the feature at GR 250587.
   d Give a GR for Mount Wellington.
   e Name the landform feature at AR 1855.
   f Name the landform feature at GR 240520.
2. **a** What is the length of the Tasman Bridge that connects eastern and western Hobart?
   b State the direction of Glenorchy from Hobart.
   c State the direction of Hobart from Mount Wellington.
3. From which of these locations could a person see the city of Hobart?
   Dead Island (AR 1750) or Punchs Reef (AR3349)
4. **a** Describe the relationship between settlement and transport patterns and the topography (landforms) of the Hobart area?
   b Explain why the expansion of the city of Hobart is hampered by the physical landscape. What options does Hobart have to expand its population?

HOW TO Topographic maps, page 426

How can we innovate from Caring for Country guidelines?

Before colonisation, the practices of caring for Country were holistic and included the community, family, and individuals. Communities ensured that everyone had enough to eat, a safe place to live, and access to clean water and medicine. Men and women shared power and decision making responsibilities and young people had access to learning.



Innovation from Caring for Country

With the colonisation of Australia and the removal of First Nations people from Country, and in many cases, community and family, the ability for First Nations communities to continue to care for Country and care for each other was severely disrupted. Despite this disruption, First Nations people have continued to share knowledge of caring for Country to younger generations and this knowledge is beginning to be applied in a range of projects in Australia today. These include Indigenous Ranger programs in charge of caring for land and marine environments using First Nations knowledges relating to caring for Country.

> Indigenous people are not just stakeholders; they should have a guaranteed seat at the table for determining what happens in local places and local country and their traditional lands. They should be decision-makers about the whole structure of grants and funding; they should not be competing with big industry groups in terms of who has a say over a place. The whole system needs to be changed.
>
> **Source 1:** State of Environment workshop participant, Western Australia, Muramin, 2021.

Source 3: Draft Caring for Country Guidelines 2023–2033, New South Wales Department of Planning and Environment

Caring for Country can be incorporated into urban design and planning through the inclusion of First Nations practices and knowledge at all stages of policy, planning and the development of projects. Some specific outcomes of the use of Caring for Country guidelines are improved sustainability, connection and respect for Country through physical structures or artworks and the naming of urban spaces.

The Aboriginal Housing Company

The Aboriginal Housing Company is an independent not-for-profit community housing provider located in Redfern, in the traditional lands of the Gadigal people. The Aboriginal governed organisation formed in 1973 as a response to the discrimination First Nations people suffered in the private rental market. The Aboriginal Housing Company is funded through the income it makes from its rental properties across Sydney and throughout regional New South Wales.

A major project of the Aboriginal Housing Company has been the redevelopment of a property in Redfern, called the Pemulwuy Project, after an important Bidjigal/Gadigal tribal warrior who bravely fought against the English invasion. The development was completed in 2022 and includes affordable housing for 62 First Nations families, a public art space and gallery featuring local Aboriginal artists, a childcare facility with allocated places for First Nations children, student accommodation, a gym, and commercial and retail space.

Source 2: One principle of Caring for Country is to ensure that people have a safe place to live. The Aboriginal Housing Company redeveloped land in Redfern, Sydney through the Pemulwuy Project to provide affordable housing for First Nations families. The aim of the project was to restore a strong and healthy First Nations community to Redfern with an emphasis on culture, spirituality and employment.

Learning ladder 4.9

First Nations Peoples' interaction with Country

1. What is Caring for Country?
2. Source 1: Explain this person's view about planning for their traditional lands.
3. How is the Pemulwuy Project an example of Caring for Country?
4. What role has the Aboriginal Housing Company played in developing Caring for Country principles? Why did they initially take action?

Environment

1. Source 2: Identify elements that distinguish this environment as connected to First Nations people.
2. What is the key reason behind the built characteristics of this site?
3. Source 3: Explain how the Department of Planning and Environment intends to include Caring for Coutry principles in its guidelines.
4. Why is it crucial that First Nations people have the opportunity to lead important sustainability projects?

HOW TO Environment, page 414

Case study

How is suburbanisation changing Australian cities?

The development of new suburbs on **greenfield**, or undeveloped, land is known as **suburbanisation**. Sydney and Melbourne have a long history of suburbanisation, resulting in sprawling low-density cities, which are often criticised as unsustainable.

Suburbanisation in Melbourne

At 2500 square kilometres, Melbourne is already one of the world's largest cities by area – and it is still expanding. More than 50 suburbs have been added since 2005. Melbourne overtook Sydney as Australia's largest city in 2023 with nearly five million people. With 60 per cent population growth in the outer western regions in the previous decade, the satellite city of Melton has now been absorbed into Melbourne's metropolitan area.

In 2017, the Victorian government attempted to provide more affordable housing by rezoning areas on the edge of the city to create 100 000 new housing blocks and 17 new suburbs in Melbourne's key growth corridors:

Melbourne key growth corridors: houses and population

Corridor	Houses	Population
West	170 000	480 000
North	117 000	330 000
South east	103 000	110 000
Sunbury	32 000	90 000

The major advantage of suburbanisation as a strategy is that affordable housing estates can be quickly established and designed. The disadvantages of suburbanisation are that open land is sacrificed to build new urban areas and expensive new infrastructure has to be built. With most jobs available near the city centre, many residents in outer suburbs face long commutes to get to work.

Careful planning needs to be undertaken to ensure that population growth is sustainable. Already planners are suggesting that by 2050 Melbourne will need:

- 1.6 million new homes
- eight new hospitals
- 67 new secondary schools
- 222 new kindergartens.

Source 1: Looking east to Melbourne (in background) over Tarneit and Melbourne's west growth corridor. In 2021, Tarneit's population was 48 953 people. It is expected to nearly double by 2026, at an average annual growth rate of nearly 13 per cent.

▲ **Source 2:** The transformation of greenfield land at Schofields (about 45 kilometres west of Sydney's CBD) has integrated open space by allowing some higher density housing.

Planning better suburbs in Sydney

Western Sydney has transformed to meet the needs of Sydney's growing and changing population, with suburbs now extending up 80 kilometres from the CBD in the south-west. Between 2012 and 2021, Western Sydney accommodated an additional 437 000 residents, increasing the population to 2.6 million. Suburban growth has been criticised, with new suburbs lacking access to jobs, public transport, essential services, trees and green spaces. More recent planning for growth areas such as Campbelltown and Penrith includes new homes and jobs growth close to transport, schools and public spaces with a focus on liveability and sustainability. The Western Sydney Aerotropolis and new Western Sydney International (Nancy-Bird Walton) Airport are opportunities for the government to plan better suburban communities with access to facilities and infrastructure before the people move in.

Learning ladder 4.10

Characteristics of places and environments

1. What is suburbanisation?
2. Why did the Victorian and New South Wales governments rezone areas on the edges of Melbourne and Sydney to allow for residential development?
3. Assess the need to create better suburbs on Sydney's suburban fringe.
4. Source 2: Analyse opportunities for better suburban planning in Sydney's west.
5. Source 2: Create a table, outlining environmental, social and economic viewpoints about suburbanisation in western Sydney.

Space

1. Source 1: Create an annotated photo sketch that identifies features of the new suburb of Tarneit in Melbourne.
2. Source 1: Explain why new housing developments are replacing farmland on Melbourne's rural–urban fringe.
3. Source 2: Identify and account for areas of higher density housing in Schofields, Western Sydney.
4. Source 2: Estimate the proportion of open space in Schofields before and after the increase in suburbanisation.
5. Source 1: Analyse the benefits of allocating more open spaces when developing remaining greenfield lands around Tarneit in the future.

HOW TO
Space, page 406

Case study

How is Sydney filling in the city?

Urban consolidation refers to the practice of redeveloping existing urban land instead of creating new suburbs. The result is urban consolidation, which creates more compact cities with higher population densities and greater sustainability.

Sydney's growing population

The Sydney Metropolitan Region covers the areas of Sydney identified as urban or for future urban development. The 2023 population of 4.9 million people is predicted to increase by over a million and require a million new homes to be built by 2041. An ageing population and growing number of smaller households has increased demand for mixed housing and created a preference for higher-density apartments and villas.

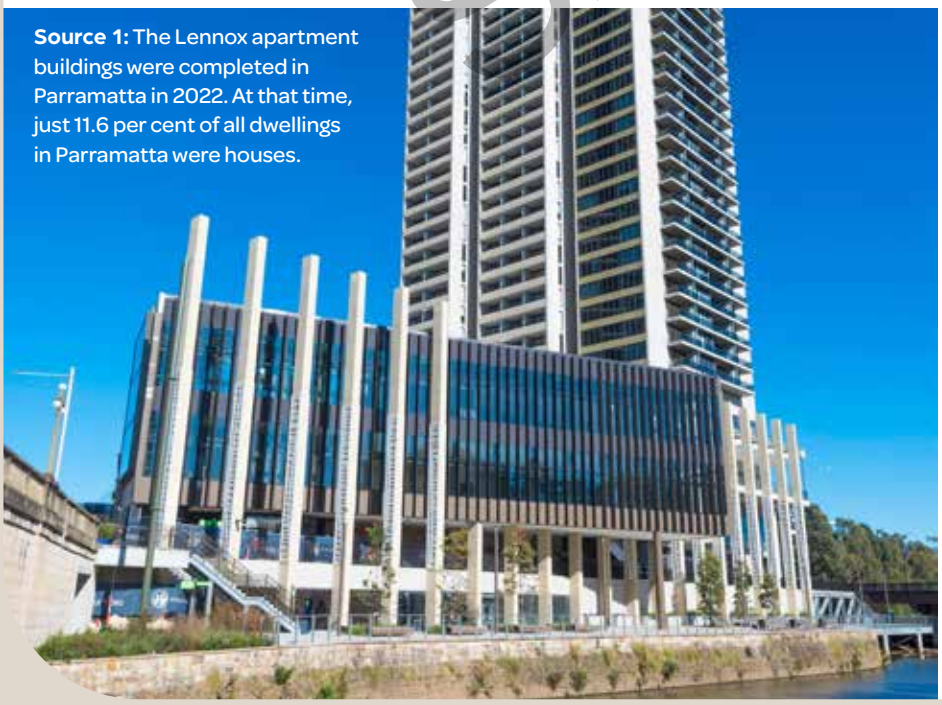
The NSW Government aims to accommodate Sydney's population growth with a balance of:

- **suburbanisation:** growth in suburbs in north-west and south-west Sydney
- **urban consolidation:** infill development within established suburbs (e.g. Parramatta, Lane Cove).

Filling in and growing up

Sydney's growth in the past decade differed to Melbourne because it was dominated by the infilling of established suburbs with apartments and townhouses rather than the establishment of new suburbs. The advantage of redeveloping existing areas is that infrastructure such as power, water and transport already exists. Higher density developments of townhouses and apartment blocks allow more people to be housed in established suburbs. Examples of higher density dwellings include:

- **Dual occupancy:** two independent dwellings on a single allotment that has be subdivided.
- **Townhouses:** separate houses with a yard on small blocks that are attached to one other in groups.
- **Apartments or units:** attached dwellings in a single building with shared facilities and open space.



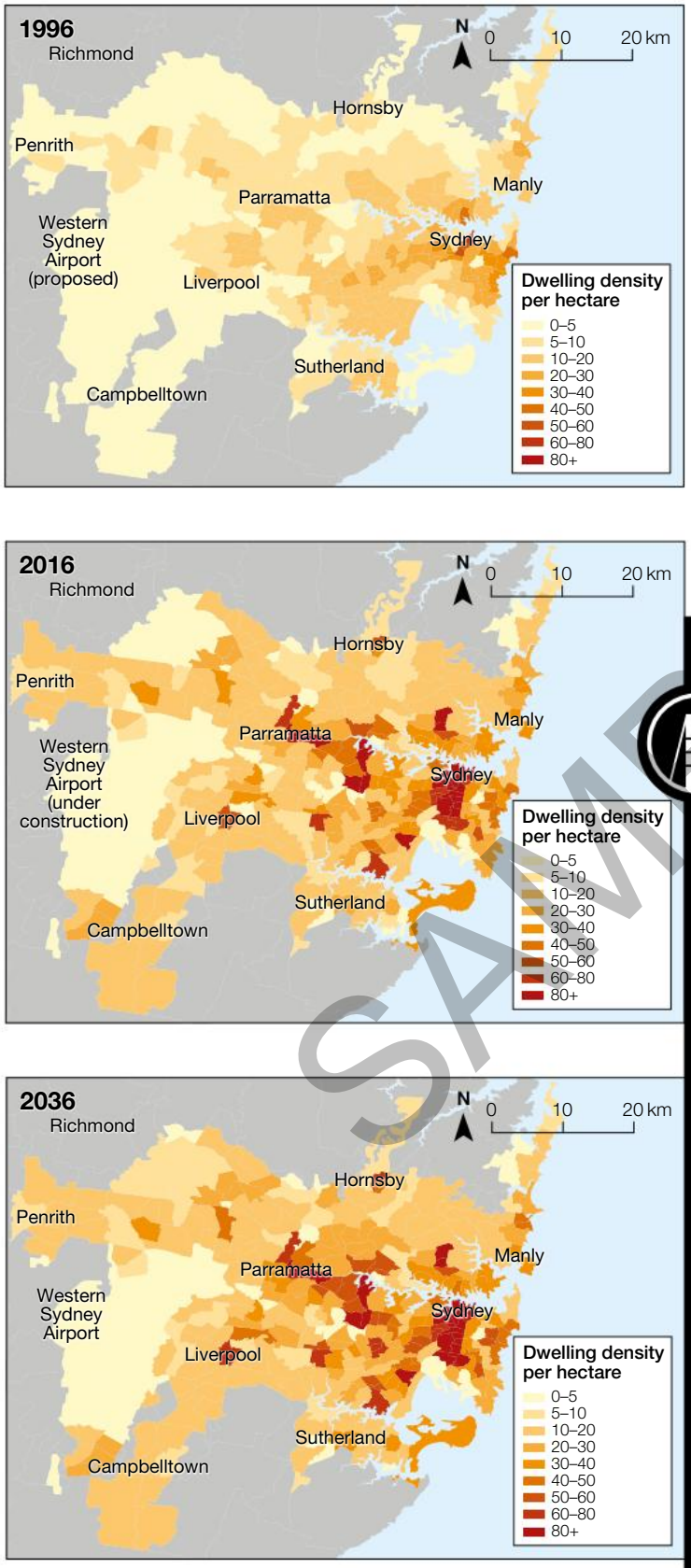
Source 1: The Lennox apartment buildings were completed in Parramatta in 2022. At that time, just 11.6 per cent of all dwellings in Parramatta were houses.

Future growth

The NSW government's 'A Metropolis of Three Cities' is a plan to divide Sydney into three cities to put people within 30 minutes of employment and services:

- Eastern Harbour City – improving liveability and sustainability.
- Central River City – improving infrastructure and services with Parramatta as its hub. Urban consolidation supplies new housing.
- Western Parkland City – attracting employment and improving transport links, including the Western Sydney Airport.

Changing housing density in Sydney 1996–2036



Source: Matilda Education Australia

▲ **Source 2:** Change in housing density in Sydney between 1996 and 2036 based on a policy or urban consolidation rather than suburbanisation.

Urban consolidation in Sydney

Source 2 shows Sydney's policy of urban consolidation over time. In 1996 most of Sydney's urban area consisted of low-density detached homes on large 1000 square metre blocks, with some medium and higher density dwellings in inner suburbs. Between 1996 and 2016 housing density increased across Sydney's urban area as housing blocks decreased in size, with more townhouses and multi-storey apartment blocks. There were only small changes in Sydney's urban boundary spread through suburbanisation, although new suburbs are still being created on greenfield sites.

It is expected that the trend of urban consolidation will continue to 2036, with new urban consolidation projects focused around public transport. This is called transit-oriented development.

Learning ladder 4.11

Processes that transform people, places and environments

1. Define the terms suburbanisation and urban consolidation.
2. How has Sydney's approach to housing a growing population differed from Melbourne's approach?
3. Explain how areas like Parramatta have appoached population growth.
4. Analyse the advantages and disadvantages of urban consolidation.
5. Evaluate the 'A Metropolis of Three Cities' plan for Sydney's future – what are the advantages and disadvantages of this approach?

Change

1. Source 1: How is Parramatta changing?
2. Source 2: Describe change in housing density in Sydney between 1996 and 2016.
3. Source 2: Explain which areas of Sydney are undergoing suburbanisation and which have experienced urban consolidation in 2016.
4. Source 2: What are the implications of low density growth?

HOW TO
Change, page 412

4.12

What is the purpose of urban renewal?

Urban consolidation, urban growth within existing city boundaries, includes infill and urban renewal projects. Urban renewal involves the repurposing of underutilised areas such as disused docklands into new multipurpose housing and business sites.

Benefits of urban renewal

Through the process of urban renewal, old industrial areas and docks are being redeveloped to provide new homes, offices and entertainment spaces.

The advantage of redeveloping existing areas is that infrastructure such as power, water and transport already exists. Higher density developments of townhouses and apartment blocks allow more people to be housed in established suburbs. New green spaces can also be created for entertainment and leisure. Some other advantages of urban renewal include:

- reduced travel times and lower transport costs
- attractive, new environments
- close to employment, shopping and services
- housing mix suits different age groups and family structures
- reduced land clearing for new suburbs
- connecting places where people work, live and play

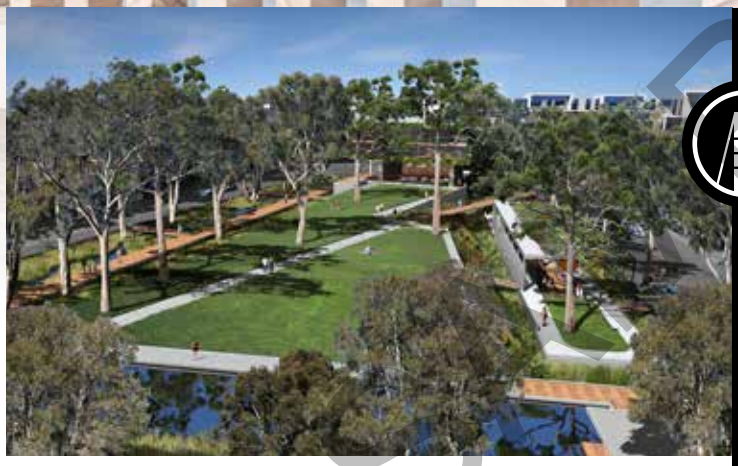
Urban renewal projects in Australia

Urban renewal is changing Australian cities on a variety of scales:

- **Small-scale projects** include reuse of old warehouse buildings or wharves for housing or offices (e.g. 'Home' in Perth and 'W' in Woolloomooloo).
- **Large showcase projects** involve the transformation of industrial and commercial sites such as factories, warehouses, wharves and shopping strips into mixed-use residential, commercial and recreational spaces (e.g. Barangaroo in Sydney, Docklands in Melbourne, South Bank in Brisbane and Elizabeth Quay in Perth).

In 2023 the Victorian Government announced Australia's largest ever urban renewal project. It will redevelop all of Melbourne's 44 ageing high-rise public housing estates and replace them with modern homes to provide **social housing** for people on low incomes or with particular needs. The project aims to triple the capacity, from 10 000 to 30 000 people.

Source 1: The former container port of Barangaroo is Sydney's largest urban renewal project. Barangaroo includes residential, commercial, retail and public spaces. It is Australia's first carbon neutral precinct through water recycling, solar energy generation and responsible waste management.



Source 2: The centrepiece of the Green Square project in inner-southern Sydney is a 6400 square metre parkland. By 2030, Green Square is expected to have 40 000 new residents and 22 000 workers with access to community facilities, offices, shops, parks and transport links.

Developing sustainable communities

Urban renewal has the power to create compact, liveable and sustainable communities. Urban villages created by renewal projects, such as Green Square (Source 2) and Barangaroo (Source 1) in Sydney, possess high liveability because the places people live, work, play and socialise in are connected.

Urban renewal projects use the latest technologies to minimise environmental impacts. Many projects aim to be carbon neutral and water positive by integrating alternative energy sources and water-sensitive landscape and building design.

Learning ladder 4.12

Processes that transform people, places and environments

1. Define the term 'urban renewal'.
2. Describe the advantages of urban renewal for growing urban areas.
3. Source 1: What action has Barangaroo taken to make the precinct more sustainable?
4. Analyse the benefits and drawbacks of urban renewal. Who might be impacted negatively by a development such as Barangaroo?

Interconnection

1. Source 1: Describe the interconnection between the Barangaroo precinct and Sydney Harbour.
2. Source 2: What interconnection have architects created between work and living spaces and open spaces?
3. How do urbal renewal projects have the power to create interconnected communities?
4. How does an interconnection to infrastructure give urban renewal an advantage over suburbanisation to deal with growing urban populations?

HOW TO

Change, page 20

Virtual site visit

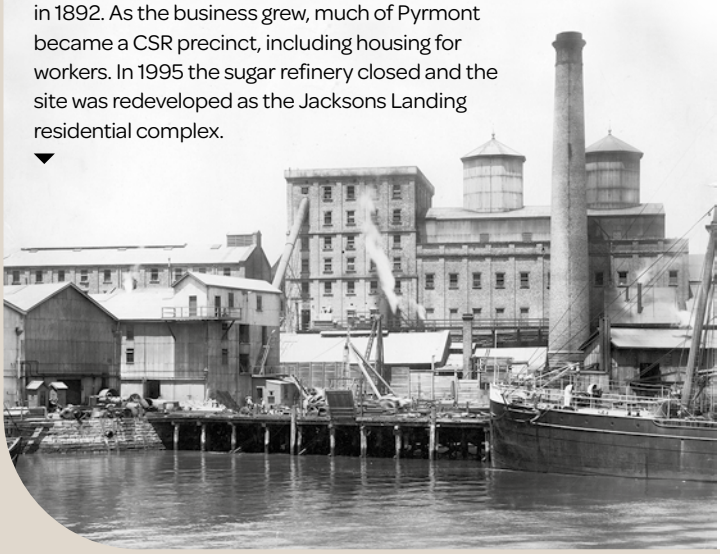
How has Pyrmont transformed?

Located less than two kilometres from the Sydney Central Business District, the suburb of Pyrmont – the Traditional lands of the Gadigal people of the Eora nation – has undergone a remarkable transformation over the past few decades.

An industrial history

Throughout the nineteenth century, much of the area consisted of quarries; the tough local sandstone extracted was ideal to develop the nearby CBD and the expanding urban settlements that surrounded it. Pyrmont sandstone was even sent around the Australian colonies, to New Zealand, Fiji, and even Canada. By 1900, the local population exceeded 30 000, many of them workers employed in the quarries and their families, along with workers in the local sugar refinery, abattoirs, shipping and wool warehouses. However, as steel and concrete became increasingly commonplace in construction following World War One, the quarries began to wind down and the waterfront area became dotted with warehouses and blue-collar light industry. The price of wool fell and industries shifted to cheaper and more expansive land in other parts of the state. By the 1980s, the population had dropped to less than 1000 and, with businesses closing and commerce changing, much of the area had become dilapidated; in the eyes of many, a visual eyesore.

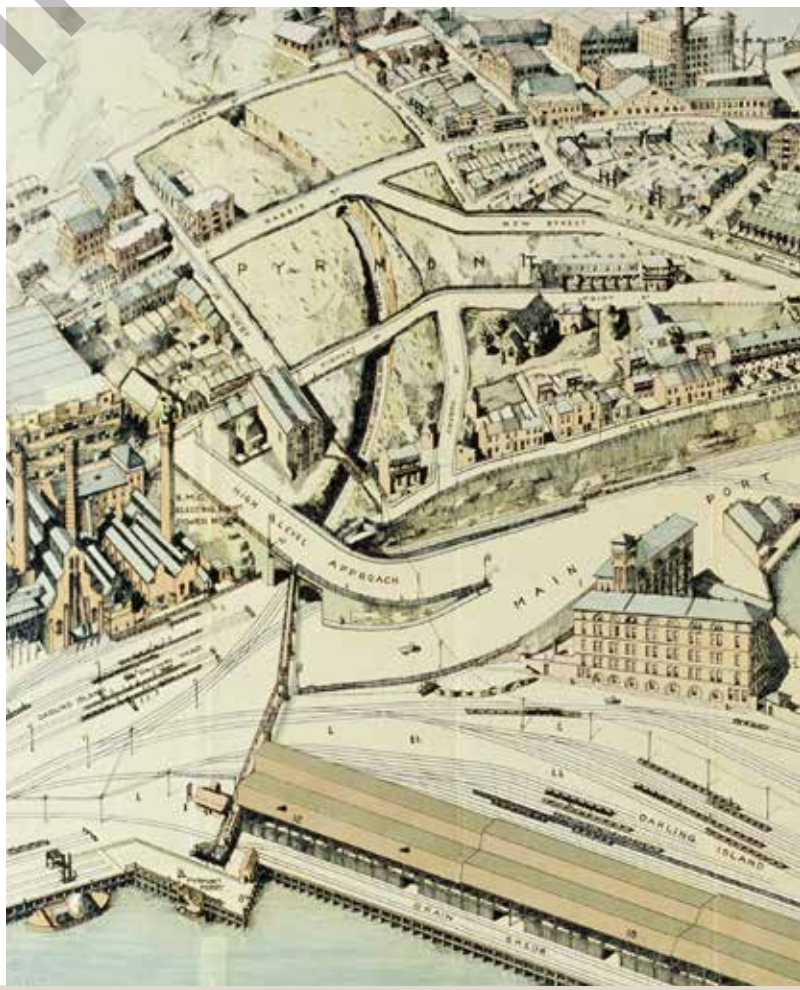
Source 1: Colonial Sugar Refinery (CSR) at Pyrmont in 1892. As the business grew, much of Pyrmont became a CSR precinct, including housing for workers. In 1995 the sugar refinery closed and the site was redeveloped as the Jacksons Landing residential complex.



Urban renewal

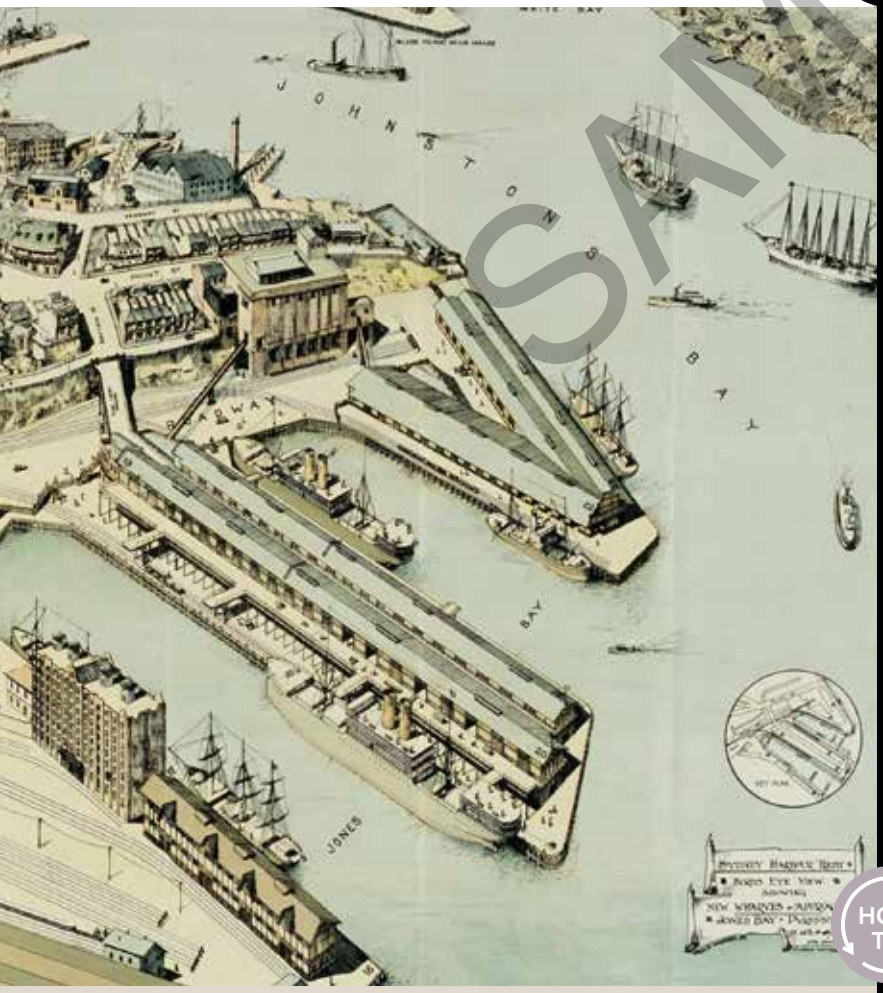
During the 1990s, the area became the focus of one of Australia's largest urban renewal programs, with the entire 100-hectare peninsula the subject of redevelopment and urban master planning on a significant scale. Given its central location and proximity to the waterfront, the area was perfect for redevelopment with a broader goal of attracting

Source 2: Lithograph of Pyrmont in 1919.



people back into the CBD to help combat urban sprawl. Under the Better Cities Program, industrial zoning was almost entirely removed and the old warehouses and facilities were replaced with office and residential spaces, including high-density developments. Original colonial buildings, including The Cooperage and Tablet House, were retained and repurposed into residential and commercial spaces, waterside walkways and parks were also included in the development to ensure both liveability and ease of access. Prominent local landmarks now include The Star Casino complex and the Powerhouse Museum. In 2023 the ABS estimated the population of Pyrmont was 13 735.

Source 3: Oblique aerial view of Pyrmont in 2021, showing the residential and commercial developments and open space on the former industrial site.



Learning ladder 4.13

Characteristics of places and environments

1. List three ways that the Pyrmont-Ultimo area was used during the nineteenth century.
2. How did the population of Pyrmont change from 1900 to 1990?
3. What factors led to the Pyrmont–Ultimo area becoming dilapidated by the 1980s/1990s?
4. Suggest why the area has changed so much over the past thirty years.

Change

1. What did the Pyrmont area become following the Better Cities Program?
2. Sources 2 and 3: How has Pyrmont changed over time?
3. Sources 2 and 3: Locate the four long sheds on the wharf at Jones Bay. What different approaches were taken with the urban renewal of the sheds in this area?
4. 'Change in urban areas is driven by the past, present and future.' With reference to Pyrmont, to what extent do you agree?

HOW TO Change, page 412

Case Study

How was a new city built in Canberra?

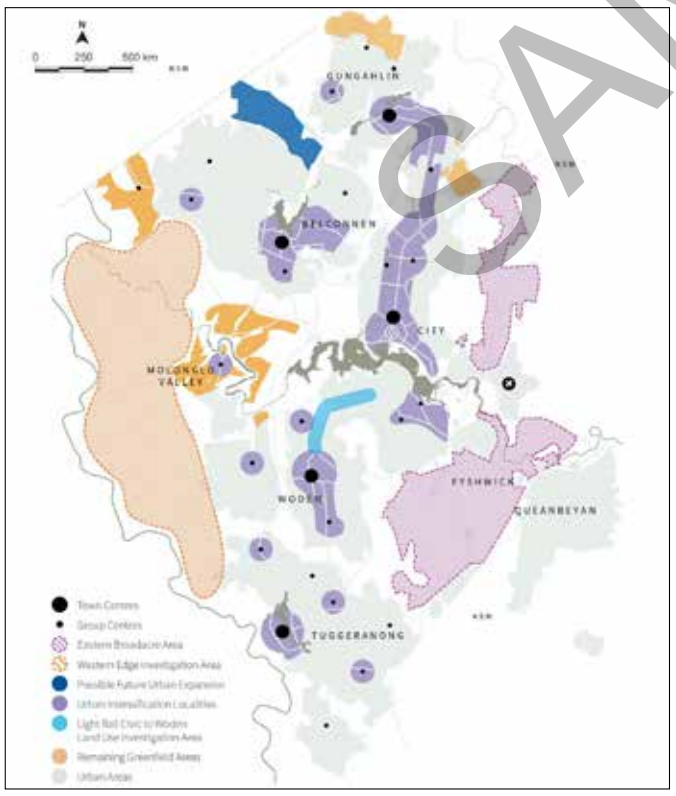
Canberra was built from the ground up in the early 1900s as Australia's largest ever **decentralision** project and the home of Australia's Federal Parliament and services.

Canberra's growing population

Canberra was selected for the location of Australia's capital in 1908 and officially proclaimed in 1913. The location was to be a decentralised inland city between Melbourne and Sydney. Canberra's growth depended on its governmental role as Australia's capital city. There was no trade, manufacturing or public transport in the early years, so population growth was very slow.

Real population growth began with the creation of **satellite towns** such as Woden (1964), Tuggeranong (1973) and Gungahlin (1991). In 2023, Canberra had over 100 suburbs and a population 472 000 people.

Strategic development plan for Canberra to 2048



Source: xxxxxx xxx xxxxxx xx xxxx xxxxxx xxx xxxxx

▲ **Source 1:** This map shows the ACT government's strategic direction for the development of Canberra to 2048.

Canberra in the future

Canberra is a planned city consisting of Civic (the CBD) and satellite towns. However, the decentralised suburbs created urban sprawl and car dependence, and it has a large ecological footprint compared to other Australian cities. In 2019 the Canberra light rail network began with with a 12-kilometre link to the satellite town of Gungahlin. Plans are underway to extend the network to Woden.

The future development of Canberra's urban area to cater for its growing population is mapped in Source 1. The strategic plan includes:

- **infill development** (urban renewal) of city centres, transit corridors and residential areas to increase housing density to cater for more people
- **greenfield development** to further expand the city.

Source 2: Satellite image of Canberra

Learning ladder 4.14

Blue heading

1. Xxxxxx. Questions to come, allow 2 lines for each question
2. Xxxxxx. Questions to come, allow 2 lines for each question
3. Xxxxxx. Questions to come, allow 2 lines for each question
4. Xxxxxx. Questions to come, allow 2 lines for each question
5. Xxxxxx. Questions to come, allow 2 lines for each question

Green heading

1. Xxxxxx. Questions to come, allow 2 lines for each question
2. Xxxxxx. Questions to come, allow 2 lines for each question
3. Xxxxxx. Questions to come, allow 2 lines for each question
4. Xxxxxx. Questions to come, allow 2 lines for each question
5. Xxxxxx. Questions to come, allow 2 lines for each question

HOW TO Xxxxxxx, page xxx

Thinking geographically

Changing places

Geographical concepts, inquiry and tools

Space, place, environment, change, inquiry

Learning Ladder: page 154

Key inquiry question

Why is Indonesia creating a new capital city?

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 locations of Jakarta and Nusantara
- reasons why Jakarta is no longer a suitable site for the capital of Indonesia
- reasons for the selection of the new site at Nusantara
- the features of Nusantara that will make it a more sustainable city
- a sketch map or original diagram showing features of the new city. Where possible, refer to the sources in this spread to support your response.

Changing urban places

Indonesia, the fourth-most populous country in the world with 275 million people, is moving its capital and centre of government to East Kalimantan, a province on the island of Borneo. Indonesia has a fast-growing economy, a growing and young population, and plentiful natural resources. Incomes are rising. By 2050, Indonesia is predicted to be the world's fourth-largest economy. Jakarta is a megacity with a population of over 11 million and continues to expand into surrounding agricultural land. The new location for a capital has been chosen for several reasons:

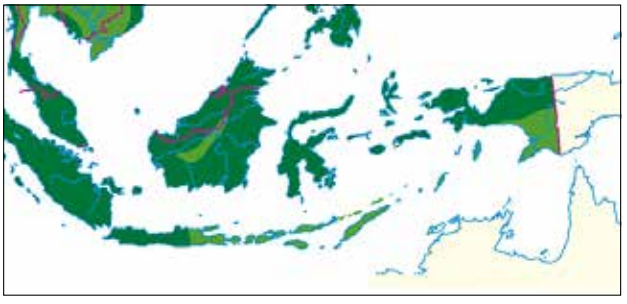
- Jakarta has serious environmental issues.
- Population growth in Jakarta makes the city unsustainable.
- Large parts of Indonesia, including Kalimantan, are underdeveloped and do not receive a fair share of government investment.
- A capital city should reflect the success and economic status of a nation.
- A new city can city can be built to be 'green' and 'smart' – digitally connected and using the latest technologies and sustainability strategies.

In January 2022, the Indonesian parliament approved the relocation of the capital to a new city called Nusantara. Nearly 1.5 million civil servants will relocate to the new city, which is where government administration will take place. Nusantara will cover 2560 square kilometres, a large proportion of which is planned to be 'green spaces'.

▲ **Source 1:** Indonesia, and the movement of its capital

HOW TO See **Geo How-To** for latitude and longitude, page 422

Indonesia's new capital city, Nusantara



Source: Matilda Education Australia

▲ **Source 2:** A new capital for Indonesia

Sources 1–2 activities

See world map, page XXX

1. Provide the geographical coordinates of Jakarta and the Nusantara.
2. State the distance and direction of Nusantara from Jakarta.
3. Analyse the spread of large cities in Indonesia and determine one advantage of relocating the capital to Kalimantan.
4. Assess the importance of a new capital to represent Indonesia's growing economic importance.
5. Evaluate the capacity of Jakarta to be a sustainable city in the future.

Source 3: Jakarta is a coastal city through which multiple watercourses flow. When it rains, low-lying areas on the coast and around rivers flood. When poorer households pump too much groundwater because piped water is unavailable or expensive, the land sinks, currently at a rate of 5–10 centimetres each year. Sinking land makes flooding worse and increases the impact of rising sea levels and the likelihood of more losses of lives, property, infrastructure and livelihoods.

Environmental challenges

Sources 3–5 activities

1 Identify environmental issues experienced by residents of Jakarta.

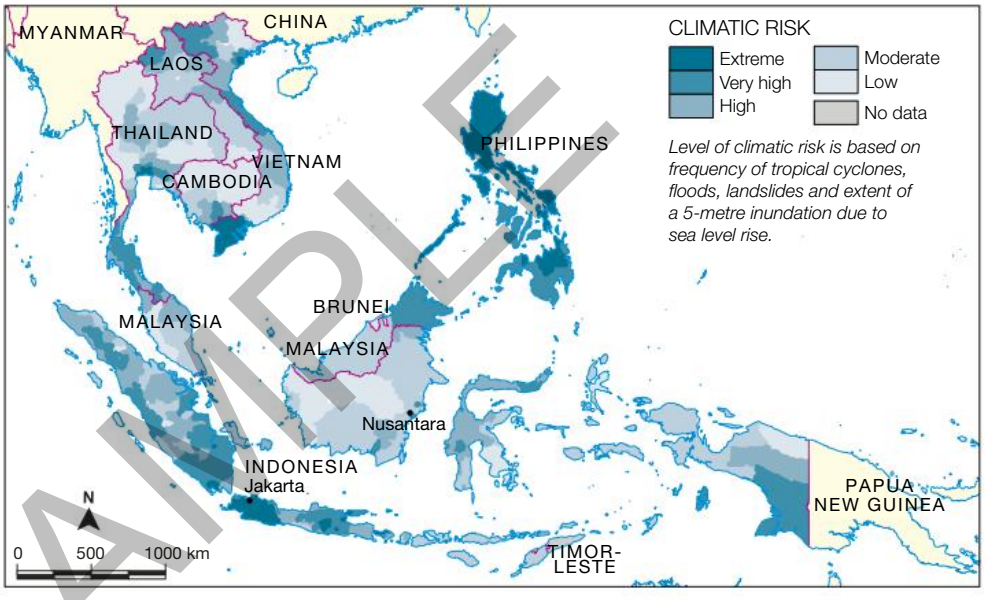
2 Source 3:
- **a** Describe the landscape in the photograph.
- **b** Explain why the poorest people live on the most flood-prone land in Jakarta.

3 Source 4:
- **a** Explain the meaning of climatic risk.
- **b** Compare the climatic risk for Jakarta and Nusantara.

4 Source 5: Calculate the proportion of Jakarta that will be vulnerable to extreme sea level rise by 2100.

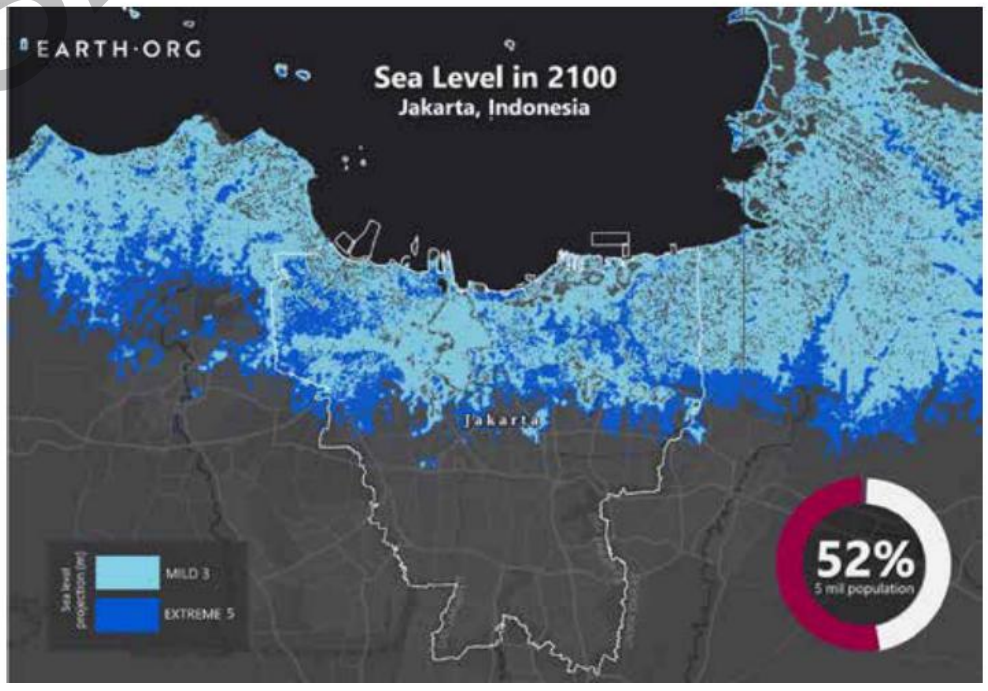
5 Assess the contribution of physical factors to the challenges facing Jakarta.

Climatic risk South-East Asia



Macmillan Global Atlas

▲ **Source 4:** Climatic risk in South-East Asia



Source: Earth.org

Source 5: A model of flooding caused by storm surges, high tides and rising sea levels that could impact Jakarta by 2100 if the problems causing the changes are not resolved. One proposal is to build a 'wall across the bay to keep out rising seas, but this would cost billions of dollars and many years to complete.

See **Geo How-to** for sketches and annotating, page 434

Source 6: Like many other megacities in the world, Jakarta is in parts a modern thriving city while at the same time unable to house its rapidly growing population with adequate housing and services.

Sources 6–8 activities

1. Create a labelled photo sketch identifying the skyscrapers and slums in Jakarta.
2. Why is traffic congestion considered unsustainable?
3. Explain why Jakarta has slums.
4. Assess the contribution of physical factors to the challenges facing Jakarta.
5. Analyse how the planned features of Nusantara should create a sustainable city.
6. Create an illustration showing the features of a residential street in Nusantara when it is completed and recognised for its sustainability.

Source 7: Limited public transport infrastructure leads to congestion and pollution.

Source 8: Authorities and planners claim that Nusantara will be green and sustainable. Residents will have access to green recreational spaces, high-density buildings will require less land and be built from ecofriendly materials, public transport will dominate the way people travel, and the city will be powered by renewable energy sources. Land is already cleared for farming so no new deforestation will be required, and the inland location will protect coastal mangroves. Infrastructure built for nearby cities close to Nusantara, such as highways and airports, will be used to reduce the environmental footprint of the new city.

Environmental change 5

CAN POLAR REGIONS SURVIVE GLOBAL WARMING? 216

HOW QUICKLY ARE FORESTS DISAPPEARING? 206

WHAT ARE THE IMPACTS OF DESERTIFICATION? 200

5.0

How can I understand environmental change?

Our world is constantly changing. While natural factors are responsible for relatively predictable changes, human activities have resulted in a range of devastating impacts on our fragile ecosystems. Now, more than ever, we must understand the world around us and how we can change it for the better.

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 toward 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 evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.

Source 1: A firefighter carrying an injured koala during a bushfire

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

5.1

What is the value of biodiversity?

Biodiversity is the total of all living things on Earth that make up the biosphere, including plants, animals, fungi and small, often invisible, microorganisms that help support life.

Types of biodiversity

There are three components to biodiversity – individual species; the genetic material that makes all species different; and the ecosystems that species create when they interact together as communities. Biodiversity can be land-based (terrestrial) or found in water (aquatic).

Species biodiversity

Scientists have identified about 1.75 million species on Earth, with millions yet to be discovered and named. Places in warm tropical climates such as the Amazon Rainforest and the Great Barrier Reef have the most biodiversity. Cold locations such as Antarctica, and dry places such as the Sahara Desert have less. Climate determines the primary **biomass** (plant matter) that forms the foundation of food chains and food webs. Where plant productivity is high a larger number of animal species can be supported.

There are places in the world where species biodiversity is highly visible to humans and because of this they support a large 'biodiversity tourism' industry. Examples include African grasslands, where large numbers of different animals such as zebra, elephant and giraffe gather at waterholes, and coral reefs where corals, sponges, fishes and crustaceans can be seen by people who snorkel or dive.

Species that are unique and only exist in one place are called **endemic**. Australia is renowned for its endemic species of plants and animals such as Tasmanian devil, quokka and rainbow lorikeet. In fact, 84 per cent of plants, 83 per cent of mammals and 45 per cent of birds in Australia are only found here. A species that is not native to a place is called **invasive**, a feral animal or an exotic plant.

Ecosystem biodiversity

Biodiversity includes all of the Earth's ecosystems, the communities of living things and their non-living environment. Each ecosystem supports a unique variety of plant and animal species, each with its own niche and role to play. For example, within the Earth's desert environments there are different desert ecosystems such as Australia's Munga-Thiri/Simpson Desert where the greater bilby and potoroo can be found. In the Sonoran Desert in Arizona, United States, the iconic saguaro cactus provides shelter, food, and nesting sites for many species of wildlife including Anna's hummingbird. The Pampas grassland of Argentina has different species of animals compared to the Serengeti, the home to one of the highest concentrations of lions, zebras, giraffes and elephants in Africa, shown in Source 1.

A **keystone species** is one that is essential to maintaining the biodiversity of an ecosystem. For example, krill in the Southern Ocean ecosystem consume phytoplankton, converting it into a food source that is the diet of fish, penguins, seals and whales. Bees and other pollinators are essential to the survival of some flowering plants. Species are known as ecosystem engineers if they modify their habitat and create new micro habitats or conditions for other species. The bilby in arid Australia moves about 20 tonnes of soil a year digging for food and burrowing underground. Tilling the soil helps seeds to germinate and tunnels create habitats for small mammals, such as hopping mice and lizards.

Genetic biodiversity

Genes contain the biological information that makes each species unique. The greater the variety of genes, the better that species can adapt to changes to its environment. The more species there are in an ecosystem the higher the total genetic diversity. This genetic material is essential for species survival and for humans who use it to create new medicines or foods in a process known as **genetic engineering**.

Source 1: Africa's savanna ecosystem is a region of tropical grassland that supports a diverse community of organisms that are highly visible. A large number of different species, including elephants, giraffes, zebras and gazelle have gathered at this waterhole. The savanna grasslands also support a large biodiversity tourism industry as tourists undertake safaris to view the animals and landscapes.

▲ **Source 2:** Australia's Simpson Desert is a vast area of dry, red, sandy plains and dunes, including the longest parallel dunes in the world.

▲ **Source 3:** Iconic saguaro cactus is endemic to the Sonoran Desert in Arizona, USA.

▲ **Source 4:** Anna's hummingbird is a native bird in the Sonoran Desert where it uses its long extendable tongue to feed on the nectar in Saguaro cactus flowers or to catch small insects.

The value of biodiversity

Every species and ecosystem has value simply because it exists. This is known as **intrinsic value**. In recent years there has been growing legal recognition of natural places such as rivers and forests in the belief that nature has the same rights as people. Biodiversity plays a critical role in how environments function, the natural processes that make environments unique and Earth habitable for humans. For people, biodiversity has economic, environmental, recreational, cultural and scientific values, providing us with clean water, fertile soil, climate control, medicines, food, recreation, and inspiration.

The benefits of biodiversity, also known as **ecosystem services**, are grouped into four categories based on whether they provide, regulate or support environments and people, or have cultural value.

- **Provisioning:** ecosystems provide humans with products or resources such as water, timber, food, fibres and medicines. It is estimated that 25 per cent of modern medicines come from the genetic material in living things, particularly in plants.
- **Regulating:** plants influence the flow of water in catchments, assist in the infiltration of groundwater by slowing runoff and prevent erosion by stabilising riverbanks. Clean water and stable environments benefit humans.
- **Supporting:** bees and other insects assist in the pollination of plants and as a result the production of plant based foods. About 30 per cent of our food comes from plants pollinated by bees. Plants also produce oxygen and play an important role in recycling nutrients such as carbon.
- **Cultural:** individuals and communities benefit from the beauty of nature, spiritual connections to living things and ecosystems as well as opportunities for relaxation, recreation and tourism. World Heritage listing is one way that the cultural value of nature is recognised.

Threats to biodiversity

At a global scale biodiversity has decreased dramatically and many species are now endangered or have disappeared through **extinction**. A species becomes endangered when its population is low or its habitat is threatened. Some species such as the South China tiger and Spix's macaw are extinct in the wild, but survive in captivity. Since 1970, the size of known animal populations have reduced an average of nearly 70 per cent.

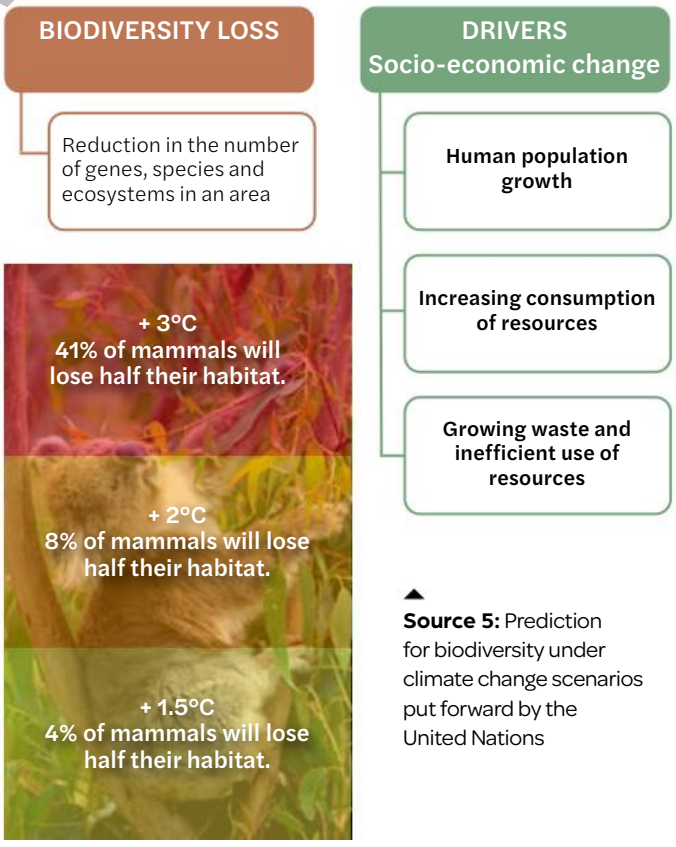
The growth of the human population to 8 billion in 2022, the increasing demand for resources and land for agriculture and settlement, as well as unsustainable resource use and waste drive the environmental changes that cause biodiversity loss. These changes include habitat destruction, pollution and climate change. Every change to a natural environment can potentially impact biodiversity without protection, conservation and sustainable management.

Protecting and managing biodiversity

Individuals, businesses, organisations, national governments, non-government organisations (NGOs) and international government organisations (IGOs) recognise the value of biodiversity and have implemented agreements and strategies for its protection. The increasing recognition and inclusion of Traditional Indigenous Knowledge and Indigenous Peoples' leadership in conservation along with non-indigenous scientific knowledge and practices is enhancing biodiversity conservation.

Examples of actions at different scales include:

- UN Sustainable Developments Goals for Climate action, Life below water, and Life on land (Goals 13, 14 and 15)
- Paris Agreement on Climate Change to limit global warming



Source 5: Prediction for biodiversity under climate change scenarios put forward by the United Nations

Biodiversity hotspots

Source 6: Global biodiversity hotspots are indicated in brown. There are 36 biodiversity hotspots on Earth where biodiversity is high, but is at high risk from human activities.

Source: Atlas for the end of the world

- UNESCO's World Heritage to recognise ecosystems of global importance
- the Convention on International Trade in Endangered Species (CITES) to regulate international trade in wild animals and plants
- IUCN and WWF work globally to conserve biodiversity
- establishment of wilderness areas, national parks and marine protected areas (MPAs).

CAUSES
Environmental change

Source 7: Causes of biodiversity loss

Habitat loss
Destruction, fragmentation or degradation of the natural habitats of species for uses such as agriculture, urbanisation, infrastructure and exploiting resources. Example: the clearfelling of forests for timber.

Invasive species
Non-native species that disrupt or modify ecosystems or habitats and compete with native species for food resources. Example: Local extinctions of native mammals in Australia due to feral cats.

Overexploitation
Overhunting, fishing or harvesting that depletes species populations and alters food webs. Example: The loss of fish stocks and depleted marine food webs.

Pollution
Addition of unwanted chemicals or nutrients that the natural systems cannot process. Example: Fish kills from oil spills and sewerage disposal into rivers and oceans.

Climate change
Changing environmental changes that species are adapted to survive in through rising sea levels, ocean acidification, heatwaves and extreme weather events. Example: Coral bleaching and bushfires.

Learning ladder 5.1

Characteristics of places and environments

1. Outline the three components of biodiversity.
2. Describe the characteristics of the places in Sources 1, 2 and 3.
3. Source 5: Explain the main drivers of biodiversity loss.
4. Explain the difference between provisioning and regulating services provided by nature.
5. Sources 5 and 7: Evaluate the impact of climate change on biodiversity. Which environmental changes from climate change will impact koalas?

Interconnection

1. Identify five environmental changes that cause biodiversity loss.
2. Sources 2 and 3: Explain the potential value of these ecosystems.
3. Source 6: Suggest how identifying biodiversity hotspots can lead to more action to protect biodiversity.
4. Sources 3 and 4: Explain the interconnection between these sources. What role does the hummingbird play in the ecosystem?
5. Source 7: Analyse how social and economic change can lead to environmental changes that cause biodiversity loss.

HOW TO

Interconnection, page 410

How are environments important to First Nations Peoples?

First Nations people worked together, sharing food and knowledge, and living in harmony with their environment – never taking more that was required and living sustainably from Country.

Connection to Country

Connection to Country is also about a connection to a place. It is these places which connect First Nations people to all living and non-living things. The three spheres of knowing Aboriginal land – the human world, the physical world and the sacred world – help us to also examine environmental change and the impacts these have to Australian First Nations communities.

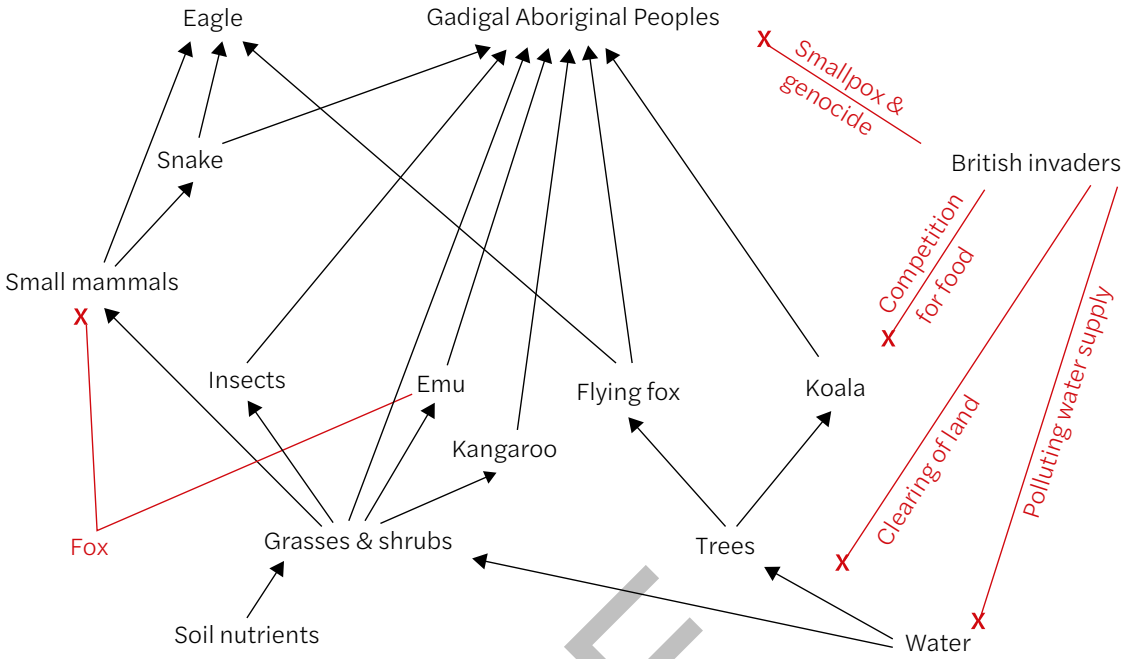
First Nations communities hold many values to help connect to Country, spirituality, stories, and community. These factors also shape an individual person's identity and how they relate to their environments. First Nations people have a **totem** or number of totems that represent their spiritual link to the land. A totem might be a natural object, animal or plants that act as guides individually and collectively but more importantly set out the stories of how to care for unique parts of Country. Clan groups have special caretaking responsibilities for their totems.

Being connected through the three spheres of 'being' First Nations are part of lore and part of the spiritual connections a group has to their environment. In more recent times these spheres have been disrupted by colonisation and subsequently these interactions with Country have changed the environment over time and also the stories shared with future generations. The connections and disruptions have caused and contributed to environmental changes over time and this requires First Nations people to share and adjust knowledge of Country to reconnect the people and reinvigorate the places.

Storytelling

Aboriginal people mostly lived a lifestyle, guided by Elders who knew the Dreaming stories, abided by customs, traditions and lore which was all interconnected to caring for environment. The protection of native ecosystems is shared by everyone in a First Nations community through storytelling and sharing responsibilities which are taught from birth. Newer stories about foxes and rabbits are also influencing our understanding of how introduced species make First Nations peoples' roles and responsibilities change over time. The stories which outline the roles and responsibilities connect people to an animal through totem relationship. These totemic responsibilities not only connect a person to that animal but to seasonal calendars, breeding cycles, hunting rules, plant lifecycles, and waterway management as well as any additional environmental care factors which nourish and sustain that life such as fire and fire farming.

Taking only what's needed from the environment is a very important factor in the health of any First Nations understanding of an ecosystem. The destruction of some Australian ecosystems occurred very quickly after colonisation, and the destruction has occurred as a result of introduced species, land clearing and the dispossession and prevention of First Nations people accessing and caring for Country. This environmental degradation has created some of the factors which are linked to climate change. The ongoing destruction of the environment continues to impact on past fragile ecosystems and those more recent but equally fragile ecosystems which have emerged.

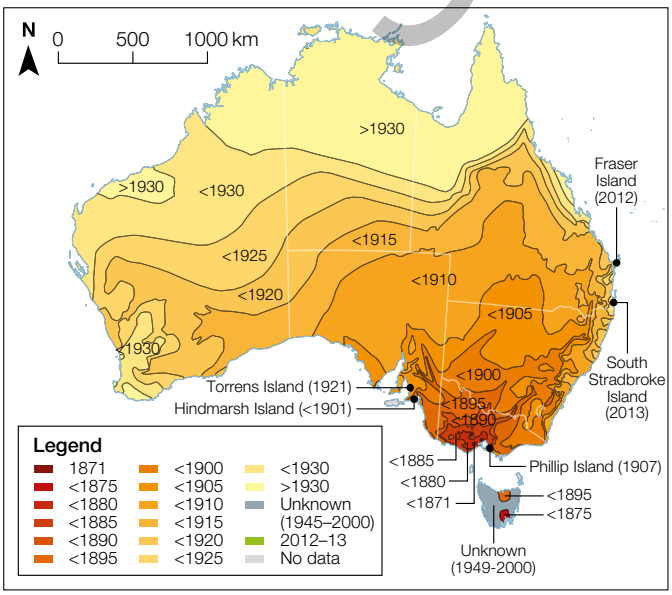


▲ **Source 2:** How the Gadigal ecosystem was interrupted by British invaders, including introduced species such as the fox.

Foxes

The fox was introduced to Australia for recreational hunting near Melbourne about 1855 and by 1870 had become a pest. Foxes were recorded to be populating almost 75 per cent of the Australian continent in just one century. This newly introduced species interrupted and destroyed many of the native animal populations as the fox ate both lower and higher animal species on a range of ecosystems which are unique to many First Nations lands. Other introduced species like rabbits, hard-hoofed animals like sheep and cattle, camels and cane toads, and crops like cotton and wheat, barley and rice all brought challenges to the fragile ecosystems.

Spread of the red fox around Australia



Source: Russell J. Fairfax

▲ **Source 1:** Spread of the introduced red fox across Australia

Learning ladder 5.2

First Nations Peoples' interaction with Country

1. What is connection to Coutry?
2. How do First Nations people live sustainably from Country?
3. Source 2: How did British invaders interrupt the ecosystem of the Gadigal Peoples?
4. What are totemic relationships and how do they help build understanding of environments?

Environment

1. What are the three spheres of Aboriginal land?
2. Source 1: Explain the spread of red foxes across Australia since their introduction.
3. What impact did the introduction of foxes to Australia have on a range of ecosystems?
4. How do First Nations Peoples' understanding of ecosystems differ from those responsible for the colonisation of Australia? What has been the impact of colonisation on ecosystems?

HOW TO

Environment, page 414

5.3

What are the causes and impacts of land degradation?

Land degradation is a global problem largely caused by human practices such as agriculture, deforestation and burning fossil fuels, which all contribute to climate change. Reforestation and improved farming practices are solutions to reduce soil loss.

Land degradation

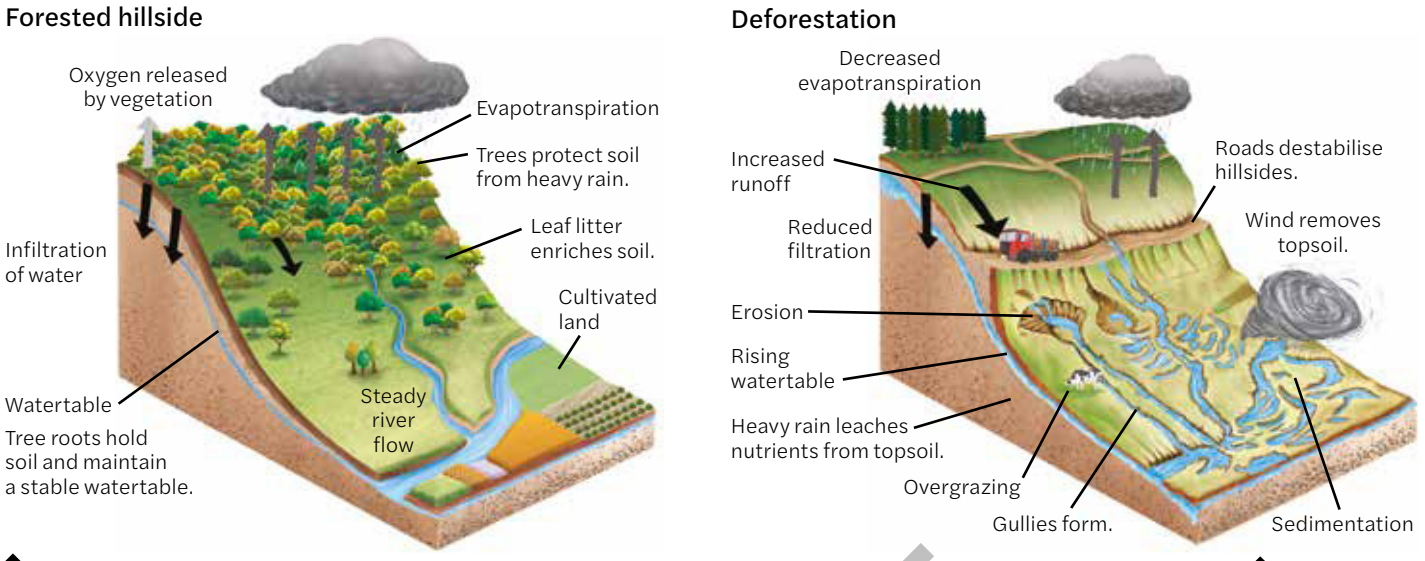
Land degradation is the declining quality of Earth's land surface, reducing its productivity and capacity to support natural vegetation, crops and pastures. The main impact of land degradation is on soil. Land degradation includes soil erosion, loss of soil fertility and structure, salinity, waterlogging and at its worst, desertification. The physical, chemical and biological characteristics of land are changed and may not recover. For example, soil loss from conventionally farmed land often exceeds the rate of soil formation and will deplete over time.

Causes and impacts of land degradation

Globally, around 24 per cent of farming land is classed as degraded, a figure dwarfed by Australia, where an estimated 66 per cent of land is degraded. Natural processes, including hazards such as droughts, floods and bushfires, contribute to land degradation if vegetation is destroyed and land is exposed to wind and water erosion. Human activities are responsible for most land degradation:

- **Land clearing:** This is the removal of natural vegetation (**deforestation**) for agriculture, settlement, timber, mining and infrastructure. Deep-rooted plants hold soil particles together, add nutrients through the recycling of decaying leaves and keep the watertable low. Plants also intercept precipitation and slow runoff, effectively protecting the top layer of soil. When vegetation is removed, wind, rain and runoff cause erosion and can leave scars on the landscape (**gully erosion**). Steep land is prone to gully erosion because the gradient accelerates runoff. Gullies reduce the productive land on a farm and restrict access between paddocks by livestock and farmers.
- **Infrastructure:** Roads, pipelines and land developments interrupt the natural flow of runoff. Areas can become waterlogged and unable to sustain plants that cannot tolerate 'wet feet' because water cannot drain away. Roads in hilly areas can channel water down hillsides, destabilising the land and causing landslides.
- **Overgrazing:** This is when the carrying capacity of the land is exceeded and there is not enough food for the number of livestock farmed. Animals eat plants to the ground and in extreme cases consume plant roots, leaving the land bare and prone to erosion. Hard hooved livestock compact the soil, increasing its vulnerability to wind and water. Overgrazing is greatest on marginal lands where climate variability means pastures vary naturally from year to year.
- **Irrigation:** This causes salinity by raising the watertable and bringing salt into the root zone of plants. Most crops cannot tolerate high levels of salt and at its worst, can form salt scalds where nothing will grow.

Source 1: Gully erosion created around a tree on farmland in Jijiga, Ethiopia.



Source 2: Pair of block diagrams showing the importance of trees to hold soil together and the impact of deforestation.

- **Monoculture and overcropping:** This is when one crop is grown continuously on the same land, or fields are not rested between crops, fertility declines, and the soil structure breaks down. When this happens, the soil becomes loose particles instead of peds or small clumps making it easier to wash or blow away. When nutrients, such as nitrogen, needed for plant growth are depleted crop yield drops. To improve fertility, farmers add fertilisers that can result in nutrient rich runoff that can pollute and degrade adjacent waterways.
- **Climate change:** Warming temperatures and heat stress, changed rainfall pattens and more intense and frequent hazard events will increase exposure to the processes that cause land degradation in many places.

Solutions

On farm solutions to land degradation include maintaining groundcover by not fallowing land between crops, leaving post-harvest stubble on fields, crop and livestock rotation, to maintain fertility and reduce overgrazing, reducing stocking rates during dry periods, contour ploughing to slow runoff and reduce gullying and wind breaks to reduce wind speed. Reforestation to replace cleared vegetation, careful planning of infrastructure corridors and more sustainable use of already cleared land can help reduce land degradation. Climate change preparedness, including changing farm practices can build resilience to climate change. The greatest impact of land degradation is felt in poorer countries where growing populations and lack of economic and technological resources limit the capacity to address the issue. In these cases, international aid is important.

Learning ladder 5.3

Processes that transform people, places and environments

1. Draw a mind map identifying the processes that cause land degradation.
2. Describe the processes of waterlogging, overgrazing and overcropping.
3. Explain the link between climate change and land degradation.
4. Create a two column table to show the causes of land degradation and one possible solution to each.
5. Assess the role that individuals, groups and organisations need to play in addressing the issue of land degradation.

Change

1. Source 1: How do plants protect soil from erosion?
2. Source 2: How do infrastructure and deforestation change the environment and cause land degradation?
3. How can farmers change their farming techniques to help reduce land degradation?
4. Source 1:
   - **a** How does the gully in this farm reduce the productivity of the land?
   - **b** Predict what this may look like in the future without intervention by the farmer.
   - **c** Suggest a solution to restore the land.

HOW TO
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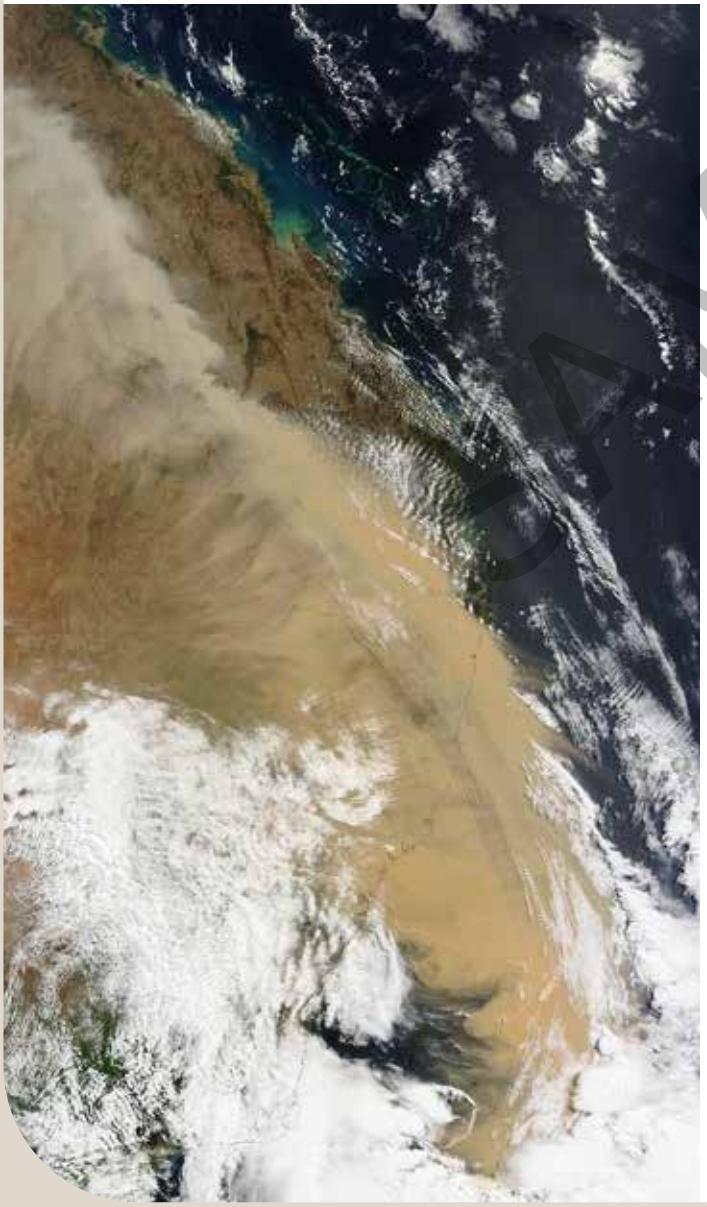
How is geospatial technology used to study land degradation?

Geospatial technologies are important tools in measuring the severity of land degradation, such as soil erosion and deforestation. Digital information can be displayed in layers over a base map to better observe spatial associations and interconnected processes to assist planning to improve the health of environments.



What are spatial technologies?

Spatial technologies are used to collect and visualise environmental data. They include a range of tools:

- **Global positioning system (GPS)**, uses satellites and ground monitoring stations to locate environmental degradation or map forests.
- **Remote sensing** involves collecting environmental data from places without being present. The data is collected using technologies such as satellites and drones equipped with cameras, thermal scanners, radar and lasers and transmitted to another location where it is manipulated to create detailed photographs and maps.
- **Geographic information system (GIS)**, maps layers of data concerning the health of ecosystems, obtained from GPS and remote-sensing sources into applications such as Google Earth and Google Maps.

How are spatial technologies used?

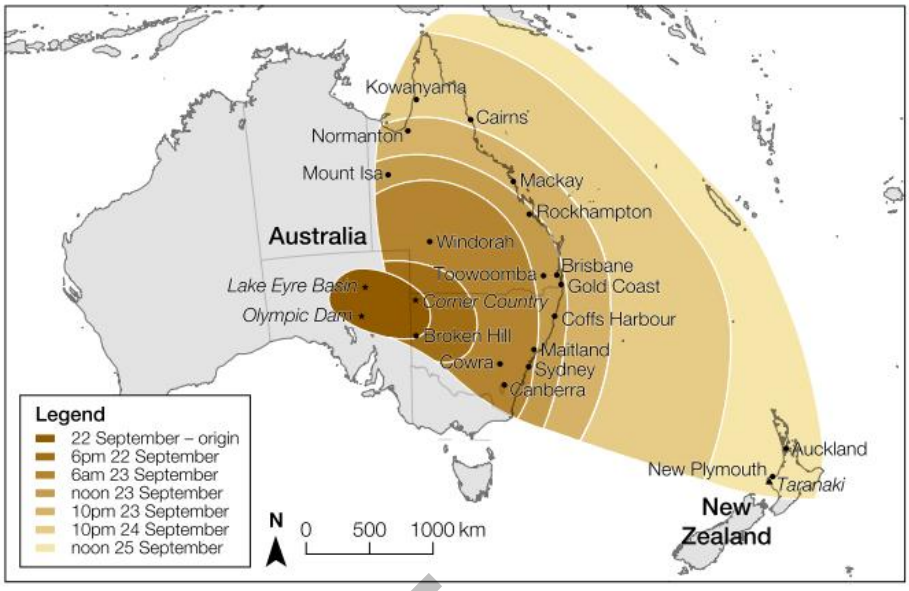
Spatial technologies are assisting humans to sustainably manage the Earth's ecosystems. Presently, all parts of the world can be captured and analysed in hours rather than weeks. Remote sensing technologies have been widely used to investigate land degradation. It is able to detect patterns of vegetation cover, which

Source 1: Satellite remote sensing has proven to be a useful tool in studying the process and movement of dust storms. In 2009 a huge dust storm swept across New South Wales and Queensland, before dumping thousands of tonnes of soil into Sydney Harbour and the Tasman Sea. The satellite data enabled the tracking of the storm and measurements of the amount of soil lost. This satellite image was captured on 23 September 2009.

can be compared to earlier images to show change in an area. Thermal remote sensing can detect the amount of moisture in the soil to enable researchers to determine the possibility of vegetation growth or fire risks.

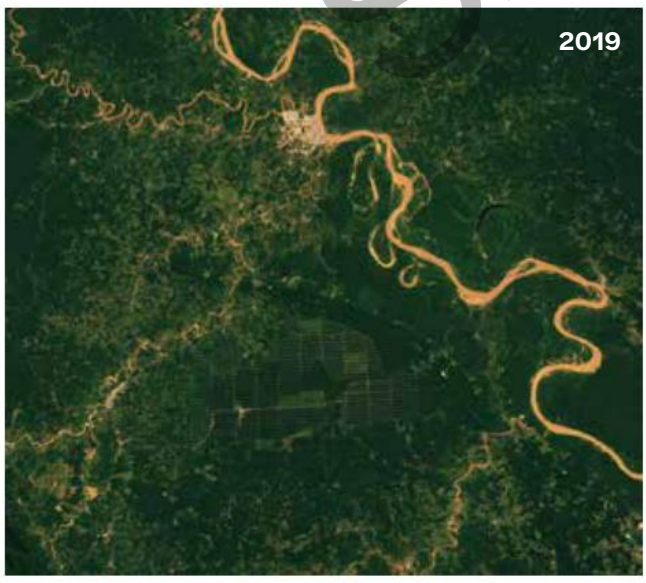
GPS and remote sensing data is combined with other data into a geographic information system (GIS) to create create maps that reveal patterns. Data gathered from satellite imagery and ground monitoring stations enabled the creation of the GIS map shown in Source 3, that shows the progression of the 2009 Australian dust storm shown in Source 1.

2009 Australian dust storm



Source: Matilda Education Australia

Source 3: GIS map showing the progress of the 2009 dust storm at various intervals across Australia and the Tasman Sea



Source 2: Deforestation of the Amazon rainforest south of Yurimaguas in Peru is clearly shown in this pair of satellite images.

Learning ladder 5.4

Representing and communicating information

1. List three different types of spatial technologies.
2. Source 3:
   - **a** How was this map created?
   - **b** What form of spatial technology is this source an example of?
   - **c** Use the map to describe the movement of the dust storm, including the origin of the eroded soil.
3. Source 1:
   - **a** What form of spatial technology is this source an example of?
   - **b** Describe what is shown in the image and where it is located.
   - **c** Compare Sources 1 and 3. At approximately what time of day was the satellite image collected?
4. Source 2:
   - **a** Why are pairs of remote sensing images taken at different time useful for geographers?
   - **b** Describe the change that occurred to the Amazon rainforest between 2001 and 2019.
   - **c** Outline the possible outcomes for wildlife that depend on the rainforest as their habitat.

HOW TO

Satellite images, page 441

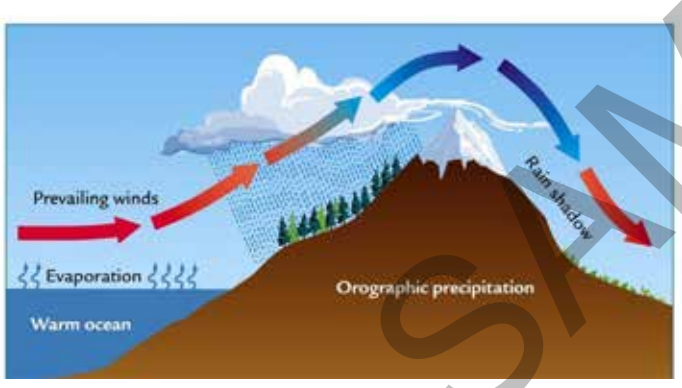
Case study

How is desertification in the Gobi Desert affecting China?

Climate change and poor management of the land by humans has seen increased desertification in the Gobi Desert region of Asia. The impact of desertification is easily seen in the huge dust storms that engulf local communities and travel thousands of kilometres.

The Gobi Desert region

The Gobi Desert is located across southern Mongolia and north-western China. It is a rain shadow desert, formed because surrounding mountain ranges like the Himalayas, block rain-bearing winds from reaching its area. This results in a desert, covered in sedimentary rock and dry grasslands, that receives an average of 177 millimetres of rain a year, with some parts receiving no measurable amount for years at a time.



▲ **Source 1:** The rain shadow desert process. This is how the mountains surrounding the Gobi cause its arid and semi-arid environment.

Causes of desertification

Desertification is the degradation of arid and semi-arid environments that results in a decrease of precipitation and vegetation cover. The Gobi Desert is experiencing rapid desertification, with the desert spreading 3600 square kilometres each year. This is being driven by natural processes, such as low and erratic rainfall, strong winds and a naturally fragile ecosystem that increases its vulnerability to desertification. However, human activities have also sped up desertification.

Deforestation and overgrazing

Overgrazing of livestock and excessive deforestation in areas surrounding the Gobi Desert has removed vegetation that binds soil together and exposed nutrient-rich top soils to wind and water erosion. The exposed soil also becomes drier and warmer, preventing vegetation from growing.

Poor water management

Over use of water resources in China and Mongolia in agricultural and mining activities, results in a loss of water retention in the ground and reduction in vegetation cover. Poor irrigation practices can also lead to the accumulation of salt in the soils, making it unsuitable for vegetation to grow.

Climate change

Climate change has also increased aridity in the Gobi Desert, decreasing annual precipitation by 7 per cent and increasing annual temperatures by 2.24°C between

Source 2: A huge dust storm engulfs a village in Golmud, home to 220 000 people, bordering the Gobi Desert. Each spring strong winds blow across the Gobi creating huge storms carrying dust and sand that cause respiratory illness, blackouts and transport disruption.

1940 and 2015. This results in soil becoming drier and less precipitation to cycle in the environment. This led to 25 per cent of lakes in the Mongolian Plateau drying up by 2010 and more than 75 per cent of Mongolia experiencing drought and desertification.

Impacts of desertification

Desertification is causing an increase in the frequency and intensity of dust and sand storms. The Gobi is the second largest dust source in the world, which is increasing as desertification enhances the amount of dust from bare soils. This dust carries toxic pollutants, bacteria, viruses and fungi, impacting the health of humans and animals who inhale it.

In 2021, Mongolia experienced the largest sandstorms in a decade, which caused extensive damage across the country. Sand was also transported to places as far as China, Japan and South Korea. As desertification progresses, native species may struggle to survive and human communities will face decreased agricultural productivity and food and water scarcity.

What are they doing to manage it?

Efforts to combat desertification in the Gobi region include sustainable land management practices, afforestation and water conservation. China has been implementing the 'Great Green Wall' since 1978, which is 4500 kilometres of 6.6 billion new trees planted to stop the advancement of the Gobi Desert and protect the soils. Success has been mixed, with some areas losing 20 per cent of planted trees within a few years.

Source 3: Mongolian community members searching for water in a river that has dried up due to desertification in the Gobi Desert.

Learning ladder 5.5

Characteristics of places and environments

1. List the factors contributing to desertification in the Gobi Desert.
2. Source 1: What role do surrounding mountain ranges play in the Gobi Desert environment?
3. Explain how humans have changed the environment in and around the Gobi Desert.
4. Predict the potential long-term effects of climate change on desertification in the Gobi Desert.
5. To what extent is climate change the biggest contributing factor leading to desertification in the Gobi? Justify your answer with examples from the text.

Place

1. Describe the location of the Gobi Desert.
2. Source 3: Describe the physical and human characteristics of this place.
3. Source 2: What impact do dust storms have on communities living in and near the Gobi Desert?
4. Assess the 'Great Green Wall' initiative in China and its effectiveness in combating desertification in the Gobi Desert.
5. Create a plan to address the impact of desertification in the Gobi region.

HOW TO

Place, page 408

5.6

How do invasive species degrade the land?

Invasive species are non-native species that disturb the ecosystems in which they are introduced. Invasive plants, animals and bacteria can harm native plants and animals, the quality of soil and water in an environment and agricultural productivity.

Ecological imbalance

Invasive species compete with native species for essential resources; such as water, food and nutrients and habitats. If the invasive species reproduce at a fast rate or do not have any natural predators in the environment, they can dominate local habitats and reduce food availability for native species.

This is seen with invasive weeds like blackberry plants that grow quickly and create a dense canopy that shades other plants, preventing them from growing. Invasive weeds also disrupt pollination processes, by attracting pollinators away from their flowers. This disrupts native seed dispersal processes, impacting the ability for native plants to distribute in an area.

With increased competition for shelter, invasive species often displace native fauna and leave them more vulnerable to predators. Food chains become disrupted as native populations of flora and fauna decline. This leads to a decrease in biodiversity, which makes ecosystems less productive and more vulnerable to threats.

Source 1: The Indian myna is an introduced species from Asia. This very aggressive bird pushes native birds like parrots and kookaburras from their nests and destroys their eggs. Indian mynas take over the roosting areas of native birds and scare away any birds entering their territory. The bullying tactics of Indian mynas exclude most bird species from territories they occupy.

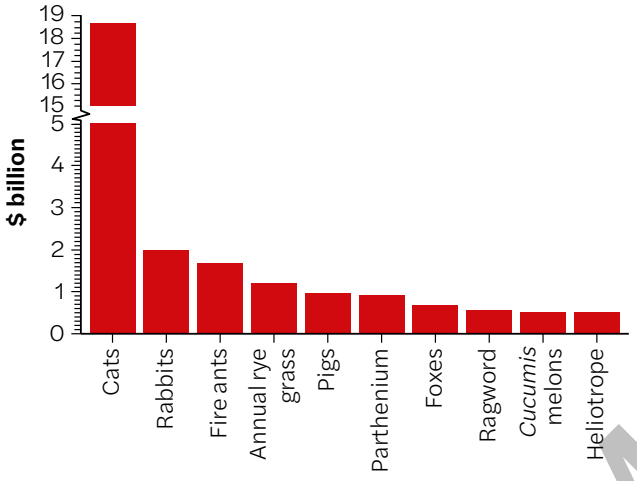
Foxes in Australia

Introduced to Australia in 1855 for hunting purposes, the European red fox rapidly spread throughout southern Australia to become one of the most damaging invasive species. With few predators other than eagles in Australia, foxes have become **apex predators**, preying on ground-nesting birds, small mammals such as the greater bilby and numbat, and reptiles. Foxes also prey on newborn lambs, kid goats and poultry. The fox has played a major role in the decline of ground-nesting birds, small to medium sized mammals such as the greater bilby, and reptiles. Foxes also cause economic losses to farmers by preying on newborn lambs, poultry and other livestock.

Source 4: Wild horses, known as brumbies, are an invasive species in many parts of Australia. They graze on the land, trample vegetation and cause soil degradation.

▲ **Source 2:** The spread of foxes in Australia has had a dramatic impact on native fauna.

Cost of invasive species to Australia over the past 60 years



Source: Matilda Education Australia

▲ **Source 3:** The cost of invasive species to Australia totals to more than $390 billion in the past 60 years. This cost is seen in the loss of crops, livestock and in attempts to manage invasive plants and animals. Feral cats are the most costly individual species, with control measures costing over $18 billion.

Impact on the environment

Invasive species also impact on the quality of the environments they invade. Through trampling, grazing and burrowing, invasive species destroy vegetation and degrade and erode the soil. Wild horses in New South Wales' Kosciuszko National Park are responsible for excessively grazing on vegetation, trampling grasslands and creating paths in their runs. This leads to increased runoff of topsoils into local waterways, resulting in lower quality turbid water sources. The introduction of feral pigs in north-eastern Queensland lead to decline of native bird and reptile populations, and impacted sugarcane, fruit, grain and vegetable crops. Feral pigs consume, uproot and trample vegetation, wallow in mud and foul dams and waterholes.

Learning ladder 5.6

Processes that transform people, places and environments

1. Describe what invasive species are and how they are introduced to new environments.
2. Explain the effects of invasive weeds on native vegetation.
3. Source 3: What are the economic impacts of invasive species in Australia, and why?
4. Assess the consequences of invasive species on food chains.
5. Undertake research to evaluate the increased vulnerability of one local ecosystems due to invasive species.

Environment

1. Identify an environment that has been impacted by invasive species.
2. Outline the effect of native species on different environments.
3. Analyse the environmental impact of one invasive species.
4. Using an example, explain how invasive species impact on predation and competition in environments.
5. Propose a strategy to address the ecological impacts of one invasive species and its effect on biodiversity in native ecosystems.

HOW TO Environment, page 414

5.7

Case study

How do rabbits contribute to soil erosion?

When European rabbits were introduced to Australia in the 1800s, the lack of natural predators, abundant food resources and favourable climatic conditions led to them reproducing at a rapid rate. Australia now has an estimated 200 million invasive rabbits.

How do rabbits cause erosion?

Rabbits cause significant damage to Australian environments. Their overgrazing of Australian vegetation and native plants has decreased plant diversity, reduced habitats for native animals and removed protective vegetation that stabilises soils. They also trample vegetation and dig burrows and warrens, which are a network of underground tunnels, that further weaken soils.

Tunnel erosion occurs when surface water runoff flows through the burrows and warrens, enlarging the tunnel until the roof collapses, resulting in potholes and gullies on the surface of the land. The erosion of soils reduces soil fertility as topsoil is degraded and lost, making it less productive for agriculture or for new vegetation to grow.

Source 1: Cross-section of a rabbit warren. Rabbit burrows and warrens lead to tunnel erosion.

Source 2: Gully erosion in South Australia caused by collapsed rabbit burrows

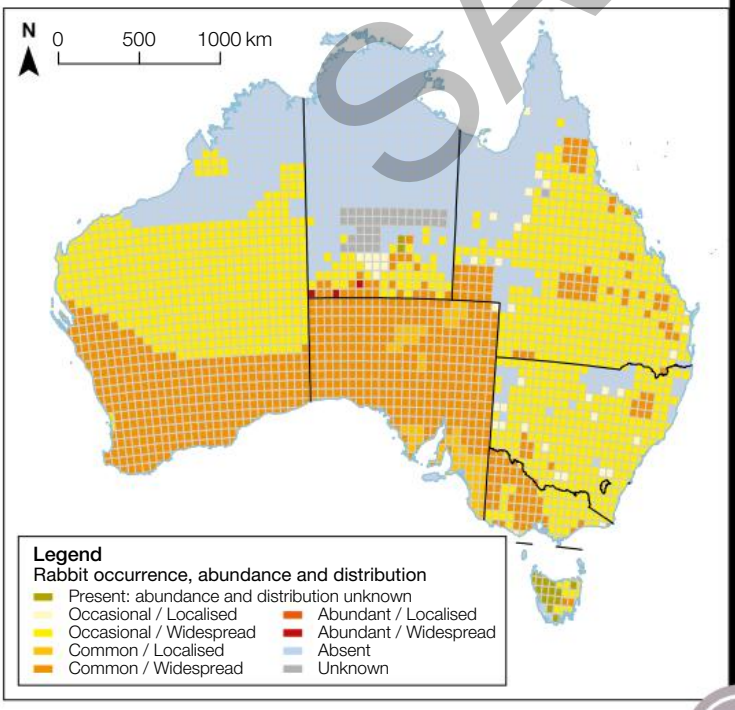
The impact of rabbit erosion

The erosion caused by rabbits currently affects approximately 322 endangered plant and animal species. Through overgrazing native vegetation, they have reduced the diversity of plant species and promoted the spread of weeds. This also reduces food sources for native herbivore species, impacting their populations. As rabbits graze plants down to ground level, they limit seed establishment, and prevent new growth. It takes less than one rabbit per hectare to prevent the successful regeneration of native shrubs.

The agricultural industry is also impacted by approximately $200 million a year, as rabbits consume about $80 million of crops and reduce the feed for livestock; with research showing that sheep who roam in rabbit-dense paddocks produce 21 per cent less wool a year. In addition to this, the government spends approximately $20 million a year in management strategies to reduce rabbit populations, including building rabbit-proof fences and introducing diseases to rabbit populations.

Some researchers argue that rabbits have provided some benefits to Australian environments. Their warrens and burrows have provided refuge for native species, such as echidnas, and they also transport native plant seeds in their faeces. However, their contribution to increased erosion in Australian environments has many ecological and economic impacts.

Presence of rabbit populations across Australia



Source: Centre for Invasive Species Solutions

▲ **Source 3:** The occurrence, abundance and distribution of rabbits in Australia

▲ **Source 4:** Wild rabbit populations in plague numbers in South Australia. The rabbits overgraze the native vegetation, exposing the soils to erosion from wind and rain.

Learning ladder 5.7

Processes that transform people, places and environments

1. List the factors that contributed to the rapid reproduction of European rabbits in Australia in the 1800s.
2. Source 3: Explain the regions of Australia where rabbits are common and widespread.
3. Sources 1 and 2: Explain the impact of rabbit-induced erosion.
4. Assess the benefits and disadvantages of rabbits to people and environments in Australia.
5. Evaluate the economic implications of rabbit-induced erosion for Australian people.

Change

1. Source 2: Describe the change that has occurred in this environment.
2. Explain the measures that the government has taken to manage rabbit populations.
3. Source 4: What are the ecological consequences of rabbits overgrazing native vegetation?
4. Propose alternative strategies or management approaches that could help mitigate the damage caused by invasive rabbit populations.

HOW TO Change, page 412

5.8

How quickly are forests disappearing?

It is estimated that one-third of the Earth's forests have disappeared in the last 10 000 years, and currently about 10 million hectares of forests are removed every year. The world has lost as much forest in the last 100 years as it did in the previous 9000, indicating that forest loss is increasing rapidly.

Why forests disappear

Deforestation

Deforestation is a permanent removal of forests for another land use, such as for commodity agriculture, mining and urbanisation. Most deforestation today occurs in low to middle income countries who are reliant on selling natural resources to wealthier countries, with 59 per cent of global deforestation occurring in Latin America and 28 per cent in South Asia. Over half of this is driven by the beef, soybean and palm oil production industries, as forests are cleared to establish agricultural land uses to feed national populations and supply the world with resources through trade.

Forest degradation

Forest degradation is forest loss that occurs when the land is cleared, or partially cleared, but the land use does not change. This occurs when people clear the land and then regrow it for timber plantations or subsistence farming or when events such as wildfires decrease the density of a forest. This type of forest loss is increasing as a result of climate change and increasing extreme weather events, such as droughts and wildfires.

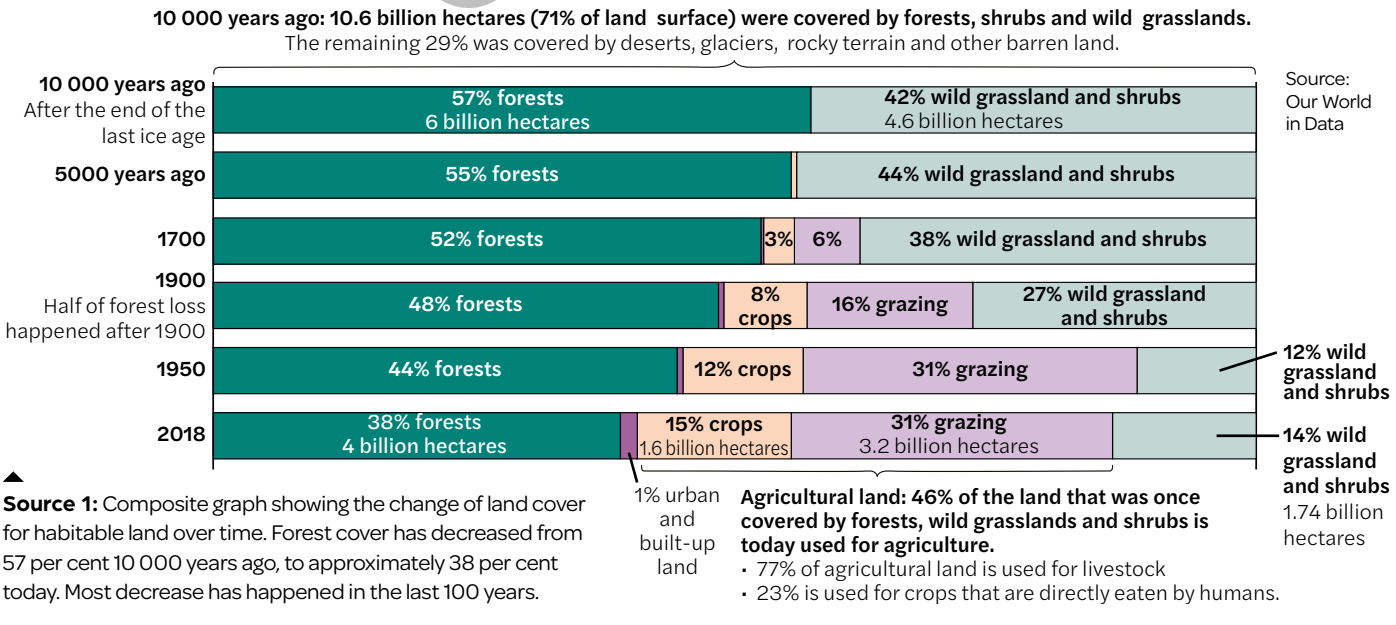
The future

Forests play a significant role. They provide more than 5000 resources for humans and are habitats for 80 per cent of the Earth's land biodiversity. They also regulate our climate by acting as a source of oxygen and a sink for carbon dioxide.

Approximately 75 per cent of forest loss each year is caused by forest degradation, rather than deforestation. This means that the land is able to regrow into forest. As a result, only 27 per cent of forest loss between 2001 and 2015 was considered permanent.

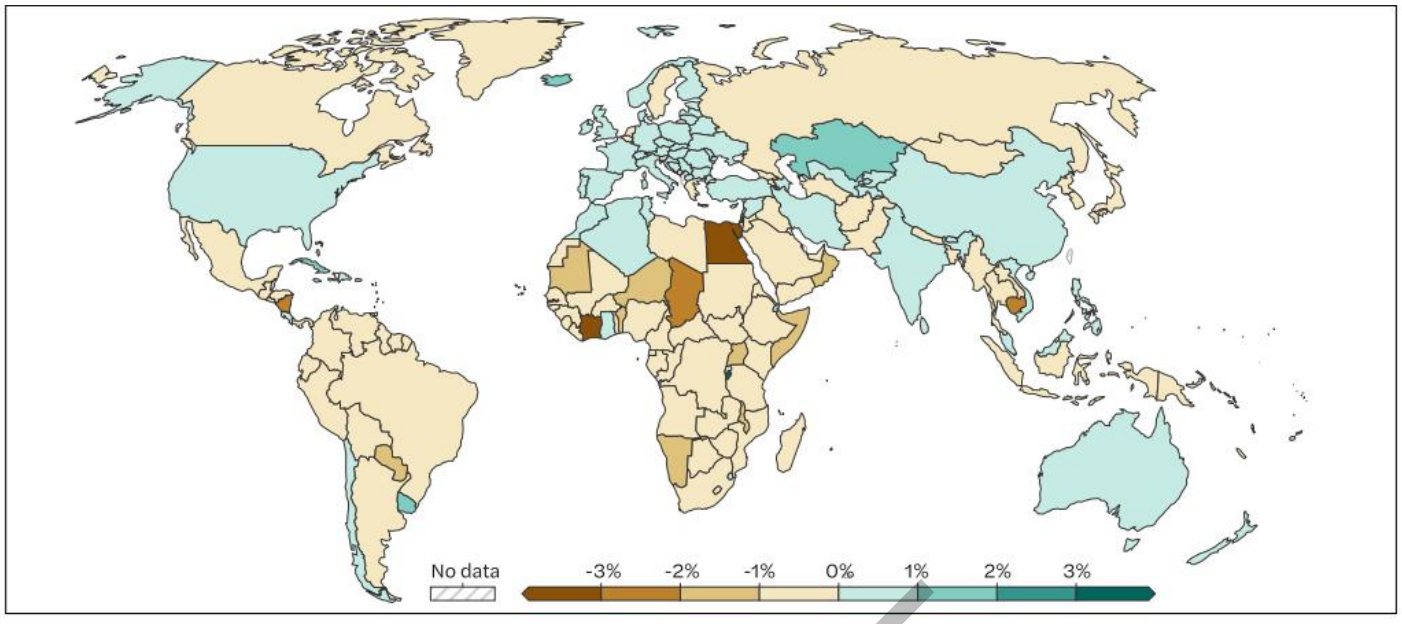
Many high income countries (such as France and Canada) have significantly reduced their deforestation and have instead increased their forest cover. This is because they have the funding and technology to invest in sustainable land use practices, trade globally

The change of land cover for habitable land



Source 1: Composite graph showing the change of land cover for habitable land over time. Forest cover has decreased from 57 per cent 10 000 years ago, to approximately 38 per cent today. Most decrease has happened in the last 100 years.

Global change in forest area, 2020



Source: Our World in Data

▲ **Source 2:** A choropleth map showing the change in forest area in the world in 2020. The countries in green are places where forest cover was gained. Countries in yellow and brown are places forest cover was lost. The USA has reduced deforestation by 47 per cent in the last ten years, gaining forest cover as old forests grow back.

for resources and enforce strict environmental regulations. In addition to this, there are an increasing amount of reforestation initiatives, such as the United Nations 'Reducing Emissions from Degradation and Deforestation' program. This program looks to provide financial and aid incentives to low income countries, such as Chile and Vietnam, to encourage them to conserve and regrow their forests.

Half of the ten million forests degraded or logged each year are regrown or are replanted. For this reason, the rate of forests disappearing is fast, but not as rapid as it can appear. It is important to note that new forest growth is often less dense and biodiverse. Therefore it is still important for governments and organisations to continue to reduce deforestation and continue to slow the rate of forest loss.

Source 3: A forest on fire. Changes to the environment and the climate are causing wildfires to be more frequent and intense around the world. This causes forest degradation and causes about 23 per cent of global forest loss each year.

Learning ladder 5.8

Processes that transform people, places and environments

1. Source 1: Describe how humans have influenced the rate of forest loss over the past 10 000 years.
2. What factors contribute the most to the rapid disappearance of forests?
3. Analyse the implications of changes through forest degradation and deforestation.
4. Source 1: Referring to trends in the graph, what do you predict the forest cover of Earth will be like in 2060?

Space

1. Source 1: How has the world's forest cover changed?
2. Source 2: Conduct a PQE on this map. What regions experience the most forest loss?
3. Source 3: Explain how wildfires impact forest degradation and why they are becoming more frequent.
4. Source 1: What are the implications of competing land uses for space?
5. Analyse why high-income countries are less likely to experience deforestation and forest loss compared to low-income countries.

HOW TO Space, page 406

Case study

What is the impact of deforestation on wildlife?

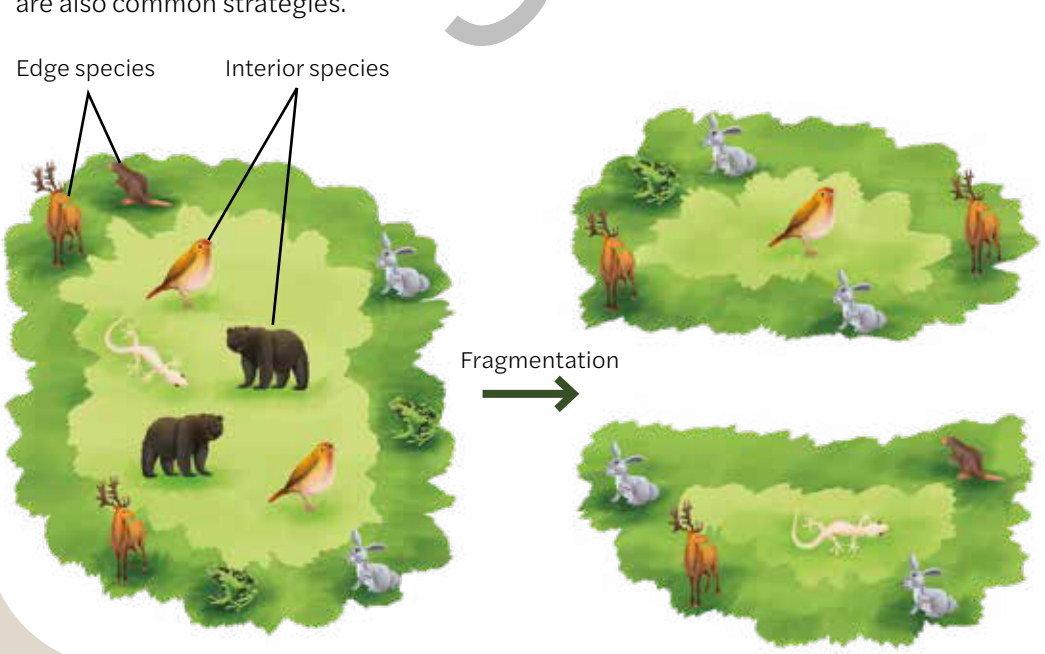
Deforestation causes habitat loss and fragmentation, the leading reason for declining biodiversity and increasing number of endangered species. Between 2007 and 2022, the number of animals under threat doubled as human landuse altered their habitats.

Habitat fragmentation

Fragmentation due to land clearing creates smaller areas of disconnected habitat that exposes wildlife to threatening edge effects such as hunting, poaching, invasive species, fires and illegal clearing. While birds can fly between patches of habitat it is not easy for large land animals to follow natural migration routes due to barriers such as roads and railways, farms, homes and fencing. Larger animals often travel hundreds of kilometres in the wild in search of food and to find a mate. Less natural habitat forces wildlife to seek food from urban areas and farms and to make dangerous road crossings.

Solutions to fragmentation include wildlife corridors, tunnels and bridges to reconnect habitat, reduce the need for wildlife to seek food elsewhere, and prevent loss of life from collisions with vehicles. Reforestation to increase the size of forest habitat, creating protected areas and legislation to prevent further land clearing are also common strategies.

▲ **Source 1:** Wildlife bridge connecting fragmented habitat



Interior habitat and species decrease with fragmentation.

Edge habitat and species increase with fragmentation.

◀ **Source 2:** Fragmented habitats have fewer species in the core area away from the impacts of humans and more species exposed to edge effects such as direct sun, wind, rain, snow. Larger species are usually the first to 'disappear' because there is insufficient habitat to meet their needs.

Forest elephants

Elephants, Earth's largest land mammals, occupy ecosystems across Africa and Asia where they follow natural migration routes in their search for food, water and mates. The 'home range' of an elephant herd in India, the country with the most Asian elephants, can vary from 250 to 3500 square kilometres. Across Asia it is estimated that 70 per cent of elephant habitat has been lost since 1700 due to landuse change, such as palm oil plantations and rice fields, leaving insufficient habitat to guarantee survival of the species. The African forest elephant is listed as critically endangered on the UN Red List, having lost almost 90 per cent of their population in one generation compared to the more well-known, endangered savanna elephant.

Elephants provide important environmental services in forests, where they are often referred to as 'gardeners' because they distribute the seeds of plants, fertilise the forest with their dung, create new habitats as they tunnel through the trees and trample vegetation, and they store large amounts of carbon.

To others, however, elephants are a threat to their livelihood or a source of income from ivory, with poaching made easier by habitat fragmentation.

Loss of Asian elephant habitat, 1700–2015

Source 3: Change in the area suitable as elephant habitat in Asian countries decreases between 1700 and 2015.

Source: De Silva et al, *Multi-Century Loss of Elephant Ecosystems*, Nature, 2023

Source 4: Why did the elephant cross the road? Because we built one across the elephant's traditional migratory path, that's why. An Asian elephant mother and calf crossing a road that fragments their habitat in Khao Yai National Park, Thailand.

Human–elephant conflict

The 500-kilometre journey of 17 elephants across China in 2020 drew a global audience and commentary from experts trying to explain the elephant behaviour. Many scientists believed the elephants were seeking new places to live because of human encroachment into their habitat in southern China. Others thought that the social behaviour of elephants was a key factor. The incident exemplified the issue of human wildlife contact as they smashed homes and raided crops and shops looking for food and water on their year long journey.

There were 1713 human and 373 elephant deaths in India between 2015 and 2018 due to human – elephant conflict and another 186 elephant deaths from collisions with trains. Elephants damage about 1 million hectares of agricultural crops worth millions of rupees each year. People in distress retaliate against elephants for the loss of lives, property and income traumatising often disorientated elephants by herding, trapping, and shooting.

Strategies for coexistence

Population growth across Africa and India has countries seeking strategies that focus on coexistence and reducing further loss of elephant populations. To be effective the welfare of elephants, the protection of forest habitats and the need for communities to safely earn livelihoods is essential. There are many strategies achieving coexistence with nature-based solutions a high priority.

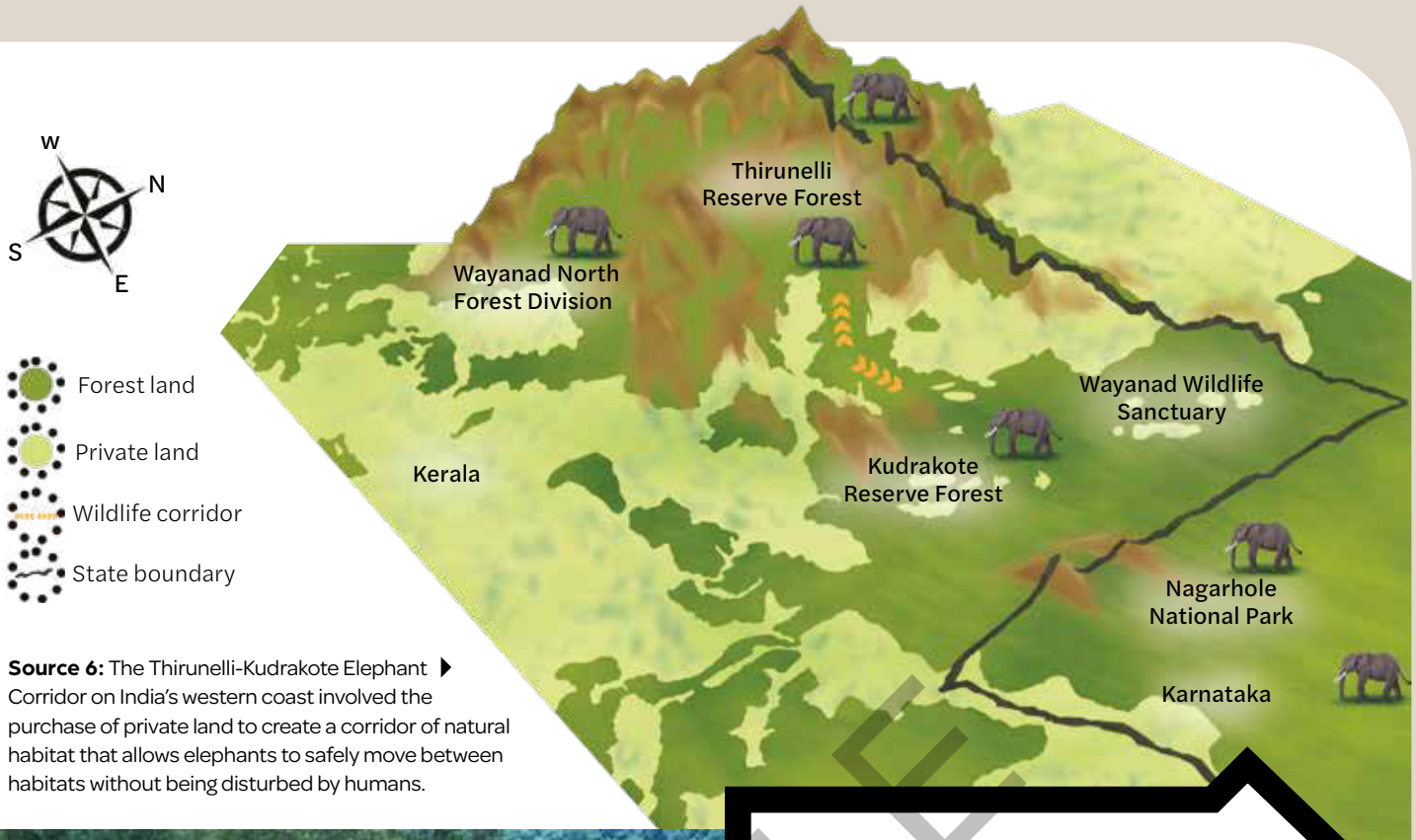
Deterrents: In Thailand lemongrass, kaffir lime and chilli, plants that elephants do not like to eat, are planted around traditional crops. Bee fences in Kenya and chilli ropes in India play a similar role. These bio-barriers have successfully deterred elephants, with an 80% success rate for the bee fences, provided communities with alternative income sources and improved human tolerance towards elephants. Bees also pollinated crops and improved yields.

Source 5: Bee hives suspended from wires protect farms in Kenya. If an elephant walks into the wire, the hives shake causing the bees to swarm. The terrified elephant will leave the area.

