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JACARANDA

GEOGRAPHY ALIVE 8

AUSTRALIAN CURRICULUM | THIRD EDITION

AUSTRALIAN CURRICULUM v9.0

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This suite of resources may include references to (including names, images, footage or voices of) people of Aboriginal and/or Torres Strait Islander heritage who are deceased. These images and references have been included to help Australian students from all cultural backgrounds