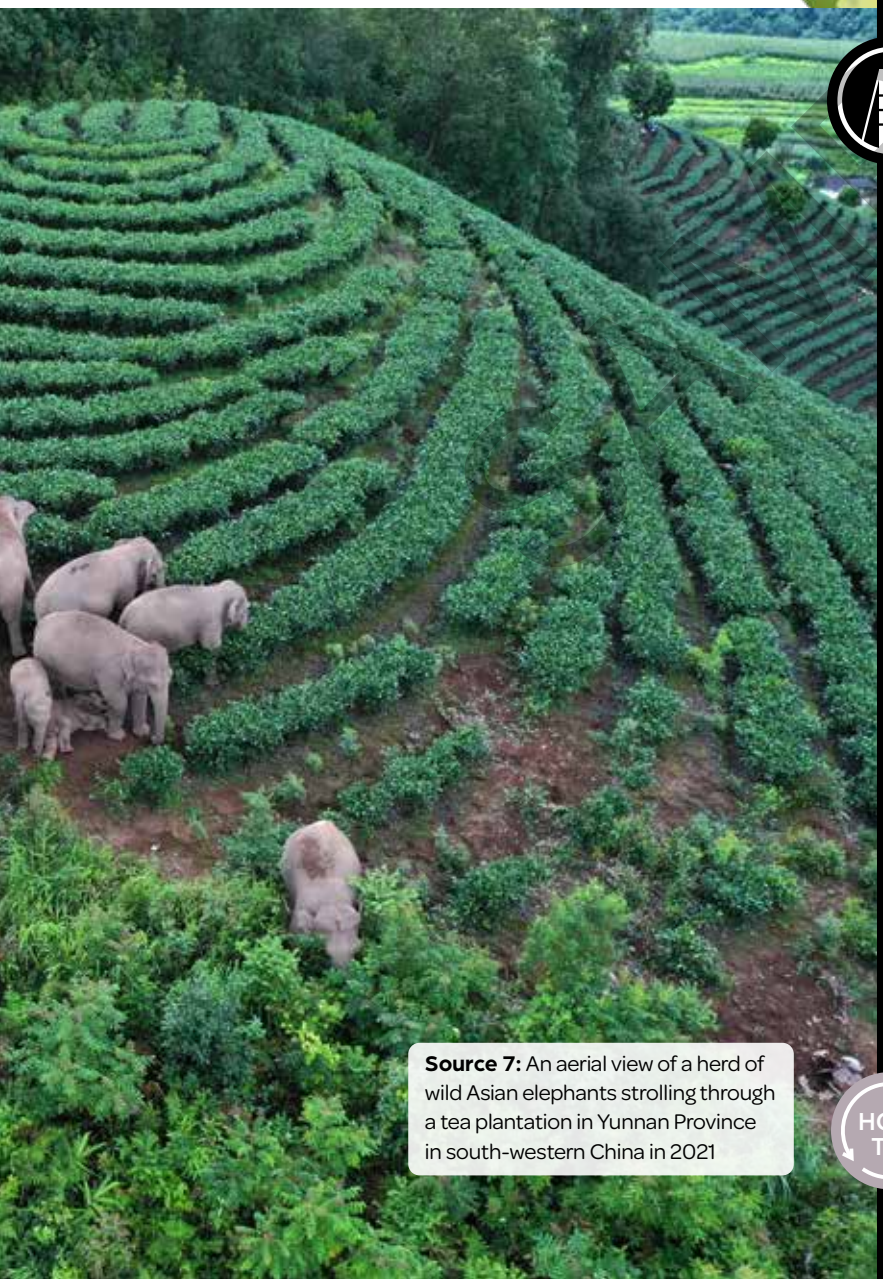
Wildlife corridors and protected areas: The Wildlife Trust of India is restoring India's natural elephant corridors to ensure elephants rights to safe passage. The Thirunelli-Kudrakote Elephant Corridor involved the purchase of private land from 37 families in a village and their resettlement. The wildlife corridor provides safe connectivity between wildlife sanctuaries and reduces human-elephant conflict.

Eco tourism: Developing eco-tourism ventures in protected areas as alternative or additional sources of employment and income can benefit both the communities and elephants.

Technology: Flashing LED lights and electric fences have had some success in stopping elephant movement. Early warning systems including SMS elephants alerts, public transport announcements, and mobile-operated red beacons are used to alert communities that elephants are nearby.



Source 6: The Thirunelli-Kudrakote Elephant Corridor on India's western coast involved the purchase of private land to create a corridor of natural habitat that allows elephants to safely move between habitats without being disturbed by humans.



Source 7: An aerial view of a herd of wild Asian elephants strolling through a tea plantation in Yunnan Province in south-western China in 2021

Learning ladder 5.9

Perspectives of people and organisations

1. Describe two human perspectives on the value of elephants.
2. Source 4: Outline the competing land uses shown.
3. Explain the views of conservationists and farmers in strategies for coexistence.
4. Source 6: The first Wildlife Trust of India elephant corridor project was labelled a win–win. What does this mean?
5. Source 5: Assess the effectiveness of nature-based solutions in addressing human–elephant conflict.

Interconnection

1. Source 4: Why did the elephant cross the road?
2. Source 2: Why is a large area of habitat better than several fragmented sections?
3. Source 1: Explain the purpose of a wildlife bridge.
4. Source 7: What elephant–human conflict is shown here? Why is it an increasingly serious issue?
5. Source 6: What are the implications for the elephants following the creation of the wildlife corridor? Sketch a location for a further wildlife corridor in this region and justify your selection.

HOW TO Interconnection, page 410

5.10

How does urbanisation change the environment?

Urbanisation is the increasing proportion of people living in urban areas. More than 50 per cent of people in the world live in urban places. The growth of large cities creates environmental and social challenges that impact on every aspect of the physical environment.

Changes to the hydrosphere

The water cycle functions differently in urban places where hard surfaces such as buildings and infrastructure cover the soil and vegetation is removed. Rivers and creeks have been channelised and concreted and drains deliver urban runoff, including the soil, nutrients and chemicals collected on its journey, into waterways and oceans. This has led to polluted waterways, lowered watertables, lack of natural spaces, loss of aquatic and terrestrial biodiversity and water scarcity.

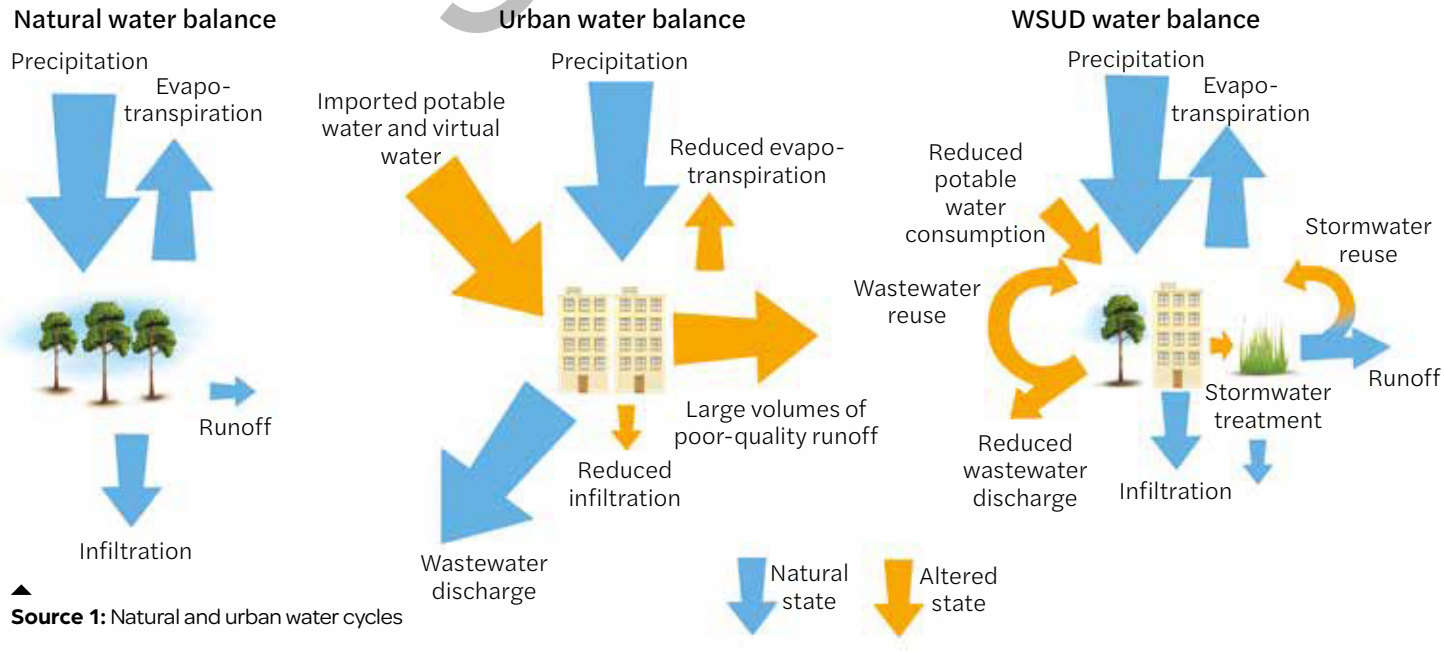
While these issues continue to plague rapidly developing urban centres in poorer countries, wealthier countries have implemented strategies such as water-sensitive urban design (WSUD), river bank rehabilitation and wastewater recycling to restore environmental functioning for healthier environments and water efficiency. Water tanks, rainwater harvesting, porous paving, wetlands, recycling household water, urban water treatment systems and waterway restoration are key strategies used in WSUD.

Changes to the atmosphere

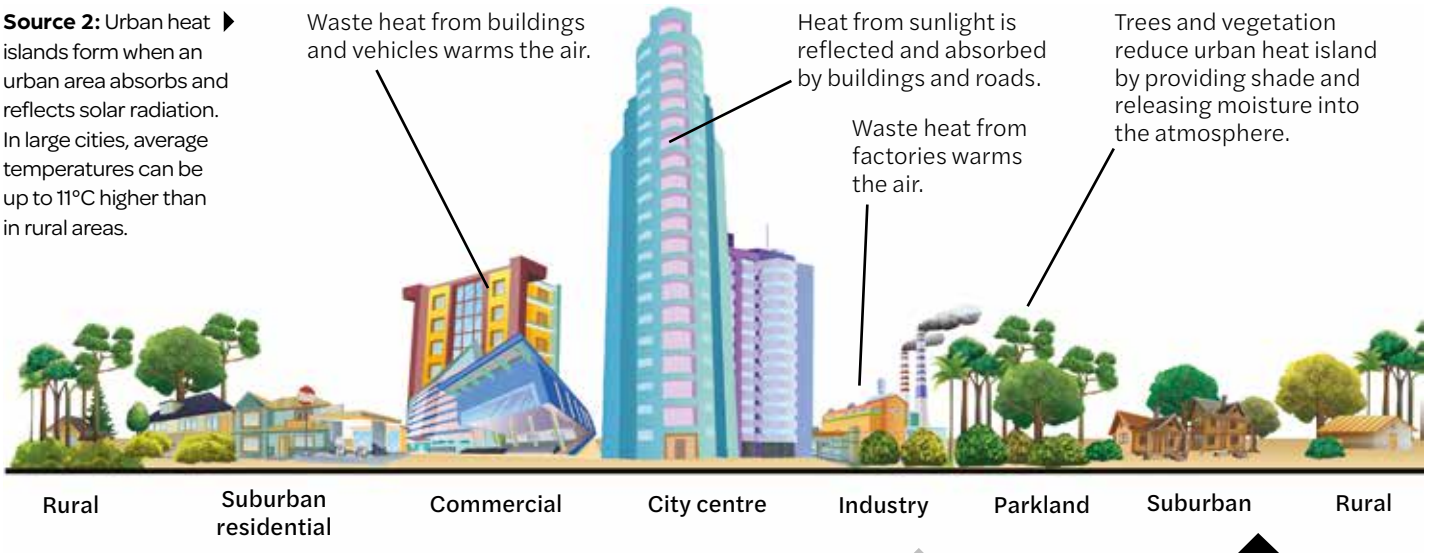
Urban heat islands are a consequence of hard surfaces and industrial activity in large cities. It results in temperatures of up to 11°C higher than surrounding rural areas. Green spaces generally reduce temperatures and commercial, housing and industrial zones experience warmer temperatures. Strategies to cool cities include:

- planting trees to provide shade and cool the air through evapotranspiration
- using light coloured building materials to reflect rather than absorb heat. Dark surfaces can be hotter by up to 21°C and transfer heat into buildings that will require cooling.

Large cities drive air pollution through emissions from vehicles and industrial and commercial activities. The World Health Organisation has set the safe air target of 0–10 microns per cubic metre of air, with measurements above 55 considered as unhealthy. In September 2023, New Delhi, India, recorded a level above 900 – an extreme and very unsafe condition.



Source 1: Natural and urban water cycles



Source 2: Urban heat islands form when an urban area absorbs and reflects solar radiation. In large cities, average temperatures can be up to 11°C higher than in rural areas.

Biodiversity and land change

Natural ecosystems have been removed or altered to create human structures, resulting in a loss of biodiversity and green spaces.

- Wetlands have been drained and natural ecosystems such as mangroves, coastal dunes and local forests have been squeezed into fragmented pockets.
- Structures such as retaining walls have altered riverine and coastal processes and changed how these environments function.
- The very weight of buildings combined with groundwater withdrawal is causing cities like Jakarta, Tokyo, New Orleans, and Venice to sink (subsidence) and face threats from rising sea levels.

Sustainable urban planning to create green cities and reduce carbon emissions are helping to address environmental changes to benefit the environment and human and non-human occupants of cities.

Source 3: A sustainable city in Almere, Netherlands with energy from a solar panel island, medium-density housing and green spaces

Learning ladder 5.10

Processes that transform people, places and environments

1. Identify the components of the natural environment that changed during the process of urbanisation.
2. Source 1: Explain how WSUD addresses unwanted changes to urban water cycles.
3. Source 2: Explain variations in the heat island effect between urban and rural places.
4. Design your own urban environment to reduce the urban heat island effect and improve the natural balance of the hydrosphere and atmosphere. Provide labels to outline the most important features.
5. Assess the value of different sustainability measures in addressing environmental issues caused by urbanisation.

Environment

1. In what ways has human activity changed the atmosphere of large cities?
2. Source 1: Describe two ways that urban areas upset the natural water balance.
3. Source 2: Explain how two strategies are used to address the urban heat island effect.
4. Discuss strategies you are aware of to address urban air pollution.
5. Source 3: Identify and analyse the strategies used at Almere to improve the urban environment.

HOW TO
Environment, page 414

Case study

How is Sydney planning for greater sustainability?

Sydney's estuaries, waterways, wetlands and forests have been heavily impacted by its urban growth. Planning for Sydney now has sustainability goals, including strategies for biodiversity and 'greening' to address historical losses in tree cover and natural habitats.

Restoring the harbour

The rehabilitation of creeks and waterways through replanting native vegetation, creating artificial wetlands and installing stormwater retention basins is contributing to improved water quality in Sydney Harbour. The dream of making the harbour swimmable again is being realised with the opening of Marrinawi Cove, an area heavily polluted during Sydney's maritime and industrial past. Additional swimming sites are planned.

Decreasing turbidity and increased oxygen saturation, considered essential for healthy aquatic environments are trends benefitting biodiversity and driving innovative projects such as Project Restore to rehabilitate harbour habitats that will further improve water quality. Strategies include:

- **modular artificial reefs** for habitat forming species such as oysters that attract other marine life. One reef is adjacent to the Sydney Opera House seawall at Bennelong Point.
- **'living seawalls'** made of 3D printed concrete tiles with niches for different species to colonise are attached to seawalls where habitats had disappeared.
- **restoring seagrasses and kelp forests** that support a high level of biodiversity in locations denuded by pollution, boat anchors and poorly designed jetties.

Greening the city

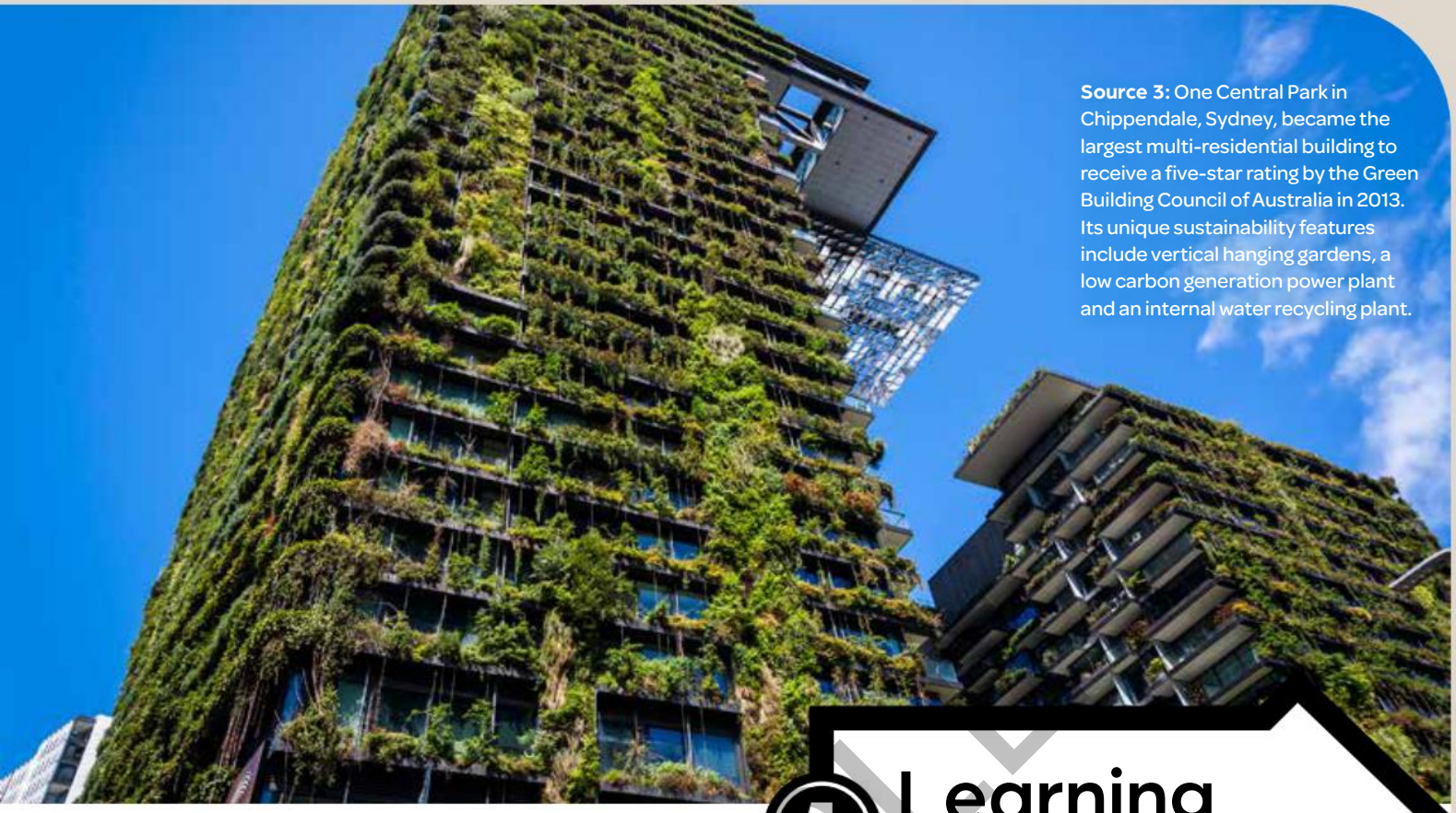
Plans for greening Sydney address multiple challenges to sustainability including the **urban heat island** effect, a lack of shade and natural places that reduces liveability, and the loss of biodiversity. Green buildings such as Central Park incorporate vertical and rooftop gardens with integrated water recycling systems. Central Park, a highly liveable high rise apartment and commercial development in central Sydney, features a unique roof that directs natural light into the buildings and grounds below.

Green corridors such as The Cooks River Greenway are zones for recreation and active transit (walking and cycling) and are rich in plant biodiversity that attracts wildlife and enriches the local ecology. Extending from the Cooks River to the Parramatta River, the corridor features bike paths, foreshore walks, places of cultural and historical interest, cafes, playgrounds and sporting facilities to enhance liveability.

Tree planting is essential for reducing heat stress in new suburbs kilometres away from the cooling influence of the coast and harbour and where there is scant vegetation cover. Sydney's Greening our City program funds projects such as Rewilding Sydney. In a similar scheme to expand the city's urban forest, cool the environment and increase habitat Greening Australia plans to plant over 170 000 native trees across Greater Sydney.

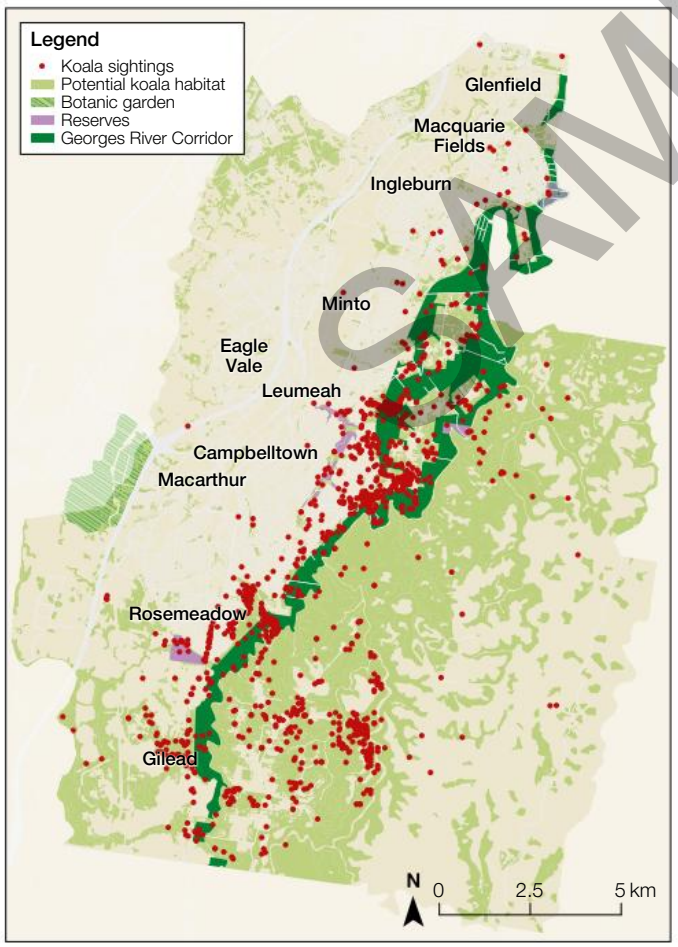
In 2023 the NSW State Government announced the Georges River Koala National Park in southwest Sydney, with koala friendly road crossings to protect the city's largest koala habitat from urban sprawl. Koala numbers in the Sydney Basin have declined by 22 per cent since 2000.

Source 1: Living seawalls provide marine creatures and seaweeds with habitat to colonise.



Source 3: One Central Park in Chippendale, Sydney, became the largest multi-residential building to receive a five-star rating by the Green Building Council of Australia in 2013. Its unique sustainability features include vertical hanging gardens, a low carbon generation power plant and an internal water recycling plant.

Georges River Koala National Park, New South Wales



Source: Matilda Education Australia

▲ **Source 2:** Georges River Koala National Park in New South Wales follows the Georges River Corridor.

Learning ladder 5.11

Sustainable management strategies

1. List two examples of environmental change caused by urbanisation.
2. Describe a management plan to improve Sydney's aquatic environments.
3. Explain how the rehabilitation of streams benefits Sydney Harbour.
4. Source 1: Explain how living seawalls can contribute to the sustainability of Sydney Harbour.
5. Analyse the value of green buildings, green corridors and rewilding to Sydney's environmental sustainability plans.

Environment

1. Identify three of Sydney's environmental challenges.
2. Source 3: Describe the environmental benefits of One Central Park.
3. Explain how a swimmable harbour contributes to the sustainability of Sydney.
4. Source 2: Analyse the plan for the Georges River Koala National Park. What are the advantages and disadvantages of a national park in this location?
5. Assess the environmental and social benefits of the Cooks River Greenway project.

HOW TO
Environment, page 414

5.12

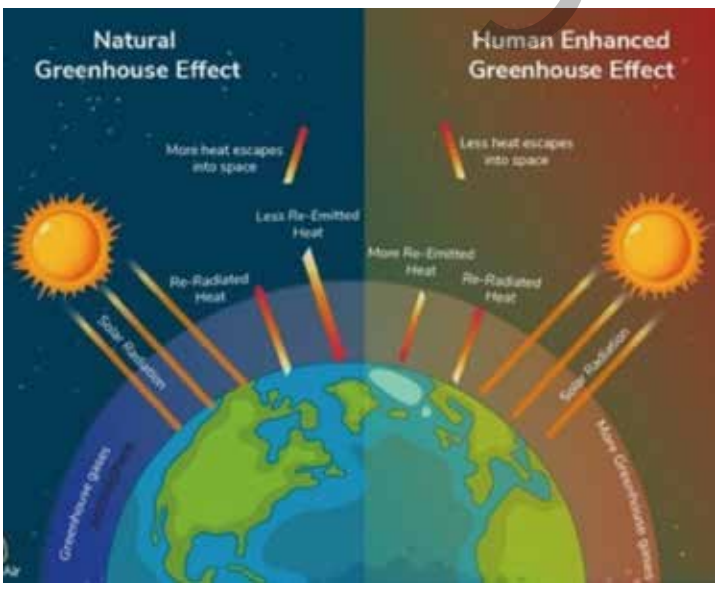
What impact is global warming having on environments?

Global warming is the long-term heating of Earth's atmosphere due to human activities that have increased heat-trapping greenhouse gases. The climate change resulting from global warming is impacting on weather systems, biodiversity and human wellbeing.

Global warming

The **greenhouse effect** is a natural process that makes Earth habitable. When sunlight hits the Earth's surface short wave radiation (light) is absorbed and reradiated as infrared or long wave radiation (heat) back into the atmosphere. Gases in the atmosphere including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2) and water vapour, absorb the heat and warm the atmosphere. When the composition of the atmosphere changes to include more greenhouse gases, more of this heat is absorbed and atmospheric warming increases. This is known as the enhanced greenhouse effect and is the cause of global warming.

Carbon dioxide is the second most abundant greenhouse gas and the key metric for measuring climate change. Pre-industrial CO_2 levels in Earth's atmosphere were around 280 parts per million (ppm).



Source 1: The cause of global warming Source: QBS

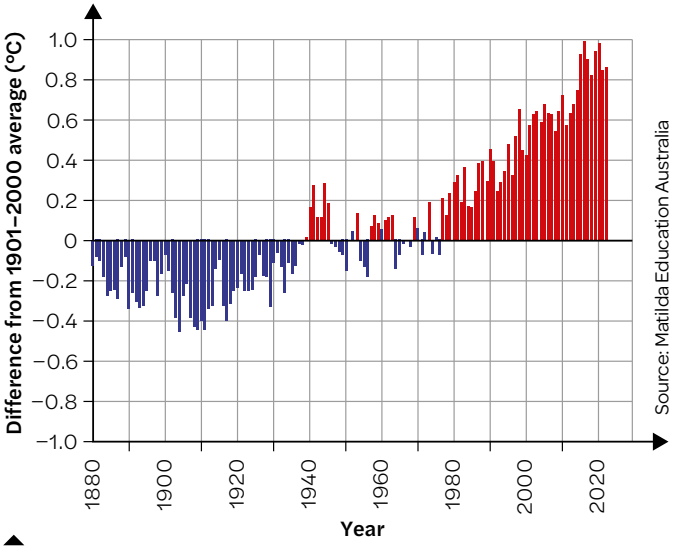
According to the Intergovernmental Panel on Climate Change Report in 2021, CO_2 concentration had increased by 2.4 ppm each year between 2011 and 2019 to reach 410 ppm. The increase is attributed mainly to burning fossil fuels, industrial production, deforestation and agriculture.

Climate change

The extra energy stored in the atmosphere is changing Earth's climate system with an average temperature increase of 0.7°C since the beginning of the twentieth century. This has resulted in the ten warmest years on record occurring since 2010. Greater climate variability, increasing extreme weather events such as droughts,

storms, and heat waves, changed precipitation patterns, melting of the **cryosphere** (frozen regions), rising sea levels and ocean warming and acidification are consequences of climate change.

Variations in global surface temperature



Source 2: Variations in global surface temperatures (measured against the 1900–2000 average) from 1880 to 2020.

Extreme weather events

The impact of intensifying and more frequent extreme weather events is being felt in countries least prepared to deal them such as the flood caused by Storm Daniel in Libya. The Mediterranean Sea region is a climate change hotspot having already experienced record-breaking temperatures, deadly wildfires and heatwaves in the summer of 2023. Tropical-like storms, known as Medicanes (Mediterranean Hurricanes) bringing torrential rain and flash flooding had been recorded in the Mediterranean Sea region since the 1980s. Storm Daniel was different.

Fuelled by a very hot summer and sea surface temperatures 2–3°C warmer than usual, extraordinary evaporation led to intense rainfall that caused catastrophic flooding across Turkey, Greece and Bulgaria before Storm Daniel crossed the sea to Libya. Two dams burst when 400 millimetres of rainfall fell in just 24 hours delivering a wall of water along the river to the Libyan port town of Derna. The flooding destroyed entire communities, killed over 11 000 people, erased river ecosystems and dumped millions of tonnes of sediment into the Mediterranean Sea. Political conflict and lack of dam maintenance were contributing factors, but scientists agree that climate change was responsible for 50 per cent of the rain that day.

Source 3: Libya's climate change–fuelled flood disaster in September 2023 sent a wall of water from two burst dams through the port of Derna, undermining buildings in its path and killing 11 000 people. Derna has two dams located upstream. The dam furtherest upsteam could not handle the pressure of water from the downpour gathered behind it. When it broke, the dam downsteam had no hope of containing the storm water and the water from the collapsed dam.

Sea level rise

The expansion of water as the ocean warms and meltwater from thawing ice sheets and glaciers are contributing to rising sea levels and putting low-lying coastal regions and islands at risk of inundation. Low-lying Pacific Island atoll nations, such as Kiribati, the Solomon Islands, Vanuatu and Tuvalu, are extremely vulnerable and already facing the loss of coastal ecosystems such as mangroves and rain forests through coastal erosion as well as saltwater intrusion into their groundwater. Most major cities in the world are in coastal zones that are vulnerable to rising sea levels.

Declining sea ice cover

The area of the Arctic Ocean covered by sea ice has been shrinking by 12.6 per cent per decade due to warmer atmospheric and ocean temperatures while the thickness of sea ice has fallen by over 30 per cent in the last 30 years. Changes in sea ice directly affect arctic wildlife and ecosystems. Polar bears and walruses rely on sea ice for hunting, breeding, and migrating. Where sea ice is late in forming, becoming thinner and melting faster, food sources are less accessible and polar bear birth rates decline. Conflict between bears and humans is increasing as they seek food in coastal settlements such as Churchill on Hudson Bay in Canada while waiting for sea ice to form. Indigenous communities who continue traditional hunting and fishing are also impacted by declining sea ice.

Changing species distribution

The distribution of an increasing number of plants and animals on land and in the oceans are shifting due to warming temperatures. All species have a range of temperatures, rainfall and other climatic conditions they require to live. When the climate changes they need to adapt or migrate to survive. On land, birds and animals can migrate more easily than plants that can take many years to invade and establish in new locations. A warming world is experiencing the greening of tundra environments as once permanently frozen soil thaws and temperatures pass the threshold of 10°C for six months of the year needed for trees to grow. The treeline is also rising in alpine environments where it was once too cold for trees.

Source 4: Changing species distribution due to global warming

Warming oceans

Marine environments face a triple threat from rising atmospheric temperatures. Warming ocean water dissolves more carbon dioxide and becomes increasingly acidic. Acidic water reduces the capacity of creatures such as corals and crustaceans to use calcium carbonate to form their skeletons. Warm water also causes **coral bleaching**.

The Australian coastline is witnessing the migration of tropical species of herbivorous fish and urchins to temperate waters where they are changing marine ecosystems. The loss of 95 per cent of Tasmania's Giant Kelp forests is a result of a stronger and warmer East Australia Current bringing with it sea urchins from NSW. Purple sea urchins have also eaten 95 per cent of the underwater kelp forests along California's Mendocino Coast where scientists have found urchins in numbers 60 times greater than normal.

Source 5: Low-lying coastal villages on Ngela Island, Solomon Islands are under constant threat of rising sea levels caused by global warming.

Source 6: Shrinking Arctic sea ice due to global warming is dramatically impacting on the polar bear's ability to hunt and migrate.

Learning ladder 5.12

Processes that transform people, places and environments

1. List four greenhouse gases.
2. Outline two causes of sea level rise.
3. Explain the link between global warming and climate change.
4. Source 3: Assess the role of climate change in the Libyan flood disaster.
5. Source 3: Analyse the environmental, economic and social impacts of the Libyan flood.

Scale

1. Describe how humans at local and national scales have caused global warming.
2. List the social, economic and environmental impacts of global warming at local and regional scales.
3. Source 6: Explain the impact of global warming at a local scale in the Arctic.
4. Source 5: How is sea-level rise affecting the Solomon Islands, and why are small island nations particularly vulnerable?
5. Source 4: How will climate change affect the habitats of species into the future, and what would be the environmental and social implications of this?

HOW TO

Scale, pages 216, 423

5.13

Case study

Will Fiji disappear as sea levels rise?

Source 1: Sea level is predicted to rise by over 30 centimetres in Fiji by 2050, putting many coastal low-lying regions at risk of flooding and inundation.

Depending on how we manage our emissions, researchers estimate that up to 1 billion people could be **displaced** as a result of global warming by 2050. One of the main concerns in the South Pacific is sea-level rise, which threatens to 'sink' low-lying islands.

Rising sea level in Fiji

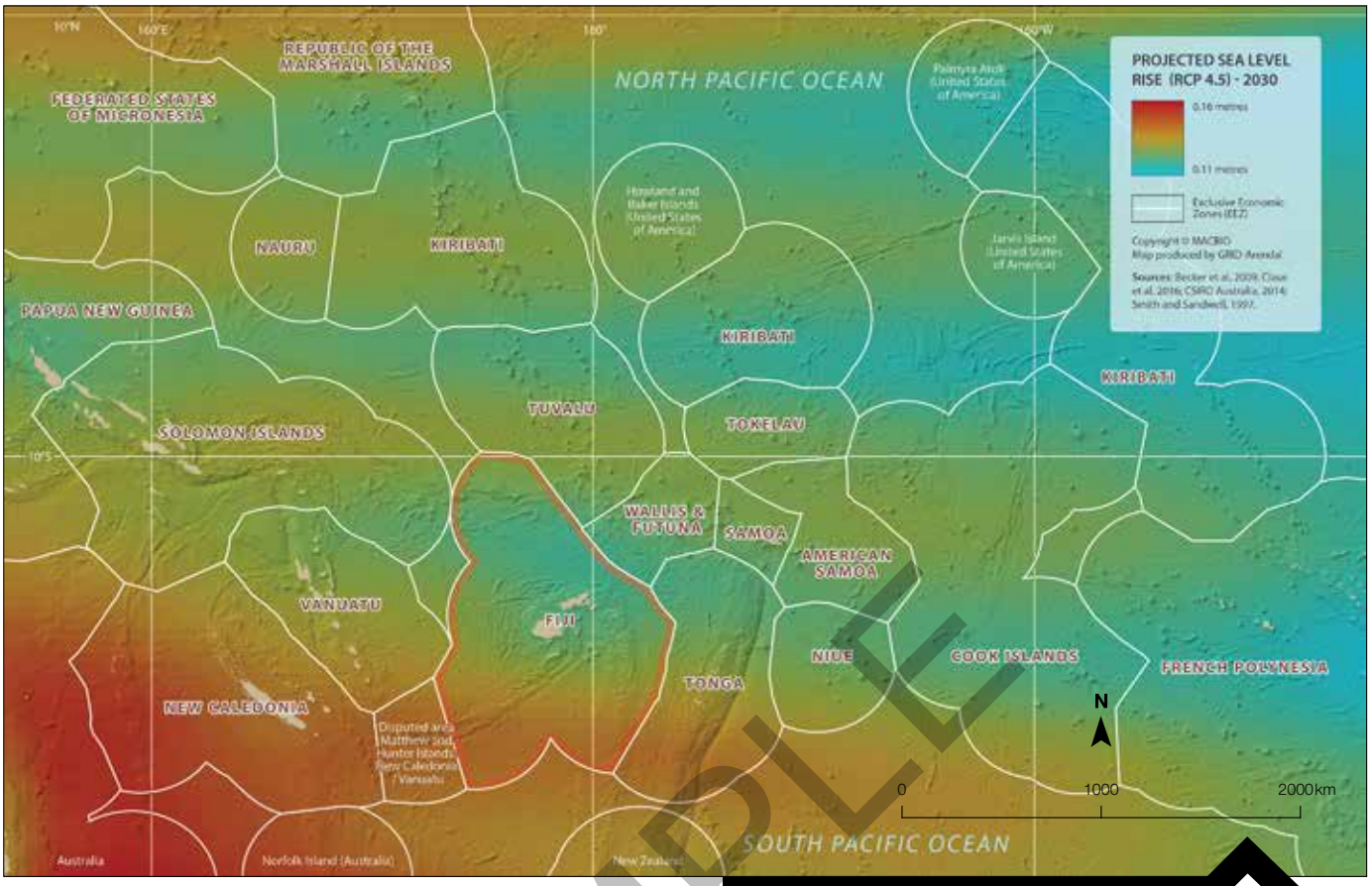
The country of Fiji comprises 332 islands and in 2023 it was home to more than 936 375 people. Fiji is characterised by its 1129 kilometres of coastline, coral reefs and small traditional villages. Fiji is particularly susceptible to sea level rise because of its connection with and reliance on coastal regions for traditions, housing and income. The National Oceanic and Atmospheric Administration recently reported that the global sea level has risen by 16–21 centimetres between 1900 and 2016 and research has estimated that 4.5 per cent of Fiji's buildings will be flooded by a further 22 centimetre sea level rise.

Responses to rising sea levels

Despite governments trying a range of measures such as building **sea walls**, years of flooding, coastal erosion and dangerous storms meant that, in February 2014, the village of Vunidogoloa moved two kilometres inland. While Vunidogoloa was the first to relocate, another five villages have since moved as a result of the changes caused by global warming. The Fijian government has identified over 830 communities that will be vulnerable to the impacts of global warming, with 45 of these being earmarked for future relocation.

Studies have found that the relocation of communities has had a significant impact on the sense of place. People have been disconnected from their traditional and sacred lands and have restricted access to fishing sites, one of the dominant local food sources. Further, it is estimated that Fiji will lose up to 5 per cent of its GDP each year as a result of the changing environment, with extreme weather events such as Tropical Cyclone Winston in 2016 only making things worse.

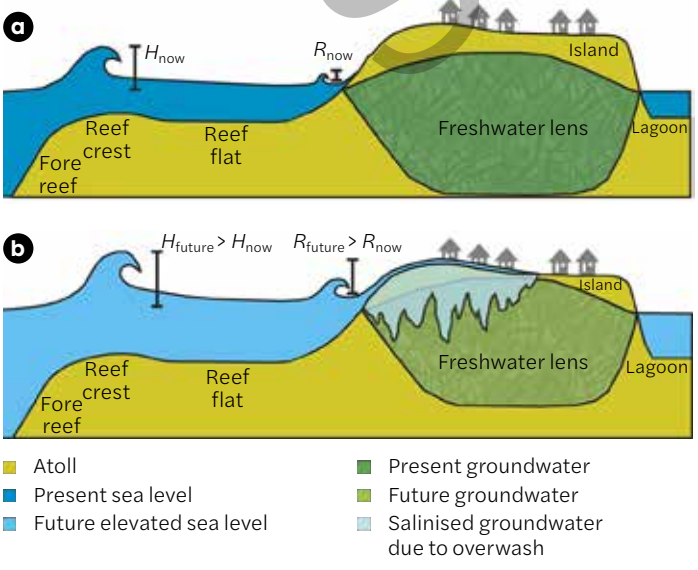
Projected sea level rise by 2030 in the Pacific region



Source: Levi Westerveld

▲ **Source 2:** Projected sea level rise by 2030 in the Pacific. Countries' Exclusive Economic Zones (EEZ) are shown in white. Fiji's EEZ is shown in red.

Fiji only emits around 0.006 per cent of the world's carbon output, yet it currently faces some of the largest consequences of climate change. In order to combat enhanced climate change and reduce local impacts, we need to change global behaviours.



▲ **Source 3:** Sea-level rise is predicted to have larger impacts than just coastal town flooding. It impacts local freshwater sources, reduces land size for residents and affects coral reef systems.

Learning ladder 5.13

Processes that transform people, places and environments

1. Why are sea levels rising?
2. Explain how sea levels are rising in Fiji.
3. Source 1: With reference to the photograph, explain the impact of a rising sea level on Fiji.
4. Source 3: Analyse the changes impacting coastal towns through rising sea level.

Change

1. Summarise how sea-level rise causes environmental change in places such as Fiji.
2. Source 2: Outline the pattern of projected sea-level rise by 2030 in the Pacific.
3. Source 3: Explain how sea-level change will impact low-lying atolls in the Pacific. Refer to three changes.
4. Explain the implications of sea-level change for coastal communities in Fiji.

HOW TO
Change, page 412

How is climate change impacting Australia?

As our climate changes, Australia is becoming more vulnerable to extreme weather events such as drought and bushfires. In the 2019–20 Victorian bushfire season alone, more than 1.2 million hectares were burned including 60 per cent of over 50 national parks and nature reserves, leading to estimates of a loss of over 1 billion native animals.

Impacts of climate change in Australia

Global warming is changing Earth's climate system and producing warmer temperatures, with already devastating effects in Australia:

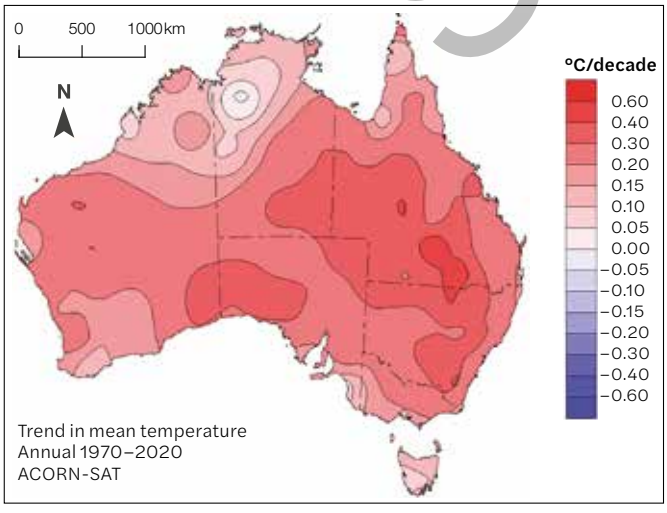
- The number of days breaking Australian heat records has doubled in the past 50 years.
- Heatwaves are occurring more often and with greater intensity. Heatwaves kill more people than any other natural disaster.
- Bushfires are increasing in number, area and intensity. The risks to people and property have increased as fire seasons have lengthened.
- Higher temperatures cause longer droughts and increased evaporation has led to intense storms.
- Warming sea temperatures are destroying Australia's kelp forests, seagrass, coral reefs (coral bleaching) and the organisms that depend on them.

Responses to climate change impacts

Important research into climate change is occurring in Australian universities and in government research organisations such as the CSIRO and Bureau of Meteorology. These researchers are studying data collected on climate change to help better predict future change and its impact on communities and biodiversity, and to establish the best ways to reduce carbon dioxide emissions.

Australia has more solar panels on home roofs per head of population than anywhere in the world, with more than one-third of Australian homes generating solar power on their roofs. Renewable energy accounted for 36 per cent of Australia's total electricity generation in 2022. Australia more than doubled the production of renewable energy between 2017 and 2022.

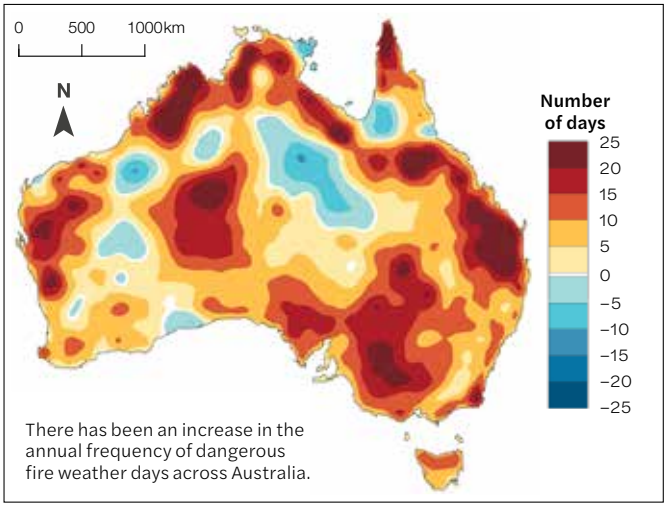
Australia temperature change °C



Source: Australian Bureau of Meteorology

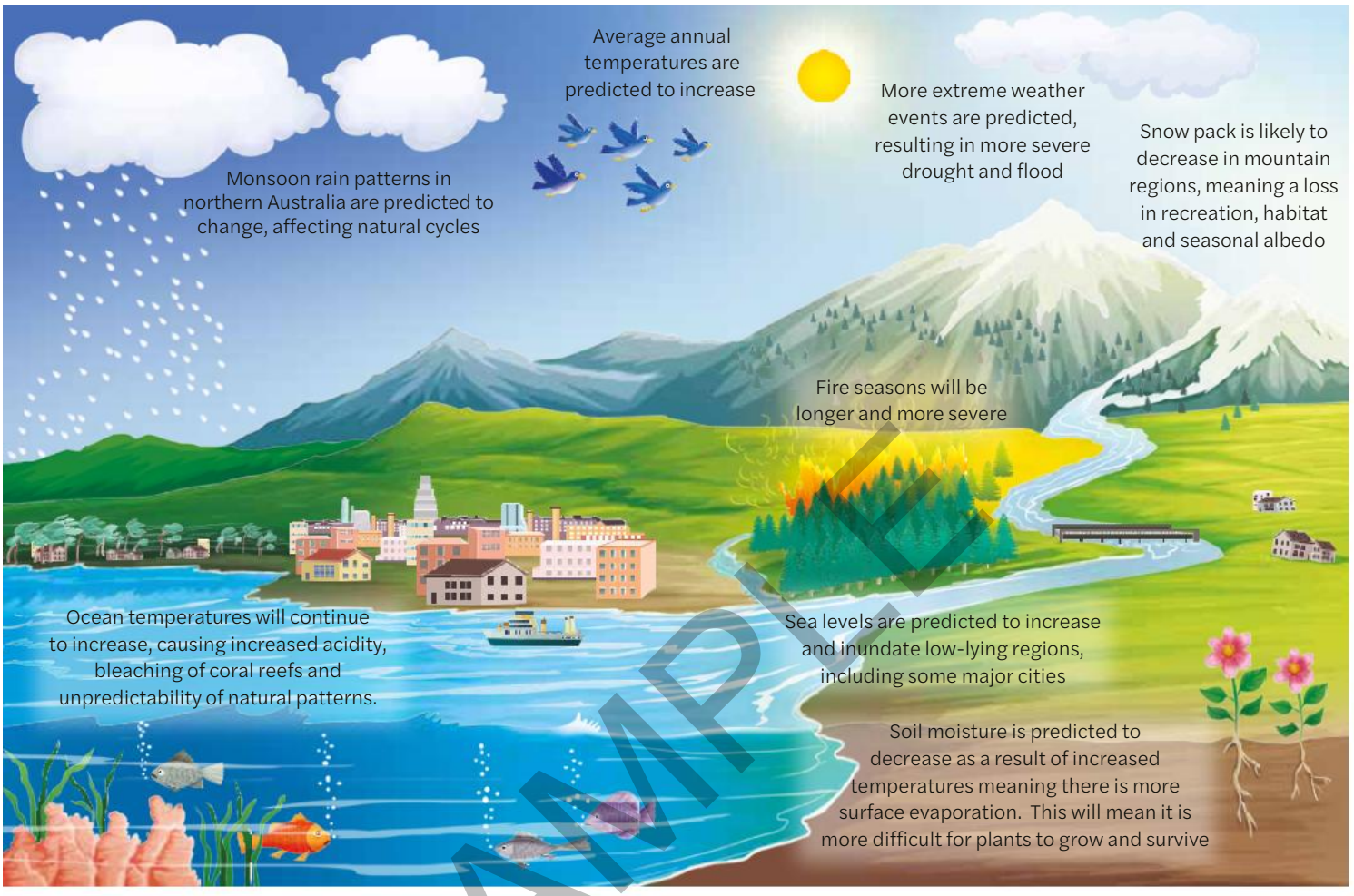
Source 1: According to the CSIRO, Australia's mean temperature has warmed by around 1°C since 1910. This map shows the temperature increases from 1970.

Australia change in number of dangerous fire weather days



Source: Australian Bureau of Meteorology

Source 2: Fire weather conditions are mostly worsening across Australia, with large areas experiencing more than 20 additional dangerous fire weather days.



Source 3: The impacts of climate change in Australia

Learning ladder 5.14

Processes that transform people, places and environments

1. List some types of environmental change occurring in Australia.
2. Source 3: Explain the impacts of climate change in Australia.
3. Explain how increasing temperatures can lead to more intense storms.
4. How will increasing temperatures in Australia impact environments and communities?
5. Outline the ways in which Australia is responding to the threat of climate change and suggest one additional way to reduce carbon dioxide emissions.

Space

1. Source 1: Describe the spatial pattern of temperature change in Australia.
2. Source 2: Explain which regions are experiencing more than 20 additional high fire danger days and why.
3. Sources 1 and 2: What the implications of change for Australia's natural and human environments?
4. Source 3: How will climate change impact oceans in the future, and what will the economic, social and environmental impacts of this be?

Space, page 406

HOW TO

5.15

Case study

How did the 2019–20 bushfires occur?

Record-breaking temperatures and severe drought led to massive bushfires across Australia in 2019 and 2020, driven by conditions created by global warming.

Australian bushfires 2019–20

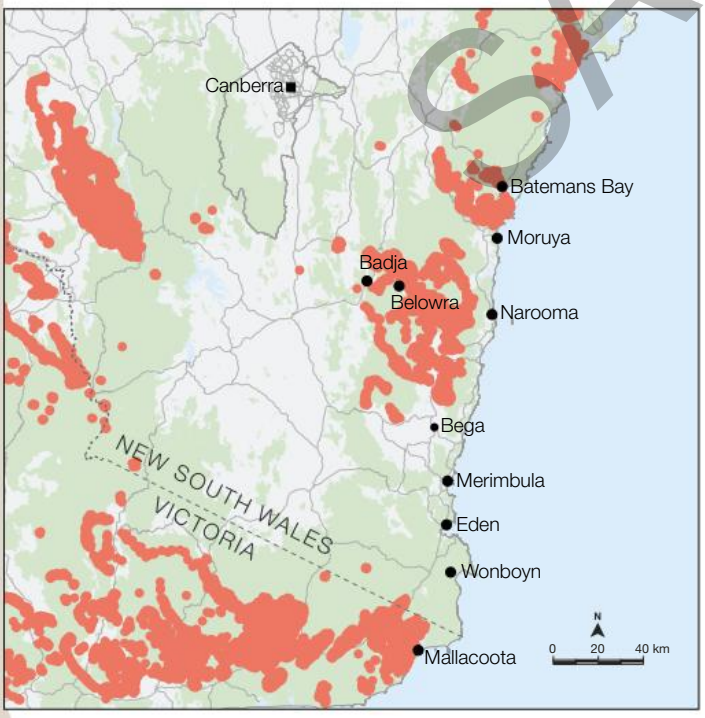
The combination of drought over much of Australia and heatwaves in New South Wales and Queensland combined to cause some of the worst fires in Australian history in 2019–20 spring and summer.

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 forward. 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.

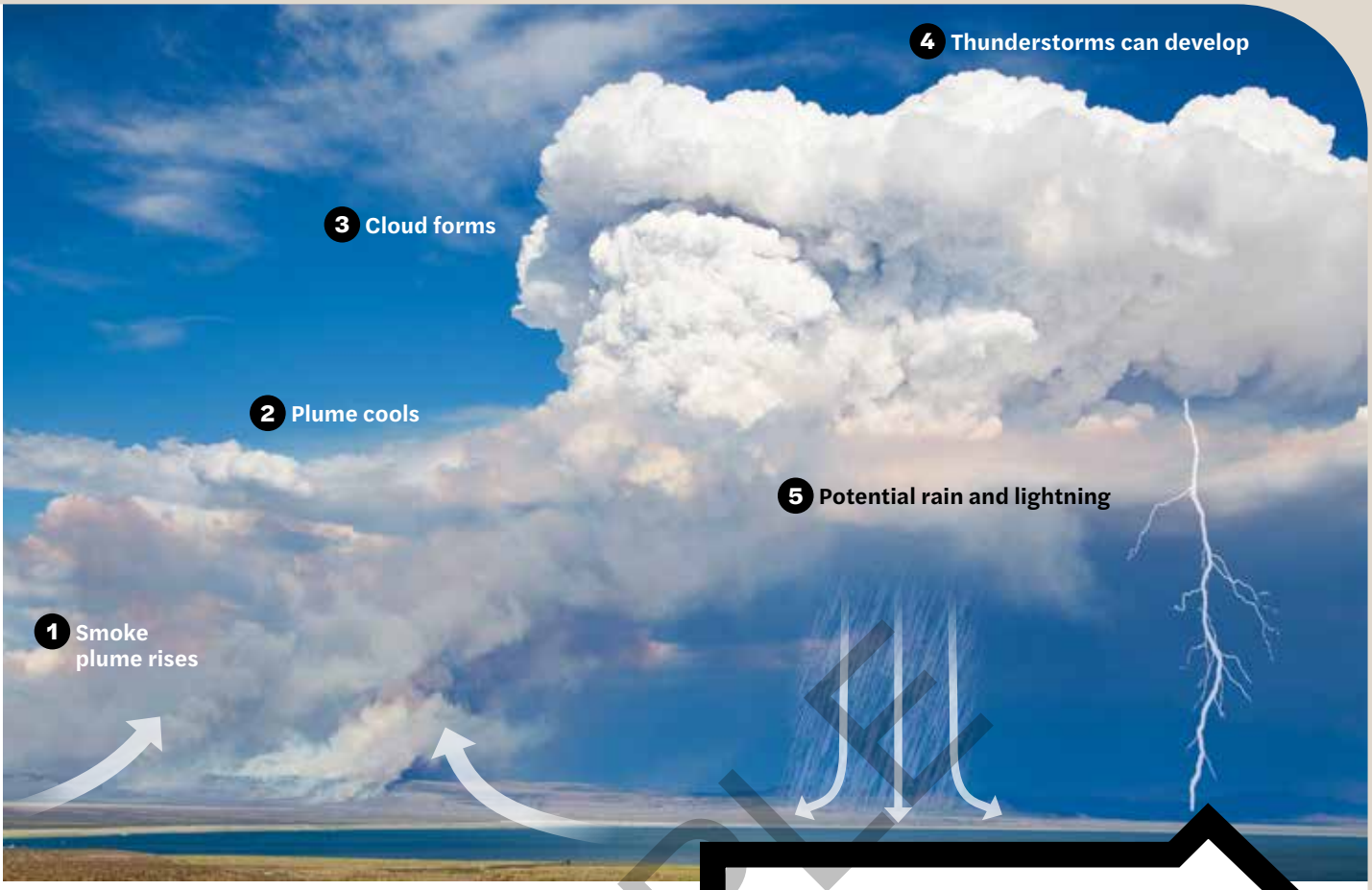
Record-breaking temperatures and months of severe drought created perfect conditions for bushfires to spread rapidly and difficult conditions for the thousands of firefighters called into action. The 2019–20 bushfires affected all states of Australia except the Australian Capital Territory, although smoke from the fires blanketed the nation's capital. More than 10 million hectares of land burned, an area almost the size of England. At least 24 humans died, along with 100 000 head of cattle and 480 000 000 native animals and birds. More than 1600 homes were destroyed, forcing thousands of people to seek shelter elsewhere.

Bushfires in the east of Australia, early January 2020



Source: NSW Rural Fire Service

Source 1: Eastern Australian bushfires in early January 2020



Source 2: Bushfires can make their own weather by creating pyrocumulonimbus clouds that produce thunderstorms with lightning.

Source 3: The remains of burnt buildings in the main street of Cobargo in New South Wales, 31 December 2019.

Learning ladder 5.15

Processes that transform people, places and environments

1. How do bushfires occur?
2. Explain the factors that impacted the 2019–20 bushfires.
3. Source 1: Which areas of New South Wales and Victoria were burned and how much land was burned?
4. What was the impact of the bushfires on the environment?

Interconnection

1. Suggest two ways that pyrocumulonimbus clouds are interconnected to bushfires.
2. Explain the interconnection of drought and bushfires.
3. How will climate change contribute to more intense and frequent bushfires?
4. What key information did fire services need to predict the movement of the bushfires to be able to warn residents to leave?

HOW TO Interconnection, page 410

Case study

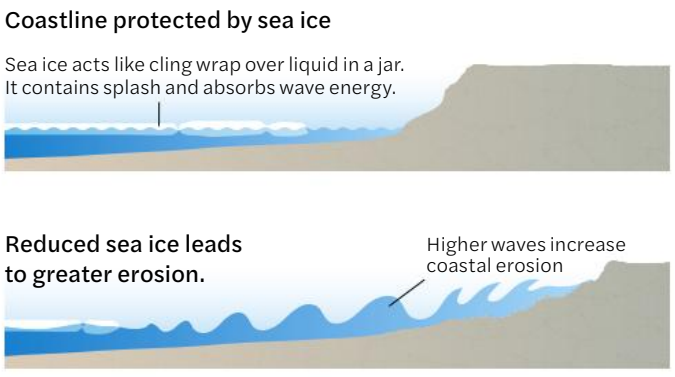
How is Alaska impacted by climate change?

Alaska, in the United States, is warming at two to three times the rate of global warming. The greatest impact is on indigenous coastal communities such as Shishmaref, where land, homes, livelihoods and traditions are being washed away.

Environmental change in Alaska

Across Alaska, warming temperatures are changing the environmental conditions that impact environments and ecosystems. Many of these changes are contributing to increased coastal erosion with places such as Shishmaref experiencing losses of up to 60 metres in some years. Environmental changes in Alaska are linked to climate change:

- **Warming oceans and marine heatwaves:** A marine heatwave between 2014 and 2016 in the North Pacific, nicknamed the 'Blob', contributed to the collapse of the Alaskan cod fishing industry, a source of livelihood for many coastal communities. The mortality rates for some species of seals and birds have increased and toxic algal blooms are becoming more common.
- **Increased precipitation, plus melting snow, ice and glaciers:** Increased river flows and flooding are driving greater erosion and delivering additional sediment to the coast. This sediment is burying coastal ecosystems and increasing turbidity – reducing photosynthesis and the primary productivity of marine ecosystems.
- **Shrinking sea ice:** The loss of sea ice and extension of the ice-free season in northern Alaska has exposed the coast to more wave action and is affecting the functioning of marine ecosystems and the behaviour of species such as seals and polar bears that depend on sea ice.
- **Thawing permafrost and reduced snowfall:** When permafrost thaws, the ground destabilises and becomes soft and mushy, water covers the land, and coastal areas are more prone to wave erosion. Low-lying coastal land and cliffs made of loose glacial sediment are particularly vulnerable. Losses of more than a metre of coastline a year have been recorded in places. Snow keeps the ground cool and slows permafrost thaw; less snow reduces that protection.
- **Rising sea levels and larger and stronger storms:** Coastal flooding and larger erosion events are increasing the loss of coastal land, particularly along the northern coast where sea ice no longer protects the land during the storm season.



▲ **Source 1:** Increasing coastal erosion due to shrinking sea ice

Shishmaref: Relocate or stay?

Coastal erosion has washed homes and traditional lands into the sea in Shishmaref and other coastal villages in Alaska. It is forcing the relocation of houses and entire villages. Airports and infrastructure such as water pipes and schools have been undermined, threatened by erosion or washed away. Access to traditional fishing and hunting grounds has been interrupted, and changes to ecosystems and the distribution of species is affecting traditional hunting and gathering practices.

The story of Shishmaref, the home of nearly 600 Inupiat Eskimos located on a small remote sand island, is repeated across many coastal villages in Alaska.

Source 3: Shishmaref's changing coastline

The late return of sea ice on the Chukchi Sea before the autumn storm season begins exposes the village to increased wave attack. After years of serious erosion, relocating houses and building barriers using materials such as sandbags to protect properties, villagers voted to leave in 2002 and again in 2016. The relocation has not yet taken place due to a lack of funds, and today only 50 per cent of residents still want to leave despite increasing threats from climate change. The places chosen for relocation have not been optimal for traditional subsistence hunting of bearded seals, fishing or berry picking and would break up the close-knit community.

Source 2: The land under this house at Shishmaref was eroded by increased wave action caused by reduced sea ice in the Chukchi Sea off the coast of Alaska.

Learning ladder 5.16

Processes that transform people, places and environments

1. Source 2: Outline what has happened to the house in the photograph.
2. How are marine heatwaves impacting Alaska's Arctic ecosystems?
3. Source 1: Explain how thawing permafrost increases coastal erosion.
4. How effective is relocation in addressing climate change threats to Shishmaref?

Interconnection

1. Create a mind map showing the connections between climate change and environmental change in Alaska.
2. Explain the link between two climate-related causes of flooding on Alaskan coasts.
3. Source 3: How might climate change cause the coast at Shishmaref to recede in the future?
4. Explain the importance of tradition in responses by Inupiat Eskimos in Shishmaref to relocation.

HOW TO
Interconnection, page 410

Environmental management

6

CAN ASIA'S RAINFORESTS SURVIVE? 246

WHAT ARE WORLDVIEWS? 238

HOW CAN ENVIRONMENTS BE MANAGED AT DIFFERENT SCALES? 234

6.0

How can I understand environmental management?

Sustainability of the Earth's environments depends on careful assessment and management to protect and repair the impacts of humans on fragile ecosystems.

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 toward 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 evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.

Source 1: The Churchill Wildlife Management Area conserves an important tract of unique wildlife habitat in the Western Hudson Bay region of Canada.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

6.1

What are worldviews?

Every person has an environmental worldview that they have formed over time as a result of influences in their life. The value people place on nature, and a perspective about how the environment is used to meet human needs, are key characteristics of an environmental worldview. There is also an ethical consideration about what a person feels is right or wrong.

Worldview

A **worldview** is a collection of beliefs about the world around us held by an individual or group. It is the lens through which the world is viewed and the perspective from which the world is interpreted. Friends and family, culture and society, lifestyles and livelihoods as well as life experience are factors that influence a person's worldview.

An **environmental worldview** is focused on how the Earth's environments, including its species and resources, are managed. Often, we do not know our worldview until confronted with an environmental issue that needs to be resolved or managed. In some societies human survival may depend on exploiting limited natural resources. People may hold different views on a range of environmental issues; however, their core values will usually remain the same. Differences in worldviews can bring individuals, groups and societies into conflict.

Three environmental worldviews

- **Earth–centred worldview:** This is a belief that nature exists for all species and that people are equal, not superior, to all other species. This view is based on the idea that life in all of its forms has a value unrelated to its use, or potential use, by humans. People with this worldview feel an ethical responsibility to look after Earth and the nature it supports for future generations. At the extremity of this view would be the total protection of natural places where human use is limited, such as nature reserves. A moderate stance would be ecologically sustainable development in which nature has a higher priority than economic growth and profit.
- **Stewardship:** This is a worldview held by Indigenous people based on the strong spiritual connection with nature embedded into every aspect of life – including daily practices, legal systems and customs. Caring for nature, the sustainable use of living species and non-living natural assets, such as land and rivers, and a responsibility to manage these across intergenerational time scales are characteristics of stewardship.
- **Human–centred worldview:** This is a belief that human intelligence sets people apart from other species and allows them to control nature for their own benefit. Nature comes second to the goal of economic growth that nations have pursued since the domestication of wildlife, the growth of agriculture and industrialisation. Over time, technological change has transformed much of the natural world into a constructed world that serves human needs and wants. At the extreme end would be the total exploitation of nature such as clear-felling forests and draining wetlands. A moderate stance would see more consideration of nature but not at the expense of economic productivity and profit.

Changing worldviews

The environmental issues facing the Earth as a result of the exploitation of and disregard for nature, such as biodiversity loss and climate change, are changing the worldviews of many people.

Examples of change include:

- sustainability and stewardship being given a higher priority in the environmental management practices of many individuals, societies and governments
- the acceptability of environmental consequences being debated publicly, often galvanising activist groups and societies into protests or civil disobedience in the hope of changing the decisions made by organisations and governments
- environmental decisions being made based on new scientific knowledge about nature and how it functions
- traditional Indigenous knowledge slowly being integrated into modern management practices.

Environmental activism

Our worldview will influence our responses to the environmental challenges facing the Earth. Individuals, groups and non-government organisations with a strong Earth-centred worldview use actions such as protests and education campaigns to promote social awareness and solutions to community and global concerns about the environment. Action can range from local grassroots strategies to national or international campaigns.

As individuals, our worldview will be influenced by the groups we join. For example, a person might feel strongly about the need to protect natural koala habitat and become a member of an environmental group advocating for the end of land clearing to save that habitat. Others might seek to balance the need for development by clearing some koala habitat, with the need to protect enough of its habitat to ensure koalas continue to survive and thrive in the region.

Source 2: These local activists have an Earth-centred worldview.

Source 1: Most people's worldview will fit somewhere along a continuum between two extremes – a human-centred view based on total exploitation of nature's resources at one end and locking up nature to protect it at the other.

Learning ladder 6.1

Perspectives of people and organisations

1. List the main characteristics of the different environmental worldviews.
2. How does stewardship vary from an Earth-centred worldview?
3. What are the different influences on an individual's worldview?
4. Provide evidence that society's worldviews are slowly changing.
5. How important is environmental activism for the sustainability of the environment in the future?

Sustainability

1. Which worldview is the least sustainable?
2. How is stewardship linked to environmental sustainability?
3. Source 1: Compare the place of sustainability in Earth-centred and human-centred worldviews.
4. Source 2: How can environmental activism promote sustainability?
5. Explain how an individual's worldview can be used to influence the decisions made by organisations and governments about the use of natural resources such as coal.

HOW TO
Sustainability, page 418

Case study

How have worldviews impacted Costa Rica?

Governments and organisations make decisions that impact nature and environments. These decisions are usually based on their worldview at the time. Following decades of forest destruction in Costa Rica, a more Earth-centred worldview among decision-makers has seen Costa Rica double its forest cover in just 30 years.

Costa Rica: Deforestation to ecotourism

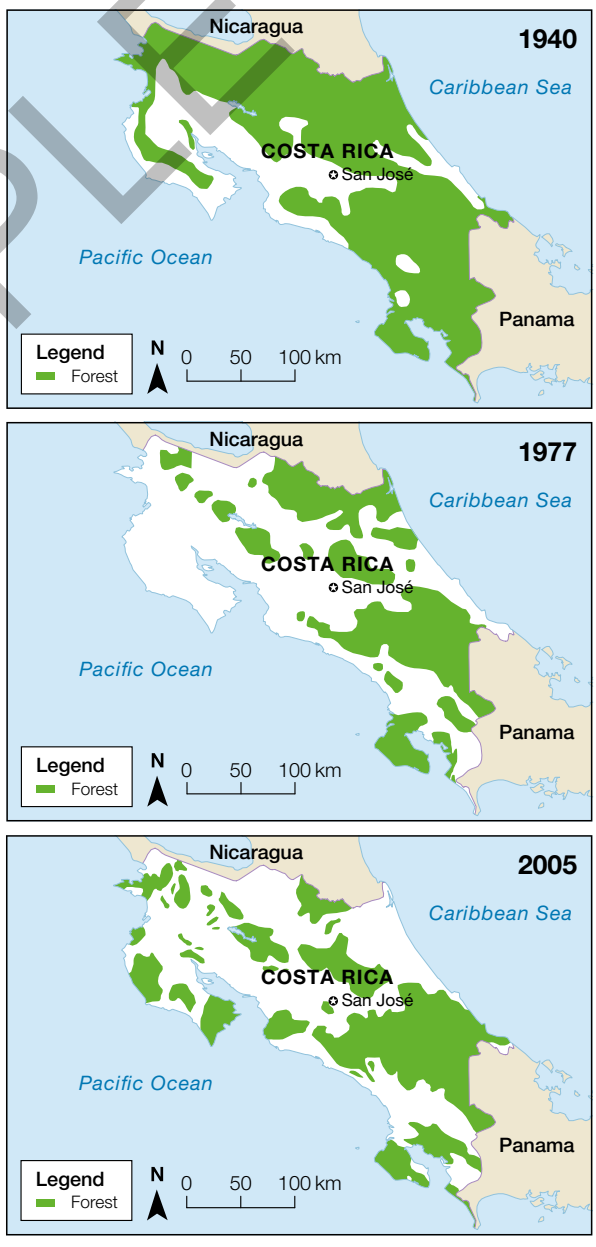
Costa Rica in Central America is endowed with tropical forests teaming with biodiversity. Forming a 'bridge of biodiversity', Costa Rica's forests are enriched by additional species from the continents of North and South America. The Corcovado National Park alone is estimated to contain over 500 tree species and 5 per cent of the Earth's wildlife species, and was once referred to as 'the most biologically intense place on Earth' by National Geographic.

Costa Ricans traditionally had a deep respect for nature from being surrounded by tropical forests, which in the 1940s covered 75 per cent of the land. However, logging and land clearing for livestock and plantations from the 1940s to the 1980s resulted in massive deforestation, during which time up to 50 per cent of the forest cover was destroyed. Costa Rica was identified as having the fastest deforestation rate in the world. The human-centred worldview of governments and businesses at the time had focused on the exploitation of nature, incentivised by lucrative contracts with US governments and fast-food companies such as McDonalds, and driven by a desire for economic growth.

A turnaround in government policy resulted in the introduction of strategies aimed at restoring the forest. This new **Earth-centred worldview** was successful because the government gave financial rewards (funded by fossil fuel tariffs) to landholders to protect their forests and biodiversity, and encouraged them to engage in ecotourism and sustainable resource use.

Source 1: A human-centred dominant worldview from decision-makers led to widespread destruction of Costa Rica's forests from the 1940s to the 1980s. In 1940 forests covered 75 per cent of Costa Rica. By 1977 coverage was reduced to 31 per cent and to just 21 per cent by 1987. A more Earth-centred worldview from the 1990s saw forest cover increase to 51 per cent by 2005 and 60 per cent today.

Costa Rica's forests in 1940, 1977 and 2005



Source: Matilda Education Australia

Source 2: Ecotourism based around biodiversity is a key industry in Costa Rica. The country was one of the earliest adopters of connecting environmental conservation with responsible travel.

Deforestation in Costa Rica was reversed through several nature-based strategies:

- bans on wildlife hunting and tree clearing without authorisation
- the establishment of over 100 national parks and other protected areas
- financial rewards for protecting nature through Ecosystem Services Programs and sustainable forestry
- priority given to responsible travel and nature conservation.

Using more of an Earth-centred worldview, the value of nature was recognised and utilised to drive economic growth that saw forest cover restored to 60 per cent and the well-being of Costa Ricans beginning to improve. In 2021 Costa Rica was awarded the Earthshot Prize, celebrating innovative solutions that benefit the Earth such as protecting and restoring nature. Costa Rica illustrates that nature-based solutions and Earth-centred worldview can benefit communities, economies and the environment.

Learning ladder 6.2

Sustainable management strategies

1. Which environmental worldview led to actions resulting in the widespread destruction of Costa Rica's forests?
2. Explain how Costa Rica reversed deforestation through an Earth-centred worldview.
3. Why was Costa Rica's rainforest used unsustainably for several decades?
4. Source 2: Analyse how ecotourism can support both an Earth-centred and human-centred worldview.
5. Source 1: Evaluate how worldviews impacted changing forest cover in Costa Rica.

Environment

1. Identify reasons for Costa Rica's high levels of biodiversity.
2. Source 1: What was the environmental outcome of Costa Rica's human-centred development after 1940?
3. How did the Costa Rican Government encourage landholders to protect and restore the natural environment?
4. Source 2: Analyse the environmental benefits of ecotourism and sustainable development in Costa Rica.

HOW TO
Environment, page 414

What are the custodial responsibilities of First Nations Peoples to Country?

Custodial responsibility is an obligation that First Nations Peoples have to care for Country, including the land, animals, plants, family and understandings of its foods, medicines and the sacred places where ancestors and spirits live.

First Nations understandings of Country

The way that Country is conceptualised by First Nations people is complex and varied. For some, Country is part of an extended kinship network; that is, Country is family. For others, Country is an extension of self. In all cases, what is clear is that there is a different relationship with Country. From a non-Indigenous perspective, the relationship with Country is one-way. That is, Country is there to be owned, developed, bought and sold, and exploited for profit. For First Nations people, the relationship with Country is two-way. In this case, the people own Country as much as Country owns the people – Country and people are almost indivisible.

For First Nations people, Country is more than just land. It is food, medicine, a classroom, lore, law and a responsibility, where stories, languages, dances, songs, communities and ceremonies are held. Country is culture, sacred places, where the ancestors and spirits reside, the past, present and future, and many other things. As such, the First Nations' way that Country is conceptualised is far more complex than non-Indigenous conceptions of land, place or nation-state.

The differences between First Nations and non-Indigenous conceptions of Country, in part, can be described through the continuum of **Earth–centred** to **human–centred worldviews**. These two terms relate to a focus on humanity or the environment as the most important entity in the world.

Most non-Indigenous people could be considered to be part of the first category because colonisation and capitalism, both introduced to the Australian continent and adjacent islands, are anthropocentric and at their heart unsustainable. Most First Nations people could be considered to be part of the second category of ecocentrism because the knowledges, responsibilities and practices caring for Country ensure that it is respected and sustainable for future generations.

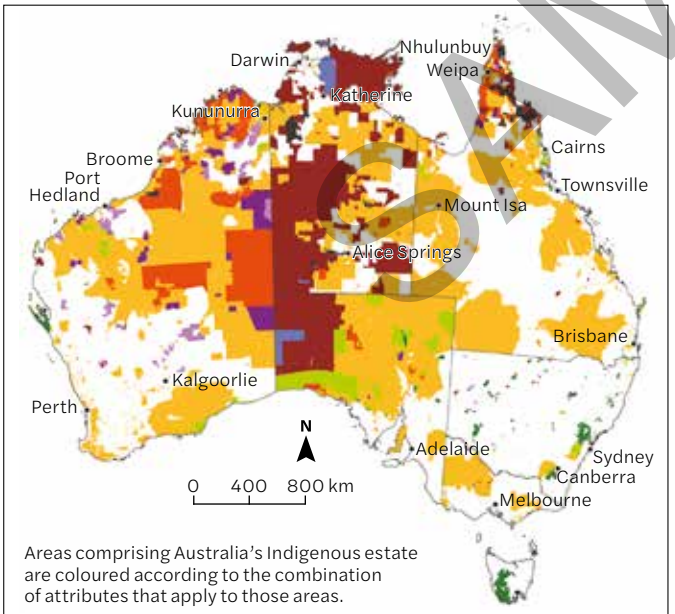
Different worldview impacts on Country

One of the major outcomes of these different worldviews between First Nations and non-Indigenous people is how the concept of sustainability is understood. For a non-Indigenous person, sustainability has traditionally been taught and conceptualised as a goal in and of itself. For First Nations people, sustainability has never been explicitly taught as a standalone concept; rather, it has been embedded across all the knowledge required to care for Country. That means that rather than being an aim, sustainability is an outcome of caring for Country.

Another impact of worldview on Country and how it is conceptualised is the relationship and relationality that First Nations people have with Country. What this means is that many First Nations people view Country as a living entity that people have custodial responsibilities for. The relationality aspect means that many First Nations people recognise that Country is not lesser, but an equal that should be respected just like any other person. An outcome of this is that in addition to the scientific understandings of Country, there are also complex spiritual connections to Country, and this is often marked and celebrated through ceremonial events throughout the year. These renew connections to Country as well as share important scientific information about Country to younger generations. This also honours the **Elders** and ancestors by continuing important cultural traditions that they also helped to perpetuate.

▲ **Source 1:** Part of caring for Country includes honouring the relationship between people and the environment. By dancing, singing and conducting ceremony on Country, First Nations people are able to renew relationships with Country as well as each other. This, alongside advanced scientific understandings of Country has allowed people to thrive across the Australian continent and adjacent islands for thousands of years.

Australia's Indigenous estate



Areas comprising Australia's Indigenous estate are coloured according to the combination of attributes that apply to those areas.

Attribute									
Indigenous owned	✓	✓	✓	✓					
Indigenous managed	✓	✓			✓	✓			
Indigenous co-managed			✓	✓			✓	✓	
Other special rights	✓		✓		✓			✓	✓

Note: All Indigenous-owned land is either Indigenous-managed or Indigenous co-managed.

Source: Department of Agriculture, Water and the Environment

▲ **Source 2:** Australia's Indigenous estate showing the attributes of ownership, management and other special rights.

Learning ladder 6.3

First Nations Peoples, interaction with Country

1. Source 2: Describe the location of Indigenous owned and managed land.
2. Explain the importance of relationality in caring for Country.
3. Analyse why Country is much more than land to First Nations people.
4. Discuss the following statement: 'If we all adopted First Nations Peoples' perspectives on the environment, we would have a much healthier and sustainable future for everyone'.

Interconnection

1. Identify five interconnections First Nations people have with Country.
2. Source 1: Describe how First Nations people honour their interconnection with Country.
3. First Nations Peoples have a special connection to Country, but this does not mean that non-Indigenous people don't. Where is your special place and why is it special to you?
4. Research your local area. Who are the Traditional Owners of your area? Are there any sacred sites or special places? What is it about them that makes these places sacred?

HOW TO

Interconnection, page 410

What strategies can we use to manage environments?

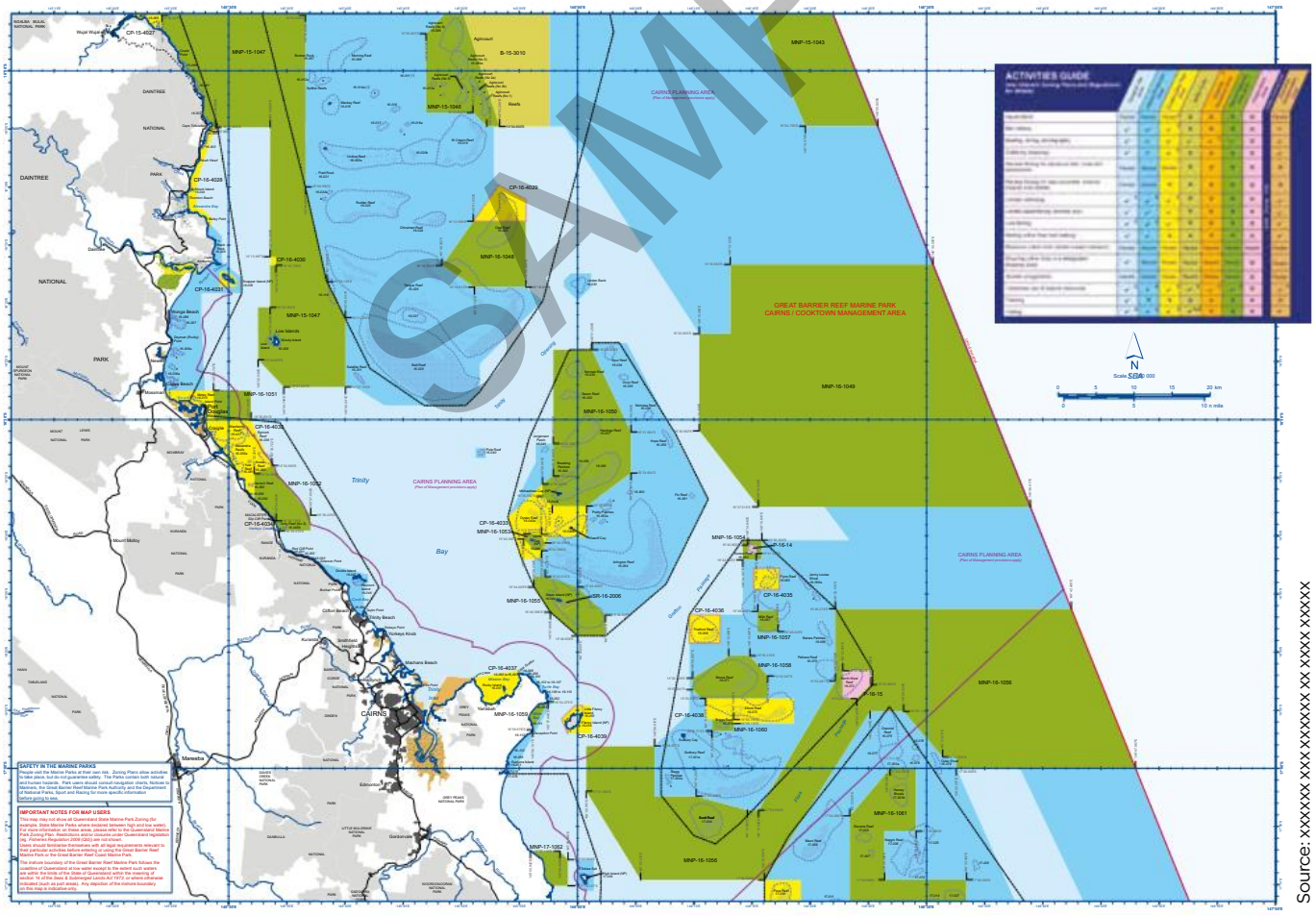
Environmental management involves implementing plans to support the functioning of environments or to enable them to overcome change. Many different strategies can be used to manage environments, and they often work best when many are used at once.

Types of strategies

Prevention strategies aim to prevent environmental degradation or negative impacts from occurring in the first place. These strategies focus on proactive measures to safeguard environments before damage happens. An example is implementing green building, which involves designing and constructing buildings using sustainable materials, reducing energy consumption and minimising waste to prevent long-term environmental harm.

Mitigation strategies focus on reducing the severity of an environmental change or challenge that has already started to occur. These strategies help lessen the negative effects and slow down further damage. An example is the Planting Together initiative in Brazil, which aims to replant 12 million hectares of deforested land by 2030, helping to restore ecosystems and reduce the impacts of deforestation.

Zoning for the Great Barrier Reef



▲ **Source 1:** An example of a legislation strategy. This zoning map for the Great Barrier Reef uses different colours to tell visitors what they can and cannot do in those areas. For example, no fishing, boating or tourism can occur in green zones. People who do not follow these rules can be fined.

Adaptive strategies help communities and ecosystems adjust to environmental changes that cannot be completely prevented or reversed. These strategies focus on building resilience and enabling systems to function despite ongoing challenges. An example of an adaptive strategy is modifying agricultural practices in response to climate change, such as switching to drought-resistant crops or using efficient irrigation systems to sustain food production in drier conditions.

There are many prevention, mitigation, and adaptive strategies, and they can often be categorised using the acronym LEAP.

Legislation

Legislation refers to creating and enacting laws or regulations. It can be used in environmental management to set standards and guidelines for environmental protection and conservation. It can also explain how these rules will be monitored and enforced. As an example, Australia has the *Environment Protection and Biodiversity Conservation Act (1999)* that is used to create rules on how communities and businesses can use environments. It has been used to restrict dredging and overfishing in the Great Barrier Reef and to create rules on how to protect endangered species, such as the Tasmanian devil and southern right whale.

▲ **Source 2:** An example of education as a management strategy. This is a sign along the Eel River in California that explains the importance of the environment and how human activities can impact the plants and animals here.

Education

This refers to creating signage and education programs that inform tourists and citizens on the importance of that ecosystem and ways they can support the environments that they visit. This can be seen with the use of signs about cassowaries in northern Queensland rainforest walks, which explain the behaviours of cassowaries and ways to prevent affecting their habits and environment.

▲ **Source 3:** An example of an action strategy. Newly planted grasses in a sand dune in the United Kingdom. These grasses will help stabilise the sand and reduce erosion.

Action

Some management strategies require specific actions to support the environments. This can include designing pathways to prevent people trampling on vegetation, reforesting areas that have been cleared for logging, replanting broken corals in coral reefs or backburning forestry to prevent larger fires.

Preservation

Management strategies can also focus on preserving environments by excluding human activities or reducing the activities that are permitted. This can include creating national parks that can only be used for picnics and hiking, fencing off areas people are not allowed to enter, or creating zones that tell people the activities they can or cannot do in an area.

Learning ladder 6.4

Processes that transform people, places and environments

1. Source 3: Describe how this action strategy is being used to manage a coastal environment.
2. Source 2: How can education be used to manage environments?
3. Create a poster that explains the benefits of the different LEAP strategies.
4. Compare legislation and preservation strategies. Which one is more effective and why?

Scale

1. Describe an example of a management strategy on a local and a national scale.
2. Source 1: Explain the management strategy used at the Cairns–Cooktown section of the Great Barrier Reef.
3. How does how national legislation may influence environmental management strategies on a local scale?
4. Assess whether global, national or local management strategies would be more effective, and why.

HOW TO Scale, pages 416, 423

6.5

How can we manage environmental change at different scales?

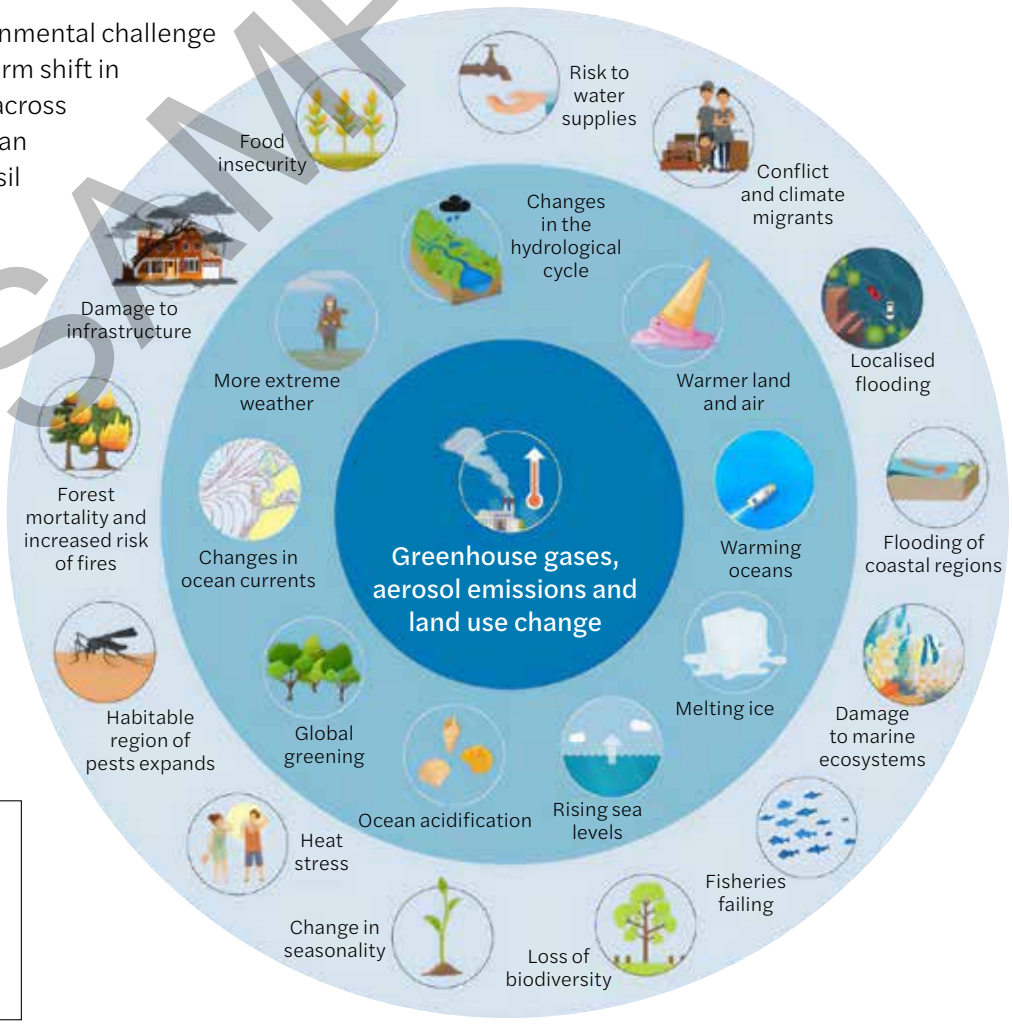
Environmental change occurs at different scales across the world. Responsibility for action can be managed holistically at a global scale, targeted at a national scale and enforced more effectively on a local scale.

Global change and management

Global environmental challenges are those that affect the Earth's natural systems, such as global atmosphere, ocean processes and global biodiversity. They are often driven by human activities and impact at local and national scales in the form of extreme weather events, displaced communities from rising sea levels or the loss of native species.

A key example of a global environmental challenge is climate change, which is a long-term shift in temperature and weather patterns across the world. It is largely driven by human activities, such as the burning of fossil fuels, which contribute to **global warming** by increasing greenhouse gas concentration in the Earth's atmosphere. There are many impacts of global warming at a global scale, such as changes to global weather patterns, increased ocean temperatures and changes to ocean circulation systems.

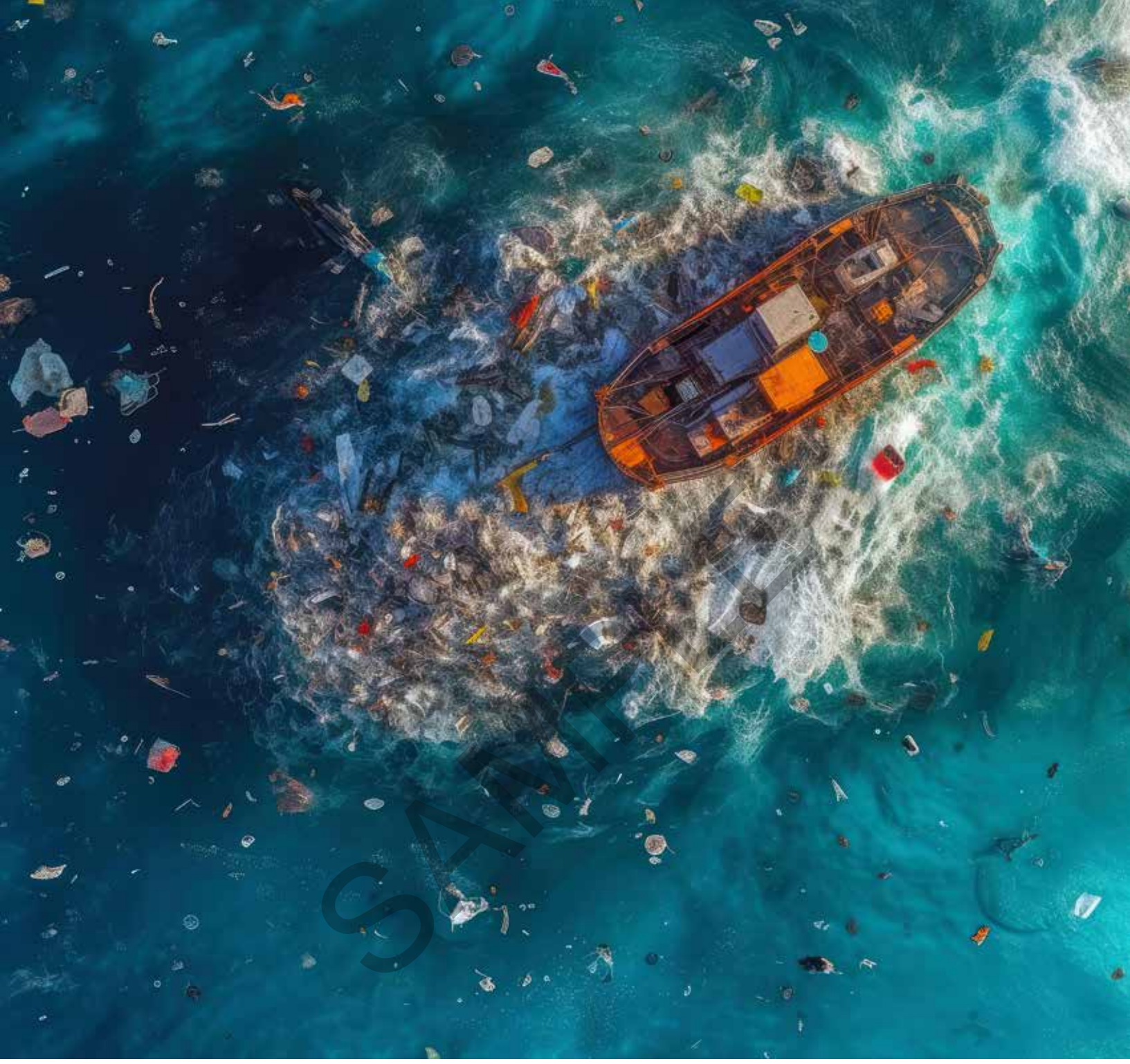
The strategies to manage the causes and impacts of climate change are complex and require international cooperation, collaborative research initiatives and global conservation efforts. The most effective way to do this is through international environmental law, which is established through **treaties** and agreements between countries. The United Nations plays a



Source 1: Climate change is a global issue that has many impacts on the national and local scales, shown in the circles of this infographic. To manage it requires nations from across the world to collaborate.

Legend

- Drivers of climate change
- Changes to the climate system
- Impacts of climate change



Source 2: An aerial photograph of a boat attempting to clean up the Great Pacific Garbage Patch. This is a pile of garbage, mostly plastic, that is trapped by ocean currents. This is a global issue, caused by many countries, and needs to be managed collectively.

crucial role in promoting and regulating these agreements. As an example, the Kyoto Protocol is an international treaty that more than 192 countries have signed. It has established targets for countries to meet to reduce their greenhouse gas emissions. Nations who do not meet these targets can face international pressure, fines or trade restrictions.

Regions of countries can also develop their own agreements around environmental management. This is particularly important for neighbouring countries who share a natural environment.

For example, the Mekong River Agreement is an agreement between Cambodia, Laos, Thailand and Vietnam that ensures each country sustainably uses the Mekong River that flows through them. This ensures that the water is clean and accessible for all people and communities across these countries.

National change and management

National environmental changes are those that impact a nations' natural systems, such as land use change, waste, native species decline and use of water. These changes need to be managed at a national scale to ensure management funding is evenly distributed, multiple perspectives are taken into consideration and management approaches are consistent. Management at this scale can include legislation, such as laws and regulations that determine how industries can function, rules on the amount of pesticides and fertilisers that farmers can use and how natural water systems can be used. It can also include preservation strategies, such as the establishment of national parks to conserve forests and the protection of native and endangered species.

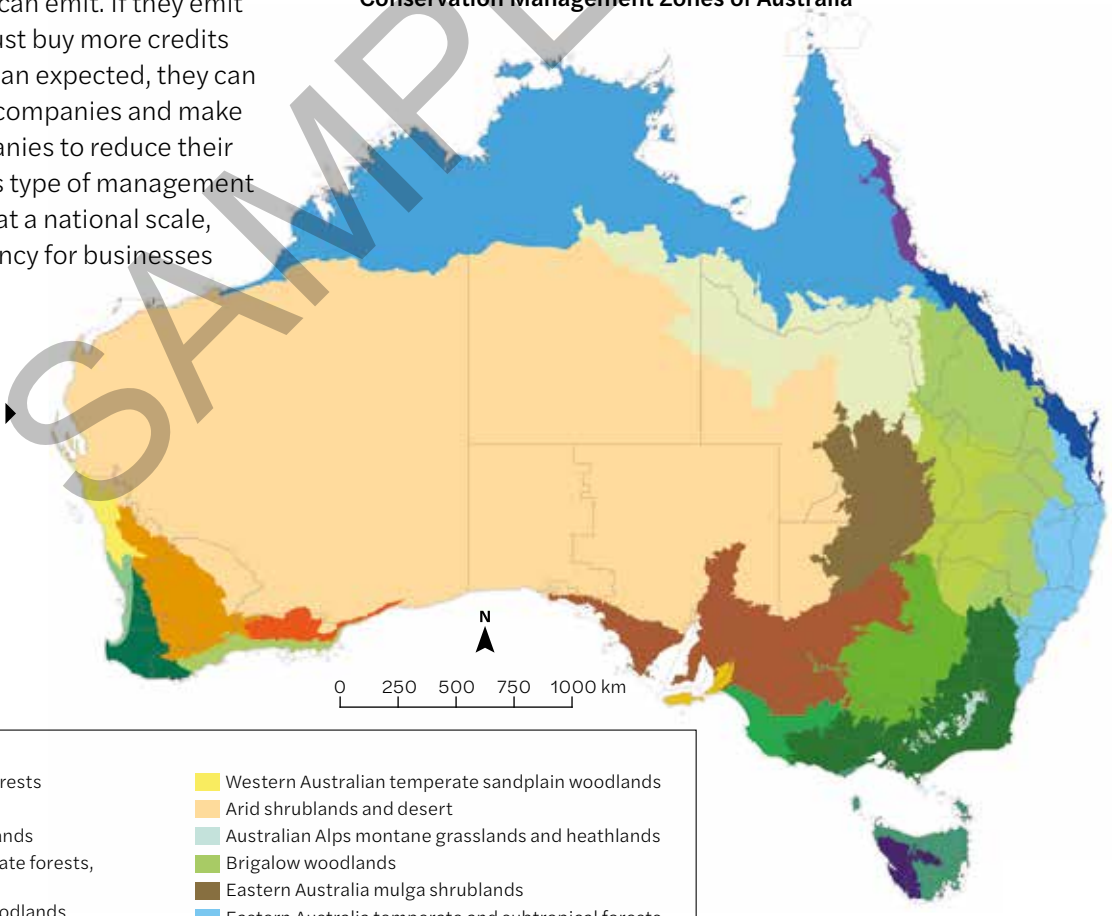
National governments can also create initiatives to encourage businesses and communities to be more sustainable. An example of this is carbon credit initiatives. Companies are provided permits that explain how much carbon they can emit. If they emit more than they expect, they must buy more credits or pay a fine. If they emit less than expected, they can sell their extra credits to other companies and make money. This incentivises companies to reduce their greenhouse gas emissions. This type of management strategy needs to be managed at a national scale, to ensure fairness and consistency for businesses across the country.

Local change and management

Local environmental change is when there are alterations to the environment within a smaller area, such as an ecosystem or a community. These changes can include pollution of local rivers and coasts, loss of local biodiversity, urban growth or air pollution from traffic. At the local scale, management strategies are often action and education strategies, which aim to promote sustainability and inform community members on how to protect the environment.

As an example, urban planning policies are usually developed at a local level. Curitiba in Brazil has implemented a range of urban planning strategies that encourage public transport to reduce air pollution and promote green spaces to support local biodiversity. The city of San Francisco, USA, aims to have zero waste by 2050 by making it mandatory for community members to recycle and use compost. Another example is the Wapichan people in Guyana,

Conservation Management Zones of Australia



Source 3: Conservation Management Zones of Australia classify geographic areas according to their ecological and threat characteristics. They help conservation planning at a national scale, including aligning national priorities with local action.

Source: Department of Climate Change, Energy, the Environment and Water

who are an Indigenous South American group that have created high-resolution maps of their traditional lands and actively preserve these environments and protect them from deforestation. These local management strategies are generally easier to enforce than global and national ones, and can make a significant difference to the sustainability of environments.

Source 4: Curitiba in Brazil has implemented this rapid bus service to encourage public transport use.

▲ **Source 5:** A young Indigenous Brazilian girl learning how to manage crops traditionally using a machete. In Brazil, Indigenous groups manage many local environments.

Learning ladder 6.5

Perspectives of people and organisations

1. Source 4: Describe how Curitiba in Brazil has improved sustainability at a local level.
2. Source 2: Explain whether global, national or local management would be needed to address the issue of the Great Pacific Garbage Patch.
3. Explain why international treaties and agreements can be complex.
4. Why has the Australian Government introduced a carbon credit scheme?
5. Create an infographic that explains how climate change can be managed on global, national and local levels.

Scale

1. Describe an example of environmental strategy on a local or a national scale.
2. Source 2: Explain how environmental change in one place can affect another.
3. Source 3: Why do national conservation management strategies also have effects at the local scale.
4. Source 5: Analyse the effectiveness of local strategies compared to global strategies.

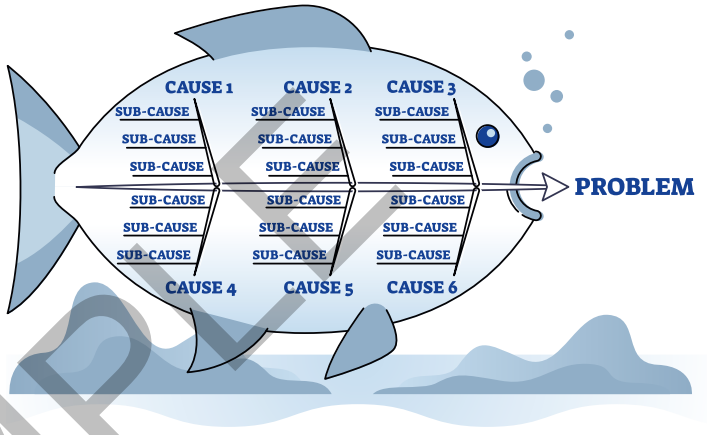
HOW TO

Scale, pages 416, 423

How do fishbone diagrams show issues to manage?

What are they?

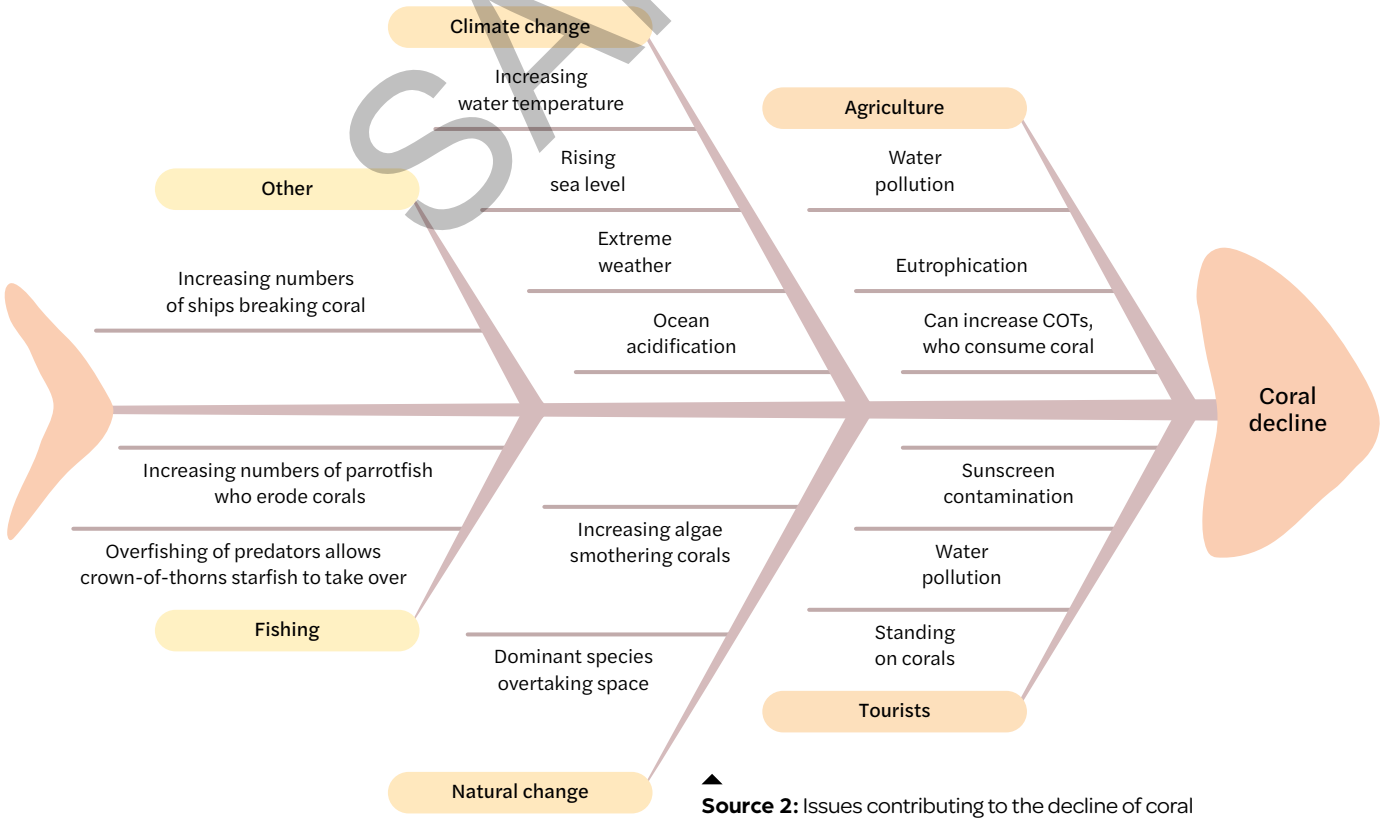
Fishbone diagrams are a useful way to display the cause and effect of something. They are used in environmental management to identify the underlying causes of an environmental issue and develop the most appropriate management strategies to address the problem. The diagram is structured like a fish skeleton, with the issue as the head of the fish and the causes of the problem listed along the skeleton.



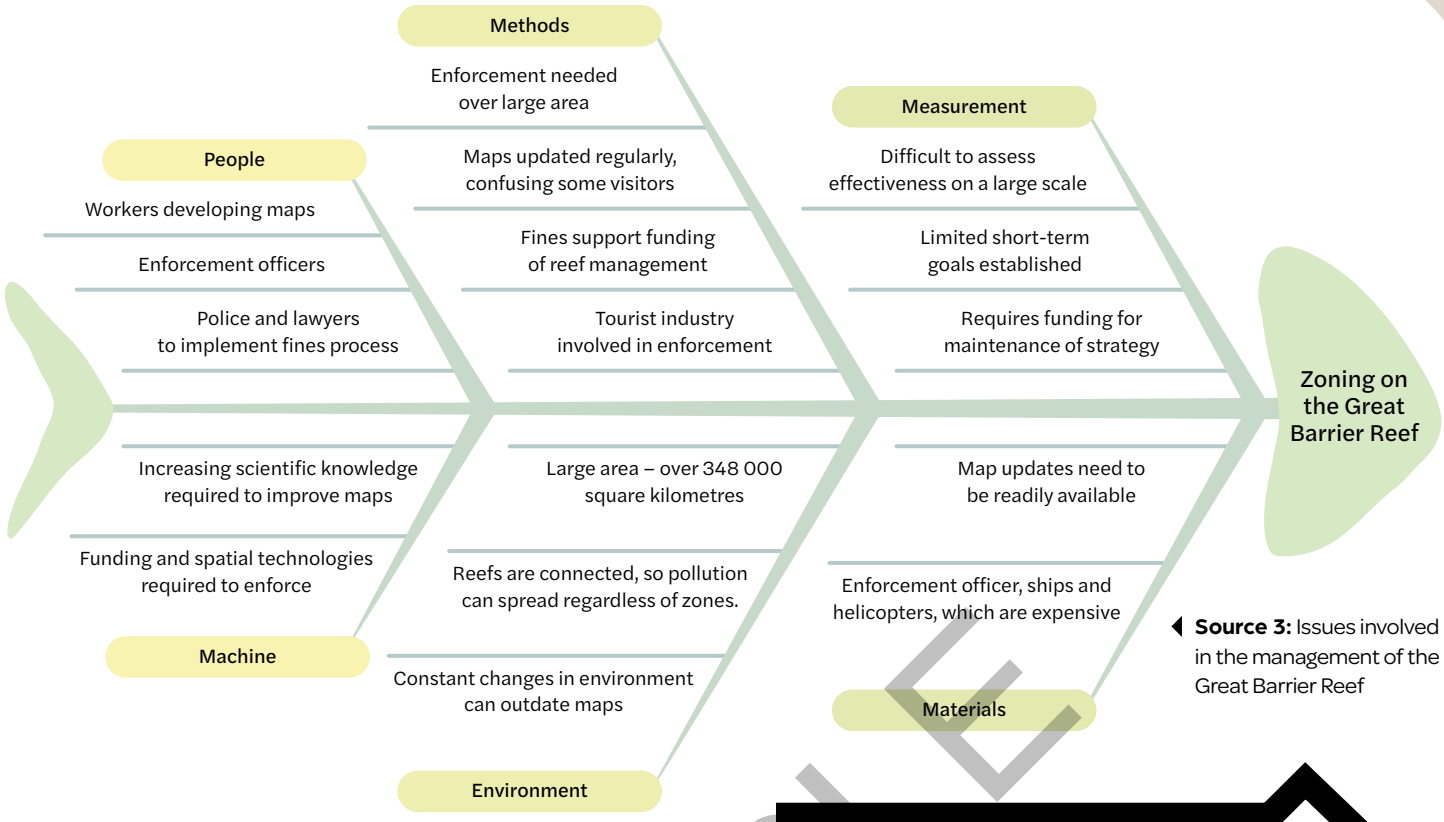
Source 1: Fishbone diagrams identify a key issue or problem and identify the underlying causes of the problem.

How to create a fishbone diagram

To create a fishbone diagram, identify an environmental issue and write it on the head of the fish. Then draw a spine with lines branching out of it. Brainstorm all the causes of the issue, and categorise them. Each line becomes a category, and you can list the different causes along each one. An example is shown in Source 2.



Source 2: Issues contributing to the decline of coral



Source 3: Issues involved in the management of the Great Barrier Reef

How can environmental managers use them?

Fishbone diagrams can be used to identify the root cause of an issue. This can help environmental managers develop targeted strategies to address the main causes of a problem and prevent similar issues from occurring in the future. Using Source 2 as an example, environmental managers can identify that climate change, agriculture and tourism are the leading causes of declining corals. From this, they can assess whether the current management strategies are sufficiently addressing these causes or not.

How can we use them to assess management strategies?

Another way fishbone diagrams can be used in environmental management is to identify all the factors that are used to implement a management strategy, and assess if there are any parts that are not effective. The following categories are helpful in this way: people, methods, measurement, machine, environment and materials. As shown in Source 3, there are many requirements to enforce the management strategy of zones on the Great Barrier Reef. An environmental manager could look at this fishbone diagram and identify issues of the management strategy, such as the capacity for maps to become outdated or the ability for the zones to be enforced across the large extent of the reef.

Learning ladder 6.6

Representing and communicating information

1. Describe what a fishbone diagram is and how it can be used.
2. Explain how environmental managers can use fishbone diagrams.
3. Source 2: Explain the main causes of coral decline.
4. Assess the validity and usefulness of fishbone diagrams.
5. Create your own fishbone diagram on an environmental topic such as:
   - air pollution
   - water pollution
   - deforestation
   - engangered species
   - introduced species
   - coastal erosion.
6. You can draw the fishbone diagram or use one of the automatic templates available online. The examples shown on these pages were created on the Canva website at: https://www.canva.com/graphs/fishbone-diagrams.

HOW TO

Flow diagrams, page 437

6.7

How sustainable are Asia's rainforests?

Asia has over 550 million hectares of forests that span across many countries with different industries, political goals, environmental regulations and levels of economic development. As a result, the forests are managed differently, which has led to different levels of forest sustainability across the continent. The sustainability of forests is the ability for forests to function and still provide social, economic and environmental benefits now and in the future.

Spatial patterns of forest sustainability

East and north–east Asia

Many countries in the east and north-east of Asia are economically developed, such as China, Japan and South Korea. These countries have the resources to implement more effective environmental policies and reforestation programs, and provide education and awareness that improve public support for sustainability. As a result, countries in this region have improved their forest cover and have twice as many forests being 'intensely managed' as the rest of the world. China has increased its forest cover by 33.5 million hectares since 1999. One strategy was building the Saihanba Forest Farm, which is now the world's largest created forest at 750 square kilometres. This forest cost $72 billion to establish and aimed to overcome desertification and provide more food resources. However, not all forests in these areas are equally sustainable, and replanted forests are often less resilient and not as biodiverse as in the past.

South–East Asia

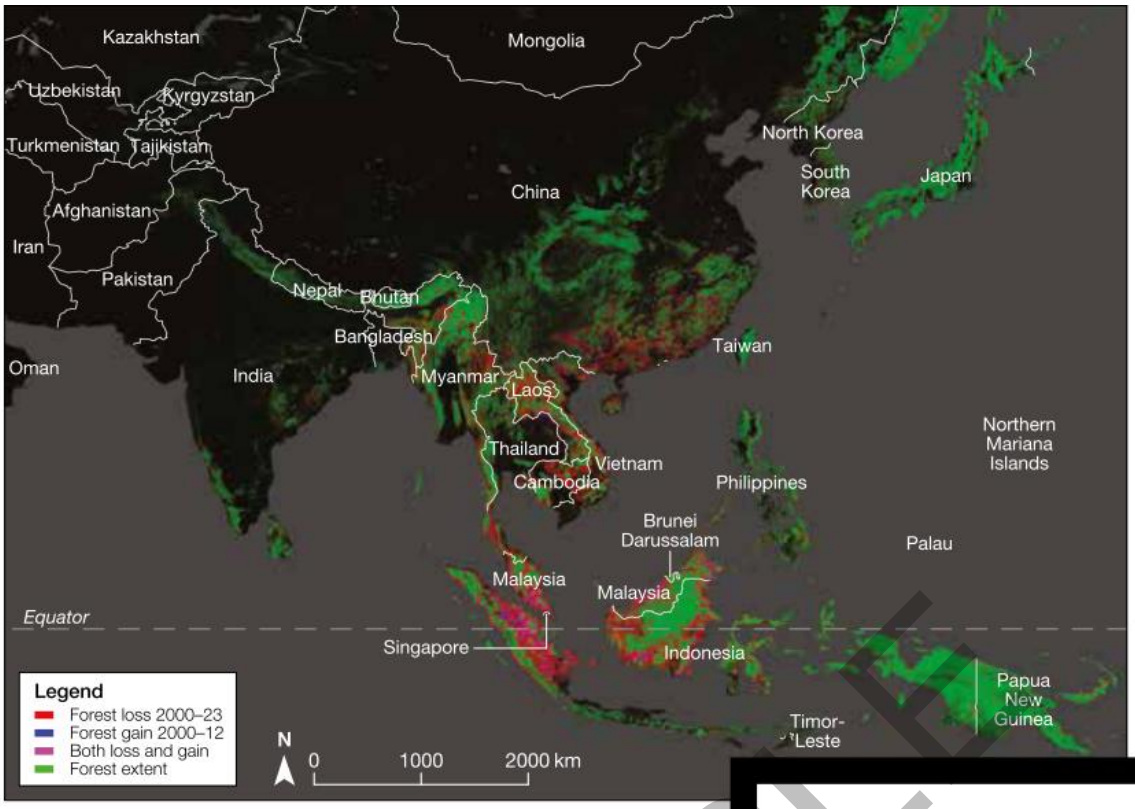
Forests are less sustainable in the less economically developed countries of Asia, such as Indonesia, the Philippines and Vietnam in the south-east. This area contains 15 per cent of the world's forests, but has lost over 80 million hectares since 2005 due to deforestation, agricultural expansion and illegal logging. Many South-East Asia countries do not have the resources to fund effective environmental programs or enforce regulations on illegal logging companies. They also rely on primary industries that require deforestation, such as palm oil plantations. If this continues, up to 40 per cent of South-East Asia's biodiversity could disappear by 2100. There are attempts at conservation, such as the ASEAN Social Forestry Network (ASFN) to promote sustainable forest management. However, the leakage effect impacts the effectiveness of these programs. The leakage effect is when deforestation industries migrate from high-income countries to low-income countries, to continue to meet global demand without being restricted by the high regulation and legislation in developed countries.

West Asia

Countries in west Asia, such as Iran and Iraq, have significantly less natural forest than other parts of Asia. This is due to the arid climate, high urbanisation and historical deforestation. For this reason, there are many conservation efforts to protect the existing forests, such as the World Heritage–listed Hyrcanian Forests in Iran. However, many conservation attempts

Source 1: Aerial view of deforestation in South-East Asia. Rainforest is being removed to make way for palm oil and rubber plantations. Fire is used as a tool for deforestation, causing serious air-quality issues in many parts of Asia.

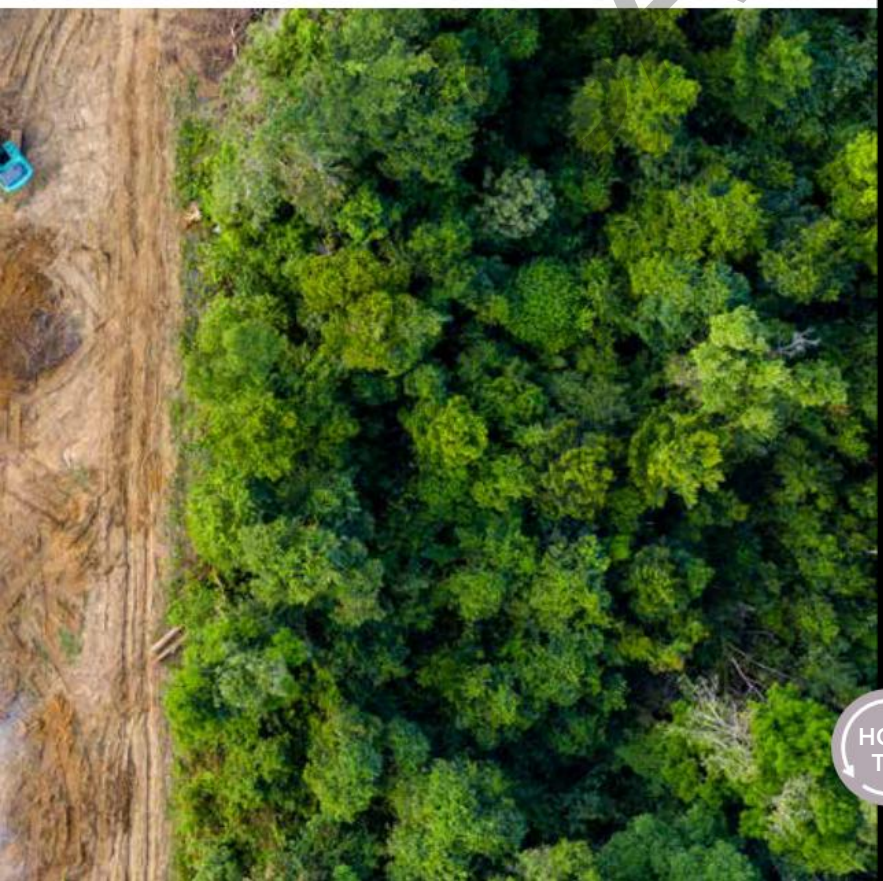
Forest cover loss in Asia, 2000–23



Source 2:
A map highlighting forest cover loss between 2000 and 2023. There is a difference between the north and north-east countries compared to the south-east countries.

Source: Matilda Education Australia

have been less effective, as urban and economic values have been prioritised. In Dubai, an afforestation project called One Million Trees was stopped after four years to use the land to build a gigantic shopping centre instead, leading to 80 per cent of trees dying. For this reason, the forests are only moderately sustainable in western Asia.



Learning ladder 6.7

Characteristics of places and environments

1. Source 1: Describe what an unsustainable forest looks like.
2. Explain how unsustainable forests can affect groups and individuals.
3. Source 2: Conduct PQE on this map, and explain why these patterns exist.
4. Analyse the benefits and challenges of developing and implementing the Saihanba Forest Farm.
5. Why do some parts of Asia focus on forest conservation while others prioritise economic development?

Space

1. Source 2: Where are Asia's most sustainable forests located?
2. Why are forests less sustainable in South-East Asian countries like Indonesia, the Philippines and Vietnam?
3. Source 2: Explain the spatial pattern caused by forest management in different countries.
4. How does the leakage effect change the spatial patterns of deforestation in Asia?

HOW TO

PQE, page 430; space, page 406

Case study

Why are forests more sustainable in Nepal?

In 1993 the Nepalese government implemented a Forestry Act. This Act created national forest boundaries, restricted the selling of timber and fuelwood, and shifted the role of forest management to community groups in a Community Forestry Program.

Community Forestry Program

Develop and enforce local regulations

Local communities work with authorities to develop regulations around how local forests are used, the quantity of resources communities are allowed to harvest and when harvesting can occur. This ensures the local community can access food, medicine and employment opportunities sustainably. Community members receive incentives to enforce these rules by patrolling forests and fining non-compliant individuals. This improves the effectiveness of the forest management as community members feel involved in conserving the forests and share responsibility in their protection.

Afforestation

Community groups work with non-government organisations, such as World Wide Fund for Nature (WWF Nepal), to restore degraded forests and create forest plantations. This improves the extent of forest cover, supports ecosystem services and increases the biodiversity of local forests.

Ecological reserves

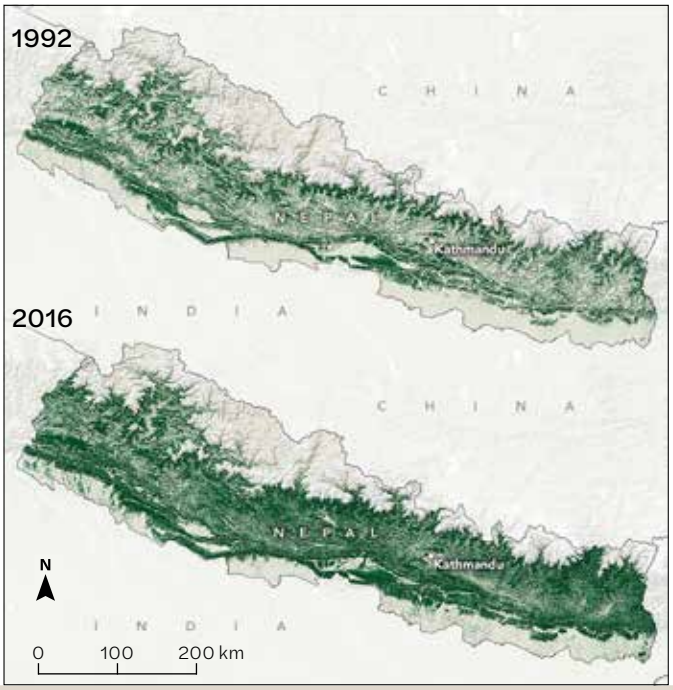
Communities and non-government organisations, such as Rainforest Trust, develop ecological reserves to prevent deforestation. In these reserves, only recreational and religious activities can be conducted. As an example, in 2018 they established a 40-acre bird sanctuary in Pachim Kusha to support the diversity of species in lowland riparian habitats, and in 2019 they protected 150 acres of the rhododendron forest from being cleared for agriculture.

How effective is the Community Forestry Program?

Today nearly 2.3 million hectares, a third of Nepal's forests, are managed by 22 000 community forest groups. Using Landsat satellite images and interviews with community members, the program has been evaluated as highly successful. Results include:

- national forest cover has doubled since 1992, from 26 per cent to now 45 per cent of the country. Some areas, such as the community forest of Devithan, have increased from as little as 12 per cent to 92 per cent in this time.
- increased biodiversity as key habitats are protected, which also protects native species such as snow leopards, red pandas, Indian pangolins and Himalayan muskdeer

Nepal's forest cover in 1992 and 2016



Source: NASA

Source 1: A map showing forest cover in Nepal between 1992 and 2016. This highlights the success of the Community Forestry Program, which focused on conserving forests and establishing forest plantations to address deforestation.

Source 2: Multipurpose management in Nepal, incorporating community and Indigenous knowledge

- sociocultural benefits for communities, as they are able to equitably access forest resources and new forms of employment, such as afforestation projects. This has led to improved living standards across Nepal.

▲ **Source 3:** A Nepali woman cutting grass in her village. The community determines how much grass, timber, food and resources individuals can harvest from the forest. This ensures that everyone can sustainably source the materials they need to live and work.

Learning ladder 6.8

Sustainable management strategies

1. Describe how the Community Forestry Program creates sustainable forests in Nepal.
2. Source 1: Explain the effectiveness of the Community Forestry Program. Consider environmental, social and economic factors.
3. Compare the management of Nepal forests to Australia. Which is more effective and why?
4. Assess why management strategies on a local scale, such as the Community Forestry Program, are more effective.

Place

1. Source 3: Who decides how much grass can be cut?
2. Describe the social, economic and environmental importance of Nepal's forests to its local communities.
3. Explain how deforestation would impact Nepalese communities socially and economically.
4. Source 2: Assess how the Forestry Act has changed the way local communities interact with their environment.

HOW TO

Place, page 408

How sustainable are the world's polar regions?

The Arctic and Antarctica make up the world's polar regions. These are the coldest places on Earth and the functioning of their environments is threatened by human activities, global warming and the impacts of climate change.

Antarctica

Antarctica, a land mass surrounded by the Southern Ocean, is the Earth's coldest, windiest and driest continent and covered by the Earth's largest **ice sheet** and the **glaciers** that flow from it. Antarctic ecosystems are mainly aquatic, and its species such as penguins, walruses and seals have adapted to surviving in the extreme cold.

Human activities are restricted to scientific research and tourism – there is no permanent human occupation or land ownership. Under the Antarctic Treaty that came into force in 1961 and the Protocol on Environmental Protection since 1991, Antarctica is designated as a place for peace and scientific research. A range of measures are used protect the environment and ensure its sustainable use. These include special protected areas, rules for shipping, waste management and tourist visits, as well as a prohibition on mining.

Antarctic sustainability

One of the threats to Antarctic environmental sustainability is pollution caused by discarded equipment and the waste associated with everyday living on scientific bases and tourist ships. Although sewage and food waste can be discarded at sea, most research stations have biological treatment plants, and harmful waste such as metals, oil and plastics must be removed by ships and returned to countries for proper disposal. Some chemical waste does enter Antarctic food webs, oil spills from shipping are a constant threat to aquatic species and birds, and pollution and litter are transported to the continent by ocean currents.

Source 1: The Arctic is an ocean covered by a thin layer of sea ice and surrounded by land. Antarctica is a continent covered by a very thick ice cap and surrounded by sea ice over the Southern Ocean.

Antarctic

Arctic

Source 2: Nenets are traditional nomadic reindeer herders in the Arctic. More than 12 000 Nenets still migrate herds of reindeer along the same routes as their ancestors did. However, climate change is impacting their livelihood, with extreme weather events and disease outbreaks killing thousands of reindeer.

The Arctic

An ocean surrounded by the lands of eight nations lying within the Arctic Circle makes up the region known as the Arctic. Ocean occupies 60 per cent of the area and is mostly covered in year-round **sea ice** (frozen sea water) that fluctuates in size with the seasons. Much of the land is underlain by **permafrost**, permanently frozen soil, and covered by ice such as Greenland's ice sheet, ice caps in mountainous areas and glaciers that flow from these.

Terrestrial ecosystems comprise boreal forests, tundra and cold deserts with large land-based wildlife such as Arctic wolves, Arctic foxes, Arctic hares, polar bears and caribou, and aquatic ecosystems that are highly dependent on sea ice. Seasonal changes in ice and snow influence the life cycles of plants and wildlife including polar bears and reindeer. The region has been occupied by 40 different Indigenous groups such as the Sami, Inuit and Nenets for 20 000 years. They used the resources of the land and sea sustainably to survive in the inhospitable environment, with hunting and fishing the main sources of livelihood.

New settlements are being developed based on the exploitation of resources including the fur trade, fishing, mining, oil and gas exploration and exploitation, and most recently tourism. Scientific exploration, military and defence activities, and industrial processing are other activities in the Arctic today. About four million people live in settlements ranging in size from large cities to small Indigenous homeland settlements, creating similar environmental challenges as urbanisation in other parts of the world including air and water pollution, waste disposal, greenhouse gas emissions and loss of biodiversity.

▲ **Source 3:** Oil fields throughout the Arctic are now being accessed. Russia's Prirazlomnaya oil platform in the Barents Sea is the first ice-resistant oil platform in the world. Special alloys were used in the construction of the platform to withstand the icy environment.

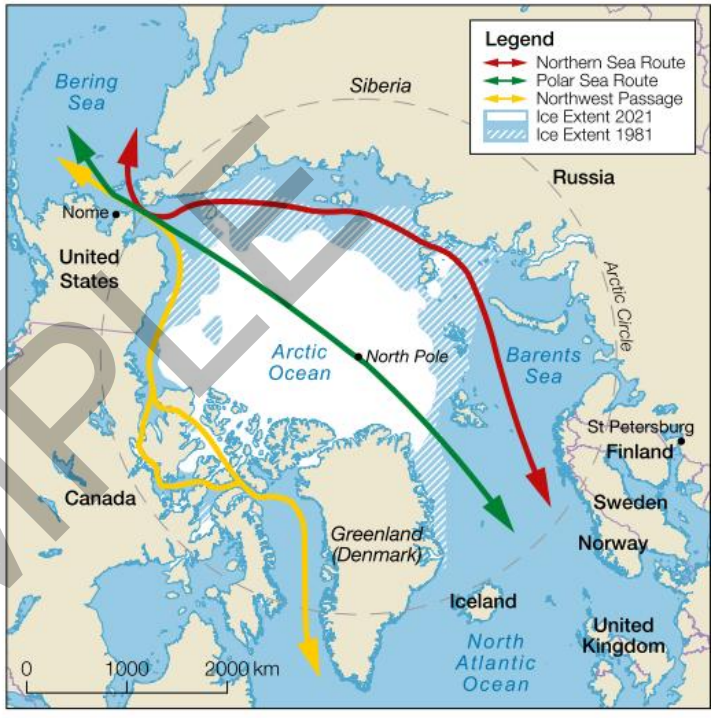
Arctic sustainability

Despite a low population density, humans have had a cumulative impact on the Arctic environment. The Arctic region is a 'sink' for pollutants from within and outside the region. Contaminants such as heavy metals like mercury and lead from industrial, mining and military activities, and persistent organic pollutants (POPs) such as PCBs and dioxins, impact Arctic ecosystems through processes such as **bioaccumulation** and **biomagnification**. Pollutants are also transported to the Arctic by wind, rivers and ocean currents from densely settled industrial areas of Europe. Litter and plastic waste from towns, fishing boats and cruise ships, and leakages from old military bases and ports are other sources of pollution.

There is no single international agreement like the Antarctic Treaty for governing and protecting the Arctic environment. The Arctic Council comprises the eight Arctic nations, representatives of Arctic Indigenous Peoples and observers from other governments and organisations. The council deals with environmental threats and sustainability issues by putting in place strategies such as The Arctic Contaminants Action Program and developing agreements such as the Stockholm Convention to address pollution. Levels of some aquatic pollutants have reduced through environmental management.

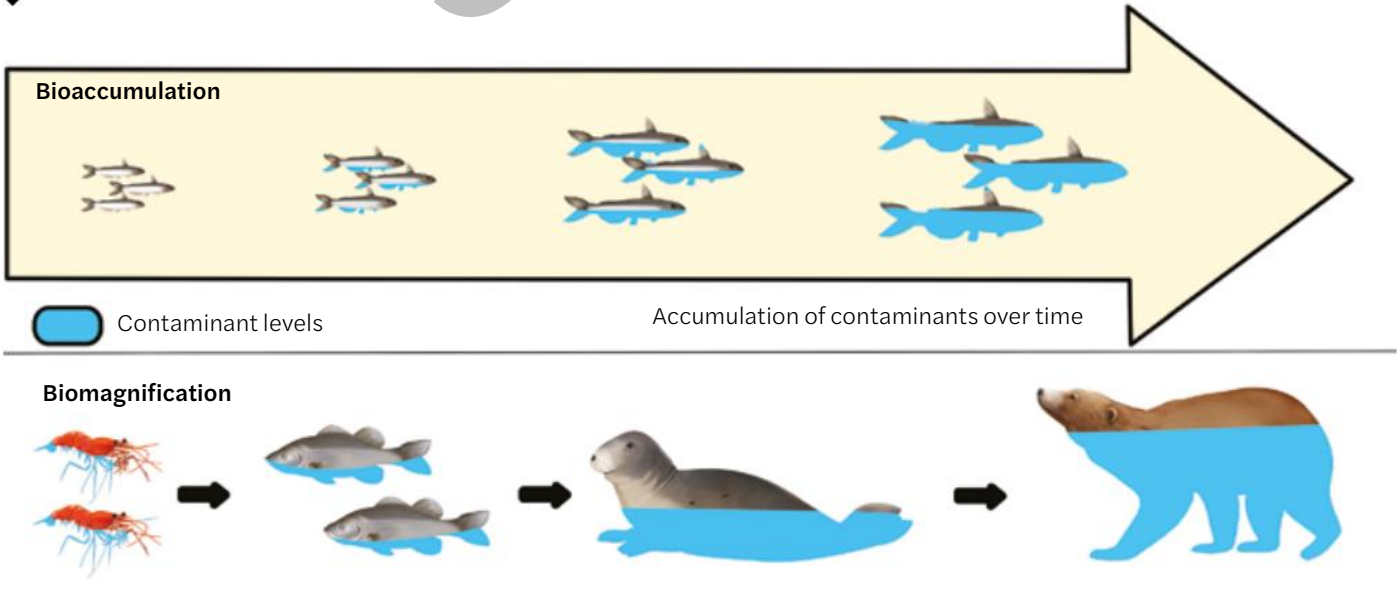
Tourism is a growing industry requiring management to reduce its impact on the Arctic environment. Threats from tourism include trampling of sites, disturbances to wildlife and sensitive ecosystems including the impact of noise, accidental wildlife kills and other impacts of big ships. Management for sustainability includes restricting ship sizes and access to sites, marine protected areas and national parks with controlled access and regulations for the disposal of waste.

Current and potential Arctic shipping routes



Source 5: Current and potential Arctic shipping routes will challenge sustainability.

Source: Matilda Education Australia



Source 4: Animals accumulate toxins over their lifetime based on the food they consume. For example, fish consume smaller fish and over time the levels of toxins in their bodies get higher. This is bioaccumulation. As contaminants move through the food chain, animals higher up accumulate the toxins from all levels in the food chain below them. This is biomagnification.

Climate change and sustainability

Rising atmospheric and ocean temperatures are impacting Arctic and Antarctic environments. Glaciers and ice sheets are melting, sea ice is contracting, Arctic permafrost is melting, sea levels are rising, and both land and sea species are migrating in response to warmer temperatures. The impacts are beginning to be felt in polar ecosystems:

- Increasing wildfires are burning the Arctic tundra.
- Food supplies of wildlife such as reindeer are reduced by increased droughts and the loss of lichens and mosses that form a vital food source.
- Polar bears are affected by reduced sea ice, their platform for hunting seals. It has been estimated that polar bears now use four times more energy in their hunt for food.
- Coastal erosion is increasing across Arctic coastlines in Russia, Canada and Alaska from a combination of rising sea levels, reduced sea ice, increased storms and the wake from ships.

Source 6: Polar bears rely on sea ice to hunt seals. Reduced sea ice is altering polar bear access to seals

Climate change will increase potential threats to future environmental sustainability. Reduced sea ice will open new ice-free sea routes in the Arctic Ocean that could result in increased shipping and access to marine resources such as fish, oil and gas. More shipping will increase noise, waste and the potential for oil spills. Tourism will grow because of a longer 'warm' season and an increase in ice-free sites to visit. New ports will be built, and others will be expanded.

It has been suggested that the Arctic needs a treaty like the one for Antarctica to address the growing challenges created by climate change. Groups such as WWF and Greenpeace have protested against the exploitation of resources in the Arctic Ocean. They have education programs to raise public knowledge and promote action. Greenpeace has taken direct action through protests at oil drilling sites.

The root cause of global warming, rising carbon dioxide levels, can only be addressed through global action by all nations and individuals to decrease greenhouse gas emissions. Global action such as the Paris Agreement set targets for countries to greatly reduce their carbon dioxide emissions.

Learning ladder 6.9

Characteristics of places and environments

1. Describe the main differences between Arctic and Antarctic polar lands.
2. Why are Arctic ecosystems mainly aquatic while the Antarctic has aquatic and terrestrial ecosystems?
3. Source 4: Explain how pollutants in the Arctic Ocean threaten wildlife through bioaccumulation and biomagnification.
4. Source 3: Explain the environmental threats posed by the establishment of oil drilling platforms in the Arctic.
5. Source 5: Analyse potential changes to Arctic sea routes including the possible environmental impacts of the change.

Sustainability

1. Identify the impacts of pollution on Antarctic and Arctic environments.
2. How does the Antarctic Treaty assist environmental sustainability in Antarctica?
3. Why is managing environmental change in the Arctic a greater challenge to sustainability than in Antarctica?
4. Create a fishbone diagram (page 244) to outline the threats to environmental sustainability from human activities in the Arctic, including threats from climate change.

HOW TO Sustainability, page 418

6.10

How effective are management strategies?

Evaluating environmental management involves determining whether an environmental management strategy is effective at improving the quality of the environment in a way that sustainably supports local communities and economies. When making an informed evaluation, it is important to consider multiple perspectives, discuss strengths and weaknesses, and make reference to important criteria.

What criteria can be used in environmental management?

Establishing criteria in an evaluation is integral, as it ensures that the judgements are consistent and measure the elements that matter. There are many criteria that can be used in environmental management. The acronym BLESS summarises some common criteria:

- **Biodiversity:** How does the strategy impact the variety of life in the ecosystem positively or negatively? This includes the diversity within species and interactions between them.
- **Longevity:** Is the strategy able to be implemented sustainably over time? This includes assessing whether it requires long-term funding, whether it is able to be enforced and whether it has negative effects that could cause harm in the future.
- **Equity:** Does the strategy provide fair access to the environment and resources for all communities and local economic activities? Or do some groups benefit more than others?
- **Sustainability:** Does the strategy support the long-term health and productivity of the ecosystem? Is it protecting the environment and resources for future generations?
- **Scalability:** Can the strategy be implemented effectively at a larger scale or adapted to other ecosystems? Or is the strategy only effective on a smaller scale?

How do I form the evaluation?

Once the management strategy is researched and criteria is determined, a judgement can be made on how effective the strategy is. A way to visualise this is to use a thermometer, like one shown in Source 2.

Assess the management strategy against three of the criteria and determine if the management strategy is good at each one or not. For each criteria that the environmental strategy is good at, increase the 'temperature' on the thermometer and for each criteria that the environmental strategy is limited, decrease the 'temperature'. If your management strategy is good at two of the criteria, but limited at another, it would sit at 'moderately effective'.

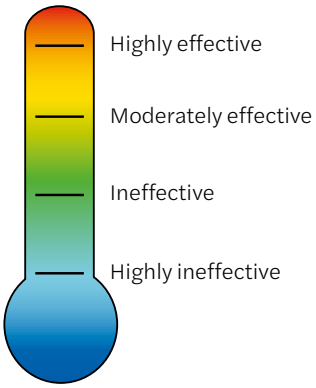
An example evaluation

There is a reforestation project in Malaysia, where they are regrowing trees to increase their forest cover. The BLESS criteria could be used the following way to evaluate this strategy:

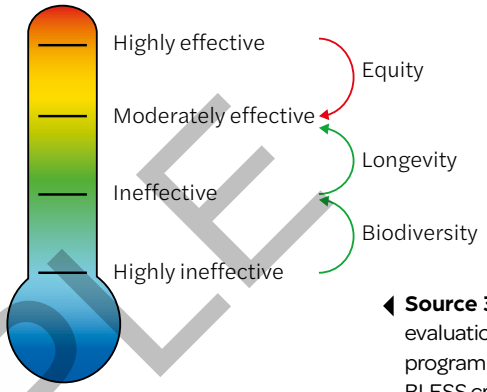
- **Biodiversity:** The strategy is achieving this criteria well, as it has increased habitats for various species and enabled their populations to increase. It has also restored ecosystems that were affected by deforestation.
- **Longevity:** The strategy is achieving this criteria well, as once trees are initially planted, they can naturally grow by themselves. This reduces the amount of time, funding and effort required to maintain this strategy in the long-term.
- **Equity:** The strategy is not achieving this criteria well. Many of the reforested spaces are on land that was once used by local communities, and has impacted their livelihoods and displaced them. This has affected them socially and economically.

Looking at these three criteria, this strategy could be considered moderately effective as shown in Source 3.

Source 1: Reforestation project in Malaysia. When evaluated using the BLESS criteria, this strategy can be considered moderately effective.



Source 2: A thermometer is an effective visual way to form an evaluation. The thermometer allows you to measure performance of criteria and assess the overall 'temperature' of the management strategy.



Source 3: Example of an evaluation of a reforestation program in Malaysia, using BLESS criteria.

Learning ladder 6.10

Sustainable management strategies

1. Rephrase the BLESS criteria in your own words.
2. Describe what an evaluation is and how a thermometer can be used to help visualise it.
3. Source 2: Explain the reforestation project in Malaysia and outline how successful it has been.
4. Apply the Sustainability and Scalability criteria to continue evaluating the reforestation project. Put your answer into a paragraph.
5. Research one of the following management strategies and evaluate its effectiveness using the BLESS criteria:
   - waste management in Sweden
   - solar energy in Germany
   - public transportation in Singapore
   - wind energy in Denmark
   - Coral Vita commercial coral in Grand Bahama.

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Fieldwork

How can we investigate environments?

Gathering **quantitative** (statistical) data and **qualitative** (descriptive) information are methods used to answer geographical inquiry questions about a selected environment.

Investigating aquatic environments

Gathering data and information about a local stream or wetland can help to make an assessment of the health of the environment, the impact of people and the effectiveness of management. A typical inquiry question would be "How healthy is the wetland behind the school?' or 'What management strategies have been implemented to improve water quality in a local creek and have they been effective'?

Collecting abiotic data

Abiotic data consists of information about the non-living components of rivers and wetlands, such as water temperature and **turbidity**. The quality of the environment will affect the capacity of the environment to support living things and the level of biodiversity in its food webs.

Qualitative methods rely on observation and recording observed features. A water quality checklist such as the Waterway Health Check in Source 3 requires no special equipment but allows an assessment to be made by allocating a score to observed features. A range of easy-to-use scientific equipment can be used to gather quantitative (statistical) data to give a more accurate picture of water health.

Source 1: Using a waterbug identification chart to identify macroinvertebrates collected in dipnets

Source 3: Tests and equipment to gather statistical data related to water quality

Aspect of water quality	Equipment and measurement	Why it is important for environmental health?
Temperature How hot or cold is the environment?	Using a thermometer Degrees Celsius (°C)	Animals and plants have a temperature range in which they can survive. Temperature affects the dissolved oxygen that organisms need to survive.
Turbidity The cloudiness or muddiness of water	With a turbidity tube NTU = Nephelometric Turbidity Units	High turbidity can suffocate aquatic organisms, reduce sunlight penetration, decrease photosynthesis and biomass productivity, and smother aquatic plants.
Salinity Salt concentration measured by electrical conductivity	Using an electrical conductivity meter (EC meter) Millisiemens per centimetre (mS/cm) Eg.1 mS/cm = 1000 µS/cm	Freshwater species survive in a narrow salt concentration range. Increased salinity can kill plants and animals and reduce biodiversity. Fresh tank water is approximately 100 µS/cm compared to sea water at about 65 000 µS/cm.
pH (acidity) A measure of how acidic or alkaline a substance is	Using pH strips pH units 0–14, 7 is neutral Lower numbers = acidic Higher numbers = alkaline	The optimal pH for most organisms (plants and animals) in Australian fresh water is 6.5 to 8.5. Higher or lower pH will reduce biodiversity as sensitive species disappear.

Waterway health check

Make notes on each category on a separate sheet.

Site information

Name of wetland/waterway:
If unnamed, what is the closest town, suburb or road.

Location:

Date:

Weather:
Has it rained in the past 24 hours?
(If yes, was it heavy rain?):

Area being rated:
Create a simple site map using a road directory or local plan. Mark in features that might affect your waterway. Mark in where you made your rating.

Provide enough detail so that when you repeat your rating, you're examining the same area.

Category 1

Land use

Walk around the area surrounding your waterway. Record land uses that you see or that you're aware of in your local area.

Create a list of places where water comes from that flows into your waterway.

Your rating

What's the land being used for around your waterway?

Category 2

Litter

Make notes on the type of litter floating on or in the water or on the surrounding land. Include natural litter such as leaves, sticks and animal faeces.

If litter seems to collect in one particular area, take a photo of that area each time you monitor your waterway so you can compare build-up.

Your rating

What kind of litter is found in your waterway, and how much is there?

Category 3

Pipes and drains

Look for pipes, drains or trenches leading into your waterway. Examine what's coming out of them (by smell and sight; don't touch or taste). Record how many there are and make notes on what you think they're there for.

Without touching the discharge from the pipes, figure out a method of calculating what the volume of any discharge is.

Your rating

What are the pipes and drains bringing to your waterway?

Category 4

Extra structures/ modifications

In addition to pipes and drains, record the presence of other artificial structures such as weirs, concrete banks, piers or any artificial modification of the water flow.

Describe what effect you think these structures have had on the waterway.

Your rating

Stormwater filters such as shown here are designed to catch litter that might accumulate in other areas.

Source 3: Waterway Health Check using observation and a scoring system

The table in Source 2 shows how temperature, turbidity, pH and salinity are measured and what the results say about aquatic health.

Collecting biotic data

The health of a waterway is reflected in the living things observed there. Plant or wildlife identification charts (Source 1) are used to determine any native species present, such as the plants along the **riparian zone** of a river or living in a wetland, and also to identify invasive species such as weeds or pests. Macroinvertebrates are captured using a dipnet, identified and counted.

Observing and assessing management strategies

Photographs and field sketches can be used to record management strategies and evidence of their effectiveness such as damaged infrastructure or weed infestation. Additional information is often provided by educational signage at different sites. The biotic and abiotic data can be used as evidence in your assessment of management. Poor management will be reflected in the poor aquatic health of the environment.

Drawing conclusions

The qualitative and quantitative data collected during fieldwork can be used to answer the inquiry question posed before the fieldwork activity – such as assessing the current heath of the environment and evaluating the effectiveness of the management of that environment.

Learning ladder 6.11

1. Identify biotic and abiotic features of an aquatic environment that can be collected during fieldwork.
2. Explain the benefits of using observation charts to determine environmental health.
3. Source 1: How does a waterbug survey provide evidence of environmental health?
4. Source 2: Justify the use of scientific equipment to collect quantitative data for assessing environmental health.
5. Analyse the importance of gathering qualitative and quantitative data using a range of techniques to make judgements about environmental health and the effectiveness of management strategies.

Environmental case studies

7

WHAT PROCESSES AFFECT MARINE ENVIRONMENTS? 278

HOW ARE RIVERS THREATENED? 298

HOW ARE COASTAL FEATURES FORMED? 262

7.0

How can I understand environmental management?

Sustainability of the Earth's environments depends on careful assessment and management to protect and repair the impacts of humans on fragile ecosystems.

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 toward the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.
	Outcomes					Geographical tools and inquiry

Source 1: Summer Haven is community in Florida, United States. Plans to deal with ongoing coastal erosion include a seawall, beach nourishment and managed retreat, where houses would be removed from the coastline.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

What are the features of coastal environments?

Coasts are where the land meets the ocean. They are a zone of transition between marine and inland freshwater and terrestrial environments. The coastal zone contains distinctive environments such as beaches, headlands, lagoons and estuaries.

Agents of change

The coastline is the boundary between the sea and the land. Coastlines are shaped by wind and waves. Layers of hard resistant rock form **headlands** and rocky coastlines, while softer rock is eroded more quickly leaving bays and inlets where beaches and other depositional features form.

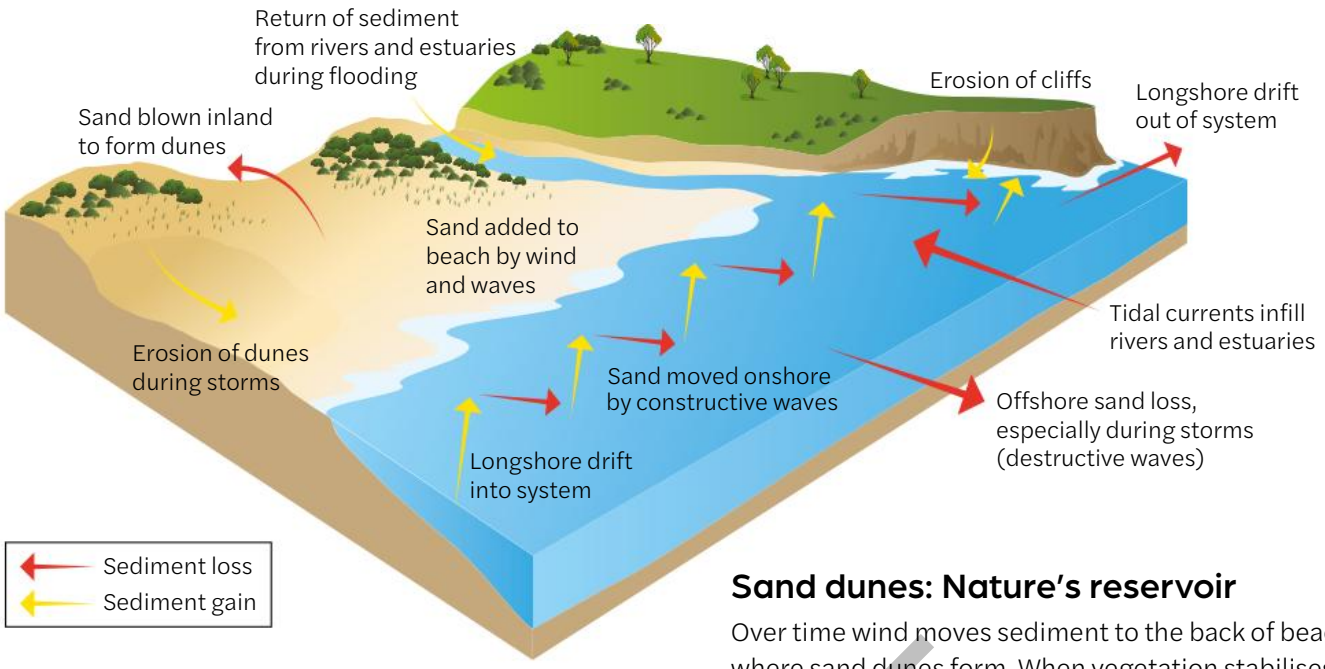
- Salt spray contributes to the **physical weathering** and **chemical weathering** of headlands and impacts the plants that grow on coastal dunes.
- Waves are generated by wind and will vary with changes in the weather. For example, **tropical cyclones** and **east coast lows** generate large destructive waves that erode beaches.
- Wind direction, strength and fetch (the distance of ocean over which wind blows) influence the size of waves. Onshore winds blowing over a large **fetch** create bigger waves and offshore winds tend to flatten the size of waves.
- Waves break when they reach shallow water, where friction with the seabed slows the base of the wave causing the top to spill over and rush forward.
- Wave energy erodes rock from headlands and transports the sediment that forms beaches, **sand bars**, **sand spits** and **sand dunes**.

Processes shaping beaches

Beaches comprise material eroded from headlands, transported by rivers and washed onshore from the continental shelf. Sand, rocks, broken shells and other marine debris is moved within the coastal zone by waves, tides, winds and currents. The continuous movement of sediment on a beach, often referred to as a river of sand, makes sandy coasts dynamic.

Waves create and transform beaches. Low and gentle **constructive waves** have a strong **swash** that builds up beaches. These mostly occur in summer. Tall, steep **destructive waves** pound onto beaches, remove sediment and transport it offshore through strong **backwash**. These mostly occur in winter or during storms. Generally, eroded sediment will return to beaches in successive periods of constructive waves. This is a natural cycle of beach renewal.

The process of **longshore drift**, created by waves hitting a beach at an angle, transports sand in a current close to shore. Sand transported this way can form sand spits across coastal bays creating **lagoons** or can blocks river mouths. Headlands can stop sand leaving a beach or the sand can travel hundreds of kilometres along a coastline. Where human structures such as **groynes** or **breakwalls** interrupt the movement of sand, beaches can no longer be replenished by waves and longshore currents and can suffer long-term beach erosion.



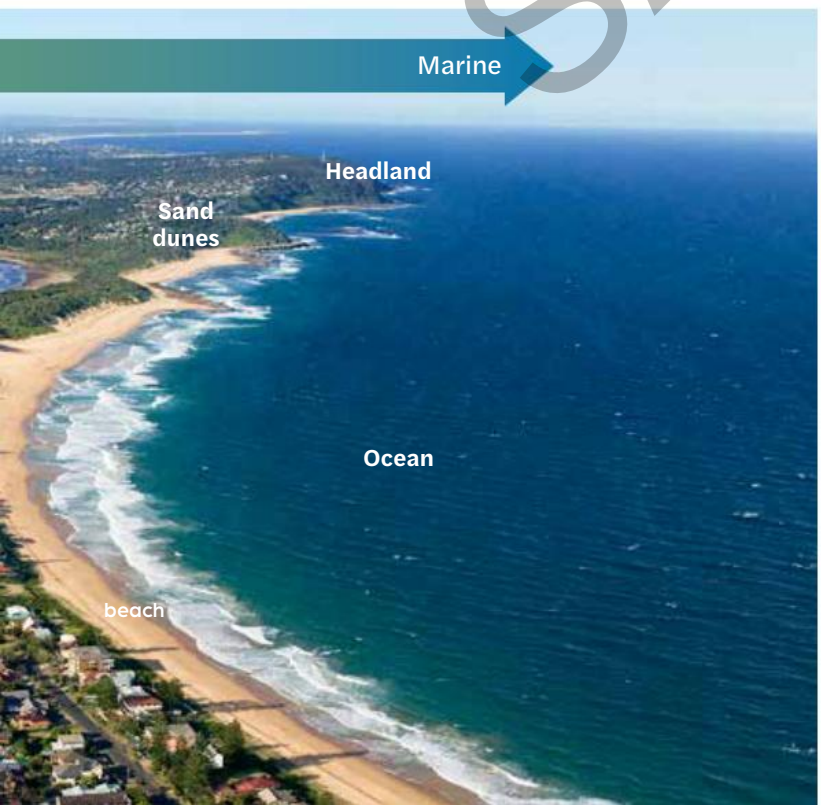
Source 1: Block diagram illustrating the processes of shaping coastal landforms such as beaches, sand dunes and cliffs

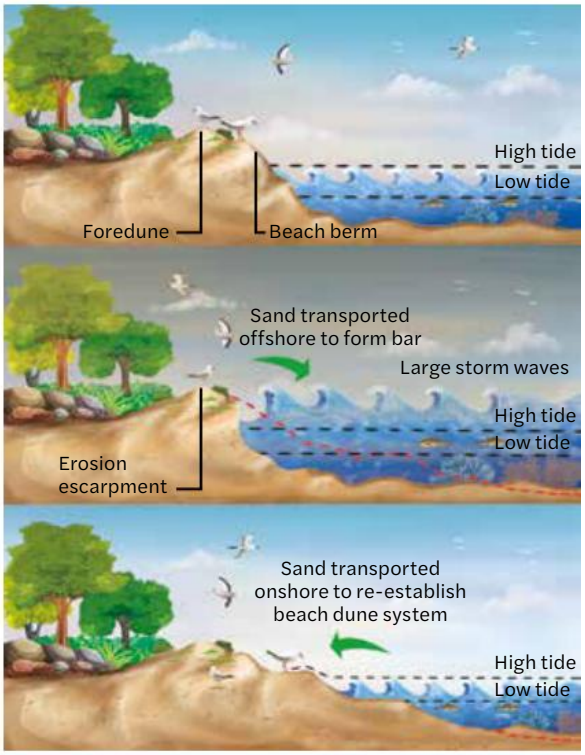
Sand dunes: Nature's reservoir

Over time wind moves sediment to the back of beaches where sand dunes form. When vegetation stabilises these dunes they become semi-permanent landforms, storing sand until the next big erosion event. These dune ecosystems support unique species of plants that bind the sand together. Moving inland from the salty winds and waves of the coastline the vegetation on sand dunes adapts to changing conditions and supports higher biodiversity. Where people have built structures such as houses and roads on dunes the sand is no longer available to absorb the erosive power of waves. This places properties at risk and necessitates protective actions such as rock walls. A loss of vegetation leaves sand dunes unstable.

Source 2: The coastal ecosystem provides four key functions to support human life for the 900 million people worldwide who live in the coastal zone:

- source: seafood, fuel, water, transport, recreation and employment
- sink: absorbs carbon dioxide, sediments, toxins and nutrients
- service: protects coast from storms and floods and regulates climate
- spirituality: relaxation and connection to nature and Country.





Source: UNSW and State of New South Wales (Department of Climate Change, Energy, the Environment and Water)

Source 3: Natural change to beaches and dunes from wave action

Processes shaping estuaries

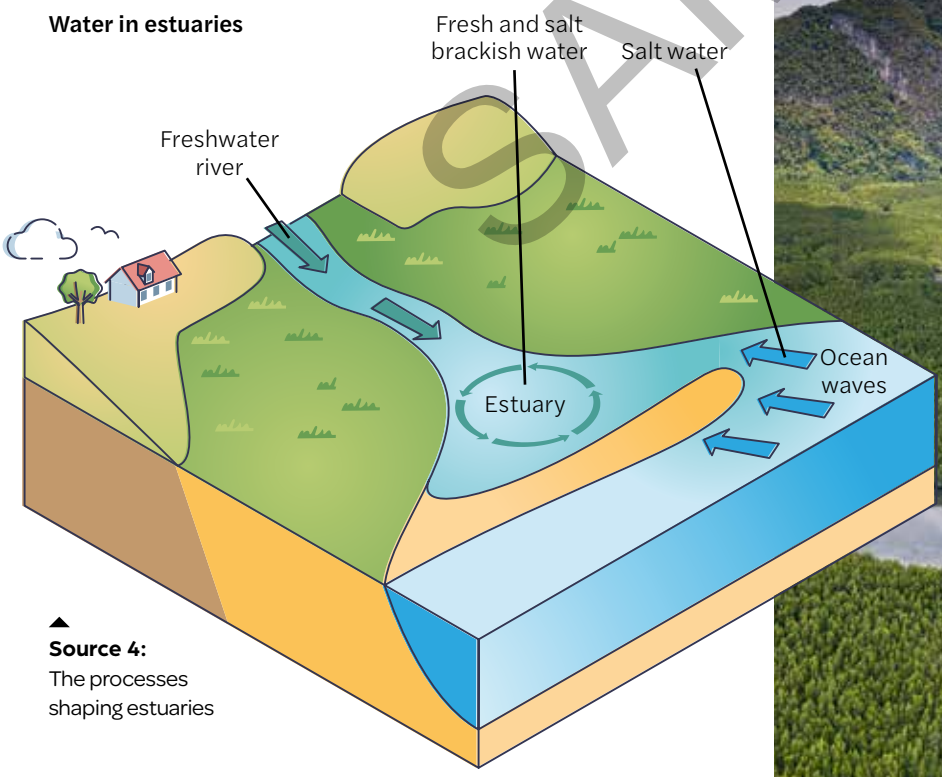
An **estuary** is a dynamic coastal environment where freshwater rivers or streams meets the tides and waves from the ocean. When freshwater and seawater combine, the water becomes brackish, or slightly salty. Water circulates into and out of an estuary daily. Tides deliver saltwater and sand while rivers deliver freshwater and finer silt or mud into estuaries. Water levels and salinity rise and fall with the tides, change as you move inland and vary between seasons. During rainy seasons, rivers flood estuaries with freshwater and during a dry season, rivers may slow to a trickle and tidal influences make the water more saline. In a storm season, **storm surges** and waves can flood estuaries with salt water.

The value of estuaries

Estuaries provide the sediment and nutrients that support ecosystems such as intertidal **mangrove** forests and saltmarshes or aquatic ecosystems such as seagrasses and kelp forests. The silt or mud delivered by rivers supports plants uniquely adapted to inundation by salt or brackish water. Plants provide the habitat and detritus (decaying plant matter) that support high levels of biodiversity including small fish, shellfish, migrating birds and shore animals and they stabilise the land against erosion. Estuaries are known as the 'nurseries of the sea' because they support the young organisms of marine ecosystems such as coral reefs.

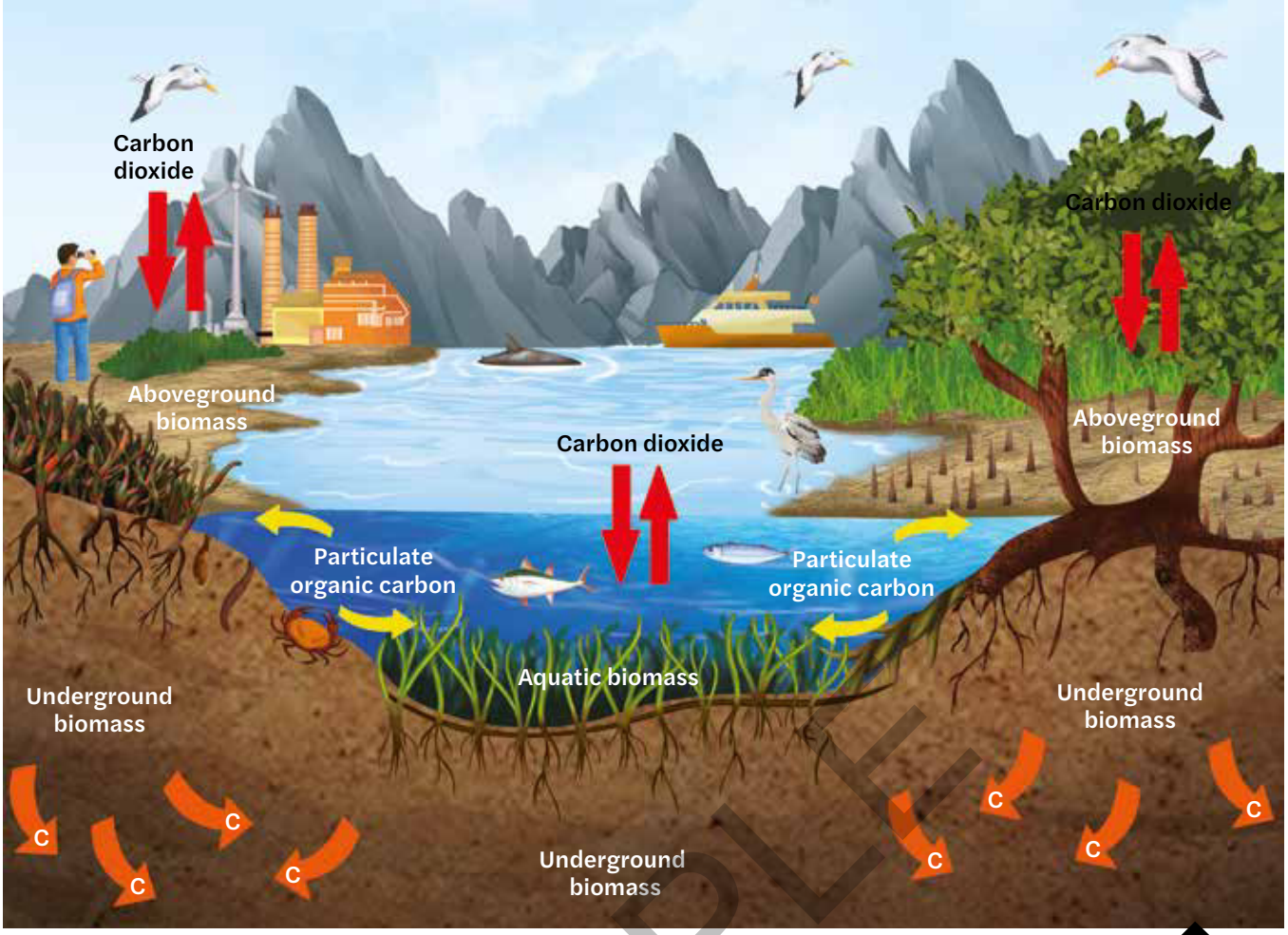
Estuaries are valued for the resources and services they provide, including a high capacity to absorb sediment and nutrients in runoff and sequestering carbon from the atmosphere into the aquatic environment – as **blue carbon** stored above and below the water.

Mangroves for example provide habitat for over 3000 fish species globally and reduce wave heights along a coast by 66 per cent. They are sources of food, tourism, transportation, recreation, and aesthetic enjoyment and the backbone of many coastal economies – fishing, tourism, trade and other commercial activities. Where people have altered the natural processes of estuaries the source, sink, service and spiritual values are lost. Water quality and biodiversity declines, coastal erosion increases, fisheries are decimated, and dead zones created.



Source 4: The processes shaping estuaries

Source 5: Oblique aerial view of the estuarine ecosystem and dense mangrove forests at Phang Nga in Thailand. Mangrove trees are one of the few plants that can survive in brackish water in estuaries.



Source 6: Blue carbon processes in a coastal estuary. Blue carbon is carbon stored by our oceans and marine environments.

Learning ladder 7.1

Processes that transform people, places and environments

1. Define 'coastal zone', 'estuary', 'beach' and 'dune system'.
2. Describe the role of wind in creating coastal environments
3. Source 3: Explain how different types of waves change a coast.
4. Source 1: Explain how sand is lost and gained on this section of coast.
5. Source 6: Analyse the importance of estuaries in storing blue carbon.

Change

1. Why are beaches described as dynamic?.
2. Explain daily and seasonal changes in estuaries.
3. Source 5: Suggest how a dam on the river would change this estuary.

HOW TO Change, page 412

How do we visualise coastal change?

Understanding how coastal environments function and change is often better explained with visual aids such as labelled photographs, GIS maps and conceptual diagrams. Seeing the issues visually helps in the development of effective management strategies.

Annotated photographs

The annotated photograph in Source 1 shows the overdevelopment of the 'tourist coast' at Cancun in Mexico where hotels have replaced dunes and natural vegetation. Without a reservoir of sand, storm erosion threatens to undermine buildings. Seawalls, beach nourishment and groynes are further changes implemented to protect lives and properties.

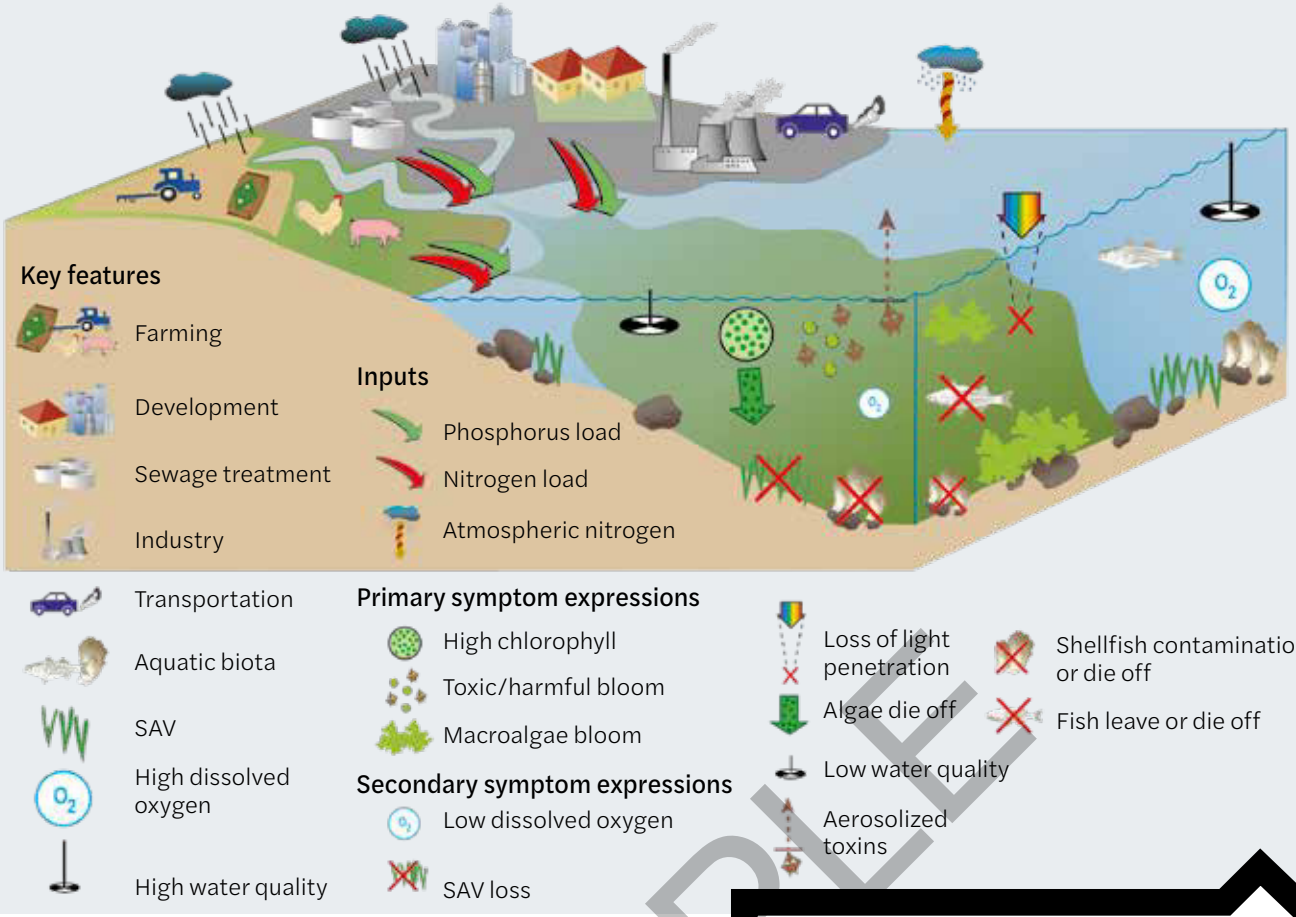
Every year coastlines across the world make news headlines because of beach erosion, the long-term loss of sand from beaches and their dune systems. Beaches erode when the sand supply cannot keep up with the sand lost. Losses are attributed to natural processes, human overdevelopment on sand dunes, the building of infrastructure such as breakwalls to improve river navigation and more recently climate change.

GIS maps

The geographic information system (GIS) map in Source 2 shows the predicted hazard lines where erosion will impact the NSW coastline at Kingscliff. GIS is a computer system that combines multiple data sources to display geographical information to help us visualise patterns. In this case, calculations of erosion from rising sea levels and storm surges have been overalyed on top of an aerial photograph to help visualise the immediate threat to the settlement of Kingscliff and the likely future hazard lines. Displaying the threat of climate change in this way assists in management and decision making.

Scientists are predicting that 50 per cent of the world's beaches could disappear by the end of this century because of climate induced coastal erosion and rising seas. Mexico and Kingscliff are already experiencing these changes.

Source 1: Annotated photograph using labels and pointers to highlight key features of overdevelopment at Cancun, Mexico



▲ **Source 2:** Conceptual diagram showing the cumulative impact on the Chesapeake Bay, the United States' largest estuary

▲ **Source 3:** Using GIS to overlay an aerial photograph of Kingscliff in NSW to show immediate and future hazard lines

Conceptual diagrams

Conceptual diagrams such as Source 3 are used to illustrate the causes and consequences of change to coastal estuaries. The estuary is polluted with nutrients from urban, industrial and agricultural activities around the estuary or delivered by rivers from its large catchment. Algal blooms deplete oxygen levels, which, along with increased turbidity, kills fish and harms the shellfish industry. Overdeveloped estuaries in most countries face similar environmental changes.

Learning ladder 7.2

Representing and communicating information

1. Name three tools geographers use to illustrate coastal change.
   - **a** Source 1: Use the annotated photograph to describe how people changed the coastal zone at Cancun.
   - **b** Source 3 (page 99): Create a simple sketch of this section of the Queensland coast and use pointers and labels to show the change that is occurring.
   - **a** Source 3: Explain how a GIS map is used to predict change.
   - **b** Source 3: Which areas are under immediate threat of erosion and how could the coast at Kingscliff be managed to minimise the impact of erosion.
2. Source 2: Use the conceptual diagram to explain the causes and consequences of an algal bloom in the Chesapeake Bay estuary.
3. Source 2: Analyse the value of conceptual diagrams to illustrate change.

HOW TO

Block diagrams, page 436; flow diagrams, page 437

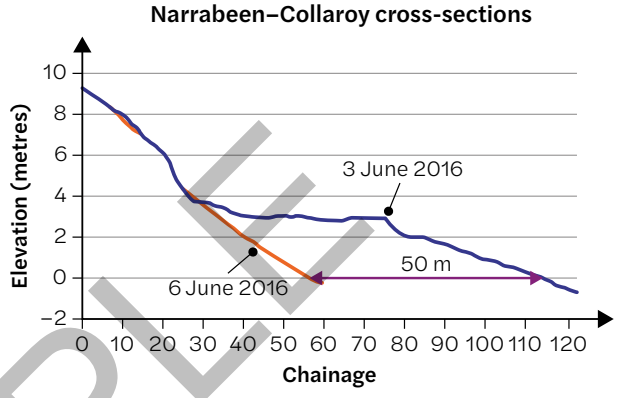
How is beach erosion managed in coastal cities?

Sydney and New York are coastal cities over 16 000 kilometres apart on two different continents. In both cities erosion threatens iconic beaches and similar management strategies are used to restore the coast and protect properties. Climate change is increasing that threat.

Sydney beaches

The Sydney coastline extends for 80 kilometres from Palm Beach in the North to the Royal National Park in the south. The hilly topography of the coast and the Sydney Harbour, Port Hacking and Botany Bay estuaries have created a mix of small beaches pocketed between headlands, larger bay beaches such as Bondi and longer more exposed beaches such as Collaroy–Narrabeen in the north and Cronulla in the south. East coast lows and the combined effects of **king tides** and strong onshore winds create waves and storm surges that cause serious erosion on exposed beaches. Collaroy Beach was impacted by storms in 2016, when 50 metres of beach was lost, and again in 2020, increasing demands for an engineered solution.

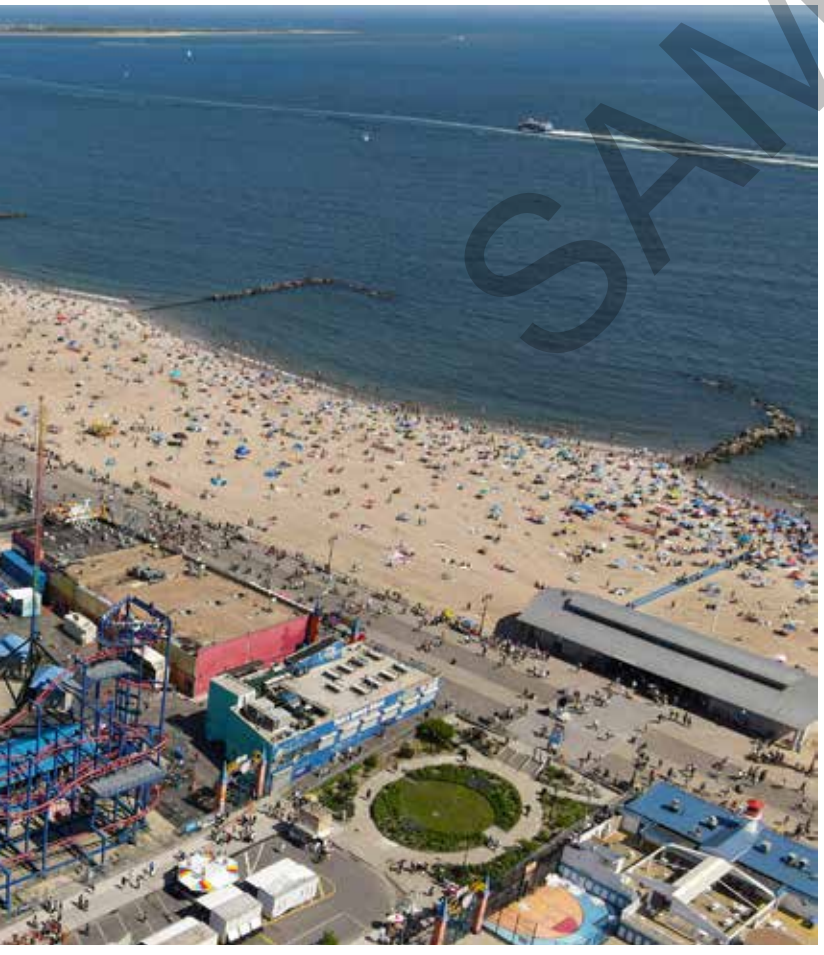
▲ **Source 1:** Collaroy Beach erosion 2016. Each erosion event leads to a call for more action by authorities to implement erosion protection.



Source: Matilda Education Australia

▲ **Source 2:** Graph showing the erosion at Collaroy Beach over three days in 2016

Source 3: Construction of the 7-metre-high $25 million Collaroy seawall. The first section was completed in 2022 and approval was given in 2023 to extend the wall by a further 80 metres.



New York beaches

New York is often referred to as a 'city of islands' that formed within the New York Harbor estuary or as barrier islands, such as Long Island, along the Atlantic coastline. Coney Island on the southern coast of Brooklyn, and Long Island, contain many of New York's most popular and iconic beaches. The topography of the coast is very flat compared to Sydney and there are no headlands to protect the beaches and trap sand in place. Intense low pressure systems known as Nor'easters and unpredictable hurricanes such as Hurricane Sandy in 2012 that travelled further north than a typical hurricane cause serious beach erosion. When storms hit New York beaches, the impacts are felt far inland as the storm surges overtop beaches and low dunes and travel several kilometres taking beach sand with them and destroying property. In Sydney, the impact is mainly felt in the narrow 'active zone' of beaches.

Source 4: The iconic Coney Island beachfront in New York City, known for the boardwalk, amusement park and long wide sandy beach. The wide beach is maintained using sand nourishment pumped from offshore. Groynes can be seen at intervals along the beach to prevent currents carrying the sand away.

Coastal management options

Using the LEAP acronym, (Legislation, Education, Action, Preservation) there are two management options most relevant to managing city coasts threatened by erosion.

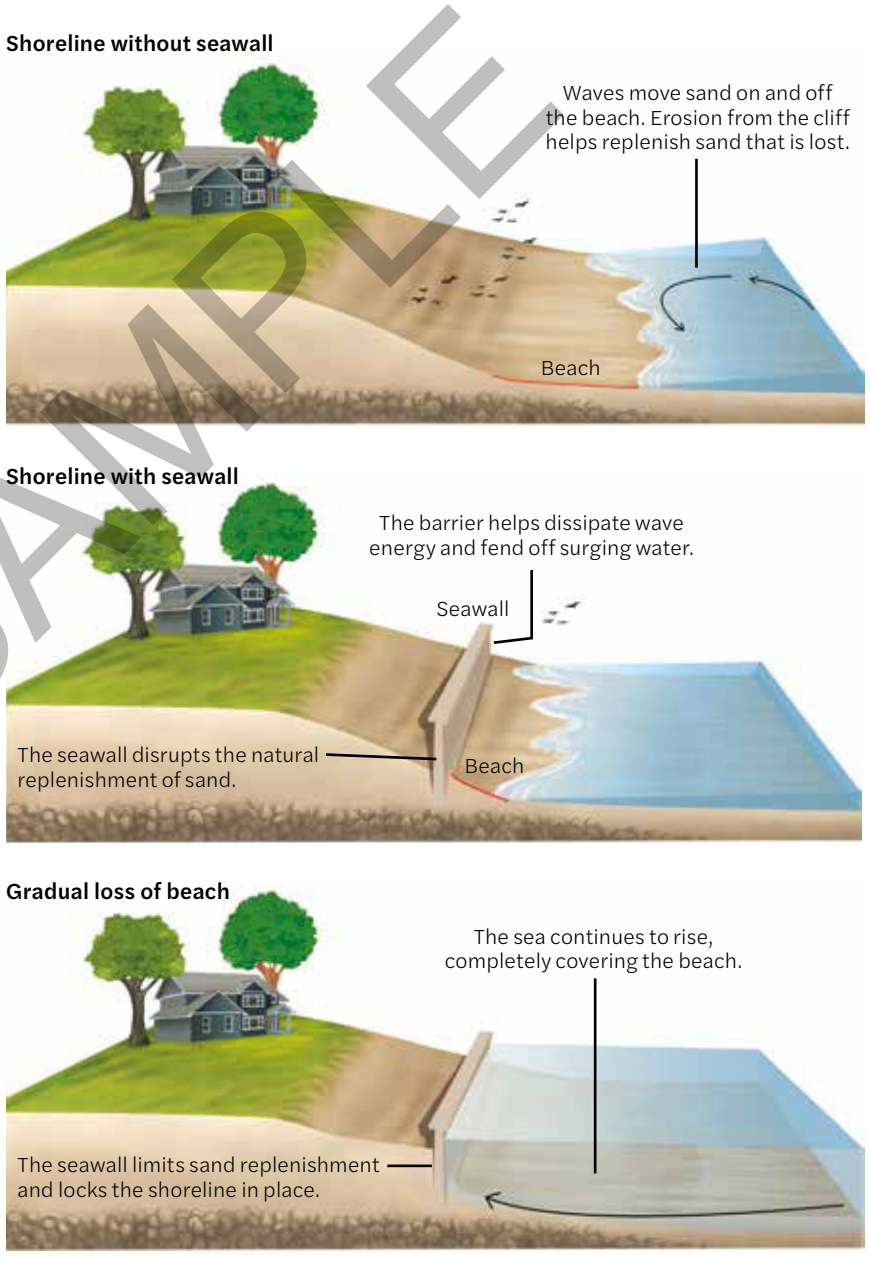
Legislation provides the legal framework for undertaking coastal management and sets out areas of responsibility such as funding and which authority undertakes the work. In Australia, states have responsibility for managing coasts within three miles (about 5 kilometres) from the coastline. The NSW Coastal Management Act 2016 sets out a vision and framework for managing coastal assets. It requires all coastal councils to have Coastal Management Plans. Funding for projects is negotiated between state and local governments and often means works cannot be completed if funding is not provided.

In the United States, a Federal Government Coastal Zone Management Act of 1972 sets out responsibilities for protecting and restoring coastal communities and resources and includes shared budget arrangements with the states. This means funding is available when needed and there are no conflicts between different levels of government.

Action provides two options.

1 Managed retreat means gradually moving developments away from the active coastal zone. The focus is on giving the beach back to natural processes. There has been very little progress using this option in Sydney other than the relocation of public assets such as Surf Life Saving clubhouses. 'Buyback' of private land needed to undertake retreat is rejected by the owners of multi-million dollar properties and faces a lack of government funding because of the cost. New York faces a similar challenge. Despite the massive impact of Hurricane Sandy and more recent erosion events, two new high-rise buildings were built on the Coney Island beachfront in 2020 and over 2000 other new houses were constructed on the island.

2 Hold the line means putting in place protections to hold back the water. The focus is on the protection of property. Strategies include the use of seawalls, groynes or beach nourishment. Sydney local councils and New York city boroughs use all three of these strategies to manage coastal erosion. At Collaroy, a controversial sea wall mostly funded by residents has begun along the most seriously eroded beachfront (see Source 3). Many locals argue that seawalls destroy beaches in the long term and whilst protecting expensive private properties, impact the rights of the public to enjoy the beach. On Coney Island, extensive beach nourishment is used to create very wide beaches that add value to the public asset – to be 'sacrificed' when storms arrive and slow the effect of storm surges. Groynes are used to keep the sand in compartments along the beach.



Source 5: The effect of seawalls on beaches

New York flood zone estimates based on climate change trends

Source: NOAA

Source 6: This map shows the growth in areas likely to flood if high estimates based on trends in climate change are reached in the coming decades.

Climate change and beach management

Rising sea levels, warmer oceans generating stronger storms and bigger storm surges are consequences of climate change that will increase threats to beaches in Sydney and New York. New York is particularly vulnerable to storm surges because of its flat topography. The surges will move further inland as sea level rises. In Sydney rising sea levels will impact an increasing number of beaches as tides come in higher and storm waves have more impact. The hold the line strategies are considered by scientists to be short term solutions and that eventually managed retreat will be the only option.

The Atlantic coastline of the United States is a global hotspot for sea level rise, with predicted rates in some areas more than two times higher than the global average. With one of the most heavily developed coastlines in the world, including nearly 12 million people living in its coastal counties and trillions of dollars of property and infrastructure within close proximity to the shore. New York's low-lying coastal environment makes the region particularly vulnerable to the impacts of sea level rise. Moreover, these vulnerabilities will only be exacerbated in the face of what are expected to be more frequent and more powerful coastal storms, as recent experiences with Superstorm Sandy and Tropical Storm Irene have shown.

Source 7: Coastal Resilience program in New York is designed to support hazard mitigation, climate adaptation and conservation planning.

Learning ladder 7.3

Processes that transform people, places and environments

1. Source 1: Outline the cause of the scene in the photograph.
2. Describe the process of 'managed retreat'.
3. Source 2: Explain the impact of erosion at Collaroy in 2016.
4. Source 4: How do groynes and beach nourishment protect the values of Coney Island Beach?
5. Source 5: Evaluate the effectiveness of sea walls in protecting beaches.

Change

1. Source 3: What change occurred at Collaroy in 2022 and 2023?
2. Source 6: Describe the change in flood zones for New York City by 2050.
3. Source 7: Explain why New York City is vulnerable to future sea level rises and storms associated with climate change.

HOW TO Change, page 412

Is management of Sydney Harbour estuary effective?

The Sydney Harbour estuary shoreline is heavily armoured with seawalls and other structures and urban growth, industrialisation and shipping have altered the abiotic and biotic environments. Scalable management strategies have been used to restore natural processes, increase biodiversity and achieve long term sustainability.

Sydney Harbour estuary

Sydney Harbour, one of the largest estuaries in the world, is a drowned river valley with a wide, open mouth, deep water channels and shallow bays and inlets that support a variety of habitats and biodiversity. An estimated 1500 Aboriginal people from several clans lived around the estuary before 1788. Evidence from rock engravings, shell middens and artefacts show that fish and shellfish were an important source of food. A clean, deep harbour full of aquatic life surrounded by extensive intertidal ecosystems and access to freshwater was the basis for the first European settlement of the estuary and evidence of thousands of years sustainable Indigenous stewardship.

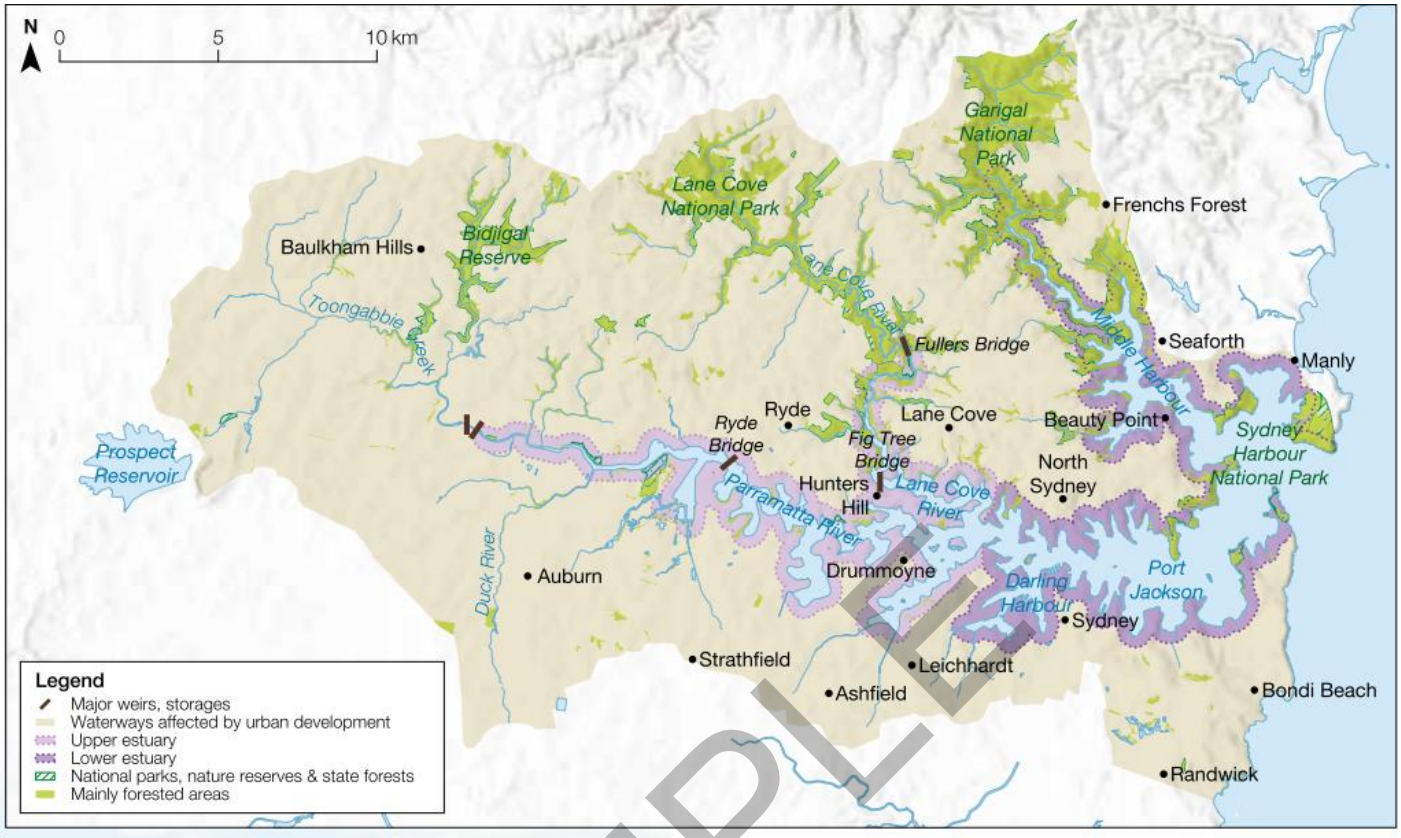
Environmental change

Some of the changes since European colonisation in 1788:

- There has been a loss of mangroves, oysters, seagrasses and kelp habitats that play an important role filtering water, stabilising shorelines and supporting biodiversity.
- Hard surfaces increased stormwater runoff into the harbour, reducing water quality with the addition of litter, sediment and nutrients.
- Industrial pollution created high concentrations of chemical contaminants in **benthic** (bottom) sediments and contributed to accumulation of toxins in larger marine species. The Union Carbide chemical factory at Rhodes was a major source of chemicals, including herbicides and Agent Orange used in the Vietnam War.
- Sewerage and wastewater seepage added bacteria and nutrients causing algal blooms and high E.coli levels that affected the health of human and non-human species.
- Invasive species were introduced via shipping and migration in warming coastal waters, including via the East Australian Current.
- Shipping in Sydney Harbour has led to the building of moorings and marinas, propeller and anchor damage, wave wake, noise and the use of antifouling paints and oil spills contributed to ongoing pollution levels and food web impacts.
- Commercial fishing devastated populations of many marine species. Fishing nets trawled along the harbour floor destroyed sea grass meadows, a breeding ground for marine life.

Source 1: An **armoured shoreline** made up of artificial structures have replaced the natural shoreline around the estuary as seen here at the Sydney Botanical Gardens, Opera House and Circular Quay and beyond. Closer to the heads and along tributary rivers and creeks more natural coastline and vegetation can be found.

Sydney Harbour estuary and catchment



Source: Matilda Education Australia

Source 2: The location and extent of Sydney Harbour and its catchment

Source 3: The darker seagrass areas have been scarred by boat mooring chains that drag along the harbour floor in Manly Cove.

Environmental management

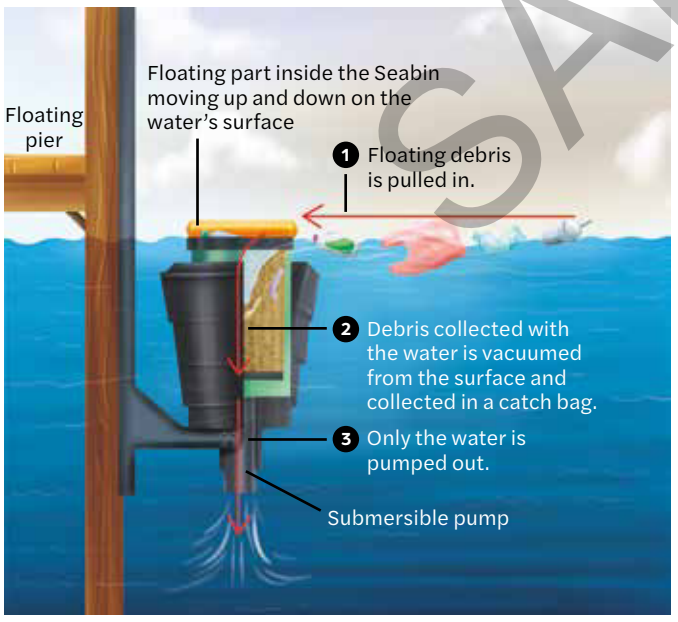
The cumulative impact of changes to the Sydney Harbour estuary have been addressed using a wide range of management strategies.

Improving water quality

Industrial waste disposal is regulated by legislation, however past pollutants remain in the benthic sediments where they can still be ingested by organisms and enter food chains. Warnings about eating fish caught west of the Sydney Harbour bridge remain as evidence of this pollution and the Bioaccumulation of toxins. More recently, plastics (including microplastics) and cosmetic products (microbeads) have affected water quality.

Strategies to manage water pollution:

- Water-sensitive urban design (WSUD) features artificial wetlands to remove nutrients from runoff and gross pollutant traps to catch litter before it reaches the estuary.
- Sediment controls are required around harbourside development sites, such as when Barangaroo Headland works were in progress.
- Rules exist for dumping of **ballast water** from ships before entering the harbour to control invasive species.
- Litter and pollutants are removed from Sydney Harbour through initiatives such as Seabin (Source 4).



Source 4: Seabin is an Australian invention designed to automatically remove fuel, oil, plastics, microplastics and other harmful contaminants. Five units gathered over 5.4 tonnes of debris from Blackwattle Bay in Sydney Harbour between 2021 and 2023, including 753 000 plastic items. Across the wider harbour, tonnes of marine litter were collected at an average rate of one plastic item every six seconds.

- Plastic container deposit schemes
- Plastic bag and microbead bans and education programs about microplastics to reduce use.

Habitat restoration and biodiversity

Biodiversity has benefitted from bans on commercial fishing in Sydney Harbour since 2006, sustainable limits on recreational fishing and bans on the use of highly toxic paint used to inhibit marine growth on boat hulls and pylons. Fish populations such as yellow kingfish have exploded, and the chartered fishing industry has grown to cater for increased recreation and tourism. The Sydney Institute of Marine Science states that fish populations are healthy with 580 species of fish, 'making it amongst the most bio-diverse estuaries for fish in the world'.

The 'Seabirds to Seascapes' project led by the NSW Department of Planning and Environment aims to revamp entire marine landscapes (seascapes), rather than small patches of habitat. The project aims to create a cleaner Sydney Harbour and boost fish population.

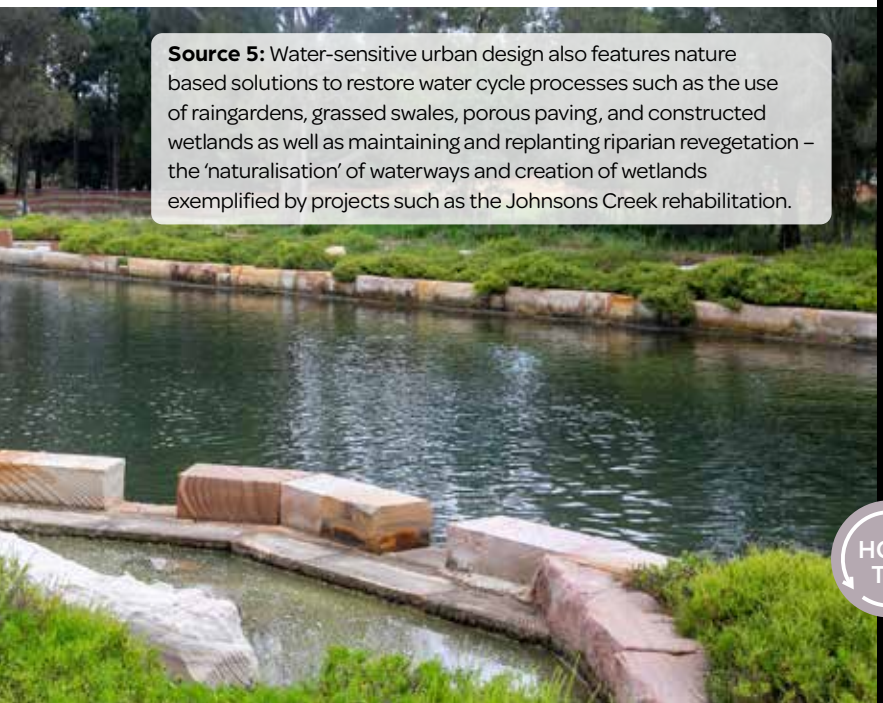
Project Restore hopes to see the return of endangered species such as White's seahorse and the green turtle, by creating oyster reefs and tiling seawalls and replanting seagrass meadows and kelp. Living sea walls are now considered the 'rooftop gardens' of the harbour.

Other initiatives to minimise impacts on marine life include re-designed jetties that allow sunlight penetration and colonisation by marine species, boat moorings that reduce the chain drag that destroys seagrasses and environmentally friendly seawalls that mimic natural rocky shorelines such as those at Barangaroo Headland.

Source 6: Marine scientists use strands of Posidonia seagrass washed-up on the shoreline to restore damaged meadows.

Education and public engagement

Public education programs and citizen science opportunities are engaging Sydneysiders with harbour restoration. In 2023 the Sydney Institute of Marine Science held two public information evenings about Project Retore and educated the public through an informative website that details the restoration projects.



Source 5: Water-sensitive urban design also features nature based solutions to restore water cycle processes such as the use of raingardens, grassed swales, porous paving, and constructed wetlands as well as maintaining and replanting riparian revegetation – the 'naturalisation' of waterways and creation of wetlands exemplified by projects such as the Johnsons Creek rehabilitation.

Learning ladder 7.4

Sustainable management strategies

1. List four strategies used to improve water quality in Sydney Harbour.
2. Outline one strategy that has been scaled to a cover larger area of Sydney Harbour to improve biodiversity.
3. Analyse the impact of marine activities on water quality and biodiversity in the estuary.
4. Source 5: Explain why a naturalised stream is better for Sydney Harbour than a concrete stormwater drain.

Interconnection

1. Identify five human impacts on Sydney Harbour that reduced its sustainability.
2. Explain the connection between water quality and biodiversity.
3. Source 1: Explain why armouring the coastline in Sydney Harbour reduced biodiversity.
4. Which strategy discussed here do you think will have the greatest beneifit for Sydney Harbour estuary? Justify your selection.

HOW TO Interconnection, page 410

How is New York Harbor estuary managed?

In 2023 the New York Harbor estuary was designated a global Hope Spot in recognition of ongoing efforts and successes in improving water quality, biodiversity and community engagement. The water is cleaner than any other time in the last century.

New York Harbor estuary

New York Harbor is one of the largest natural harbours in the world, and like Sydney, has faced significant modification. The estuary begins at the mouth of the Hudson River where it empties into New York Bay, then the Atlantic Ocean. It is a drowned river valley, but unlike Sydney, the land was broad and flat. The city shares the estuary with New Jersey on the western side of the harbour. Fresh water from the Hudson and other rivers meets salt water from the Atlantic Ocean. The tidal influence reaches Troy, 250 kilometres upstream, and the lower estuary has a tidal range of 1–2 metres.

Like Sydney, intertidal zones support diverse habitats and species, including 500 species of birds and fish. Shallow mudflats, wetlands and 68 islands provide habitat and food for algae, crabs, clams, invertebrates and fish, and are breeding grounds for migratory birds. Tributaries provide a range of habitats from salt water to fresh water that also support diversity of species.

Source 1: New York Harbor estuary looking towards Manhattan with the Hudson River on the left.

New York Harbor

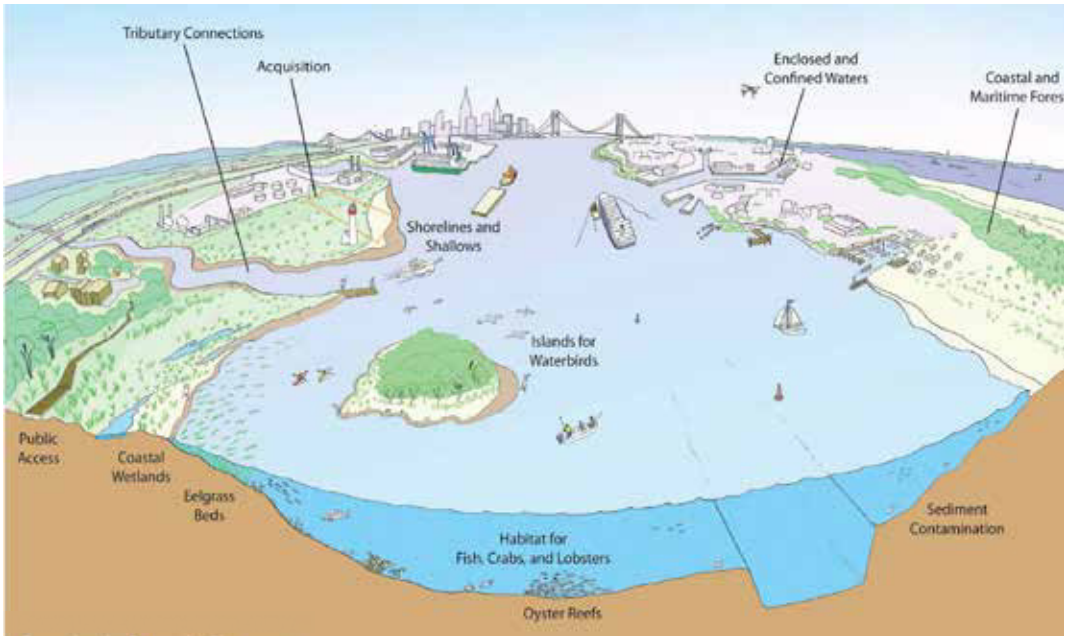
Source: Matilda Education Australia

Source 2: The spatial extent of the New York Harbor. The estuary begins at the mouth of the Hudson River, where freshwater from the Hudson and East Rivers meets salt water from the Atlantic Ocean.

Environmental change

Settlement of New York City began in 1608 and it has subsequently grown into the United States' most densely populated city of 8.6 million people. Throughout more than four centuries, the water in the estuary was degraded through pollution from untreated sewage, shipping and industrial waste dumping. The quality of the water reportedly hit its lowest point in the 1960s, after which time restoration efforts began. Further environmental change has occurred through **dredging** to deepen navigation channels and the replacement of marshy shorelines with an **armoured shoreline** of sea walls and rocks.

In 2022 the Port of New York and New Jersey was the largest container port in eastern United States, transporting 9.5 million tonnes of goods. Container ships, barges, oil tankers, cargo vessels, tugboats, and other merchant ships contribute pollutants such as toxic antifouling paints and oil spills to the estuary. Invasive species such as the Asian shore crab have been introduced to New York Harbor through the release of ship ballast water, resulting in a 95 per cent decrease of the native flatback mud crab population in the estuary.



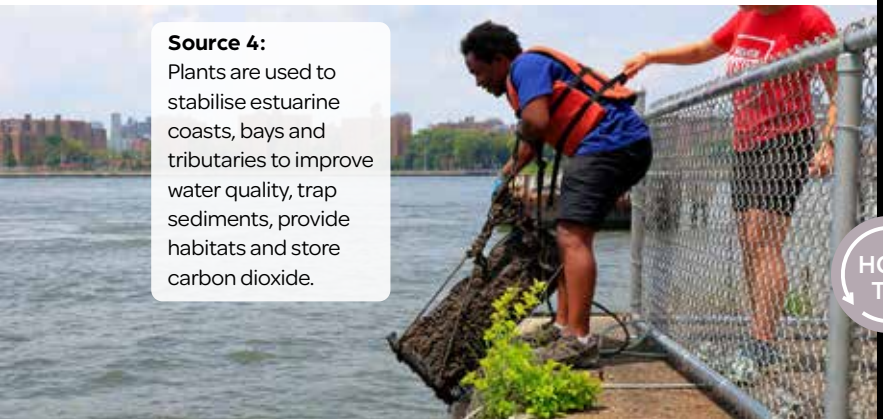
▲ **Source 3:** The 12 target restoration plan adopted by the Hudson River Estuary Program aims to reduce the sources of pollution, protect and restore habitats and biodiversity, improve public assess to the estuary and to help fishing and port operations to become more sustainable.

Significant dredging took place to increase the depth of navigation channels to cater for the largest container ships. Cruise ships also berth in the harbour at Manhattan and Brooklyn. By comparison, although Sydney has a large cruise tourism industry, the harbour no longer operates as Sydney's main trade port.

Environmental management

In New York City, legislation such as the *Clean Water Act* (1972) was the beginning of strategies to restore water quality. Upgrading of sewage treatment combined with the natural flushing by tides has helped to dramatically improve the quality of the water, leading to a large increase in marine life. Even humpback whales have returned to the waters off New York City.

Biodiversity is also being improved through programs such 'Living shorelines' and '1 Billion Oysters'. Oyster reefs, played an important role in the city's history as a source of food and industry, are being restored for their environmental values, along with salt marshes and wetlands. Wetlands and natural shorelines will assist New York deal with the threat of sea-level rise that will seriously impact the low-lying city.



Source 4: Plants are used to stabilise estuarine coasts, bays and tributaries to improve water quality, trap sediments, provide habitats and store carbon dioxide.

Learning ladder 7.5

Sustainable management strategies

1. List three similar causes of environmental degradation in New York and Sydney.
2. Outline one strategy that addresses biodiversity loss in New York Harbor estuary.
3. Compare the impact of shipping on the sustainability of the New York Harbor and Sydney Harbour estuaries.
4. Create a two-column table to categorise the strategies implemented in New York and Sydney to improve their estuaries. Decide appropriate headings for your two categories.

Interconnection

1. Identify human impacts on New York Harbor that reduced its sustainability.
2. Compare the causes of estuarine degradation in New York and Sydney.
3. Explain two management strategies from Sydney and New York that are similar in their aims and methods.
4. 'Sydney does estuary management better than New York.' Prepare arguments for both sides to debate the topic.

HOW TO Interconnection, page 410

What processes influence marine environments?

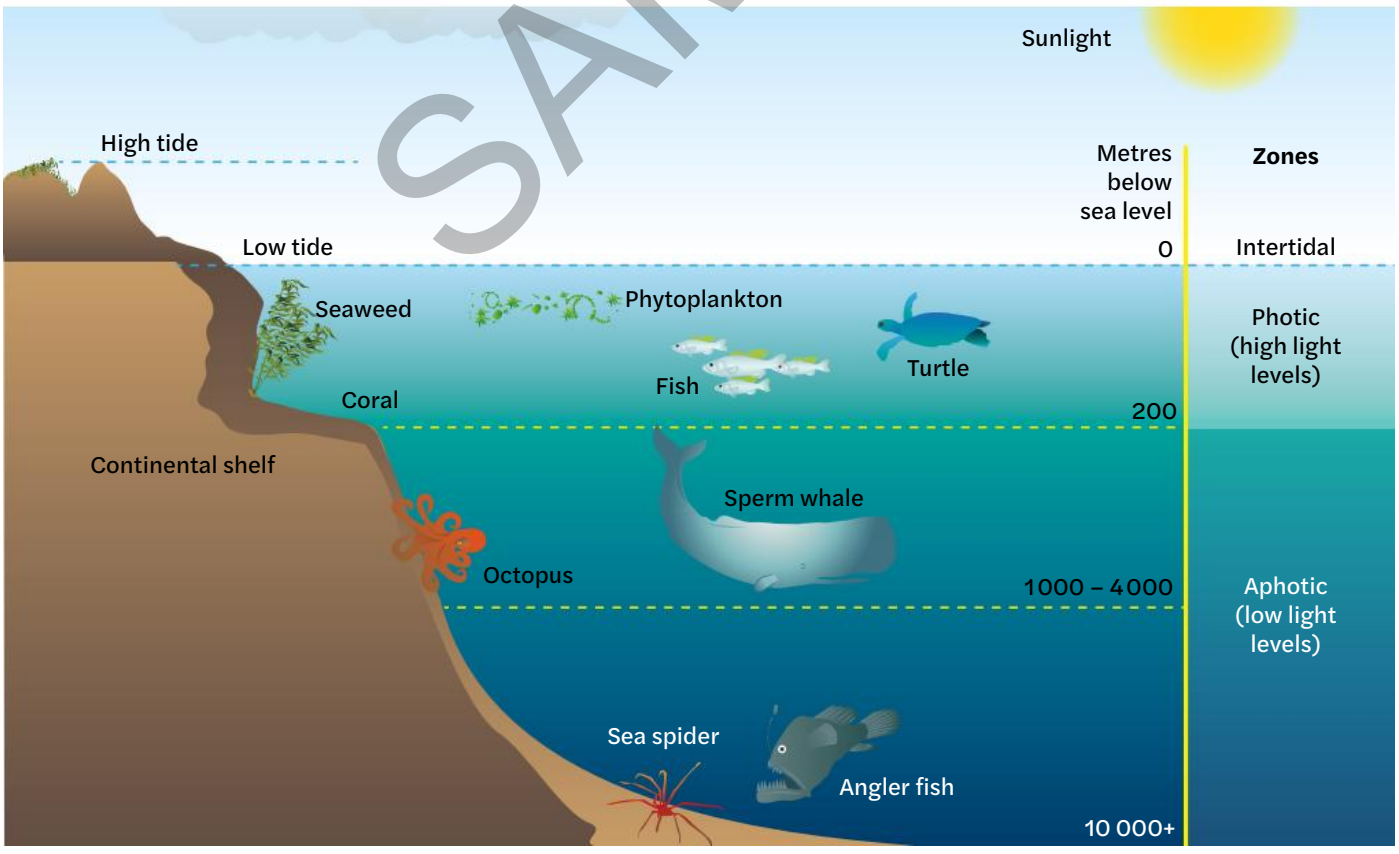
Marine environments produce half of the world's oxygen and dissolve nearly half of the carbon dioxide produced by humans. Marine environments support sea life through complex food webs and ocean currents distribute heat and nutrients across the globe.

Marine ecosystems

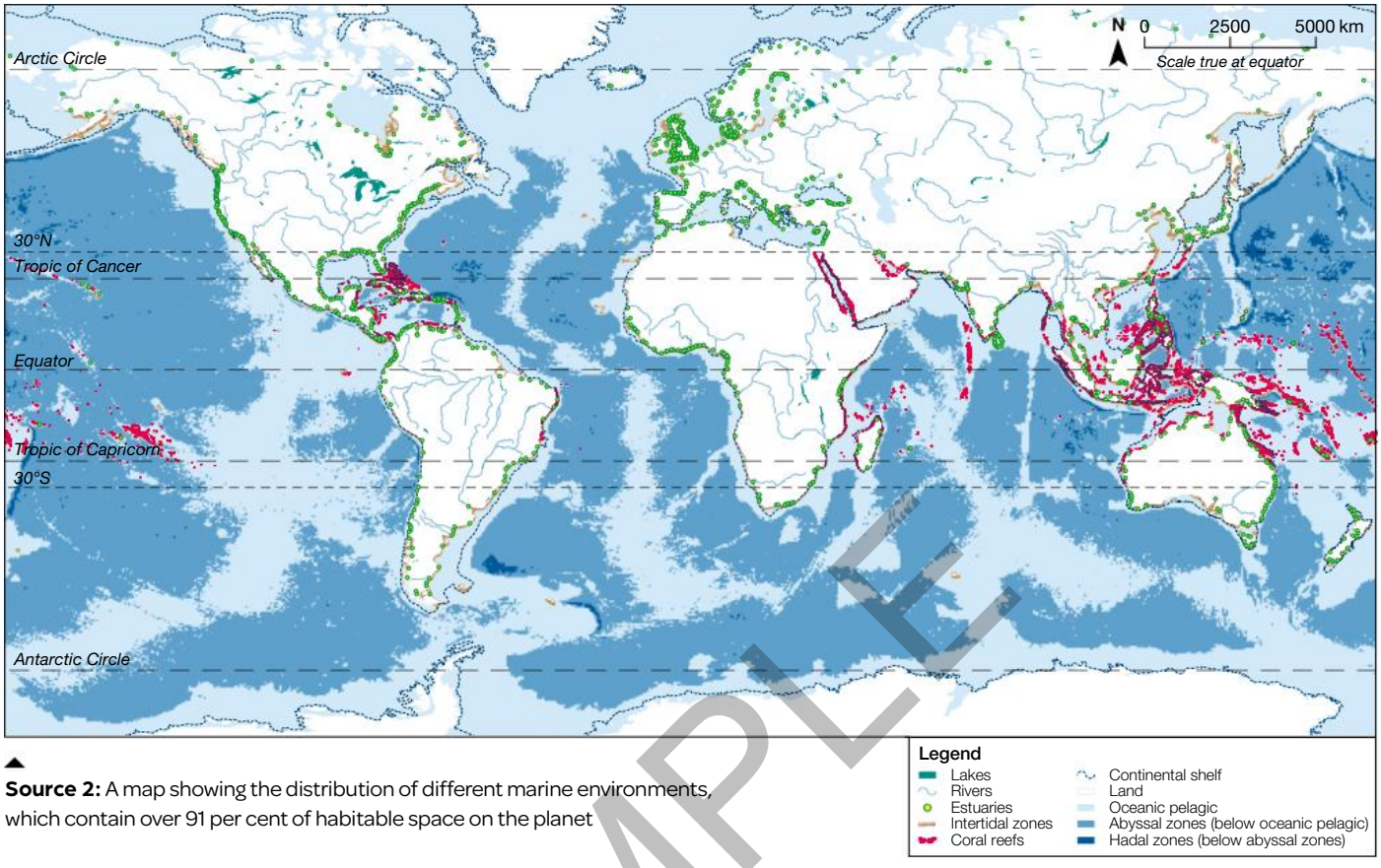
Marine ecosystems are aquatic environments found in or near the ocean where there is a higher salt concentration. They cover 71 per cent of the Earth's surface and are highly biodiverse, containing over 250 000 species. Marine ecosystems are three times more productive than land environments of equal size. As shown in Source 2 there are many types of marine environments, each with unique physical and biological characteristics; including the open ocean, the deep-sea, polar marine ecosystems, coral reefs and coastal systems such as estuaries and salt marshes.

Marine environments are highly valuable, providing many environmental services and a source of income for hundreds of millions of people around the world through fishing, oil, sand, mining and tourism industries. They also produce 50 per cent of the worlds oxygen and are an important global **carbon sink**, with almost half of the carbon dioxide produced by humans being dissolved in cold currents and then carried to the bottom of the ocean.

Source 1: The three main marine zones are based on the amount of sunlight they receive. The top 200 metres is called the euphotic zone, which contains the most sunlight, and the most marine biodiversity. Next is the dysphotic zone, which is between 200 and 1000 metres. Then the aphotic zone, which receives very limited sunlight.



Marine ecosystems



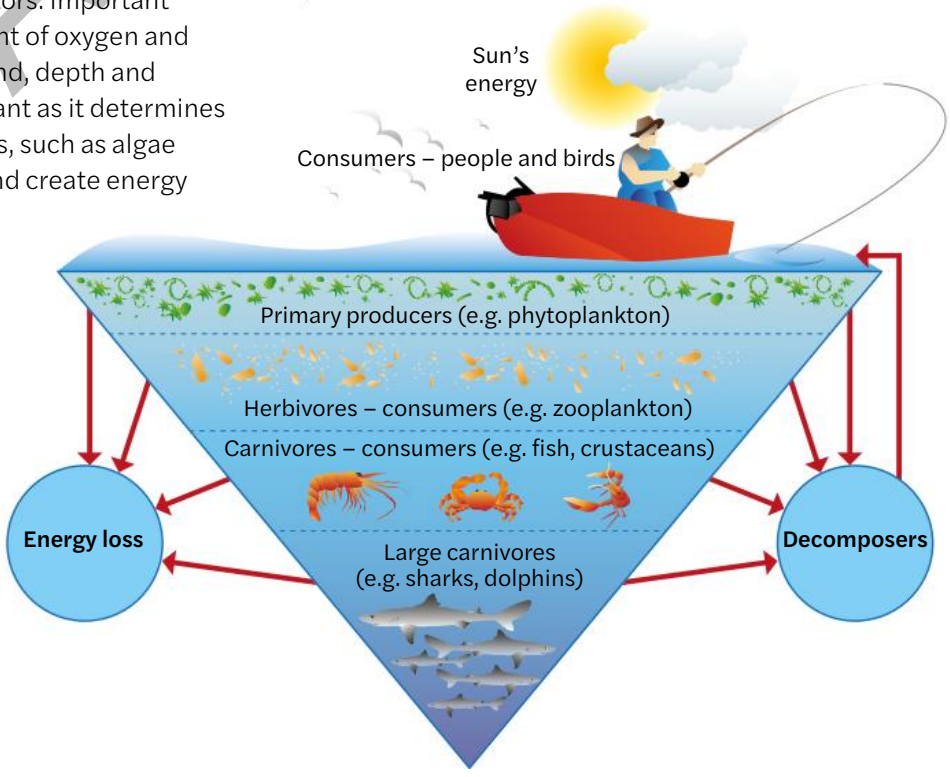
Source 2: A map showing the distribution of different marine environments, which contain over 91 per cent of habitable space on the planet

Source: Matilda Education Australia

Food webs

The different marine environments are defined by unique biotic (living) and abiotic (non-living) factors. Important abiotic factors include sunlight, the amount of oxygen and nutrients within the water, proximity to land, depth and temperature. Access to sunlight is important as it determines the amount of light available for producers, such as algae and phytoplankton, to photosynthesise and create energy to support complex marine food webs. This energy then moves through the food web as organisms consume one another, as shown in Source 3. This results in the shallow **photic** marine environments that are closer to the coast having more sunlight, and therefore a higher biodiversity compared to deeper **aphotic** marine environments that are colder, darker and denser; shown in Source 1. Many of the worlds marine biodiversity hotspots are found in shallow and warmer waters, such as the Benguela Current Large Marine Ecosystem off Namibia.

Source 3: Marine food web



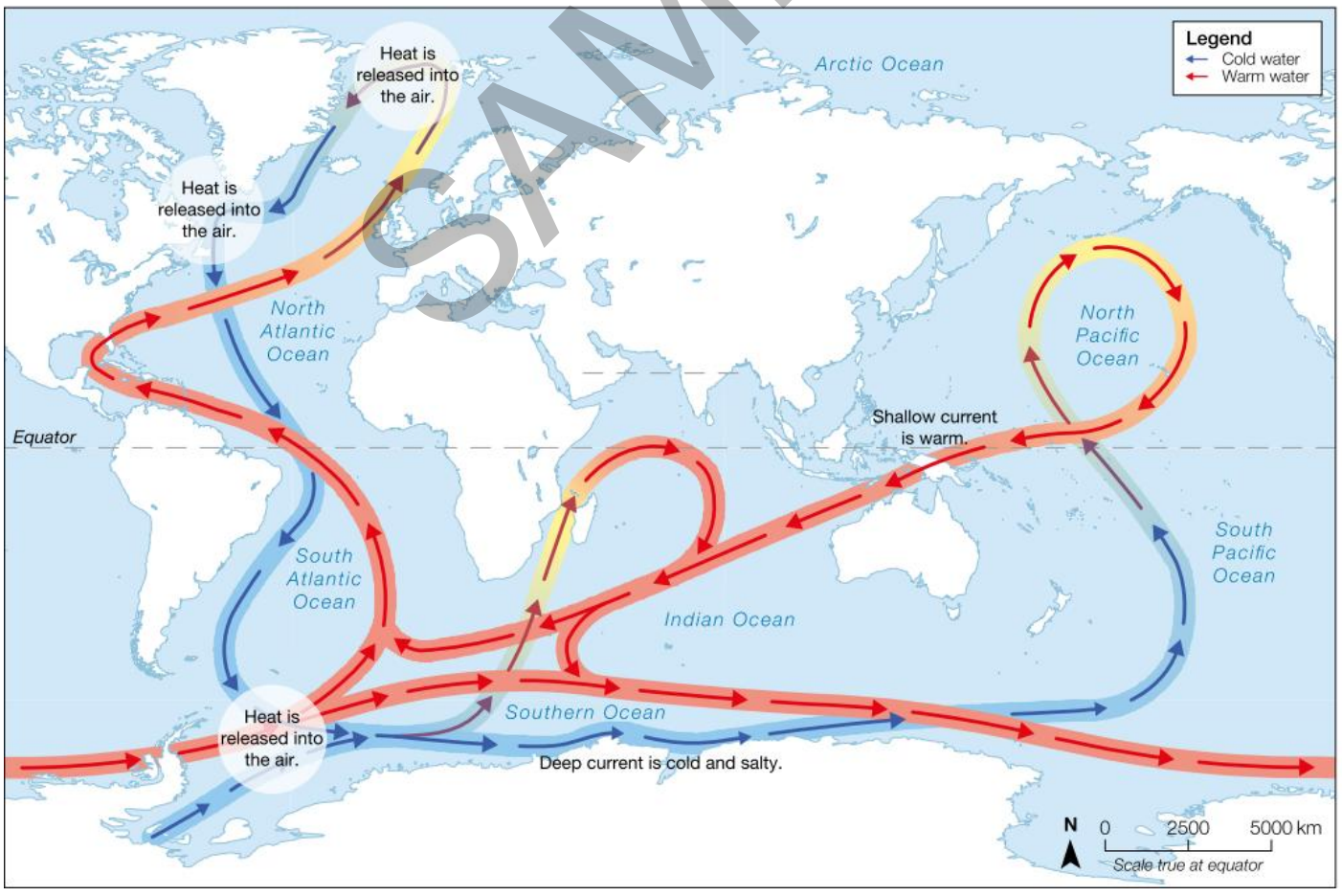
Ocean currents

There are large consistent ocean currents that circulate the Earth known as the **thermohaline circulation**, shown in Source 5. These large-scale circulations are driven by gravity, temperature and the density of salt in the water. Ocean water is warmed at the equator and then gravity and the turning of the Earth push that warm water toward the poles. The water is evaporated as it travels, resulting in a high density of salt. As the water cools down and becomes saltier, it sinks toward the bottom of the ocean. Eventually the current mixes with warmer waters and the process starts over again. These ocean circulations play an integral role in regulating the temperature of marine environments and the global climate, as it moves heat around the planet and distributes nutrients between the marine environments. Ocean circulation systems are also used by animal species to support their migration, such as green turtles and loggerhead turtles who use the East Australian Current to migrate to Peru and Chile.

Source 4: Researchers have used satellite tracking devices to discover that loggerhead turtles undertake an incredible migration of nearly 13 000 kilometres. Using passages of warm water in the thermohaline circulation, hatchlings from nesting beaches in Japan and Australia migrate across the Pacific to feed off the coast of Baja California, Mexico, Peru and Chile. They spend up to 20 years growing to maturity and then migrate back to the beaches where they hatched to mate and nest and live out the rest of their lives.

Source 5: The thermohaline circulation is a continuous movement of water across the Earth. It acts like a conveyor belt, moving water across and beneath the oceans.

Thermohaline circulation



Source: Matilda Education Australia

Source 6: A school of fish swim through the prop roots of a mangrove forest at high tide. Mangroves are located in intertidal zones where they have adapted to survive in high tides, where there roots are submerged in water and low tides where the water withdraws and their roots are exposed.

Waves and tides

Tides are driven by the gravitational pull of the moon and sun. When the moon is directly overhead or on the opposite side of the world, it can cause the ocean water to bulge and move higher; causing high and low tides. There is an intertidal zone on coastlines which can be exposed to air during low tides and submerged in water during high tides. The organisms of these intertidal ecosystems, such as mangroves and marshes, have adapted to survive both in and out of water. For example, mangrove trees (Source 6) have developed aerial roots that allow them to absorb oxygen and exclude salt. They can also secrete salt through their leaves, enabling them to survive in salty conditions. Waves are influenced by tides, but are also caused by wind, as it drags the top layer of water. Tide and wave processes are important to marine environments as they flush water through the environments, preventing them from becoming too salty or experiencing turbidity. They also remove polluted water, carry nutrients between marine environments, influence the weathering and erosion of marine environments and promote oxygen in the water.

Learning ladder 7.6

Processes that transform people, places and environments

1. Describe three processes that influence marine environments.
2. Source 3: Draw a food chain that exists in marine environments, with arrows to demonstrate which animals consume others..
3. Source 5: Explain how the thermohaline circulation influences at least two different marine environments.
4. Sources 1 and 3: What would the impact on marine food webs be if sea levels were to rise?
5. Source 5: What would be the impact on marine environments if the thermohaline circulation process stopped working?

Space

1. Source 1: Describe the difference in coastal to deep water marine environments.
2. Source 2: Explain the distribution of marine environments.
3. Source 5: Explain why this spatial distribution of cold and warm water occurs.
4. Source 6: How do intertidal zones change and how have mangrove trees adapted to these changes?

HOW TO
Space, page 406

How are humans changing marine environments?

Marine environments are susceptible to human–induced changes, as they experience a range of pressures from human use and waste that can be transported through connected ocean currents and marine processes.

Pollution

Eutrophication

Nitrogen and phosphorous used in farm fertilisers and washing detergents can make their way through runoff into marine environments. This nutrient enrichment, called **eutrophication**, promotes the growth of blue-green algae and can lead to algal blooms. Algal blooms can impact marine environments by becoming toxic and decreasing the population of species, such as molluscs. They can also reduce producer access to sunlight and oxygen, reducing their populations and creating hypoxic or dead zones, as shown in Source 3.

Plastic pollution

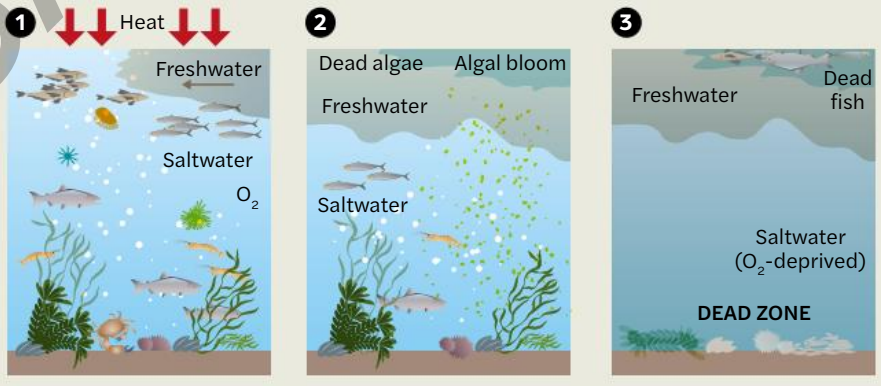
Over 14 million tonnes of plastic pollution makes its way into the ocean every year from poor waste management, littering, runoff from land and maritime activities. This amount is set to increase to more than 37 million metric tonnes per year by 2040, as human populations increase and consume more. Plastic pollution affects marine environments by impacting food webs as organisms consume the plastic leading to suffocation, entanglement, infections and changes to their feeding and reproductive behaviours. The breakdown of larger plastic items and fragmenting of debris and synthetic fibres also create microplastics. These microplastics are then ingested by marine organisms and make their way up food webs. The amount of microplastics then magnifies as it moves higher up the food chain, leading to the biomagnification (see page 252) of these plastics by longer living fish that are higher on the food web.

Climate change

Warming temperatures

Climate change refers to the long term shifts in temperature and weather patterns, caused primarily by human activities that emit greenhouse gases. This has a large impact on marine environments. It results in rising average global temperatures, which can affect the temperature of ocean currents and lead to the stress and decline of marine species populations; such as corals and krill. This can also force species of fish, like the Atlantic mackerel, to migrate to higher latitudes in search of colder water. This can affect the ecosystems they migrate to as it increases competition for food and habitats.

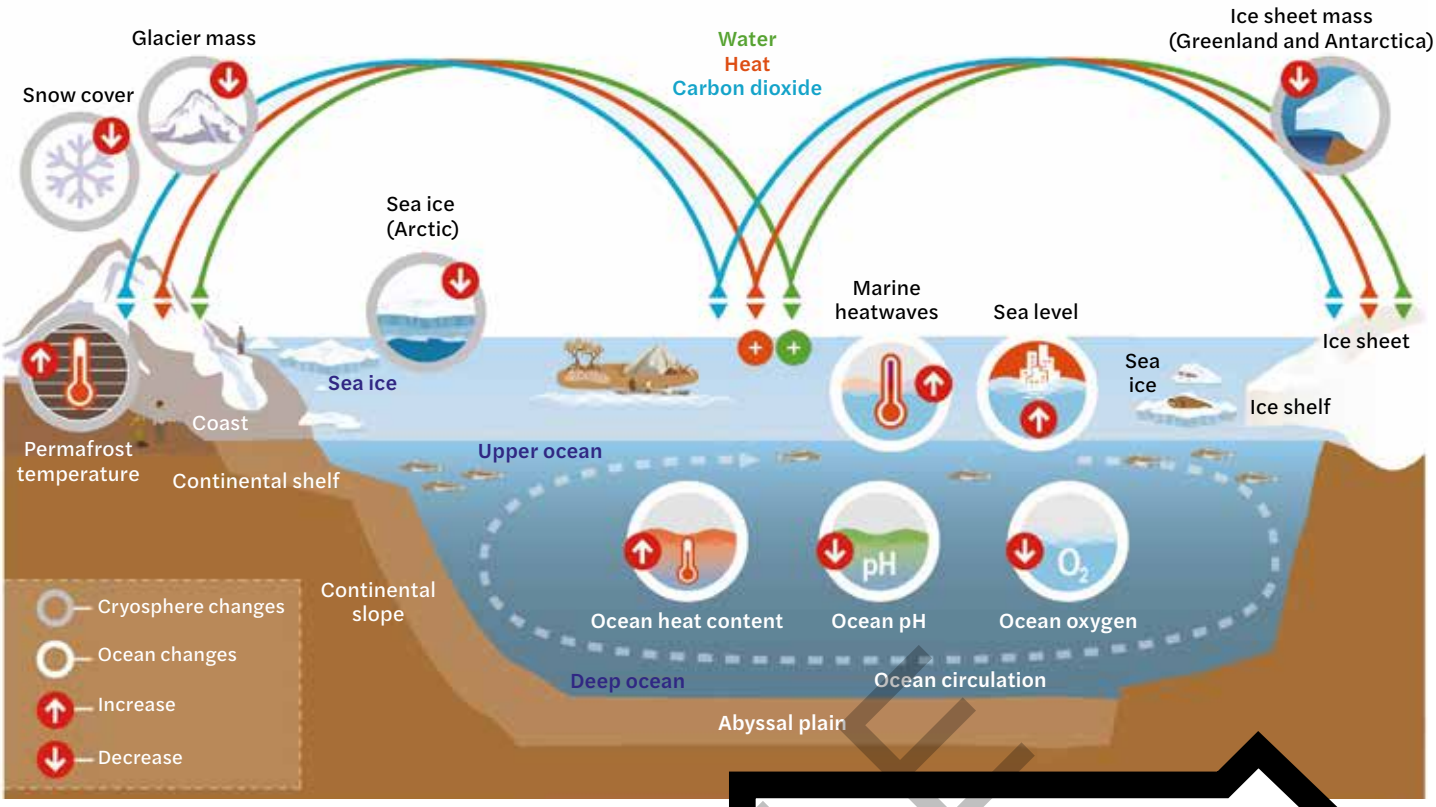
Source 1: A diagram explaining the role of algal blooms, driven by eutrophication, creating dead zones in marine environments



Sun-heated fresh water runoff creates a barrier layer in the sea, cutting off the saltier water below from contact with oxygen in the air.

Nitrogen and phosphorus from fertiliser and sewage in the freshwater layer ignite huge algal blooms. When the algae die, they sink into the saltier water below and decompose, using up oxygen in the deeper water.

Starved of oxygen and cut off from resupply, the deeper water becomes a dead zone. Fish avoid the area or die in massive numbers. Tiny organisms that form the vital base of the marine food chain also die.



▲ **Source 2:** The impacts of climate change on the cryosphere (icy environments) and marine environments

Rising sea levels

Warmer temperatures also result in the **thermal expansion** of water and the rapid melting of land glaciers and ice sheets, resulting in sea-level rise. This can reduce the sunlight needed to reach deep sea environments, can submerge coastal estuaries and marshes and can threaten nesting sites for turtles and seabirds. Climate change can also increase the frequency and intensity of extreme weather events, causing storm surges that rapidly raise sea levels and cause flooding, erosion and damage to nearshore habitats such as coral reefs and salt marshes. The increased runoff from coasts into marine environments after large weather events can also create turbidity in the water, reducing producer species access to sunlight and affecting food webs.

Source 3: An oblique aerial view of a red algal bloom off the coast of Florida. The karenia brevis algae feeds on the nutrient-rich run off from farms, causing it to stay for longer and spread more widely. The 2017 algal bloom, dubbed the 'Red Tide', killed 100 manatees, 127 dolphins, 589 sea turtles and hundreds of tonnes of fish.

Source: FRLA

Learning ladder 7.7

Processes that transform people, places and environments

1. Describe the impact of global warming on the cryosphere.
2. Source 1: What impact does freshwater runoff have on marine environments?
3. Explain how plastic pollution impacts marine environments.
4. Create a fishbone diagram (page 244) to outline the threats to marine environments from human activities, including threats from climate change and biomagnification.

Change

1. Source 3: What has caused this algal bloom to occur?
2. Source 1: Explain what causes a marine environment to form a dead zone.
3. Source 2: Explain the changes to the marine environment shown in this diagram.
4. Analyse the implications of global warming on marine environments using examples from these pages.
5. What action must humans take to decrease the impact of biomagnification on species that rely on marine environments?

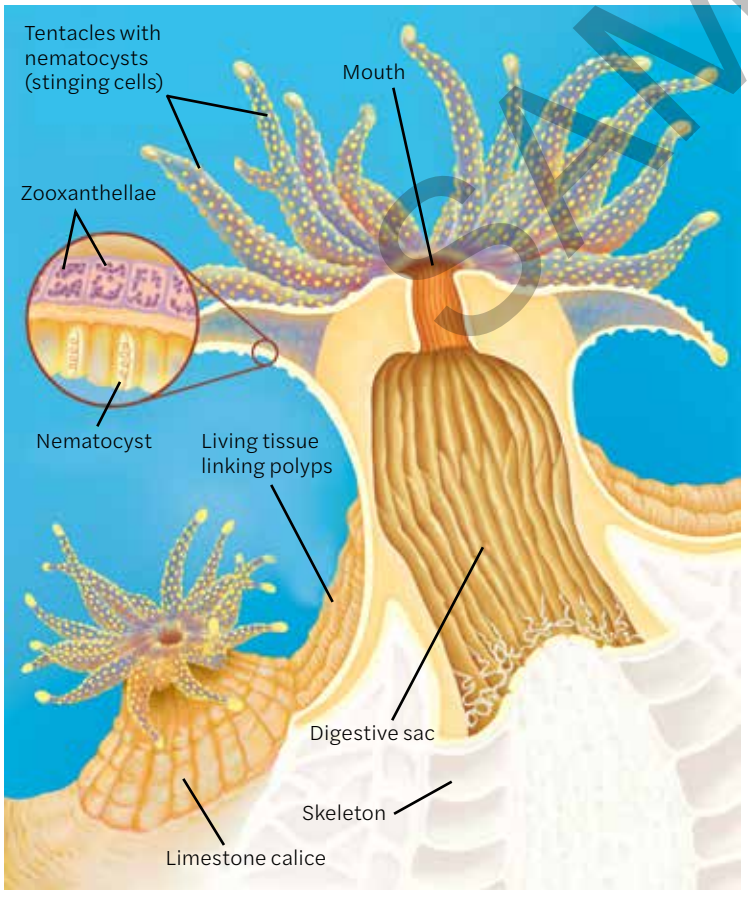
HOW TO Change, page 412

What environmental changes affect coral reefs?

Coral reefs are very susceptible to changing water temperatures and quality, along with decreased sunlight from sedimentation. Invasive species and overfishing also impact coral reefs, along with damage from shipping and tourism.

Biophysical processes in coral reefs

Coral reefs are a marine environment that grow in shallow, salty and warm water. Most coral reefs are located in the tropics along coastlines, as this provides the optimum temperature and depth of water for coral polyps to access sunlight and grow. **Coral polyps** are the tiny animals that make up coral reef systems. These polyps have a **symbiotic relationship** with an algae called **zooxanthellae**, which lives in their tissue. Coral provides a habitat for the algae, and in return the algae uses photosynthesis to produce carbohydrate energy for the coral polyps. A healthy coral reef system has a strong balance of diverse types of both soft and hard corals, with a good balance of algae, herbivorous fish and predators. There are many changes that can affect the healthy functioning of coral reef systems, which can be seen when we compare changes in the Great Barrier Reef with changes in the Mesoamerican Reef.



▲ **Source 1:** Anatomy of a coral polyp.

The Great Barrier Reef

The Great Barrier Reef (GBR) is the world's largest coral reef system, composed of over 900 islands and 2900 reefs. It is approximately 344 400 square kilometres along the north-east coast of Australia as shown in Source 2. The GBR is a barrier reef, as it runs parallel to the coastline and absorbs energy from waves and currents to protect the shore. It is highly biodiverse, providing a habitat for over 9000 marine species that are subject to many environmental changes.

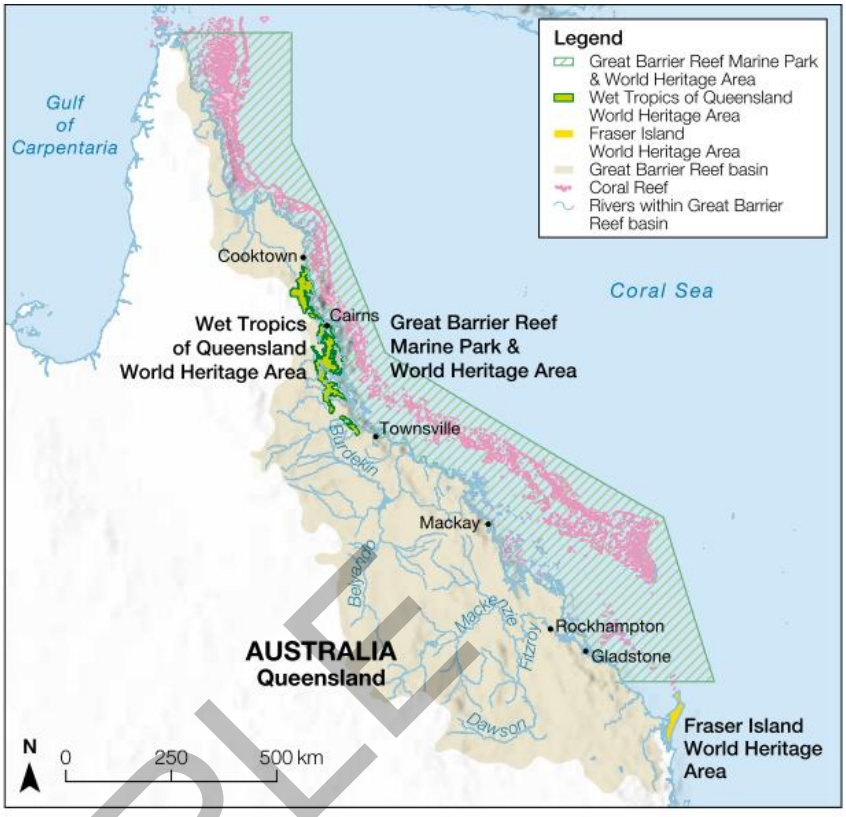
Coral bleaching

The Great Barrier Reef has been experiencing an increasing number of coral bleaching events over the past two decades, with four mass bleaching events over a seven year period from 2016. This occurs when corals experience stress, such as warmer waters or changes in water quality, and they release zooxanthellae from their tissues. Zooxanthellae provide coral polyps with colour, which is why they turn white when the algae is released. This is what we call coral bleaching. Bleached corals are not dead, but many cannot survive more than a few weeks or months without zooxanthellae as they are more at risk of coral diseases and starvation. If the stress is reduced, the algae can return to the coral polyps and continue their symbiotic relationship. The short time between these mass bleaching events makes it more difficult for the coral reefs to overcome the stress. Today, 91 per cent of corals on the GBR have experienced bleaching at least once and as many as two-thirds of coral are affected in each bleaching event.

Overfishing

Fishing occurs in approximately two-thirds of the GBR. Fishing can affect food chains in the GBR. Commercial fishing industries are particularly harmful, as the large technologies used by these industries result in large numbers of fish being caught at a time and can accidentally catch endangered species, such as dugongs and turtles. Fishing of particular species can also lead to a disproportionate number of prey and not enough predators. This is seen with the overfishing of triton snails and tropical snappers who feed on crown-of-thorns starfish (COTs). This is a contributing reason that there is an increase of COTs outbreaks on the GBR. In areas that experience outbreaks, COTs can consume up to 90 per cent of coral. There have been four outbreaks since 1960.

Australia's Great Barrier Reef



Source: Matilda Education Australia

▲ **Source 3:** Location of the Great Barrier Reef in Australia's north-east. This site provides millions of jobs in the tourism and fishing industries. It is also a significant cultural site for First Nations Peoples.

◀ **Source 2:** Staghorn coral undergoing coral bleaching on the GBR

Source 4: A crown-of-thorns starfish consuming coral on the Great Barrier Reef. These starfish can consume up to 90 per cent of coral within an area. Overfishing of their predators and increased nutrients from agriculture are the leading causes of crown-of-thorns starfish outbreaks. ▼

The Mesoamerican Reef

The Mesoamerican Reef (MAR) stretches along the coastline of Mexico, Belize, Guatemala and Honduras. It contains the second largest barrier reef system and is highly diverse, with hundreds of rare and endangered species. Over 40 per cent of coral cover has declined in 50 years and two-thirds of the coral reef structures are considered at 'high' risk.

Sediment and pollution

The location of the MAR has resulted in more than one-third of the reef being at a high risk of sedimentation and pollution. This is because it follows the coastline of many countries with growing populations that use the reef for tourism and economic activities. This results in sewerage discharge into the reef, urban runoff and tourist development. This also leads to many ships and boats moving through the reef to transport people around Mesoamerica, resulting in oil leaks and the discharge of wastewater and sewerage from ships. This sedimentation and pollution increases the turbidity of the water, reducing the amount of sunlight that is able to reach the coral polyps and zooxanthellae. This causes coral stress, and can lead to bleaching. It also increases nutrients in the water, which can lead to eutrophic events. This is when algae grows in the water, further reducing sunlight for the corals and at times smothering them.

Coral disease

The high threats to the MAR has resulted in the coral being vulnerable to coral disease, which can impact coral polyps or the symbiotic relationship they have with the zooxanthellae. A common coral disease is the stony coral tissue loss disease (SCTLD), which travels quickly and leads to a high mortality rate of coral. SCTLD weakens coral tissue, leading to as much as 98 per cent of some species declining across the MAR. This decline of coral cover, reduces habitats and food sources for other species in the reef and impacts food chains. Ocean currents and ships are able to transport the disease, resulting in reefs across the Caribbean Sea being affected by SCTLD and other diseases.

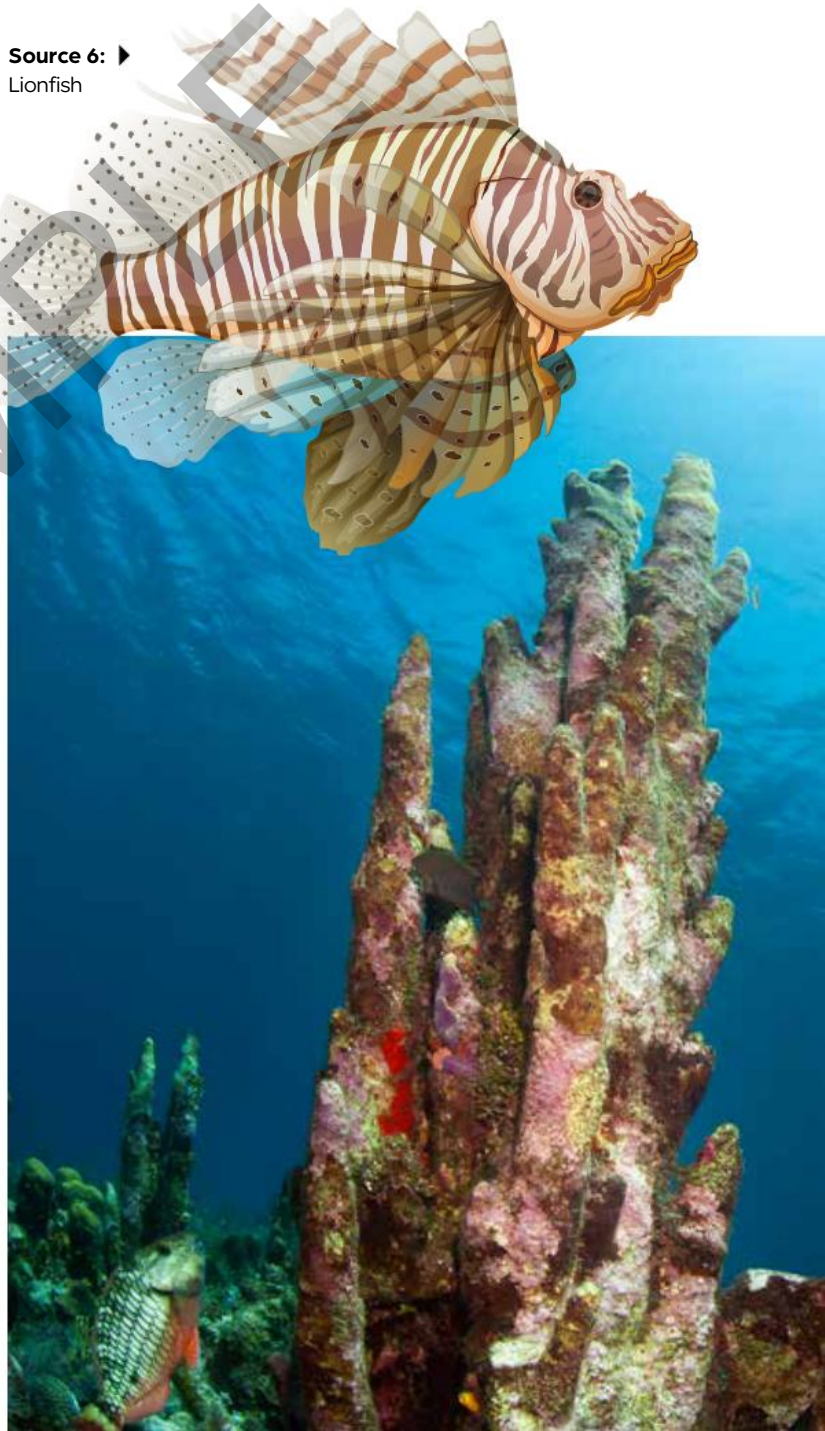
Invasive species

Lionfish are a venomous fish who are native to the Indo-Pacific region. Since the 1980s, they have become an invasive species in the MAR.

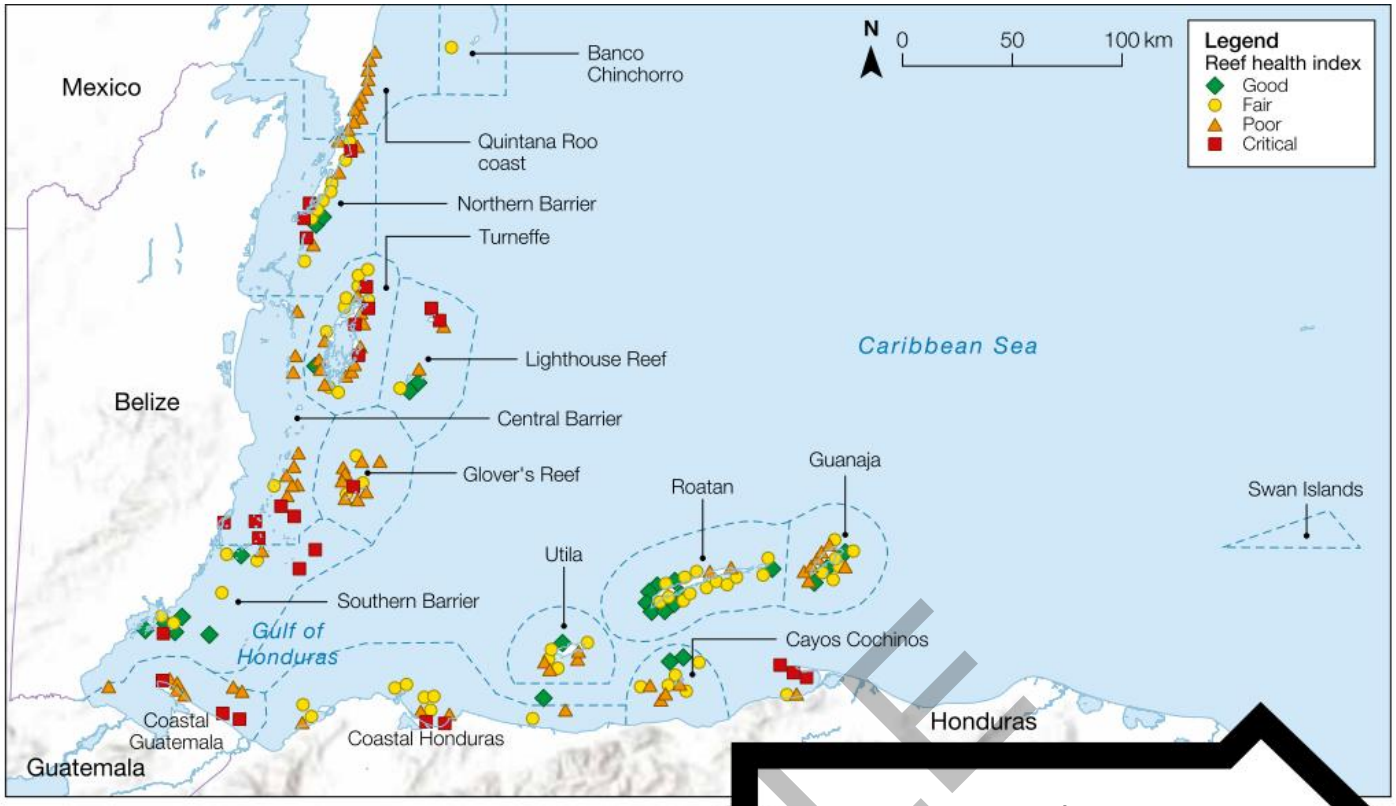
Source 5: Sea turtle swimming over dead coral that is affected by SCTLD in the Mesoamerican Reef.

This is probably due to ocean currents transporting larvae or ships releasing water containing lionfish larvae. Lionfish thrive in the Caribbean Sea, as there are a lack of natural predators, an abundant food source and it is easy to move across the interconnected coral reef systems. They have drastically reduced native fish populations by preying on them and competing with them for food and habitats. They have affected the balance in the coral reefs by consuming large populations of herbivorous fish, whose role it is the consume the algae that grows on top of corals. The reduction of these types of fish has led to algae smothering many corals and preventing photosynthesis for the zooxanthellae.

Source 6: Lionfish



The Mesoamerican Reef



Source: Matilda Education Australia

▲ **Source 7:** A map of the Mesoamerican Reef in the Caribbean Sea. The map also displays the health of the reefs, with orange and red indicating poor to critical condition

Learning ladder 7.8

Characteristics of places and environments

1. Draw a food chain of the GBR: crown-of-thorns starfish, coral, triton snail, algae.
2. Sources 2 and 7: Describe the locations of the GBR and MAR.
3. Explain how overfishing can impact coral reefs.
4. How do the characteristics of the MAR and the Great Barrier Reef GBR create unique environments, despite both being coral reefs?
5. Compare the cause and effects of lionfish outbreaks in the MAR from crown-of-thorns outbreaks in the GBR. What are the similariries and differences?

Environment

1. Source 2: What is a barrier reef?
2. Source 3: What is the process of coral bleaching and how does it affect the environment of coral reefs?
3. Compare the changes occurring in the GBR and MAR environments.
4. Create a fishbone diagram (see page 244), grouping the major threats to the MAR.
5. Determine which of the GBR or MAR is more at risk from environmental change and why.

HOW TO

Environment, page 414

How can change impact reefs differently?

Both the Great Barrier Reef (GBR) and Mesoamerican Reef (MAR) experience similar environmental changes due to human activities, but the extent of those changes differs between the reefs. Location and local populations can have an impact on the effects of environmental change in these reefs.

Location

Both the GBR and MAR reefs have experienced coral bleaching due to marine heatwaves, but the GBR has been affected more severely. This is partly due to its larger size and its location in a region that is experiencing faster warming. This has contributed to a larger number of mass bleaching events in the GBR compared to the MAR. Whereas the location of the MAR makes it more vulnerable to sea-level rise and coral disease, as it has a lower elevation and disease can transport between the reefs across the Caribbean easily.

Local populations

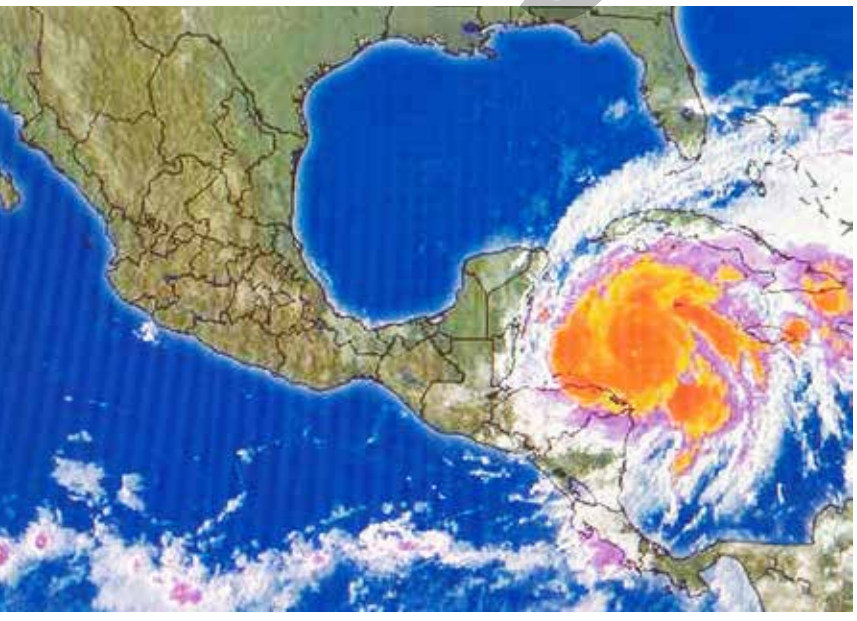
Both reefs experience issues of overfishing and sedimentation, but the MAR is more likely to experience significant impacts of these. This is because it borders four countries that are rapidly developing. As a result, the MAR is impacted by more coastal development, fishing activities and the use of ships and transportation; increasing pollution, sedimentation and the risk of overfishing. Whereas the GBR only follows the coastline of Australia, where it is protected by one authority that creates and enforces rules to protect it, such as regulations on the types and amount of fish that can be caught. As a result, overfishing affects over 60 per cent of the MAR, and a much smaller percentage in the GBR.

Extreme weather

Severe storms and cyclones create large, powerful waves. When large waves break over coral reefs, they can break corals from their footing and convert large areas of reef into rubble. Storm conditions can also bring on coral bleaching through stress. Increased rainfall from storms and cyclones often flood coastal areas, increasing runoff and sedimentation into reef waters.

Climate change is causing higher ocean temperatures, which is in turn increasing the intensity and the frequency of cyclones and storms. When tropical storms occur more frequently, the reef does not have enough time to recover

The GBR experiences more frequent extreme weather events, with approximately four cyclones a year compared to one to two hurricanes every five years in the MAR. This is because the East Australian Current transports warm water toward the south of the GBR, increasing the number of cyclones and the amount of reef that can experience these events. Further, the GBR is often closer to the continent than the MAR, meaning cyclones can often form and the effects of flooding and sedimentation from the land can be more extreme.



Source: Alamy/Iiene MacDonald

Source 1: A satellite image of Hurricane Eta over the top of the Mesoamerican Reef. This low pressure system affected central America in 2020. In the Northern Hemisphere, low pressure systems turn anti-clockwise, which can be seen in this image. The MAR is more vulnerable to intense hurricanes with stronger wind speeds.

Source 2: Brown and green sediment from river runoff flows across the Great Barrier Reef following heavy rain from Cyclone Nelson in February 2007. Sediment increases the turbidity of the water and blocks sunlight that keeps coral alive. The runoff also carried pesticides washed off farmlands. The effects of sedimentation can be more extreme in the GBR as the reef is often closer to the coastline.

Source: NASA image courtesy the MODIS Rapid Response Team, Goddard Space Flight Centre

The location of the MAR makes it more vulnerable to intense hurricanes with stronger wind speeds. For example, Hurricane Eta (2020) reached Category 4 intensity with winds of 240 kilometres per hour, while cyclones impacting the GBR rarely exceed Category 3 strength. This is because the hurricanes that impact the MAR often develop for longer periods of time over the warm waters of the Gulf of Mexico, intensifying before reaching the MAR.

Source 3: Cyclone Debbie in 2017 created large waves that broke coral and left piles of rubble on the floor of the Great Barrier Reef.

Learning ladder 7.9

Processes that transform people, places and environments

1. List two factors that can influence the health of coral reefs.
2. Source 3: What was the impact of Cyclone Debbie on the environment of the GBR?
3. Create a diagram to explain how extreme weather can impact the natural processes of coral reefs.
4. Assess why the MAR is more prone to the effects of human activities and population growth.
5. Evaluate whether the GBR or MAR are more at risk from sedimentation. Support your position with an example.

Place

1. Source 2: Describe the physical characteristics of this place.
2. Source 1: Use geographic terminology, such as hemispheres and countries, to describe the location of Hurricane Eta in this satellite image.
3. Source 2: Explain what damage is occurring in this image and the impact it will have on the coral reef.
4. Source 1: Analyse why the MAR is more prone to damage from hurricanes, even though it has fewer events than the GBR.

HOW TO Place, page 408

How are coral reefs managed?

Marine Park Authorities can be successful in protecing biodiversity in coral reef environments. They establish coastal zones to control how marine regions are used and help coordinate reef restoration and protection activities.

Regional strategies

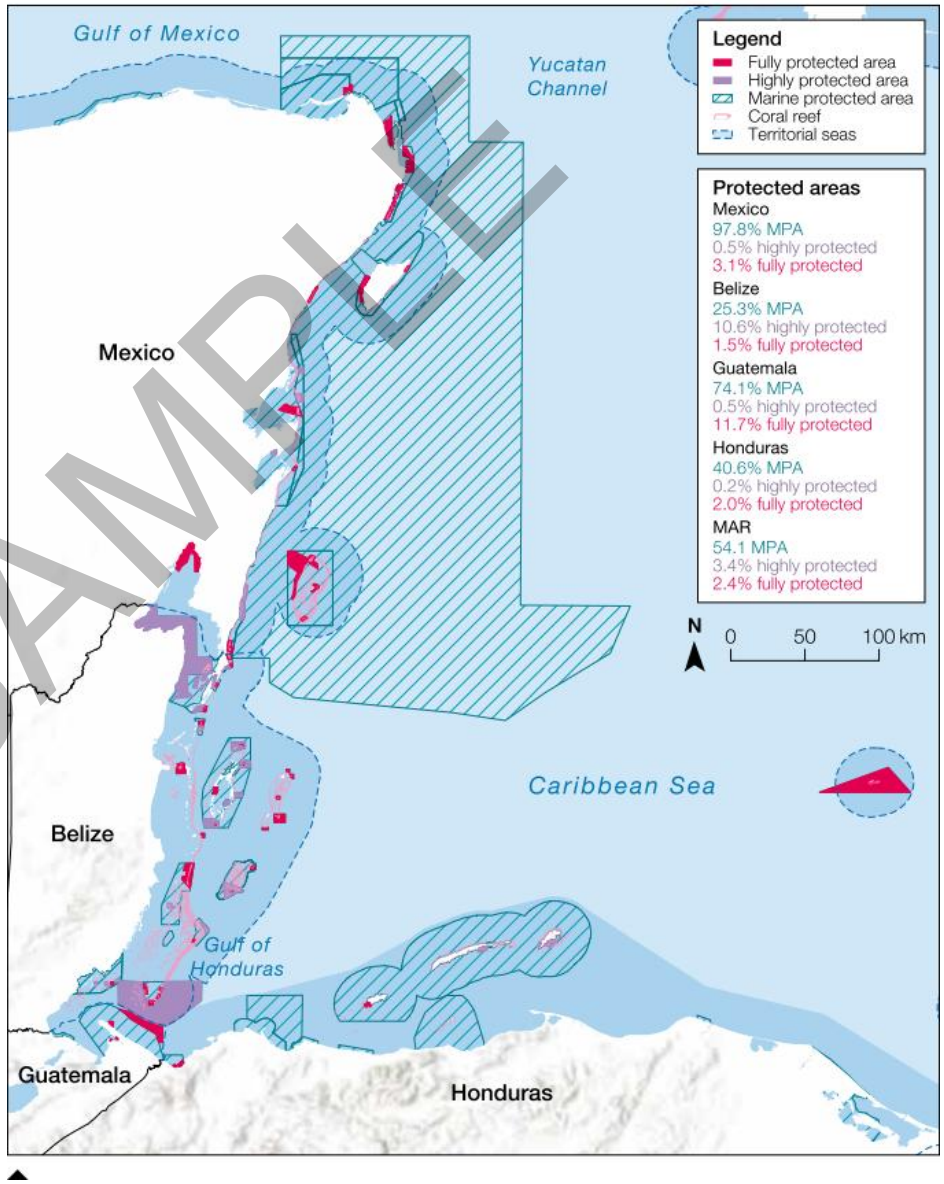
Marine Park Authorities

A **Marine Park Authority** is a government or non-government organisation established to manage and protect a specific marine environment. Their role is to allocate funding, monitor environmental changes, implement management strategies and enforce rules and regulations. By centralising the authority to a group, it is easier to meaningfully address and make decisions on how to manage changes in marine environments. Marine Park Authorities (MPAs) implement marine protected areas, which limit the activities of humans in parts of the marine environment to protect species, habitats and reduce the impacts of overfishing and pollution with 'no take' or 'minimal activity' zones.

The Great Barrier Reef Marine Park Authority is the one central authority for the Great Barrier Reef (GBR). It has established marine protected areas, enforces fishing regulations, determines the path and number of ships permitted to move through the reef and funds itself through fines and issuing permits to tourism companies for permission to use parts of the reef.

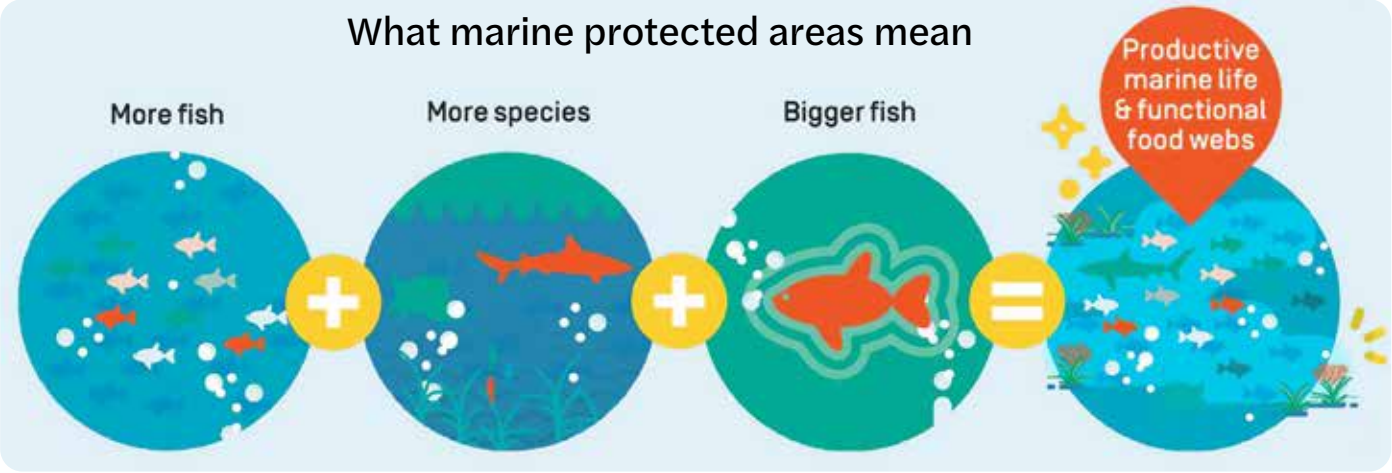
In the Caribbean Sea there are 285 Marine Park Authorities, with approximately 14 of these managing the Mesoamerican Reef (MAR). This makes it difficult to implement and enforce rules in this interconnected environment, as each organisation

Marine protected areas of the Mesoamerican Reef



Source 1: Mesoamerican Reef countries have designated over 50 Marine Park Authorities to manage over 50 per cent of the MAR territorial waters. Most MPAs allow fishing, with only 2.4 per cent of the waters in full protection. The Great Barrier Reef has 33 per cent of the marine park fully protected from fishing to ensure replenishment of fish stocks.

Source: Matilda Education Australia

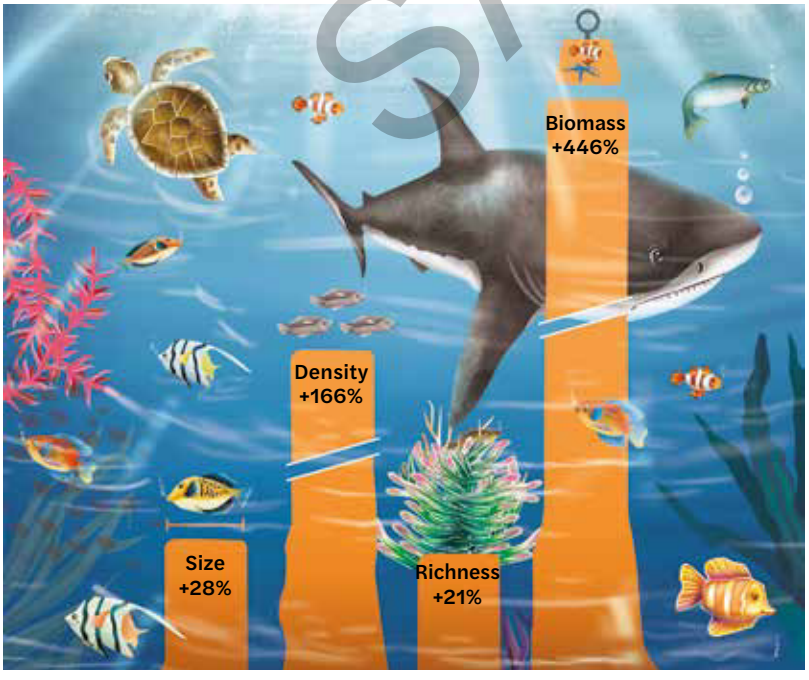


▲ **Source 2:** Marine Protected Areas are established by Marine Park Authorities, to protect habitats, species and natural processes. This leads to a greater diversity of species, more marine life, higher productivity and functional food webs.

implements and enforces different rules. This makes it difficult to manage and for communities to understand and follow. As a result only 6 per cent of MPAs in this area have been identified as 'effective'.

Coastal zoning and land use

Implementing coastal zoning and land-use regulations, such as the Australian Government's Great Barrier Reef Marine Park Zoning Plan (2003) and the Bay Island Land Use Zoning Plan in Honduras, implement regulations about the types of activities allowed in sections of the reef. They also regulate the amount of development, the materials and the use of land in areas that runoff into the reefs. This protects the lagoons, wetlands and coral reefs from excessive pollution and tourism. In Queensland, the government have implemented rules for farmers around the amount and type of fertiliser used and how it is applied near coastlines. This reduces the amount of excessive nitrogen and phosphorous that can runoff into the Great Barrier Reef.



▲ **Source 3:** A global review of coral reefs has shown that well-managed MPAs can greatly improve the quality of marine environments.

▲ **Source 4:** The Great Barrier Reef Marine Authority has made the *Eye on the Reef* app available to help people understand the zoning rules that apply in the Great Barrier Reef Marine Park.

Source 5: A coral planting tree in the Great Barrier Reef. This is part of the reef restoration management strategy, which focuses on growing corals and then planting them on damaged reefs.

Local strategies

Reef restoration

Reef restoration management strategies aim to restore damaged reefs and promote their recovery. One way to implement this strategy is to develop underwater nurseries that grow coral in controlled conditions before planting them onto damaged reefs, as shown in Source 5. Others seek fragmented coral polyps on the sea floor and attach them to damaged areas to promote new growth. This management strategy supports the biodiversity of coral, and increases coral cover across the marine environment. There are 14 reef restoration projects across the Great Barrier Reef. There is also a project funding research into and editing of coral genes to help them be more resilient in warm and extreme conditions.

Many countries bordering the Mesoamerican Reef, such as Mexico, Belize, and Guatemala, have implemented their own reef restoration programs and policies. These programs often focus on specific areas or target specific threats to the reef on the coastline of their countries.

Source 6: Broken pieces of coral are collected from the floor of the Mesoamerican Reef and grown in underwater nurseries. When ready, the coral is attached onto damaged areas of the reef using special clips.

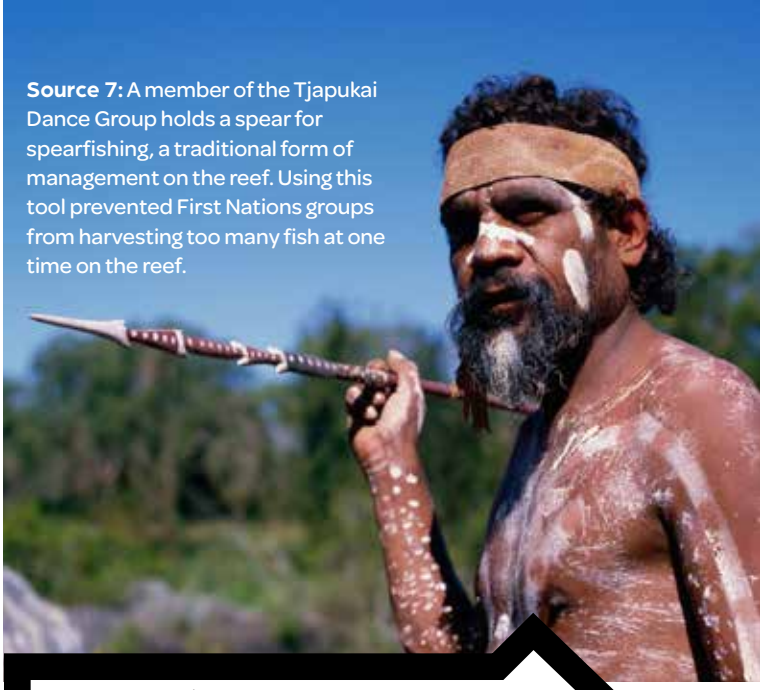
Coral disease initiatives

The impact of coral disease is more complex to manage, as the interconnected nature of marine environments can lead to the spread of disease into different areas. There are management strategies that address areas where a disease has plagued corals, such as Black Band disease around Heron Island Reef in the GBR or White Syndrome at Glovers Reef in the MAR. One strategy is to spread probiotics into the affected reefs, to spread beneficial bacteria to enhance coral immunity and fight disease. Another method is to have marine biologists inject diseased coral with anti-biotics and monitor its effectiveness. Most often these strategies also include cutting off diseased corals, to reduce the spread of coral disease and promote healing. In the GBR, these initiatives have become so effective that the Reef Restoration Foundation's Biocontrol program is increasing its scale. Meanwhile, the numerous authorities managing the Mesoamerican Reef has resulted in only some areas receiving this management strategy.

Traditional and customary management

Traditional groups are integral to sustainable marine environmental management. First Nations groups have effectively managed the GBR for thousands of years, implementing a range of strategies that have influenced contemporary management today. Traditional strategies include preservation zones and fishing restrictions, which have influenced zoning today, and the use of traditional totems. Totems involve the connection of a family or kinship network to a species. That family, clan and kinship then take on the role of respectfully managing that population by reducing hunting and protecting mothers and babies to support reproduction.

Traditional ecological knowledge of the reef has been passed down for generations, and contemporary science is using this information to make more informed decisions on GBR management. Similarly, there are traditional groups on the coast of the Mesoamerican Reef that also promote traditional fishing practices, to reduce the number of fish being removed at a time.



Source 7: A member of the Tjapukai Dance Group holds a spear for spearfishing, a traditional form of management on the reef. Using this tool prevented First Nations groups from harvesting too many fish at one time on the reef.

Learning ladder 7.10

Perspectives of people and organisations

1. Source 1: Which country has introduced the greatest protection of the Mesoamerican Reef?
2. Describe how coastal zoning and land use reduce environmental change.
3. Source 3: Explain how well managed MPAs can improve the quality of marine environments.
4. Analyse local strategies to manage coral reefs. Which do you think is the most effective and why?
5. Create a table to compare the following features of management between the GBR and MAR: management authority, funding, management history, key threats, management effectiveness.

Sustainability

1. Source 5: Identify this management strategy.
2. How do Marine Park Authorities (MPAs) manage coral reefs, and why are they more effective in some places than others?
3. Source 7: How does customary management by First Nations groups support reef protection?
4. Why might governments and businesses have different views on how coral reefs should be managed?
5. Who should have the most control over reef management—local communities, national governments or international organisations? Justify your answer.

HOW TO Sustainability, page 418

How do inland freshwater environments function?

Rivers, wetlands, lakes and groundwater are interconnected freshwater environments formed by the operation of the water cycle within catchments. Water is stored and transferred between environments and catchments by water cycle processes.

Processes in freshwater environments

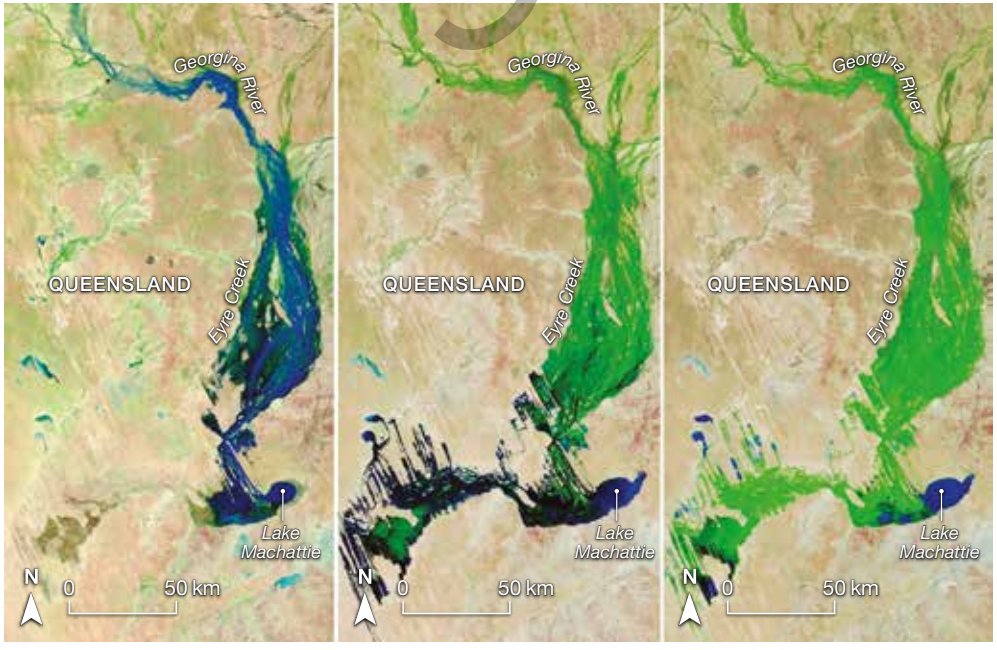
Processes that create and connect freshwater environments include:

- the **orographic** effect of moist air rising over mountains produces precipitation
- **runoff** from precipitation forms rivers, floodplains and wetlands
- snow accumulation forms ice sheets and glaciers that store freshwater
- snow and glacier melt (**ablation**) releases water slowly into rivers
- **infiltration** recharges aquifers and purifies water as it percolates through soil and rocks
- **groundwater** provides the base flow and recharge for rivers and wetlands
- Erosion creates floodplains and floods deposit rich alluvial soils that support a diversity of ecosystems and species.

Environmental connections

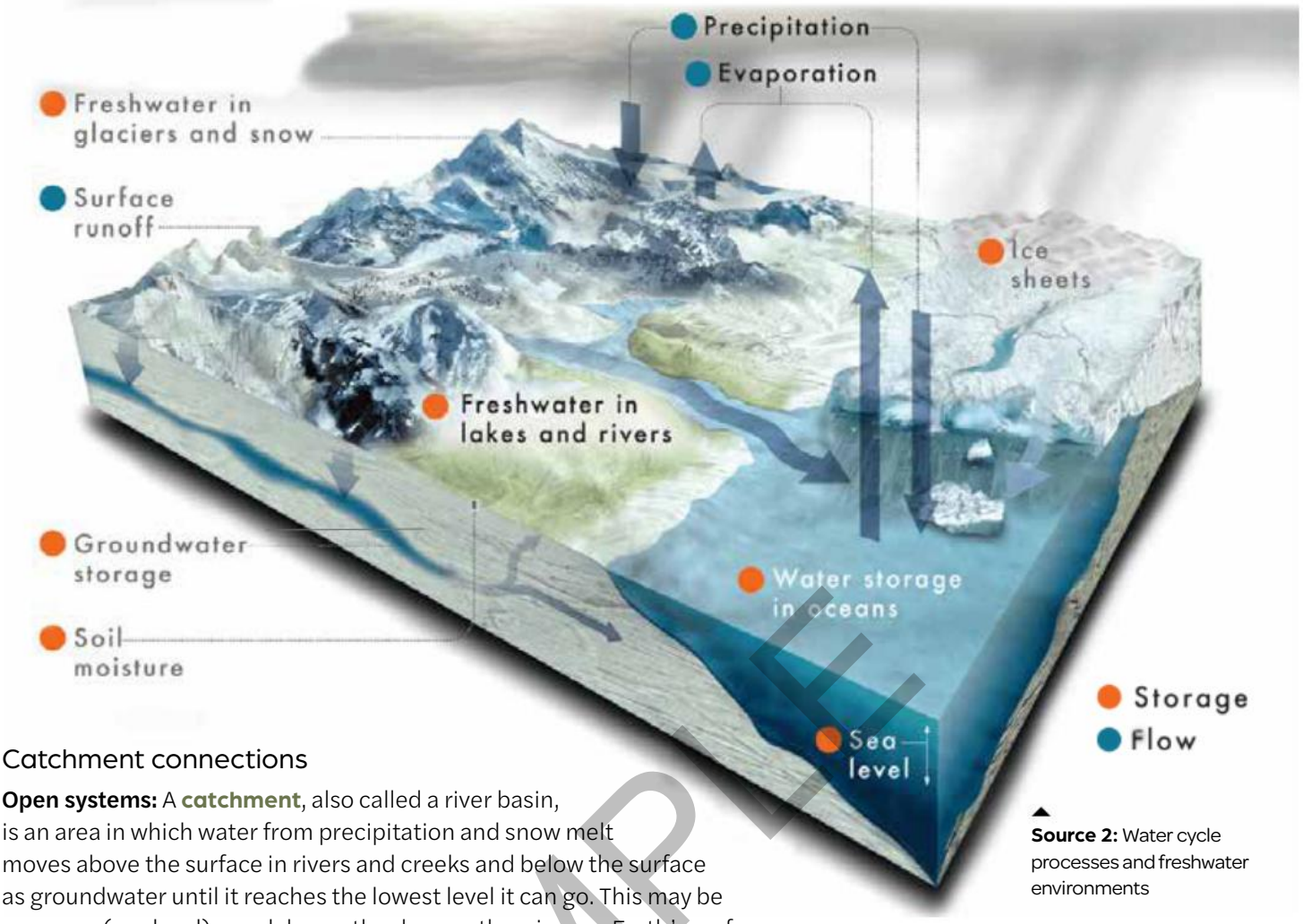
The biotic (living) and abiotic (non-living) features of freshwater environments are determined by the quantity and quality of the freshwater they receive and how that changes over time. Natural change is a response to weather and climate. Rivers for example have a pulse – like a heartbeat – in which river flow is linked to 'wet' and 'dry' or winter and summer seasons. Wetlands connected to rivers will dry out when river flow is low and renew during times of peak flow. The plants and animals living in freshwater environments are adapted to these changing conditions.

In the Kati Thunda–Lake Eyre Basin the cycle of flood, and drought, known as a 'boom' and 'bust', can be many years apart. During 2020–22 however, under the influence of **La Niña** conditions in the western Pacific Ocean, the basin experienced three consecutive years of flood. Each boom period creates a proliferation of life in rivers and their floodplains and wetlands in response to the inflow of water and when the water recedes, life becomes dormant again.



Source: NASA

Source 1: NASA Earth Observatory satellite image showing the transformation of the inland water environments in the Lake Eyre catchment between January and July 2023. Floods inundated cattle farms and isolated towns while providing the habitat and nutrients that support biodiversity.



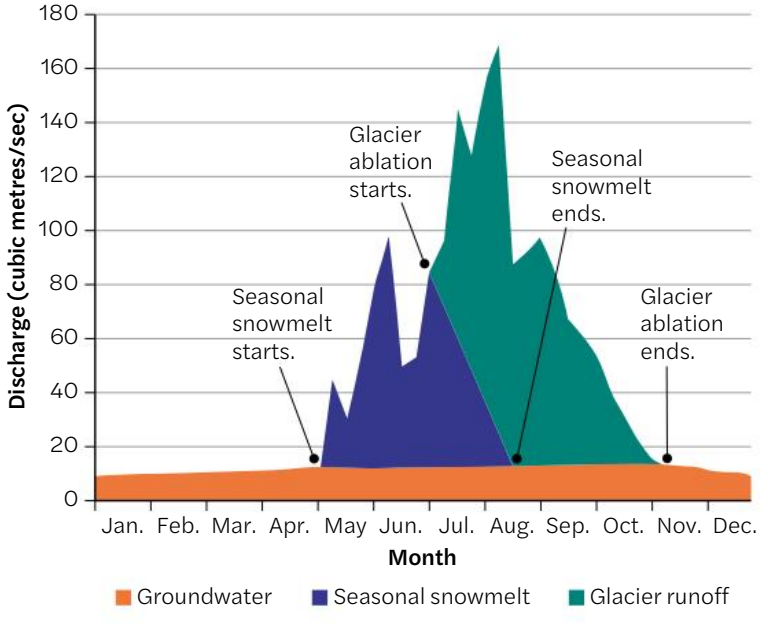
Source 2: Water cycle processes and freshwater environments

Catchment connections

Open systems: A **catchment**, also called a river basin, is an area in which water from precipitation and snow melt moves above the surface in rivers and creeks and below the surface as groundwater until it reaches the lowest level it can go. This may be an ocean (sea level), sea, lake, wetland or another river on Earth's surface, or an **aquifer** deep below. Catchments function as open systems in which water enters and leaves the system throughout the year and there could be seasonal or yearly variations in precipitation, evaporation and infiltration. Cycles of drought and flood that impact freshwater environments are determined by these variations.

Water towers: Mountains occupy 25 per cent of Earth's surface and play a critical role in the availability of water for riverine environments, acting as reservoirs or water towers that distribute clean, clear water. For example, **glaciers** supply over 40 per cent of the water in Pakistan's Indus River and snow in the Rocky Mountains, United States, contributes 70–80 per cent of water in the Colorado River. At the 'Third Pole', the name given to the Hindu Kush Himalayan (HKH) mountain region in Asia, snow and ice are a source of water for Asia's ten largest rivers. In these examples melting snow and ice release a **pulse flow** of water that keeps ecosystems and communities downstream alive, particularly when river basins are experiencing drought. The hydrograph in Source 3 shows the contribution of snow melt and glacial melt (ablation) to river flow in a tributary of the Aral Sea – providing the pulse of the river in the absence of precipitation.

Hydrograph separation in the Aral Sea region



Source: Matilda Education Australia

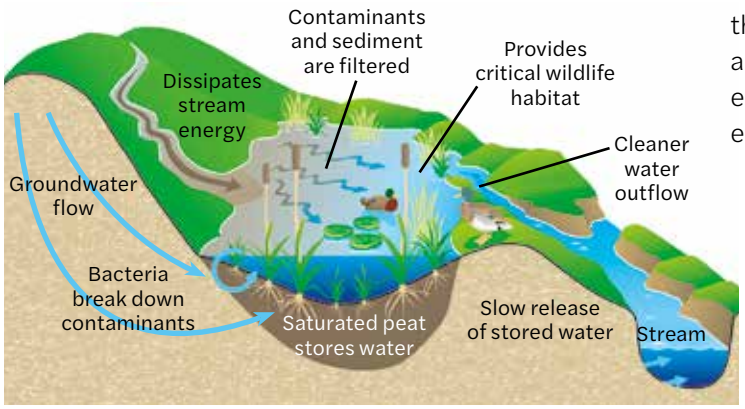
Source 3: Hydrograph of a river fed by snow and glacier melt (ablation) in the Aral Sea region in central Asia

Floodplain connections

Rivers: Erosion and deposition create different river environments and habitats and provide sediment and nutrients for freshwater species. In the upper reaches of a catchment rivers erode vertically creating deep valleys while downstream, where gradients are lower, they erode horizontally to create wide **floodplains** on which sediment is deposited. When rivers overtop their channels through flooding they transfer water, sediment and nutrients such as nitrogen and organic matter (leaves, bark) between river and floodplain environments including wetlands, swamps and old river channels (billabongs).

Floods: Each year Europe's rivers deposit an estimated 250 tonnes of sediment and 96 tonnes of fine organic matter per hectare onto floodplains. Floods renew alluvial soils and nourish rivers and wetlands, stimulating terrestrial and aquatic plant growth and wildlife breeding cycles. Many aquatic native species use high flow and flood events to migrate between habitats. Golden perch in the Murray River migrate as far as 1000 kilometres upstream to spawn and the red emperor fish on Great Barrier Reef begins its life cycle in Queensland's rivers. The survival of many plants such as river red gums depends on these intermittent water flows.

Wetlands and groundwater: Rivers contribute water to **wetlands** and are also recharged by them. Wetlands play an important role in keeping river environments healthy by filtering sediment and unwanted nutrients and are also habitats for native wildlife such as fish, frogs and waterbirds. The processes connecting rivers and wetlands are shown in Source 4. Groundwater flows also contribute to the availability of water in rivers and wetlands. During dry times, these flows provide a base level of water that may prevent these environments from completely drying out. These are known as 'groundwater dependent ecosystems.'



▲ **Source 4:** Wetlands processes and connections

River channels and riparian connections

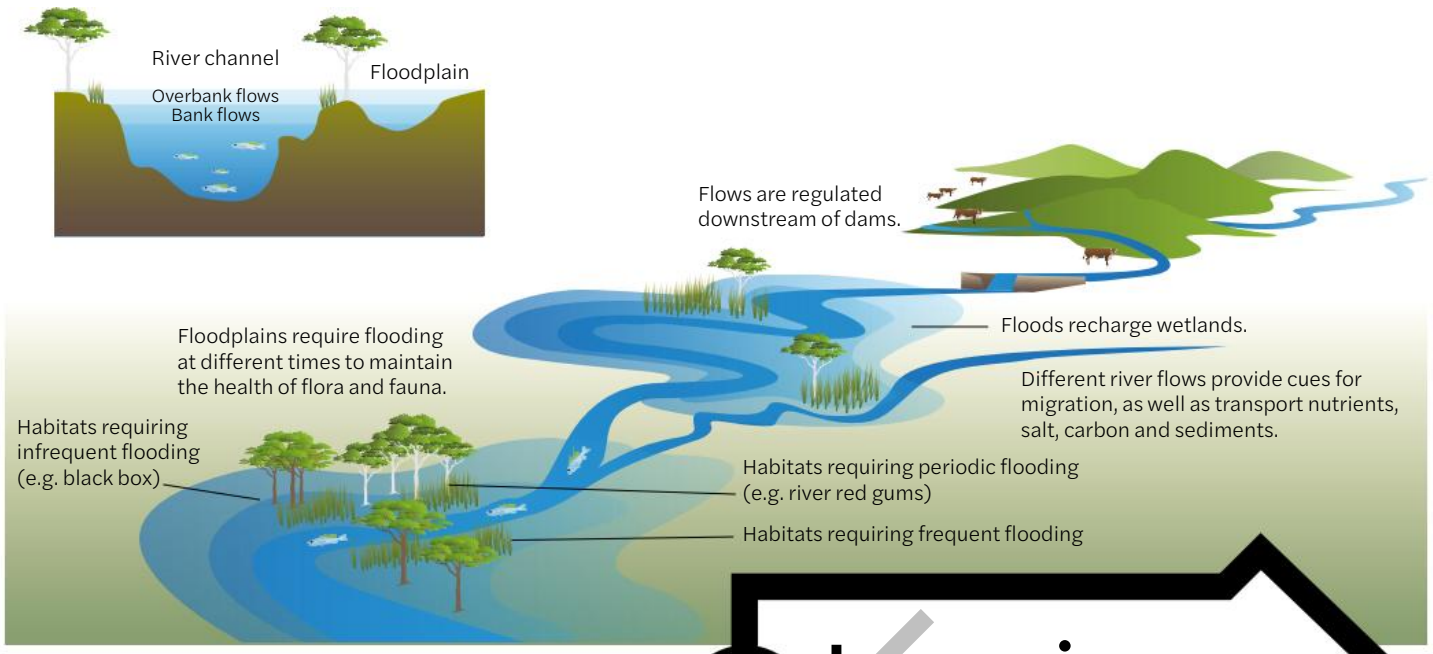
River channels and their riparian zones (land and vegetation that border rivers) are living environments that provide habitats, breeding grounds and refuges for a diversity of aquatic and terrestrial plants and animals.

- Riverine habitats vary from deep pools to shallow, fast flowing rapids, protected riverbanks and riverbed sediments such as gravel and rocks.
- Within each habitat aquatic plants, sediment and nutrients support complex food webs.
- Debris such as tree branches is an essential source of food, habitat and surfaces for small aquatic plants to grow on (biofilm).
- Aquatic species are adapted to stable water temperatures within rivers.
- The lifecycle of fish species such as salmon and barramundi involves migration between different river habitats.

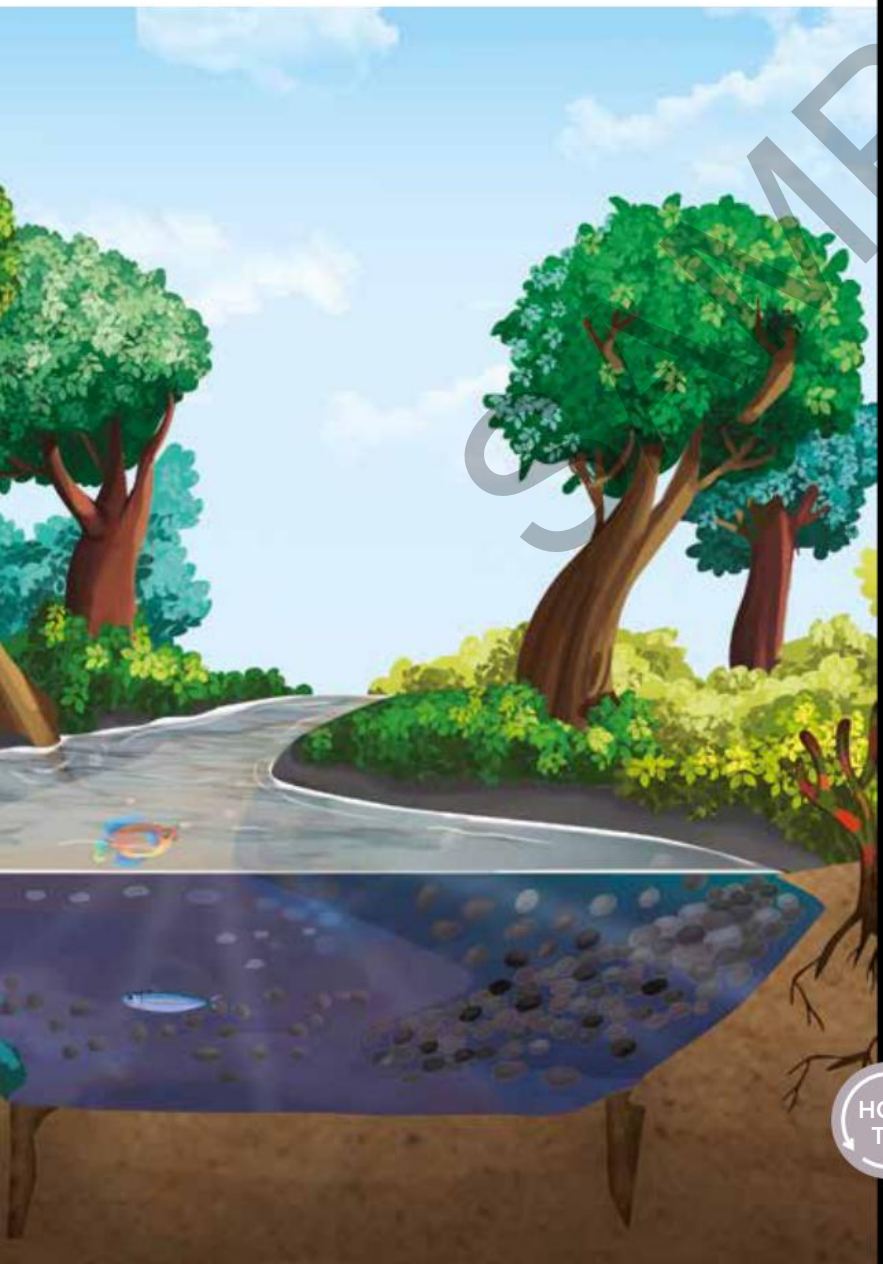
The riparian zone plays an important role in healthy river functioning by stabilising riverbanks, slowing the runoff entering channels, trapping sediments, reducing water temperatures and providing food and habitats, such as snags, for aquatic species. In healthy river catchments vegetation cover and wetlands slow runoff, remove pollutants and allow water to percolate slowly into aquifers, which recharge streams with clean water.

When people change freshwater environments by withdrawing water for agriculture or domestic use, degrading water quality or building dams, they are altering natural flows and processes that can have environmental, social and economic consequences.

Source 5: River channel and riparian connections. Rivers and riparian zones provide a range of habitats for plants and animals.



Source 6: River and floodplain connections



Learning ladder 7.11

Processes that transform people, places and environments

1. Source 2: Identify three freshwater environments that store water in a catchment.
2. Source 1: Explain how weather influences the biotic and abiotic characteristics of freshwater environments in the Lake Eyre Basin.
3. Source 3: How important is snow and glacial melt in the flow of the Sokh River in central Asia. Use statistics in your response.
4. Source 4: Analyse the processes that connect wetlands and river environments.
5. Create a sketch of the creek in Source 5. Label the river channel, riparian zone and the diversity of river and riparian habitats that support biodiversity.

Interconnection

1. Identify three interconnected freshwater environments.
2. Describe the role of precipitation and infiltration in the functioning of inland water environments.
3. Explain the connection between the 'Third Pole' and inland water environments in Asia.
4. Source 6: Analyse the importance of connections between rivers and floodplains to the biotic (living) components of floodplain environments.
5. Debate the statement: 'Without the water cycle processes there would be no inland water environments'.

HOW TO Interconnection, page 410

How do people change freshwater environments?

The growth of world population past 8 billion, urbanisation, economic development and climate change mean that Earth's freshwater environments are under enormous stress.

Drivers of change

Stresses have pushed freshwater environments beyond their ability to repair naturally, reducing their source (fresh water, food), service (habitat, flood protection), sink (carbon dioxide, organic matter) and spiritual (visual amenity and religion) values to people and nature. Degradation of freshwater environments occurs through **anthropogenic** (human) processes causing many problems:

- **Cultural eutrophication** from increased nutrient loads (nitrates, phosphates) causes **algal blooms** that block light and deplete oxygen levels.
- Bioaccumulation of toxic substances is an increase in the amount of chemicals in animals over time.
- Turbidity from erosion and invasive species such as Asian carp, blocks light and suffocates living things.
- Water extraction increases nutrient concentrations and water temperatures.
- Pollution levels that are lethal for many species.
- Climate change is altering habitats, water flows and temperatures.

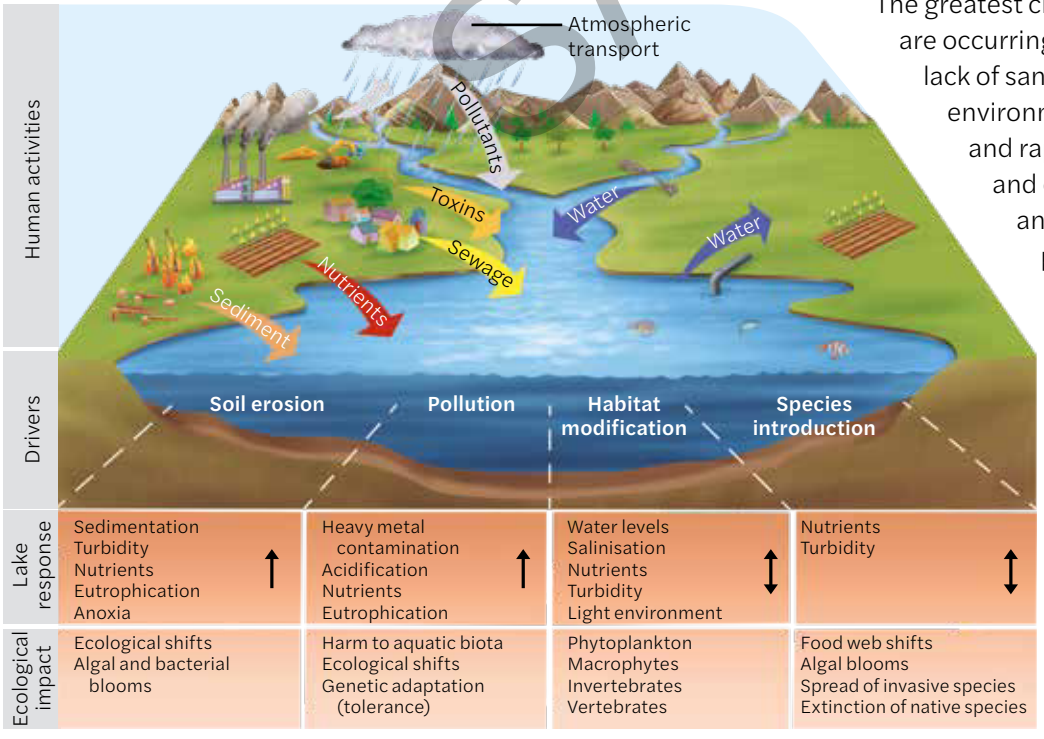
Declining river health has caused high extinction rates for freshwater organisms, up to six times higher than for marine and terrestrial ecosystems. An estimated 20 per cent of total freshwater species are endangered or extinct.

Environmental losses as a consequence of unsustainable water extraction:

- Rivers such as the Colorado River, United States, no longer reach the sea.
- Aquifers such as Indus River Plains Aquifer in India have been depleted.
- Wetlands, lakes and seas such as Lake Chad in Africa have shrunk so much that cartographers are redrawing world maps.
- The number of free-flowing rivers, unregulated by dams and weirs has fallen by about 60 per cent.

Pollution from tanneries

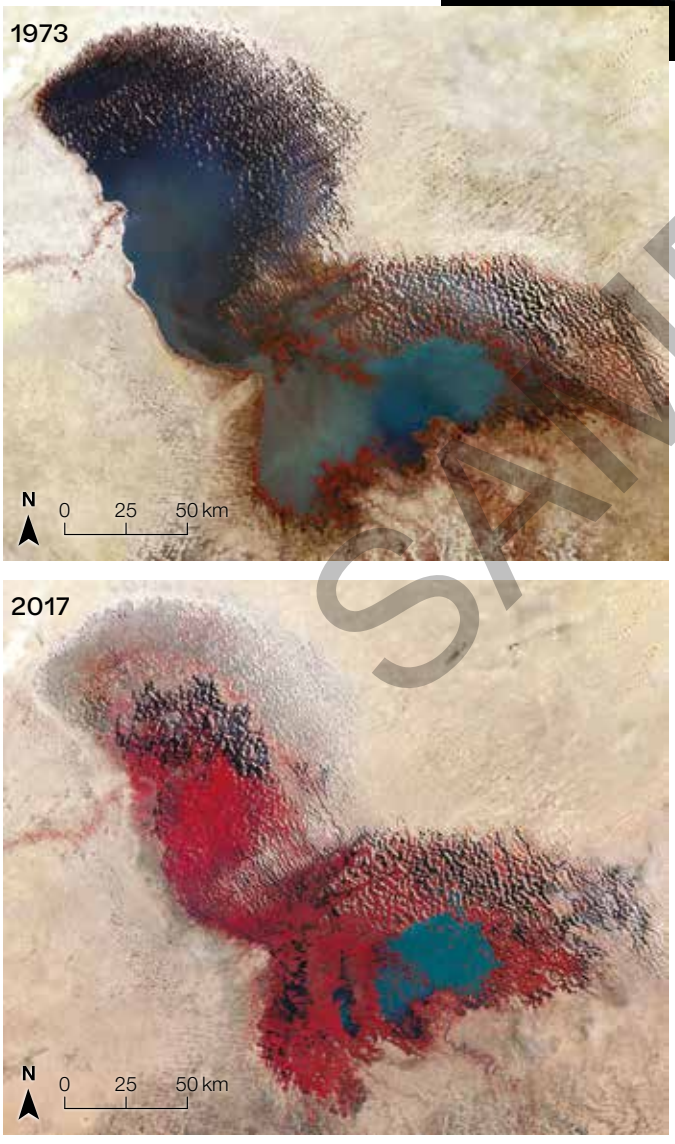
The greatest changes to freshwater environments are occurring in developing countries due to lack of sanitation and waste disposal, weak environmental laws on industrial pollution and rapid urbanisation. The use of dyes and chemicals in **tanneries**, where animal skins are turned into leather products are a significant source of water contamination in Asia, with evidence that up to 80 per cent of dye-containing industrial wastewaters from poorer countries are released untreated into waterways.



Source 1: Main drivers of change to a freshwater environment

Untreated dyes colour the water, reduce light penetration and impact photosynthesis by aquatic plants. The growth of microalgae, the foundation of the aquatic food chain is inhibited by synthetic dye. In fish, dye deposits in gills and brain tissue causing respiratory distress, liver damage and kidney dysfunction.

Source 2: In Bangladesh, tannery industries have led to Hazaribagh in Dhaka being listed as one of the top 10 polluted places on Earth. Leather production includes many harmful discharges of water that are toxic to people and ecosystems.



Source 3: Lake Chad has shrunk by around 80 per cent since the 1970s due to reduced rainfall from climate change and the use of irrigation. These false colour satellite images differentiate between vegetation (red), shallow water (blue) and deep water (black).

Learning ladder 7.12

Processes that transform people, places and environments

1. Define eutrophication, turbidity and water extraction.
2. Source 1: Describe one impact for each of the four drivers of change shown.
3. Source 2: Explain why the environment shown in the photograph would have low levels of biodiversity.
4. Create a flow diagram that shows the impact of dyes from tanneries from when they are created to the impact in a freshwater environment.

Place

1. Source 2: Why is Hazaribagh one of the most polluted places on Earth?
2. Source 3: Describe the change in Lake Chad between 1973 and 2017.
3. Source 3: Explain the reasons behind the loss of water in Lake Chad.
4. Research how water is used in tanneries, including where the wastewater goes. Also research sustainable solutions for tanneries. What is one key change that could be made to tanneries to make them more environmentally friendly?

HOW TO
Place, page 408

How have dams changed the Colorado River?

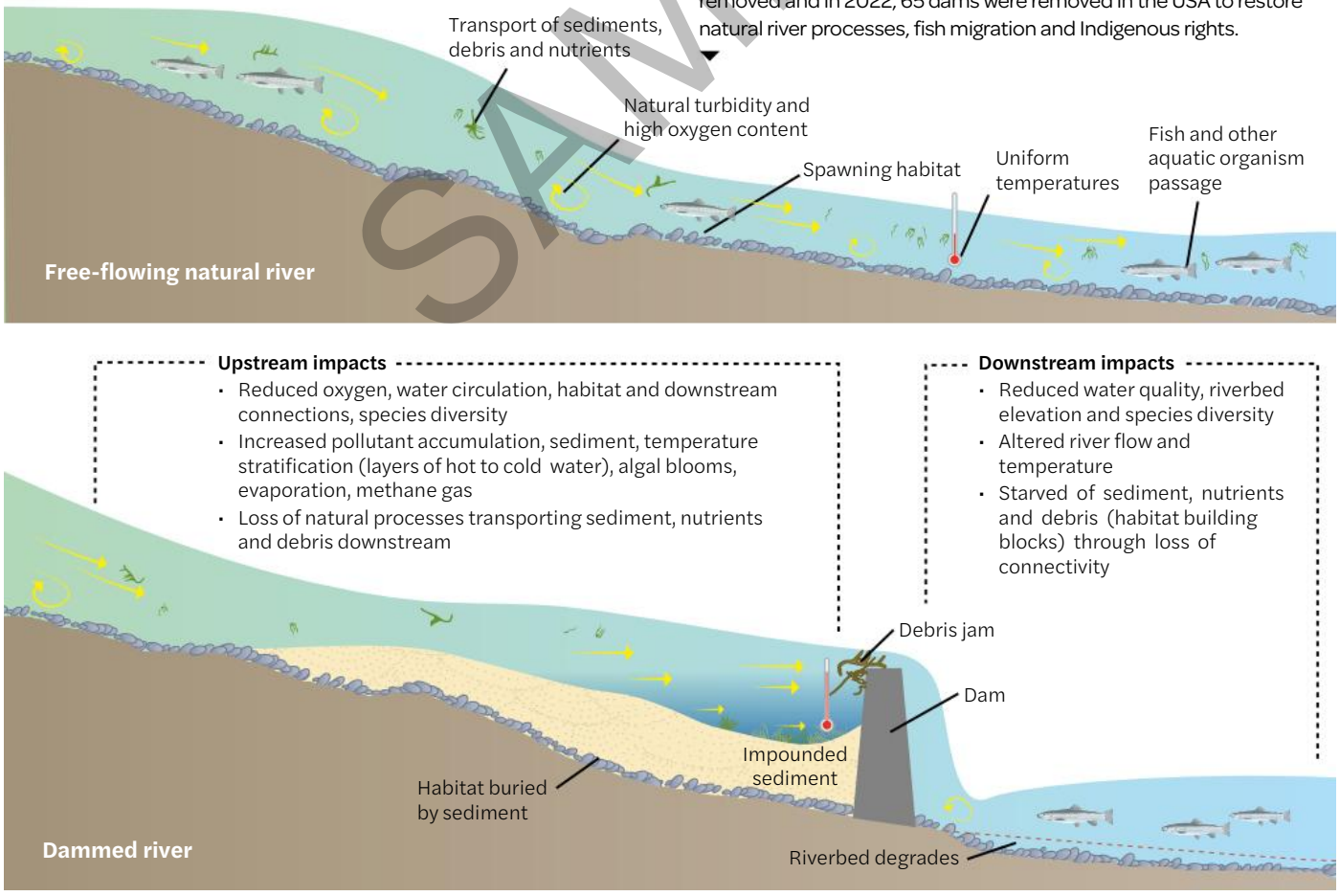
Dams change rivers by interrupting natural cycles of runoff to create reservoirs of water for human use – for economic and social benefits. There are consequences of alterations to river channels, floodplains, riparian zones and ecosystems for nature and communities.

The impacts of dams

Over 57 000 large dams on Earth trap freshwater for irrigation, **hydroelectric power,** urban water, navigation, flood and drought control – benefitting millions of people. About 16 per cent of global food production and 20 per cent of electricity generation is attributed to large dams. Hydroelectric dams now produce 40 per cent of Earth's renewable energy, a figure expected to increase as the world pivots from fossil fuels to clean energy to reduce carbon emissions. Africa's largest dam, Grand Ethiopian Renaissance Dam, was built to provide reliable power to 60 per cent of the Ethiopian population and assist in its transition to green energy.

Dams can also reduce food and **water security** and impact downstream communities. The 60 million people living in the Lower Mekong Basin who rely on fish as their main source of protein have been impacted by dams built upstream in China, Thailand and Vietnam. Brazil's Belo Monte Dam in the Amazon Basin cut river flow in the Xingu River by 85 per cent, reduced fish stocks, impacted culturally important species such as turtles and flooded 400 square kilometres of tribal land. Source 1 shows changes to the abiotic and biotic characteristics of rivers upstream and downstream of a dam.

Source 1: Dams have had a number of impacts on riverine environments. Across Europe over 6000 obsolete dams have been removed and in 2022, 65 dams were removed in the USA to restore natural river processes, fish migration and Indigenous rights.



The Colorado River

Over 100 years, 14 large dams have been built along the Colorado River from the Shadow Mountain Dam in the mountains of Colorado near Denver to the Morelos Dam at the US-Mexico border. The largest dams are the Hoover Dam and Lake Mead reservoir and the Glen Canyon Dam and Lake Powell. The Grand Canyon lies between these two dams. At least 20 minor dams have been built on tributary rivers. Water is used to irrigate crops, produce hydroelectric power and provide sites for recreation. Pipelines deliver essential water supplies to large cities, towns and other communities such as Las Vegas and Denver.

The extensive damming of the Colorado River meant so little water that the river stopped flowing regularly into the delta in Mexico and into Gulf of California after 1960, decimating the natural ecosystems and the lives of the Indigenous Indians such as the Cucapá tribe who depended on the river resources.

Source 2: The Colorado River from source to mouth

Major dams in the Colorado River Basin

Source: Matilda Education Australia

Source 3: The flow of the Colorado River is controlled by the Glen Canyon Dam, forming Lake Powell, the USA's second largest artificial reservoir.

The Grand Canyon

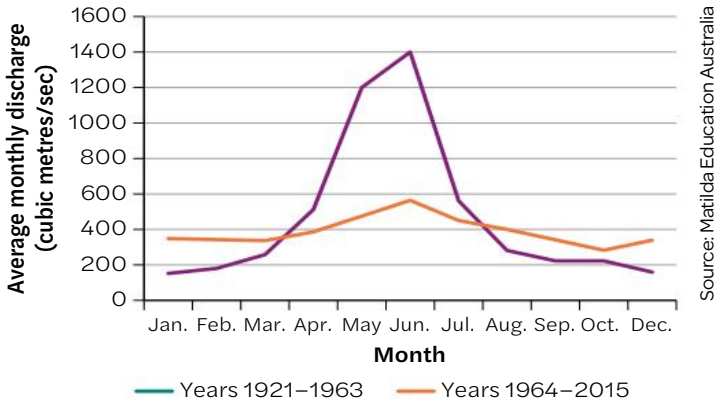
River flow

Before the Glen Canyon Dam was completed in 1963, snowmelt resulted in spring runoff of 3 400 cubic metres per second that delivered up to 57 billion kilograms of sediment, habitat forming tree branches and nutrients to the Grand Canyon. The hydrograph in Source 4 shows the end of the seasonal pulse flow in spring and the flattening out river flow after the dam was constructed.

River environments now depend on daily water releases from the dam, timed to produce electricity to meet peak demand. The sediment and water flows that formed critical fish habitats such as rapids and deep water pools were replaced by cold, clear, nutrient poor water and regular flows that resulted in the loss or endangerment of eight native species of fish, four endemic to the Grand Canyon. Channel and riparian vegetation changed in a similar process.

Climate change and drought has increased evaporation and reduced snowfall, river runoff and subsequent dam levels.

River flow before and after the construction of the Glen Canyon Dam



Source: Matilda Education Australia

Source 4: Hydrograph showing Pre-Dam and Post-Dam monthly average flows of the Colorado River at Lee Ferry, Arizona, below the Glen Canyon Dam.

Source 5: In July 2022 Lake Mead was filled to just 27 per cent of its total capacity – its lowest level ever. The largest reservoir in the United States supplies drinking and irrigation water to millions of people across seven states, tribal lands and northern Mexico. Over-extraction and long-term drought caused by climate change have reduced water in the Colorado River Basin.

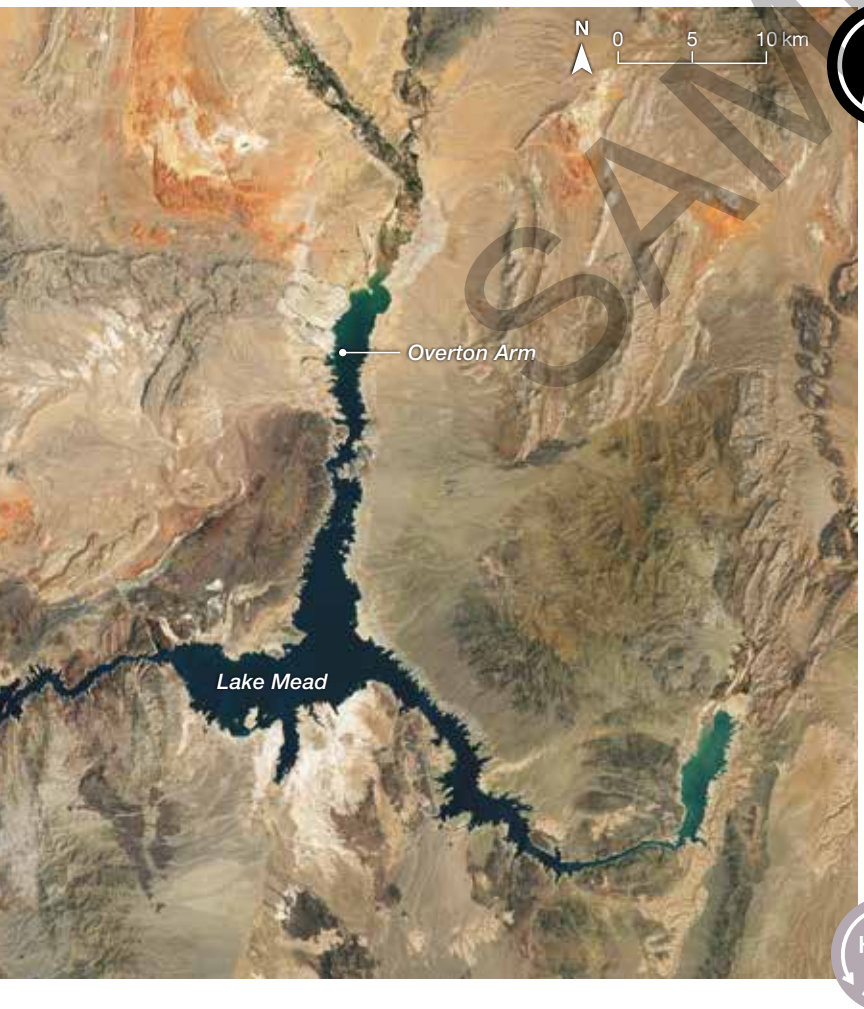
Management

The future of the highly reregulated Colorado River is precarious and it is now considered the nations most endangered river. Management and protection in the Grand Canyon National Park has successfully restored components of natural ecosystems. Two large water releases or pulse flows, in 2014 and 2023, were also used to move sediment around to restore river habitats such as riparian zones and pools and riffles.

Exotic species such as rainbow trout competed with native species. Management actions included **electrofishing**, using electricity to attract and stun fish, to remove trout from the Colorado River and its tributaries. This process has helped to restore native fish biodiversity and ecosystem processes – less trout, more macroinvertebrates, more flying insects and birds that feed on the insects.

There are growing calls to remove the Glen Canyon Dam to create deeper downstream flows and to use further pulse flows to restore river environments below dams. These however are short term and unguaranteed responses to the crisis facing the Colorado River.

▲ **Source 6:** The Colorado River in the Horseshoe Bend section of the Grand Canyon below the Glen Canyon Dam near the city of Page. Climate change and overuse has reduced the river's flows by 20 per cent since 2000.



Learning ladder 7.13

Processes that transform people, places and environments

1. Source 2: What lakes have the construction of the Hoover and Glen Ganyon dams formed?
2. Use a table to list the features of the Colorado River in the Grand Canyon before and after dams.
3. Explain the use of pulse flows to restore river environments.
4. Source 4: Analyse the management strategies used to repair and protect the Colorado River. Which strategy do you think can have the greatest impact?

Change

1. Source 1: Identify three downstream impacts of dam construction.
2. Source 5: Describe the change in Lake Mead between 2000 and 2022.
3. Source 5: Explain how this change has occurred.
4. Source 4: Analyse changes to river flows at Lees Ferry and use statistics to explain the changes.

HOW TO Change, page 412

7.14

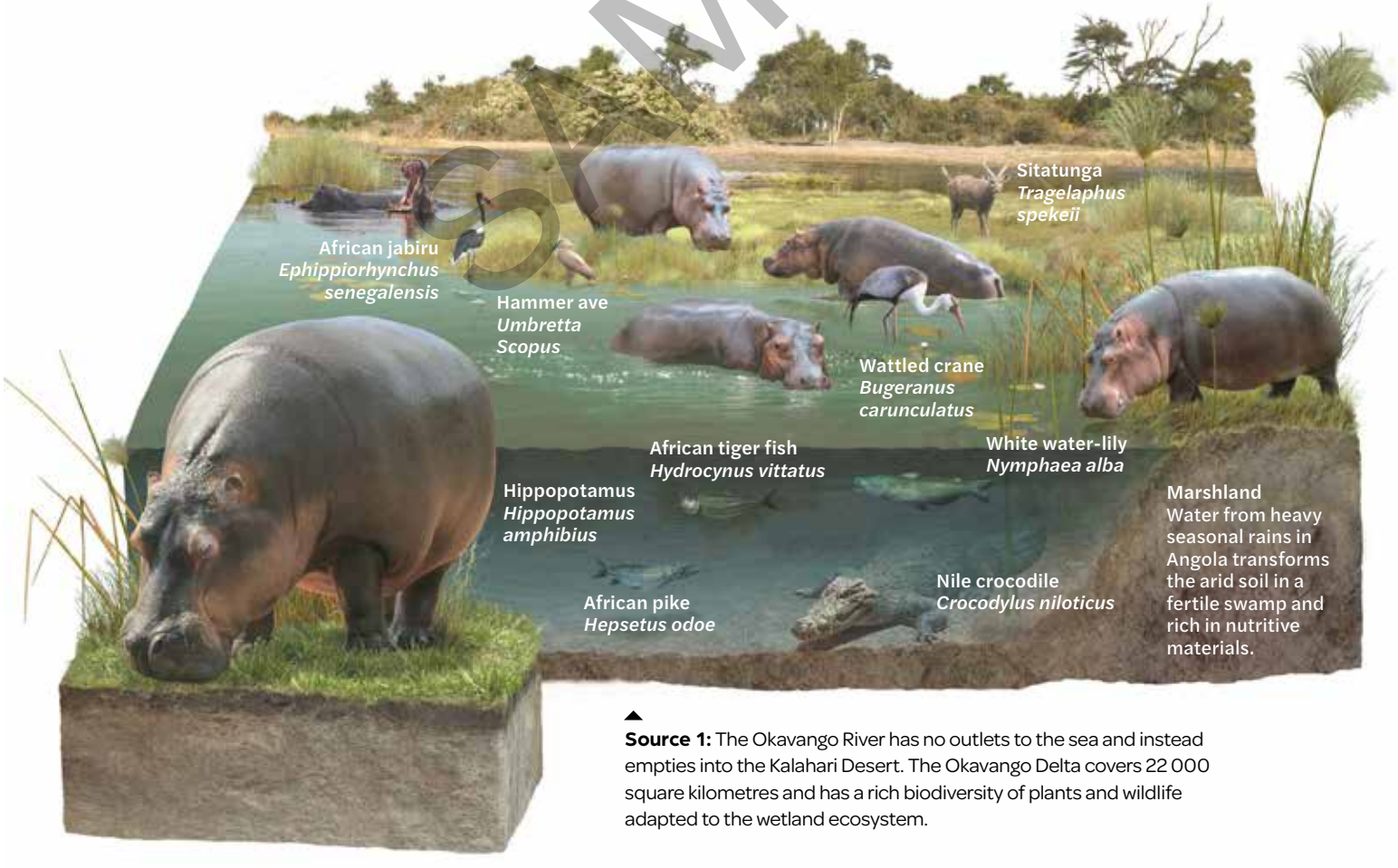
How is the Okavango Delta managed?

Management at a variety of scales is used to restore or maintain recognised environmental values – the source, sink, service and spiritual values that benefit humanity and the natural world. Sustainability is achieved when effective management creates a state of equilibrium in which society and nature coexist and the needs of both are met.

The Okavango Delta

The Okavango Delta is a vast fan-shaped inland wetland in the Kalahari Desert in Botswana. The source of water is the highlands of Angola, a region known as the 'water tower' that distributes water to 11 surrounding river basins. Groundwater from highland lakes, rivers and peatlands flows southwards into the Cuito and the Cubango Rivers which form the Okavango River and provide 95 per cent of its flow. The river flows through Namibia before entering the wetland in Botswana where it fills a shallow basin that varies in height by only 2 metres and ends its journey. Most of the water in the delta is evaporated or transpired.

Although water flows constantly all year, it is a pulse flow in June and July (Botswana's dry winter season) that delivers 2.5 trillion gallons of water and stimulates the productive natural cycles in the wetland. Permanent and seasonal wetlands and lakes, channels and floodplains within the delta support a diversity of habitats such as grasslands and woodlands and 2000 species of plants and animals, many threatened or endangered such as black and white rhinoceros and giant ground pangolin. The delta is home to the largest population of elephants on Earth, hippopotamuses, cheetahs, wild dogs, lions and 24 species of globally threatened birds such as vultures and the southern

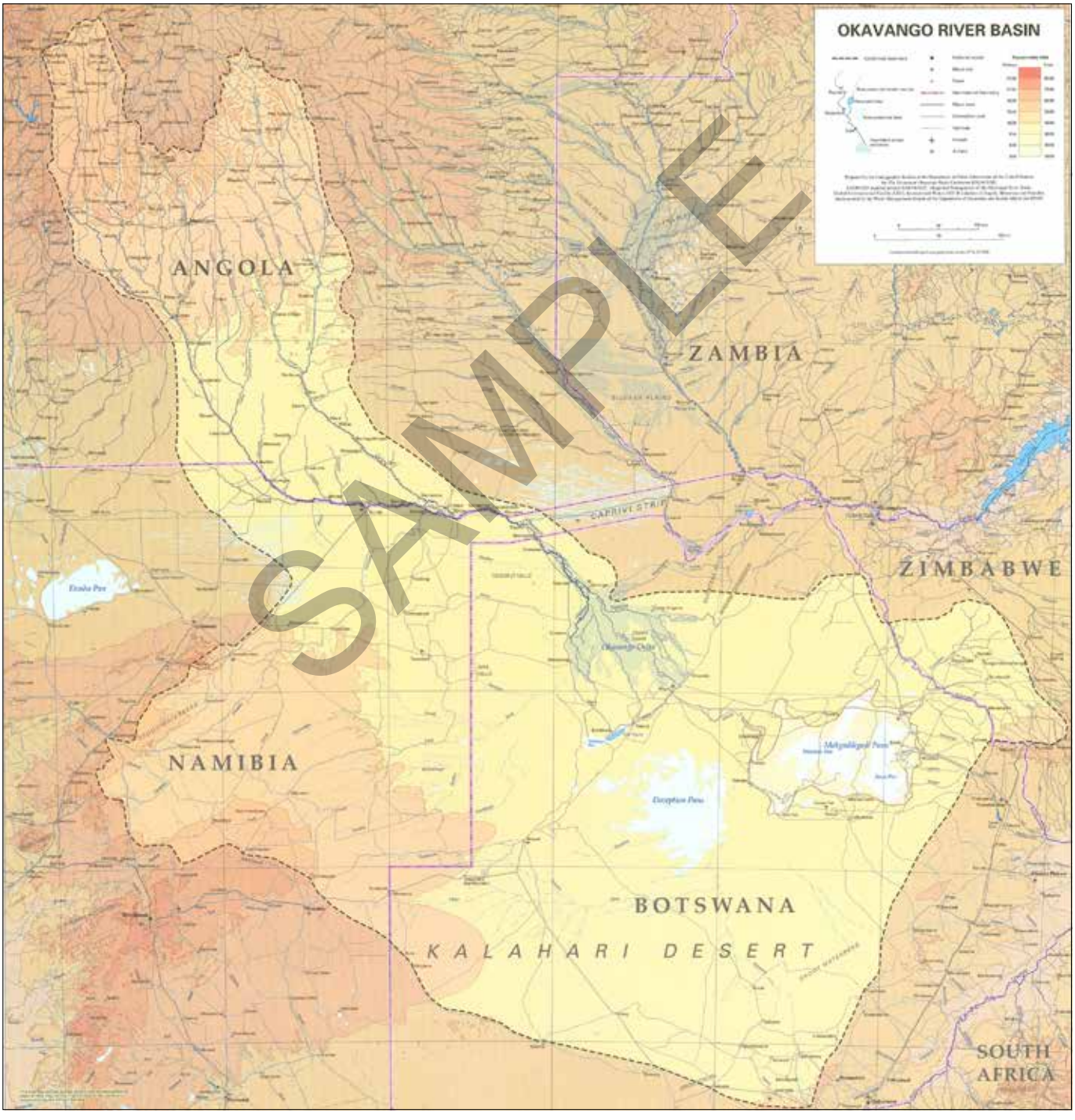


Source 1: The Okavango River has no outlets to the sea and instead empties into the Kalahari Desert. The Okavango Delta covers 22 000 square kilometres and has a rich biodiversity of plants and wildlife adapted to the wetland ecosystem.

ground-hornbill. It is a refuge for migrating species such as elephants, zebra and wildebeest. This biodiversity forms the basis of a thriving tourism economy and sustainable use of the wetland by local communities who work in tourism and as subsistence farmers.
The size of the wetland makes the Okavango Delta and the peatlands that help deliver water from the source in Angola are important **carbon sinks** in the fight against climate change.

▲ **Source 3:** Elephant feeding in front of the tented ecotourism accommodation in the Khwai Private Reserve in the Okavango Delta.

Location of the Okavango Delta



▲ **Source 2:** The Okavango River catchment

Source: UN Geospatial Information Section

Management at a range of scales

The delta is unique in that it is largely pristine having avoided the consequences of human activities as a result of its vast size, low surrounding population density, difficult access, lack of upstream dams and protection internationally and within Botswana.

International recognition

The Okavango Delta was designated a RAMSAR wetland of international significance in 1996 and inscribed as a World Heritage site in 2014 due to its unique natural systems, exceptional biodiversity and scenic values. These recognitions place a responsibility on Botswana to ensure the environment is continuously managed to protect its outstanding universal values.

Botswana is also a signatory to CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, a global agreement to regulate the international trade of species targeted by poachers for their tusks and horns, such as elephants and rhinos. These are found in abundance in the delta and need extra vigilance to deter poaching.

Source 4: Oblique aerial view of elephants in the Okavango Delta wetlands in Botswana.

National protections

Botswana has taken many actions and enacted legislation aimed at protecting its natural resources and environments. These include:

- creation of the Moremi Game Reserve in 1963 to protect wildlife from hunting
- creation of an ecotourism policy in Botswana, soon after, to reduce the human impact of tourism to small eco-lodges around the reserve
- 1968 Forest Conservation Act to guide the management and use of forests and wood resources that form important habitats in the delta by regulating community access to firewood and thatching grass with limited permits issued each year
- 1992 Wildlife Conservation and National Parks Act that provides guidance for managing protected areas such as National Parks and game reserves including wildlife crimes in the delta region and the issuing of hunting licenses used by local communities for subsistence hunting
- 1975 Fisheries Protection Act to regulate, control, protect and improve fish species in the delta that are targeted by local populations and tourism businesses.

Source 5: Guides and safari ecotourists tour the channels of the Okavango Delta.

Okavango River catchment

The Okavango Delta is highly protected and managed within Botswana and within the World Heritage and RAMSAR site boundaries. The biggest threats to the delta come from the larger **catchment**, including Angola and Namibia where deforestation, poaching and hunting, wildfires, water withdrawal for agriculture and large scale water projects in Angola have implications for downstream Botswana. The survival of the delta is dependent on maintaining the water flow that drives the wetlands natural processes and biodiversity.

Regional agreements with neighbouring countries such as The Permanent Okavango River Basin Water Commission (OKACOM), established by Angola, Botswana and Namibia, plus collaboration between governments, businesses and organisations working in the region are aiming to increase sustainable landuse around the delta to minimise these outside threats. Involving Indigenous groups is placing a focus on community based development for improving wellbeing and sustainable income sources based around the values of the environment.

OKACOM is working with a variety of NGOs such as the Nature Conservancy, World Wildlife Fund (WWF), Conservation International, Namibia Nature Foundation and National Geographic's Okavango Wilderness Project (NGOWP) to work towards development that balances the needs of people and nature across the basin. De Beers, the large diamond company working in Botswana joined National Geographic's NGOWP in a partnership – Okavango Eternal – to preserve the source waters of the delta by working locally with communities and using traditional knowledge to build sustainable livelihoods such as tour guiding, beekeeping and improved farming practices.

Learning ladder 7.14

Sustainable management strategies

1. List four values of the Okavango Delta that require protection.
2. Why is international recognition important for sustainable management of freshwater environments such as the Okavango Delta?
3. What factors contribute to the effective management of the Okavango Delta?
4. Why is involving local communities in management decisions a pathway to achieving the sustainable use of resources in and around the catchment?

Interconnection

1. List three threats to biodiversity of the Okavango Delta that originate outside of Botswana.
2. Source 1: What is the connection between Angola and the Okavango Delta?
3. Explain why the future of the Okavango Delta relies on the flow of water from upstream.
4. Why is management at national and international scales focused on maintaining biodiversity?
5. Sources 3 and 5: Analyse the connection between improving the well-being of people living in the Okavango River catchment and protecting the values of the Okavango Delta.

HOW TO Interconnection, page 410

How is technology used to manage freshwater environments?

Using technology

Technology is the application of scientific knowledge and ideas for practical purposes. Throughout history technological developments have enabled freshwater environments to be exploited, dammed, channelised, drained and transformed to the detriment of natural systems. Technological innovation now plays an important role in environmental management improving our capacity to monitor and improve water quality, the health of freshwater ecosystems and reduce impact of natural hazards such as flooding.

Effective and sustainable management of freshwater environments requires accurate and current data and information. Technology is used to:

- gather qualitative and quantitative data on biotic and abiotic characteristics of an environment
- monitor environments to detect environmental change
- provide hard and soft engineering solutions to environmental challenges
- collect evidence to evaluate management strategies.

Earth observation

Remote sensing

Remote sensing is a major source of information for environmental change detection. Imagery acquired from satellites, aircraft and drones provides visual data at a range of scales allowing comparisons for characteristics of freshwater environments to be made, such as the change in water levels in Lake Mead on page 122.

Information from over 150 Earth Observation satellites currently in orbit is captured, visualised and analysed to determine environmental features. New sensor technologies using a range of light spectrums (visible, infrared and microwave) have improved remote sensing capabilities and made monitoring large, often remote environments possible. Thermal infrared imagery visualises water qualities such as temperature – beyond what the eye can see.

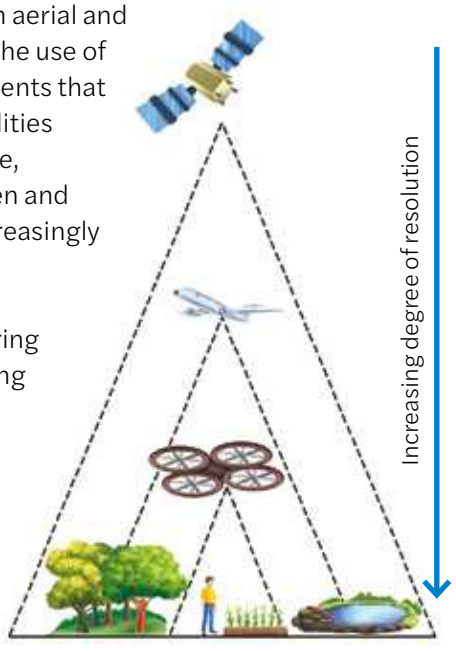
Geotagging and satellite tracking

Geotagging and satellite tracking of aquatic wildlife improves knowledge and understanding about species lifecycles and movements that can be used to enhance their protection. In 2022–23 two Amazon river dolphins were tagged and monitored in their natural flooded forest habitat. The data were mapped and analysed to plan for better protection of the unique freshwater species.

Smartphones and apps take geotagged wildlife photographs that are automatically added to the database using the Broadband Global Area Network for collation and mapping after the expedition.

Onsite data collection

Satellite data is supplemented by information from aerial and drone surveys and the use of multiprobe instruments that measure water qualities such as temperature, pH, dissolved oxygen and salinity on-site. Increasingly more sophisticated technologies mean automated monitoring stations are replacing in-person scientific data collection.



Source 1: ▶ Technologies used in remote sensing.

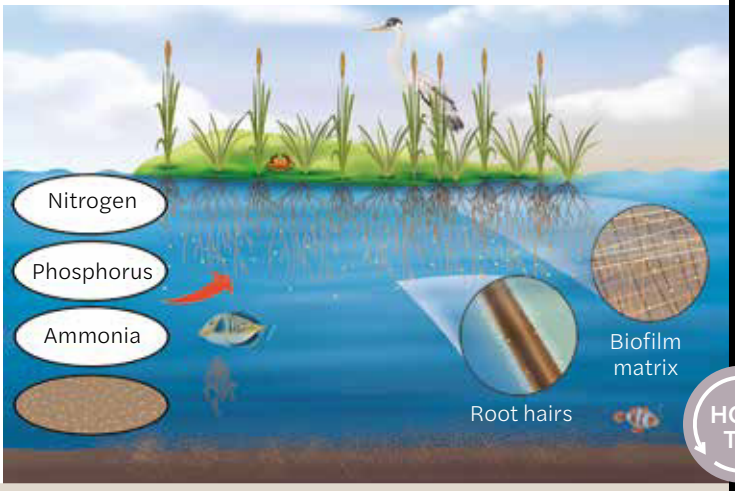
Since the 1980's automated snow **telemetry** instruments measured the yearly snowpack in the Colorado River headwaters. A Next Generation Water Observing System (NGWOS) has recently been installed to monitor snow pack and snow melt, the source of 95 per cent of the Colorado River flow. High-fidelity, real-time data will be used to predict water flows and inform decision making. In 2022, high temperatures melted Colorado's snowpack rapidly and almost a month earlier than normal in some places. The snow melt data led to new regulations for water withdrawal downstream to balance environmental river flows and human demand for water along the increasingly depleted Colorado River.

Environmental DNA (eDNA) technology can identify species based on minute traces of DNA left as a creatures moves through as watercourse, such as when an elephant crosses a stream (Source 3). Sampled water is filtered and sent to a lab for genome sequencing to identify species.

Engineered solutions

- Water-sensitive urban design (WSUD) uses soft engineering solutions such as artificial wetlands, grassed swales and wetland islands to absorb pollutants, increase infiltration and sustain natural ecosystems. Floating wetlands mimic natural wetlands – they work using the same processes, plants and microorganisms, bacteria and algae that break down toxins as well as absorbing nutrients and providing habitat (Source 2). Floating islands are used across the United States, Canada, Australia, New Zealand, Singapore, the UK, Korea and Europe to improve water quality and restore freshwater habitats.

Source 2: Floating islands use wetland plants like rushes, reeds and sedges onto a biofilm matrix mat that floats on the water surface. Roots grow through the matrix and root hairs help with nutrient uptake and filtering particles. Fish and migratory birds use the floating wetlands for refuge and crabs and other aquatic species colonise them.



- Fish migration structures such as fish ladders on dams, weirs and locks are hard an engineered solutions to ensure the survival of migratory species such as salmon.
- Electrofishing and biological controls (toxins and pheromones) are used to manage invasive species such as carp that threaten water quality and native species like the Murray Cod. In the USA where Asian carp have spread through the Mississippi River Basin and pose a threat to The Great Lakes, electric barriers and carp (water) canons are used to repel the fish.

Source 3: The DNA of a single elephant in the Okavango Delta can be monitored using eDNA technology, where water samples are collected and processed to detect tiny traces of DNA left by the elephant.

Learning ladder 7.15

Representing and communicating information

1. Source 1: What is remote sensing and how do satellite technologies make it possible.
2. Differentiate between soft and hard engineered solutions to environmental challenges. Refer to examples of freshwater environments.
3. What are the advantages of geotagging in understanding freshwater species? What information did researchers discover about Yatü from geotagging?
4. Source 2: How can engineered solutions that mimic natural ecosystems be used to develop management solutions for freshwater environments. Provide an example.
5. Select and rank four technologies you would use if given the task of leading an environmental investigation into a remote wetland environment. Justify your choices.

HOW TO

Visual communication, page 436

Thinking geographically

Environmental change and management

Geographical concepts, inquiry and tools

Place, change, environment, sustainability, tools, inquiry

Learning ladder: page 260

Key inquiry question

Why is it important to protect Gondwana forests?

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 Dorrigo National Park
- the environmental, social, cultural and economic values of Dorrigo National Park
- the impact of environmental change on the national park
- the effectiveness of management strategies implemented
- one sketch map or simple diagram.

Where possible, refer to the sources in this spread to support your judgments.

Dorrigo National Park

Dorrigo National Park, located on the east coast of New South Wales (30.3666° S and 152.7333° E), is a key part of the Gondwana Rainforests, a UNESCO World Heritage site. Spanning 11 900 hectares, the park features lush subtropical rainforests around the Wonga Walk, which is rich in diverse tree species and dense vegetation, and also warm temperate rainforests around the Never Never Picnic Area, which are less complex and dominated by coachwood and sassafras trees. It is home to diverse flora and fauna, including ancient Antarctic beech trees, Eucalyptus species (e.g. Sydney blue gum), ferns, mosses and the Red-necked pademelon, long-nosed potoroo, koala, 120 bird species, regent bowerbird, superb lyrebird, noisy pitta, spotted-tailed quoll, sooty owl and swamp wallaby. The Gumbaynggirr are the Traditional Owners of Dorrigo National Park. Many of the natural features of the park's landscape are associated with their Dreaming.

Human activities, such as deforestation and agriculture, have significantly reduced the extent of these rainforests. Contemporary tourism and climate change also pose a threat, altering natural processes and introducing pests and disease. The park has been protected through conservation, and recently the government has planned to invest $56.4 million to enhance sustainable tourism with new walking tracks, suspension bridges, and a rainforest centre. These initiatives support the local economy by creating over 250 jobs while preserving the park's rich biodiversity and ecological integrity.

Source 1 activities

1. Outline the location of Dorrigo National Park.
2. Explain the ecological importance of Dorrigo National Park.
3. Create a food web for Dorrigo National Park using the animals listed in the text.
4. Analyse how human activities can impact on the environment at Dorrigo National Park.

Source 1: The nature, impacts and management at Dorrigo National Park

Climate of Dorrigo National Park

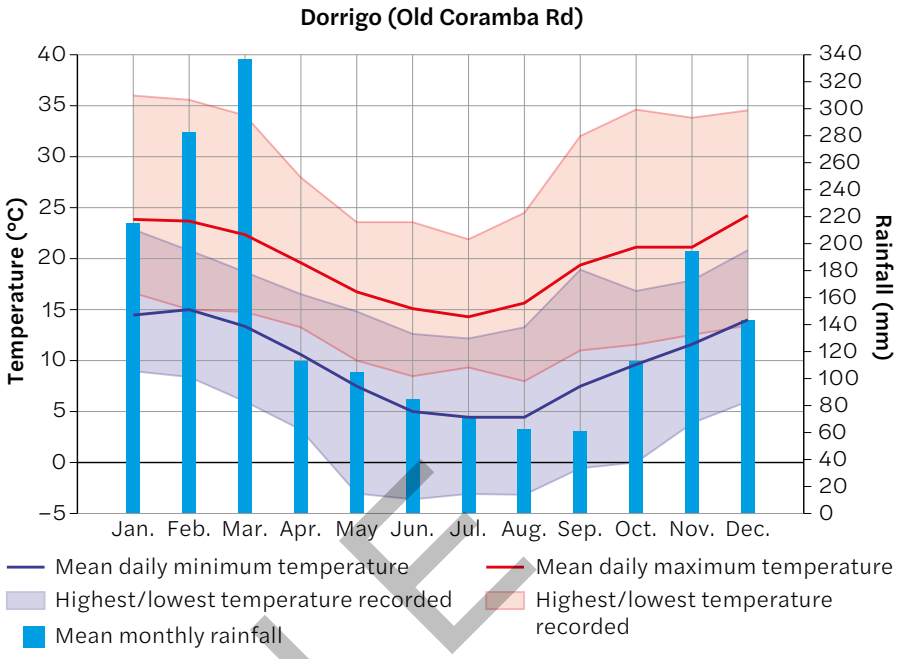
Source 2 activities

1 Which months have the highest and lowest precipitation?

2 Determine the average highest and lowest temperatures and precipitation for the following months:
   - **a** March
   - **b** June
   - **c** August
   - **d** November.

3 Determine the difference between the highest maximum and lowest minimum temperatures for the following months:
   - **a** February
   - **b** April
   - **c** September
   - **d** December.

4 Calculate the annual average precipitation in Dorrigo.



▲ **Source 2:** Climate graph of Dorrigo National Park

Source: Matilda Education Australia

Features of Dorrigo National Park

▲ **Source 3:** Skywalk at the Dorrigo National Park

▲ **Source 4:** Dangar Falls in the rainforest of Dorrigo National Park

▲ **Source 5:** Footbridge and Crystal Falls in the rainforest of Dorrigo National Park

▲ **Source 6:** View over Dangar Falls in Dorrigo National Park

Sources 3–6 activities

1 Identify one value of Dorrigo National Park shown in the sources.

2 Describe one value of Dorrigo National Park.

3 Describe a biophysical process evident in the photos.

4 Source 3: Explain the management strategy shown.

5 Answer the following photograph questions:
- **a** Which two photographs are oblique aerial photographs?
- **b** Which photograph has the smallest scale?
- **c** The sun rises in the east and sets in the west. Is it morning or afternoon if the photographer for Source 6 is facing south?

6 How effective has conservation (making Dorrigo a National Park) been in managing and protecting it?

Topography of Dorrigo National Park

Source 7 activities

1 Calculate the bearings for the following:
- **a** McGrath Hump to Dibbs Head
- **b** Dome Mountain from Dibbs Head
- **c** Wild Cattle Creek to Dome Mountain

2 Calculate the distance between the following points:
- **a** Dome Mountain and Dibbs Head
- **b** McGraths Hump and Never Never Picnic Area
- **c** The highest spot height on the map, to McGraths Hump

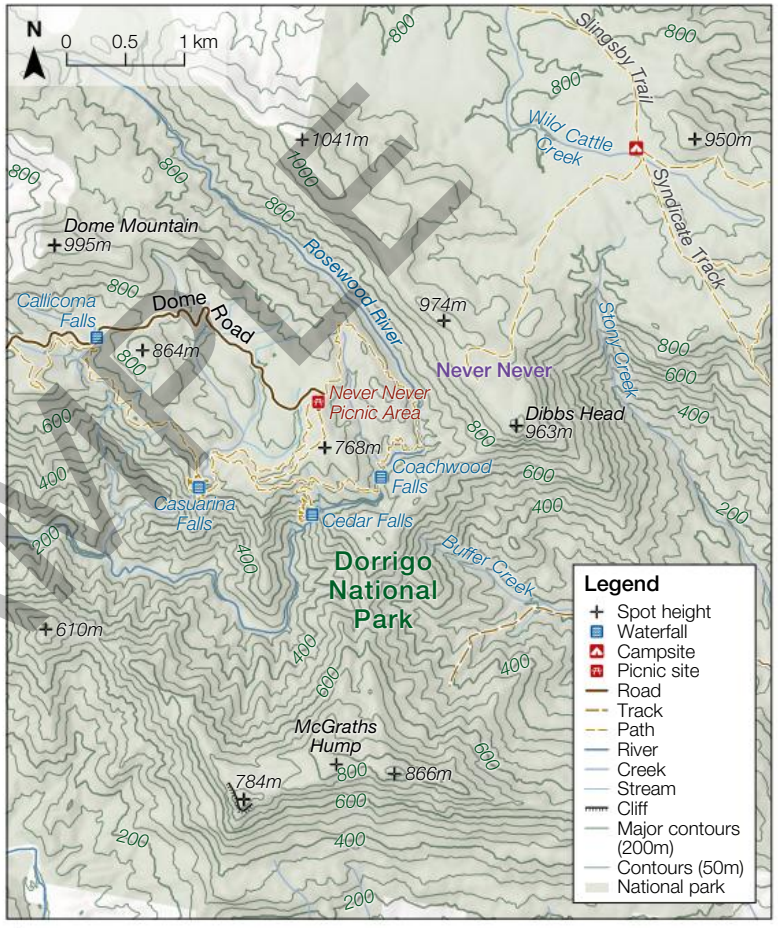
3 Calculate the local relief between:
- **a** The campsite on Wild Cattle Creek and Never Never Picnic Area
- **b** Calicoma Falls and the 610m spot height in the southwest quadrant?

4 State the aspect of:
- **a** The southern part of the map
- **b** East of Dibbs Head

5 Calculate the gradient between the following points:
- **a** Dibbs head and the 400 metre contour line to the south
- **b** The campsite on Wild Cattle Creek and the 950 metre spot height to the east

6 Construct a cross-section between:
- **a** The spot height of Dome Mountain and the campsite at Wild Cattle Creek
- **b** Calicoma Falls and the spot height at 610 metres in the southwest quadrant.

Topographic map of Dorrigo National Park



Source: Matilda Education Australia

Source 7: A topographic map of Dorrigo National Park

Human wellbeing and development

8

HOW DOES SAFETY IMPACT WELLBEING? 338

HOW IS HUMAN WELLBEING MEASURED? 313

HOW IS GENDER LINKED TO WELLBEING? 344

8.0

How can I understand human wellbeing?

Human wellbeing is an expression of health, safety, happiness and other measures that vary between people and places. However, human wellbeing has no globally recognised definition, as it is a complex concept. It involves many aspects of our lives including social, historical, economic, environmental and political factors.

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 toward the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.
	Outcomes					Geographical tools and inquiry

Source 1: Safety and peace are key elements to human wellbeing and happiness.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

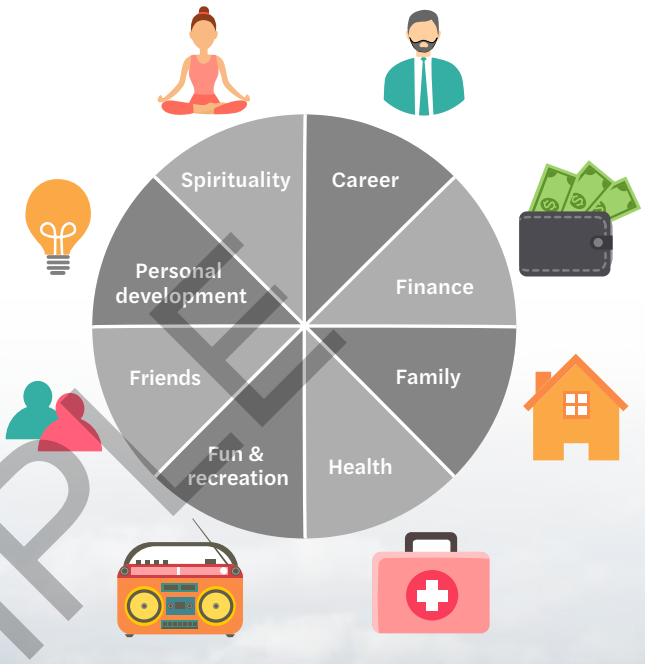
Geographical concepts

What is human wellbeing?

When we think about the term 'wellbeing', we generally consider a person's mental and physical health. In Geography, we can measure a number of factors that contribiute to wellbeing, and use this data to inform policy or develop appropriate infrastructure.

Human wellbeing

Human wellbeing is centred on the idea that people want to be healthy, happy and safe. Human wellbeing is multidimensional; that is, a range of factors influence wellbeing depending on person and place. Wellbeing can be affected by a person's access to social connection, income, food and resources, peace, social and economic equality, and freedom. Wellbeing is also influenced by a person's feelings, emotions, thoughts and life satisfaction. The way a person describes their wellbeing may change over time as their circumstances change.



▲ **Source 2:** A range of factors determine a person's wellbeing.

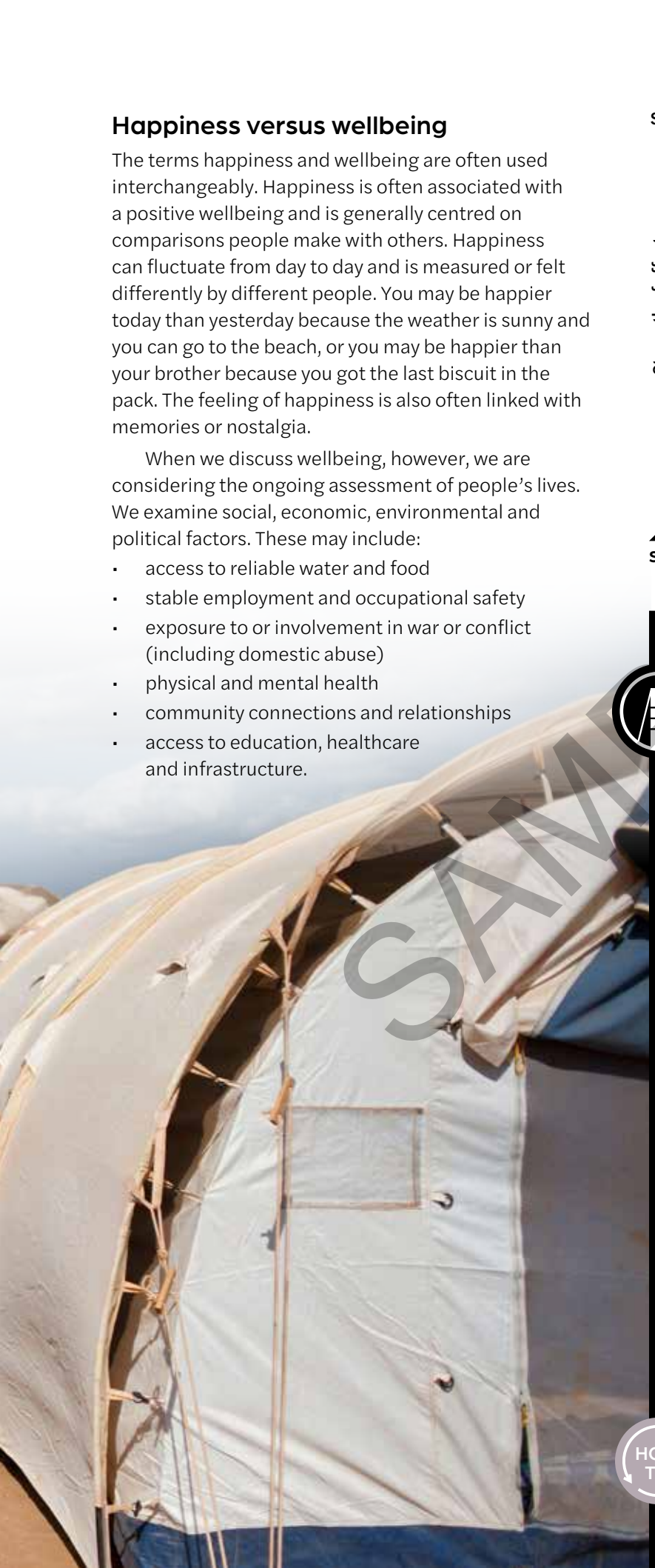
Source 1: Happiness and wellbeing are determined by a range of factors including local climate, living conditions, safety and freedoms. Ahmed, from Kismayo in Somalia, lives at the Dadaab refugee camp in Kenya. He is a political refugee and receives a ration card and a tent to live in. However, like thousands of other refugees, he is not allowed to live or work outside the refugee camp. His situation has a strong impact on his wellbeing.

Happiness versus wellbeing

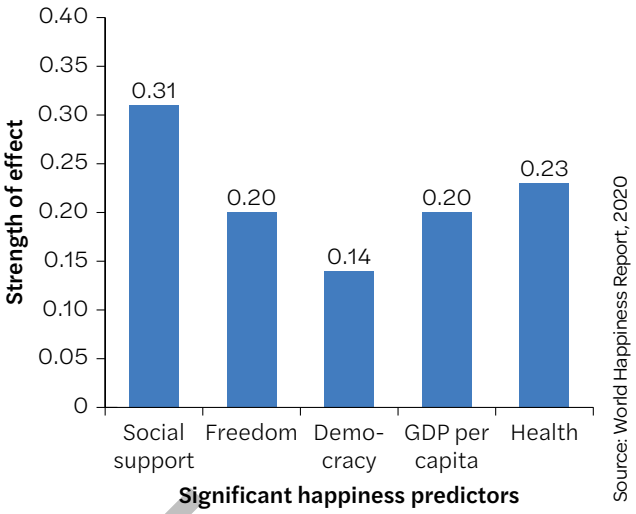
The terms happiness and wellbeing are often used interchangeably. Happiness is often associated with a positive wellbeing and is generally centred on comparisons people make with others. Happiness can fluctuate from day to day and is measured or felt differently by different people. You may be happier today than yesterday because the weather is sunny and you can go to the beach, or you may be happier than your brother because you got the last biscuit in the pack. The feeling of happiness is also often linked with memories or nostalgia.

When we discuss wellbeing, however, we are considering the ongoing assessment of people's lives. We examine social, economic, environmental and political factors. These may include:

- access to reliable water and food
- stable employment and occupational safety
- exposure to or involvement in war or conflict (including domestic abuse)
- physical and mental health
- community connections and relationships
- access to education, healthcare and infrastructure.



Significant predictors of happiness in 124 countries



Source 3: A range of factors predict human happiness.

Learning ladder 8.1

Characteristics of places and environments

1. List four factors that contribute to human wellbeing.
2. Create a mind map highlighting factors in your life that you associate with day-to-day happiness.
3. Explain why happiness and wellbeing may differ between people and place.
4. Sources 1 and 2: What are the factors highlighted in Source 2 that impact Ahmed's wellbeing.
5. Imagine you are part of a research group measuring happiness and wellbeing in Australian teenagers. List two primary methods and one secondary method you could use to gain data to answer your research question. Evaluate whether the primary or secondary data would be more effective in understanding the wellbeing of Australian teenagers.

Interconnection

1. Source 1: How is Ahmed's wellbeing affected as a refugee living in a camp?
2. Source 2: Explain how family and friends are interconnected with wellbeing.
3. Source 3: Which are the main predictors of happiness? Suggest why they are important.

HOW TO Interconnection, page 410

8.2

How is human wellbeing measured?

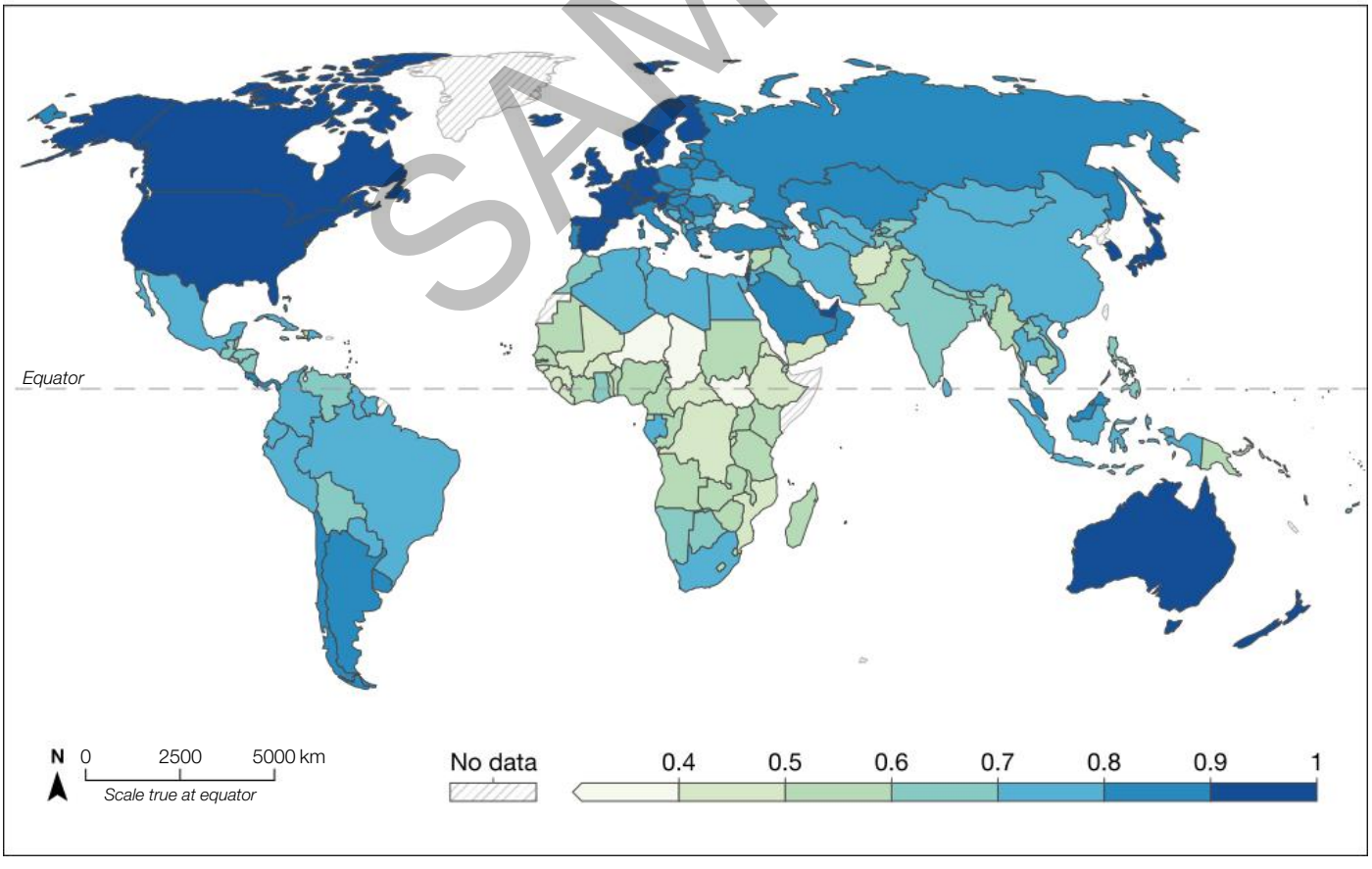
Given that so many factors influence a person's wellbeing, we cannot simply measure wellbeing by a country's GDP or by surveying someone's happiness. Instead, many frameworks measure wellbeing using a range of objective and subjective factors.

Objective factors are those that can be measured using numerical data such as counts or percentages. Objective measurements normally focus around health, wealth and education. On the other hand, **subjective measures** tend to be more opinion-based. Communities may be asked to rank their happiness on a scale from 0 to 10, or may self-report mental health or life satisfaction. While objective measures may provide analysts with a more scientific and quantitative view of a country's wellbeing, subjective measures can be just as important.

Since 1990, the Human Development Report has provided objective data for United Nations to analyse human development and compare the human wellbeing of around 190 countries and territories. As part of the report, the **Human Development Index (HDI)** measures the key dimensions of human wellbeing based on gross national income per capita, average years of education and average life expectancy

Source 1: Human Development Index (HDI) data for 2021 on a global scale. HDI is a summary measure of key dimensions of human development: a long and healthy life, a good education, and having a decent standard of living. Scores are between 0 and 1 and higher values indicate longer life, better education and a higher standard of living.

Human Development Index, 2022

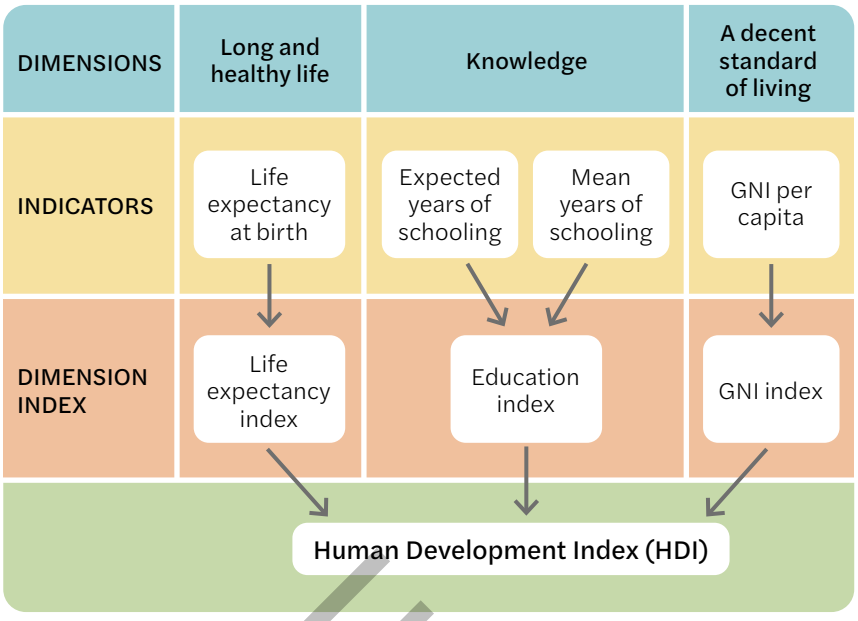


Source: Our World in Data

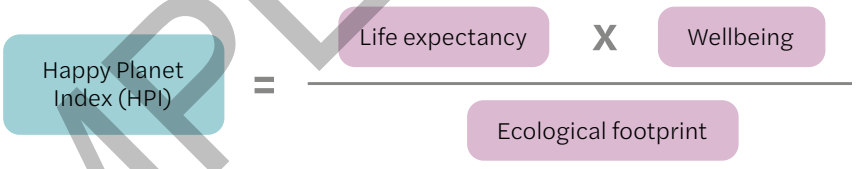
(as an indicator of health). HDI data can be graphed and mapped to help visualise patterns of wellbeing and development on a various scales. Countries like Australia where the lifespan, education level and gross national income are higher are rated at the highest levels of the HDI.

The Happy Planet Index (HPI) is another example of a wellbeing measurement that takes both objective and subjective factors into account. The HPI combines three wellness indicators for each country: life expectancy, wellbeing (based on subjective life satisfaction surveys), and ecological footprint (the average amount of land needed for each person to sustain a country's average consumption).

The Happy Planet Index measures sustainable wellbeing by ranking countries by how they deliver long and happy lives using Earth's limited environmental resources. The results provide geographers with different data and distributions that can be used by policymakers to help improve their community's health and wellbeing.



▲ **Source 2:** Flow diagram indicating how the HDI is calculated



▲ **Source 3:** Diagram indicating how the HPI is calculated

Learning ladder 8.2

Characteristics of places and environments

1. Source 1: Identify three countries with the highest Human Development Index (HDI) scores and three with the lowest scores.
2. Describe how HDI measures the characteristics of a country's wellbeing.
3. Why do some countries score higher on HDI than others?
4. How does a country's ecological footprint influence its ranking on the Happy Planet Index (HPI)?
5. How might an increase in education and healthcare access impact a country's HDI ranking over time?

HOW TO Place, page 408

Place

1. Source 1: What is Australia's Human Development Index rating?
2. How would the HDI of a country influence its characteristics?
3. Consider the three key dimensions of the HDI: a good education, decent standard of living and living a long and healthy life. Do you think there are any other key factors missing from this list that would have an impact of human wellbeing or development? Provide at least one suggestion of another key factor that should be considered for future reports.
4. Choose one country represented in the Human Development Report (https://hdr.undp.org/data-center/country-insights#/ranks). Click on your country of interest. Using the 'Country Insight' data and trends, predict how this country's development may continue to change in the future.

8.3

How does economic wellbeing vary on a global scale?

We live in an unequal world of 'haves' and 'have nots'. Combinations of economic, social, technological, political and environmental factors are the reasons for spatial variations between and within countries.

An unequal world

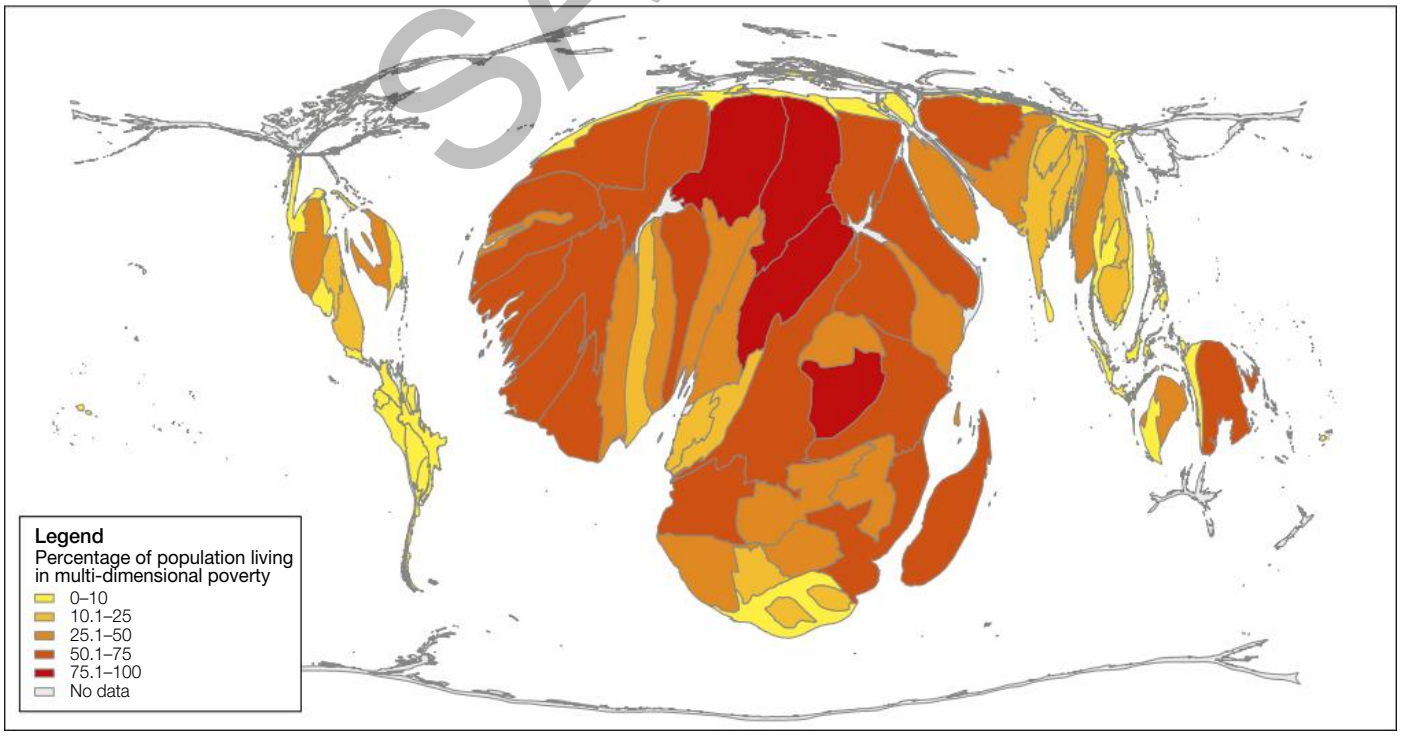
Economic inequality, or the gap between rich and poor, is the uneven distribution of income and economic assets (wealth). The wealthiest 12 per cent of the population receive approximately 85 per cent of the world's GDP or income, and tend to live in developed countries such as the United States, Western Europe, Japan and Australia. In contrast, the poorer 88 per cent of the world's population receive only 15 per cent of world's income and live in developing countries in Africa, Asia and Central America.

Super-rich

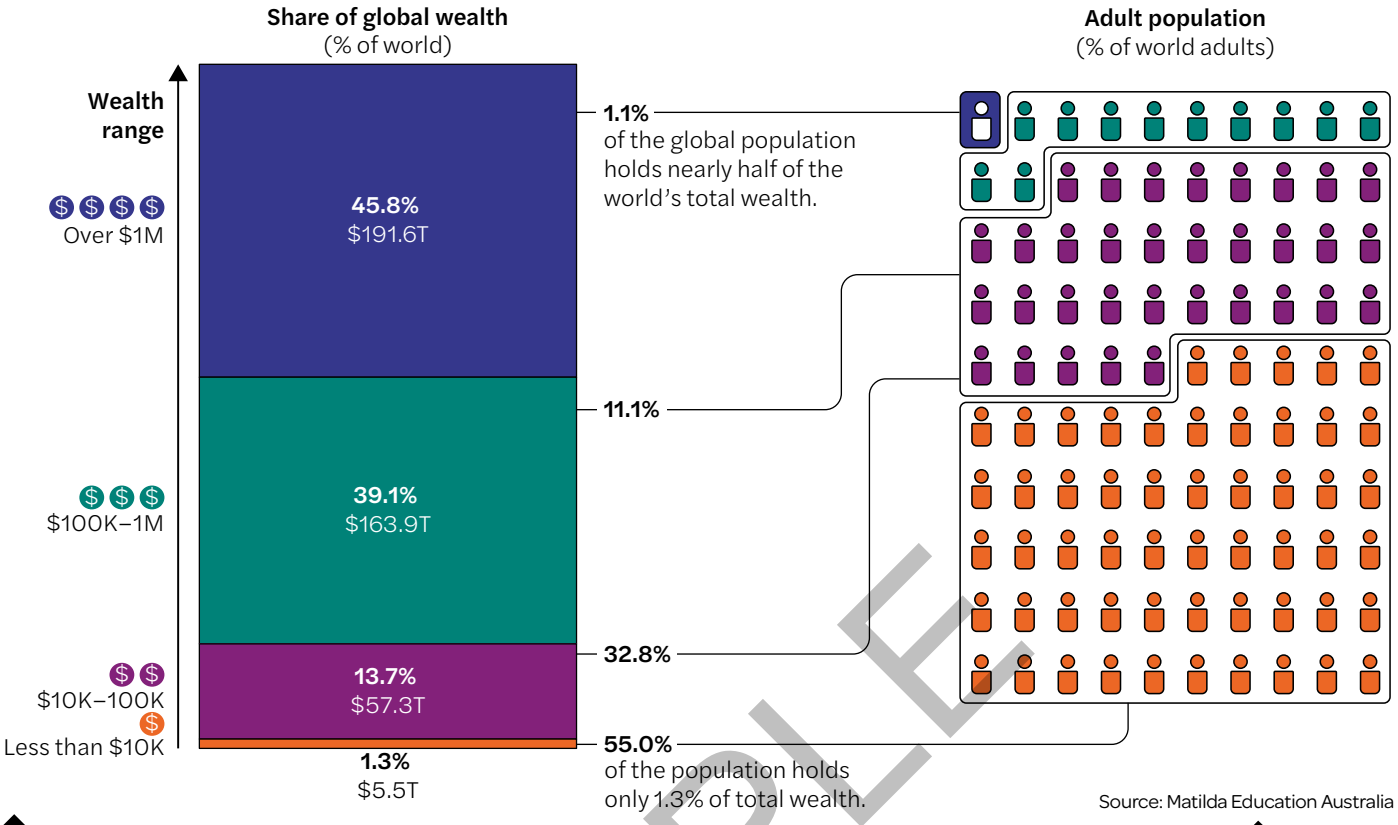
Income and wealth are increasingly concentrated in the hands of a few. In the decade between 2008 and 2018 the number of billionaires nearly doubled. By 2023, eight of the richest people in the world own the same wealth as half of the world (the 3.6 billion poorest people).

Source 1: The Global Multidimensional Poverty Index uses 10 indicators to understand how people are impacted by poverty through health, education and standard of living. People who experience deprivation in at least one third of these weighted indicators are categorised as multidimensionally poor.

Populations living in multi-dimensional poverty



Source: Matilda Education Australia



Source 2: We live in a greatly unequal world where 1.1 per cent of the world's population controls nearly half of all its wealth.

Poverty

Eradicating **extreme poverty** for all people everywhere by 2030 is a key goal of the 2030 United Nations Agenda for Sustainable Development. Extreme poverty is defined as surviving on less than $2.15 per person per day. In the past 30 years there has been a great reduction in extreme poverty. In 1990, 38 per cent of the world's population were in extreme poverty. By 2019, this had fallen to 8.4 per cent.

Sub-Saharan Africa and South Asia have the most people living in poverty. These poor people are predominantly women and children, refugees, members of ethnic minorities, indigenous people, illiterate and unskilled. Many live in war-torn areas, in environments experiencing natural disasters such as floods, and on land that is degraded by soil erosion

Poverty is more than just a lack of money. It encompasses hunger and lack of adequate shelter, clean water, sanitation, health services, basic education and freedom. The Multidimensional Poverty Index (MPI) aims to capture a range of indicators, as people living in multidimensional poverty may not be income-poor, but may lack food, health services, education and clean water. The MPI reflects the intensity of poverty when a person faces a number of deprivations at the same time.

Learning ladder 8.3

Characteristics of places and environments

1. Source 2: How much of the world's wealth is held by just 1.1 per cent of the adult population?
2. How much wealth do super-rich individuals control?
3. Explain why the impact of multidemensional poverty encompasses more than money.
4. Go to en.wikipedia.org/wiki/Multidimensional_Poverty_Index <Hannah to provide URL when able> Rank the MPI indicators from the most valuable to the least valuable indicators of poverty.
4. How would the world change if wealth was distributed more evenly?

Space

1. Where are the world's wealthiest countries?
2. Source 1: Describe the global pattern.
3. Source 1: Explain why this spatial distribution occurs.

HOW TO

Space page 406

8.4

What are the causes and impacts of spatial variations of wellbeing?

Wellbeing across the world is uneven. Economic, social and environmental factors lead to large divisions between countries and within them.

Global and regional variations

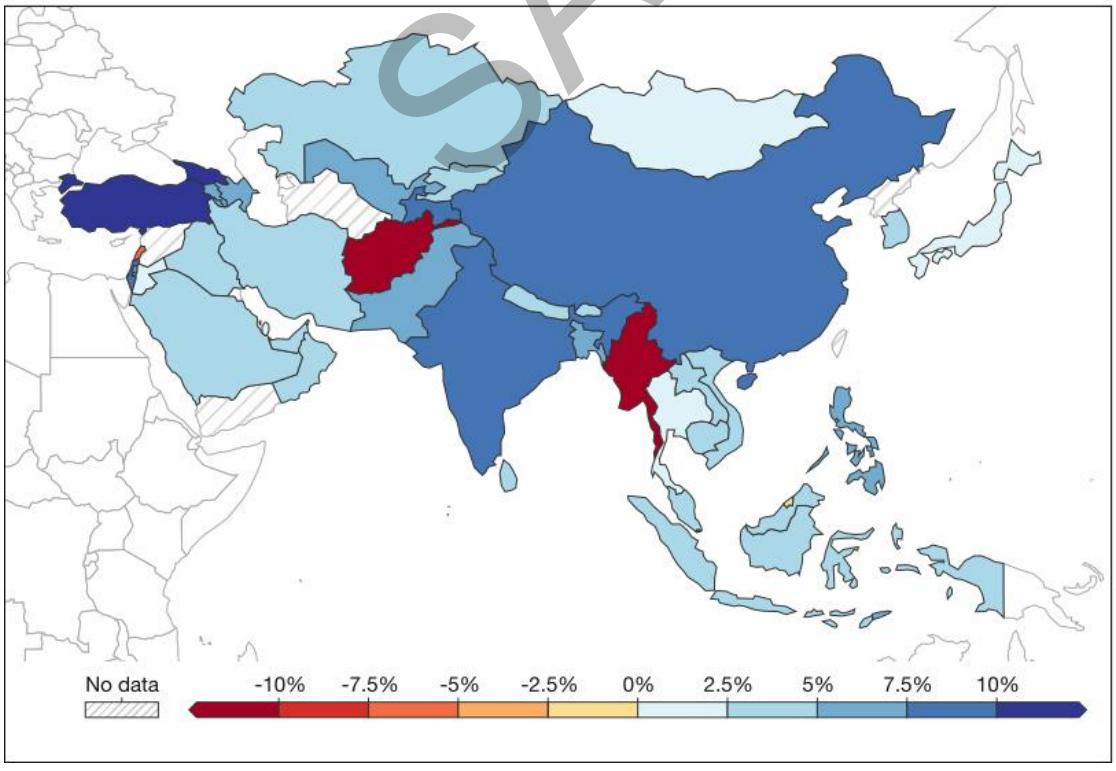
Total factor productivity

Regions or countries with strong economies have higher wellbeing levels due to better job opportunities, higher incomes and improved living standards; with the opposite being true for regions with high poverty rates. Economists believe that total factor productivity (TFP) has led to the differences in wealth across the world. TFP is a measure of the efficiency of an economy to make more money without needing more inputs, such as labour and capital. It is like a baker developing skills and tools to make better cakes, without needing extra ingredients or effort. South Korea's investment in research, development and technological innovation led to increased TFP. This fostered economic growth, a higher GDP per capita and positioned South Korea as a global leader with strong global competitiveness. This positively impacted wellbeing through job creation, education investment, improved infrastructure and more effective social services. Many nations become disadvantaged in the global economy if they cannot make investments into infrastructure and services that drive TFP, due to outstanding debt and a lack of resources, trade agreements and skilled workforce.

Environmental quality

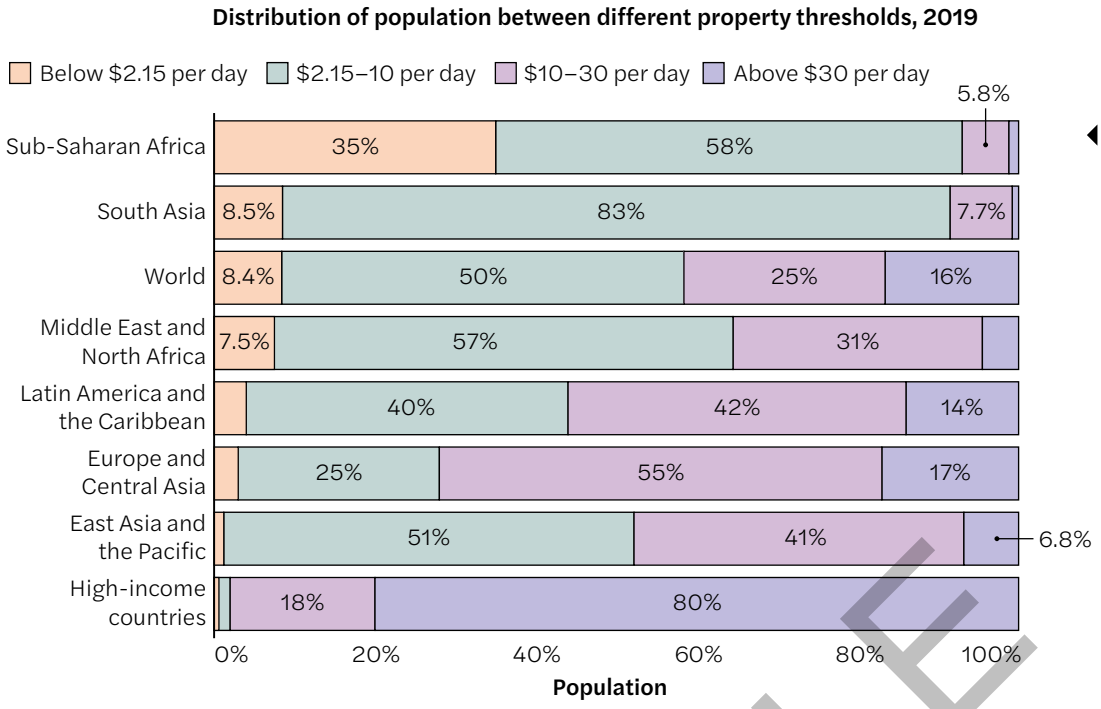
Countries that are rich in minerals, water, a consistent climate and fertile soils are more likely to have a higher wellbeing. These factors make it easier to evenly

Global annual GDP variation, 2023



Source 1: A choropleth map showing global variations of GDP per capita 2023. This highlights how some countries are able to capitalise on Total factor productivity, such as China and India, while poorer nations cannot.

Source: Our World in Data



Source 2: The distribution of populations in regions across the world who live in different levels of income and poverty. This demonstrates that there is a higher rate of extreme poverty in Sub-Saharan Africa, South Asia and the Middle East and North Africa.

Source: Matilda Education Australia

distribute access to food, clean water and employment through the development of primary and secondary industries. Countries that lack these environmental factors, such as Yemen and Somalia, have lower life expectancies and higher food insecurity. Unequal access to resources also leads to conflict over resource ownership, both between nations and within. This can be seen with conflict over oil resources in the Middle East, diamonds in Sierra Leone and forests in Malaysia and Colombia. Desertification and erratic rainfall in regions, seen throughout the Sahel desert in countries like Mali and Sudan, have led to violent water wars. These conflicts have resulted in the deaths of hundreds of thousands of people and threaten the peace and security of communities. Further, locations that are vulnerable to natural disasters, such as earthquakes and droughts, can experience challenges to their wellbeing. This is seen in eastern Nepal, where intense earthquakes in 2015 killed thousands of people, lowered Nepal's GDP, displaced families, resulted in higher unemployment, destroyed houses and infrastructure and led to a decline in tourism.

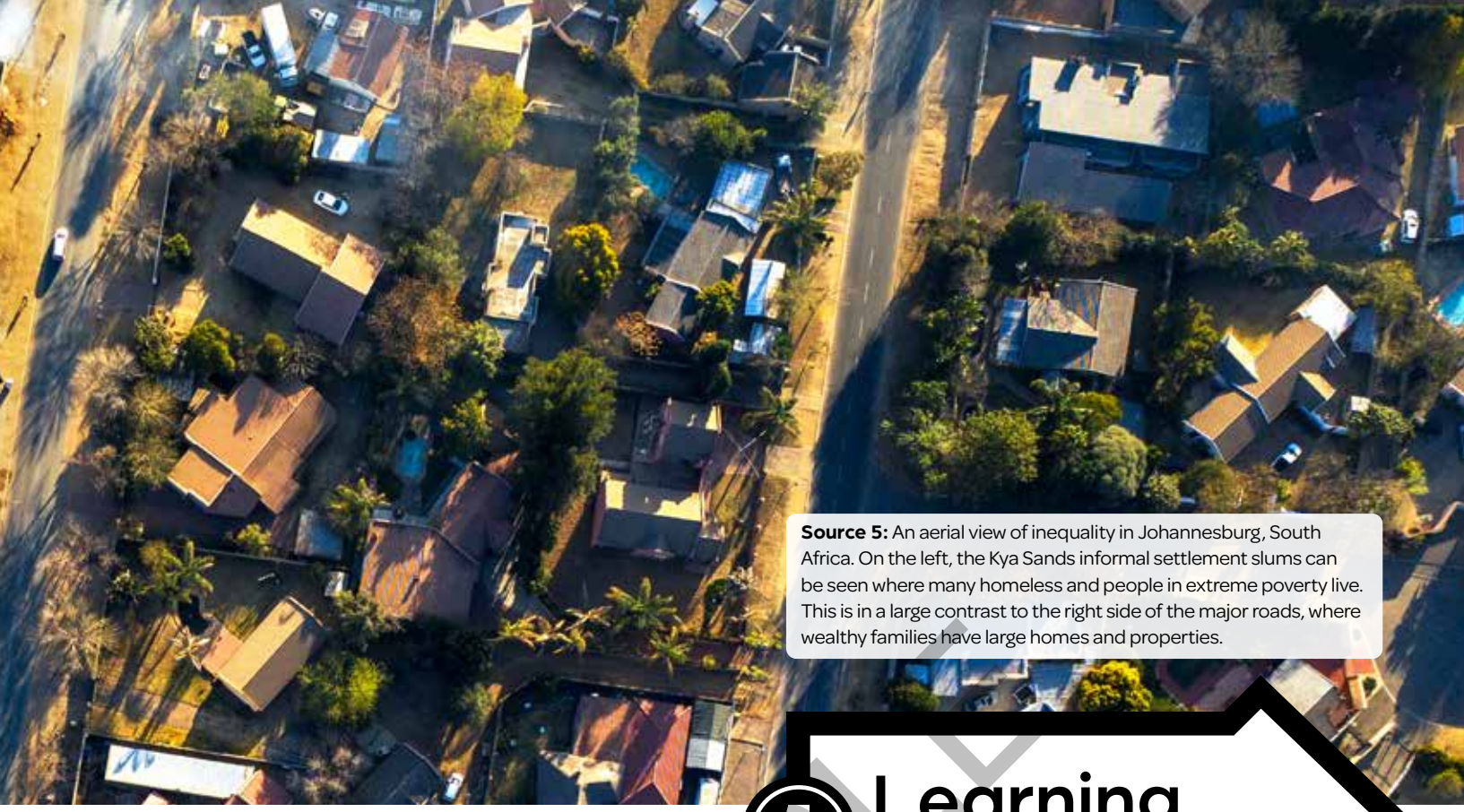
Source 3: A destroyed house in Kathmandu, Nepal, after the 2015 earthquake. Places that experience more frequent or intense natural disasters are more likely to have a lower human wellbeing.

National and local variations

Socioeconomic segregation

Within countries and cities, a division between wealthy and poor spaces occurs. This socioeconomic segregation is caused by a range of factors, including housing prices, transport accessibility and processes such as gentrification. As an example, Johannesburg in South Africa is one of the wealthiest cities in Africa. It serves as a hub for various industries, including technology and entrepreneurship. However, there is significant spatial inequality in the city, reflected in a Gini coefficient of 0.74 (a score that ranges from of 0 [perfect equality] to 1 [perfect inequality]) and the top 5 per cent of households earning 28 times more each year than the bottom 20 per cent. Within the same city, there are 15 000 homeless people that live streets away from over 840 multi-millionaires. The wealthy groups tend to increase housing prices and create gated communities that exclude poorer groups These spaces have higher quality social amenities, community centres, recreational spaces, services and healthcare infrastructure. This division leads to a difference in wellbeing within cities. This process occurs around the world, including in Sydney, New York and Singapore. This division can also be seen when comparing rural to urban areas.

Source 4: A low-caste woman in India cooking in her kitchen. Women and low-caste groups in India experience high rates of prejudice and discrimination, leading to wide differences in the wellbeing of groups across India.



Source 5: An aerial view of inequality in Johannesburg, South Africa. On the left, the Kya Sands informal settlement slums can be seen where many homeless and people in extreme poverty live. This is in a large contrast to the right side of the major roads, where wealthy families have large homes and properties.

Prejudice and discrimination

Prejudice, the concept of pre-judging someone based on characteristics such as their race or gender, can severely impact social cohesion and contribute to social exclusion, social unrest and higher rates of crime and discrimination. In India, a person's gender and the caste they belong to affects their wellbeing. Women are subject to many traditions that impede their quality of life, such as forced child marriages, dowry burnings, unpaid work, illiteracy and extreme poverty. About 8 million female foetuses have been aborted over the past decade, as selective abortion occurs when people value a son over a daughter. An estimated 6.8 million fewer girls will be born between 2020 and 2030 due to this practice of female infanticide. People born into the lowest Dalit caste in India are also more likely to face discrimination in accessing education, employment and social acceptance. This is especially the case in isolated rural villages and regions with lower access to quality education and police authority such as in many northern states. High rates of prejudice and discrimination to Indigenous groups across the world further create spatial variations in wellness. Racism towards First Nations people contributes to higher rates of lower mental health, lower educational successes, higher rates of poverty and homelessness and a high representation in the prison population (about 30 per cent).

Learning ladder 8.4

Processes that transform people, places and environments

1. What are the main factors contributing to uneven wellbeing across the world?
2. Describe the environmental factors in determining the wellbeing of a country.
3. Explain the concept of total factor productivity (TFP) and how economists link it to global wealth disparities. Refer to South Korea in your answer.
4. Source 5: Explain the concept of socio-economic segregation and how it leads to variations of human wellbeing in cities.

Scale

1. Source 1: Describe the spatial variations of income growth across the world in 2023.
2. Source 2: Explain how three factors have contributed to the distribution of poverty thresholds around the world.
3. Create a diagram that displays different variations of human wellbeing on a global, regional, national and local level.
4. Analyse how variations in national and local wellbeing collectively contribute to global disparities in quality of life.

HOW TO

Scale, pages 416, 423

How does population growth and change impact human wellbeing?

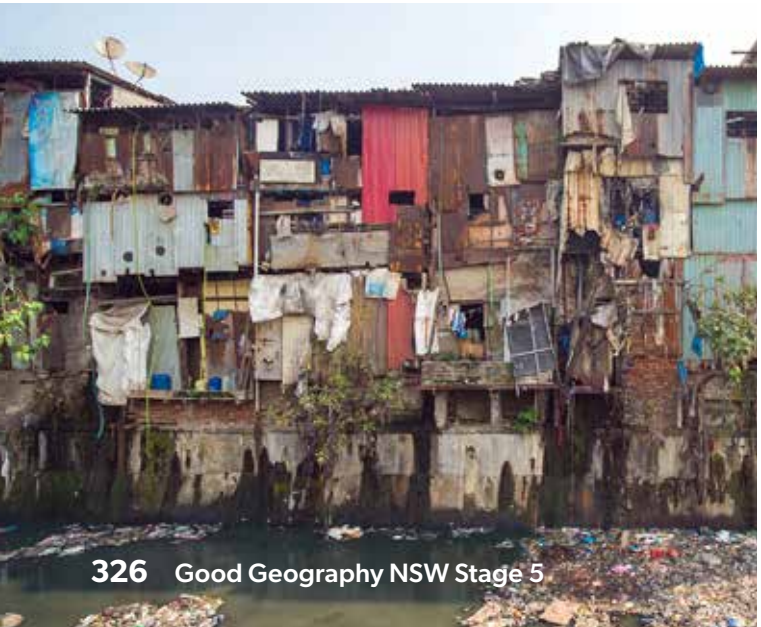
Housing and infrastructure

Increasing populations increase demand for housing and infrastructure, such as transport and sanitation systems. Often increasing population can lead to rapid urbanisation, as people move from rural areas to seek work in the cities. If this happens too rapidly, it is difficult to develop the infrastructure and housing required for everyone. This can result in issues with housing affordability and in many megacities of the world, results in the development of informal settlements and slums. In India, 49 per cent of the urban population live in slums. These are self-made dwellings that are overcrowded, unstable and lack access to services such as electricity or water. This impacts the wellbeing of these communities as the poor living conditions can result in widespread diseases, the consumption of unsanitary water, illegal and unsafe electricity circuits, minimal job opportunities and reduces the opportunity for children to access an education.

Resource availability

Increasing population sizes can affect the availability of important resources such as water and food.

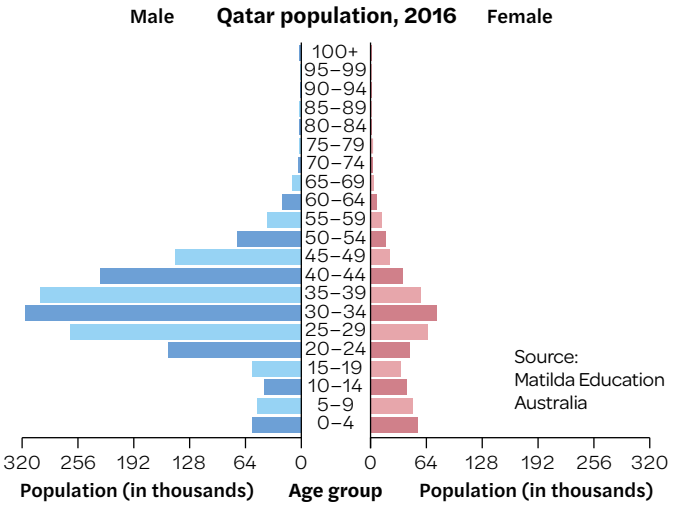
Source 1: An impoverished slum in Mumbai, a city in India. These slums are densely populated, with insecure housing that have little to no access to infrastructure such as electricity and clean water.



Growing demand for resources can result in higher prices to access them. In addition to this, as populations grow and urbanisation reduces agricultural land, there is less food able to be produced to support growing populations.

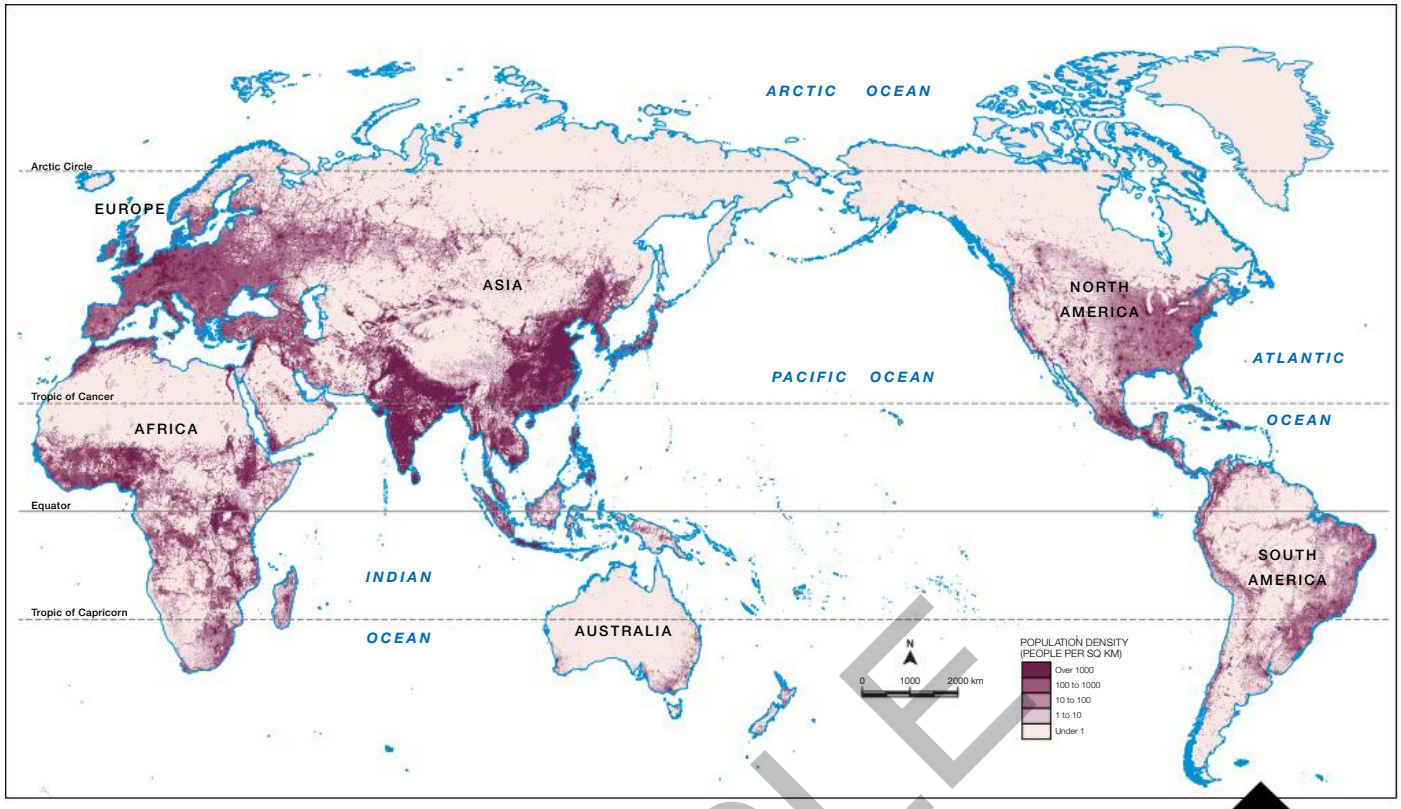
Health

An increase in life expectancy and a reduction of the fertility rate and **infant mortality rate** improves wellbeing as people are able to live longer and in healthier conditions. It also adds to population growth and increasing **population density**. This is the number of people found per square kilometre. The higher the population density, the more likely transmissible diseases are to spread through populations. This was seen in New York during the COVID-19 pandemic, where the close living quarters and strong use of public transport in the city contributed to the high transmission of COVID-19. This resulted in immense pressure on medical systems in the city during the pandemic and led to over 45 000 deaths.



Source 2: A population profile of Qatar, a country in the Middle East. This graph shows the number of females and males in each age group. There are significantly more men in each age group than there are women. This can make it difficult for men to find wives and can affect the types of services availbe to women in these cities.

Global population density



Source: Matilda Education Australia

Source 3: Dot distribution map of population density, the number of people per square kilometre in a country or place. A higher population density can result in overcrowding, limited resources and higher disease transmission.

Social dynamics

Changes to the composition of a population can contribute to social and political challenges. To reduce overpopulation, China introduced the one-child policy in 1980. This led to widespread female **infanticide** as it was more culturally valuable for families to have boys. As a result, the population of China now has an uneven distribution of males to females and a high ageing population. The government amended the policy to a two-child policy in 2016 in an attempt to overcome these social challenges.

Many countries in the Middle East also experience an uneven male to female ratio, due to the high migration of skilled men to countries such as Qatar. This can affect the ability for men to find female partners and affect community wellbeing. Other challenges can be a high age-dependency ratio. In Japan there are a high number of elderly that are economically reliant on the working-age groups (15–64) to maintain the economy. Many low-income countries, such as Nigeria and Somalia, experience a high young-dependency ratio as a result of their high birth rates. This means the working age group experience pressure to work and run the economy to support the funding of healthcare, education and welfare for the large number of children in the country.

Learning ladder 8.5

Perspectives of people and organisations

1. Define 'population density' and its impacts on human wellbeing.
2. Explain how China attempted to control its population to improve wellbeing.
3. Source 2: Explain how the gender distribution of Qatar affects the wellbeing of both men and women. Refer to statistics from the population profile.
4. What challenges does Japan face due to a high age-dependency ratio?

Space

1. Source 1: How do living conditions in Indian slums impact the wellbeing of the population?
2. Source 3: Describe the spatial pattern of population density in the world.
3. Explain why population dense cities such as New York are more vulnerable to disease transmission.
4. Compare the impact of population issues in low income and high income countries on wellbeing.

HOW TO

Space, page 406

How do I use population profiles to show human wellbeing?

How do I interpret a population profile?

Population profiles have horizontal bar graphs that represent the number or percentage of persons in each age group. The bars are divided to show male statistics on one side and female statistics on the other. For example in the population profile for Italy in Source 1, 4.0 per cent of the population were males aged 50–54. As the population is 58 870 762, we can use this information to learn that there were approximately 2 354 830 men aged 50–54 in Italy in 2023.

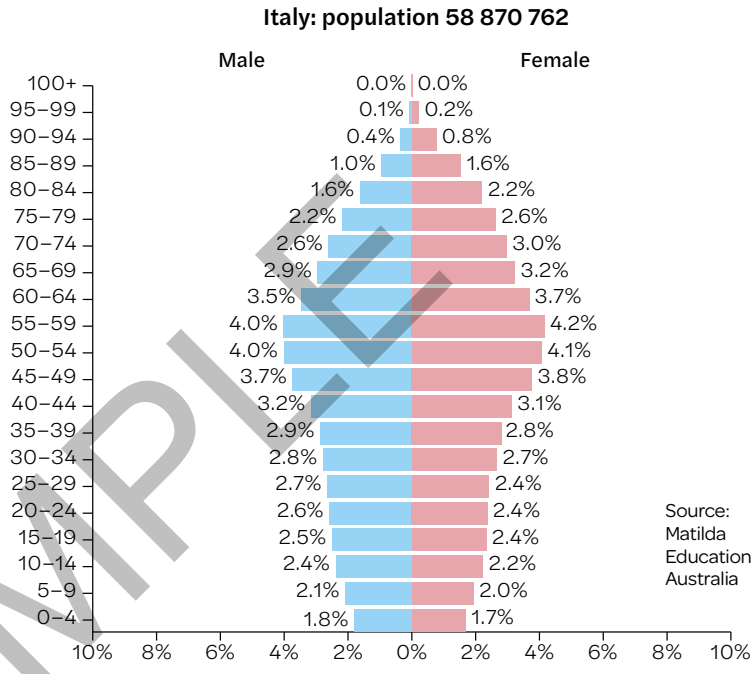
How can I use population profiles?

Assessing the level of development

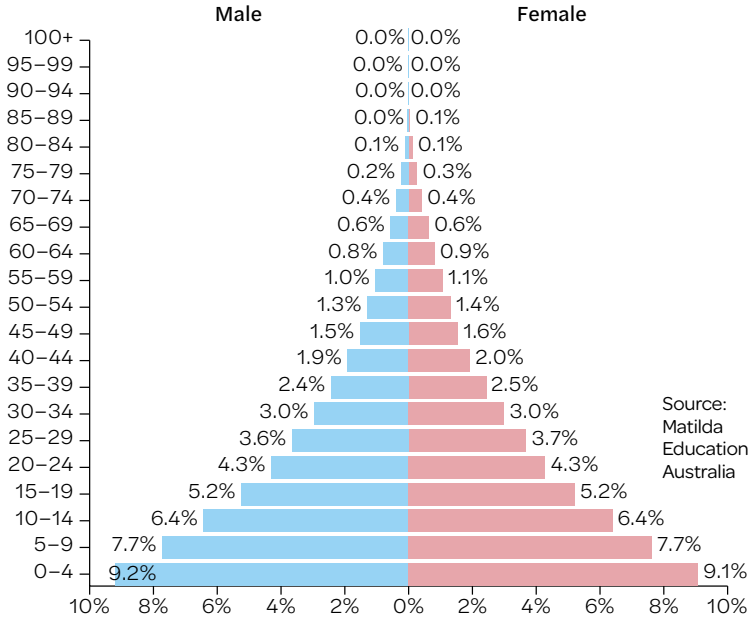
Interpreting the shape and distribution of population profiles provides a lot of information. For example, a profile with a wide base and narrow top suggests a high birth rate, high child mortality rate and low life expectancy, such as the Democratic Republic of Congo in Source 2. Whereas a profile with a narrow bottom and heavy top indicates a low birth rate and high life expectancy, such as Italy in Source 1. From this it can be inferred how developed or economically advanced a nation is, as a longer life expectancy and lower birth rate usually indicate effective healthcare and family planning systems.

Identifying challenges

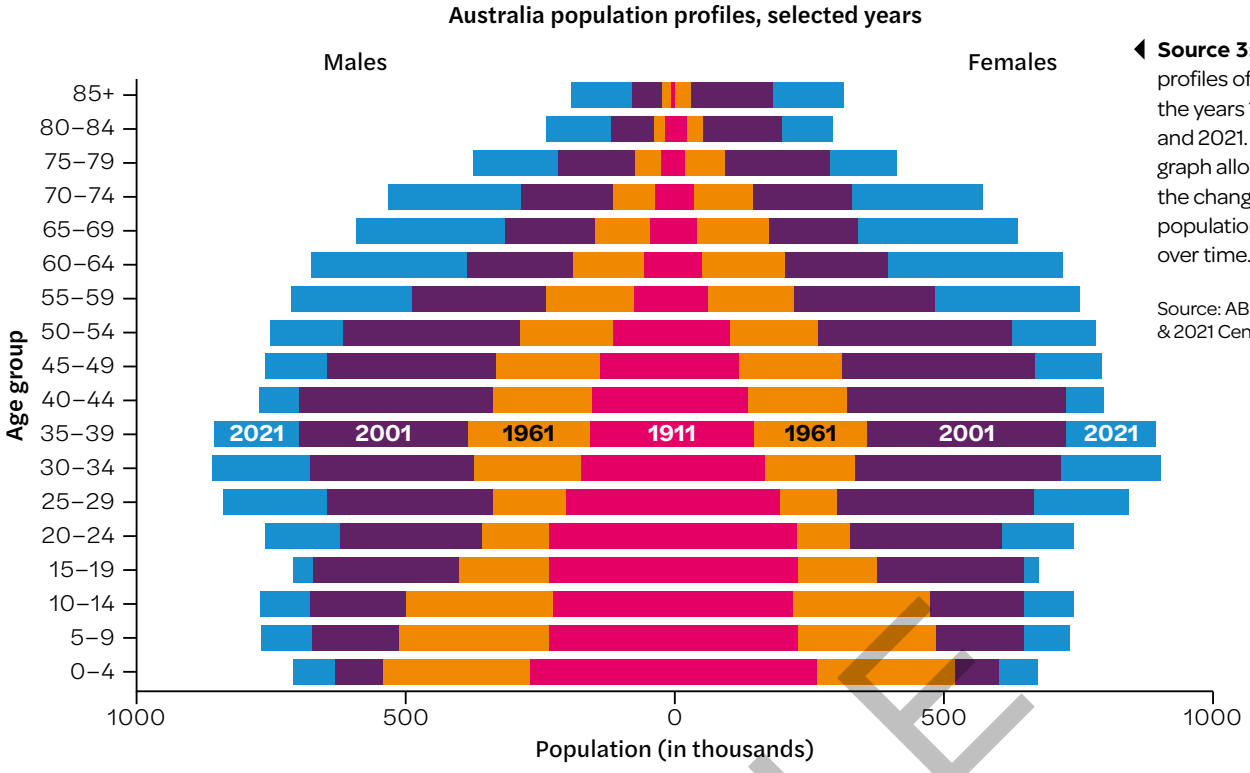
Looking at a population profile also displays challenges facing a place, such as their **age dependency ratio**. This is how many people are the working ages of 15–64 compared to the population that depend on them, such as the elderly and children. A country such as Italy in Source 1 has a high age dependency ratio, as there are a large number of elderly that rely on a smaller working age group to keep the economy



▲ **Source 1:** Italy population profile, 2023



▲ **Source 2:** Democratic Republic of Congo population profile, 2023



Source 3: Population profiles of Australia in the years 1911, 1961, 2001 and 2021. This collective graph allows us to see the changes to the population of Australia over time.

Source: ABS, 1911, 1961, 2001 & 2021 Censuses

functioning. This has been used in the past by nations to implement policies to increase their future working age group, such as Australia's baby bonus policy that paid families for each child they had.

Looking at change

Comparing the population profiles of a country over time can display trends in how the population has changed. The profiles often get larger and the largest age groups usually change from a larger young population to an older one. This can be seen in Source 3 where population profiles of Australia's history are shown in the one graph. Policymakers and demographers can use this information to make predictions about a country or place and implement programs to prevent issues. A famous example of this is the one child policy in China, which aimed to reduce the rapid population growth in the country.

Learning ladder 8.6

Representing and communicating information

1. Describe what a population profile is and how it can be used.
2. Source 2: Describe the age and sex distribution for Democratic Republic of Congo.
3. Sources 1 and 2: Compare the population challenges of the Democratic Republic of Congo and Italy.
4. Source 3: Explain changes in Australia's age and sex distribution over time.
5. Use the information in the table provided to construct a population profile of China.

HOW TO Population profiles, page 440

Age group	Male (%)	Female (%)
0–4	2.3	2.0
5–9	3.3	2.9
10–14	3.4	2.9
15–19	3.1	2.6
20–24	3.0	2.6
25–29	3.2	2.8
30–34	4.1	3.7
35–39	4.1	3.8
40–44	3.6	3.4
45–49	3.5	3.4
50–54	4.3	4.3
55–59	4.0	4.0
60–64	2.6	2.7
65–69	2.5	2.8
70–74	1.9	2.2
75–79	1.1	1.3
80+	0.6	0.8

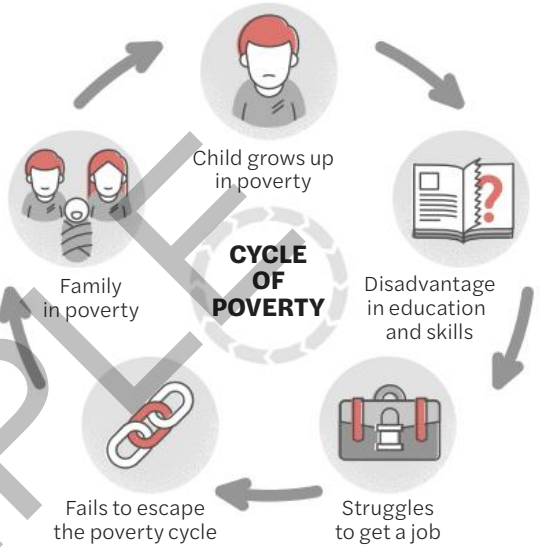
How does poverty impact human wellbeing?

Poverty is strongly interconnected with wellbeing. We often link poverty with economic hardship brought about by lack of or inability to work, however poverty can stem from a range of factors from access to education to global warming.

Patterns of poverty

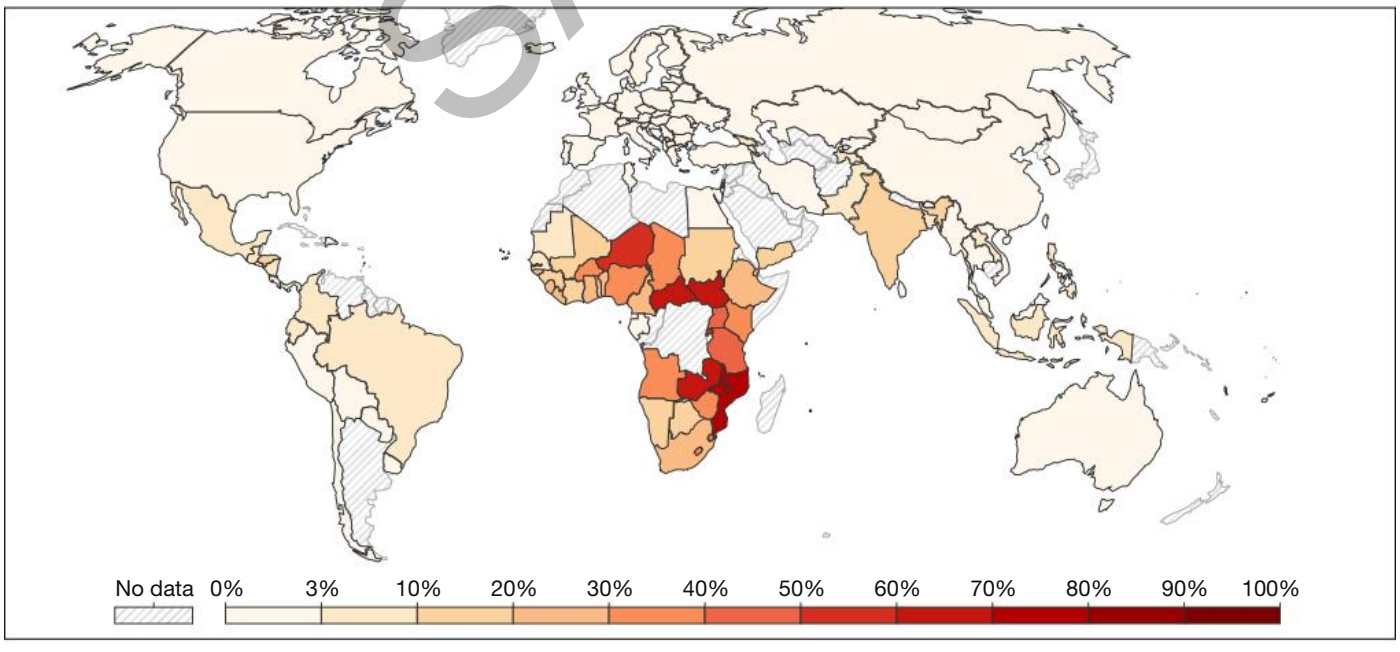
The United Nations (UN) describes poverty as 'more than the lack of income and productive resources to ensure sustainable livelihoods. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion, as well as the lack of participation in decision-making'. While the rates of extreme poverty have halved in the last 30 years, around the world more than 800 million people still live on less than US$1.25 per day.

Global warming is also going to have a huge impact on global poverty rates. In 10 years, it is estimated that our changing climate will force 68–132 million more people into extreme poverty. Currently, over 132 million people who are living in extreme poverty are located in high-flood-risk regions. As sea levels rise, these people will become climate refugees.



▲ **Source 1:** Poverty is strongly interconnected with lack of access to education. More than 70 per cent of adults who live in poverty have only limited education, meaning they are more at risk of unemployment and are less able to provide for their families.

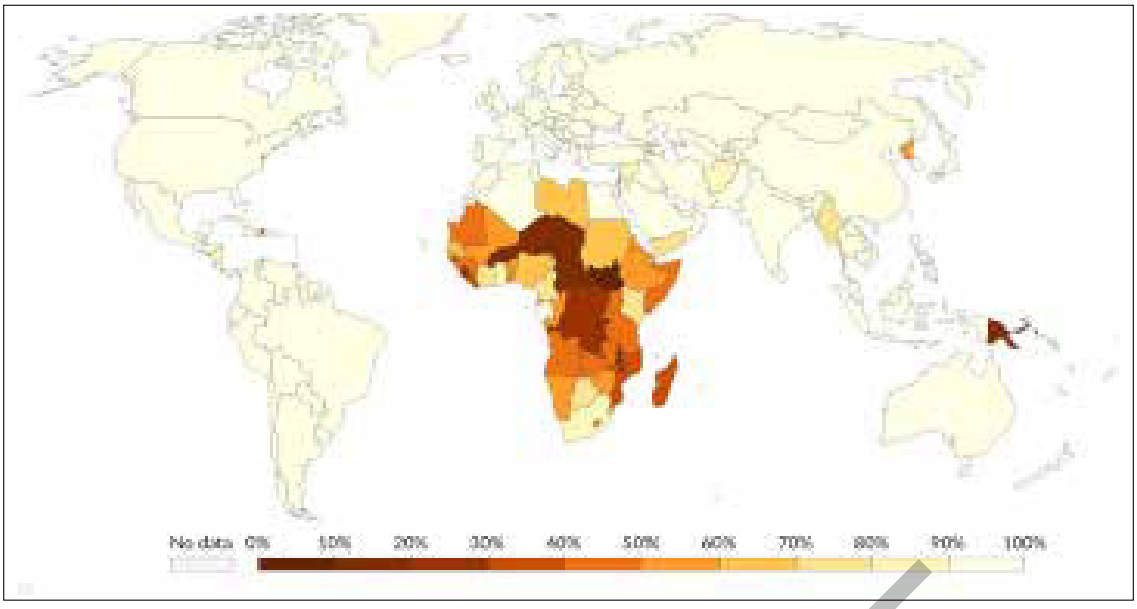
Share of population living in extreme poverty, 2022



Source: Our World in Data

▲ **Source 2:** Extreme poverty on a global scale has declined greatly from the last generation, however it is still a major issue especially in some Sub-Sahara African regions.

Electricity access, 2022



Source: Our World in Data

Source 3: Percentage of the population with access to electricity in 2022

Energy poverty

While the term 'poverty' is usually closely connected to finances, there are other shortages that can affect people, such as a lack of electricity or 'energy poverty'. Researchers estimated that, in 2019, 10 per cent of the world's population did not have access to electricity and more than 2 billion people did not have access to safe cooking fuels. As a result, these communities are exposed to toxic indoor pollution from alternative, unsafe fuels and have limited health care (because electricity is required to provide high-quality health care). Unsafe cooking fuel inhalation is responsible for more than three million deaths per year globally.

Source 4: Poverty is sometimes linked only with LEDCs. However, it is estimated that in 2022 over 3.3 million (13.4 per cent) Australians lived below the poverty line, of which 761 000 are children (16.6 per cent).

Learning ladder 8.7

Processes that transform people, places and environments

1. List three potential factors that may lead to poverty in someone's lifetime.
2. Describe how poverty is interconnected with human wellbeing.
3. Source 1: How would the wellbeing of a child stuck in the poverty cycle be impacted by a charity such as The Smith Family.
4. How could someone change the poverty cycle? What challenges would they face in trying to achieve this?

Space

1. Source 3: State the region most impacted by poor access to electricity.
2. Source 2: Using PQE, describe the spatial distribution of the population living in extreme poverty in 2021.
3. Source 2: Explain why this spatial distribution occurs.
4. Imagine you are a charity set up to assist children to better access education.
   - **a** List three countries you would target. Provide rationale for your selection.
   - **b** Analyse how the charity's money would be best spent to help the most children access education in these nations.

HOW TO
Space, page 406

Case study

What is the scale of poverty in Los Angeles?

Homelessness is a symptom of poverty and an inability of authorities to provide income and shelter to the poor. Skid Row in Los Angeles (LA) is the largest concentration of homeless people in one location within the USA.

Homelessness in Los Angeles

Of the four million people who live in greater Los Angeles, 75 000 were homeless every night in 2023, an increase of 9 per cent between 2020 and 2023. Although Los Angeles has fewer homeless people than New York, a greater percentage live 'rough' or 'unsheltered' – on the streets, in derelict abandoned buildings or at transport hubs rather than temporary shelters for the homeless. The greatest concentrations are in Los Angeles City.

What is Skid Row?

Skid Row was officially established in 1976 by Los Angeles city officials as an area to 'contain' the homeless in one location, an area of one square kilometre a short distance from the city centre. The area had already developed as a magnet for the homeless over many years. Within Skid Row, being homeless and living on the streets in makeshift shelters was tolerated, there was less policing and enforcement of laws that made lying down or sleeping in a public space a criminal offence, and services for the poor such as soup kitchens were concentrated. Since that time, despite efforts to increase the supply of emergency shelter in Los Angeles, homelessness has grown as a result of increasing unemployment and has spread beyond the 'official' limits of Skid Row. A more concerning statistic is the increasing death rate of LA's homeless and the concentration of homicide victims among the homeless – comprising 21 per cent of the city's total homicide rate.

Causes of poverty and homelessness

Unemployment, low incomes and the increasing rental costs caused by a housing shortage are the main causes of homelessness in LA. People who lose their jobs cannot pay rent and those on low incomes cannot

Source 1: Homeless population counts in Los Angeles City

Year	City of Los Angeles		
	Total	Unsheltered	Sheltered
2023	46 260	32 680	13 580
2022	41 980	28 458	13 522
2021	No count conducted due to COVID-19		
2020	41 290	28 852	12 438
2019	36 300	27 221	8 944

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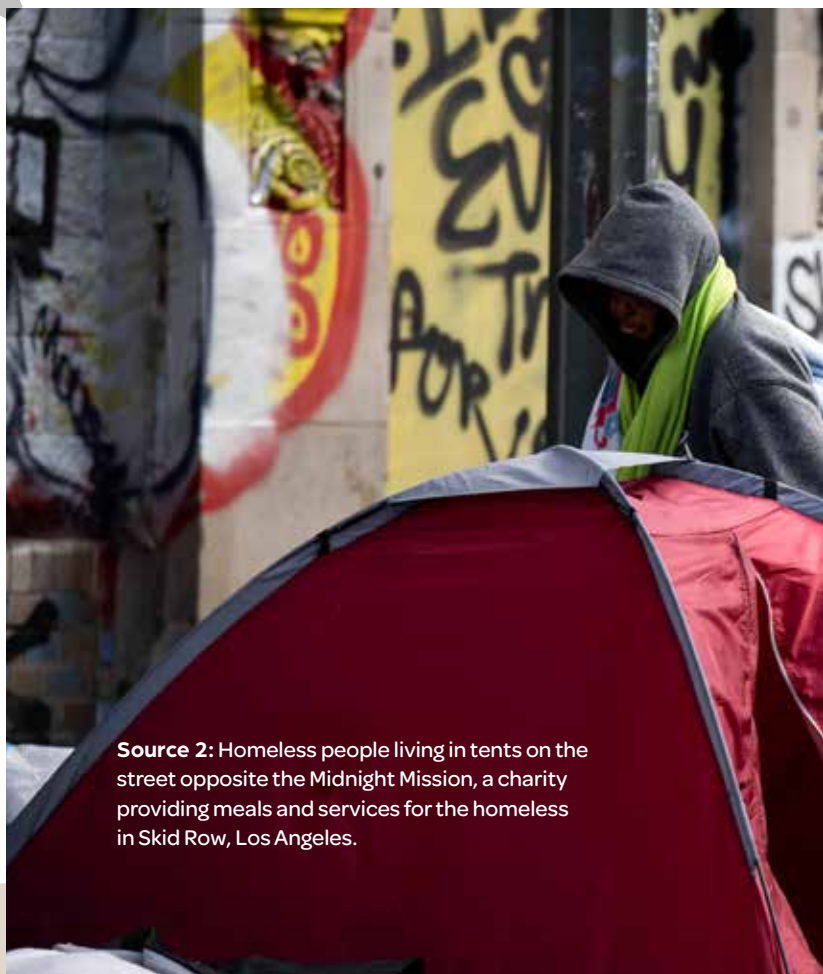
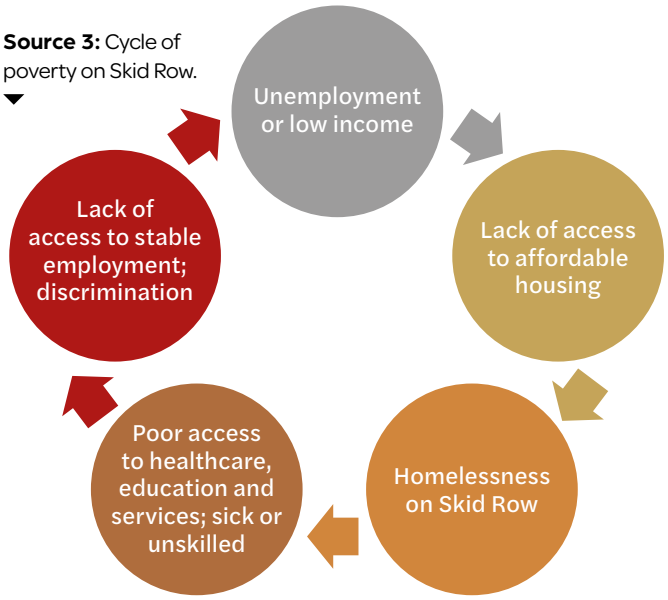


Source 2: Homeless people living in tents on the street opposite the Midnight Mission, a charity providing meals and services for the homeless in Skid Row, Los Angeles.

Source 3: Cycle of poverty on Skid Row.



afford increasing rents. Most housing in LA is privately owned and is rented at the market rate and the supply of subsidised government housing is very limited. It has been reported by the US Government Accountability Office that for every rent increase of $100 in LA there is a 9 per cent increase in homelessness. Being homeless sets in place a cycle of poverty that is hard to escape.

At increasingly high risk of homelessness is another 900 000 Los Angeles residents who spend over 90 per cent of their income on rent. The homeless come from a diversity of backgrounds however black Americans (56 per cent), Latinos (24 per cent), drug addicts, the disabled and mentally ill are among the population groups most represented in Skid Row.

Is there a solution?

Improving the wellbeing of the homeless on Skid Row is focused on housing rather than reducing poverty and helping people to break out of a cycle of poverty. In other large wealthy US cities such as New York and Boston, where more housing is provided, only 3 per cent and 5 per cent of the homeless respectively are sleeping 'rough'. In 2023 over 22 000 LA homeless were given temporary housing through an increasing supply of shelters and programs such as Inside Safe that uses motel accommodation.

There are different perspectives on how to solve the housing crisis and improve the wellbeing of those on 'Skid Row. These include providing a basic wage, the decentralisation of Skid Row to spread the provision of services equally among city precincts to a revitalisation and redevelopment of Skid Row as a more liveable place without displacing the homeless.

Learning ladder 8.8

Characteristics of places and environments

1. What is Skid Row? Refer to its location and features in your response.
2. How is homelessness in Los Angeles different to other major US cities, including New York City?
3. Source 1: Compare the population of homeless people in LA City in 2019 and 2023, including the proportion living in sheltered and unsheltered places.
4. Source 3: Explain how living on Skid Row can trap people in a cycle of poverty.

Interconnection

1. What is the link between poverty and homelessness?
2. Source 2: Describe the wellbeing of people living in the type of shelters seen in the photograph.
3. Suggest why LA officials chose to create Skid Row as an official location for homeless people rather than address the causes of homelessness.

HOW TO
Interconnection, page 410

8.9

How does health influence wellbeing?

A healthy life requires clean water, sanitation, a balanced diet and the right to health services. Unfortunately, millions of people do not have access to doctors, hospitals and life-saving drugs. Most of these people live in developing countries.

Poor health and poverty

Good health eludes the majority of the world's population. HIV/AIDS, diarrhoea, tuberculosis, malaria and pneumonia kill most people living in developing countries. However, poverty is both a cause and a consequence of poor health. Poverty increases a person's chance of suffering from poor health, as they are unable to afford doctors' fees and drugs. Others living in remote rural areas are unable to obtain and cannot afford transport to a health centre.

Poor people living in developing countries tend to live in overcrowded, substandard housing, lacking sanitation and clean water. Under these conditions diseases spread rapidly. This is the case in the favelas of Rio de Janeiro in Brazil and slums in Mumbai.

Other factors contributing to poor health:

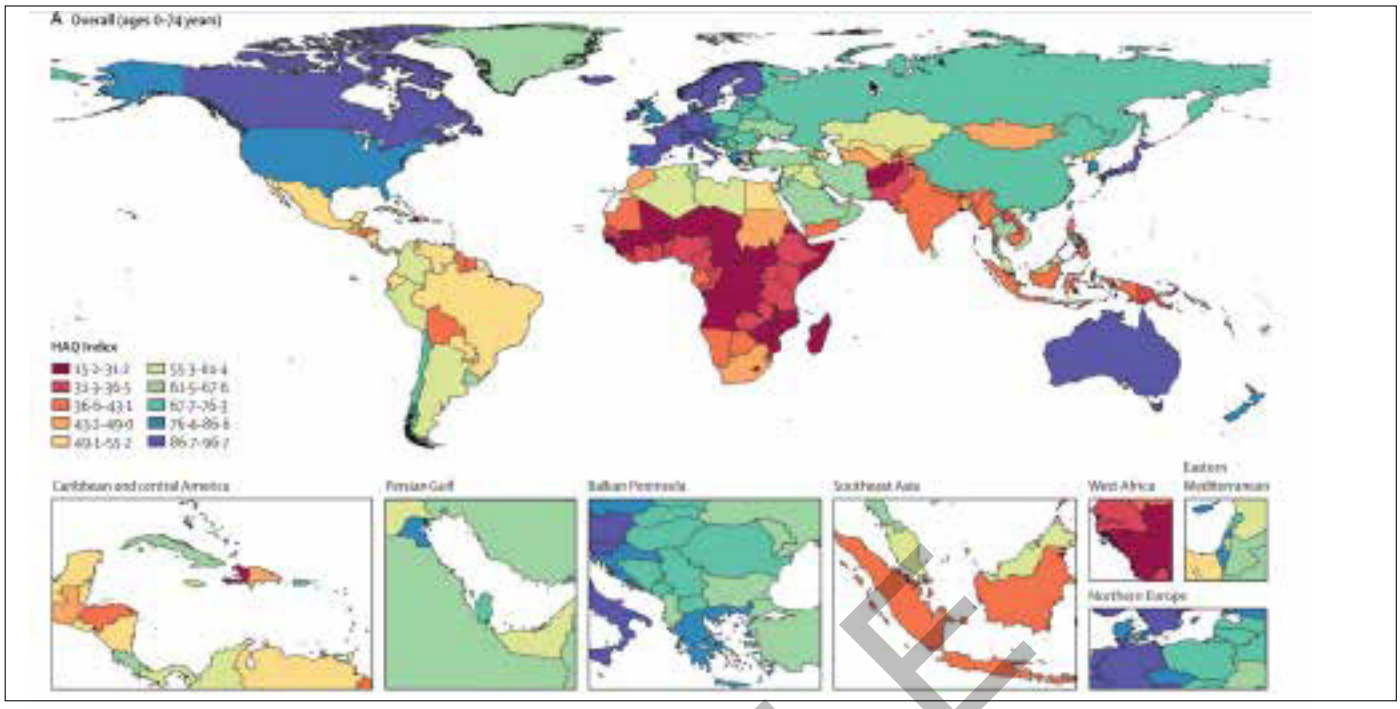
- **Lack of education:** people are unaware of the causes of diseases, and as a result are unable to prevent their spread. The education of women improves children's nutrition and hygiene, and as a result, their health.
- **Malnutrition:** poverty leads to malnutrition when money is unavailable to purchase adequate and nutritious food.
- **Cost:** on average, most developed countries spend 5.5–8 per cent of their **gross domestic product** on health, while the poorest of developing countries spend 1–3 per cent. The differences in health expenditures are reflected in the quality of health systems (e.g. hospitals) and the population's health indicators (e.g. life expectancy and **infant mortality rate**).
- **Environment:** the environment can greatly affect heath; e.g. in Nigeria, health deteriorated as oil pollution in the Ogoniland area contaminated drinking water and ecosystems, and the health of many Egyptians is affected by thousands of factories polluting the air with lead and poisonous gases.

Source 1: Somalian women with children queue for medical attention at a medical clinic.

Source 2: Doctors per 10 000 people for selected countries

Somalia	Cambodia	India	World	China	Australia	Uruguay	Sweden	Cuba
0.6	2	7	17	24	41	62	71	84

Healthcare Access and Quality index, 2019



Source: XXXXXXXXXXX

Source 3: The Healthcare Access and Quality (HAQ) Index is measured on a scale from 0 (worst) to 100 (best) based on death rates from 32 causes of death that could be avoided by timely and effective medical care.

- **Work:** employment in environments with hazardous asbestos and toxic industrial waste leads to a decline in health. In Potosi, Bolivia, most of the population do not live beyond 40. They suffer from silicosis and other forms of lung poisoning, caused by working in the mines.
- **Lifestyle:** diet and exercise can greatly impact on health; e.g. South Pacific Islanders have high rates of diabetes, a result of eating processed food that is high in fats, salts and sugars; lung diseases from smoking; and cirrhosis of the liver from drinking alcohol.

Indicators that measure health

Health indicators are included in the Healthcare Access and Quality Index (HAQ in Source 3), Human Development Index (HDI on page 318) and Multidimensional Poverty Index (MPI on page 320). Organisations such as World Vision and the Global Fund and government departments such as the Australian Department of Foreign Affairs work to improve health.

Of greatest concern globally is a fear of emerging new infections against which humans have little immunity. For example, in Vietnam thousands of chickens were killed to stop the spread of avian flu. In West Africa, Ebola has become a major health issue. Poor health systems in the region have contributed to its spread.

Learning ladder 8.9

Characteristics of places and environments

1. List three measurements used as health indicators.
2. Describe the links between poor health and poverty.
3. How can a lack of education influence someone's health?
4. Collect and annotate photographs of health facilities in developing countries in Africa or Asia. Compare these facilities with those in Australia.

Place

1. Source 1: Where are these women queuing for medical services?
2. Source 2: How many doctors are available for the population in Somalia in Africa?
3. Source 2: How does the number of doctors available to the population in Australia compare to other countries?
4. Source 3: Explain the HAQ Index for Somalia and Australia. What factors have impacted the results for these two countries?

HOW TO Place, page 408

Case study

How does malaria impact health and wellbeing?

Malaria is a disease transmitted by female mosquitoes when they bite a person to feed on their blood. Malaria seriously impacts the wellness of millions of people, particularly in Africa where it is a leading cause of illness and death.

Spatial patterns and trends

Nearly half of the world's population is classified as 'at risk' of malaria. The countries with populations most vulnerable to infection are in tropical regions with hot, wet climates and water surfaces where mosquitoes lay their eggs and larvae grow. In 2021 there were 247 million reported cases and 77 per cent of deaths due to Malaria were children under five years of age, mostly in Sub-Saharan Africa.

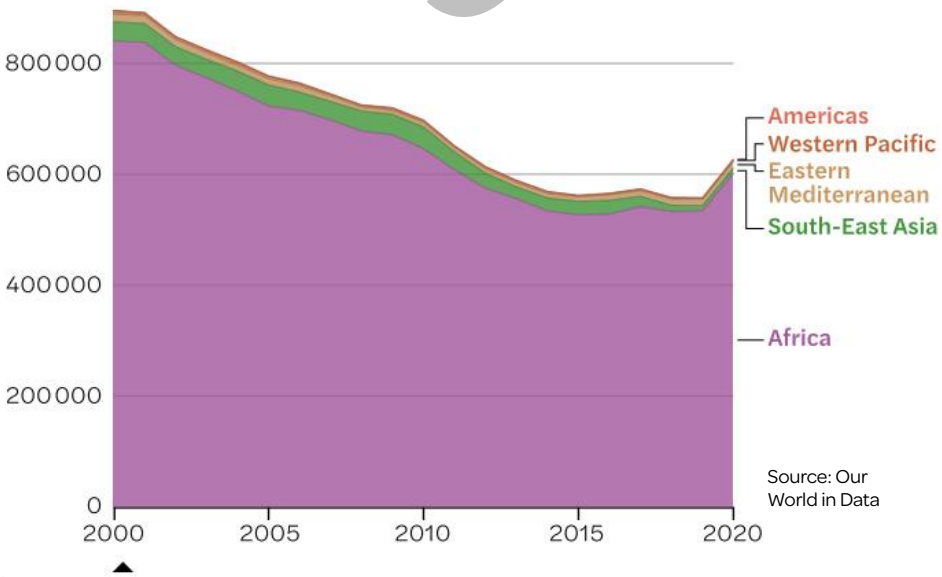
Malaria has been eradicated from much of the world, however it remains endemic (consistently present) across large areas and many places without current cases remain highly vulnerable to infection and transmission. According to the 2020 World Malaria Report report, 29 countries accounted for 96 per cent of malaria cases globally and just four countries – Nigeria (27 per cent), the Democratic Republic of Congo (12 per cent), Uganda (5 per cent) and Mozambique (4 per cent) – accounted for almost half of all cases worldwide.

Malaria and human wellbeing

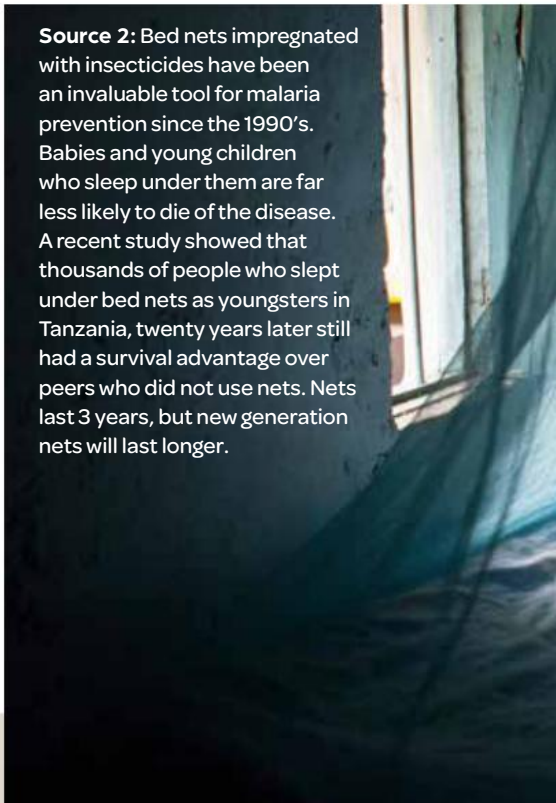
Malaria is debilitating when it causes fever, chills, headaches, nausea, muscle pain and fatigue and life-threatening when it disrupts blood supplies to vital organs. Consequences of non-treatment include kidney failure, seizures, mental confusion, coma and death.

Productivity, food security and education are impacted by Malaria and reinforce a cycle of poverty in poor countries where Malaria is still prevalent. The poorest fifth of the world's population carries the burden of almost 60 per cent of global cases each year.

Malaria deaths by world region, 2020



Source 1: Estimated annual number of deaths from malaria by region.



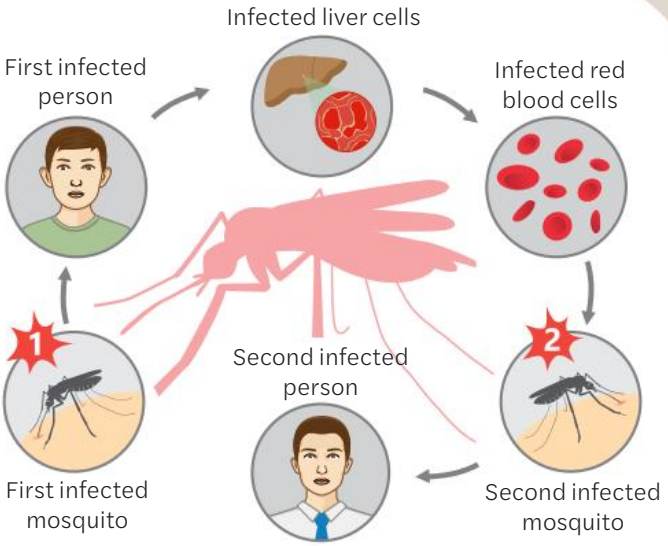
Source 2: Bed nets impregnated with insecticides have been an invaluable tool for malaria prevention since the 1990's. Babies and young children who sleep under them are far less likely to die of the disease. A recent study showed that thousands of people who slept under bed nets as youngsters in Tanzania, twenty years later still had a survival advantage over peers who did not use nets. Nets last 3 years, but new generation nets will last longer.

Illness prevents people working. For farmers, this means less food production and for children, not attending school. The poor are less able to access medical supplies and if poorly educated, may not understand the preventative measures needed to reduce infection rates in their communities. Countries with high rates of Malaria generally have lower GDP and spend their healthcare budgets on treating malaria patients rather than addressing other healthcare and social needs.

Improving wellbeing

United Nations Sustainable Development Goal 3 'Ensure healthy lives and promote wellbeing for all ages' and Target 3.3 to end epidemics and tropical diseases including malaria by 2030, have become the focus of global, regional and national health and research organisation work. Successful interventions include:

- insecticide-treated mosquito nets (ITNs) that shorten mosquitoes' lifespan and ability to transmit malaria
- indoor residual spraying (IRS) to kill mosquitos that land on inside walls using a rotation of different insecticides to prevent insecticide resistance
- rapid diagnostic tests (RDTs) to enable fast, cheap and accurate diagnosis of malaria for communities too far from hospitals and health clinics
- seasonal malaria chemoprevention to treat children under five across Africa using a monthly course of medicine during peak malaria season
- vaccines to prevent infections and gene technology to control mosquito numbers.



▲ **Source 3:** A parasite is transmitted via the bites of infected mosquitoes. The parasites multiply in the liver of infected persons, and then infect red blood cells. When a mosquito bites an infected person, a small amount of blood is taken which contains malaria parasites that are injected into the next person bitten.

Learning ladder 8.10

Processes that transform people, places and environments

1. Source 1: In which region of the world do most malaria deaths occur?
2. Source 3: Describe the transmission cycle for malaria.
3. Mind map the ways malaria affects people's health and wellbeing.
4. Suggest reasons why poor countries in tropical locations are least able to eradicate the disease.
5. Weigh up the different approaches for reducing the impact of malaria. Which do you think would be the most effective and why?

Environment

1. How does climate influence the occurrence of Malaria?
2. What are the characteristics of environments where malaria occurs?
3. Explain the interconnection between mosqitoes and tropical environments.
4. Source 2: Analyse the impact of bed nets in reducing illness and death from malaria in tropical environments.

HOW TO
Environment, page 414

8.11

How does safety impact human wellbeing?

Safety is a very important factor determining people's sense of wellbeing. Millions of people around the world live in countries involved in war and civil unrest or in places where their physical safety is at risk from crime or political discrimination.

War and civil unrest

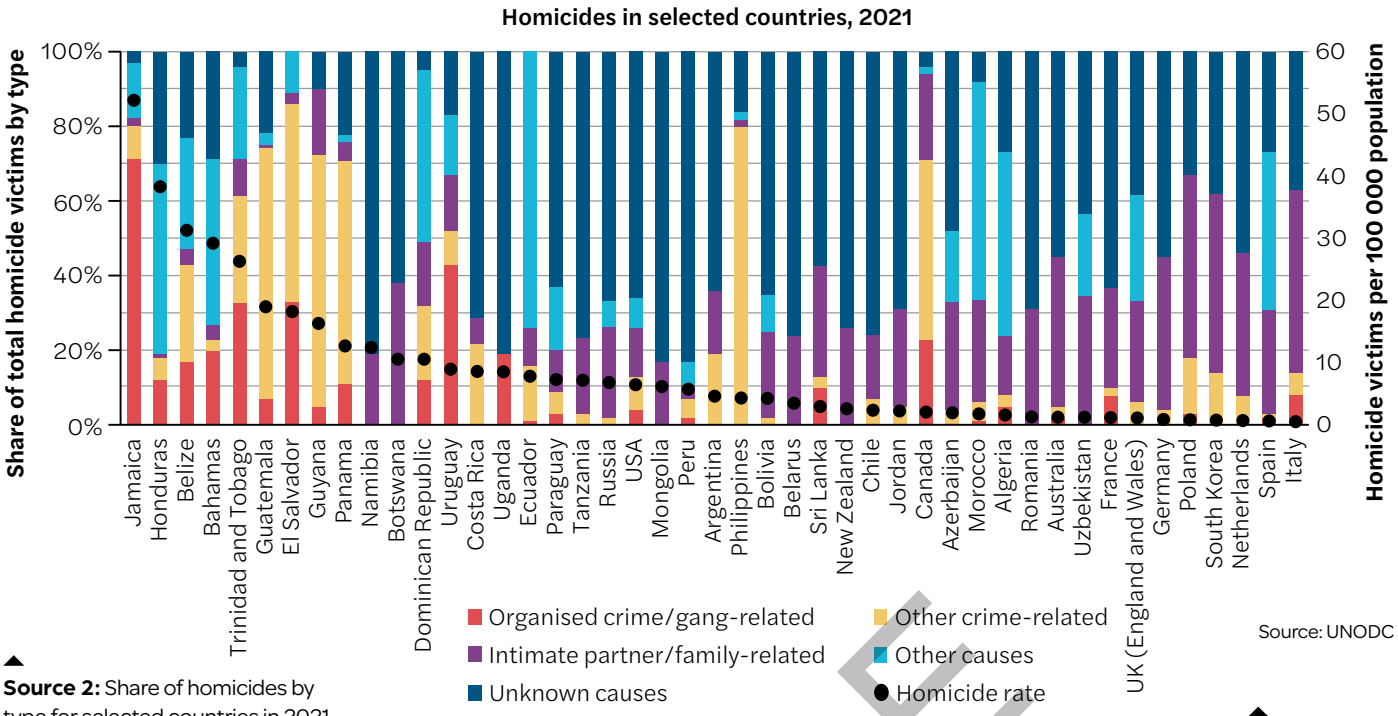
War and civil unrest impacts people's safety and their physical and mental wellbeing. They interrupt access to housing, work, food, education and health care. A nation's infrastructure, such as power plants, bridges, schools and hospitals, can be destroyed through conflicts such as the Russia–Ukraine war that began in 2022 (see page 340).

Persecution, the systematic mistreatment of religious, cultural or political groups, is a further political factor impacting the wellbeing of people. The human rights of groups are violated or threatened because of their political opinion or membership of social group, nationality, race or religion. The safety of minority groups is compromised because of the fear of persecution as a result of who they are or what they believe. Persection can lead to harassment, imprisonment, and violence inflicted by a dominant political or cultural group on minority groups.

War and persection often leads to people fleeing their homes as **refugees** to seek safety and find food and shelter for families. Escape from war and persecution often involves difficult and dangerous journeys to reach safety. In 2022, 108.4 million people worldwide were forcibly displaced due to conflict, persecution, violence and human rights violations. Most never cross an international border and remain as **internally displaced people** (IDP) in their own country. After more than 10 years of conflict, one in every three Syrians remain as IDPs in 2022.

The Australian Government maintains travel advisories for most countries in the world to assist people to travel safely. The highest advisory level is 'Do not travel'. At the start of 2024 the Australian Government assigned the highest warning for 22 countries that it was unsafe to travel to, including Russia, Ukraine, Sudan, South Sudan, Syria, North Korea and Venezuela.

Source 1: Maram camp for internally displaced people in Syria's north-western Idlib province in March 2023



Source: UNODC

Source 2: Share of homicides by type for selected countries in 2021 (or latest available year)

Crime impacts on wellbeing

Wellbeing is under even greater threat from the impacts of crime. On average, 52 people in the world die from intentional homicide every hour. Between 2019 and 2021, there was an annual average of 440 000 deaths from intentional homicide – nearly five times as many deaths as those occurring from armed conflict. In 2021, Africa accounted for 38 per cent of all deaths from homicide, the Americas had 34 per cent, Asia had 24 per cent, Europe accounted for 4 per cent and less than 1 per cent of homicide deaths occurred in Oceania. Just 10 countries accounted for 58 per cent of all homicide deaths in 2021 – Brazil, Nigeria, India, Mexico, South Africa, the United States, Colombia, Pakistan, Russia and Ethiopia.

Nearly 40 per cent of homicides occurring in the world are connected to organised crime and gang-related violence. In 2021, eight of the highest 10 countries for homicide rates in the world were located in Latin America and the Caribbean. Large-scale drug trafficking in the region and the expansion of transnational criminal organisations has resulted in persistently high levels of lethal violence in the region. Jamaica had the highest rate with 58 homicide deaths per 100 000 people. Gang violence in Jamaica is responsible for up to 70 per cent of homicides in that country. Young Jamaican men become involved in generational gang structures, with access to firearms imported from the United States and funded by cocaine and marijuana shipments bound for the United States.

Learning ladder 8.11

Processes that transform people, places and environments

1. List the aspects of human wellbeing affected by conflict.
2. Source 2: In what category were most known homicide victims found in Australia in 2021?
3. Source 1: How would Maram camp meet the needs of Syrian refugees and improve their wellbeing.
4. Explain how crime impacts the wellbeing of people in Jamaica.
5. Analyse the impact of conflict and crime on human wellbeing. What are some strategies that could be employed to reduce their impact on wellbeing?

Place

1. Source 1: Where is this camp located?
2. Source 1: Describe the physical and human characteristics of Maram camp.
3. What characteristics of a place would force people to flee as refugees?
4. Source 2: Analyse the graph. Which country has the greatest share of homicide victims due to gang-related crime? Why is this the case?

HOW TO
Place, page 408

Case study

How has the invasion of Ukraine affected the wellbeing of its citizens?

Impacts on wellbeing

War disrupts every aspect of people's lives and their physical and mental wellbeing including access to shelter, a livelihood, food, education, health care, family and safety. The bombing of major cities in Ukraine destroyed houses and businesses, killed or injured thousands of civilians and destroyed infrastructure such as bridges, schools, shops and hospitals. Many places had become unliveable. In southern cities such as Mariupol, 90 percent of residential buildings were affected by fighting and food and water are scarce.

By September 2023 the UN Human Rights Office had documented over 9600 civilians killed in Ukraine although they believed the actual toll to be much higher. Families were traumatised and torn apart by death or separation when fathers and brothers enlisted to fight. Women, children and the elderly were left to seek safety.

Fleeing to safety

In the early months of the war there was an exodus of millions of Ukrainians. Over 2.5 million internally displaced people (IDPs) fled from cities in the south and west and from the capital Kyiv where bombing was concentrated – to smaller towns and farms in the countryside mostly in the west where they believed they would be safe. This number swelled to over 67 million as the conflict worsened. Those who chose to stay faced living without access to electricity, food, water and medicine because of damaged infrastructure, mined roads and farmland, blocked ports and continuous attacks.

As many as 5 million residents fled as refugees to other European countries, particularly Poland. Some then travelled to overseas destinations such as Australia. Over 50 per cent of Ukrainians that crossed the border into neighbouring countries were from cities in the east and south and 31 per cent were from the Kyiv region.

Evacuees used a network of cars, trains, buses and humanitarian corridors or had to travel on foot via 60 border crossing points to escape. An estimated 1.6 million refugees were forcibly transferred to Russia and forced to renounce their Ukrainian nationality while unaccompanied children were given Russian citizenship and adopted by Russian families.

Aid and livelihoods

Aid efforts by the UN Refugee Agency, host nations, **non-governmental agencies** (NGAs) and foreign nations worked to house, feed, support and employ hundreds of thousands of extra persons amid increasing costs of living caused by the war. Children were enrolled in schools where possible, and refugees sought employment. However, a failure to adequately meet the basic needs of a growing number of refugees in many

Source 1: People cross a destroyed bridge as they evacuate the city of Irpin, northwest of Kyiv, during heavy shelling and bombing in March 2022.

Movement of refugees from Ukraine, 24 February to 5 March 2022

Source 2: Refugees from Ukraine in just 10 days between February 24 and 5 March 2022. Ukraine is a country in eastern Europe that shares a long border with Russia and five other countries (Moldova, Romania, Hungary, Slovakia and Poland).

Source: Matilda Education Australia

European countries meant refugees began returning home to Ukraine, preferring to risk danger than be a refugee struggling to survive in another country. The need to reconnect with or find family was a major factor for a lot of returning residents.

Many civilians caught in the conflict no longer have an income, or it is greatly reduced. Farmers have abandoned fields or downscaled their operations because of limited access to seeds, fertilisers, pesticides, animal feed and fuel. Many refugees who returned home left again because they could not find employment or housing.

Learning ladder 8.12

Processes that transform people, places and environments

1. List the aspects of human wellbeing affected by conflict.
2. Source 2: Describe the movement of refugees from Ukraine into surrounding countries following Russia's invasion.
3. Source 1: Refugees were forced to flee with what they could carry. What immediate needs would they have?
4. Explain how the trauma of war impacts the mental health of children and young people.
5. Analyse the impact of conflict on the population of Ukraine and neighbouring countries.

Change

1. Source 1: Describe how the liveability of Irpin changed in 2022.
2. Suggest why some people moved to Russia when the conflict began.
3. Explain how war changed the wellbeing of millions of Ukrainian people.
4. Justify the change of mind of a refugee who decided to return to Ukraine before the conflict is over.
5. 'War changes people, places and environments.' Analyse this statement using evidence.

HOW TO Change, page 412

8.13

How does access to natural resources impact wellbeing?

Human wellbeing is strongly tied to socioeconomic development. As incomes and opportunities improve, so too does access to education, gender equality and political freedoms. These developments can be fuelled by the sale of natural resources and the associated opportunities this brings. However, the reality is that the road to improved wellbeing is not necessarily straightforward.

For some nations, an abundance of natural resources does not necessarily translate to improved wellbeing; rather, it can have the opposite effect. This curious phenomenon is known as the **resource curse** (or the paradox of plenty). For example, the nations of Venezuela, Zimbabwe, South Africa, Nigeria, Democratic Republic of the Congo and Angola all have an abundance of different types of natural resources, including oil, gas, rare minerals, precious stones and more, yet rank low on many wellbeing and development measures. By contrast, some resource-poor nations, such as Japan, Taiwan and Singapore, are among the world's highest-ranking nations.

The reality of the resource curse is that many factors influence the use of natural resources and the potential wealth they bring. Some may be internal, including political decision making, corruption and government spending priorities – is the country's new-found wealth invested in empowering citizens with education and economic support, or is it channelled into other areas, such as the military? In some cases, money can be used to consolidate political power and influence, leading to civil conflict and instability.

Source 1: Gold miners in the Democratic Republic of the Congo. Small-scale gold mining is a key source of income, but is also targeted by armed rebels.

Source 2: Kanpur in the state of Uttar Pradesh in India has some of the worst air quality in the world.

External factors also play a role, including the presence of foreign investors and multilateral relationships. The very same natural resources that fuel the global economy do not necessarily translate into improved wellbeing for the nations that provide them. Furthermore, extracting natural resources can leave a legacy of environmental degradation that leads to long-term issues, such as erosion, species loss and air pollution.

On a local scale, natural resources can also put strain on communities and the environment. In Moranbah, in central Queensland, regional mining has been linked to high levels of dangerous microscopic dust particles, known as PM2.5, and nitrogen oxides in the air, leading to long-term health risks. Nevertheless, mining remains the economic lifeblood of the community.

Similar cases can be found around the world, but are often heavily clustered in emerging economies. Of the 20 cities with the highest rates of particle matter in the air globally, 17 are found in India, Pakistan and Bangladesh. In the Indian city of Kanpur, PM 2.5 levels reach 173 micrograms per cubic metre of air. For comparison, a level of 1.5 micrograms per cubic metre of air is considered the healthy maximum. The city, located in the Indian state of Uttar Pradesh, is home to significant manufacturing and leatherworking centres.

The impacts on wellbeing and the environment in Kanpur and Moranbah are vastly different, but both are tied to the economic development of each location; the spatial variation between each is a further example of global disparity.

Learning ladder 8.13

Processes that transform people, places and environments

1. What is the 'resource curse'?
2. How is wellbeing generally tied to socioeconomic development?
3. Source 1: Explain why the resource curse impacts wellbeing in countries such as the Democratic Republic of Congo.
4. Conduct further research into a country with a resource curse, such as Sierra Leone, Venezuela or Angola. Discuss the factors that seem to have prevented it from using the resource to improve wellbeing on a national *scale*.

Interconnection

1. Source 2: Why might high levels of dust particles in the air be bad for wellbeing?.
2. Using interconnection, suggest how an abundance of natural resources might benefit a nation.
3. Why might the Democratic Republic of the Congo rank poorly on the Human Development Index despite having significant reserves of natural resources?
4. Compare Kanpur and Moranbah. Explain why both have issues with air pollution, but why the problem is significantly worse in South Asia.
5. Explain why a resource-poor nation, such as Singapore, might experience significantly higher levels of wellbeing and development than a resource-rich nation such as Zimbabwe.

HOW TO
Interconnection, page 410

How is gender linked to inequality and wellbeing?

Being a man or a woman affects every aspect of a person's life, including education, work and social expectations. Many opportunities in life remain out of reach for poor, rural, uneducated females living in developing countries.

Discrimination against women

While some women are free to express their opinions and earn an income equal to men, there are millions who are discriminated against from birth—just because they are female. Sub-Saharan Africa, the Middle East and North Africa have the highest levels of discrimination against women. Many countries within these regions have discriminatory laws in relation to marriage and property rights, or do not provide adequate protection against gender-based violence.

Top ten Global Gender Gap Index countries, 2024

Rank	Economy	Score (0=1, 1=parity)	Score change from 2023	Rank change from 2023
1	Iceland	0.935	+0.023	-
2	Finland	0.875	+0.012	+1
3	Norway	0.875	-0.004	-1
4	New Zealand	0.835	-0.021	-
5	Sweden	0.816	+0.001	-
6	Nicaragua	0.811	-	+1
7	Germany	0.810	-0.006	-1
8	Namibia	0.805	+0.003	-
9	Ireland	0.802	+0.007	+2
10	Spain	0.797	+0.007	+8

Source: World Economic Forum

Source 1: The ten best performing countries in the 2024 Global Gender Gap Index

Global Gender Gap Index

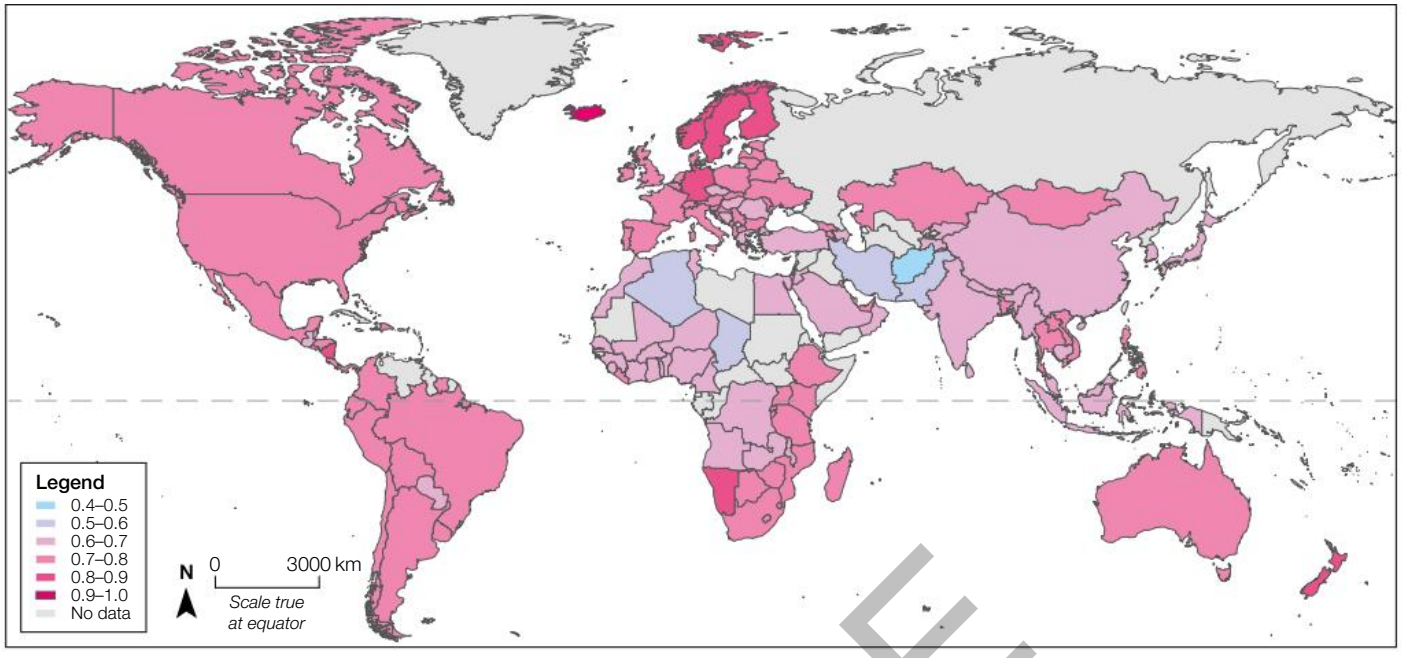
The World Economic Forum's Global Gender Gap Index (GGGI) measures gender inequality. The GGGI ranks countries according to gender gaps by examining four dimensions:

- economic participation and opportunity (e.g. salaries and access to high-skilled employment)
- educational attainment (e.g. access to basic and higher-level education)
- political empowerment (e.g. representation in decision-making structures)
- health and survival (e.g. life expectancy).

All countries were assigned a score between 1 (equality) and 0 (inequality). In 2022 the global average score was 0.681. Iceland was the top performing country with a score of 0.908. Afghanistan was the worst performed country (0.435). Australia was ranked 43rd (0.738) and New Zealand, ranked 4th (0.841).

Source 2: In 2022 the theme for International Women's Day was 'Break the bias'; imagining a gender equal world 'free of bias, stereotypes and discrimination'. Celebrations take place around the world to highlight the political, social, economic and cultural achievements of women.

Global Gender Gap Index, 2022



Source: World Economic Forum

▲ **Source 3:** Global Gender Gap Index for each country. All countries are assigned a score between 1 (equality) and 0 (inequality).

Despite progress in gender gaps, the Global Gender Gap Report noted the following problems:

- excessive number of female deaths in some countries
- differences in girls' access to schooling
- unequal access to economic opportunities (employment and wage gaps)
- differences in the right to be heard.

Learning ladder 8.14

Perspectives of people and organisations

1. What does the Global Gender Gap Index measure?
2. Why would people and organisations use the Global Gender Gap Index?
3. Why do some countries and organisations focus on addressing gender discrimination more than others?
4. Source 2: Why do organisations and communities celebrate International Women's Day?
5. How might governments, businesses and social groups differ in their views on closing the gender gap?

Space

1. Source 1: Countries in which continent are the best performed in equality between sexes?
2. Source 3: Use PQE to describe the global pattern of the Global Gender Gap Index for 2022.
3. Source 3: Suggest reasons to explain the pattern.
4. Reflect on your learning and suggest strategies that could be implemented to reduce the gap within Australia and in an African country. Present your findings as an oral report.

HOW TO

PQE, page 430; Space, page 406

8.15

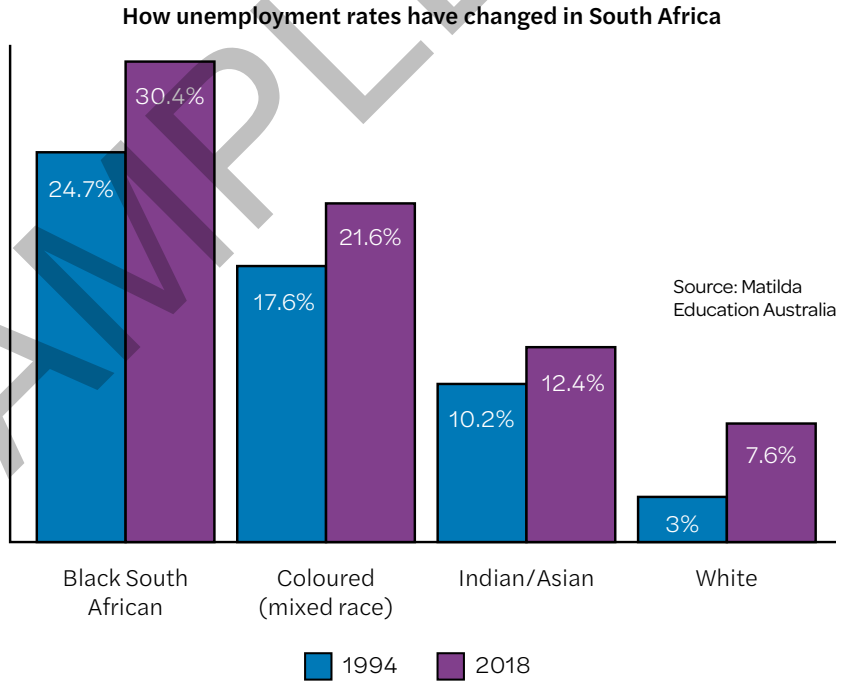
What are the causes and consequences of variations to human wellbeing in South Africa?

South Africa is considered one of the wealthiest and more developed countries in Africa. However, when looked at on a national scale, it is one of the most unequal countries in the world. Many groups across South Africa experience high levels of poverty, unemployment and unequal access to socially valued resources, such as education and healthcare, due to a variety of influences.

Historic influences

Causes

From 1948 to 1994, South Africa experienced a system of racial segregation called Apartheid. Institutions, such as the government, were controlled by white populations who placed political and economic restrictions on non-white people. Key policies, such as the Group Areas Act, forcibly relocated non-white communities to the least desirable and underfunded areas of the country, far from city centres. Policies also restricted non-white populations' access to quality education, healthcare and employment opportunities. As a result, there was little to no investment in areas with high black populations.



Source 1: A graph highlighting the inequalities of unemployment/income between different racial groups in South Africa. Unemployment rates have risen across all groups, but remains significantly higher among black South Africans.

Consequences

Desirable areas have significantly larger white populations and a higher quality of wellbeing, seen in the Gauteng and Western Cape provinces, where people have easier access to employment in cities, higher education attainment rates, longer life expectancies and high incomes. However, many undesirable areas that non-white populations were moved to, such as southern Johannesburg or Eastern Cape, continue to have large black populations and experience poorer wellbeing. These are places that either have low water access, are far from cities or are in the least desirable areas on the outskirts of cities.

Consequently, these areas do not have many sustainable or affordable services and businesses, leading to lower employment, lower educational outcomes and higher crime rates, with 72 per cent of residents in these areas saying they feel unsafe to walk in their community at night. As black populations are more likely to grow up in areas with less education and employment access,

in areas that are less desirable, they often experience **intergenerational disadvantage**. Intergenerational disadvantage is where families who grow up in poverty or disadvantaged areas have less capital to invest in education and healthcare for their children, reducing their opportunity for **social mobility** (to move up social 'classes' and improve their situation). This is in contrast to those who grow up in wealthy families, who often have access to high-quality education and tutoring, social networks and who inherit capital from their families to invest in housing and businesses. Apartheid contributed to intergenerational disadvantage for black groups in South Africa, and this has shaped spatial variations of wellbeing today.

The areas reserved for white populations through the Apartheid system have also had the highest quality investments over time, leading to high house prices that make them inaccessible to black communities today. This has reinforced the spatial variations in wellbeing across South Africa, seen in Source 3. In 2015, the country had the highest Gini coefficient (at 0.6321), indicating that they had significant inequalities, a strong polarisation of their labour force and high wage gaps.

Rural–to–urban migration

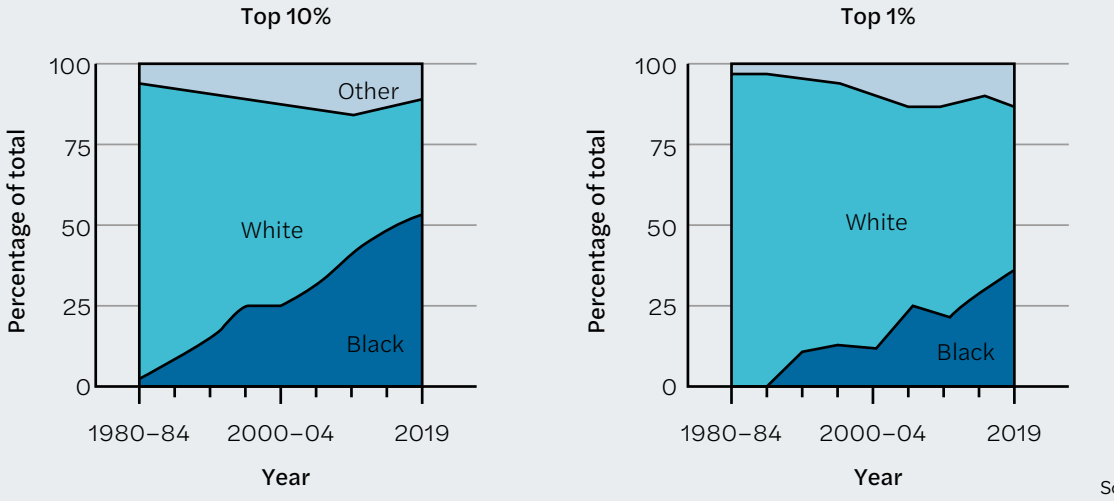
Causes

It is easier for governments and businesses to establish services in areas with large populations, as this ensures the services can be accessed by many and sustained over time. In South Africa, this has resulted in the development and investment of services in cities like Johannesburg, Cape Town and Durban. These residents have higher access to employment, education, health, technologies and improved infrastructure. This is in contrast to rural communities who often lack infrastructure, have limited access to health or computer technologies and have limited services. Many people migrate to cities to obtain work or services. However due to discrimination and high city prices, many of these rural-to-urban migrants are unable to access employment, and cannot afford housing and services in the cities.

Consequences

When too many people migrate to a place, there are often not enough services, jobs or housing to accommodate them quickly enough. In South Africa, this has led to the development of informal settlements (also called slums), which are unregulated temporary housing structures set up by impoverished communities. This creates spatial variations of wellbeing within cities, with some areas of the city being well kept and economically stable, and others experiencing rising poverty, reduced investments and the closure of businesses and work opportunities. The increasing population has also caused a strain on services, with a backlog in housing developments, extended wait times for healthcare services, increased traffic congestion, increased crime and pressure on existing infrastructure. The vast differences in poor and wealthy areas in cities also leads to conflict, with many wealthy groups actively fencing off their housing and communities to reduce access by poor communities and lower classes.

South Africa: share of black and white earners



Source 2: While wealth redistribution is happening, it is slow, and equality is still along way off. It is important to remember when looking at these graphs that the black population in South Africa is much larger than the white population.

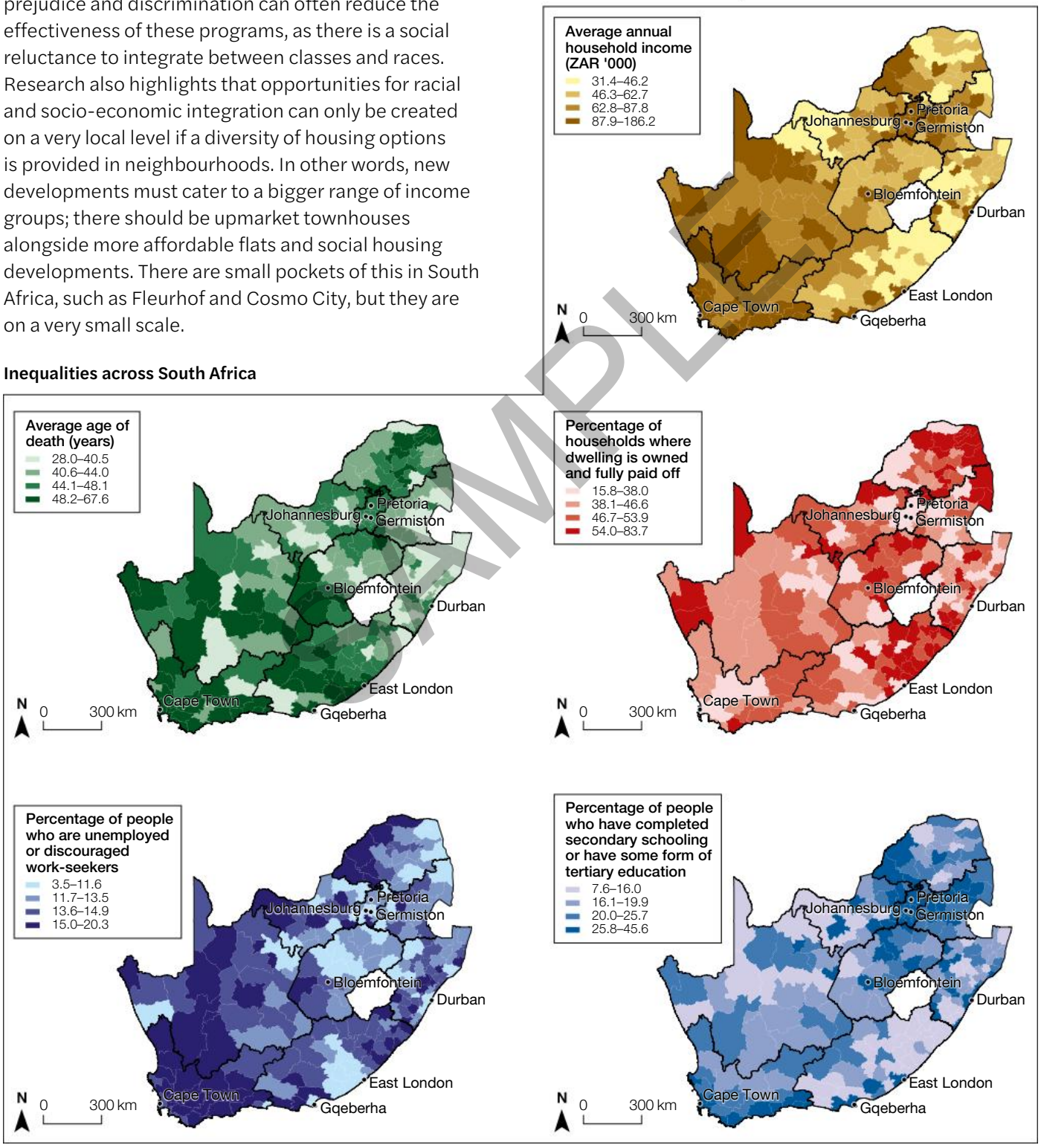
Source: Matilda Education Australia

Changes

The government has attempted to reverse the effects of segregation for decades, implementing policies aimed at improving the gaps between the rich and the poor and improving wellbeing overall. Over half of the annual government budget in 2019 was dedicated to initiatives to improve these spatial variations, such as welfare opportunities, subsidies for businesses to hire black people, increased education services and scholarship opportunities to improve tertiary education rates. However, historic prejudice and discrimination can often reduce the effectiveness of these programs, as there is a social reluctance to integrate between classes and races. Research also highlights that opportunities for racial and socio-economic integration can only be created on a very local level if a diversity of housing options is provided in neighbourhoods. In other words, new developments must cater to a bigger range of income groups; there should be upmarket townhouses alongside more affordable flats and social housing developments. There are small pockets of this in South Africa, such as Fleurhof and Cosmo City, but they are on a very small scale.

Source 3: Inequalities across South Africa, displayed in income, life expectancy, home ownership, unemployment and access to schooling. Assessing these choropleth maps allows us to see patterns on the areas that have poorer wellbeing, such as the west of South Africa where there is less access to water and fewer cities.

Inequalities across South Africa



Source: M Hamann, R Biggs & B Reyers, 2016

Source 4: An aerial image of the spatial difference that can occur within cities. This can be seen by comparing the area west of the highway, with wealthy communities and larger houses, to the eastern side, which contains smaller, temporary and often dilapidated housing.

Learning ladder 8.15

Processes that transform people, places and environments

1. Describe one cause that influenced variations in human wellbeing in South Africa today.
2. How did the Apartheid system affect the distribution of resources and wellbeing among different racial groups in South Africa?
3. Explain how rural-to-urban migration has influenced the spatial variations of wellbeing within South African cities?
4. How does historic segregation create intergenerational disadvantage?
5. How effective have current government initiatives been in addressing the inequalities created by historical policies, such as Apartheid?

Change

1. Describe how spatial variations have changed in South Africa over time.
2. How has rural-to-urban migration changed wellbeing within cities?
3. Explain how the development of informal settlements contributes to spatial variations of human wellbeing in some South African cities.
4. What challenges remain in addressing the spatial inequalities in human wellbeing in South Africa?
5. Predict how future urban planning and policy changes could further impact the spatial variations of wellbeing in South Africa.

Change, page 412

HOW TO

8.16

What factors influence wellbeing in Australia?

Australia performs well on global indicators of development, wellbeing and liveability. Australian cities regularly rank among the top 10 most liveable cities in the world. The status of Australia and Australian cities reflects a high level of wellbeing – they are safe places to live with the goods, services and infrastructure needed to live a good life.

Wellbeing of the nation

Factors contributing to Australia's high general level of wellbeing include political stability and geopolitical security, a strong democracy, the rule of law and respect for rights, a moderately growing population based on immigration and a respect for multiculturalism, high average incomes, high levels of educational attainment, low unemployment and a society based on egalitarian (classless) principles.

Natural resources, such as minerals, energy and agricultural land, have enabled Australia to be a 'double net exporting' country, exporting more food and energy than it imports. Australia's diversified economy has created economic wealth from multiple sectors including:

- commodity exports, such as iron ore, beef and wool
- services, such as tourism, international education, scientific research and ICT
- industrial production, such as high-tech medical equipment like Cochlear.

Inequalities within the nation

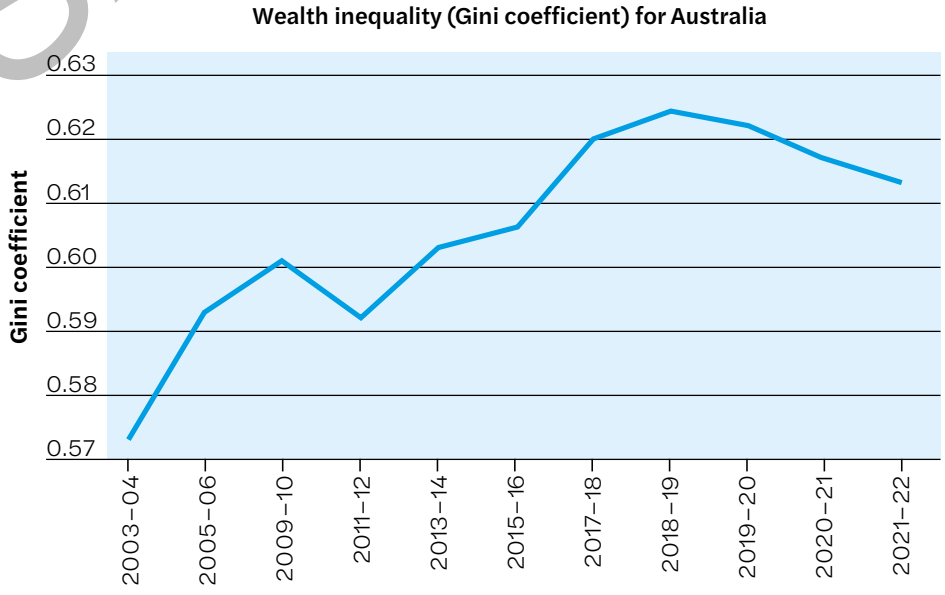
Despite Australia's overall wealth, its distribution is increasingly uneven and there are inequalities in many measures of wellbeing, including income, access to services and facilities, affordable housing, education and health outcomes.

Inequality in Australia is reflected in the **Gini coefficient** (Source 1). Australia falls below the global average for 88 countries compared by the World Bank.

The wealthiest 10 per cent of Australians held almost 50 per cent of all wealth in 2022 and the wealth of 130 billionaires grew by an average of 12 per cent, increasing their share to equal that of the poorest 30 per cent or 2.8 million households. Much of this wealth is held in property, an asset the poor are increasingly unable to access due to increasing interest rates and rising property values – a situation widening the gap between rich and poor.

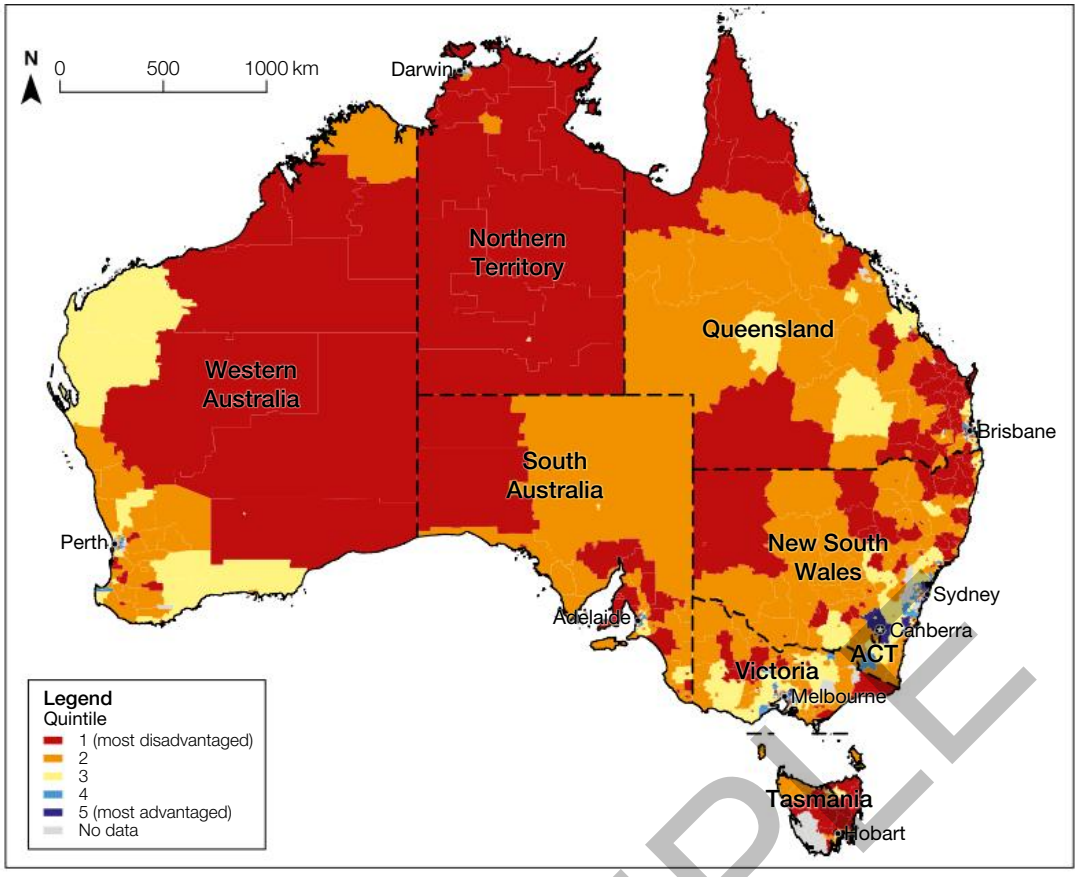
Spatial variations

Key factors that explain income inequality are level of educational attainment, employment status, gender, disability, race or ethnicity and geographic location. There are also significant variations in wellbeing between rural and urban places, within large cities and between Indigenous and non-Indigenous Australians.



▲ **Source 1:** The Gini coefficient is a measure of inequality ranging in value from zero (complete equality) to one (complete inequality). Source: ABS

Index of socio-economic advantage and disadvantage in Australia, 2021



Source 2: Choropleth map showing the areas of advantage and disadvantage in statistical regions of Australia in 2021

Source: Matilda Education Australia

Remoteness divide

Approximately 28 per cent of the Australian population lives in rural and remote areas where they generally experience poorer health outcomes including shorter life expectancy, higher levels of chronic diseases such as diabetes and injury, poorer access to health services and lower levels of education – with a smaller range of employment and career opportunities. Incomes were on average 15 per cent lower than those living in capital cities in 2019–20 yet prices for goods and services are higher.

Urban divide

Within Australia's largest cities there is a distinct geography of advantage and disadvantage (see page 354). The poor live in more affordable locations mostly in small pockets within existing suburbs or further from the city centre. The rising cost of living and escalating real estate prices and rents is widening the gap between the urban rich and poor.

Learning ladder 8.16

Characteristics of places and environments

1. Identify five reasons for Australia's high level of human wellbeing.
2. Source 2: Describe the pattern of disadvantage in Australia.
3. Source 1: Explain how the gap between rich and poor is widening in Australia.
4. Explain Australia's remoteness divide and urban divide using examples.

Interconnection

1. What is the connection between liveability and human wellbeing?
2. Describe the link between Australia's wealth and being a double net exporting country.
3. Explain the barriers to better health outcomes in rural and remote communities.
4. Assess the accuracy of the statement 'Inequality has a postcode'.

Interconnection, page 410

HOW TO

What is the state of wellbeing of First Nations Peoples?

Many institutions are structured in a way that limits access by First Nations people, leading to disparities in wellbeing between Indigenous and non-Indigenous Australians.

Cycles of disadvantage

Wellbeing of First Nations people is impacted by gaps in health, education, jobs, and overall socio-economic status. It is crucial to acknowledge the diversity among First Nations people and unique needs, as attempting to provide a broad summary risks oversimplification or stereotyping. Discrimination and historical injustices limit access to essential services, education and economic inclusion, continuing cycles of disadvantage. Despite limited progress made through governmental and grassroots efforts, substantial barriers persist in achieving equitable outcomes for First Nations Peoples.

Measures of wellbeing

The wellbeing of First Nations Peoples in Australia is measured using indicators like health outcomes, education levels, job opportunities, income, housing quality, and participation in cultural activities, and it goes beyond the simple definition of absence of ill health. Health indicators include life expectancy, infant mortality rates and chronic disease prevalence, while educational attainment is assessed through school attendance and retention, literacy rates and completion of Higher Education qualifications. Employment rates and income levels reflect economic participation and financial security. Housing conditions indicate access to safe and adequate housing, and cultural participation reflects engagement with First Nations languages, traditions and practices. Spiritual wellbeing, which is crucial in First Nations cultures, is often overlooked in mainstream evaluations of wellbeing.

Disparities of wellbeing

Health

Health disparities are a significant issue for First Nations Peoples in Australia, with significantly poorer health outcomes compared to non-Indigenous Australians. According to a report by the Aboriginal Health Council of South Australia, historical injustices have led to limited access to culturally appropriate healthcare services, contributing to ongoing health challenges. Statistics show higher rates of chronic diseases like diabetes, cardiovascular disease, and respiratory conditions among First Nations populations. For example, First Nations people are almost four times more likely to have diabetes than non-Indigenous Australians. In some communities, limited access to healthy foods and nutrition education exacerbate these disparities.

Mental health is another area of concern. First Nations communities experience disproportionately high rates of psychological distress, depression, and suicide. Australian Bureau of Statistics data shows suicide rates among First Nations Peoples are twice as high as those among non-Indigenous Australians, highlighting the urgent need for targeted interventions and culturally appropriate support services.

Education

Educational attainment remains a significant challenge, with First Nations students facing barriers such as limited access to quality education, cultural insensitivity in curriculum and teaching methods, resulting in lower retention rates compared to their non-Indigenous counterparts. In 2021, the Year 12 or equivalent attainment rate was 1.3 times as high for non-Indigenous Australians aged 20–24 as for Indigenous Australians (91 per cent compared with 68 per cent).

Employment

Employment opportunities for First Nations Australians are still behind, with higher rates of unemployment and underemployment adding to socio-economic challenges. According to the Australian Bureau of Statistics, the unemployment rate among First Nations Peoples was 20.4 per cent in 2020, more than double the rate for non-Indigenous Australians.

Source 1: First Nations children perform a traditional dance at the Laura Quinkan Indigenous Dance Festival. Here, dances are used to share stories and unite First Nations groups from across Cape York and the Torres Strait.

These disparities are not random; systemic barriers in education, workforce participation and discriminatory hiring practices have prevented the accumulation of wealth within First Nations communities, often perpetuating cycles of economic hardship.

Improving wellbeing

Preserving culture and connection to land are vital for the wellbeing of First Nations Peoples. However, ongoing challenges such as land dispossession, cultural erasure, and lack of recognition of rights contribute to intergenerational trauma and weaken cultural resilience. These obstacles not only disrupt identity and purpose but also hinder wealth building within First Nations communities. Land and cultural assets are crucial for economic stability and long-term prosperity, but historical and contemporary constraints imposed on access to and control of Country continue to limit opportunities.

When First Nations wellbeing is optimised, it signifies a society where these communities have fair access to essential services, education, and economic resources. This involves empowering First Nations leadership and self-determination through initiatives like community-controlled health services and educational programs that integrate Indigenous knowledge. For example, successful models such as the Aboriginal Medical Service Redfern in Sydney offer culturally appropriate healthcare, while schools like the Yiramalay/Wesley Studio School in Western Australia incorporate First Nations culture into the curriculum. The Yirrkala School, with its two-way learning system, encourages mutual respect and understanding between First Nations and non-Indigenous cultures.

Learning ladder 8.17

First Nations Peoples' interaction with Country

1. List variations in health outcomes for Indigenous and non-Indigenous Australians.
2. Source 1: Describe how connection to culture and community is important for the wellbeing of First Nations people.
3. How have historical injustices and discrimination impacted the wellness of First Nations people?
4. Analyse how wellbeing is measured and why disparities exist between Indigenous and non-Indigenous Australians.
5. How important are First Nations organisations in improving the wellbeing of First Nations groups in the future?

Sustainability

1. Describe the challenges that make it difficult to achieve sustainable wellbeing for First Nations Peoples.
2. How do First Nations organisations contribute to the long-term wellbeing of their communities?
3. How does preserving culture and Connection to Country support the sustainability of First Nations communities?
4. What role does culturally appropriate healthcare play in ensuring sustainable health outcomes for First Nations Peoples?

HOW TO
Sustainability, page 418

8.18

How does wellbeing vary on a local scale?

Studying patterns of wellbeing at a local scale helps to identify areas that require funding and services, and research interconnections between socio–economic disadvantage and outcomes in health, education and housing.

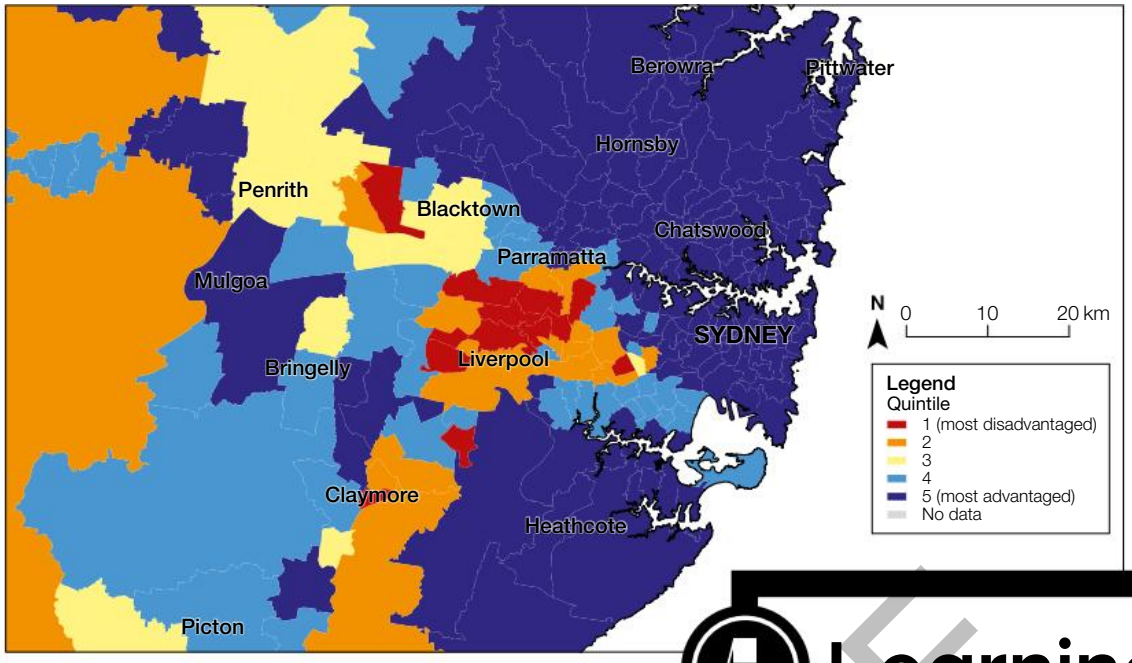
Advantage and disadvantage

Socio-Economic Indexes for Areas have been developed by the Australian Bureau of Statistics (ABS) to rank areas in Australia according to their relative socio-economic advantage and disadvantage. The calculations take into account income, education, occupation, housing, employment, family structure and other factors from census data to rank an area's advantage and disadvantage.

A score is given to an area, with an average of 1000. Scores lower than 1000 indicate relative disadvantage and scores above 1000 indicate relative advantage. For example, Pittwater has a score of 1126 to indicate it is one of the most advantaged suburbs in Sydney. Claymore in Sydney's west is rated as a relatively disadvantaged area with a score of 757.

Source 1: Church Point is a waterside suburb at the southern end of Pittwater in Sydney's north. It is one of the most advantaged suburbs in Sydney.

Index of Socioeconomic advantage and disadvantage in Sydney postcodes, 2021



Source: Matilda Education Australia

Source 2: Choropleth map showing the areas of advantage and disavantage in the postcodes of Sydney in 2021

Sydney has a greater range of higher and lower socio-economic characteristics than other capital cities across Australia. In other words, not all Sydneysiders experience the same high level of human wellbeing as those living in Pittwater.

Pittwater, postcode 2107

Pittwater is a popular tourist site in the Northern Beaches LGA, with sailing and life saving clubs, cafes, restaurants and parks. With views of the Pacific Ocean and Pittwater, some homes are worth over $27 million. The area has a high socio-economic status and is classified as relatively advantaged. If you live in the suburb of Pittwater you are one of 63 000 people. The median age is 46 years. The area contains a highly educated population, of which over 33 per cent have a bachelor degree or higher. Over 97 per cent are employed, and nearly half are professionals or managers. Approximately 43 per cent earn $3000 or more a week and 17 per cent rent a home.

Claymore, postcode 2559

Claymore is located in the Campbelltown LGA in Sydney's west. This place has **social housing**, low rent housing for people who cannot afford private rental market rents or need medical or age-related support. Claymore has a low socio-economic status and is classified as relatively disadvantaged. If you live in the suburb of Claymore you are one of 2500 people. The median age is 28 years. Around 16 per cent of the population have completed Year 12. Over 87 per cent are employed, and nearly one-third are machinery operators, drivers or labourers. Approximately 10 per cent earn $3000 or more a week and more than 70 per cent rent a home.

Learning ladder 8.18

Perspectives of people and organisations

1. What are the factors that make Pittwater a relatively advantaged place?
2. Source 1: Describe some of the factors that make Pittwater a relatively advantaged place.
3. List some of the factors used to rate Claymore as a relatively disadvantaged place. Explain how these factors would impact on human wellbeing in this community.
4. Explain the advantages of social housing for relatively disadvantaged persons? What are the alternatives for disadvantaged persons who cannot access social housing?

Place

1. How is the relative advantage or disadvantage of a place determined by the ABS?
2. Source 2: How are the Claymore and Pittwater postcodes rated in terms of advantage and disadvantage.
3. Explain the human characteristics used by the ABS to calculate relative advantage and disadvantage.
4. Source 2: Analyse the usefulness of the data collected for different places across Sydney. How might it be used by planners and governments?
5. Evaluate the factors that can change Claymore into a place of greater advantage.

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Place, page 408

Improving wellbeing

9

HOW DOES AID IMPROVE WELLBEING? 378

HOW DO NON-GOVERNMENT ORGANISATIONS IMPROVE WELLBEING? 388

HOW CAN WE IMPROVE ACCESS TO EDUCATION? 374

9.0

How can I understand improving wellbeing?

Human wellbeing is an expression of health, safety, happiness and other measures that vary between people and places. However, human wellbeing has no globally recognised definition, as it is a complex concept. It involves many aspects of our lives including social, historical, economic, environmental and political factors.

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 toward the top.

Steps in knowledge progression	Characteristics	Processes	Perspectives	Sustainable management strategies	First Nations Peoples	Representing and communicating information
5	I can evaluate the impact of changes to the characteristics of places.	I can evaluate the impact of changes to processes.	I can evaluate the impact of perspectives on outcomes.	I can evaluate the effectiveness of strategies in achieving sustainability.	I can justify the importance of First Nations Custodianship in future decision-making.	I can synthesise a range of tools, terms and concepts to create geographical information.
4	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 geographical information.
3	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 geographical information.
2	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 geographical tools, concepts and terms.
1	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.
	Outcomes					Geographical tools and inquiry

Source 1: A woman driving a car for the first time in 2018 after the government of Saudi Arabia lifted the ban on female drivers. This change in law by the government improved the wellbeing of Saudi Arabian women by providing them the opportunity to travel to work, school or the doctors.

Place	Space	Environment	Interconnection	Scale	Sustainability	Change	Steps in skill progression
I can evaluate the impacts of changes to places.	I can predict changes to spatial distributions and their impact.	I can evaluate the nature and rate of environmental changes.	I can predict future changes to interconnections and their impact.	I can evaluate the importance of scale in solving geographical challenges.	I can justify which strategies are most sustainable and explain why.	I can evaluate the impact of changes.	5
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.	4
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 interconnections.	I can analyse how scales interract to influence geographical processes.	I can analyse the long-term impacts of sustainable and unsustainable practices.	I can analyse the impact of change.	3
I can use geographical vocabulary to describe a place.	I can explain spatial distributions.	I can explain physical processes.	I can explain the influence of interconnections.	I can explain how processes vary across scales.	I can explain the importance of social, environmental and economic sustainability.	I can explain the causes and effects of change.	2
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.	1

Geographical concepts

How can we improve global wellbeing?

Improving human wellbeing involves working together across local, national and global scales to ensure more equitable access to safe food, health services and education for all.

Sustainable Development Goals

In 2015 the United Nations states established the Sustainable Development Goals (SDGs). These 17 goals and 165 targets were signed with an aim to end poverty, increase environmental sustainability, and build a peaceful and prosperous world by 2030. In order to achieve these targets, nations need to create strong initiatives and work together to end inequalities and improve human rights.

Achieving the SDGs is not easy. Leaders must find a balance between social, economic and environmental sustainability. In other words, they need to consider how to maintain or help their own country prosper, while also developing positive relationships and providing aid, assistance and advice to other world regions. In some instances this means ending decades-long conflicts and finding homes for millions of displaced people.

Challenges of improving equity

There are many challenges in meeting these goals. Experts estimate that eradicating poverty may cost around $66 billion a year and creating sustainable and useable infrastructure may cost over $7 trillion globally. The world population is expected to increase to 9 billion by 2050, which means that food and energy production will also need to rise by up to 70 per cent putting pressure on already degraded environments.

The third SDG is to ensure good health and wellbeing on a global scale. The global COVID-19 pandemic in 2019–21 stopped and even reversed some of the work to meet this target by limiting access to and effectiveness of health services. Key vaccination and aid programs were blocked and strict lockdowns and reductions in trade only acted to further increase global inequalities in education and access to safe food. It is estimated that 71 million people were pushed into extreme poverty during this time. As we rapidly approach 2030, much more needs to be done to meet these goals.

Source 1: Sustainable Development Goals developed by the UN

GOOD HEALTH AND WELLBEING

Challenges	Solutions
ENVIRONMENTAL FACTORS KILL MILLIONS OF PEOPLE every year causing nearly one-quarter of all deaths worldwide 	 **AVOID AND REDUCE POLLUTION** to prevent millions of premature deaths every premature deaths every year
POLLUTION, CHEMICAL EXPOSURE, CLIMATE CHANGE, and **ULTRAVIOLET RADIATION** contribute to more than **100 DISEASES** affecting primarily young children and elder people 	 Work with energy, transport, agriculture and industry sectors to **CREATE A HEALTHIER ENVIRONMENT**
AIR POLLUTION is the world's largest environmental health risk killing 6.5 million people prematurely every year 	 **ADOPT CLEANER ENERGY** to reduce indoor and outdoor air pollution and save millions of lives 

Source 2: There are significant challenges that countries face when trying to meet the SDGs. World leaders need to work together to overcome these challenges and meet targets.

Learning ladder 9.1

Sustainable management strategies

1. Source 1: Describe two of the Sustainable Development Goals that the UN states hope to achieve by 2030.
2. Explain the challenges of making an equitable world.
3. Source 2: How do sustainable practices to improve health and wellbeing?
4. Source 1: Create your own strategy to address SDG2. What are the advantages of your proposal and what challenges might you face in implementing it.
5. Source 1: Evaluate the 17 Sustainable Development Goals by grouping the goals into categories. Which categories are best represented and which are under represented. What goals could be added to any under represented categories?

Change

1. What do the Sustainable Development Goals aim to change?
2. Source 2: Describe suggested solutions to the challenges of improving good health and wellbeing.
3. Review progress for SG3 by visiting unstats.un.org/sdgs/report/2022/Progress-Chart-2022.pdf.
   - **a** Which world target is the most progressed?
   - **b** In which world regions has the least progress been made?
   - **c** For which goals and in which regions have the targets been reached?
4. Analyse the implications of not meeting the SDGs by 2030. What should world leaders do if this happens? What changes would you make to any new goals made?

Change, page 412

9.2

How can we tackle population issues?

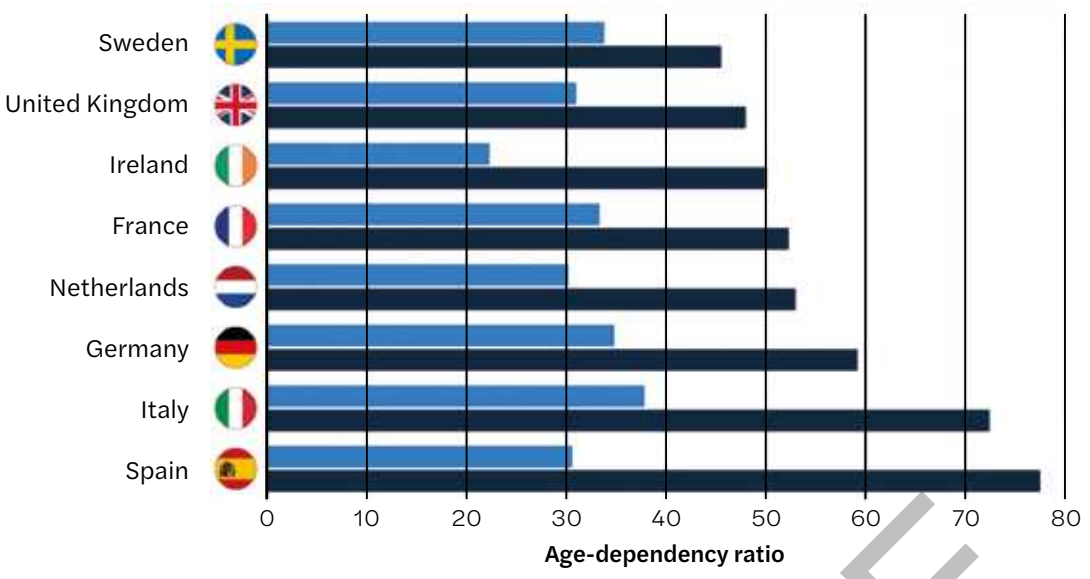
Changes in population create challenges for nations ranging from the provision of infrastructure and age appropriate services to the depletion of natural resources, environmental degradation and economic growth. Strategies must be appropriate to the demographics and culture of each nation to ensure the wellbeing of all citizens.

Ageing populations

The result of falling fertility rates, a declining number of births and increasing life expectancy is a rapidly increasing share of population in the 65 years and older age group. An increase in the **age–dependency ratio** (people over 65 years per 100 working age people) means an increasing burden on working age populations to support older generations and the health care cost associated with ageing. It also means changing communities to better cater for aged populations and growing concerns about workforce size and economic growth.

Source 1: Men playing Janggi Korean chess in the street in Seoul, capital of South Korea. The proportion of people aged 65 years in South Korea now accounts for more than 20 per cent of the total population.

Europe's age-dependency ratio, 2015 and 2020



Source 2: The dependency ratio is number of people aged over 65 years per 100 people of working age. The ageing of Europe's populations is characterised by decreasing fertility and mortality rates, and a higher life expectancy among European populations.

Source: OECD

Strategies implemented to address ageing populations in countries such as South Korea and Australia include:

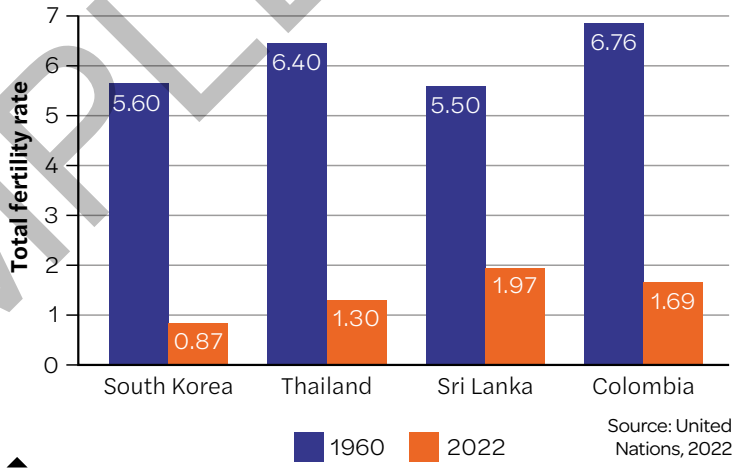
- investing in elderly care and support services such as accommodation
- establishing healthy ageing programs to reduce a growing burden on health systems
- extending the age of retirement and access to the aged pension
- changing workplaces to value older people and reduce discrimination.

To stimulate population growth countries such as Japan and South Korea are:

- implementing policies to increase fertility and birth rates
- increasing overseas migration
- introducing women-friendly policies to support women having careers and families
- changing social and cultural norms to involve men more in the raising of families.

Paid parental leave, subsidised or free childcare, and bonus payments are commonly used to incentivise having children. Japan and South Korea have traditionally resisted foreign migration – a policy they are changing as concerns about a shrinking workforce grow. For women globally, however, the cost of living and family wellbeing has become one of the greatest barriers to increasing family size. A South Korean Office for Government Policy Coordination survey of young 19–34 year old adults in 2021 revealed 36.7 per cent did not want children.

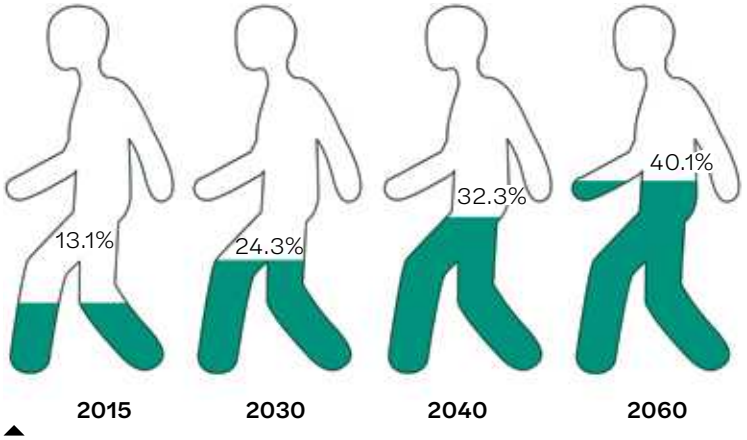
Total fertility rates, 1960 and 2022



Source: United Nations, 2022

Source 3: Total fertility rates for selected countries 1960 and 2022. The total fertility rate of a population is the average number of children that are born to a woman over her lifetime.

Ratio of elderly over 65 in South Korea



Source 4: Percentage of people over 65 years of age in South Korea, 2015–60, based on current trends

Source: Statistics Korea

Source 5: The Cabbages and Condoms restaurant started as a small vegetable stand at the Population & Community Development Association where vegetables were sold, alongside T-shirts, condoms, and oral contraceptives.

Rapid population growth

Where high fertility and birth rates result in rapidly growing populations a range of successful programs are being used to slow or reverse current trends. Fertility rates across Asia have dropped by nearly 10 per cent over the past decade. Thailand is used as a model for successfully reducing its fertility rate using a range of strategies since the 1970s, with rapid economic growth following. Ironically, Thailand is now facing an aged population crisis in much the same way as China following the successful one child policy. Both countries are having to pivot to strategies that now encourage having children.

Successful policies and programs that contribute to lowering fertility levels include:

- free and easy access to family planning
- raising the minimum legal age of marriage
- integrating family planning into health care
- improving female education and employment opportunities
- tackling poverty to reduce maternal births and child deaths.

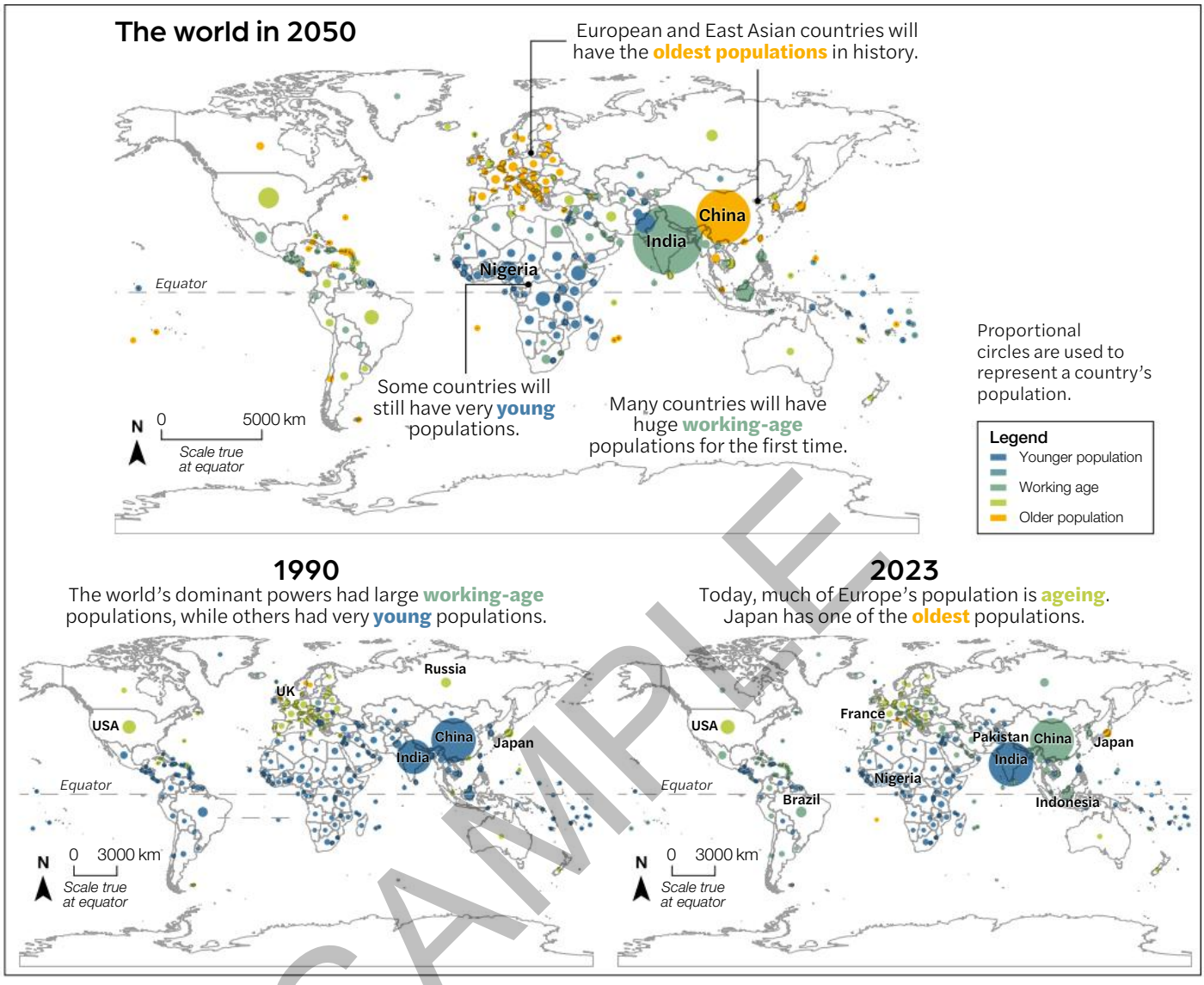
Advancing the rights of women and girls is promoted in the Population Matters 2022 report Power to the People: how population policies work as one of the most powerful solutions to high fertility rates. The report also states a clear correlation between education and the number of babies women have, their concern for the environment and climate change. This may impact their decision-making, and an understanding that reducing population growth helps lift people from poverty.

Thailand population challenges

Following an intensive government programme in the 1970s, the number of children per family in Thailand dropped from six to 1.5 by 2015. The population growth rate subsequently dropped from 3 per cent to 0.4 per cent. The programme involved access to contraception and education, improved health facilities and a focus on female empowerment. Discussing family planning and sexual health was normalised through a creative communications campaign to make contraception visible and family planning discussions normal. The unique strategy included police distributing condoms in a Cops and Rubbers campaign and the opening of Cabbages and Condoms, a restaurant chain – based on condoms being be as accessible as cabbages.

By 2020 however, Thailand's population growth had stalled, the country was now facing an ageing population in which aged persons comprised 20 per cent of the population. The fertility rate had dropped to 1.3. Younger generations are putting greater value on their personal life and careers or expressing concerns about the cost of living, raising children and having a work life balance. Thailand is looking to implement strategies used by countries such as China, Korea and Italy to address this new population challenge.

Age structure of the world's population by country



Source: Matilda Education Australia

Source 6: Predicted populations in 2050 based on current trends and compared to the status in 1990 and 2023

Learning Ladder 9.2

Processes that transform people, places and environments

1. Source 6: Identify three population trends related to continents in 2050.
2. Source 5: Explain the strategies used in Thailand to change the fertility rate.
3. Source 3: Provide possible reasons for the decline in fertility rates.
4. Analyse the connection between population policies and human wellbeing using examples. Refer to 9.5 on page 372 to assist with your response.

Change

1. Define 'fertility rate', 'age dependency' and 'female empowerment'.
2. Source 2: Describe how population trends change the age-dependency ratio.
3. Source 4: Explain the predicted changes to South Korea's population to 2060.
4. Source 4: Propose three strategies that South Korea could implement to increase the fertility rate and slow the predictions shown in this source.

Change, page 412

HOW TO

How is Japan improving community wellbeing?

Japan is facing a huge demographic challenge: an ageing population coupled with potential population decline. Decades of low fertility rates, combined with one of the longest life expectancies in the world, means that, by 2025, one-third of the Japanese population will be over the age of 65.

In 1945, Japan was a nation in ruins. The legacy of World War II's firebombing campaigns and the atomic bombings of Hiroshima and Nagasaki had left the country in tatters. Yet, decades later, it rose to become the world's second-largest economy and a vibrant hub of manufacturing and technological advancement that transformed the everyday lives of people and industries around the world. A post-war baby boom saw the population grow rapidly, but now it is in decline.

Factors that have contributed to the population challenge in Japan:

- Rural-to-urban migration has contributed to some of the highest rates of urbanisation and population density in the world.
- Cost-of-living pressures have made having a large family very expensive.
- For many women, having children meant fewer work opportunities, essentially forcing them to choose between their career or having a family.
- Immigration rates have long been the lowest among MEDCs.

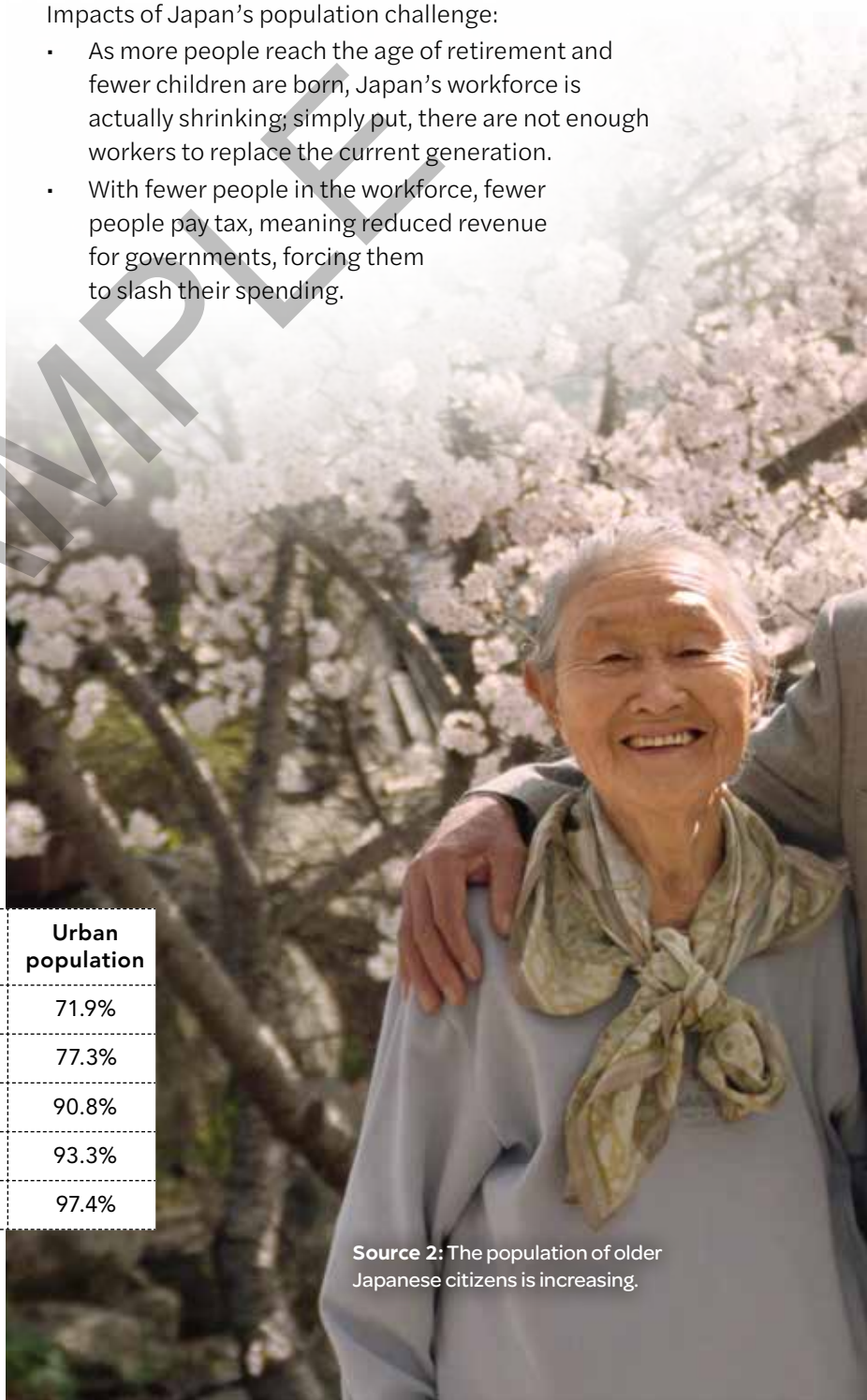
Impacts of Japan's population challenge:

- As more people reach the age of retirement and fewer children are born, Japan's workforce is actually shrinking; simply put, there are not enough workers to replace the current generation.
- With fewer people in the workforce, fewer people pay tax, meaning reduced revenue for governments, forcing them to slash their spending.

Source 1: Japan's changing demographics, 1970–2050

Year	Population	Growth rate	Fertility rate	Median age	Urban population
1970	105 million	1.28%	2.04	28.8	71.9%
1990	125 million	0.43%	1.65	37.3	77.3%
2010	128 million	0.03%	1.34	44.7	90.8%
2030	121 million	– 0.5%	1.37	52.1	93.3%
2050	106 million	– 0.7%	1.37	54.7	97.4%

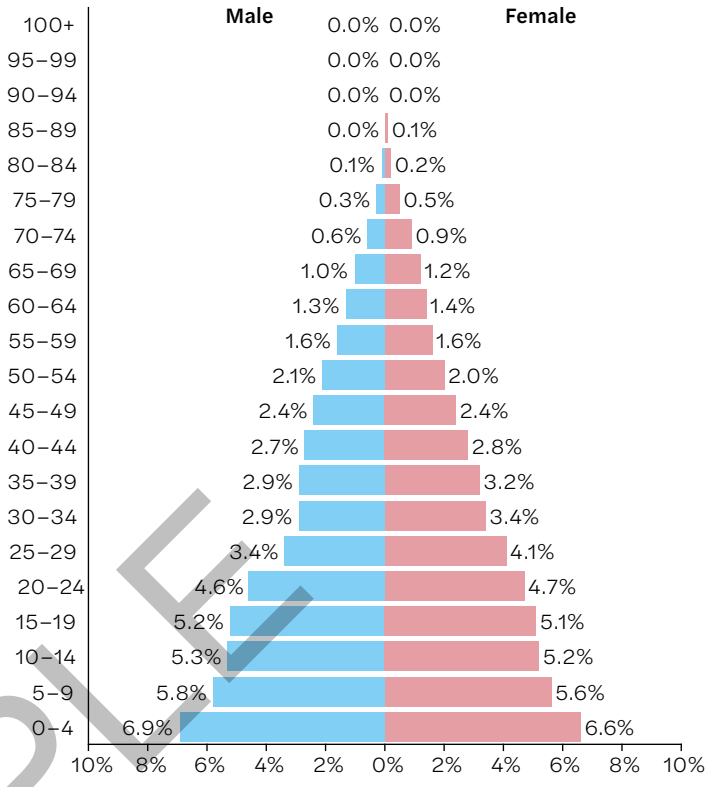
Source: xxxxxx xxx xxxxxx xx xxxx xxxxxx xxx xxxxxx xx xxxx



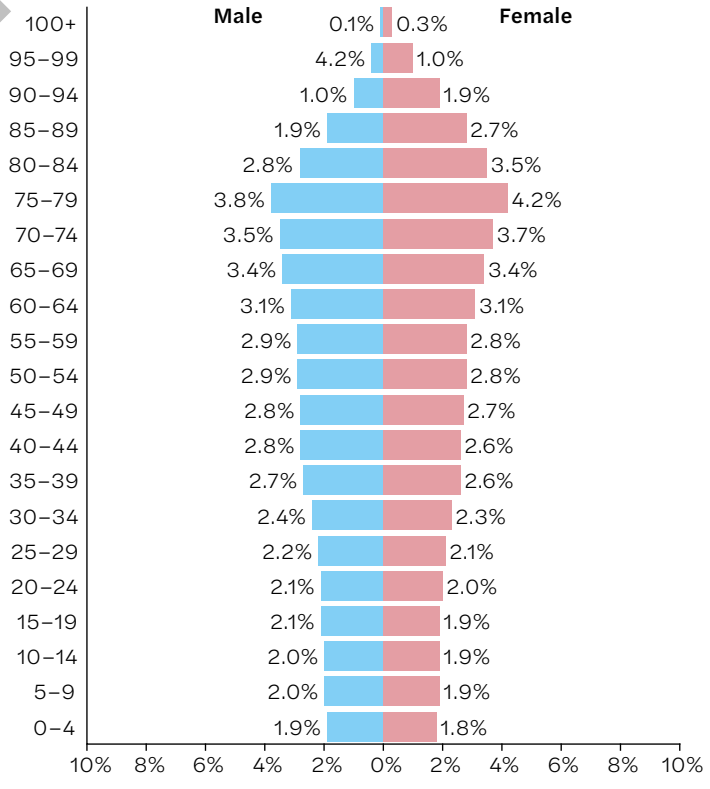
Source 2: The population of older Japanese citizens is increasing.

- Some industries, such as aged care and medical fields, continue to grow as the population ages, but many others, including schools in rural areas, are in decline. Businesses without enough workers are also closing.
- With a heavily urban population, many rural areas can fall into neglect, particularly as revenues and public spending decline.
- With shrinking local industries, such as agriculture and manufacturing, the nation is becoming increasingly reliant on imports.
- While government revenues are decreasing, there are increased costs for healthcare and pensions.

Japan, 1950, population 82 802 084

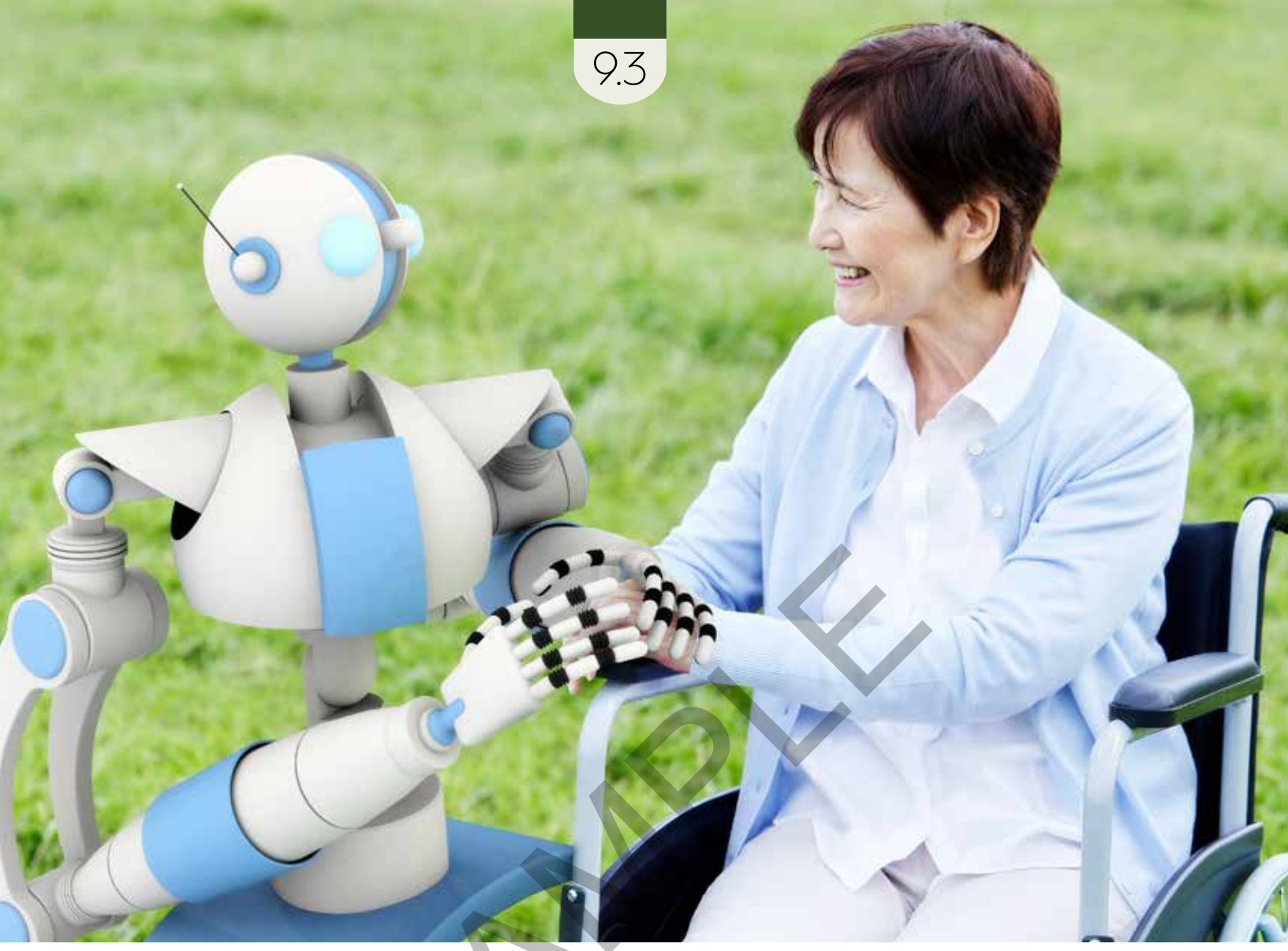


Japan, 2050, population 105 804 022



Source: PopulationPyramid.net

Source 3: Population profiles of Japan in 1950 and projected for 2050



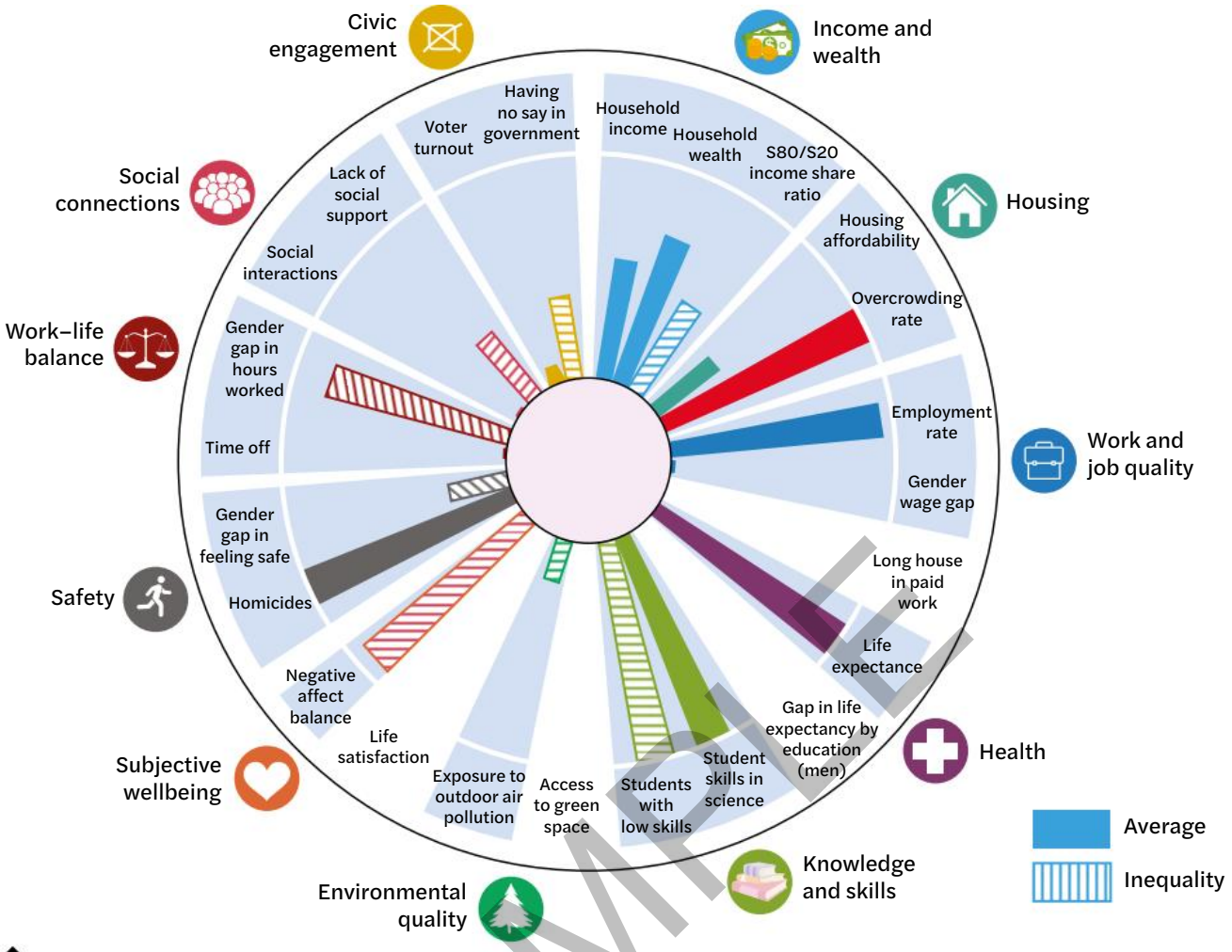
Source 4: Robots are becoming part of aged care in many countries.

With these population challenges in mind, the Japanese government have created a range of responses to address these issues. At a policy level, the government has raised the eligibility age for the national pension from 60 in 2018 to 65 in 2025, with a view to further increasing it to 70 in the near future. This aims to increase both workforce capacity and taxation income, while also reducing the growth of pension payments.

Increasing female workforce participation is another way to maintain the economy, part of a broad economic stimulus package introduced by former Prime Minister Shinzo Abe, dubbed 'Abenomics'. Other responses aim to increase birth rates by supporting the costs of childbirth and providing funding for childcare and family support.

The growing cohort of elderly citizens remains a significant challenge to economic and social wellbeing and while a special category of work visa was created in 2016 to help fill work shortages – by 2025, the government predicts a shortfall of around 380 000 specialist workers – only 17 such visas were issued to candidates who passed difficult language exams. The development of elder-care robots has been flagged as a priority area for government funding, both to help fill the labour shortage and offer an economic lifeline for domestic industries to export the technology to other countries with similarly ageing populations.

Current technology available includes beds that transform into wheelchairs; robotic therapy animals; robots that assist in areas where power, mobility and monitoring are required; and robots that run games, coordinate exercise sessions and act as basic conversation partners. The Japanese labour ministry has invested more than $50 million in developing and implementing such technology across 5000 facilities nationwide.



Source 5: Japan's relative strengths and weaknesses in wellbeing compared to other OECD countries. Longer bars indicate higher wellbeing, whereas shorter bars indicate lower wellbeing.

Learning ladder 9.3

Processes that transform people, places and environments

1. What population challenge is Japan facing?
2. How will people's lives and wellbeing be affected by an ageing population in Japan?
3. Source 5: Which factors would be most important to people over 65 years of age? How does Japan perform?
4. Source 4: To what extent is technology an adequate solution for Japan's population challenge?

HOW TO Change, page 412

Change

1. Source 1: Identify when Japan's population began to decrease.
2. Source 1: Describe the trends in Japan from 1970 to 2050 for:
   - **a** population
   - **b** growth rate
   - **c** fertility rate
   - **d** median age
   - **e** urban population.
3. Source 3: Explain how Japan's working-age and non-working-age cohorts have changed over time. Ensure you use data to support your response.
4. Immigration has helped other countries, such as Germany, maintain population growth despite an ageing population and has been touted as a possible solution for Japan's population challenge. Evaluate the following statement: 'Immigration would help maintain Japan's population growth, but would bring many other challenges with it'.

How can we improve wellbeing for women?

Higher wellbeing of women results in boosted economies, enhanced social stability, improved governance and creates more connected and educated communities.

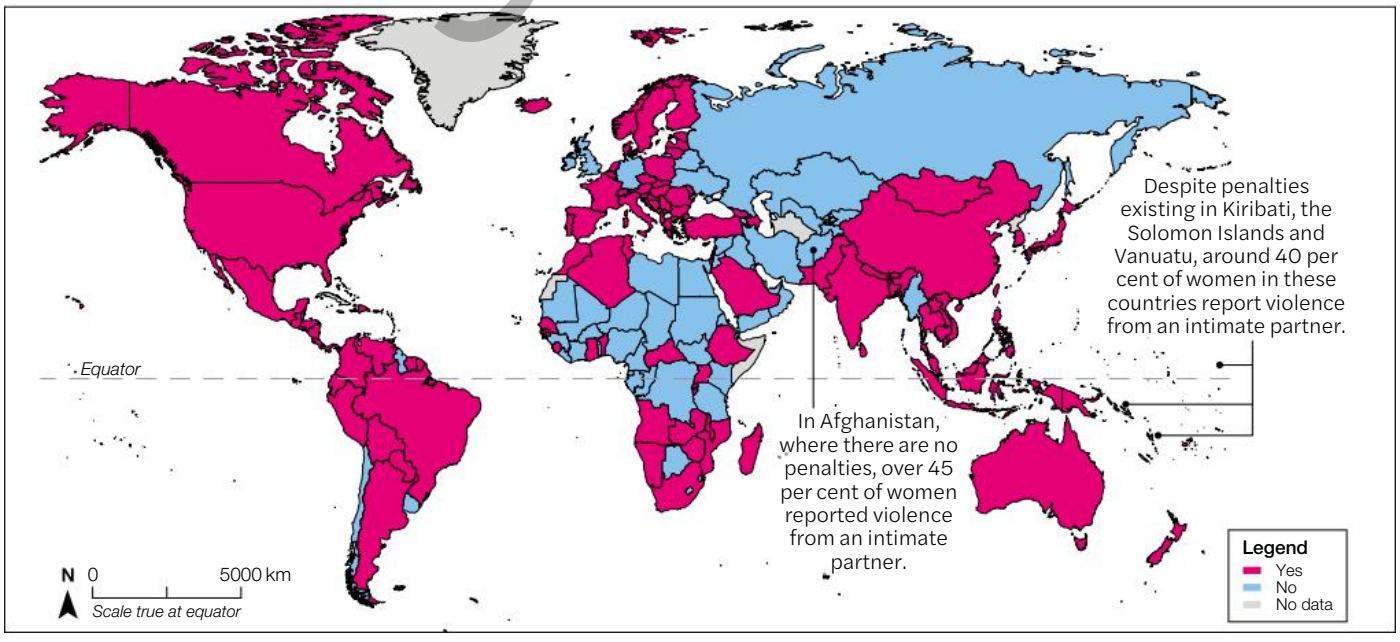
Female disadvantage

Women still experience disadvantage across the world, particularly in low income regions such as Sub-Saharan Africa and the Middle East. Some issues that impact the wellbeing of women:

- Gender pay gap, with women earning less than men for the same work across their lives.
- Women spend more than three times the amount of time as men on unpaid domestic work.
- Globally women are less likely to access secure housing and secondary education.
- Approximately 100 000 women are victims of human trafficking each year.
- More than 85 per cent of sweatshop workers are female.

Source 1: A map highlighting countries who do (orange) and do not (dark blue) have criminal penalties for domestic violence to protect women and their wellbeing.

Countries that do (pink) and do not (blue) have criminal penalties for domestic violence, 2023



Source: Matilda Education Australia

What can be done?

Intergovernmental organisations

Intergovernmental organisations establish important frameworks that create principles and goals for gender equality. An example includes the United Nations Convention on the Elimination of All forms of Discrimination Against Women (CEDAW) treaty, which sets out to increase awareness and eliminate gender discrimination. The treaty establishes goals for nations to improve women's wellbeing, monitors the progress and holds countries accountable for not meeting goals. Through CEDAW, Morocco reformed its family law code to provide women more rights in divorce and enacted a law to criminalise violence against women. Other intergovernmental programs work to monitor and act on human rights issues and develop international laws to protect women. This is seen with the International Trafficking Protocol established to define, prevent and combat trafficking, assist victims and promote cooperation among countries to uphold the Protocol.

Source 2: Doctors Without Borders is a non-government organisation that brings medical care to people affected by conflict, disasters, epidemics, and social exclusion.

National governments

The government of a nation is able to identify, develop and fund initiatives to improve women's wellbeing. This can be in the form of policies, laws, welfare or programs that improve women's access to social resources such as education, employment and housing. Here are some examples:

- Scotland, England and New Zealand offer free sanitary period products to all girls in schools to prevent them from missing school if they can't afford tampons and pads.
- The Australian Government implemented a Child Care subsidy in 2018 to support families in covering the cost of childcare. This supports women to return to work after having a child.
- The Bolivian Government developed a Juancito Pinto program that provided families with a conditional cash transfer as an incentive to send their girls to school to improve education access for women in Bolivia.

Non-government organisations

Non-government organisations (NGOs) are important at providing the funding and technology to improve women's wellbeing and empower global communities. An example is Doctors Without Borders (Medecins Sans Frontières), which operates globally to build hospitals, clinics, provide maternal services for girls, vaccinations and mental health support. It also trains locals in rural and remote areas to ensure they have the skills to support their communities in the long term. Over 1 million patients globally have benefitted from Doctors Without Borders, particularly in places such as Afghanistan, where women are culturally not allowed to be helped by male doctors and are also not allowed to work. This means there are no females doctors are available to communities without the assistance of volunteers from NGOs such as Doctors Without Borders.

Learning ladder 9.4

Characteristics of places and environments

1. What are some of the issues that impact the wellbeing of women globally?
2. Describe the benefits of improving women's wellbeing for a place.
3. Source 2: How does Doctors Without Borders contribute to improving women's wellbeing?
4. Discuss whether non-government organisations or national governments are more effective at improving women's wellbeing.
5. Research one of the following initiatives and evaluate its effectiveness: Women's Health Research Institute, 6 priorities for Women and Health by WHO, Candlelight Foundation in Somalia, Barefoot College in India.

Scale

1. Source 1: Describe the pattern of places that have a higher security for women compared to those who do not.
2. How significant is the gender pay gap globally and how does it vary across different regions?
3. How does the uneven scale of unpaid domestic work done by women compared to men impact women's wellbeing?

HOW TO Scale, pages 416, 423

Case study

How has the wellbeing of women improved in Rwanda?

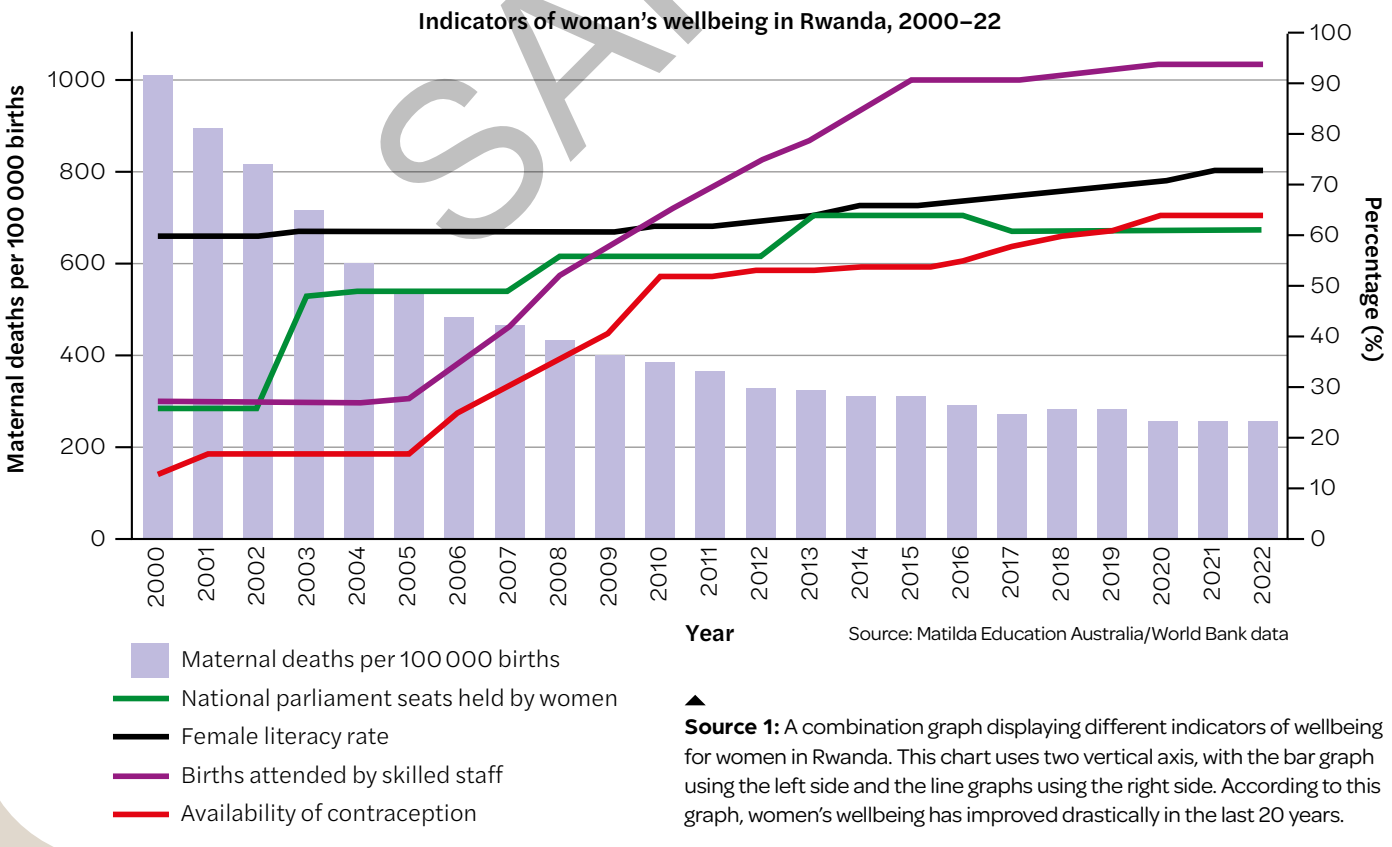
Rwanda is a low income country located in East Africa with a population of 13.8 million. Women in Rwanda have historically experienced low wellbeing, due to cultural expectations for them to marry young, have many kids and not pursue education or work.

Wellbeing of Rwandan women

Cultural expectations to bear children and look after the home have resulted in a low social mobility for women and a lack of power to make decisions for themselves or in their homes. Following the 1994 Rwandan genocide, women comprised 70 per cent of the remaining Rwandan population, requiring them to take on new economic roles to fill the workforce and play an active role in rebuilding Rwanda's government and legal systems. This, alongside support from non-government and community organisations, has seen Rwanda become a global leader for female equality.

Government and law

In 2003, the Rwandan constitution was amended to include gender equality, guaranteeing women equal rights and a quota of 30 per cent of women in all parliamentary positions. By 2008, Rwanda became the first country in the world to have a female majority in parliament and today more than 60 per cent of parliament positions are held by women. This has led to many pro-female laws and initiatives, including mandatory three months maternity leave for women, an outlawing of marital rape and establishing gender-based violence centres for women to seek support if they experience domestic violence.



Source: Matilda Education Australia/World Bank data

Source 1: A combination graph displaying different indicators of wellbeing for women in Rwanda. This chart uses two vertical axis, with the bar graph using the left side and the line graphs using the right side. According to this graph, women's wellbeing has improved drastically in the last 20 years.

Workforce participation

Non-government organisations (NGOs) have been crucial in improving Rwandan women's access to the workforce. Buy from Women is an initiative led by UN Women that provides a digital platform for Rwandan women to use to forecast their expected agricultural produce, manage their profits and it connects them to information about market prices and financial services. Other NGOs have implemented microloans to support female-led businesses in Rwanda. A microloan is a small loan provided to women with little to no interest, enabling women to buy equipment or agricultural goods to establish a business with little risk. These initiatives empower women to make decisions for their family and improves their opportunities in life. In 2020 Rwanda was ranked among the top 10 countries in the world to have narrowed the gender pay gap.

▲ **Source 3:** Harvard researchers have implemented a mobile health platform in Rwanda that uses artificial intelligence and computers to predict any infections in C-section wounds after women give birth. This technology is 90 per cent effective and has helped reduce the maternal mortality rate in Rwanda.

▲ **Source 2:** A Rwandan women tending to trees in her coffee plantation. It is common for women of Rwanda to choose to take their babies to work.

Women's health

Today Rwanda has a comprehensive health care system with initiatives to train community health workers. Women across Rwanda have access to skilled birth attendants and postnatal care. This has led to a rapid decrease in the **maternal mortality rate**, which is the number of mothers who die for every 100 000 births. In Rwanda it has decreased from 1007 per 100 000 births to 259 per 100 000 births between 2000 and 2020. These centres also increas access to contraception, which enables Rwandan women to delay when they have children and reduce the number of children they have.

Learning ladder 9.5

Processes that transform people, places and environments

1. How has the wellbeing of women in Rwanda changed since 1994?
2. Describe an initiative that improved Rwandan women's wellbeing on a national scale.
3. Source 1: Explain the factors that contributed to the maternal mortality pattern evident in the graph.
4. Analyse the role of culture in influencing women's wellbeing in Rwanda over time.
5. Evaluate the effectiveness of the constitutional amendment for gender equality in 2003. Refer to data from Source 1 in your response.

Place

1. Where is Rwanda located? Research its latitude and longitude and use scale to find its approximate size.
2. Source 2: Explain how the physical and human characteristics of a place can influence the wellbeing of its people.
3. Source 3: How important is it to increase access to technologies to improve women's wellbeing in Rwanda? Refer to healthcare and employment in your response.

HOW TO

Place, page 12

How can we improve access to education?

Globally, one in five children are not attending school. Community and government initiatives can implement programs and strategies to improve school attendance.

The importance of education

Education is an integral in providing the opportunity for social mobility. Social mobility is the ability to move up, or down, social classes. Through obtaining an education, a person is more likely to obtain higher paying work and access housing and healthcare. It also provides the ability to engage as a citizen, by having the literacy skills of reading and writing required to vote or understand the legal system.

Accessibility

Some children are unable to access education because they live in a remote location, in a conflict zone where schools are closed or there are a lack of qualified teachers. Children in Nepal and Kenya travel as far as 4–8 kilometres each day to attend school.

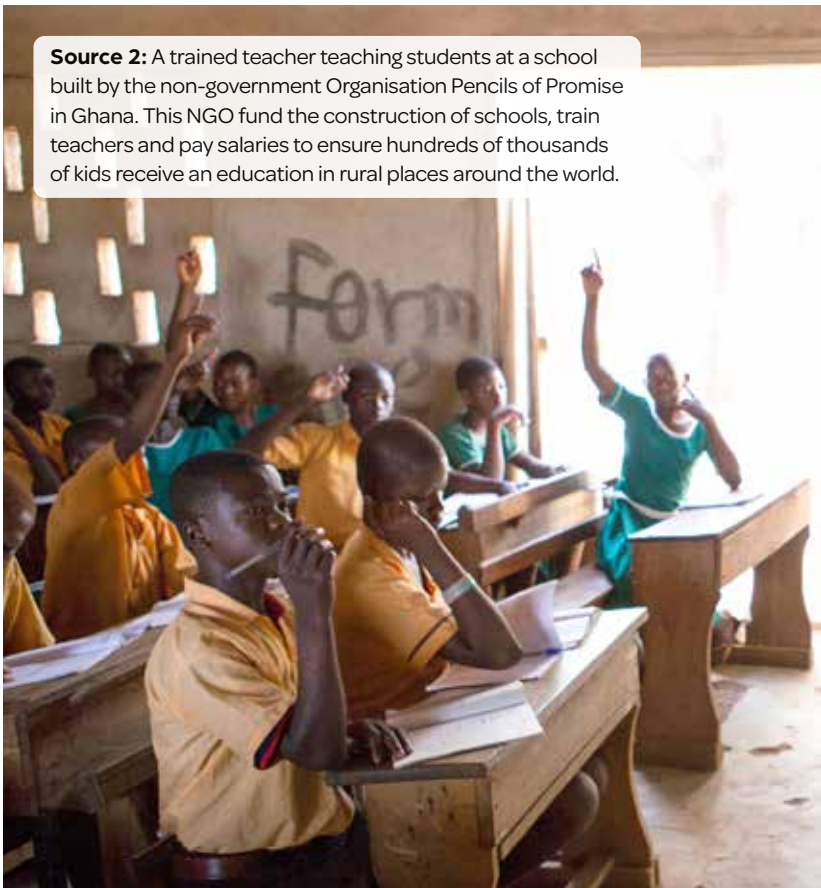
Non-government organisations (NGOs) such as Pencils of Promise partner with local rural communities in low income countries to build school infrastructure. They have built over 550 schools in six countries, including Ghana and Guatemala, providing education to over 150 000 students. They also train teachers in rural areas. Other NGOs, such as Education Above All (EEA), have used technology to increase access to education for over 12 million children in rural and remote communities in countries such as Jordan and Pakistan. EEA have developed online learning platforms, online interactive storybooks in local languages and digital libraries to promote literacy and numeracy skills. This reduces the travel time required for children to access an education.

Affordability

School fees, uniforms, textbooks and transportation costs can make education unaffordable for families in low-income countries where they are more likely to have six or seven children. Many low-income families stop children from going to school as they rely on them to work for the family business to bring in an income. Many national government programs around the world aim to remove this barrier by providing resource packs to families. These cover school supplies or scholarships to cover school fees. The Ethiopian government offers food and cash transfers to vulnerable households on the condition they send their children to school. This has helped decrease food security and led to an increase of literacy rates in Ethiopia.

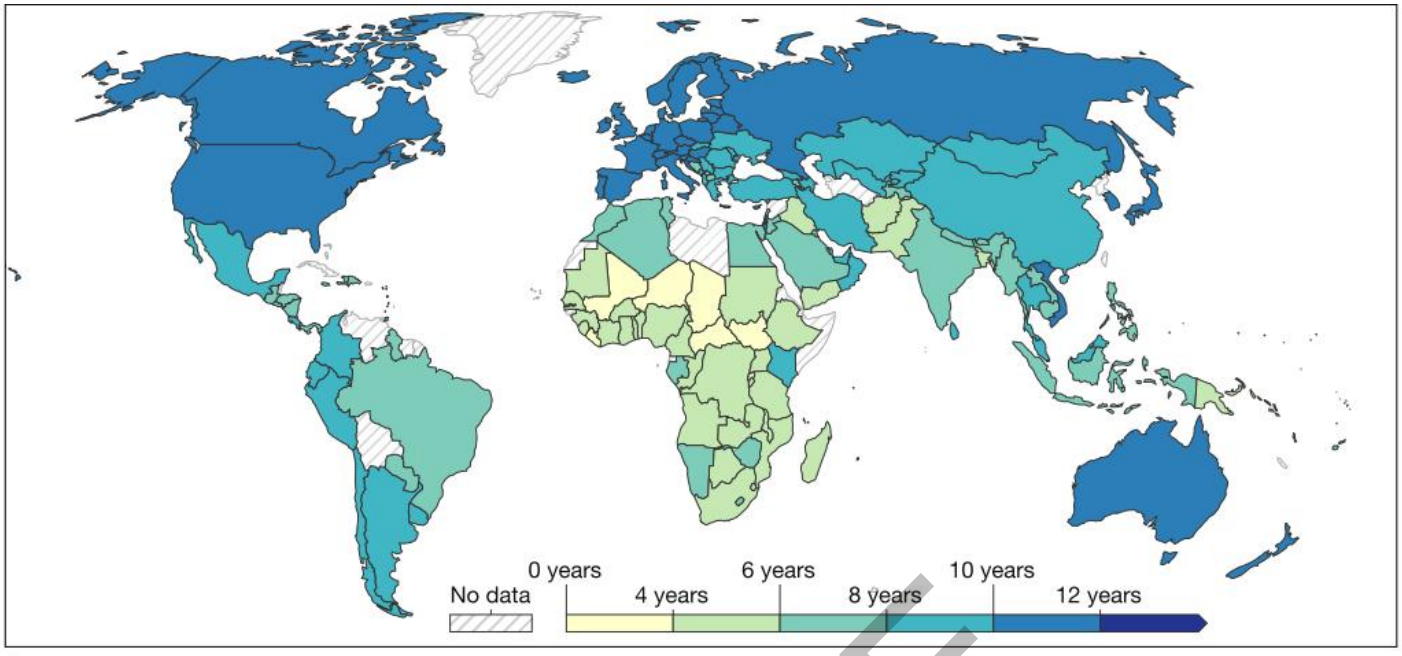
Cultural barriers

There are cultural barriers that can reduce the access or effectiveness of education for some groups. In some **patriarchal societies**, where men hold the positions of power, girls are not allowed to obtain an education or they are expected to marry at a young age which can prevent them pursuing an education. Further, the curriculum, language used or school system may exclude some groups, such as those with a disability and Indigenous or ethnic minority groups. This can make education challenging to access for these groups.



Source 2: A trained teacher teaching students at a school built by the non-government Organisation Pencils of Promise in Ghana. This NGO fund the construction of schools, train teachers and pay salaries to ensure hundreds of thousands of kids receive an education in rural places around the world.

Average learning adjusted years of schooling, 2020



Source: Our World in Data

Source 1: A choropleth map highlighting the average years of schooling a person undertakes in each country based on the amount and quality of education they receive. The higher the level of education, the higher the average income and life opportunities for an individual.

Governments can implement anti-discrimination laws to prevent people being excluded from education. Many community initiatives have also implemented schools that target specific groups, such as girls schools in Saudi Arabia or remote Indigenous schools in Vietnam that teach in local dialect so students can understand the content.

Learning ladder 9.6

Perspectives of people and organisations

1. What are some barriers that prevent children from accessing education?
2. Source 1: Describe the patterns of access to quality education around the world. Refer to three countries in your answer.
3. Explain the role of cultural barriers in reducing educational opportunities.
4. Develop a strategy to improve access and affordability of education in one country in the world.
5. Compare the effectiveness of government and non-government initiatives to improve education.

Sustainability

1. How do education programs support the long-term wellbeing of communities?
2. Source 2: Why is training local teachers an important step in making education initiatives sustainable?
3. What challenges make it difficult to create long-term, sustainable education programs in rural areas?
4. How can cultural and technological strategies improve the sustainability of education programs?

HOW TO
PQE, page 430; sustainability, page 418

Case study

How has Vietnam improved access to education?

A key priority in restructuring and modernising Vietnam was to increase education, as the government saw the importance of having an educated workforce with the skills and training required to underpin business and growth.

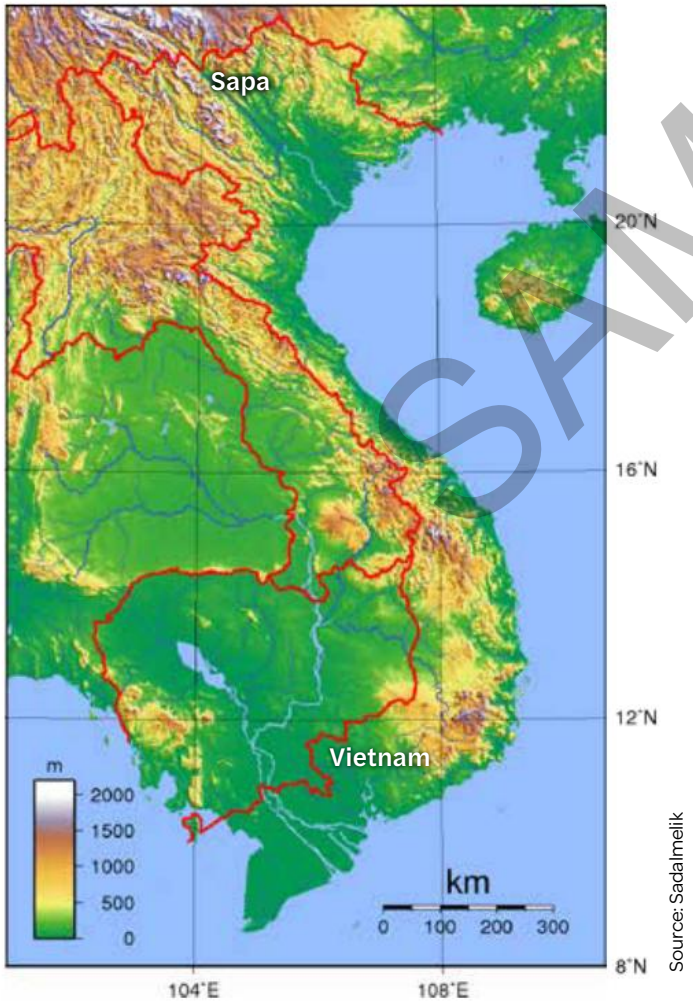
Improving education

Vietnam is a country in South East Asia with a population of 98.1 million. It was once considered one of the poorest developing nations, but in 1986 they restructured their economy to increase business and wealth, in a reform called the Doi Moi. The success of Doi Moi has seen Vietnam rapidly develop into a low-middle income country today with plans to become a highly developed nation by 2045.

Following the Doi Moi reform, the government created five-year Socio-Economic Development Strategy Plans (SEDSP) that established national education targets; such as achieving 95 per cent of students completing primary school and having at least 30 per cent more ethnic minority children in schools. To achieve these, they allocated 15–20 per cent of their entire spending budget each year to fund programs and strategies that targeted barriers to education, such as accessibility and affordability. One of these was the Education For All (EFA) action plan, which:

- increased the number of schools, especially in rural and remote mountainous areas
- increased teacher training
- provided language support for ethnic minority groups
- paid a Campus Support Fund that allowed schools to provide a free education for vulnerable families

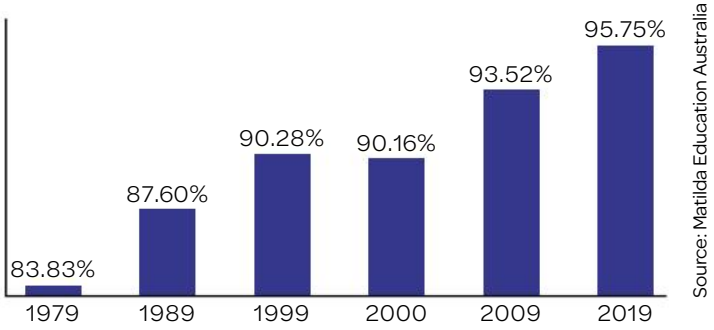
Relief map of Vietnam and neighbouring countries



Source: Sadalmelik

▲ **Source 1:** A relief map of Vietnam shows it is a highly mountainous country. This can make accessing education difficult for those who live in remote mountainous areas.

Vietnam's literacy rate, 1979–2019



Source: Matilda Education Australia

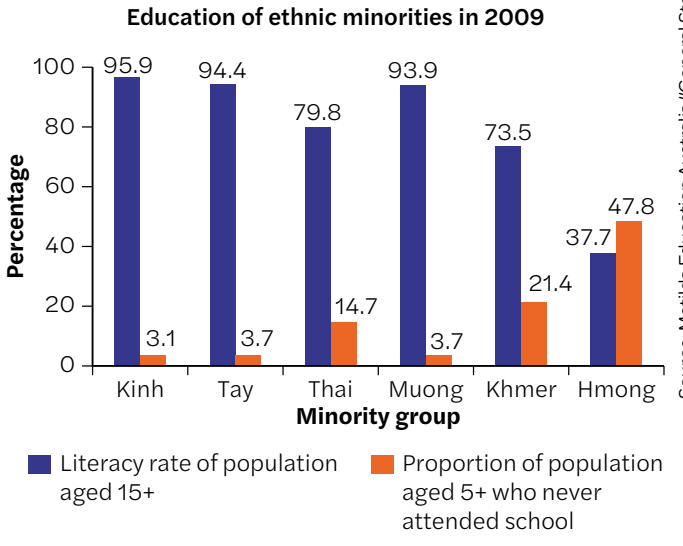
▲ **Source 2:** Literacy rates in Vietnam from 1979 to 2019

- provided boarding schools for students to reduce travel time for remote families
- spent over $280 billion building telecommunications infrastructure so over 29 000 education institutions and remote families could access the internet for online learning platforms.

How successful have they been?

Following the programs and strategies, significantly more children are attending school and receiving an education in Vietnam today. Since 2000, kindergarten enrolments have increased from 72 per cent of children to 98 per cent, primary school enrolments have increased from 94 per cent to 97 per cent and high school enrolments have increased from 33 per cent to 77 per cent. The literacy rate has grown from less than 80 per cent in 1980 to over 98 per cent today and registrations for tertiary education, such as university or vocation centres, have increased from 133 000 students in 1987 to 2.6 million in 2022. Also, 100 per cent of schools delivered basic education programs on sex, violence and abuse prevention, and HIV knowledge by 2022.

This all indicates that there is an improvement in the accessibility of education in Vietnam. However, there is progress to be made on the equal quality of education provided to students across Vietnam, as many rural ethnic minority groups are still not meeting education targets and continue to be disadvantaged in accessing regular teacher support. Some remote communities have literacy rates as low as 40 per cent and little-to-no school access. This is a new focus for Vietnam moving forward as they work towards the international Sustainable Development Goals and continue to focus on education improvement.



Source: Matilda Education Australia/General Statistics Office data (Ministry of Planning and Investment, 2011)

▲ **Source 3:** Educational performance of ethnic minorities in Vietnam

▲ **Source 4:** A Hmong girl and her teacher in a school in Sapa, Vietnam. The initiatives put in place by the government have seen a drastic increase in education rates across the country.

Learning ladder 9.7

Processes that transform people, places and environments

1. What is the Doi Moi reform and why was it implemented in Vietnam?
2. What strategies were implemented to achieve the education targets in Vietnam?
3. Explain why education was a focus for the economic development and spending budget of Vietnam.
4. Assess the effectiveness of the Education For All action plan.
5. Source 3: What challenges does Vietnam face in providing equal quality of education to all students?

Environment

1. Source 1: How does the environment of Vietnam make it difficult for the government to provide equal education to all?
2. Sources 1 and 3: Describe the environment at Sapa, home of the mountain Hmong people.
3. Source 3: Explain the difference in education access for ethnic minority groups in Vietnam.

HOW TO
Environment, page 414

9.8

Which organisations are working to improve wellbeing?

Large international government organisations such as the United Nations and international non-governmental organisations such as Amnesty International work to help improve some of the largest issues facing wellbeing.

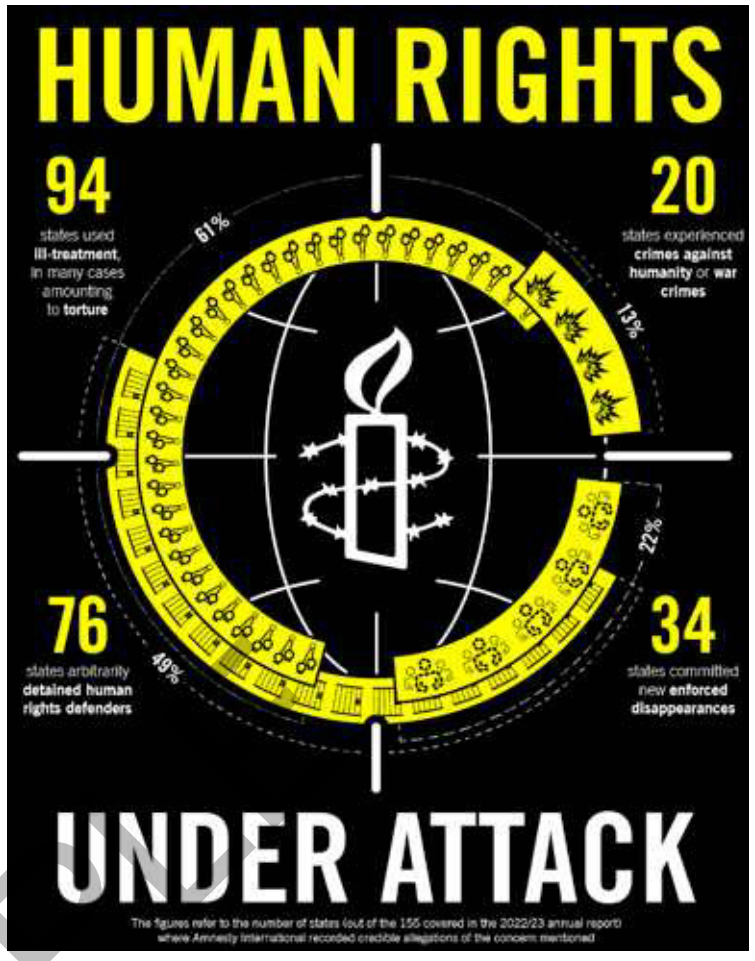
The United Nations

The United Nations (UN) was founded in 1945. It is an **international governmental organisation** (IGO) that aims to facilitate cooperation in economic development, social progress and human rights.

As of 2024, there are 193 member states that endeavour to improve human wellbeing by:

- maintaining peace and security (through actions such as clearing landmines)
- encouraging friendly relations among nations
- solving economic problems (e.g. poverty), social problems (e.g. infection rates of malaria), cultural problems (by working to conserve indigenous cultures) and environmental problems.

Source 1: Children play at a centre for orphans and vulnerable children funded by UNICEF in Malawi, Southern Africa. UNICEF is the United Nations Children's Fund, which works to improve the wellbeing of children.



Source 2: Human rights issues highlighted in Amnesty International's 2022–23 annual report.

The UN Economic and Social Council is responsible for international economic and social cooperation and development. It also coordinates humanitarian assistance when disasters such as floods and earthquakes occur. Other UN bodies and offices involved in human wellbeing include:

- United Nations Development Program (UNDP), which annually publishes the Human Development Index on human wellbeing, which incorporates poverty, health and education
- United Nations Children's Fund (UNICEF), which works to improve children's wellbeing
- World Food Programme (WFP)
- Food and Agriculture Organization (FAO)
- United Nations Population Fund (UNFPA)
- High Commissioner for Refugees (UNHCR)
- International Strategy for Disaster Reduction (ISDR).

Amnesty International

Amnesty International is a worldwide movement of 10 million members and supporters in over 150 countries. Each year the organisation generates activities to prevent and end human rights abuses such as torture and the death penalty. It also reinforces the rights of children, women, minorities, indigenous people, refugees and prisoners of conscience.

Amnesty reduces human rights abuses by placing pressure on governments and companies via demonstrations, letter-writing campaigns, awareness-raising concerts and email petitions. Amnesty's Crisis Prevention and Response team uses satellite imagery to identify human rights abuses in crisis hot spots such as Syria, Iraq, Russia, Israel and Sudan.

Some key activities of Amnesty:

- In 2016, Amnesty documented evidence suggesting that the Sudanese government was using chemical weapons against its own people.
- In 2023, AI documented how the legal systems of 12 African countries werebeing used to discriminate against LGBTI ((lesbian, gay, bisexual, transgender and intersex) individuals.
- In 2023, Amnesty called for the investigation of violations of international law by all parties in the Israel–Palestinian conflict, including an immediate ceasefire, the release of all civilian hostages, and for Israel to end its inhumane siege of Gaza.

Learning ladder 9.8

Perspectives of people and organisations

1. Source 1: What is the role of UNICEF?
2. Source 2: Describe the human rights violations highlighted in the Amnesty International infographic.
3. Explain how the UN aims to improve human wellbeing.
4. Explain the differences and similarities between the United Nations and Amnesty International.

Change

1. List three changes that Amnesty International is working towards.
2. Source 2: How was the play equipment and centre for children funded?
3. Explain the techniques used by Amnesty to bring about change to improve wellbeing.

HOW TO
Change, page 412

How is overseas aid used to improve wellbeing?

Overseas aid is critical to improve the economic development and welfare of low-income countries and to assist countries to deal with natural disasters and the impact of conflict.

Overseas aid

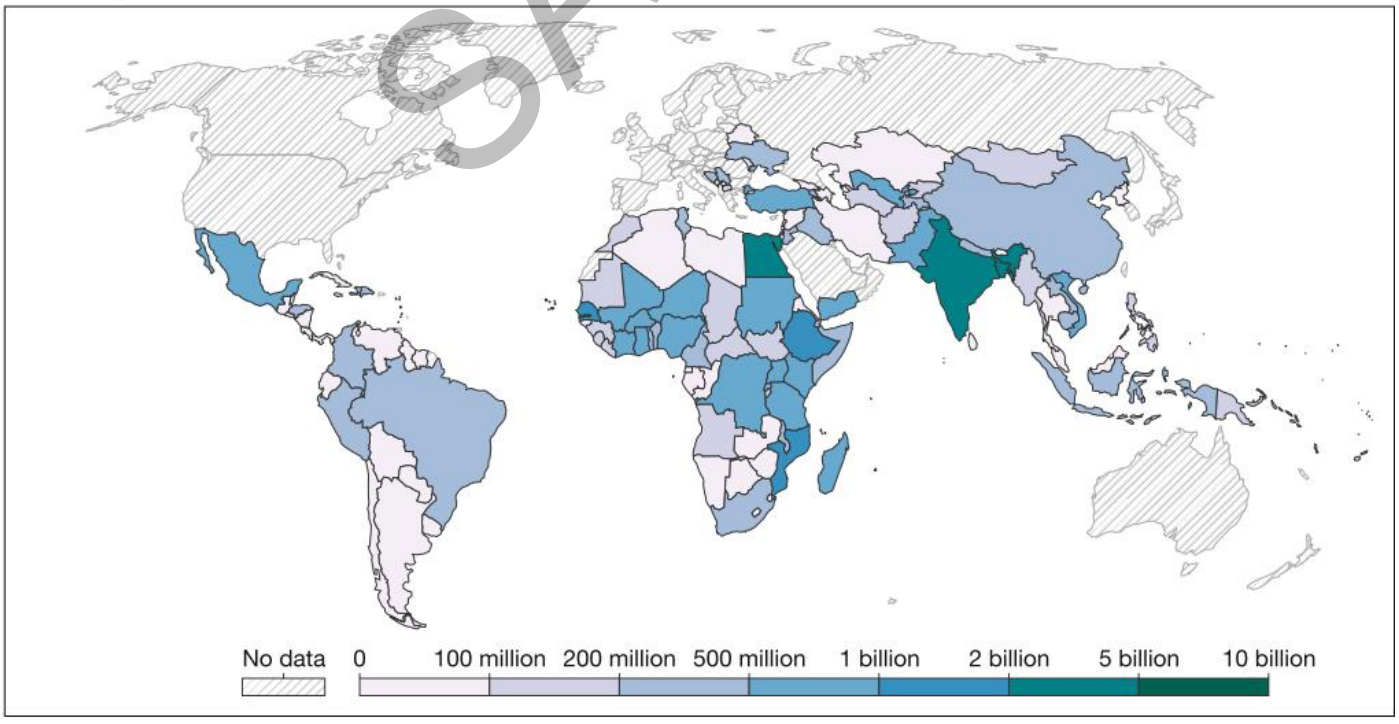
Overseas aid is the transfer of money, food and services from developed countries (e.g. Australia) to developing countries (e.g. Papua New Guinea). The Australian Government's overseas aid, or official development assistance (ODA), is distributed in a variety of forms:

- **Bilateral aid** is given from one government to another; e.g. 30 per cent of the Australian Government aid in 2023–24 was directed to Pacific nations.
- **Multilateral aid** is given by governments from many countries and is distributed through international organisations; e.g. the Australian Department of Foreign Affairs and Trade (DFAT) distributes food through the World Food Programme (WFP).
- **Humanitarian aid** is given to help communities recover from disasters and conflict; e.g. Australia provided $14 million in humanitarian assistance to Yemen in 2022–23. Food prices had doubled and famine loomed as Ukraine, Yemen's largest wheat supplier, was plunged into war.
- Partnerships with non-government organisations (NGOs) are grants that are given to NGOs, such as World Vision, to deliver Australian aid programs to reduce child labour in developing countries.
- Community involvement is aid given by personal involvement; e.g. The Australian Volunteers Program supports volunteers to develop skills.

Official development assistance

In 1970 the world's rich countries agreed to give 0.7 per cent of their GDP to international development each year. Over the past 10 years, only 0.2–0.3 per cent of GDP has been allocated to overseas aid. However, this varies between countries. Scandinavian countries are the largest donors as a percentage of GDP.

Aid by recipient country, 2021



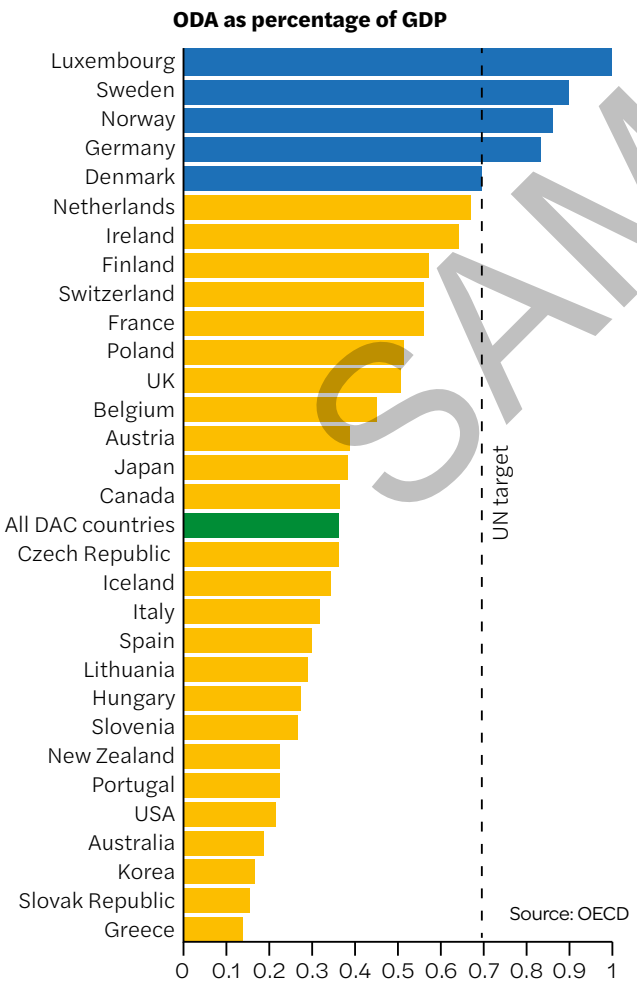
Source: Our World in Data

▲ **Source 1:** Aid in miilions of $US dispersed to countries in need in 2021.

Sweden contributes 0.9 per cent of its GDP, whereas Australia donates 0.2 per cent. The United States contributes 0.22 per cent e of its GDP, but contributes the largest amount in dollars, around $60 billion in 2022. War-torn Ukraine was the largest recipient of ODA in 2022.

Effective global aid

The effectiveness of development aid in achieving economic or human development is important. Some argue against providing aid, as it wastes aid dollars and does not reach the poor who need it. As a result, IGOs and NGOs have implemented effective aid policies that focus on quality aid. The OECD Development Assistance Committee (DAC) is an international forum of large funders of aid, and has 32 members. The DAC evaluates ODA programs for effectiveness and transparency. That is, it aims to ensure that aid dollars are not wasted but are spent wisely to improve the wellbeing of people who need it most.



Source 2: Official development assistance in 2022, by members of the Development Assistance Committee

Source 3: Yemenis displaced by conflict, receive food aid and supplies to meet their basic needs in 2022. Food prices had doubled and famine loomed as Ukraine, Yemen's largest wheat supplier, was plunged into war.

Learning ladder 9.9

Perspectives of people and organisations

1. List the different types of aid distributed by Australia.
2. Source 2: Describe the nations that give the largest percentage of their GDPs as official development assistance.
3. Source 2: Explain the contribution of the United States as a percentage and as a gross contribution in 2022.

Place

1. Source 3: What humanitarian crisis impacted Yemen in 2022?
2. Source 1:Use a world political map to identify countries that received more than $1 billion in aid in 2021.
3. Source 1: What are the characteristics of countries in need of overseas aid?

HOW TO
Place, page 408

How is foreign aid helping Papua New Guinea?

Papua New Guinea (PNG) has a special place in Australia's foreign relations, largely due to geographic proximity and the fact that Australia administered PNG from 1946 until independence in 1975. As a result, Papua New Guinea is the highest recipient of Australian aid of any country. Overseas aid, also referred to as foreign aid, is critical in improving wellbeing and promoting stability in PNG.

Development problems

Papua New Guinea, with a population of 9.3 million, is classified as a lower middle-income country and is ranked 156th out of 191 countries on the Human Development Index (see page 318). About 80 per cent of Papua New Guineans live in traditional rural communities and survive on **subsistence** crops and small-scale cash crops. Approximately 85 per cent of Papua New Guineans are considered as poor by the World Bank, due to their low disposable income, low educational attainment and low access to electricity:

- GDP per capita is $3116.
- Forty per cent of its population live below the extreme poverty line.
- Primary school attendance is 63 per cent for boys and 57 per cent for girls.
- The adult literacy rate is 63 per cent.
- Life expectancy is 65 years.
- The mortality rate for those under five years is 43 per 1000 live births.
- Only 15 per cent of PNG residents have reliable access to electricity.

Australian aid to PNG

Delivering effective aid in Papua New Guinea is difficult. Corruption is widespread, so careful measures need to be put in place to ensure aid money is reaching the intended audience. Communication and the provision of education is made difficult as PNG is the most linguistically diverse nation on Earth, with 839 known languages. Papua New Guinea is also one of the world's most rural countries, with 87 per cent of its people living in remote, rugged areas outside of urban centres. Delivery of services and infrastructure to remote communities is expensive and as a result, access to healthcare, education and transport is difficult.

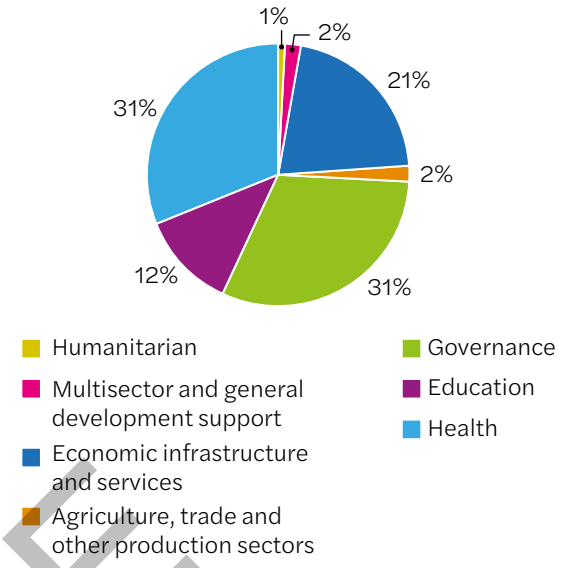
> The objective of Australia's development program is to advance an Indo-Pacific that is peaceful, stable, and prosperous. A region that is predictable – where differences are resolved by international law and norms, and where we can cooperate, trade, and thrive. To achieve this requires sustainable development and lifting people out of poverty.
>
> **Source 1:** Extract from Australia's International Development Policy, 2023, Department of Foreign Affairs and Trade

Australia's International Development Policy guides its cooperation with PNG on programs to deliver improvements in the economy, governance, law and justice, health, education and climate change.

Papua New Guinea is the largest recipient of funding from Australia for critical infrastructure works to build and improve ports, roads, telecommunications, and electricity grids. Australian assistance insists on quality and local input to ensure the greatest benefits for PNG. Other key features of Australian aid to PNG:

- Australia's Transport Sector Support Program helps maintain 40 per cent of PNG's national priority roads to connect communities to markets and services.
- The ANGAU Memorial Hospital in Lae was redeveloped, along with improving rural health infrastructure, and providing health planning and training.
- Increased access to services for gender-based violence survivors helped 13 617 women and girls in 2022.
- Australian aid enabled 666 155 vaccinations to children across 12 provinces in 2022.
- Aid from Australia helped install over 10 000 household solar systems through the off-grid power grants program 'Pawarim Komuniti'.

Development assistance to PNG from Australia, 2021



Source 3: Australian aid to PNG in 2024

Source: xxxxxx xxx xxxxxx xx xxxx xxxxxx

Source 2: An Australian project called Light for Learning is installing solar power in houses and community buildings to enable studying and other activities at night. Light for Learning is delivered through the Pawarim Komuniti grant program, an Australian aid program that has helped deliver solar systems to more than 10 000 households in Papua New Guinea.

Learning ladder 9.10

Perspectives of people and organisations

1. Why is Papua New Guinea considered poor by the World Bank?
2. Explain the factors influencing wellbeing in PNG.
3. Source 1: What are the key objectives of Australia's International Development Policy?
4. Analyse how language and remoteness can impact the delivery of aid to Papua New Guinea.

Interconnection

1. Source 3: Describe where most of Australia's aid budget for PNG was directed in 2024.
2. Source 2: Explain the multiple benefits of the Light for Learning project for remote communities in Papua New Guinea.
3. How important is aid in providing social and economic improvements in PNG?
4. Using examples, predict the importance of Australian aid initiatives on the economic development of Papua New Guineans.

HOW TO
Interconnection, page 410

How is Australian wellbeing addressed at a national scale?

The Australian Government, non-government organisations (NGOs), community groups and individuals are involved in addressing wellbeing issues and reducing inequality nationally, although there are criticisms that as a wealthy country we could do more.

Human rights and discrimination

Legislation is required to enforce Australia's obligations under the United Nation's Universal Declaration of Human Rights. The rights of individuals are protected by Australian laws such as the *Racial Discrimination Act 1975* and *Human Rights and Equal Opportunity Commission Act 1986*, as well as the work of NGOs like the Refugee Council of Australia and Amnesty International. Reducing discrimination can significantly improve the welfare of groups within Australian society. It is unlawful to discriminate on the basis of age, disability, race, gender, marital status and sexual orientation in all areas of public life, including education and employment.

The Australian Human Rights Commission, established through legislation in 1986, handles complaints of unlawful discrimination. Australia has a good record in protecting human rights compared to many nations, however the treatment of asylum seekers and the gap in wellbeing of Australian Aboriginal and Torres Strait Islander Peoples (see page 394) remain areas of concern.

Government support and services

To reduce income inequality the Australian government uses a progressive tax system in which those on the lowest incomes pay little or no tax. The tax collected from higher income earners is used to fund income support and provide social and economic programs and services for the poorest and most vulnerable including the unemployed, the aged and those with disabilities.

A snapshot of welfare in 2023 reported by the Australian Institute of Health and Welfare stated that five million people were receiving an income support payment such as Job Seeker and Youth Allowance, 2.6 million were receiving an aged pension, and there were 573 000 participants in the National Disability Insurance Scheme at the time. Other types of support include rent assistance, subsidised child care and child support.

Medicare, Australia's public healthcare system, assists with the cost of health services such as doctor and hospital visits, while the Pharmaceutical Benefits Scheme subsidises the cost of many medicines. The failure of Medicare to cover basic dental health limits the capacity of the health system to fully address inequality.

The national minimum wage in Australia, the lowest amount you can legally be paid for doing a job, is $23.23 per hour, one of the highest in the world. This payment was increased by 8.6 per cent in 2023 because of a cost of living crisis. Many welfare organisations believe

Source 1: Orange Sky Australia is an NGO providing a free mobile laundry and shower service for people experiencing homelessness, and more recently those living in disadvantaged remote communities. The vision of Orange Sky is to improve the standard of hygiene of the homeless and restore their dignity through better health outcomes, through providing access to appliances most could not access.

Source 2: Australia's progress in achieving no poverty, reducing inequality and life on land (biodiversity loss) went backwards in 2023.

this is too low and barely covers rising basic living costs, particularly the cost of accommodation. Without additional support many low income families live in poverty and rely on charities to pay bills, eat three meals a day and access other services.

Non–government organisations (NGOs)

Thousands of NGOs in Australia support the poor and disadvantaged in matters ranging from access to food, shelter, clothing and education to applying for work and mental health. The Smith Family supports disadvantaged children through programs designed to improve educational access. In 2023 this included 62 822 Learning for Life sponsorships and career education programs to assist students in the transition from school, tertiary education or training into work. The Red Cross focus on accommodation in the belief that this is an essential right and a prerequisite for improved wellbeing. Services include accommodation for the homeless and the provision of meals, showers and first aid.

Australia's wellbeing performance

The UN Sustainable Development Goals (SDGs) can be used as indicators of improvements to human well being in Australia. Of the 17 goals, many are directly connected to aspects of wellbeing such as poverty (1), hunger (2), health (3), education (4) gender equality (5), water and sanitation (6), energy (7), work (8) inequalities (10) and peace and justice (11). Although a highly developed country, Australia's progress in achieving these goals and improving wellbeing of all groups on Australia society had stalled in 2023 and the ranking on progress had slipped to 40th from 166 countries. Less than 50 per cent of SDG targets have been achieved or are on track for Australia and 30 per cent of targets have worsened since the last report including the areas of poverty rates and inequality.

Learning ladder 9.11

Perspectives of people and organisations

1. Describe the perspective of the Australian government on strategies to address human wellbeing.
2. Source 1: Explain how the approaches of NGOs like Orange Sky to improve human wellbeing differ from the government perspective.
3. Analyse Source 1. How might the homeless benefit socially from this service?
4. Source 2: What shortfalls and successes in performance did Australia have in attaining UN Sustainable Development Goals in 2023?

Scale

1. How does the Australian government support wellbeing at a national scale?
2. Source 1: How does Orange Sky address wellbeing at a local and national scale?
3. How does Australia's wellbeing performance compare to global progress on the Sustainable Development Goals?
4. How can changes on a national scale influence wellbeing on a local scale?
5. Why do some wellbeing challenges, such as housing affordability and cost of living, vary at local, national and global scales?

HOW TO
Scale, pages 416, 423

How can we address homelessness in Australia?

Across Australia, on any given night, more than 120 000 people are homeless. Only 6.2 per cent of people without a home are sleeping rough. The majority of homeless people find shelter in crisis accommodation, rooming houses, overcrowded dwellings or by couch surfing.

Homelessness remains an ongoing issue in Australia, one that was thrown sharply into focus during the 2020 COVID-19 lockdowns, when 2000 homeless people were provided with emergency accommodation in Melbourne. More recently the rental crisis caused by limited rental accommodation and rapidly increasing rents has pushed people into homelessness. Data from New South Wales shows that there were 35 000 people who were homeless in 2023 and 10 000 of them had some form of employment, but were unable to find or afford rental accommodation. Many homeless people are living in cars or with friends while trying to hold a job down.

Ongoing accommodation has proved to be a boon to the wellbeing of those involved, who have reported reduced rates of anxiety, depression and other ongoing health concerns. Furthermore, stable shelter has provided a platform for individuals to overcome addictions, seek stable employment and re-establish routines and connections with family and friends. Long-term funding, however, remains an ongoing concern, with governments exploring a range of accommodation options, rather than continuing to fund expensive hotel rooms.

Homelessness is traditionally associated with people sleeping rough on the streets, yet this represents only a fraction of the actual issue. As seen in Source 2, just 6 per cent of Australia's homeless in 2021 were sleeping rough. Homelessness can actually be divided into three categories:

1. Primary: People without conventional housing. This includes people living rough on the streets, squatting illegally, sleeping in improvised shelter or in their car.
2. Secondary: People who move frequently between accommodation, staying with friends or family, or staying in crisis housing or short-term boarding houses.
3. Tertiary: People living in mid- to long-term boarding accommodation or caravan parks without the security of a lease or private facilities.

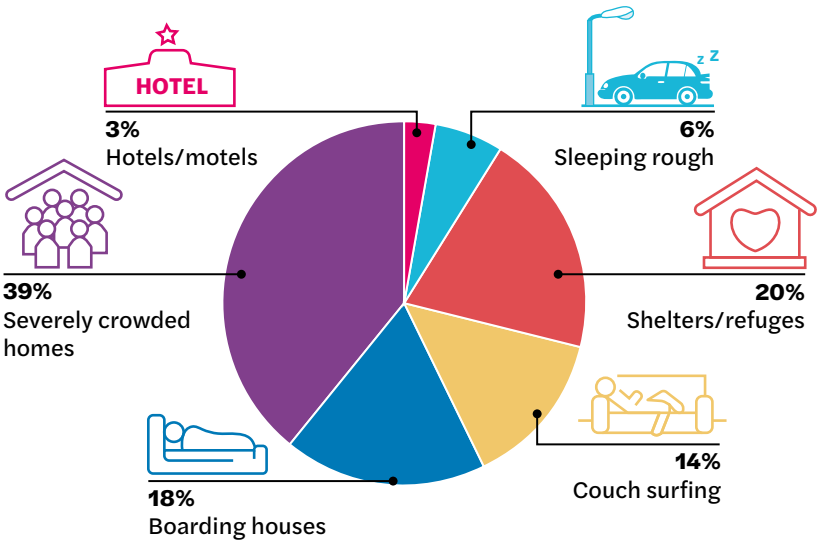
Source 1: A homeless man rests in Hosier Lane, Melbourne.

Addressing the factors behind homelessness remains key to addressing inequality on a local scale. Factors that lead to homelessness may include:

- marital/family breakdowns
- domestic violence
- alcohol/substance abuse
- mental health issues
- unemployment
- eviction/loss of accommodation
- past or recurring trauma.

State and territory governments have primary responsibility for housing and homelessness. There are a broad range of government services, programs and initiatives to try to address these issues, as well as a host of non-government organisations, charities and religious missions. One such provider is the City of Melbourne, which facilitates the following services:

- a dedicated homelessness support team to provide welfare
- weekly meetings with other organisations to support complex cases
- connecting with grassroots organisations to help the homeless
- providing free training for local businesses to better support and understand the homeless community
- funding appropriate organisations that support the homeless
- preparing a guide for how to find and access budget services
- conducting a biannual Streetcount event to gather demographic data on those sleeping rough across Melbourne.



▲ **Source 1:** Homelessness in Australia by accommodation type, 2021

Learning ladder 9.12

Perspectives of people and organisations

1. How many people are homeless in Australia?
2. Describe the three different classifications of homelessness.
3. How does the City of Melbourne support the homeless?
4. How might an NGO like Orange Sky (page 384) approach the issue of homelessness? What are some of the positive outcomes of their program for homeless people?

Interconnection

1. Identify the factors that can lead to homelessness.
2. Sources 1 and 2: Which accommodation type is this man using?
3. Explain why trends in rental accommodation are adding to the issue of homelessness. Create a mind map to demonstrate why this can create further issues and why inequality is increasing.

HOW TO Interconnection, page 410

9.13

How do NGOs improve wellbeing?

Non-government organisations (NGOs) work to improve the wellbeing of people across the world. They work within nations, regions and globally depending on their goals, often targeting multiple outcomes at each location.

Key features of NGOs

Non-government organisations work collaboratively with national governments, international government organisations (IGOs) such as UNICEF and the World Health Organization (WHO), other NGOs and community groups to provide essential infrastructure and services. They also advocate for change, such as the legal protection of groups or individuals, better government funding for wellbeing programs or raising global awareness of disadvantage and injustice.

Issues tackled by NGOs include health crises in conflict zones such as Ukraine or following natural disasters like the 2023 flood in Libya; provision of of health infrastructure and services; environmental challenges including access to clean water and climate change; human rights, particularly the treatment of refugees, minorities, prisoners and women; and the empowerment of poor communities through the provision of skills training or microloans.

Key features of NGOs:

- They are independent of governments, but must work within the legal system.
- They are not for profit, but can raise revenue to fund activities and pay staff.
- They are largely voluntary, utilising the professional skills and passions of volunteers.
- They are dedicated to addressing social, economic and environmental issues to improve people's lives.

The work of NGOs

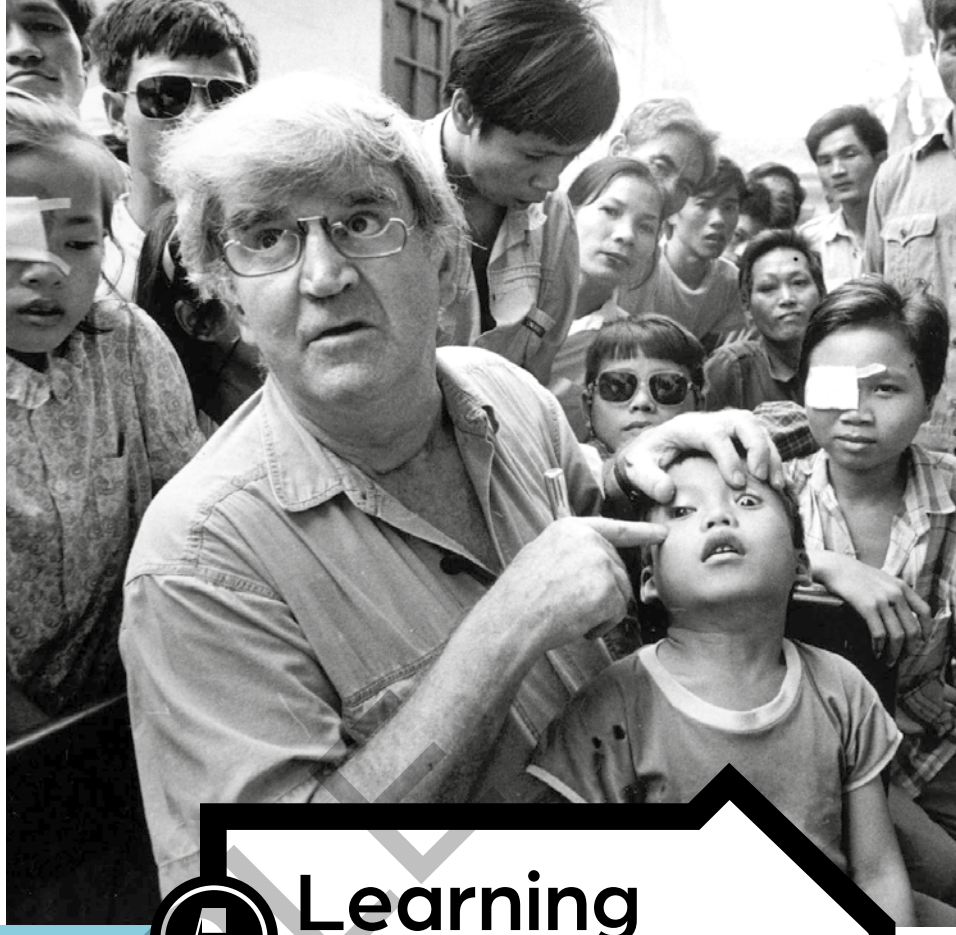
Emergency care: Save the Children is an NGO that works in 120 countries providing healthcare, education, aid and emergency assistance to improve the lives of children. During 2021 the organisation responded to 103 humanitarian crises and assisted nearly 43 million children. In 2024 emergency care involved the provision of water, food, bedding and urgent medical treatment to families with children impacted by the conflict in Gaza.

Source 1: Doctors without Borders established a burns unit at Port au Prince Hospital in Haiti following the 2010 Earthquake, a facility it maintains to treat victims of escalating violence in the country. Volunteers often work in dangerous locations in conflict zones such as Haiti. This clinic was closed in 2022 because violence was a danger to the volunteers.

Empowerment and capacity building: SurfAid works to empower remote communities connected to us by surfing to lead their own sustainable development projects, providing a 'hand up, not a handout'. For example, to improve local food production through agriculture in 2022, SurfAid coached 1463 farmers in practices to improve nutrition and established farm demonstration plots where farmers could practice the new farming methods.

Advocacy and freedom: Amnesty International promotes the protection of human rights through awareness campaigns and mobilising the public to support change (see page 379).

Medical care and training: The Fred Hollows Foundation is an Australian NGO that works in 25 countries to provide eye care and restore the vision of millions of people affected by preventable eye diseases such as cataracts, trachoma and diabetic retinopathy that cause blindness. Restoring sight reduces poverty by enabling patients to access work and education. Training local eye doctors, nurses and health workers; building facilities such as local clinics and regional hospitals and using new technologies builds capacity for progress to continue once the NGO leaves.



Source 2: Professor Fred Hollows, who died in 1993, examines the eye of a young patient at Hanoi Institute of Ophthalmology in Vietnam in 1992

▲ **Source 3:** Indonesian people reached by SurfAid's programs in 2023–24.

Learning ladder 9.13

Sustainable management strategies

1. Define 'empowerment', 'capacity building', 'advocacy', 'not for profit' and 'voluntary'.
2. Source 2: Describe how the Fred Hollows Foundation ensures progress in eye health is sustainable after the NGO leaves a country.
3. Explain why empowerment and capacity building are sustainable solutions to wellbeing issues. Refer to one example.
4. Analyse the key features of NGOs that enable them to sustain activities in multiple countries over many years.

Change

1. Source 1: What changes did volunteers from Doctors Without Borders deal with in Haiti?
2. Describe the types of wellbeing issues NGOs work to change.
3. Source 3: What strategies are used by SurfAid to bring about change?
4. Analyse the following statement from the Transparent Hands website drawing on examples to support your response: 'NGOs can help build stronger, more resilient communities and contribute to a more just and fair society'.

HOW TO
Change, page 412

How is Sea Shepherd protecting livelihoods in West Africa?

Sea Shepherd is a global NGO dedicated to conserving the world's oceans, ecosystems, and species. They target illegal fishing, unsustainable fishing practices and marine habitat destruction. Since 2016 Sea Shepherd has increased its presence in West Africa where illegal fishing activities are threatening the livelihoods of artisanal (small scale) fishermen.

West African marine fisheries

West African countries such as Ghana, Gabon, Gambia, Liberia, and Sierra Leone rank among the poorest on the 2022 UN Human Development Index (HDI). Sierra Leone for example ranked 181 out of 191 countries with 53 per cent of the population living beneath the national poverty line. Fisheries account for up to 20 per cent of primary production and are an important source of nutrition for coastal populations. Fish consumption in Gabon is double the global average at 40 kilograms per year and in Gambia, 300 000 people depend on artisanal and small-scale fisheries for their livelihoods. Fishing contributes to the GDP of these nations through small commercial fishing operations and the sale of fishing permits to other countries.

Source 1: Artisanal fisheries in Ghana using traditional wooden boats rely on coastal ecosystems for livelihoods and nutrition. Much of the catch is sold directly from boats to local families.

Overfishing and illegal fishing

West Africa is one of the world's major fishing regions and increasingly important to international fishing fleets from China, Korea, Russia and the European Union. West African fishery productivity is declining from over-exploitation and illegal activities of large, sophisticated fishing fleets, threatening food security and livelihoods. The greatest threat is from illegal, unreported, and unregulated (IUU) fishing, commonly known as poaching. West Africa has the highest IUU in the world at 40 per cent of the total catch.

Sea Shepherd partnerships

Sea Shepherd is working in partnership with governments in Gabon, Liberia, Sierra Leone, Tanzania, Benin, Namibia and Gambia to combat IUU fishing. Their mission remains one of marine conservation while also protecting economies and the livelihoods

Source 3: Large industrial fishing fleets from China and Europe outcompete the simple boats of local fishers and use technology, large nets and demersal trawling to maximise their catch. One sophisticated Chinese trawler can catch 500 per cent more fish in a day than the yearly catch of a small artisanal group of boats catches in a year.

of local communities. Sea Shepherd provides patrol vessels and expertise to enable government authorities to enforce fishing regulations and marine conservation laws, check licences, arrest offenders, and provide evidence for successful prosecutions.

In 2017 Gabon's commitment to marine conservation was reflected in the creation of nine new marine parks and 11 reserves in 2017 covering 26 per cent of its territorial waters to protect marine habitats and species. Gabon however has relied on partnerships with Sea Shepherd to enforce these zones and prevent IUU fishing. Operation Albacore involved marines, fishing inspectors and National Park rangers joining the crew of Sea Shepherd onboard the ship Bob Barker to enforce regulations, monitor licences and arrest illegal fishing crews and vessels during tuna seasons. The operations uncovered extensive under reporting of tuna catches by European tuna boats that led Gabon to cancel licences and negotiate a new and better deal that included processing tuna within Gabon to create local employment opportunities.

Source 2: In 2017, Sea Shepherd launched a campaign in partnership with the Liberian Ministry of National Defense to fight illegal, unreported and unregulated fishing in the West African coastal waters of Liberia.

In Operation Gambian Coastal Defense, Sea Shepherd undertook at-sea patrols in Gambia's coastal waters assisted by navy marines. They intercepted 22 trawlers, 14 in prohibited no go zones, one of which was charged with 56 counts of fishing in the Special Management Area created to exclude industrial fishing. In total, Sea Shepherd's IUU campaigns in West Africa arrested 84 vessels since 2016 and provided invaluable training for local authorities to improve their coastal surveillance capacity.

Learning ladder 9.14

Sustainable management strategies

1. What is Sea Shepherd's main mission?
2. What activities are responsible for the overexploitation of fish stocks in west Africa?
3. Source 2: What activities does Sea Shepherd undertake during IUU fishing campaigns?
4. Sources 1 and 2: Compare the sources. How does unregulated competition impact the livelihoods of West Africans?
5. In your opinion, can the activities of Sea Shepherd permanently deter IUU fishing in West Africa? Justify your response.

Place

1. Where is this artisanal fishing taking place?
2. Describe the importance of fishing to West African nations.
3. How do Gabon and other African nations benefit from their partnerships with Sea Shepherd?
4. Visit the Sea Shepherd website to investigate a Sea Shepherd campaign to address IUU.

HOW TO
Place, page 408

9.15

How did heritage and community improve wellbeing in New York?

New York City's High Line is a 2300-metre-long elevated linear public park located in Manhattan's West Side. It was developed when neighbourhood residents saved the historic freight rail line from being demolished in 2009, and instead renewed it into a hybrid public space where visitors can experience nature, art and community. It is approximately 9 metres above the ground, enabling people to walk freely in the city without stopping to cross roads. The High Line exemplifies how urban renewal projects can leverage underused heritage infrastructure to enhance community wellbeing and create health-promoting environments.

Green space

The High Line offers a significant amount of green space in a highly concreted area of Manhattan that lacks public parks. There are more than 500 species of plants and trees that have been planted along the High Line, contributing to an aesthetic and recreational space. Green spaces are known to improve mental health, reduce stress and enhance physical health by encouraging active lifestyles.

Community engagement

The park provides a venue for community activities and cultural events; including stargazing tours, LGBT family picnics and Tai Chi. Volunteers engage in planting activities and run free public tours of the High Line several times a week. Many artists develop art installations or run performances across the High Line, to be admired by community members (see Source 3). Community organisations also run many events on the High Line. High Line Teens provides paid employment for teenagers that builds skill and leadership through civic engagement and public programs on the park. High Line Wellness offers mobility and

New York City High Line

Source: Matilda Education Australia

▲ **Source 2:** A map of the New York City High Line

Source 1: An aerial photograph of the New York City High Line; an elevated linear public park that doubles as a walkway on the West Side. This park improves wellbeing by providing a recreational space where community can connect and engage in activities together.

wellness programs serving aged populations. As of 2021, an intergenerational High Lines Neighbourhood Council was established. They are a group who live, work and study in Chelsea or the West Side of Manhattan. They meet regularly to discuss ideas and collaborate on creating community programs across the High Line that meet the needs of different groups of people in the city. These community programs, driven by community members, improve wellbeing by fostering a strong sense of belonging, connection and community.

Accessibility

The High Line is accessible to all demographics across New York City. It is free to use, ensuring all socio-economic groups have access. It also has four elevators along the High Line for greater accessibility.

Improved environment

The extensive landscaping along the High Line is purposely designed to include a wide variety of perennials, grasses, shrubs and trees that were chosen for their hardiness, sustainability and ever-changing colours across all four seasons. This has improved urban biodiversity by providing a space for insects, birds and small mammals. It has also improved heat island issues, as vegetation provides shade and cooling evapotranspiration, decreasing surface temperatures. It also absorbs excess gas emissions, reducing air pollution and improving air quality for urban residents.

There is an initiative to 'buy an insect or a plant' for the High Line. The money raised funds community projects and the upkeep of the High Line.

Improved sense of place

The development of the High Line has revitalised the West Side of Manhattan, leading to an increase of small businesses and art galleries, and increasing the desirability of the neighbourhood. This has led to local economic growth and improved access to a diverse range of businesses, recreational opportunities and dining options.

▲ **Source 3:** Art installations are found throughout the High Line, with new ones being added regularly. This contributes to culture and a sense of belonging by showcasing the works of local artists and represent the cultural heritage and diversity of the community.

Learning ladder 9.15

Characteristics of places and environments

1. How does the High Line's green space contribute to the mental and physical health of the community?
2. Describe the impact of community engagement activities on the High Line in promoting wellbeing among residents.
3. Explain how the diverse plant life on the High Line improves urban biodiversity and contributes to environmental wellbeing.
4. Analyse how the High Line's community-driven programs improves the wellbeing of different demographic groups.
5. Evaluate the role of accessibility features on the High Line in enhancing inclusivity and wellbeing for diverse demographics, including those with disabilities.

Place

1. Source 2: Describe the location of the High Line.
2. What elements make the High Line a distinct place compared to other areas in Manhattan?
3. Source 3: How does the High Line reflect the cultural identity of the West Side of Manhattan?
4. In what ways have heritage and community been important in the effectiveness of the High Line in improving wellbeing?
5. Evaluate how the High Line has shaped the socio-economic landscape of the surrounding neighbourhood. What are the potential positive and negative consequences of such transformations on the local community?

Place, page 408

HOW TO

What action is being taken to improve wellbeing for First Nations Peoples?

After many failed attempts to close the gap in wellness outcomes for Indigenous Australians, it is clear that First Nations Peoples' communities need to be empowered to lead, design and implement programs tailored to their specific needs and aspirations.

Fostering wellbeing

Fostering a sense of wellbeing in First Nations communities is crucial and requires genuine support from institutions. This entails government bodies, healthcare providers, and community organisations committing to providing ample resources for initiatives led by First Nations people. Understanding the historical and systemic causes of trauma is paramount, prompting institutions to create culturally sensitive programs prioritising self-determination and community control. Policies should focus on funding and assisting First Nations communities in developing their healing plans. It is important to note that not all First Nations people require access to these culturally appropriate services, and that many First Nations people are strong in culture, language, community, and Country and work hard to share these aspects of life with the next generations of First Nations young people.

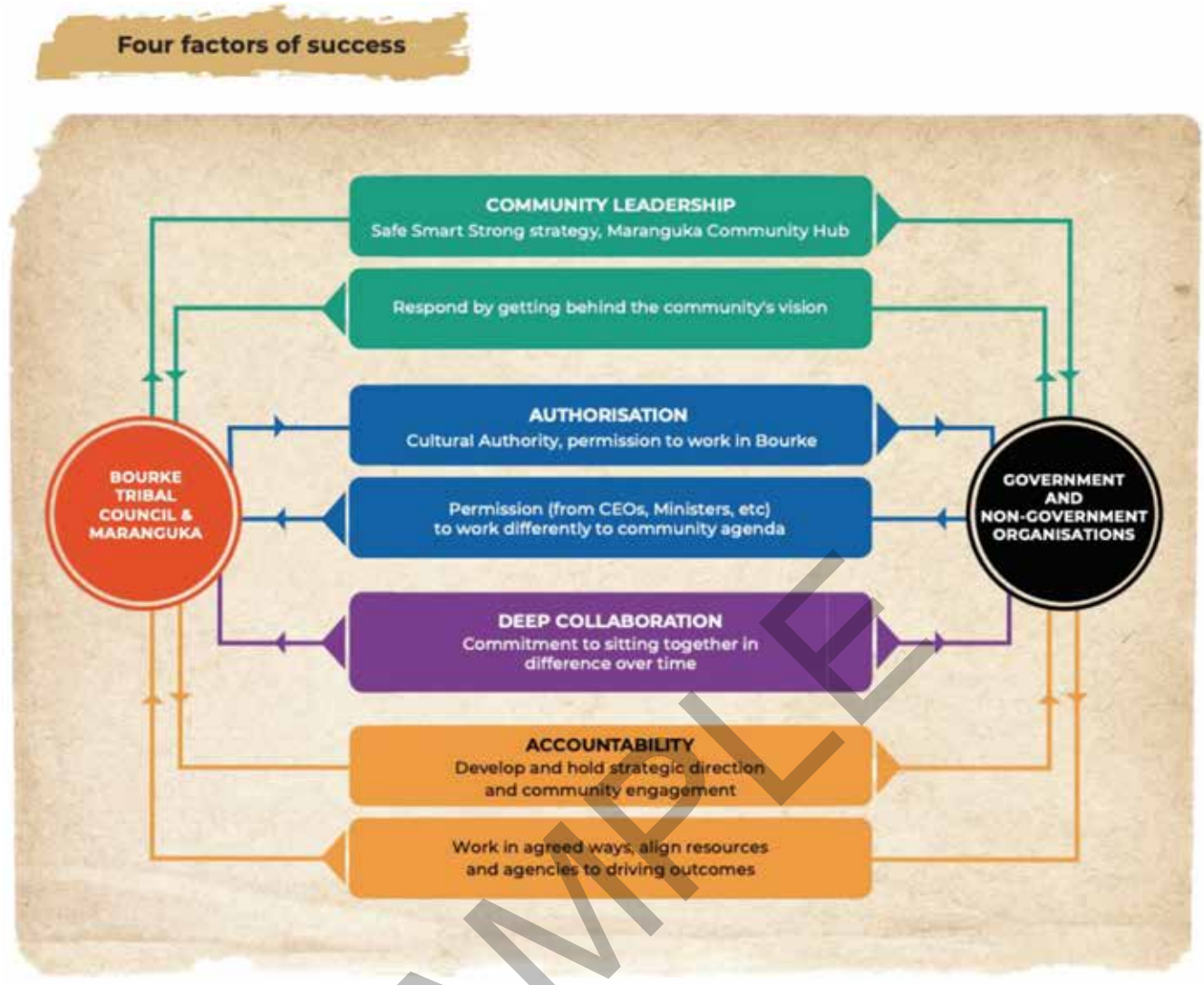
Community–led initiatives

Recognising the multifaceted challenges facing their communities, local initiatives provide crucial social connections and support networks. Involvement in cultural practices proves beneficial, improving physical health, emotional wellbeing, and reducing risky behaviours. Throughout Australia, First Nations communities have established healing centres and cultural hubs, serving as vital sources of resilience and overall wellness. These initiatives prioritise culturally informed healing methods like bush medicine, yarning circles, and ceremonial practices. Supported by organisations like the Healing Foundation, these grassroots projects encompass culturally appropriate and trauma-informed care that responds specifically to the needs of the community.

Land management programmes led by First Nations rangers not only contribute to environmental conservation but also promote cultural identity and economic empowerment. Similarly, language revitalisation projects aim to preserve First Nations languages and strengthen cultural connections within communities. Collaborative, community-driven

Source 1: 'And then their children were taken. They were moved to strange homes with people they didn't know and they weren't allowed to see their families. Those children became known as the Stolen Generations. These children didn't have their parents to give them a cuddle, or their grandparents to read them a story. This made the children very scared and very sad for a long time.'

The Healing Foundation's Intergenerational Trauma video



Source 2: Maranguka is an Aboriginal-led model of justice reinvestment based in Bourke in north-west NSW. Justice reinvestment is an approach to reducing criminal behaviour. Informed by data, Aboriginal communities are empowered to provide the best support for vulnerable families and develop solutions for issues likely to push young Aboriginal people into criminal activity. Maranguka is a collaboration between the Bourke Tribal Council, Just Reinvest NSW and the community of Bourke.

approaches, such as the Maranguka Justice Reinvestment Project, prioritise local needs and cultural healing to address issues effectively. The social and emotional wellbeing of First Nations children and youth is also influenced by factors like racial discrimination and family stress. Resilience-building programmes and culturally sensitive interventions have shown positive outcomes in improving mental health and resilience among First Nations youth. Together, these community-led initiatives work to repair deep wounds and foster strength in First Nations communities, nurturing not only hearts and minds but also physical resilience.

Source 3: The Stronger Smarter Approach is used in schools across the country to embrace a strong and positive sense of what it means to be Aboriginal in contemporary Australian society.

Education and employment programs

Improving educational outcomes and creating employment opportunities are crucial for enhancing overall wellbeing. Government initiatives such as the Indigenous Advancement Strategy aim to empower First Nations individuals and communities by providing skills development, mentoring, and job placement support. Additionally, efforts to decolonise classrooms and workplaces play a vital role in fostering inclusivity and cultural responsiveness. Initiatives such as embedding First Nations perspectives and knowledge into curriculum frameworks, implementing cultural competency training for educators and employers, and promoting First Nations–led initiatives in educational and professional settings contribute to creating more equitable and respectful environments as well as enabling non-Indigenous students to benefit from First Nations knowledge and wisdom. For example, programs like the Stronger Smarter Institute work to empower First Nations educators and leaders to enact positive change within educational institutions, while initiatives like the Aboriginal and Torres Strait Islander Employment Strategy focus on increasing First Nations representation and participation in the workforce through targeted recruitment and support programs.

Primary healthcare services

Indigenous Medical Services, Aboriginal Community Controlled Health Organisations (ACCHOs), and other primary healthcare providers play a crucial role in delivering culturally appropriate care to First Nations peoples. These services offer a holistic approach to healthcare, addressing not only physical ailments but also social and emotional wellbeing. Many ACCHOs offer programs targeting chronic disease management, mental health support, and preventive care. In 2019, a public hospital in Adelaide pioneered a program that integrates First Nations healing practices, led by Ngangkari (healers), with Western medicine to treat First Nations patients. This initiative taps into 60 000 years of healing methods, emphasising touch, breath, and bush medicine to address not just physical ailments but also the spiritual wellbeing of individuals. Collaborating with doctors and nurses, Ngangkari offers complementary treatment alongside medical care, enhancing patients' overall healing experience.

Mental health and wellbeing initiatives

Emphasising the importance of cultural identity and connection to Country, various programs have emerged to bolster the mental health and wellbeing of First Nations communities. Notably, initiatives such as Beyond Blue's Indigenous Social and Emotional Wellbeing Program offer tailored support and resources designed to combat depression, anxiety, and suicide ideation within First Nations populations. Similarly, the Indigenous Mental Health First Aid Training program seeks to enhance mental health literacy and build support networks within First Nations communities. These initiatives, grounded in cultural understanding and community engagement, address the unique mental health challenges faced by some First Nations peoples.

Closing the Gap

Closing the Gap refers to the Australian Government's commitment to reducing disparities in health, education, and socioeconomic outcomes between First Nations and non-Indigenous Australians. The national

strategy has faced criticism for its failure to achieve its intended outcomes. Despite significant investments and efforts, the targets related to life expectancy, infant mortality, education, and employment have not been adequately met. Government-funded programs under this strategy have been criticised for their top-down approach, lack of meaningful engagement with First Nations communities, and insufficient allocation of resources to First Nations–led initiatives.

While some progress has been made in improving access to healthcare and promoting education and employment opportunities, the systemic barriers and entrenched inequalities faced by First Nations Australians remain largely unaddressed. The failure of Closing the Gap highlights the need for a more collaborative, community-driven approach that empowers First Nations peoples to lead the design and implementation of solutions tailored to their specific needs and aspirations. Simply pouring funds into programs without addressing the underlying structural issues and involving First Nations communities in decision-making processes is unlikely to bring about the desired improvements in First Nations health and wellbeing. This approach has become more complex and challenging in the wake of the failed Voice to Parliament Referendum which would have been a key advisory body to help support First Nations outcomes.

▲ **Source 4:** Part of the Close the Gap dashboard, 2022

Source 5: Anangu healer Cyril Mckenzie working at the Royal Adelaide Hospital

Learning ladder 9.16

First Nations Peoples' interaction with Country

1. Source 4: Which Close the Gap targets are on track?
2. Describe the approaches to improve educational outcomes.
3. Source 1: Explain the role of The Healing Foundation in helping families and individuals deal with intergenerational trauma.
4. Analyse the impact of one First Nations organisation in enhancing improvements in healthcare.

Change

1. Why is understanding past trauma important to improving First Nations wellbeing?
2. Source 5: Why is the involvement of Ngangkari (healers) an important change in the hospital system?
3. Source 2: How is the Maranguka model a new approach to improving crime in Bourke?
4. What are the implications of pouring funds into wellbeing programs without collaboration and leadership from First Nations communities?

HOW TO Change, page xx

Thinking geographically

Human wellbeing

Geographical concepts, inquiry and tools

Place, scale, environment, change, inquiry

Learning Ladder: page XXX

Key inquiry question

Is human wellbeing improving in Bhutan?

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 Bhutan
- the key social and economic characteristics of Bhutan
- Bhutan's performance using a variety of wellbeing indicators (negative and positive)
- areas where improvements in human wellbeing can be made
- efforts to address one aspect of wellbeing
- at least one illustration such as an annotated sketch map, photograph or graph.

Where possible, refer to the sources in this spread to support your response.

Physical and human characteristics of Bhutan

Location of Bhutan

HOW TO
See **Geo How-To** mapping skills page 422

Source 1: Bhutan is a landlocked country in the Himalayan mountain region of mainland Asia.

Source: Adobe Stock/stu-shaii

Source 2: Key facts about the Kingdom of Bhutan

Leaders	Head of government: Prime minister; Head of state: King
Capital	Thimphu
Population	777 200. Nearly one-third is under age 15, while about three-fifths is under 30, making it a young population.
Ethnicity	Bhutia (descendants of Tibetan migrants) 50% Nepalese 35% Sharchops (descendants of Hill tribes) 15%
Total area	38 394 square kilometres
Population density	20.2 persons per sq km – highest in the fertile valleys, lowest in the Himalayas
Urban-rural populations	Urban 34% Rural 66%
Life expectancy at birth	Male: 68.8 years Female: 71.7 years
Literacy	Male: 78% Female: 63% (15 years and over)
Income per capita	US$3176
Economy	Bhutan is a lower-middle income country with an economy dominated by agriculture using limited land that is terraced to grow a variety of crops and raise livestock. Recent small-scale irrigation is helping productivity. Cement, chemicals, wood products and processed foods are the main manufacturing industries. Investment in infrastructure such as roads and power are improving economic opportunities such as mining and tourism. Most trade is with India.
Imports and exports	Imports include machinery, transport equipment, metals, petrol, food and textiles. Exports include electricity, copper wire and cable, metals, cement, and polyester yarn, spices, timber and handicrafts.
Environment	Mountainous – 70% of the land is forested or under natural grasslands

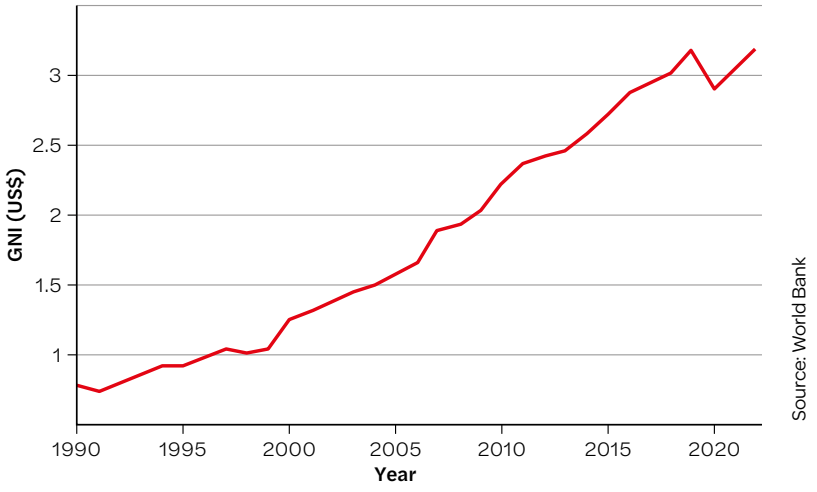
Source 3: The Great Buddha Dordenma is a gigantic Shakyamuni Buddha statue in the mountains of Bhutan, near Thimphu, the capital. Buddhism is the spiritual heritage of Bhutan and followed by 75 per cent of the population. The mountainous landscape and fertile valleys separated by long ridges are seen below. The country is rich in natural resources, but few are exploited.

Sources 1–3 activities

1. Define the following terms: landlocked, human wellbeing, population density.
2. Describe the geographic location of Bhutan using geographical terminology.
3. Mind map features of Bhutan that suggest it has a lower-middle income economy.
4. Explain why Bhutan has an economy dominated by agriculture.
5. Source 3: Analyse the photo using the Layers of Inference method.
6. Assess the capacity of Bhutan to improve human wellbeing. Refer to characteristics of the country that may limit or support the potential for change.

Indicators of human wellbeing in Bhutan

Gross national income (GNI) Bhutan, 1990–2020

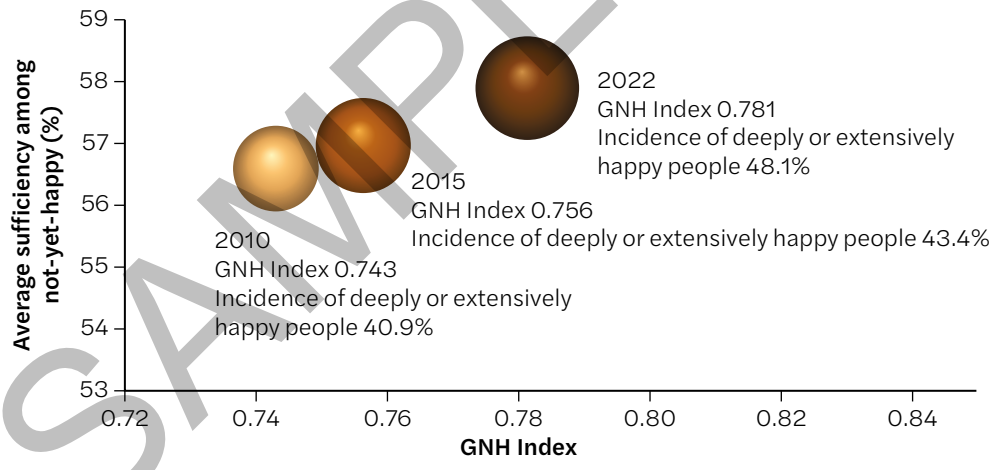


Source: World Bank

Source 4: Gross national income (GNI) per capita is used globally as an indicator of development and people's economic wellbeing.

Source 5: The Gross National Happiness (GNH) Index was adopted in the constitution of Bhutan in 2008. It uses a multidimensional approach based on balancing material wellbeing and the spiritual, emotional and cultural wellbeing of people and needs of society. The four pillars of GNH are fair socioeconomic development (better education and health), conservation and promotion of a vibrant culture, environmental protection and good governance. Although the number of extensively happy people had improved in 2022, there were variations between rural and urban, male and female, and different age groups.

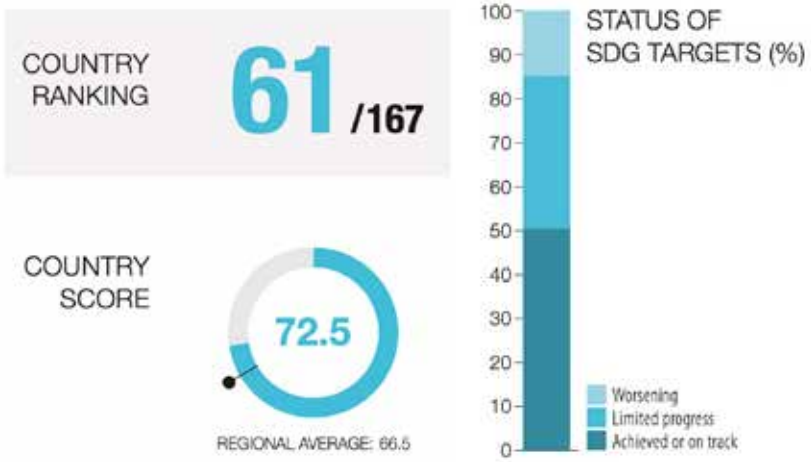
Bhutan Gross National Happiness (GNH) performance 2010–22



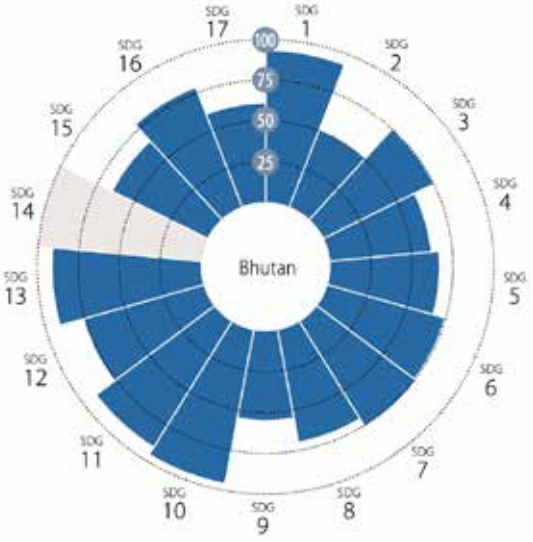
Source: Centre for Bhutan & GNH Studies, 2023

Source 6: Sustainable Development Goals report for Bhutan, 2024. Countries report to the UN on their achievements in relation to the 17 SDGs. Progress on the indicators for each goal are averaged to create a radar chart. A dashboard is used to show if progress has been made across the 17 goals.

Overall performance



Average performance by SDG



SDG dashboards and trends

Source: JD Sachs, G Lafortune and G Fuller

Note: The full title of each SDG is available here: https://sdgs.un.org

Source 7: GNH Index: rural versus urban

		2010	2015	2022
GNH Index	Rural	0.715	0.731	0.771
	Urban	0.786	0.811	0.796
Incidence of happy people	Rural	37.4%	38.1%	46.4%
	Urban	50.2%	54.6%	50.5%

Source: Centre for Bhutan & GNH Studies, 2023

Source 8: GNH Index by gender

	National	Male	Female
GNH Index	0.781	0.814	0.762
Incidence of happy people	48.1%	55.3%	43.8%
Incidence of not-yet-happy people	51.9%	44.7%	56.2%

Source: Centre for Bhutan & GNH Studies, 2023

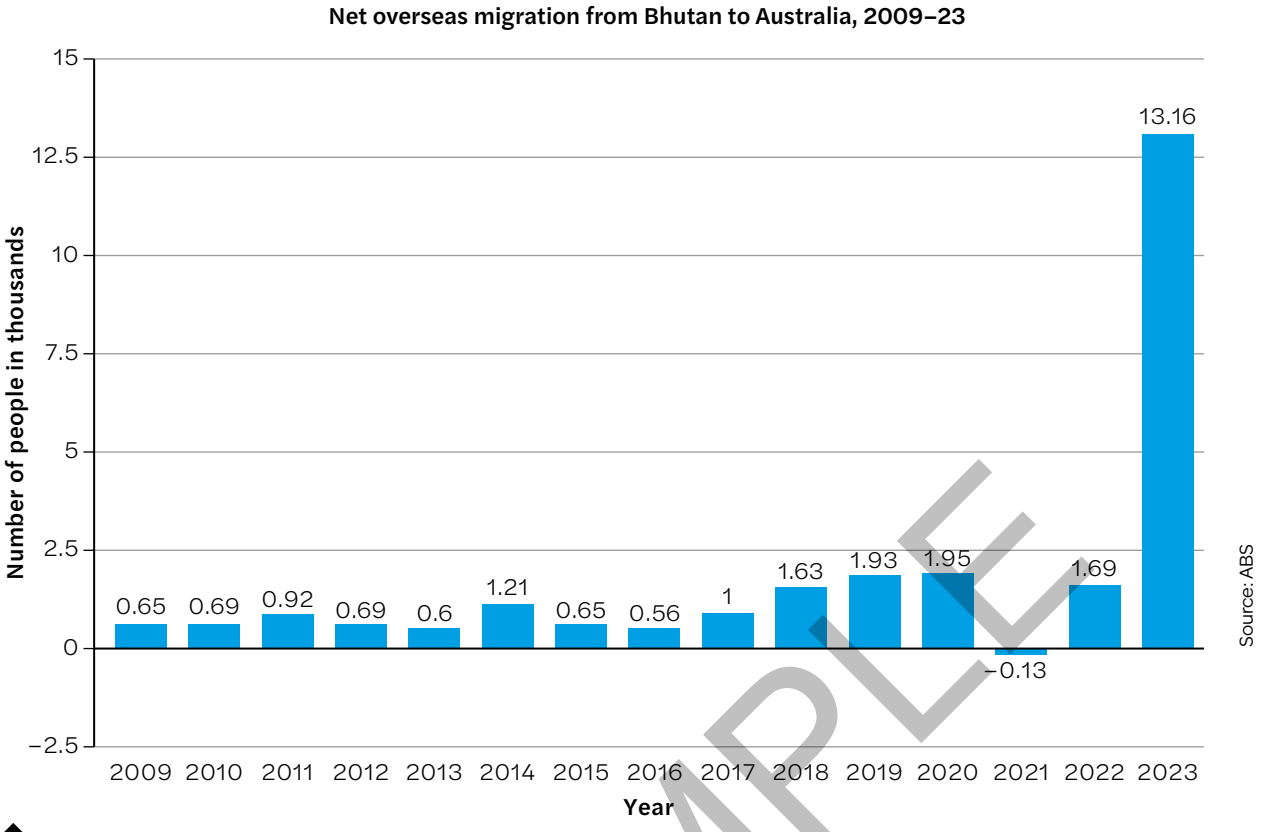
Source 9: GNH Index by age

Age group	15–39	40–64	65+
GNH Index	0.797	0.769	0.741
Incidence of happy people	51.1%	45.7%	40.7%

Source: Centre for Bhutan & GNH Studies, 2023

Sources 4–9 activities

1. Outline each of the measures of wellbeing: GNI, GNH and SDGs.
2. Explain the benefits of using quantitative data (statistics) to report on aspects of human wellbeing. Refer to the sources in your response.
3. Source 4:
   - **a** Calculate the change in GNI per capita between 1990 and 2025.
   - **b** Suggest reasons for the change.
4. Source 6:
   - **a** Identify four goals that Bhutan is closest to reaching.
   - **b** Rank in order the four goals in which Bhutan has the poorest achievements.
   - **c** Suggest ways that Bhutan could address one of these goals.
5. Sources 4, 5 and 6: Identify and analyse trends in relation to human wellbeing for GNI per capita, SDGs where improvements have been made and the GNH index.



Source 10: Migration from Bhutan to Australia, the second-largest destination country. News headlines such as 'Bhutan's jobs woes drive an exodus to Australia' (Reuters 2023) and 'The employment challenges in Bhutan are causing a significant migration to Australia' (Medium) attempt to illustrate a social change occurring in Bhutan. Migration from Bhutan has increased dramatically since the COVID-19 pandemic. Reports show that young people in particular are leaving Bhutan for study and to seek lifestyles and economic opportunities not available in Bhutan. New technologies and social media make moving abroad more attractive and once overseas countries like Australia make it possible to gain visas to stay and work. Educated professionals such as civil servants, doctors and teachers are also leaving –seen by many as a 'brain drain'. The challenge for Bhutan is to provide incentives for young and educated people to stay, or return, such as increasing incomes and opportunities for a richer life, rewarding life.

Sources 10–11 activities

1 Identify two reasons for increased migration of young people from Bhutan.

2 Source 11: What message do we understand about human wellbeing in Bhutan?

3 Explain the challenge facing the Bhutan government in relation to growing its economy and improving the wellbeing of its residents.

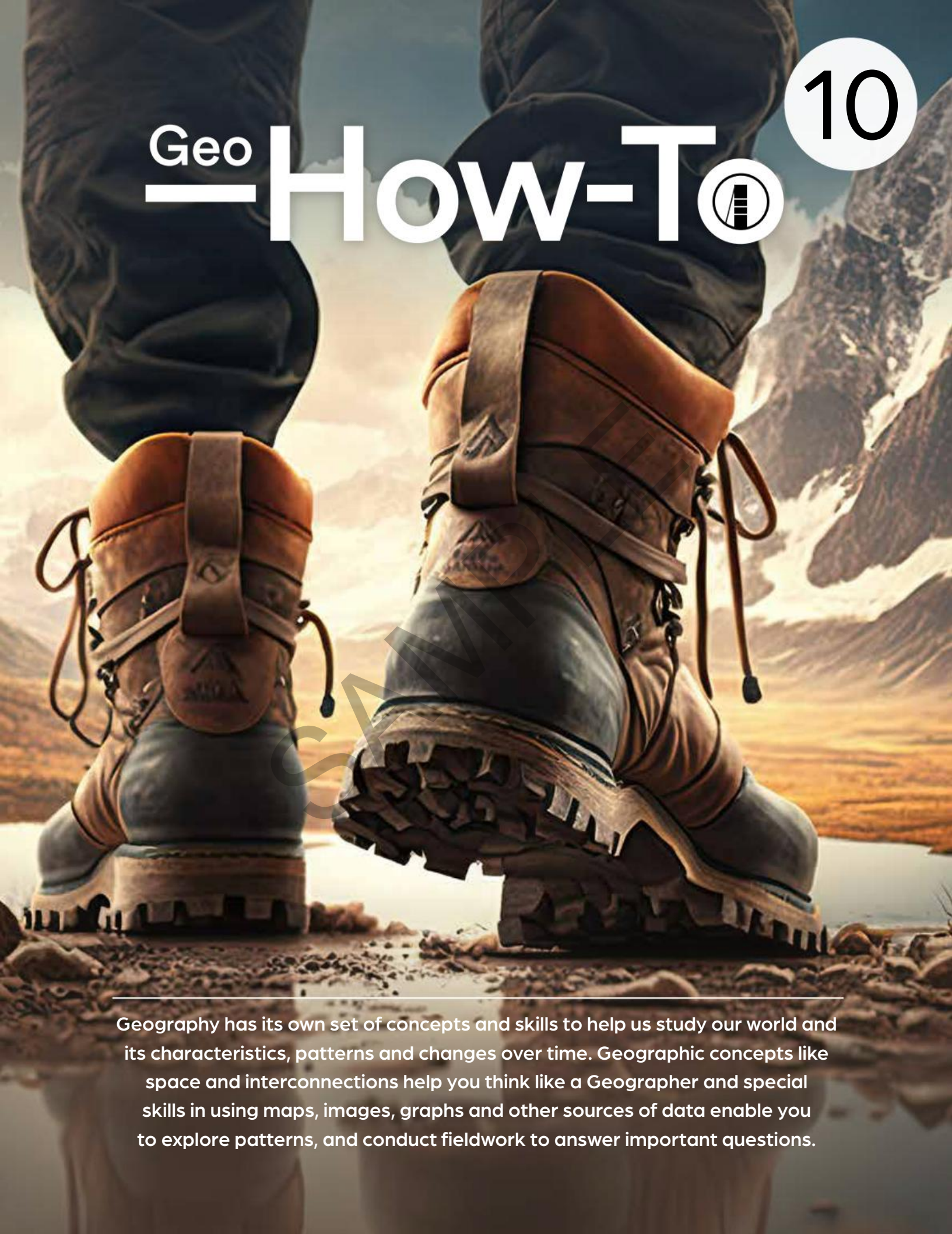
4 Why is ecotourism being targeted as a potential employment solution? Consider what you know about the natural environment and culture in Bhutan.

5 Analyse the potential benefits of ecotourism for different groups in Bhutan society.

- In Bhutan, communities are increasingly looking at ecotourism as a way to boost their economies and protect the environment and endangered species.
- About 50 per cent of Bhutan's population is under 25.
- Ecotourism is viewed as a potentially viable future for the younger population and women.
- Ecotourism projects under development include homestays, birdwatching, nature-based activities and local festivals.
- To build back better from the socioeconomic losses caused by the pandemic that displaced about 50 000 Bhutanese.

The country is now positioning itself as a 'a model ecotourism destination' to help recover.

Source 11: The rise of ecotourism in Bhutan



Geo How-To 10

Geography has its own set of concepts and skills to help us study our world and its characteristics, patterns and changes over time. Geographic concepts like space and interconnections help you think like a Geographer and special skills in using maps, images, graphs and other sources of data 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

The concept of space involves looking at the way things are arranged on Earth and how we change the spaces where we live. The study of space has two key components:

1. location – where a space is found on Earth
2. spatial distribution – the arrangements and patterns of natural and human features on the surface of the Earth.

1 I can recognise location

The first step is to recognise where a space is found on Earth. When you are trying to recognise location, ask: How can I describe the location? Where on Earth is it found? What does the environment look like?

For example, Source 2 shows that the space the elephants are occupying is swampy grasslands located in the Okavango Delta, in the country of Botswana and the continent of Africa. All of these are geographgical spaces.

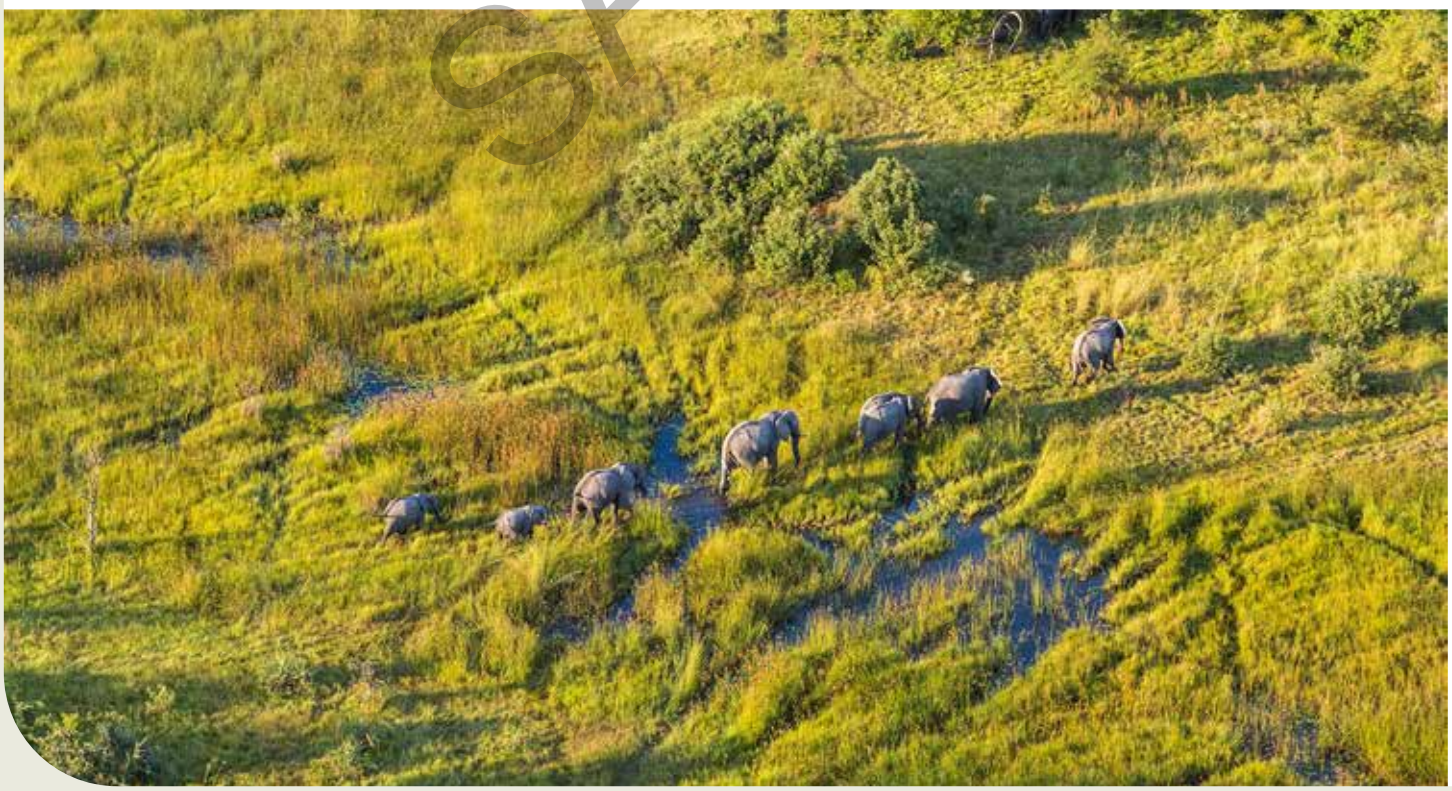
2 I can recognise spatial distribution

The second step is to recognise if a spatial distribution is formed. When you are trying to recognise a spatial distribution, ask: Can I see a pattern? Is the feature I am looking at spread out in a line or bunched together?

For example, the aerial view (from above) in Source 2 helps us see that the elephants have formed a linear pattern (the are in a line) as they move through the land.

Source 2: Aerial view of a herd of African elephants in the Okavango Delta, located in north-western Botswana in southern Africa.

Large animals such as elephants can be observed from the air using planes, helicopters, drones and even satellites. Surveys of elephants help us understand how many elephants are found in a space and where they are located within that space. Understanding the spatial distribution of elephants helps geographers develop plans to manage both the health of this endangered species and the environments they live in.



Map of 1854 cholera outbreak by John Snow , drawn and printed by C. F. Cheffins.

Source: John Snow

Source 3: Dr John Snow created this dot distribution map in 1854 to help understand why so many people in London's Soho district were dying from cholera. Snow's map showed that most deaths occurred near the Broad Street pump, where people collected their water. The pump was turned off to prevent further deaths, and Snow proved that cholera was spread via the water, not from from the air as most people believed.

3 I can describe spatial distribution

Describing spatial distribution is more challenging, because you have to recognise a pattern and describe it, rather than just noticing it.

Geographers use the PQE method to describe spatial distribution patterns (see page xx):

- **P**attern – a trend in the data. Use the legend to see if there is a pattern in the data shown. In Source 3, cholera deaths are clustered around the Broad Street pump.
- **Q**uantify – use numerical data to provide evidence of a spatial pattern. Conduct a count or use the scale to measure. In Source 3, more than 200 cholera deaths occurred within 100 yards (90 metres) of the Broad Street pump.
- **E**xception – data points that don't fit the spatial pattern. In Source 3, some cholera deaths are nearer to the Brewer Street pump.

4 I can explain why a spatial distribution occurs

Explanations require you to answer the question *why?* When explaining spatial distributions, you need to state the reasons behind the pattern, or outline its effect. In Source 3, the concentration of cholera deaths around the Broad Street pump suggested that people were contracting the illness from the water supplied by the pump.

5 I can analyse spatial distributions and suggest actions

When you analyse a spatial distribution, you look very carefully at the pattern formed to see what action can be taken to improve or manage a situation. For example, by carefully analysing John Snow's map in Source 3, it is clear that nearly all cholera deaths were found close to the Broad Street pump and not the other pumps in Soho.

Actions suggested by the findings were to shut down the Broad Street pump and to make sure water supplies in other areas were kept clean to stop cholera from reoccurring.

Place

The concept of place can be described using location, characteristics and human meaning. Places can range in size. The Sahara Desert, the world's largest hot desert, is a place that covers 9.2 million square kilometres. Your home is also a place. Places can be natural (shaped by the environment) or built (made by humans).

1 I can recognise the relative location of a place

The first step is to recognise the **relative location** of a place and describe it using characteristics of the land, political territories (such as countries) and the points of a compass.

For example, the relative location of the emirate of Dubai (Source 4) is in the north-east of the country of the United Arab Emirates. The city is located on the coast of the Persian Gulf and on the north-eastern edge of the Arabian Desert. (See page 422 for guidance on using compass points.)

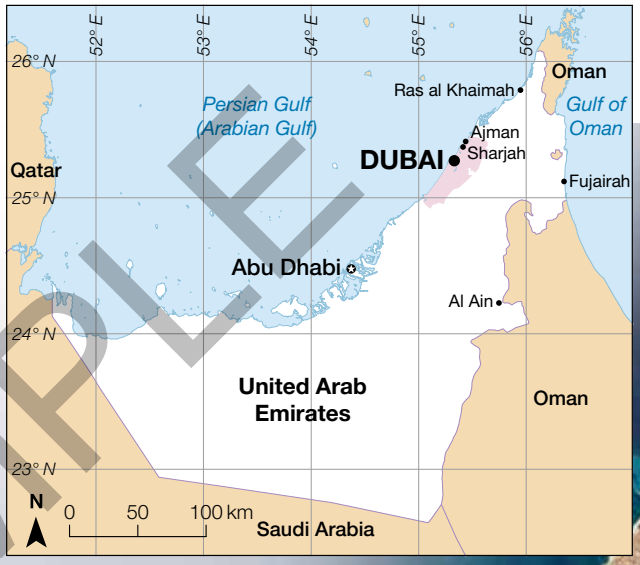
2 I can determine the actual location of a place

A more accurate way to pinpoint the location of a place is to use a grid. On maps of large areas, such as countries of the world, we use the lines of **latitude** and **longitude** to give the **absolute location** of places.

For example, the location of Dubai is at the intersection of latitude line 25.2 degrees north of the equator and longitude line 55.3 degrees east of the prime meridian. (See page 422 for how to use latitude and longitude.)

Detailed topographic maps also use grid system to find the absolute location of places (discussed on page 426).

United Arab Emirates



Source: Matilda Education Australia

Source 4: The relative location of the city of Dubai is on the north-eastern coast of the United Arab Emirates. The absolute location of Dubai is 25.2N, 55.3E. Dubai is located within the Arabian Desert, on the coast of the Persian Gulf. The centre of Dubai is dominated by multistorey skyscrapers, including the Burj Khalifa, the world's tallest building. To create more usable space, land has been reclaimed from the Persian Gulf in the shape of palm trees and a world map.

Source 5: Place has a much deeper meaning for First Nations peoples. They have a deep spiritual, physical, social and cultural connection to the land, often described as **connection to Country**. Palyku woman Ambelin Kwaymullina explains: 'For Aboriginal peoples, Country is much more than a place. Rock, tree, river, hill, animal, human – all were formed of the same substance by the ancestors who continue to live in land, water, sky. Country is filled with relations speaking language and following Law, no matter whether the shape of that relation is human, rock, crow, wattle. Country is loved, needed and cared for, and Country loves, needs and cares for her peoples in turn. Country is family, culture, identity. Country is self.'

Source: Getty images/ Satellite Earth Art

3 I can describe the physical and human characteristics of a place

Describing the characteristics of a place can be more difficult, because you have to recognise features in the landscape and detail them, rather than just providing the location.

When using a satellite image such as Source 4, look for physical features such as the desert, creeks and the gulf; and human features such as buildings, roads and reclaimed land.

When using maps, use the legend to identify the physical and human features shown on the map.

4 I can explain how people influence places and attach meaning to them

A location becomes a place when humans attach emotion or meaning to it. People have different experiences in places and feel connections to them. Consider the sense of security you have when visiting a close relative's house or the sense of belonging you feel when attending your church or local sporting club. We describe this connection to a place in Geography as 'sense of place'. A person's attachment to a place helps form their identity and can connect them to other people, their ancestors or culture.

In Source 5, the relationship between the human and physical characteristics is a close one. For First Nations peoples, Country is much more that a place. People are a part of their Country and their Country is part of them.

Places can be as small as your bedroom or as big as a country or region. Places are dynamic and are constantly changing due to environmental processes and human influences.

5 I can analyse the relationships between places, including their similarities and differences

It is difficult to study one place in isolation. Places are connected through social, economic, environmental and political factors.

For example, the coastal positioning of Dubai (Source 4) provides opportunities for trade with other places. It also is a good place to travel to take advantage of the warm climate and expansive beaches.

Places can also be compared, and similarities and differences can be studied. You might compare Dubai to Singapore, which has also reclaimed land to increase rates of urbanisation. You could compare Dubai to other desert cities such as Las Vegas, USA, to analyse how and why these places have developed rapidly over time.

Interconnection

The concept of interconnection helps geographers understand the connections between two or more things and how these interactions affect environments and the way we live. Interconnection is the idea that two things, or phenomena, are related, interact or affect one another. For example, an interconnection between heavy rainfall in one area impacting people who live on floodplains hundreds of kilometres away.

1 I can recognise that two things are connected

The first step in understanding interconnection is to recognise that things are connected. For example, imagine you have bought new clothes made in China. There are links between the company that designs the clothes and the manufacturer in China. A further connection happens when the clothes are transported from China to where you buy them in Australia

2 I can identify an interconnection between two phenomena in an environment

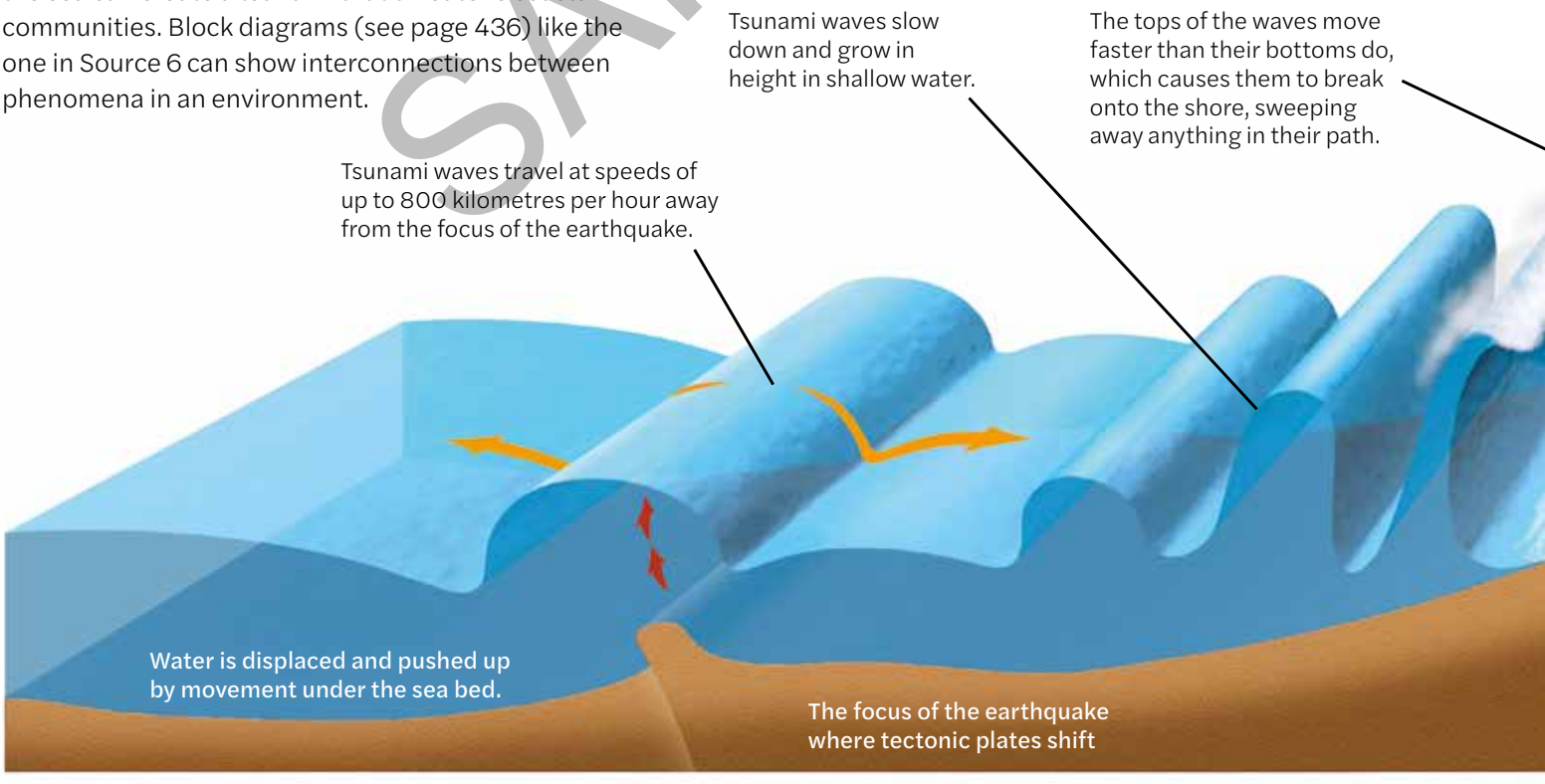
Phenomena are things we observe to happen in an environment. A change or action of one phenomenon can affect another. For example, an earthquake under the sea can create a tsunami that threatens coastal communities. Block diagrams (see page 436) like the one in Source 6 can show interconnections between phenomena in an environment.

3 I can describe interconnections involving phenomena, people and places

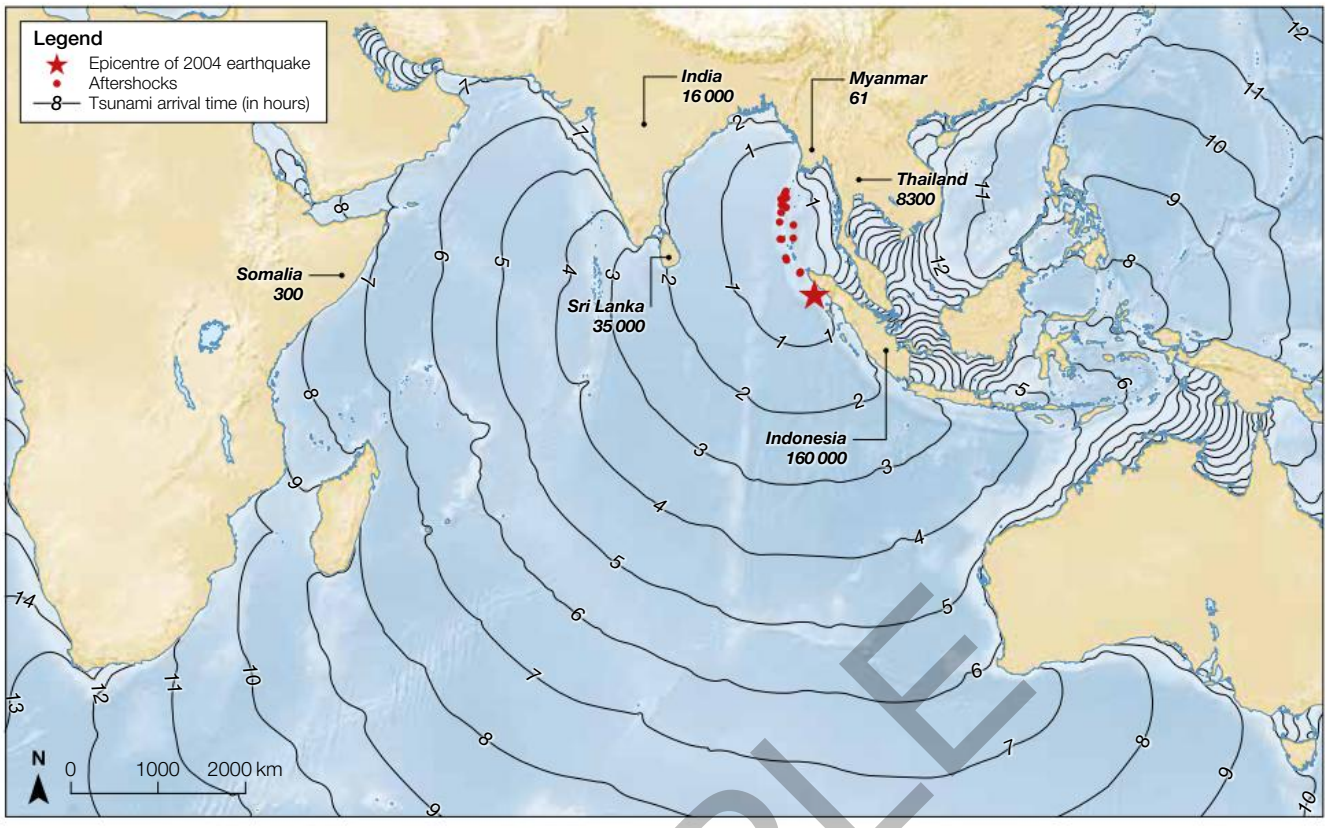
Describing an interconnection between two phenomena is a higher-level skill. You have to identify the interconnection, and also describe what is occurring.

For example, Source 6 shows the interconnection between earthquakes and tsunamis. To describe the interconnection, you might say that the earthquake causes the ocean floor to rise, pushing the water above it upwards, which sets a tsunami in motion.

Source 6: Block diagram showing the interconnection of an earthquake and a tsunami.

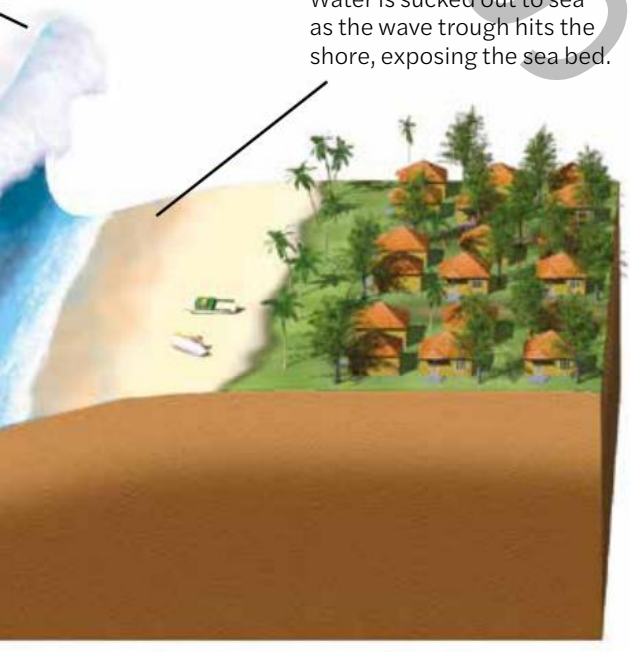


Indian Ocean earthquake and tsunami travel times



Source: Matilda Education Australia

Source 7: This flow map shows the movement and interconnection between two or more places on the map. The red star shows the location of the earthquake that occurred on 26 December 2004. The red circles show the aftershocks felt on the day after the earthquake and the numbered lines show the hours taken for the tsumani to travel from the focus of the earthquake. Finally, the number of deaths that the tsunami caused in each country are shown in the labels. (For more informatin, see flow maps on page 425).



4 I can explain how interconnections occur

Explaining how interconnections occur requires a further level of understanding. You need to ask 'why' an interaction occurs. For example, in Source 7 we can ask why did 35 000 people die in Sri Lanka, when it is 1600 kilometers away from the source of the earthquake?

The earthquke pushed up the water above it to set a tsunami in motion. Tsunamis can travel at up to 800 kilometres per hour, so in about two hours, the tsunami travelled 1600 kilometres to Sri Lanka, killing 35 000 people.

5 I can analyse the implications of interconnections and suggest actions

Once you explain an interconnection, you can dig deeper to analyse the implications of the interconnection. Analysis requires some further research and thought about suggested actions. For example, when analysing Source 7 you could ask, and suggest answers for, the following questions:

What type of aid might the affected nations need? Tsunamis destroy buildings, roads and airports, so people will need shelter and transport will be difficult. They will also need fresh water as many sources could be contaminated.

How can the impact of disasters like the 2004 tsunami be made less severe in the future? Tsunami warning systems can set up to alert people as soon as possible that a tsunami is on the way and to move to higher ground.

Change

Change refers to how a *place* is altered due to shifts in the environment or to meet the needs of humans. Change is easy to see when it occurs rapidly, such as a flood, landslide or clearing a forest. Changes over a long period of time, such as global warming or the movement of landmasses, are more difficult to observe. Change can be positive or negative, and geographers play a role in helping to manage change.

1 I can recognise that change has occurred to a place

The first step is to recognise that a change has occurred. You might notice a new building or road in your area. Or you could see a seasonal change such as blossoms appearing on trees. We can also see change on the maps and graphs we research. For example, the annual rainfall for Sydney in 2022 was much higher than previous years and twice the average rainfall.

2 I can identify change over a short and long period of time

Identifying short-term change is usually easier than recognising changes over the longer term. We can usually see the results of a landslide or flood (Source 9), or building on land immediately. Longer-term changes such as movements in the Earth or weathering of the land are harder to observe as they can take place over hundreds, thousands or millions of years. Geographers look for evidence of change, such as the shapes of features in the landscape, to understand how things have altered (see Sources 8 and 9).

3 I can describe change in a place or environment

Describing change to a place or in an environment is a higher-level skill. First you must identify the change, then you can explain what has occurred. This may mean you need to examine two sources of evidence. For example, Sources 8 and 9 show the change that occurred in Condobolin over a short period of time in November 2022. The Lachlan River flooded onto the surrounding floodplain, covering farms and roads.

Source 8: Satellite image of the Lachlan River at Condobolin in central-west New South Wales on 6 July 2022.

Source: Copernicus Sentinel data 2022

4 I can explain how change in a place or an environment has occurred

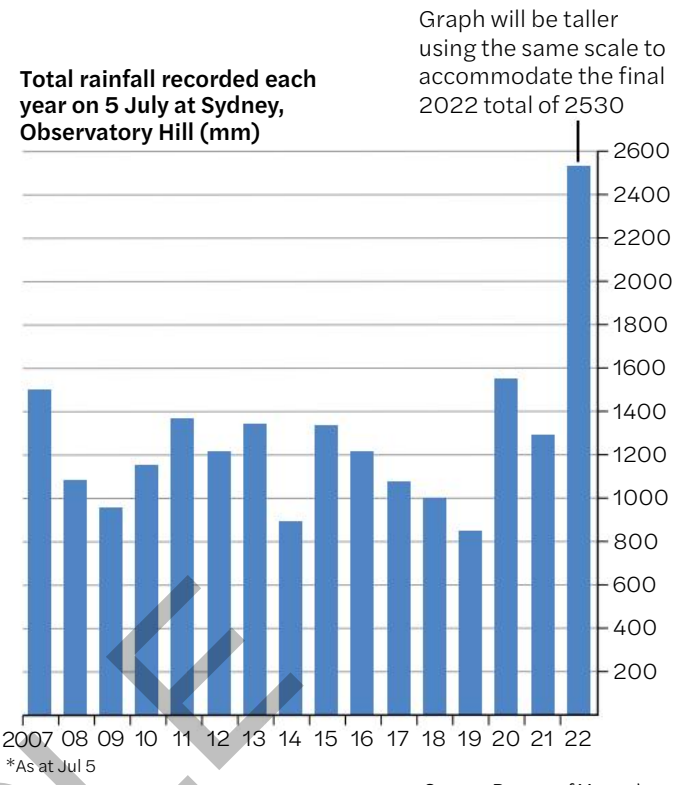
Explaining how change occurs requires a higher level of understanding. You need to ask 'why' the change is occurring. For example, in Source 9 we can ask: Why has the water in the Lachlan River spilled over its banks at Condobolin?

The Lachlan River is part of a drainage basin that covers 84 700 square kilometres of land. When water falls anywhere in this region, it can flow into creeks that flow into smaller rivers that eventually flow into the Lachlan River. Heavy rainfall hundreds of kilometres away can lead to flooding at Condobolin.

5 I can analyse the implications of change and suggest actions

Once you explain why a change has occurred, you can analyse the implications of the change. Analysis involves further research and thought about how to manage the change sustainably. For example, an analysis of the flood event shown in Source 9 might involve asking:

- Which areas of Condobolin are prone to flooding?
- What warning system is in place to measure the height of the water upstream? When is the river height expected to peak at Condobolin?
- What action do residents of Conobolin need to take? Where can sand bag levees be built? Where is a safe place of refuge for the community?



Source: Bureau of Meterology

Source 10: Average rainfall across New South Wales in 2022 was the second highest on record (since 1900), with many places recording their highest ever annual totals. New South Wales' average annual rainfall in 2022 was 863.6 mm, 55 per cent above the 1961–1990 average. Sydney (Observatory Hill weather station) recorded its highest annual rainfall since records began in 1858. The 2022 total rainfall for Sydney was 2530.0 mm, more than double the annual average rainfall for the city.

Source 9: Satellite image of the Lachlan River in flood at Condobolin in central-west New South Wales on 18 November 2022.

Source: Copernicus Sentinel data 2023

Environment

Environments are defined by their **geographical characteristics**. Natural or physical environments are those that are largely untouched by humans, such as forests, deserts and mountains. Human or built environments have undergone significant change, such as cities, towns, mines and farms. Studying the concept of environment helps geographers understand the processes driving the formation of natural environments and manage changes humans are making to it.

1 I can recognise different environments

The first step is to recognise that different environments are made up of elements and organised in some way. For example, a forest environment is an area with a large number of trees that are densely clustered together. The village shown in Source 11 is another example of an environment. It is made up of houses that are clustered together as a distinct group.

2 I can identify a range of physical and built environments

When you can recognise different environments, you can begin to group them into physical (natural) and built (human) environments. The topographic map extract in Source 12 shows a range of physical and built environments in the region around Darwin in the Northern Territory. The city of Darwin is a built environment that has been changed by humans for the purpose of settlement and economic activity. The physical environments on the map are the natural areas that are largely untouched by humans, such as forests, mangroves (shrubs and trees that grow in salt water) and swamp land.

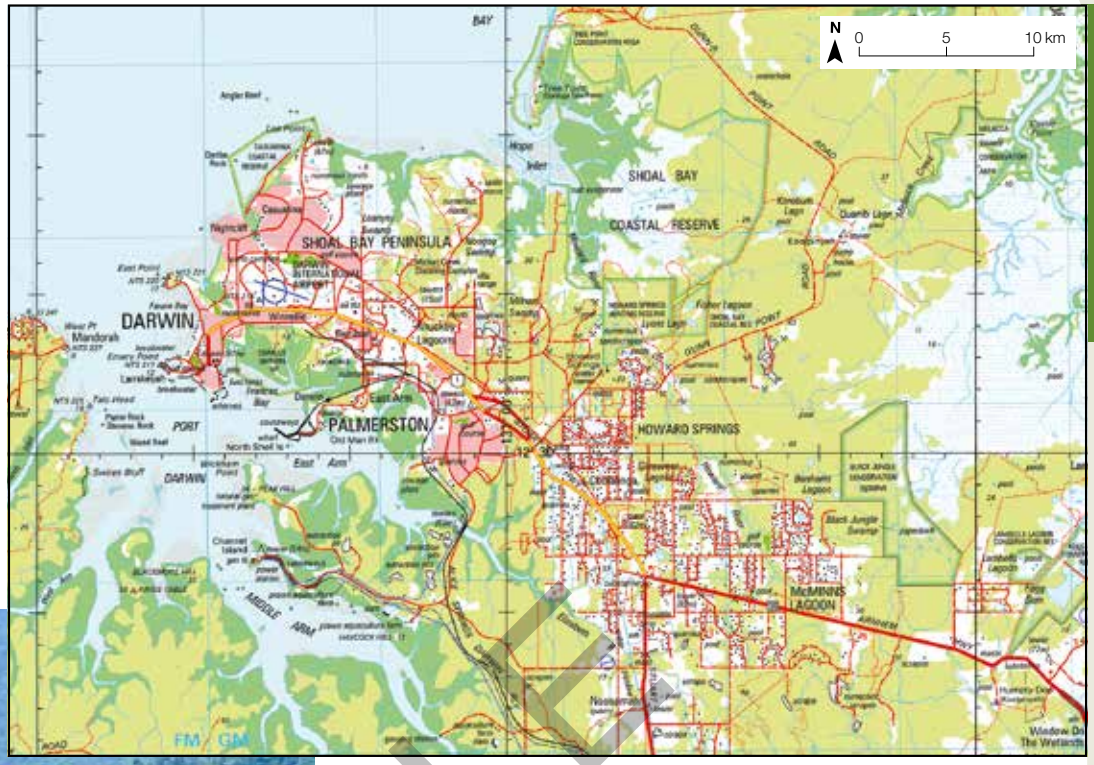
3 I can describe the physical and built characteristics of environments

Describing the characteristics of environments is more challenging, because you have to recognise features of the environment and describe them, rather than just identifying them.

When describing the built environment in Source 11, look for changes to the physical environment such as the terraced rice paddies on the hillsides and the village of houses clustered on the hilltop.

Source 11: Rice terraces and a farming village in Longsheng, Guangxi province, China. Farmers in this region have greatly changed the physical mountain environment to form a distinctive built environment of terraced rice farms.

A topographic map of Darwin, NT and surrounds



Source: Commonwealth of Australia (Geoscience Australia)

Source 12: Topography is the study of the surface of the land. Topographic maps show the different environments present on the Earth's surface.

This topographic map is of the tropical region around Darwin. It shows few contour lines, indicating the land is very flat. Built environments shown include the cities of Darwin and Palmerston (shown in pink) and the suburban areas of Howard Springs and McMinnis Lagoon (black squares). Natural environments include forests (light green), mangroves (dark green) and swamp (blue dashed lines).

4 I can explain the processes behind the formation of physical and built environments

You may need to do further research to uncover the processes behind the formation of natural and human environments. You need to investigate 'why' the physical or built environment has formed.

For example, in Source 11, the rice farmers have created a built environment of terraced rice farms on the hillsides of Longsheng in China. Flat rice fields are cut into hillsides as a series of steps known as **terraces**. The terraced fields are flooded to help the rice plants grow.

In Source 12, the location of the mangrove environment gives some clues to their formation. Mangroves are shrubs and trees that grow in mud and are one of the few plants that can tolerate salt water. They thrive along rivers and estuaries in tropical and subtropical regions.

5 I can analyse the impact of change to physical and built environments

Once you can describe and explain the processes forming environments, you can start to analyse the impacts of change. For example, in Source 12 you can see that growth in the suburb of McMinnis Lagoon would have an impact on the surrounding forest and the Howard River.

Scale

The concept of scale relates to the size of an area. Geographers study phenomena and patterns at a range of different scales. Different outcomes and explanations can be achieved at local, regional, national or global scales. For example, drought conditions may make it difficult for your garden to grow at a local level or be part of a global climatic pattern such as El Niño.

1 I can recognise examples of small and large spaces

Recognising different sized spaces is an important first step in understanding different scales. For example, a local park is an example of a small space and a forest is an example of a larger space. A geographer might also look at the location of all of the forests in the world. They cover a very large space on Earth.

2 I can identify examples of local, regional, national and global scale

Geographers explain four different levels of scale to help guide their investigations:

Local scale is a small space on Earth such as a community, town or farm. Studying a geographic theme at the local scale helps identify outcomes for people. For example, the farmer in Source 13 has to purchase grain and hay to feed his sheep because the drought destroyed the pasture on the farm.

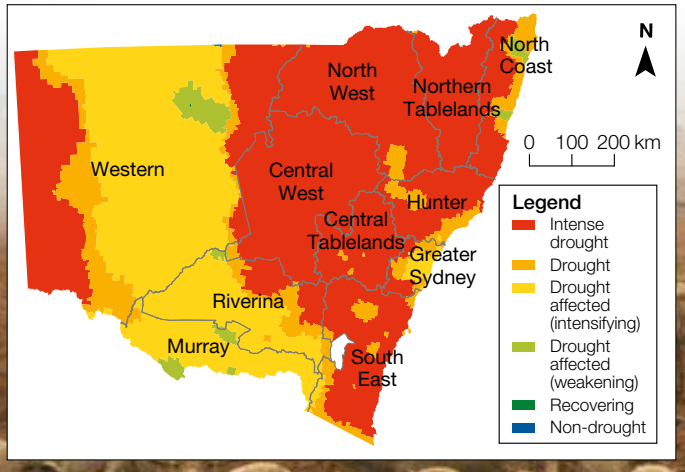
Source 13: Local scale is a specific place such as a neighbourhood, farm or town. At the local scale, geographers recognize that every place on Earth has unique natural and human features. This farm in Queensland faced severe drought in November 2021, and the sheep had nothing to eat.

Regional scale refers to spaces that are larger than a local scale, but smaller than a national (whole country) scale. Examples of regional scales studied in geography include the states of Australia; large natural areas such as deserts, forests and alpine areas; and large administrative areas such as Australian Antarctic Territory or the Murray–Darling Basin. Source 14 shows examples of the level of drought in regional areas in New South Wales in the 2019–20 period. The state itself is also an example of a regional scale.

National scale refers to a country or nation. Geographical issues at a national scale affect the entire country. Source 15 shows the Australian rainfall patterns that caused the drought conditions occuring at a national scale in Australia in 2017–19. Australia's government had to help farmers during this period and ration the water availabe in regions suffering drought. During periods of drought, countries also produce less crops and reduce livestock, which impacts.

NSW drought 31 January 2019 to 31 January 2020

Source: Matilda Education Australia



Source 14: Regional scale refers to a geographical area that is larger than a single community but smaller than a nation. This map shows how the region of New South Wales and smaller regions within it were all facing drought in the 12 months to 31 January 2020. The regions in eastern New South Wales, such as the Northern Tablelands, were facing intense drought conditions.

Global scale studies patterns that occur across the whole world. Global phenomena and issues can help explain conditions occurring at other scales. Source 16 shows that Australia's drought in 2017–2020 was driven by a global climate phenomenon known as El Niño.

3 I can describe phenomena or patterns at a local, regional, national or global scale

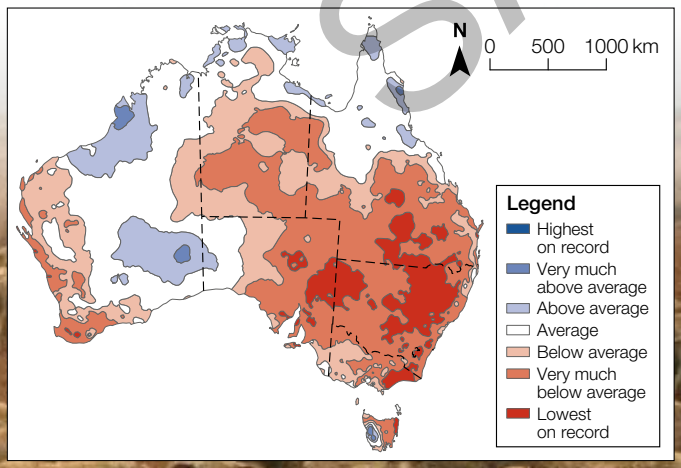
When describing patterns at different scales, you need to identify the scale and then outline the important phenomena or issues impacting on that space.

For example, Source 15 shows the rainfall deciles (a ranking compared with the average) at a national scale for Australia in the 2017–20 period. Geographers use the PQE method to describe spatial distribution patterns shown on maps such as this (see page 430):

- **P**attern – identify a trend in the data. Use the legend to see if there is a pattern in the data shown. Much of south-eastern Australia experienced rainfall that was very much below average or the lowest on record in the 2017–19 period.
- **Q**uantify – use data in the legend to provide evidence of a spatial pattern. The most extreme shortfall occurred in the northern half of New South Wales, where rainfall was the lowest ever recorded.
- **E**xception – find any data points that don't fit the spatial pattern. Central-Western Australia received above average rainfall in the 2017–19 period.

Australian rainfall 1 January 2017 to 31 Dec 2019

Source: Matilda Education Australia



Source 15: National scale describes a specific country or nation. This map shows the nation of Australia and the rainfall it experienced from 2017 to 2019. National scale focuses on patterns and issues that affect the entire country or a large portion of it. This map shows that much of south-eastern Australia has had below average rainfall over a three-year period, leading to drought.

4 I can explain how geographical phenomena or issues differ according to scale

Explaining what happens at different scales requires a further level of understanding. You need to ask 'why' an event or pattern is occurring and compare its effects at a range of scales. For example, Sources 13 to 16 all refer to the drought that occurred in Australia in the 2017–20 period:

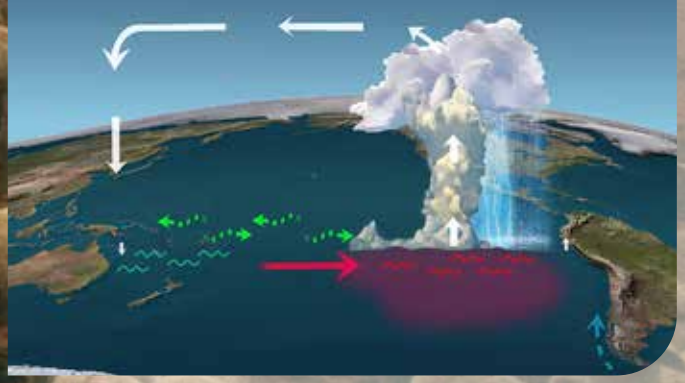
At the global scale, the El Niño climate pattern delivered high rainfall in the Americas in the eastern Pacific and low rainfall to Australia in the western Pacific. At a national scale, Australia had to deal with drought conditions impacting the south-east of the nation. Intense drought was particularly felt throughout eastern New South Wales, where water supplies were threatened. At the local level, residents had their water rationed and farmers lost crops and had to buy feed for livestock.

5 I can analyse the implications of a global issue at a range of scales

To analyse an issue you need extend your research to gain a greater understanding of its effects. For example, an analysis of the implications of El Niño at a range of scales might involve asking:

- What action might national governments need to take to combat the drought conditions caused by El Niño?
- How might state governments at a regional scale supply water to residents in drought?
- What action might households take to reduce their water use in drought conditions?

Source 16: Global scale refers to broad patterns that occur across the world. This diagram shows the impact of the global climate system known as El Niño . It sometimes occurs in the Pacific Ocean, but El Niño affects weather all over the world. In El Niño years, very high rainfall is experienced in the Americas while Australia and other parts of the world suffer drought.



Sustainability

Sustainability is the concept of maintaining and preserving resources and environments for future generations. Living in a sustainable way means that we meet our current needs without compromising the needs of future generations. Geographers use the concept of sustainability to investigate how resources can be carefully managed to ensure they will still be available in the future.

1 I can recognise renewable and renewable resources

The first step in understanding sustainability is to recognise those resources that we use that are renewable and those that are non-renewable.

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 regenerate. Examples of renewable resources include water, trees and solar energy.

Non–renewable resources are resources that are only available in limited amounts. If we overuse them, they will run out. These resources include the fossil fuels: oil, natural gas and coal, which take millions of years to form inside the Earth. Source 18 shows that in 2020, most of the energy used around the world came from fossil fuels.

2 I can identify examples of sustainable practices

Sustainability maintains that humans must interconnect with natural environments sensibly to ensure there will be adequate resources left for future generations. Some examples of sustainable practices include:

- **Reduce, reuse, recycle:** Reduce the amount of waste by reusing bags for shopping and refilling drink, soap and shampoo bottles rather than disposing of them; and using washable cloth wipes and nappies in place of disposable nappies and paper towels.
- **Use renewable energy:** Use renewable energy such as hydroelectricity and wind power. Install solar panels on the roof to provide renewable energy to your home and choose an electric car that uses fewer fossil fuels (see Source 17).
- **Use less resources:** Reduce your impact by changing your everyday choices: turn off appliances when you are not using them, dress warmly rather than using heating, and walk, cycle or use public transport when you can.

3 I can describe sustainable management of resources and environments

Describing sustainability is a higher-level skill. You not only have to identify sustainable management, but you also need to describe what is occurring.

For example, Source 17 shows a sustainable home that uses special solar roof tiles to capture energy from the sun. The solar power is stored in batteries and means the home and car can run on electricity without using non-renewable resources such as coal.

Source 17: Tesla is a US electric vehicle and alternative energy company. The company's mission is to speed up the world's transition to clean, sustainable energy resources. Tesla designs and manufactures electric vehicles, battery energy storage and solar panels.

Tesla electric cars have a powerful battery, which is charged by electricity. This gives power for the car to travel for around 700 kilometres. The lithium ion battery is similar to batteries in mobile phones and recharged through an electric point in the home or at dedicated recharging stations.

4 I can explain the importance of sustainabilty practices to ensure future wellbeing

Explaining the importance of sustainability requires you to ask 'why' the sustainability practice is a good thing and link it to outcomes at different scales. For example, in Source 19 we can ask why an increase in electric car sales is a good thing for the world.

An advantage of electric cars is that they do not consume as much non-renewable energy as cars with petrol engines. A further advantage is that electric cars don't release carbon dioxide (CO_2) that contributes to global warming. A disadvantage electric cars is that the electricity may have been produced from a non-renewable resource such as by burning coal.

5 I can analyse sustainable environmental worldviews and management approaches

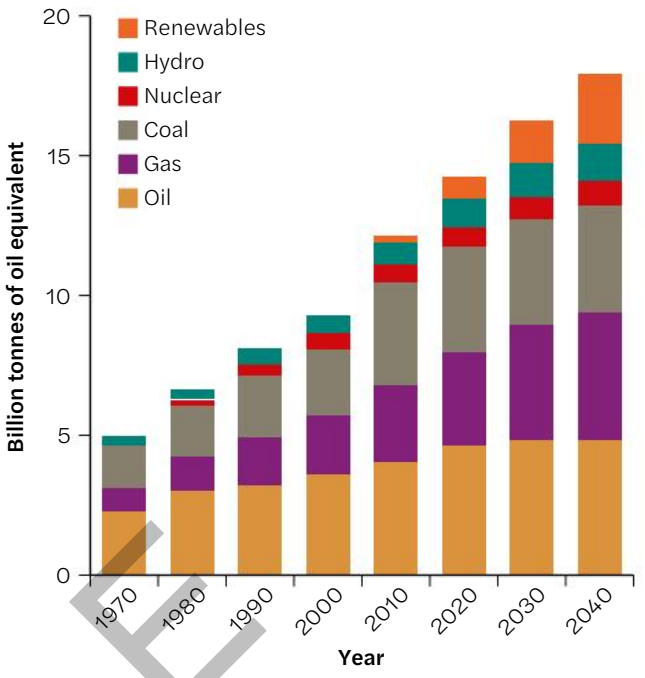
Analysing sustainability requires you to dig deeper to understand environmental worldviews – the values and assumptions that inform how a person views the environment and its management.

People with different environmental worldviews can disagree on how sustainability issues like climate change and renewable energy should be managed. Pro-environment and pro-development worldviews need to be considered when framing solutions.

Tesla's solar roof builds in solar panels so that they look like roof tiles. The photovoltaic cells transform solar energy into electrical energy. The electricity is passed through an inverter to convert the direct current produced by the solar cells into alternating current to be used in the home, stored in batteries or returned to the national electricity grid.

The Tesla Powerwall is a home battery to store the electrical energy transformed by the solar panels. Energy collected during the day is stored in the battery and made available to use any time.

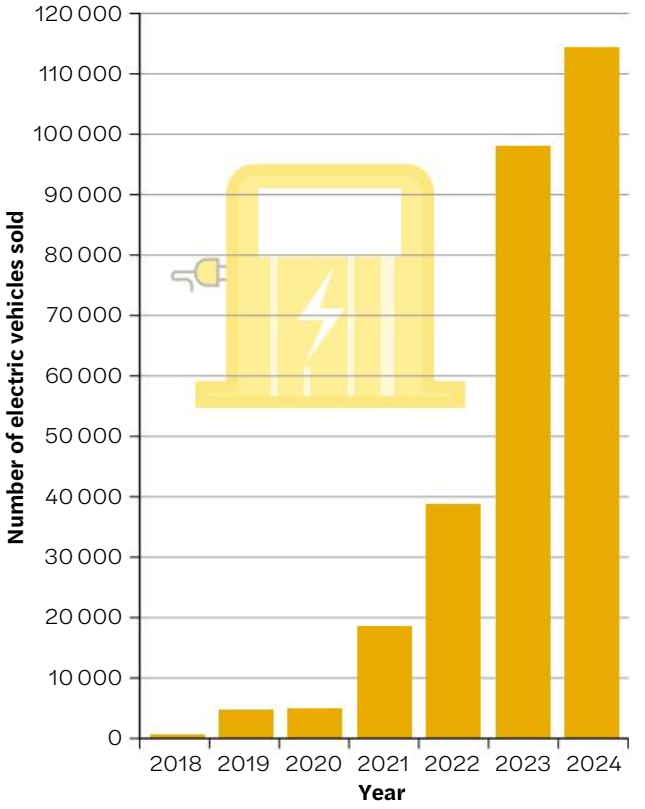
Worldwide energy consumption, 1970–2040



Source: EIA

Source 18: This graph shows global energy consumption by energy type (projected to 2040)

Electric vehicle sales in Australia



Source: Matilda Education Australia

Source 19: The number of electric vehicles sold in Australia has had a steep increase in recent years.

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

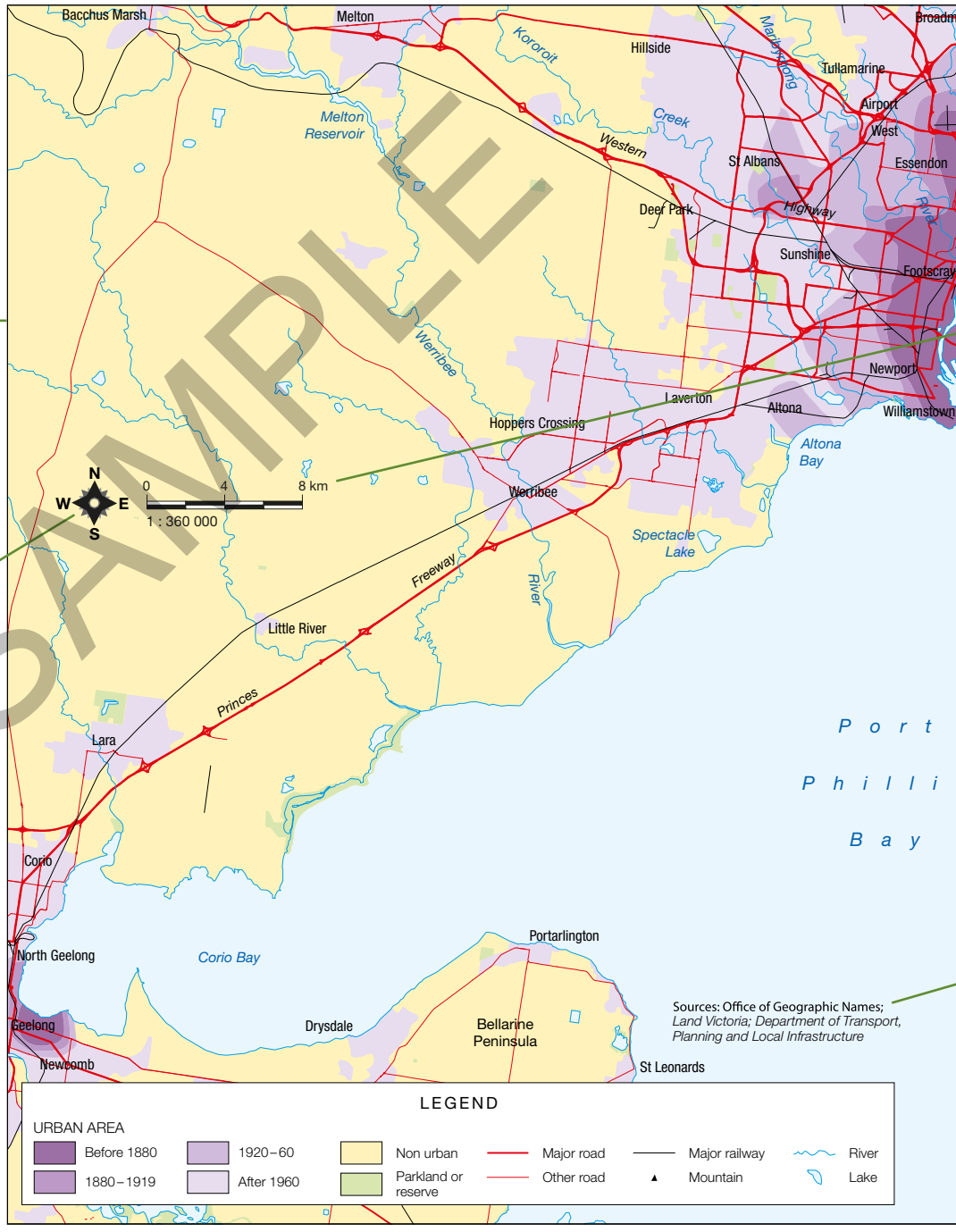
Borders are important, because they show the edges of the mapping field. A border provides a clear area for you to construct your map, and makes it look clear and neat.

O Orientation

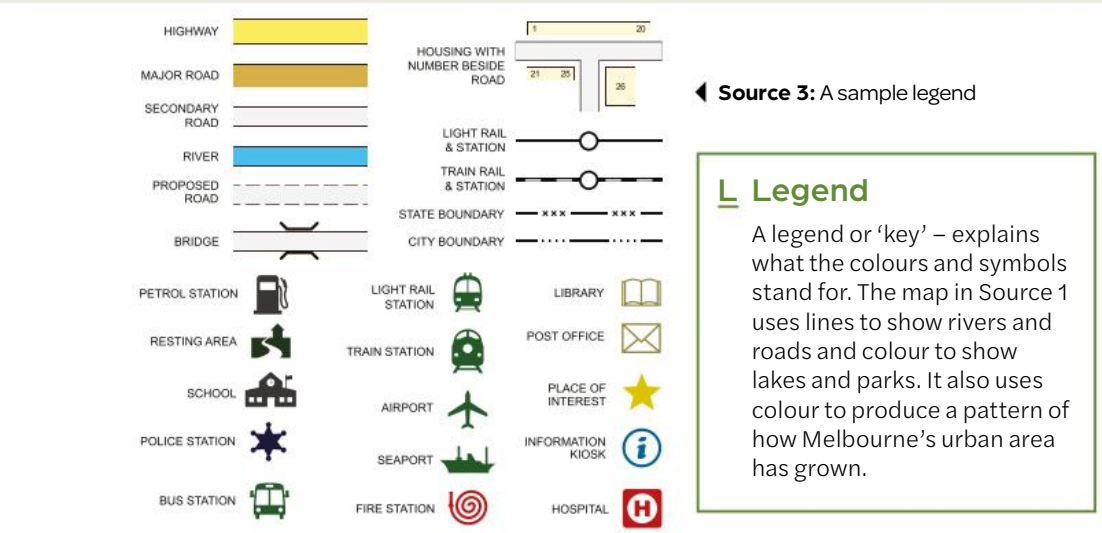
Orientation refers to the compass direction. The four cardinal points on a compass are north, east, south and west. The points in between, such as north-east, give more accurate directions.

▲ **Source 1:** Cardinal points of the compass

Urban growth in Melbourne



▲ **Source 2:** Urban growth in Melbourne



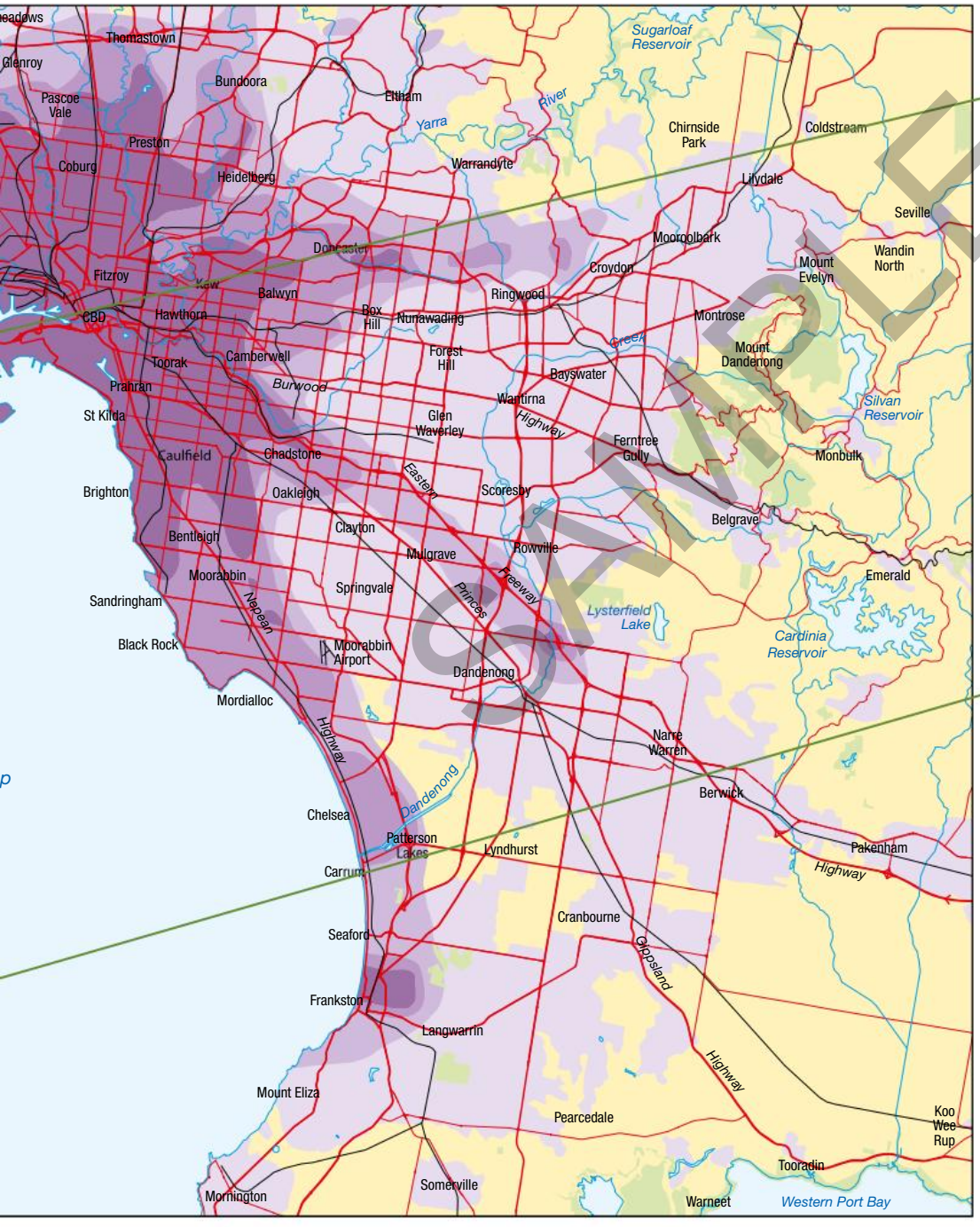
Source 3: A sample legend

L Legend

A legend or 'key' – explains what the colours and symbols stand for. The map in Source 1 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

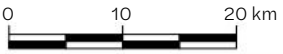
A title tells us what the map shows, and gives us some understanding about it. Make sure you always add the date and the time to your sketch maps – this will allow you to monitor change over time in a location. The title of this map is 'Urban growth in Melbourne'.



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

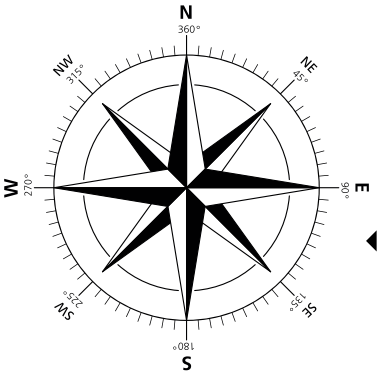
It is important to let the reader know where you obtained the information for your map – which is known as your source. The source can also indicate whether the map is trustworthy.

(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



Source 4: Cardinal and intercardinal points of the compass

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.

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 west of Broome. Port Hedland (B3) is located south-west of Broome.

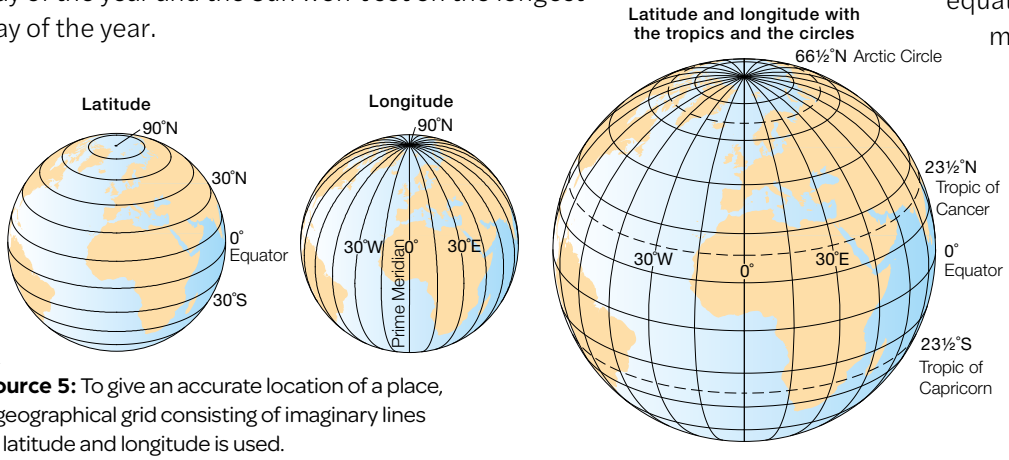
Latitude and longitude

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).

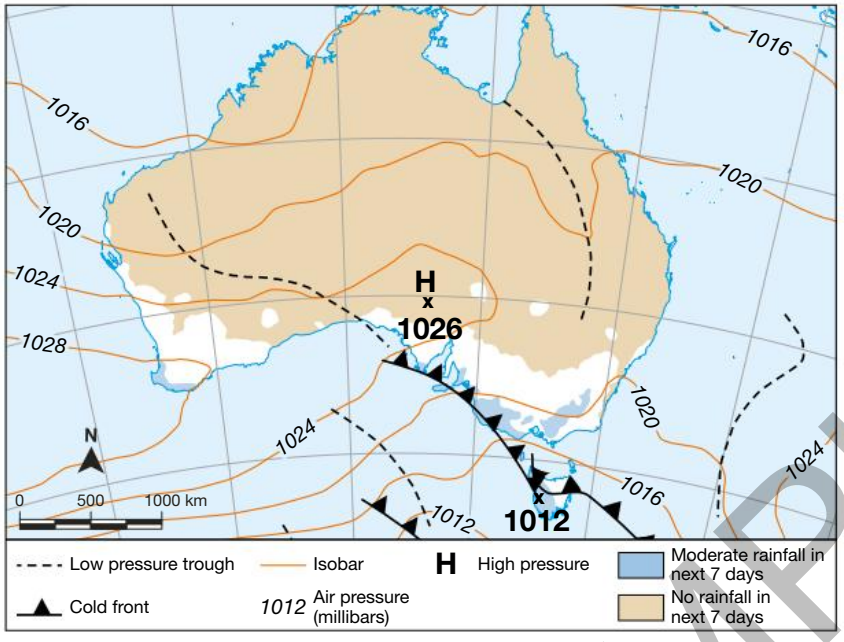
Source 7: This car model is a scaled-down version of the real car. This is a 1:64 scale model of a VW Beetle car. One centimetre length of the model represents 64 centimetres of the real car.

Types of maps

Weather maps

Weather maps show conditions in the atmosphere.

Weather map – Australia, 23 Aug 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

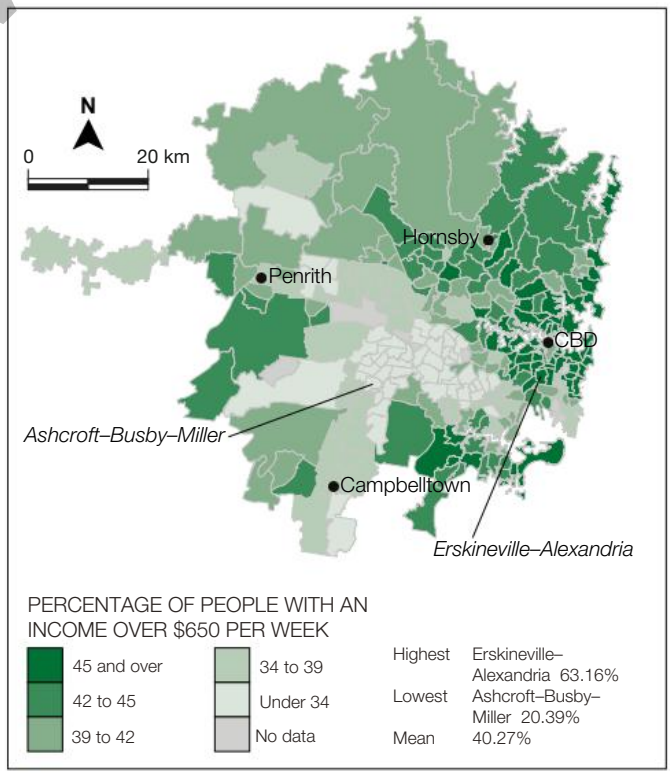
Choropleth maps use colour to show the spatial distribution of data.

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



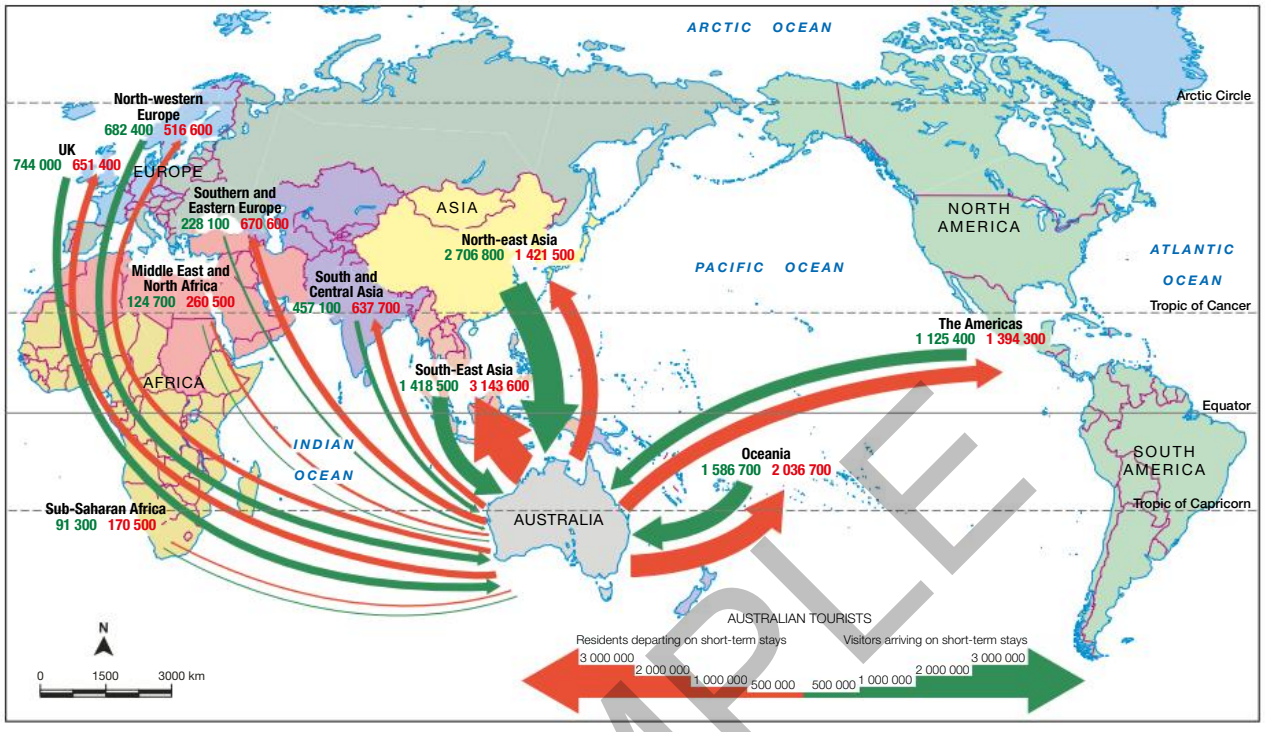
Source: MAPgraphics

Source 9: Choropleth map showing the distribution of income in Syney's LGAs

Flow maps

In flow maps, arrows show the direction of movement and thickness shows size of movement.

Australian tourism – arrivals and departures



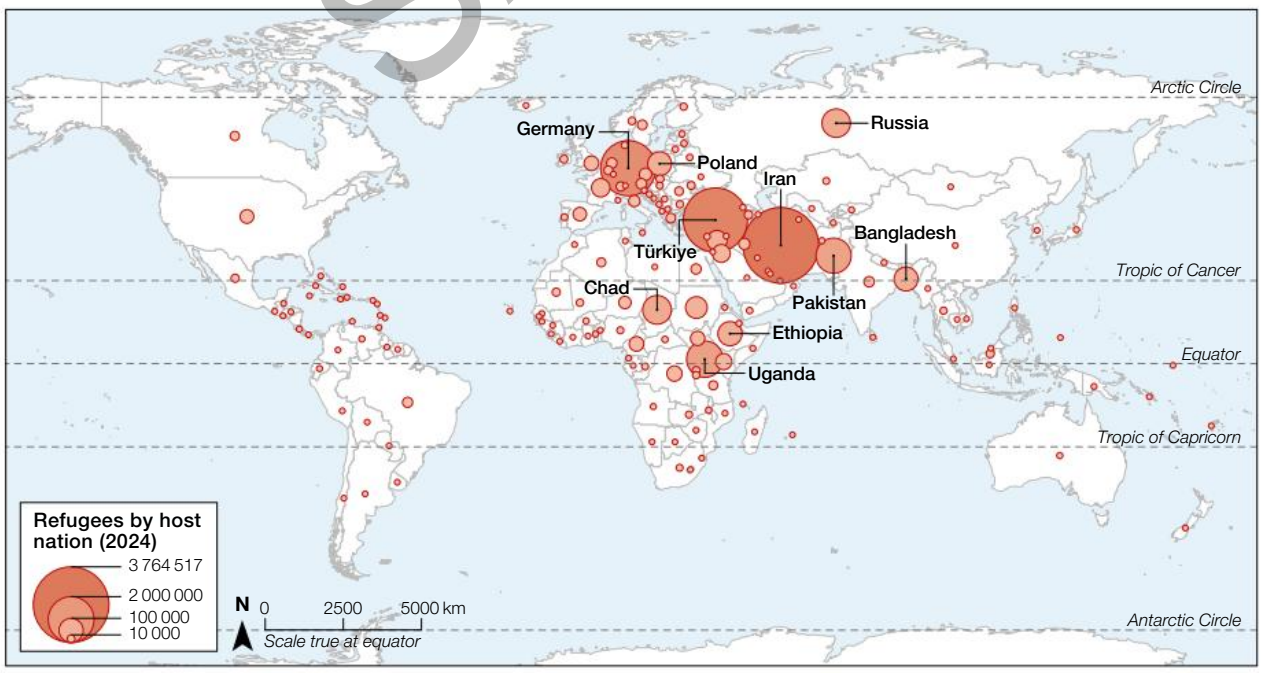
Source: MAPgraphics

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.

Refugees by host nation, 2024



Source: MAPgraphics

Source 11: Proportional symbol map showing the number of refugees by host nation in 2024.

Topographic maps

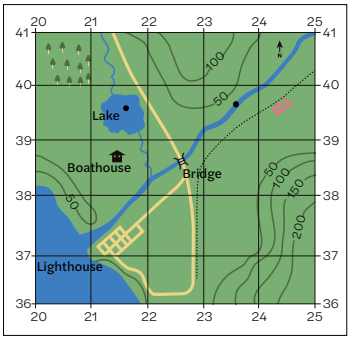
Topography is the study of land surface. Topographic maps show the different human and natural features on the ground, such as towns, roads, railways, forests, lakes and rivers. Topographic maps use contour lines to show different heights, helping you identify the shape of the land and features such 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

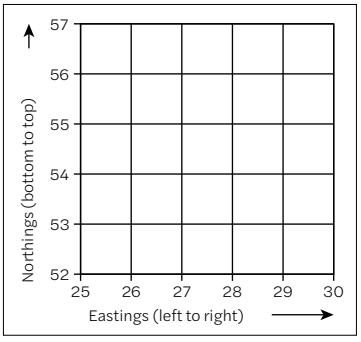


Source 12: This simple maps shows contour lines and grid references.

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'.

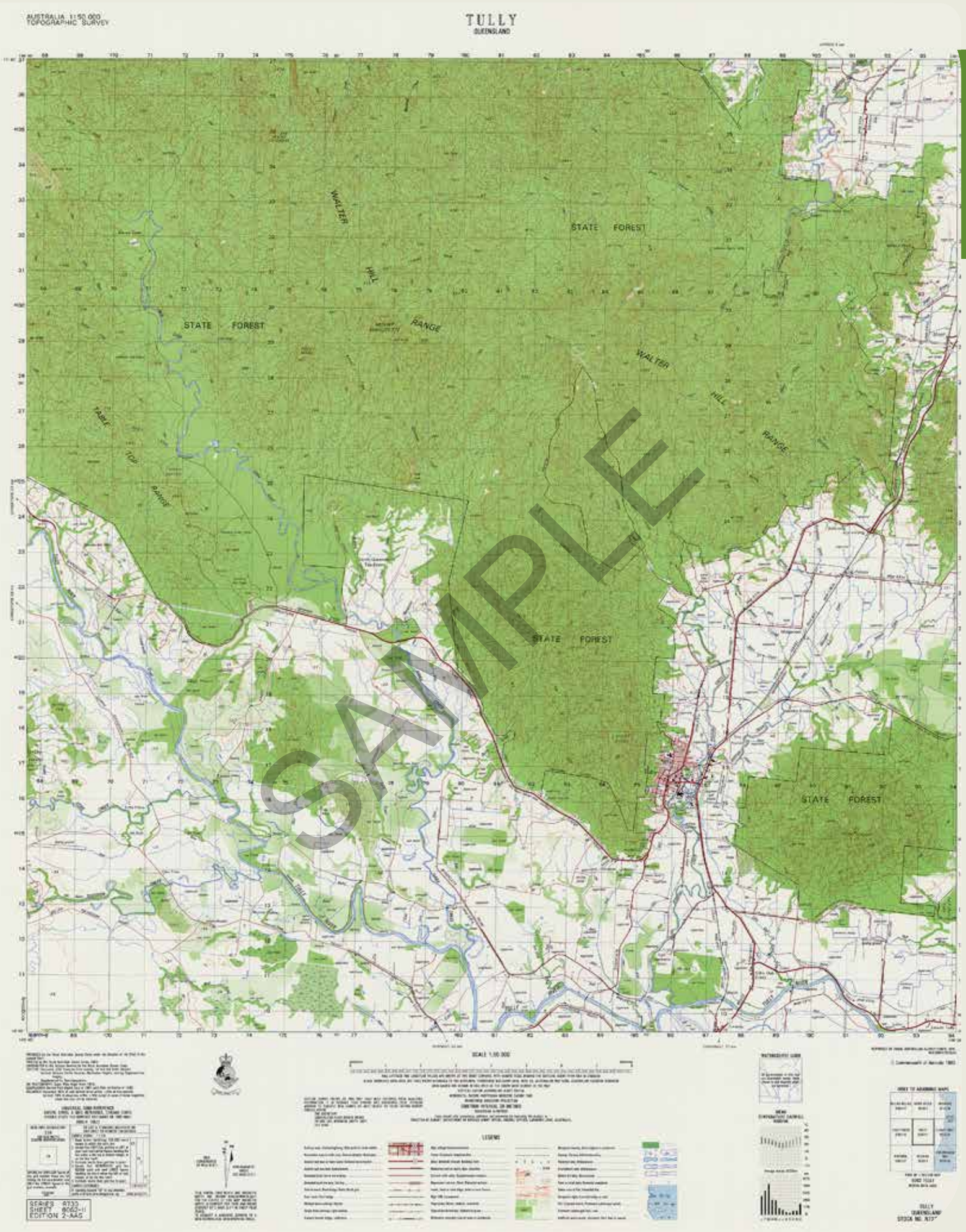
For our example, the boathouse is located at the four-figure grid reference AR2138. This reference takes us to the bottom left-hand corner of the grid square that the boathouse is located in. The lake is located at AR2139 and the bridge is located at AR2238.

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.

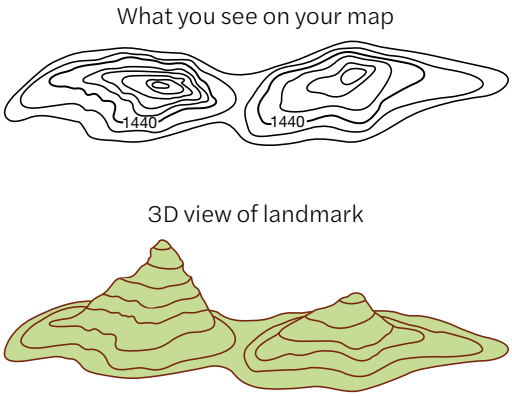


▲ **Source 14:** Topographic map of Tully

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.

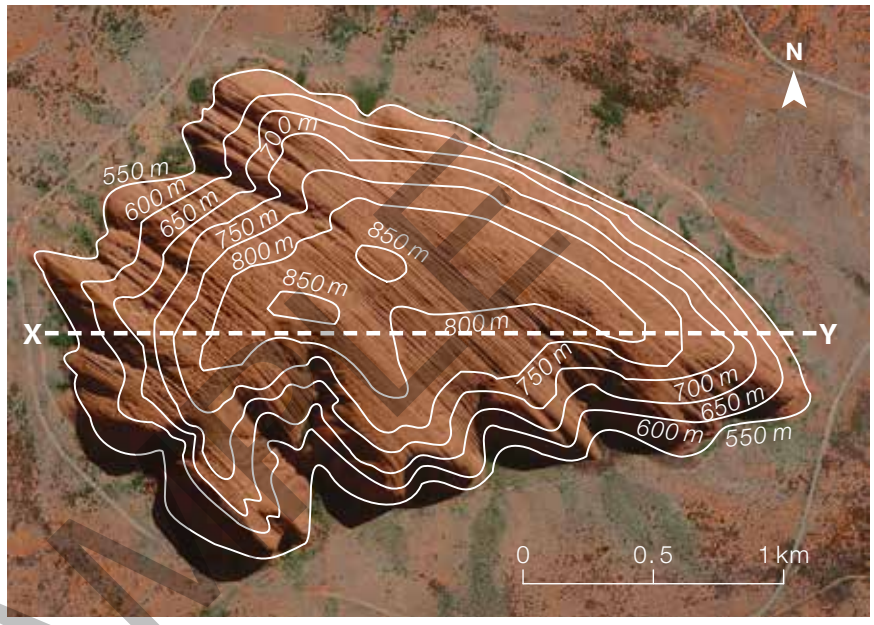
When drawing a cross-section by hand, we finish with a two-dimensional (2D) side-on view of the terrain; however, computer programs can create three-dimensional (3D) representations to enhance our understanding, as shown in Source 15.

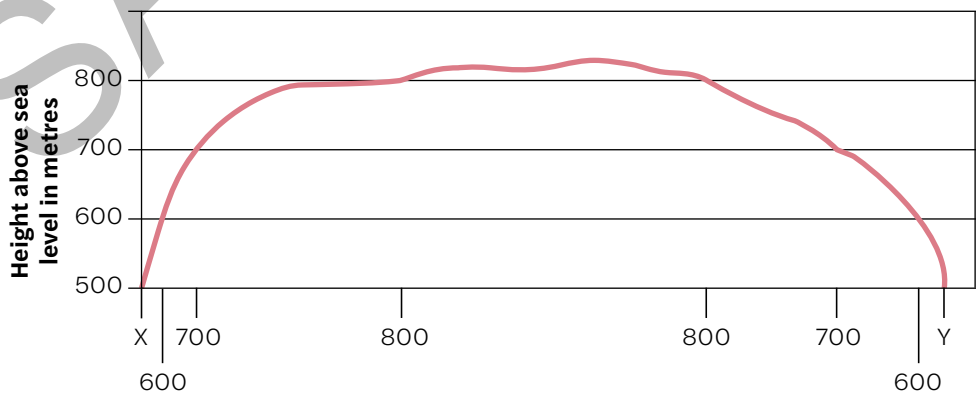


Source 15: The difference between what you see on a cross-section versus the 3D view of a landmark

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.



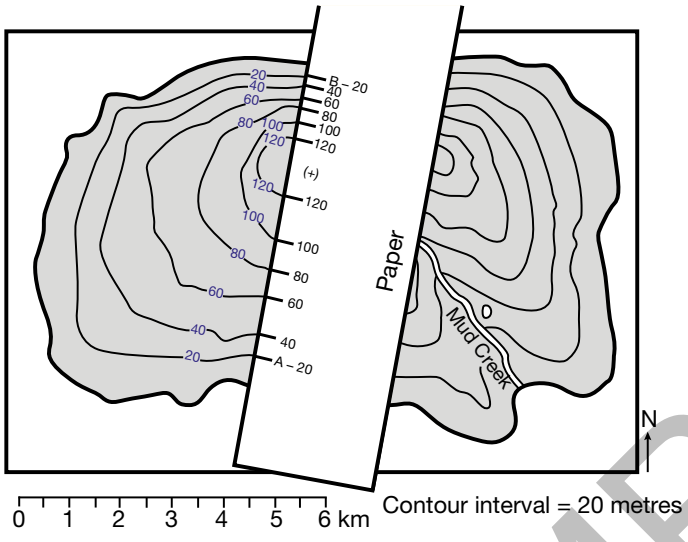


Source 17: A simple cross-section of Uluru, x and y are matched to the transect line in Source 16.

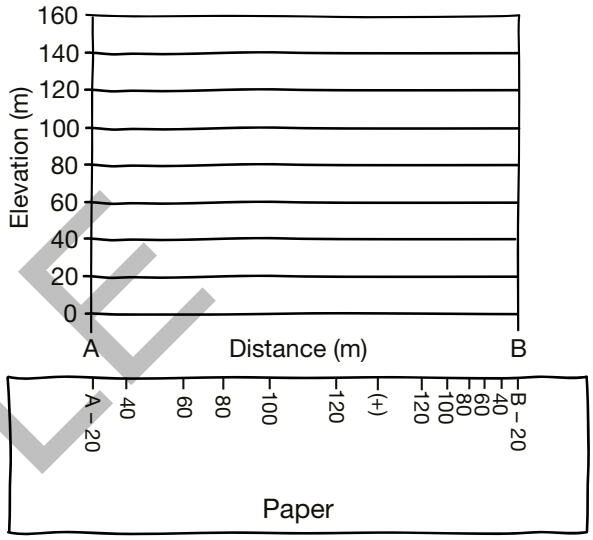
Source: Contour map from Matilda Education Australia, Geoscience Australia

How to draw a cross-section

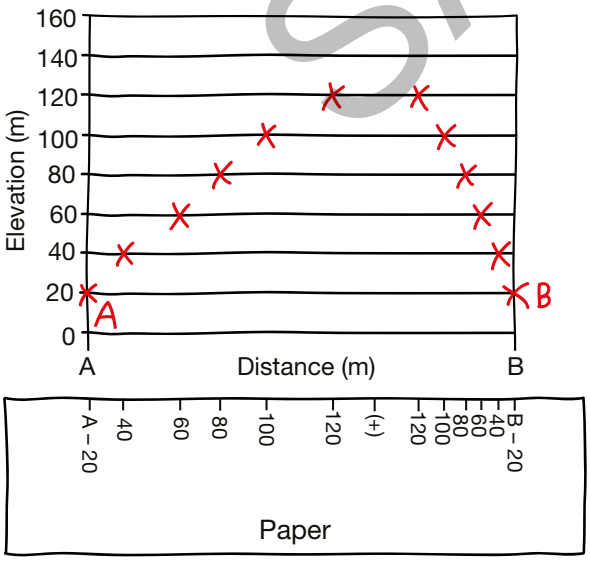
a Place a straight edge along the line between points A and B. Mark each contour line at the point it touches the edge of the paper and record the height.



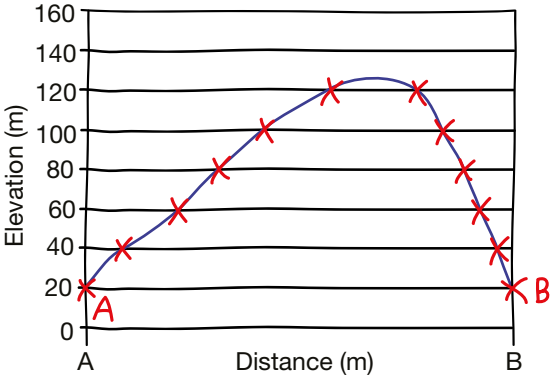
b Draw a vertical scale like the one below. You need to decide on a scale depending on the range of elevations presented on the contour map.
For example, for the Uluru cross-section in Source 17, 1 centimetre represents 100 metres.



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 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 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 432).

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 USA'. 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...

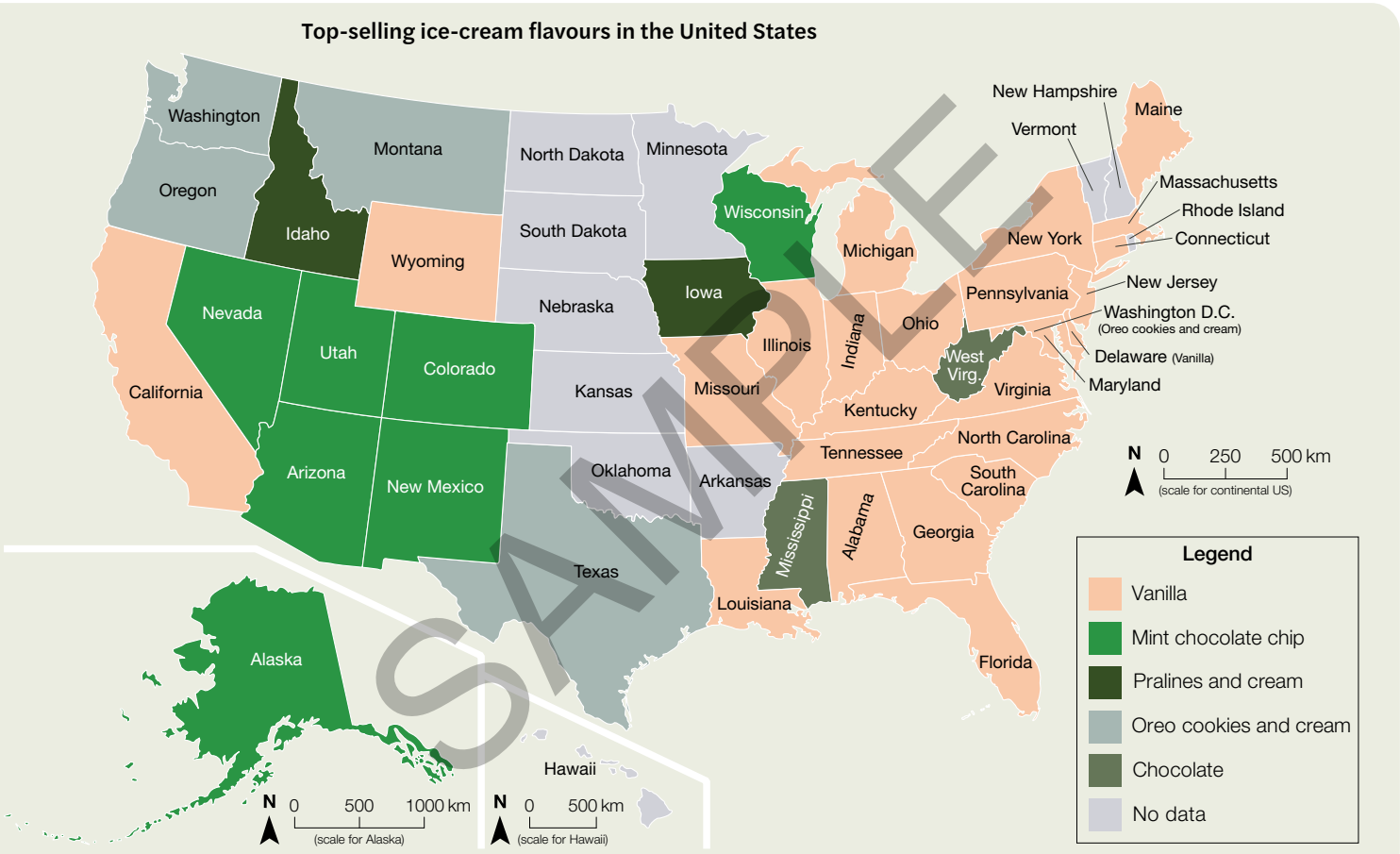
For example:

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 as their favourite flavour, which is an exception to the pattern.



Source 18: This map of the United States shows the favourite Baskin-Robbins ice-cream flavours

Source: Base map from iStock/Vectorius 2016, data from Baskin Robbins

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

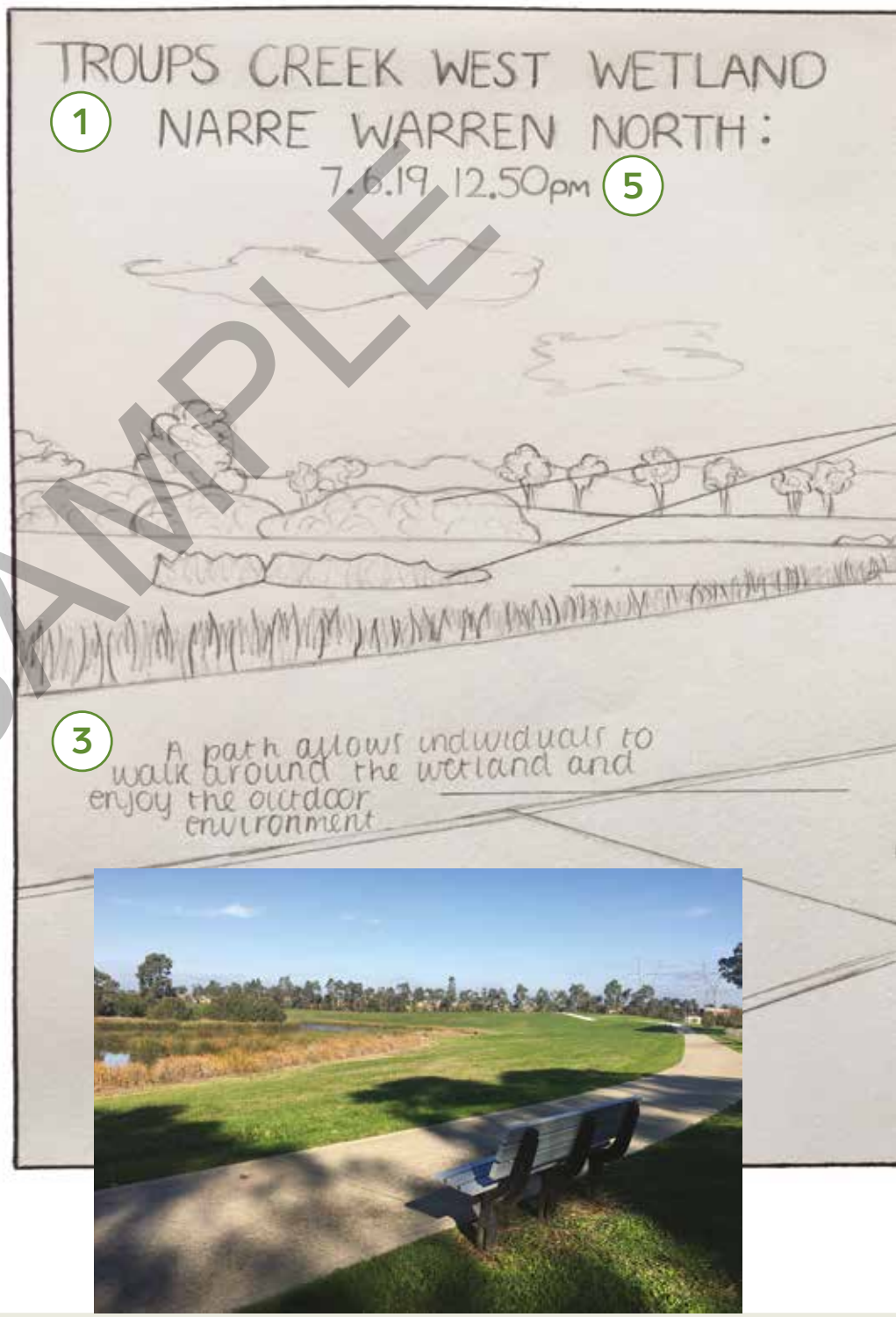
An orientation shows the direction that you were facing when you made your sketch. You need to use a compass so you can record a correct orientation.

A Annotations

3

Annotations (or notes) are the most important thing to complete when drawing a field sketch.

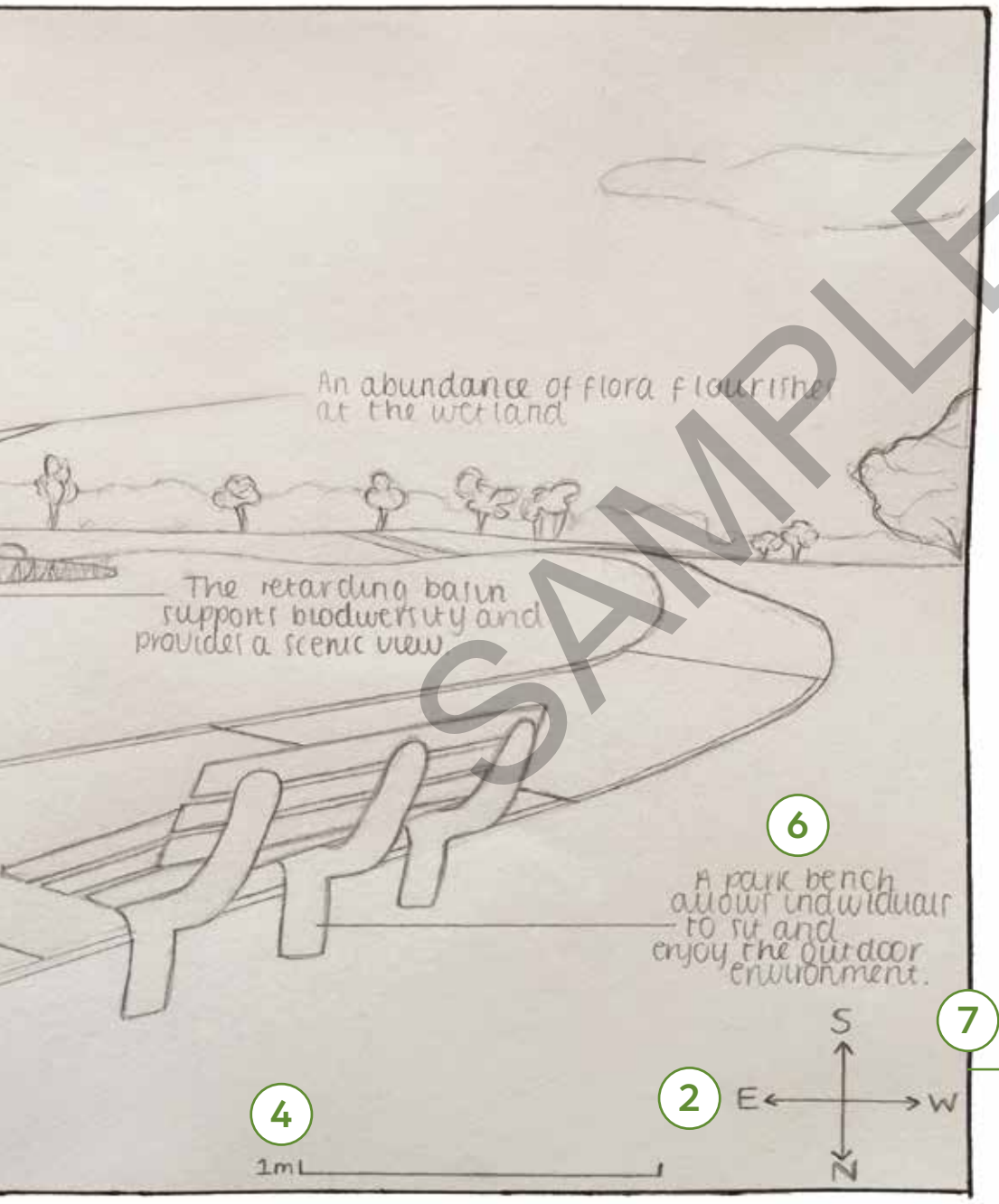
Annotations allow you to record details about what you see, and explain how elements of your drawing relate back to the inquiry question. Make sure that the lines to your annotations are made with a ruler – and that they do not overlap.



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

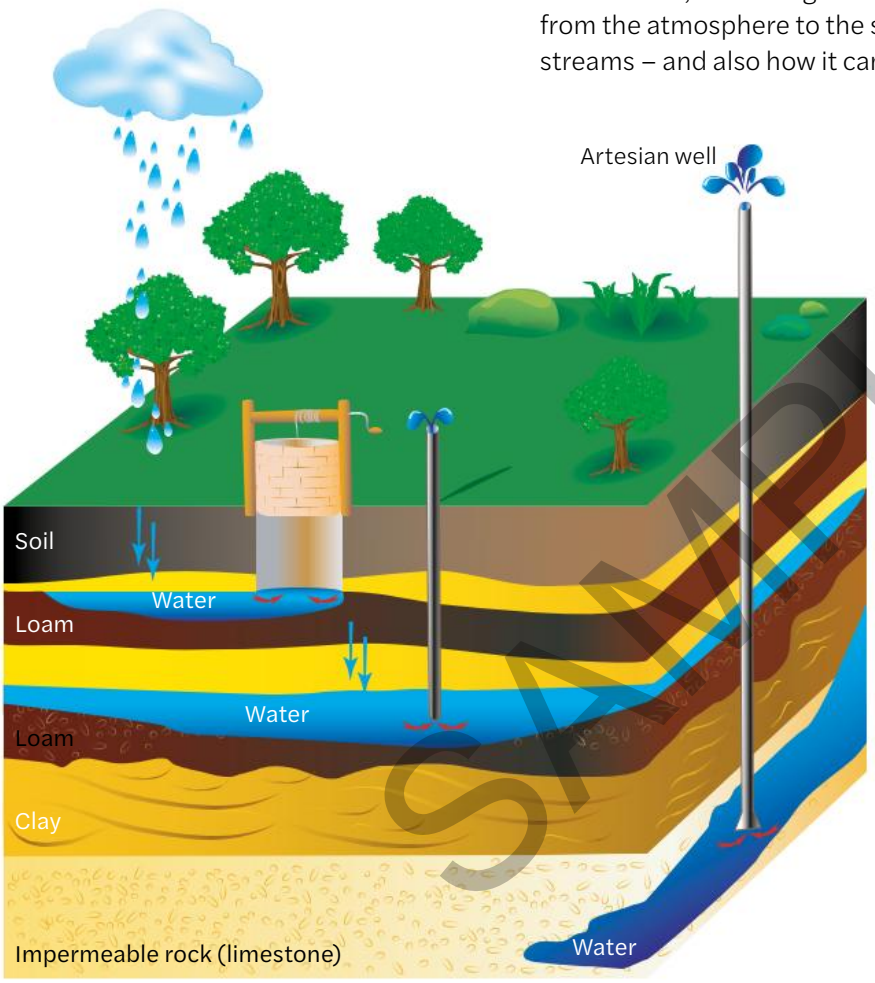
Always include a border so it is clear where your sketch starts and ends.

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.

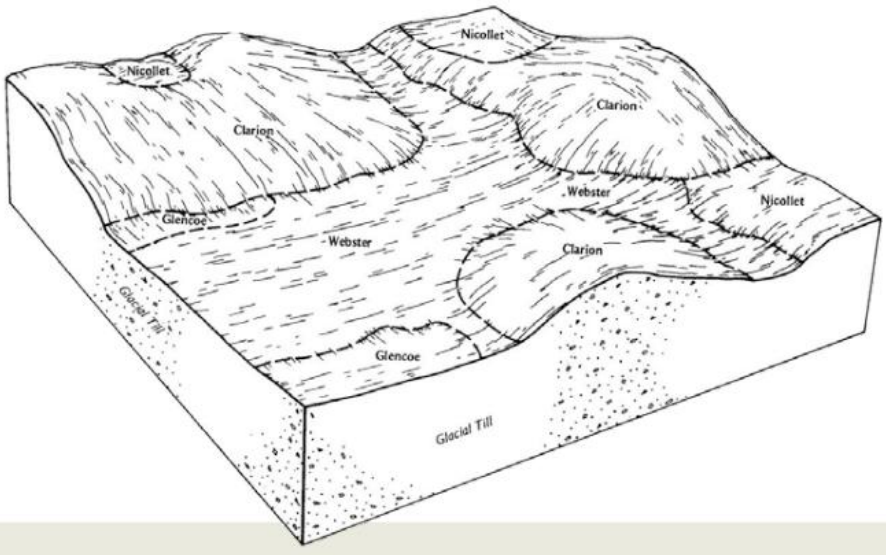
For instance, block diagrams can help us visualise how water can move from the atmosphere to the surface of Earth through rivers, oceans and streams – and also how it can move under the ground.



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.

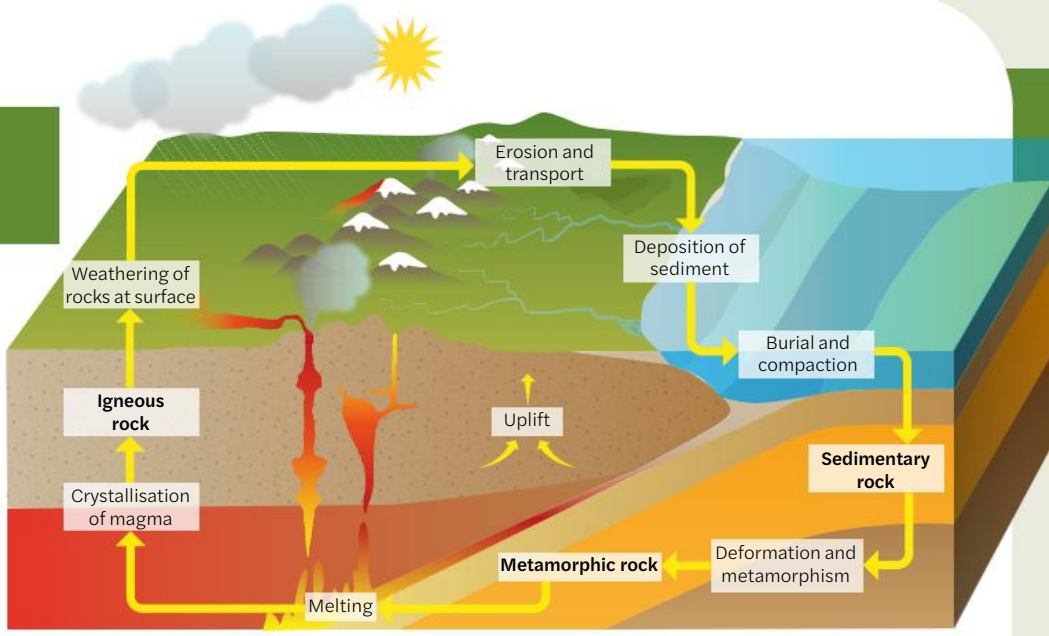
Source 21: A block diagram



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

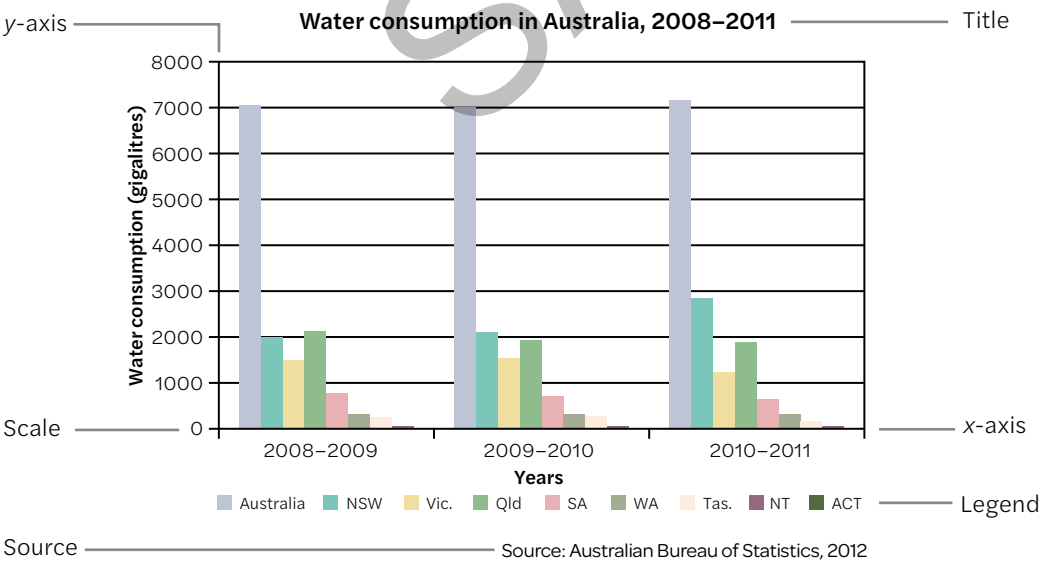
Each graph has an *x*-axis and a *y*-axis. The *x*-axis is the horizontal axis and the *y*-axis is the vertical axis. Make sure you label each axis.

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

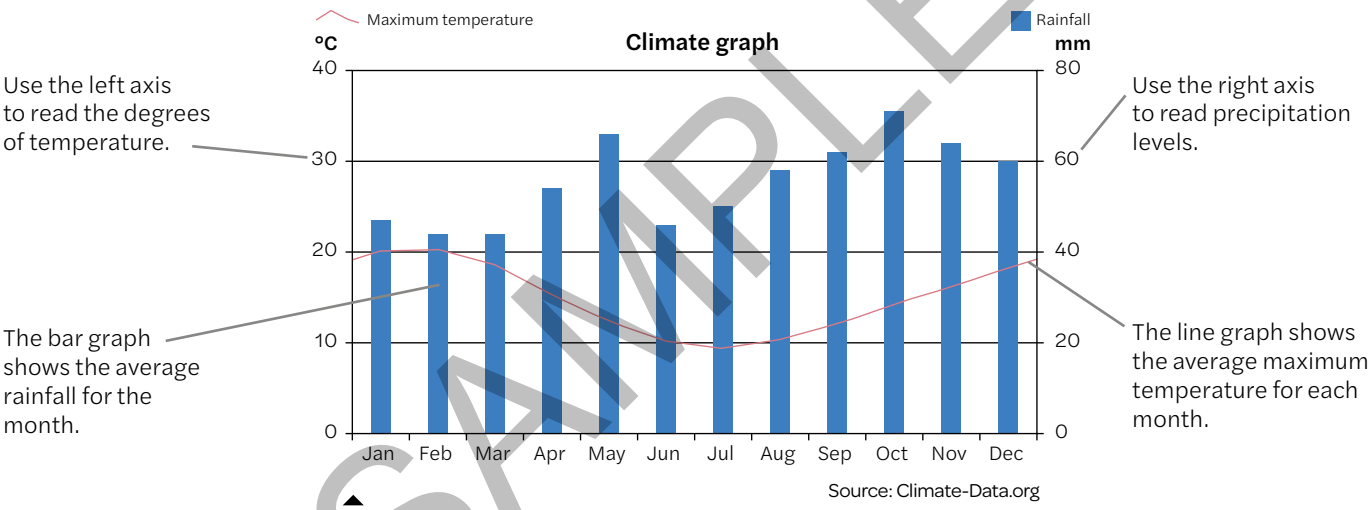
A **climate graph** shows two types of data on one graph. It shows both the average temperature and rainfall that a region usually receives over a year.

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

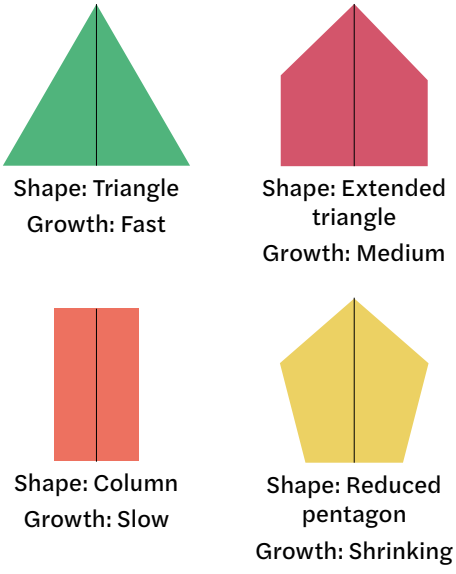
What is the difference between weather and climate?

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



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 profile 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 pyramids come in different shapes: triangles, columns, pentagons and so on. The shape tells you about the population. If the shape is:

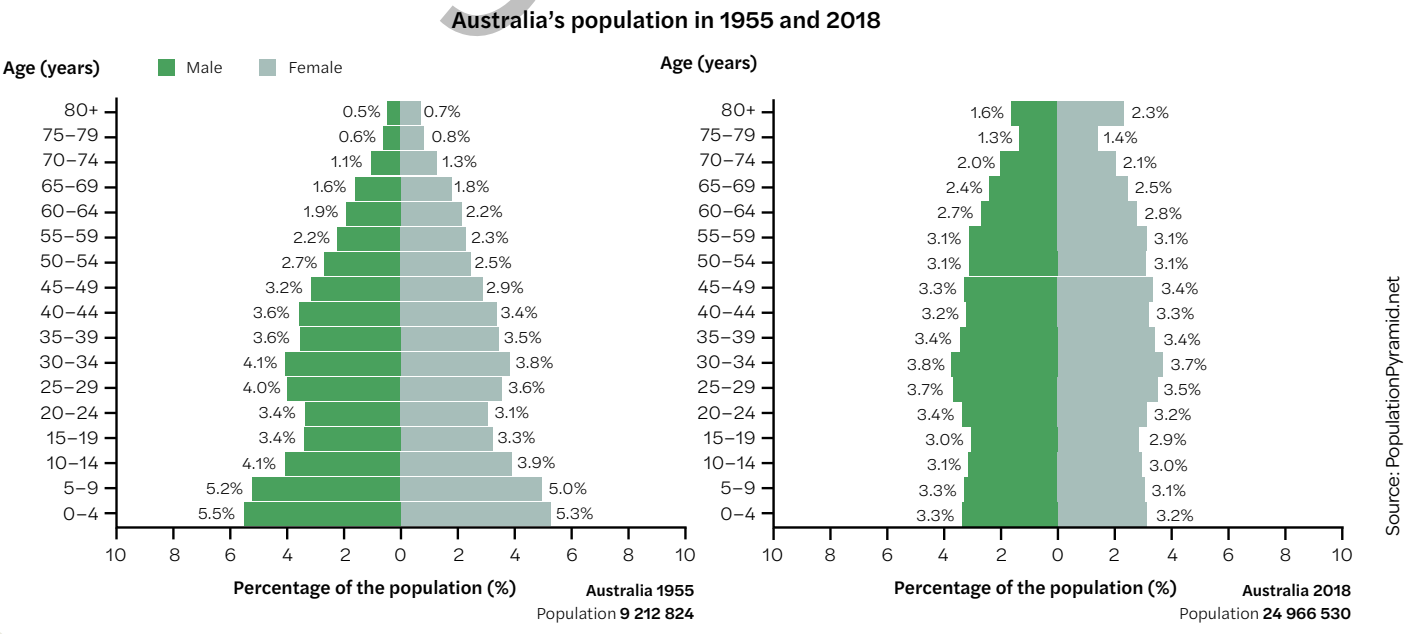
- a triangle: growing population, with more young people than old people
- a box: slow or stable growth, with equal numbers of old and young people
- an upside-down pyramid: aging or declining population, with more old people than young people.

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 2024, the largest population cohorts are within the working-age groups, 30–34 and 35–39, accounting for approximately 3.7 per cent of the total population. Overall, the pyramid presents a barrel-like shape rather than a classic triangular form, indicating an ageing population, longer life spans, and a relatively stable population size.

Source 28: Population profiles showing Australia's population in 1955 (left) and 2018 (right)



Satellite images

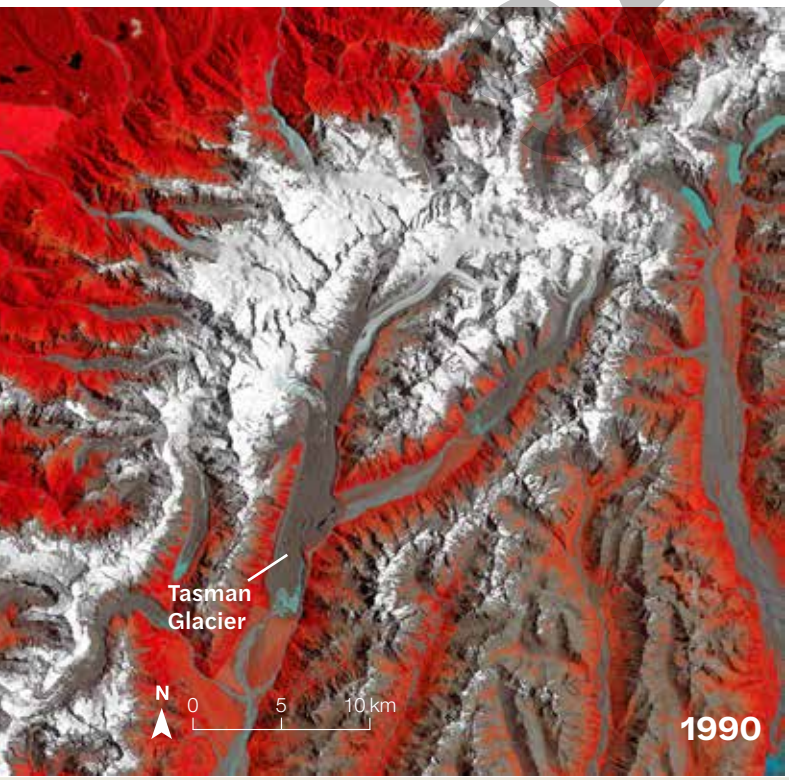
Satellite images are pictures of Earth taken from space. Satellites orbit the Earth and record images of the Earth's surface. We can use this data to see an event, such as a volcanic eruption, or to observe a change in land cover or other spatial patterns over time. Satellite images taken in daylight provide the most information.

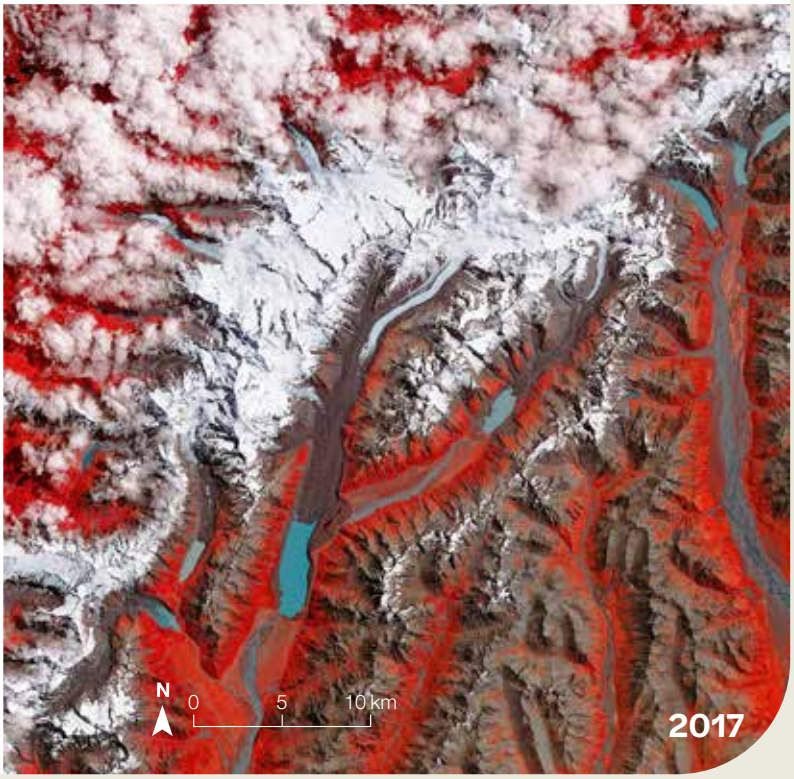
How can I use colour to interpret satellite images?

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.

"This desk job is killing me Jim. I need to be out in the field."

Source: CartoonStock.com

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?

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

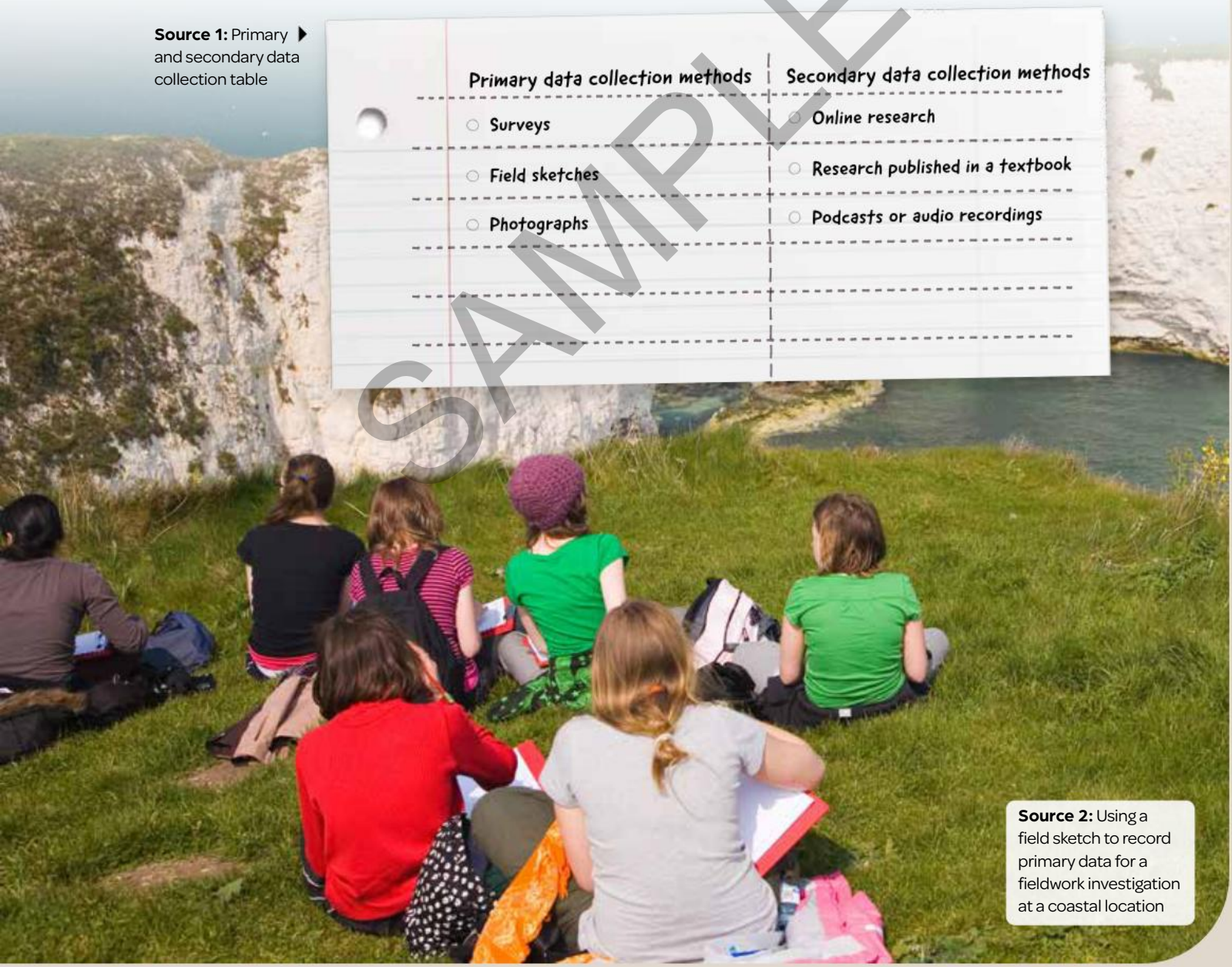
Once collected data in the field using primary and secondary methods, you need to communicate your findings.

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 a 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

Fieldwork Task 1

What are the challenges of planning for urbanisation in your place?

As our national population continues to grow, our communities are under pressure to change in order to meet the new demands and needs of their residents. This creates challenges for urban planners, who need to ensure that these areas have access to enough resources and sustainable living practices for both the locals and the new arrivals. Whether you live in a rural or an urban community, it is likely that your *place* has changed significantly over time. Fieldwork is an excellent way to review, monitor and predict change and challenges your area has faced or may face is the future.

Inquiry location

As a class, you will need to determine a field site that has undergone some change over time. This change should be linked with an increase in population and may be obvious, such as a growth in urbanisation, or may be more subtle, such as a reduction in the size of a standard housing block or increased resources or infrastructure such as the appearance of major shopping centres or freeways.

Source 3: A new freeway in eastern Melbourne, Victoria

Inquiry question

How can we design an urban space that meets the needs of its residents?

Hypothesis

Different people require different resources within the same urban space.

Writing your report

Defining your topic and method

1. State your research location, question and hypothesis.
2. Provide a brief outline of the location, characteristics and history of your local region, using around four or five sentences.
3. State two primary fieldwork techniques you used to complete this fieldwork and describe how they were helpful in answering the inquiry question.
4. State two secondary resources you used in the lead up to the fieldwork and describe how they were helpful in answering the inquiry question.

Presenting your data

Present the data you collected using tables, graphs, sketches with annotations, photographs and so on.

Analysing the data

Answer your inquiry question: How can we design an urban space that meets the needs of its residents?

Consider:

- What is urbanisation and why does it occur?
- When did or will urbanisation occur in your area?
- What new infrastructure will the urbanisation of your community provide?
- What are the different needs of the community?
- How can urbanisation help meet these needs?
- What are some negative impacts of urbanisation?

If you completed a survey:

1. What were your main findings?
2. How does this help us answer the inquiry question?
3. Were you surprised by these results? Why or why not?

Drawing conclusions

1. Summarise the key findings of your research.
2. Was the hypothesis correct (supported)? Why or why not?
3. Record five key pieces of evidence (such as data, photos, sketches or surveys) that support your answer above.

Evaluating your research

1. Which methods were the most successful for collecting data to answer the inquiry question? Why?
2. Which methods were the least successful for collecting data to answer the inquiry question? Why?
3. What changes to your fieldwork approach would you suggest to future Year 8 students completing the same task?

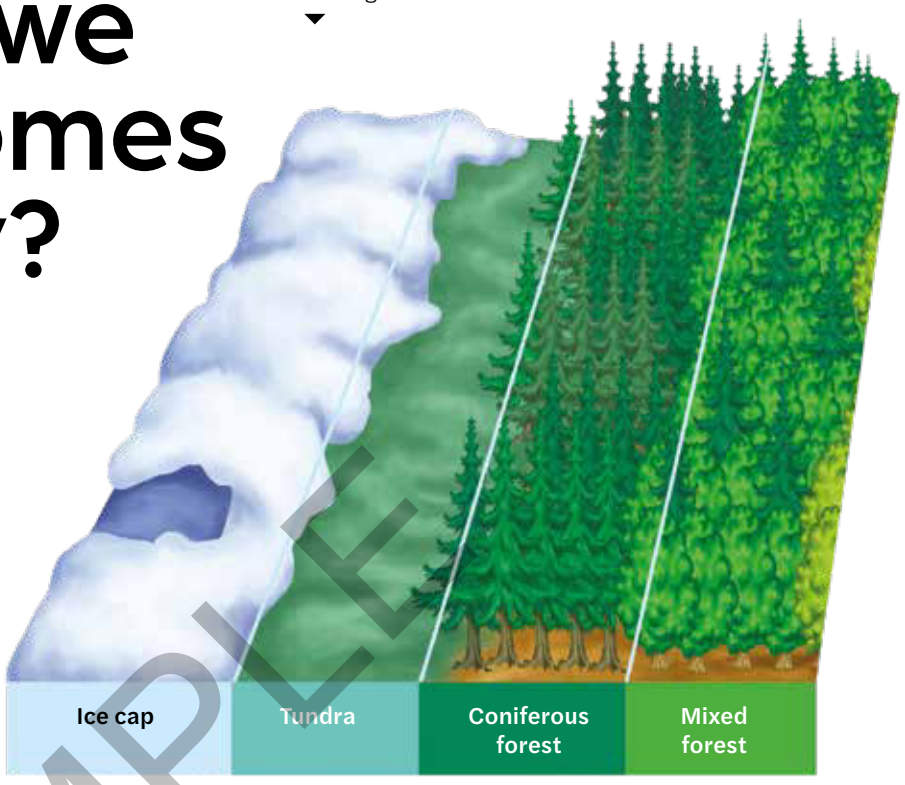
Handing in your report

Once you have completed all the steps of your fieldwork report, you are ready to collate your work into a folio and take action! What changes would you make to your local area so it can plan for the challenges it may face in the future as population grows?

Fieldwork Task 2

How can we explore biomes virtually?

Source 4: This diagram uses 11 categories of biome.



Background to fieldwork approach

Biomes vary on a number of scales. Because they are so diverse, the way we use them to produce resources, such as food, also varies. Dry, desert-like areas produce less than regions that receive high levels of rainfall and sunlight. Studying biomes can help us understand our world better.

Our choice of fieldwork location is usually limited to accessible places near school. However, we can use virtual fieldwork as a viable alternative to investigate inquiry questions. In this section, you will conduct a virtual fieldwork inquiry using Google Earth to answer a inquiry question you design as a class.

Inquiry question

The inquiry question you create needs to be focused on how the world's biomes have changed over time because of human actions. As a class, brainstorm these terms and craft a question that you will be able to answer via virtual fieldwork. Some questions you may consider:

- How have humans changed Earth over time?
- How do human actions affect our food security?
- How does increasing human population lead to loss of agricultural land?

Once you have a question, you need to create a hypothesis. You may all have a slightly different hypotheses, but that will create a more interesting analysis.

Pre-fieldwork research

Once you have decided on an inquiry question, you are ready to complete some pre-fieldwork research. Explore the internet, books and other resources for information about key concepts or processes that readers must know in order to understand your report.

Introduction and method

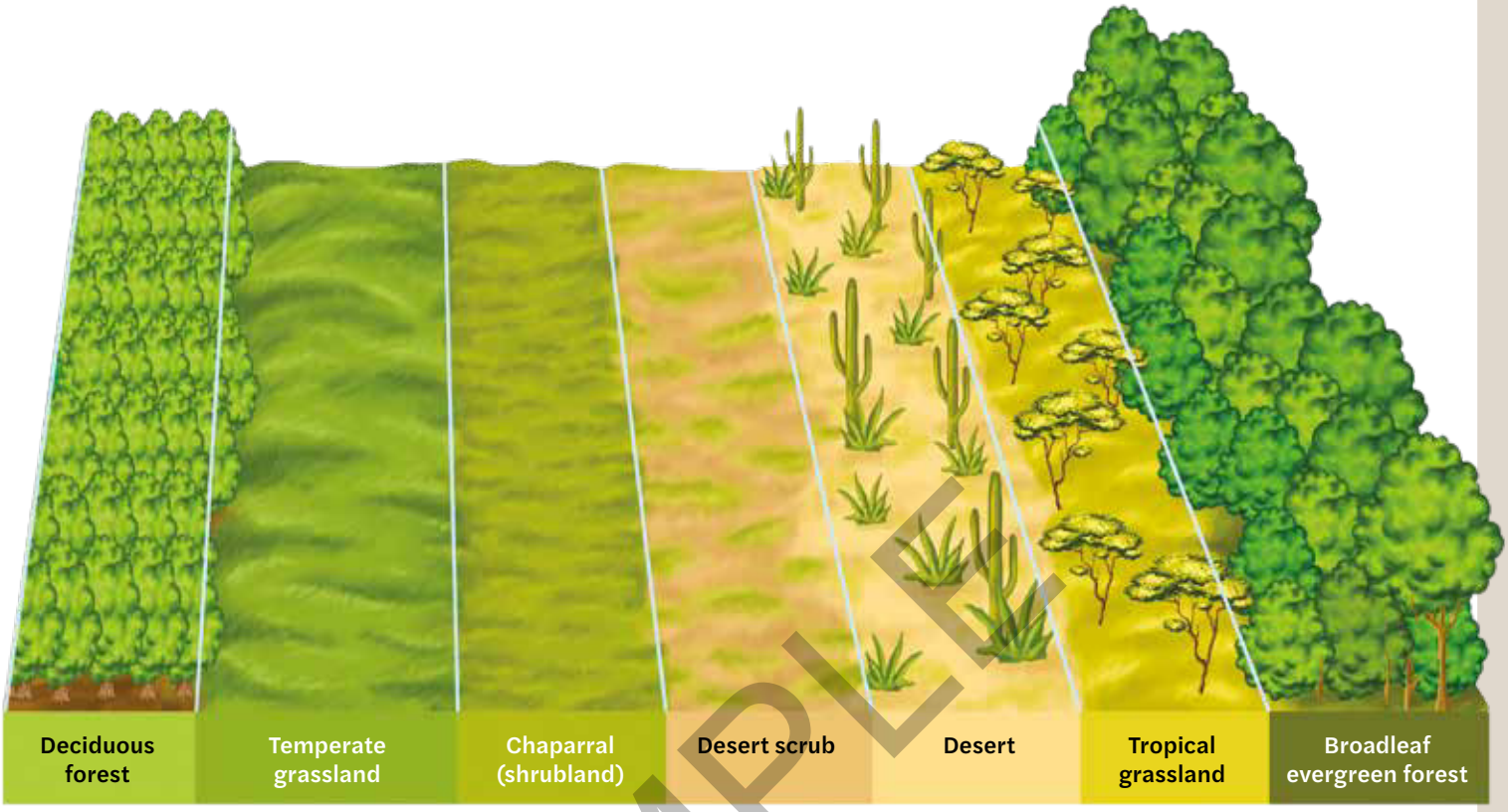
1. State your inquiry question and hypothesis.
2. Provide some background information so that readers will understand all key terms and concepts in your report.
3. State two primary fieldwork techniques you used to complete this fieldwork and describe how they were helpful in answering the inquiry question.
4. State two secondary resources you used to prepare for your fieldwork and describe how they were helpful in answering the inquiry question.

Collecting your data

As this is a virtual fieldtrip, you need to decide as a class which area of the world you will focus on. You might instead choose to break into research groups and look at different parts of the world.

These weblinks may help when exploring your chosen question.

- Visit the Google Earth Engine website at mea.digital/GHV9_G5_1.
- Read an article about time lapse data at mea.digital/GHV9_G5_2.



- Go on a virtual nature tour from Google Earth at http://mea.digital/GHV9_G5_3.
- Visit the Biome viewer website at http://mea.digital/GHV9_G5_4.
- Discover world human population change over time at the World Population History website at http://mea.digital/GHV9_G5_5.

Presenting your data

Present the data you collected using tables, graphs, annotated sketches and photographs.

Analysing your data and drawing conclusions

Using the data you collected while on your virtual fieldtrip, consider how this information helps you to answer the inquiry question. Does it support your hypothesis? Or are you beginning to change your mind? Complete the following tasks.

1. Summarise the key findings of your research.
2. Was your hypothesis correct (supported)? Why/why not?
3. Record five key pieces of evidence (data, photos, sketches or surveys) that prove or disprove your hypothesis.
4. Which methods were the most successful for collecting data to answer the inquiry question? Why?
5. Which methods were the least successful for collecting data to answer the inquiry question? Why?
6. What changes to your fieldwork approach would you suggest to future Year 9 students completing the same task?

Handing in your report

Once you have completed all the steps of your fieldwork report, you are ready to collate your work into a folio and submit it to your teacher.

How do I use geospatial technology in my fieldwork?

Using geospatial technology involves engaging with digital platforms to collect, present and analyse data collected in the field. The skills involved in using geospatial technology are not just for fieldwork reporting, but are also useful for work in engineering, surveying, construction, town planning, architecture, mining and entrepreneurship. Use of geospatial technology can be as simple as using your smartphone as part of your fieldwork or accessing free resources online.

Maps and apps

In the past, you may have used fieldwork booklets created by your teacher to structure your research and field experience. While data collection and mapping on paper is helpful, using applications such as Google Maps to track routes and find new locations can be more efficient and effective. Interactive maps allow you to find the latitude and longitude of locations, describe geographical characteristics and define temporal and spatial scales. Geographic apps can also be useful, especially when collating photos or surveys and presenting data in a digital fieldwork portfolio.

- Google Earth
- Google My Maps
- Google Tour Builder
- Google Street View
- Scribble Maps
- National Geographic MapMaker Interactive

- ARCGIS Survey123
- Field counter apps (traffic surveys or other counts)
- Geocam or GPS map camera apps
- My Tracks
- MapMyWalk

Source 5: You may wish to explore some of the apps or virtual maps listed to help you with your fieldwork.

Geocaching

In primary school you may have done some orienteering. In orienteering, tasks are designed to help you develop map and compass skills to locate objects or race to a finish line. Improvements in geospatial technology have allowed orienteering to become an activity known as Geocaching. This digital scavenger hunt encourages players to use an app, GPS tracking and clues to locate hidden objects around the world. You may be surprised by how many geocaches are in your local area.

Source 6: Geocaching has a wide following of geography enthusiasts who use clues and maps to locate treasure around the world.

Glossary

A

abiotic the non-living parts of the environment, such as sunlight, water, temperature and soil

adaptive strategies techniques or behaviours that people or communities develop to adjust to environmental or social changes, such as shifting agricultural practices to cope with drought or building houses designed to withstand floods

age-dependency ratio the ratio of the dependent population (young people under 15 and elderly people over 64) to the working-age population (ages 15–64). A high age-dependency ratio means there are more dependents for every working adult, which can strain resources

agroecological a study of how agricultural systems interact with the environment, including the relationships between plants, animals and their surroundings

agroforestry the practice of growing trees alongside crops or livestock, on the same land, to benefit the environment, improve soil quality and increase biodiversity

algal blooms rapid growth of algae in water, often due to excess nutrients such as nitrogen or phosphorus. These blooms can reduce oxygen levels and harm aquatic life, sometimes creating 'dead zones'.

altitude the height of a place above sea level. It can affect climate and the types of plants and animals that live in an area

anthropogenic caused or influenced by human activity, especially environmental changes such as pollution, deforestation and climate change

apex predators the top predators in an ecosystem, with no natural predators themselves. They help maintain the balance of the ecosystem by controlling the populations of other species. Examples include lions and sharks

aphotic the part of the ocean or a body of water that does not receive any sunlight, making it too dark for photosynthesis to occur

aquaculture the farming of aquatic organisms, such as fish, shellfish and plants, in controlled environments such as ponds, rivers or tanks

aquaponics a system that combines aquaculture (fish farming) with hydroponics (growing plants without soil), where fish waste provides nutrients for plants and plants help filter and purify the water for the fish

aquifer underground layers of water-bearing rock or sand where water is stored. People can use this water for drinking and irrigation

arable land that is suitable for growing crops. it must have the right soil, climate and water availability

B

backwash water returning to the sea from the beach

ballast water water carried in ships' ballast tanks to stabilise them. Ballast water can contain invasive species that are transported to new locations, causing environmental harm when released

benthic relating to the bottom of a body of water, such as the ocean floor, lakes or rivers. Benthic organisms live in or on the sea or river bed

bilateral aid aid given by one country directly to another, usually in the form of money, resources or expertise. Bilateral aid is often provided to support development, humanitarian efforts or diplomatic relations

bioaccumulation the process by which harmful substances, such as pesticides or heavy metals, build up in an organism over time. These substances accumulate in the tissues of the organism faster than they can be removed

biodiversity the variety of different species of plants, animals and microorganisms and the ecosystems they form. it is important for a healthy environment and ecosystem

biomagnification the increase in concentration of harmful substances as they move up the food chain. For example, small organisms may accumulate toxins and when larger animals eat them the toxins concentrate in the larger animal's body

biomass the total mass of living organisms in a given area or ecosystem; it includes plants, animals and microorganisms and is used as an indicator of the amount of energy available in that system

biome a large area of land characterised by its climate, vegetation and wildlife. examples include forests, deserts and tundras

biotic the living parts of the environment, such as plants, animals and microorganisms

block diagram a visual representation of a system or process using blocks or shapes connected by lines to show the flow of information or the relationships between different parts. It is commonly used to simplify complex processes or structures

blue carbon carbon stored in marine and coastal ecosystems, such as mangroves, seagrasses and salt marshes, which play a key role in mitigating climate change by capturing and storing carbon dioxide

breakwalls structures built along coastlines to protect the shore from erosion and reduce the impact of waves and storms; also known as sea walls or groynes

bubble chart a type of chart used to show the relationship between three variables, where each bubble represents data points and its size reflects the value of one of the variables

bushfires fires that occur in natural landscapes, particularly in forested or grassland areas, often in hot and dry conditions. They can be caused by natural factors or human activities

C

carbon sink a natural or artificial reservoir that absorbs more carbon dioxide from the atmosphere than it releases, helping to reduce the concentration of greenhouse gases. Forests, oceans and wetlands are examples of carbon sinks

carrying capacity the maximum number of individuals or species that an environment can sustainably support without it being degraded over time

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 war between groups within the same country, often due to political, social or ethnic conflicts. It can lead to widespread destruction and displacement of people

climate change long-term changes in temperature, weather patterns and other climate factors on Earth, often caused by human activities like burning fossil fuels and deforestation

climate graph a graphical representation of the climate of a particular area, showing the average temperature and precipitation over a period of time, usually monthly. This helps with understanding the general weather patterns in a region

commodities basic goods or raw materials that are traded, such as oil, wheat or gold

commodity crops crops that are grown to be sold, rather than for personal use. They are often sold on global markets, and include coffee, cotton and rice

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

coral bleaching a phenomenon where coral reefs lose their vibrant colours due to stress factors like higher water temperatures. Bleaching occurs when coral expels the algae living in it, which provide nutrients and colour

coral polyps small, soft-bodied organisms that make up coral reefs. Polyps secrete calcium carbonate to form the hard skeleton of a coral reef

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

cryosphere the frozen water part of the Earth's system, including ice caps, glaciers and snow. It plays a critical role in the Earth's climate system

cultural eutrophication the process where excess nutrients, often derived from human activities such as farming or from wastewater, cause an increase in algae and plant growth in water bodies, leading to a decline in water quality and loss of biodiversity

custodial responsibility the duty or responsibility to take care of and protect something, such as the environment or a specific natural resource, for future generations

D

deforestation the clearing of a forest to make room for a different land use, such as farming

dependency ratio a measure of the number of people who are dependent on others for support (typically children and older people) compared to the number of working-age people who provide that support. A higher ratio means there are more dependents for every worker

desertification the process by which fertile land becomes desert due to factors such as drought, deforestation or poor farming practices; it reduces the land's ability to support life

destructive waves strong, powerful waves that cause erosion and damage to coastlines. These waves have high energy and can wear down rocks and cliffs

diasporas groups of people who have spread or been displaced from their original homeland to live in other parts of the world, often maintaining cultural ties with their country of origin

displaced people who are forced to leave their home or place of residence due to factors such as conflict, natural disasters or environmental changes, but they remain within their own country

E

Earth-centred worldview a perspective that prioritises the health and wellbeing of the Earth and its ecosystems. People with this worldview believe that all living things are interconnected and that humans must respect and preserve the planet

east coast lows storm systems that form off the eastern coast of Australia, often leading to heavy rainfall, strong winds and coastal flooding. They are a type of intense low-pressure system

ecosystem a community of plants, animals and other organisms in their physical environment

ecosystem services the benefits that humans receive from the environment, such as clean air, water, pollination and fertile soil, which help sustain life

electrofishing a technique used to catch fish by temporarily stunning them with an electric current, making them easier to collect for research or management purposes

embers small, glowing pieces of coal or wood left over after a fire; they can continue to burn or cause fires to spread

endemic a species that is native to and found only in a specific area or region, such as a particular country, island or ecosystem

environmental worldview a way of seeing and understanding the world that emphasises the importance of protecting the environment and recognising the limits of human impact on natural resources and ecosystems

estuary a coastal area where freshwater from rivers meet and mix with saltwater from the sea. They are highly productive ecosystems that support a variety of wildlife

eutrophication the process of nutrient enrichment in a body of water, often leading to excessive algae growth, reduced oxygen levels and damage to aquatic life

extensive farming a type of farming that involves large areas of land with low levels of labour and capital. The focus is on producing large quantities of crops or livestock

extinction the permanent disappearance of a species from the Earth, usually due to changes in the environment, habitat loss or human activity

F

famine a severe shortage of food that leads to widespread hunger and malnutrition, often caused by drought, war or economic problems

fetch the distance over water that the wind blows in a single direction. A longer fetch results in larger waves, as the wind has more time to transfer energy to the water

flow diagram shows the steps in a process or the flow of information using symbols and arrows; it helps to visually represent how a process works, such as the water cycle or a manufacturing process

food insecurity a situation where people do not have enough food to meet their daily nutritional needs, often due to poverty or problems with food supply

food security the state of having access to enough nutritious food to maintain a healthy life. It is about having reliable food sources

forest degradation the decline in the quality of a forest, often due to logging, deforestation or climate change, which reduces its ability to provide ecological benefits such as clean air, water and habitat

free trade agreements (FTAs) agreements between countries to reduce or eliminate trade barriers, such as tariffs, to make it easier to buy and sell goods between them

G

genetic engineering the modification of an organism's genetic material, often by adding or altering genes, to achieve desired traits such as resistance to disease or improved productivity

Geographic Information System (GIS) a system used to collect, analyse and display spatial and geographic data, allowing users to visualise and understand patterns in geography and environmental information

geotagging the process of adding geographic information, such as latitude and longitude coordinates, to photos, videos or other media. It helps to locate where the media was created or captured

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-based navigation system that provides location information, allowing people to determine their exact position anywhere on Earth

global warming the long-term increase in Earth's average surface temperature, primarily due to human activities like burning fossil fuels, which release greenhouse gases and trap heat in the atmosphere

globalisation the process of the world becoming more connected through trade, communication and travel, making it easier for goods, services and information to flow across borders

greenhouse effect the trapping of heat in the Earth's atmosphere by gases such as carbon dioxide, methane and water vapour, which leads to a warming effect on the planet

gross domestic product (GDP) the total value of all goods and services produced in a country over a specific period, often used to measure the size and health of a country's economy

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

gully erosion the process whereby water, usually from heavy rainfall, cuts deep channels into the land, removing soil and causing damage to the landscape

H

habitat the natural environment where a plant or animal lives. It includes all the conditions and resources it needs to survive

headland narrow, high land jutting out into the sea, formed of harder rock that resists erosion

hemisphere one half of the Earth, divided either by the equator (into the northern and southern hemispheres) or by the prime meridian (into the eastern and western hemispheres)

horticultural relating to the practice of growing fruits, vegetables and flowers

human-centred worldview a perspective that focuses on human needs, values and rights, sometimes at the expense of environmental health. People with this worldview may prioritise economic growth or development over environmental protection

humanitarian aid assistance provided to people in need, particularly during crises such as natural disasters, war or famine; it includes food, water, shelter, medical care and other essential services

hydroelectric power electricity generated by the movement of water, typically through dams that harness the energy of flowing water to turn turbines and produce power

I

ice sheet layer of ice covering a large area of land for a long period of time

infant mortality rate death of children who are one year old or younger

infanticide the act of intentionally killing an infant or young child. This can be due to cultural, social or economic reasons, although it is illegal and morally condemned in most societies

infiltration process where water (rain, hail or snow) soaks into the soil

informal settlements areas where people live in houses or shelters that are built without official planning or approval, often lacking basic services such as water, electricity and sanitation; they are often called slums

infrastructure physical and organisational requirement needed for the operation of a society, for examples, roads, water supplies

inquiry question an open-ended question to prompt an investigation

intensive farming a type of farming where farmers use large amounts of labour, capital and technology to produce high yields of crops or livestock on small areas of land

intergenerational disadvantage the passing down of disadvantages, such as poverty, lack of education or poor health, from one generation to the next, making it difficult for individuals to improve their situation in life

internal migration the movement of people from one area to another within the same country, often in search of better living conditions, work or education

internally displaced people people who have been forced to leave their homes due to conflict, violence or disasters, but who have not crossed an international border. They remain within their own country

international governmental organisation (IGO) an organisation made up of member states or governments that work together on issues of international concern, such as the United Nations (UN) or the World Health Organization (WHO). IGOs help to coordinate actions on global challenges such as health, security and development

intrinsic value the inherent worth of something, often used in relation to nature or ecosystems, meaning that they have value in themselves, regardless of their usefulness to humans

invasive a species that is not native to a specific area and has the potential to cause harm to the environment, economy or human health

invasive species non-native species that spread rapidly and outcompete native species, often disrupting ecosystems and causing environmental damage

irrigation the artificial application of water to land to help crops grow, especially in areas where there is not enough natural rainfall

K

keystone species a species that has a disproportionately large impact on its environment relative to its abundance. the presence or absence of a keystone species can greatly affect the structure of an ecosystem

king tides exceptionally high tides that occur when the earth, moon and sun align in a way that amplifies the gravitational pull, causing the water level to rise higher than usual

L

la Niña a climate pattern characterised by cooler than average sea surface temperatures in the Central and Eastern Pacific Ocean, which can cause changes in global weather patterns, including more rainfall in some areas and droughts in others

lagoon a shallow body of water separated from the open sea by a barrier such as a sandbank or coral reef; often contains diverse ecosystems

land degradation the deterioration of the land's quality, often due to human activities such as deforestation, overgrazing and poor farming practices, making it less able to support plant and animal life

latitude the distance north or south of the equator, measured in degrees. It helps determine the climate of a region

less economically developed countries (LEDC) countries with lower standards of living, income and industrialisation; they often face challenges like poverty, limited access to healthcare and lack of infrastructure

liveability a measure of how comfortable and pleasant an area is to live in. It includes factors like safety, healthcare, education, housing and access to clean water and air

longshore drift the movement of sand in a zigzag fashion along the beach until it meets an obstacle such as a headland or groyne

loss of fertility when the soil loses its ability to support plant growth, often due to overuse, erosion or lack of nutrients

M

malnutrition a condition that occurs when a person's diet does not provide enough nutrients, leading to health problems. It can be caused by insufficient food or a lack of the right types of food

mangrove coastal trees or shrubs that grow in saline or brackish water; they provide habitat for wildlife, help protect shorelines from erosion and act as carbon sinks

marine park authority an organisation responsible for managing and protecting marine parks and reserves. It ensures the conservation of marine life and ecosystems while allowing for sustainable use of marine resources

maternal mortality rate the number of women who die from pregnancy-related causes per 100 000 live births. A high maternal mortality rate often indicates problems with healthcare access and maternal care

megacity a city with a population of over 10 million people. These cities are often economic and cultural hubs, but can also face challenges, such as overcrowding and pollution

microloans small loans given to people, especially in developing countries, to start or improve their businesses, often with low interest rates

migration strategies the methods and approaches used by individuals or groups to move from one place to another in response to factors such as climate change, conflict or economic opportunities. These strategies can include temporary relocation, permanent settlement or movement in search of resources

migration the movement of people from one place to another, either within a country or across borders, often for reasons such as work, safety or better living conditions

monoculture the practice of growing one type of crop over a large area, which can be risky because it can lead to soil depletion and greater vulnerability to pests

more economically developed countries (MEDC) countries with high standards of living, high income and advanced industries. They often have better access to healthcare, education and infrastructure

multilateral aid aid given by several countries, often through international organisations, to support development or humanitarian efforts. This aid is usually provided to countries in need and is coordinated to maximise its impact

N

nomadic a way of life where people move from place to place rather than settling in one location, often in search of food, grazing land or resources

non-government organisations (NGOs) independent organisations that work to provide aid, support or advocacy on social, environmental or humanitarian issues. They are not controlled by the government

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 located north of the equator

O

objective factors factors that are based on facts and measurable data, such as income levels, education or employment rates. These factors can be observed and quantified without personal opinions influencing them

orographic rain that occurs when warm, moist air is lifted over a mountain

P

pastoral relating to the practice of raising animals for food, wool or other products. Pastoral farming often involves grazing animals such as sheep or cattle

patriarchal society a social system in which men hold the primary power and authority in areas such as politics, family and decision-making. In patriarchal societies, women and children may have less power and influence

peri-urban agriculture farming that takes place on the outskirts of cities; it provides fresh food to urban areas and helps people live near the city

permafrost ground that remains frozen for more than two consecutive years; commonly found in polar regions. Due to climate change, when it melts it can release greenhouse gases such as methane

persecution the mistreatment or unfair treatment of individuals or groups, often due to their race, religion, ethnicity or political beliefs. Persecution can lead to discrimination, violence and forced migration

photic the zone in the ocean or water where enough sunlight penetrates for photosynthesis to occur; typically in the upper 200 metres of the ocean

photo essay a collection of photographs that tell a story or illustrate a particular subject, often accompanied by captions or text to provide context or explanations. They are used to communicate ideas, events or emotions

physical weathering the breakdown of rocks by wind, water and temperature changes

population density the number of people living per unit of area, typically measured in people per square kilometre. High population density often means crowded living conditions

primary research methods methods of collecting firsthand data, such as through fieldwork, surveys, experiments or interviews

pulse flow a controlled release of water from a dam or other water management system to mimic natural river flows, benefiting ecosystems like wetlands and riparian zones

pyrocumulonimbus clouds clouds that form during intense fires, creating a towering, thunderstorm-like cloud that can produce strong winds, lightning and further spread the fire

Q

qualitative data non-numerical data based on qualities or characteristics based on observations, interviews and written accounts

quantitative data numerical data based on measurements or counts

R

rainfed agriculture agriculture that relies on natural rainfall to water crops, rather than using irrigation systems

rainfed crop a crop that is grown using only natural rainfall as its water source, without artificial irrigation

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

remote sensing the use of satellites or aircraft to collect data about the Earth's surface, often used for monitoring environmental changes, such as deforestation or for weather prediction

renewable energy energy that comes from natural sources such as the Sun, wind or water, which can be continuously replenished

resource curse a phenomenon where countries with abundant natural resources (e.g. oil or minerals) often experience slower economic growth, corruption or conflict due to over-reliance on these resources instead of developing other sectors of the economy

riparian zones areas of land located along rivers, streams and other water bodies. riparian zones are important for water quality, providing habitat for wildlife and acting as buffers against pollution

runoff water that flows over the surface of the land and into rivers and lakes

rural areas located outside of cities and towns, usually characterised by open land, farms and fewer people. They often have more space but fewer services and opportunities compared to urban areas

S

salinisation the process by which salt builds up in the soil, often due to excessive irrigation, making it harder for plants to grow

salinity the concentration of salt in the soil or water. High salinity can damage plants and reduce agricultural productivity

SALTS an acronym used in Geography for structuring graph analysis: 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

sand spits narrow, sandy landforms that project from the shore into the water, often formed by the movement of sediment along coastlines due to wave and current action

satellite images photographs or data captured by satellites orbiting the Earth. These images provide detailed views of the Earth's surface, including landscapes, weather patterns and human activity. They are used in environmental monitoring, mapping and research

satellite towns smaller towns or communities that are located near a large city, but are independent from it. They often provide housing, jobs and services to people who work in the nearby city, but prefer to live in less crowded areas

scatter plot a type of chart that shows the relationship between two variables by plotting points on a grid, allowing patterns or trends to be observed

sea ice frozen ocean water that forms in polar regions; plays a critical role in regulating Earth's climate by reflecting sunlight and helping to maintain the balance of the global temperature

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 research methods that rely on previously collected data, including government reports, academic sources and historical records to analyse geographical patterns

sequester the process of capturing and storing carbon dioxide from the atmosphere, often through natural ecosystems like forests or oceans, to help reduce climate change

sketches simple drawings or diagrams that represent an idea, object or scene; often used to quickly capture a concept or to illustrate something in a basic and informal way

slum a heavily populated urban area characterised by substandard housing, poverty and lack of access to basic services such as clean water, sanitation and electricity

social housing affordable housing provided by the government or non-profit organisations for people with low incomes or in need. It is intended to ensure that everyone has access to safe and decent housing, regardless of their financial situation

social mobility the ability of individuals or groups to move up or down the social and economic ladder. High social mobility means that people have a good chance of improving their standard of living, while low mobility means people's social position is largely determined by their background

social value the importance or worth of something to society; it can include factors such as cultural, educational or environmental benefits

soil erosion the removal of the top layer of soil by wind, water or human activity; can lead to the loss of fertile land and damage to the environment

southern hemisphere the half of the Earth south of the Equator

SPICESS an acronym for the seven geographical concepts of Space, Place, Interconnection, Change, Environment, Sustainability, and Scale used to understand and examine geographic issues and relationships

spot fires small fires that occur away from the main fire front, often started by embers carried by the wind; can lead to the spread of large wildfires

stewardship the responsible management and care of resources, such as land, water and natural habitats, to ensure they are used sustainably and preserved for future generations

storm surges an abnormal rise in sea level caused by strong winds from a storm, such as a hurricane or cyclone, pushing water towards the shore and leading to coastal flooding

subjective measures factors based on personal opinions, feelings or experiences. These measures can vary from person to person and are often difficult to quantify, such as people's feelings about their quality of life or sense of safety

subsistence a way of life where people grow just enough food to feed themselves and their families, with little left over to sell

subsistence farming farming that is done primarily to feed the farmer's family, with little or no surplus for sale

suburbanisation the process by which people move from cities to the surrounding suburbs, resulting in the growth of suburban areas. This often happens because of a desire for more space, lower costs and quieter living conditions

sustainability the ability to use resources in a way that meets current needs without harming the ability of future generations to meet their own needs. It focuses on environmental, social and economic balance

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

symbiotic relationship a close and long-term relationship between two different species that live together, often providing benefits to each other; examples include mutualism (both benefit) and parasitism (one benefits at the expense of the other)

T

tanneries facilities where animal hides, especially from cows and goats, are processed to produce leather; often involves chemicals that can be harmful to the environment if not managed properly

tariffs taxes or duties placed on imported or exported goods to raise their prices and make them less competitive

telemetry the use of technology to collect data remotely from animals, vehicles or other sources, often used in wildlife monitoring or environmental research

temperate a climate zone characterised by moderate temperatures and distinct seasons, neither too hot nor too cold

terra nullius a legal concept meaning 'land belonging to no one'. It was used historically to justify the colonisation of lands that were already inhabited by Indigenous people

terrestrial ecosystems ecosystems that are found on land, such as forests, grasslands and deserts. They support a wide variety of plant and animal life

thermal expansion the increase in the volume of water as it warms up, leading to rising sea levels; occurs as the temperature of the ocean increases due to climate change

thermohaline circulation the global movement of ocean water driven by differences in temperature and salinity, which helps regulate climate by distributing heat around the Earth

TOASTIE an acronym for a method for structuring field sketches using Title, Orientation, Annotations, Scale, Time, Information and Edge

totem an object, animal or plant that is considered sacred or symbolic by a group of people, often used in cultural or spiritual practices; often linked to the identity of indigenous communities

tropical cyclones 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

tunnel erosion type of erosion where water flows beneath the surface of the soil, creating underground channels or tunnels that can cause surface land to collapse.

turbidity the cloudiness or haziness of water caused by particles, such as dirt, algae or pollutants, suspended in the water. High turbidity can affect water quality and the health of aquatic life

U

undernourishment a condition in which people do not get enough calories or nutrients to maintain a healthy life. It is often linked to poverty, poor food distribution or environmental factors

urban consolidation the process of increasing the population density in an existing urban area, typically by building more apartments or higher buildings, rather than expanding the city outwards into rural areas

urban relating to cities or towns; they tend to have higher population densities, more infrastructure and greater access to services compared to rural areas

urbanisation an increase in the proportion of people living in urban areas

V

vertical farming a method of growing crops in stacked layers, often inside buildings, using artificial lighting and controlled environments to maximise space and efficiency, especially in urban areas

W

water scarcity a situation where there is not enough fresh water to meet the needs of a population or ecosystem

water security the availability of sufficient and safe water for drinking, sanitation, agriculture and other uses; crucial for maintaining public health and economic stability

wetlands areas where water covers the ground for long periods, including swamps, marshes and bogs; important for biodiversity, water filtration and flood control

worldview a person's or society's overall perspective on the world, including their beliefs, values and understanding of the environment, society and how humans interact with them

Z

zooxanthellae tiny, symbiotic algae that live inside coral polyps and provide them with food through photosynthesis; critical for the health of coral reefs, as they contribute to the coral's vibrant colour and energy production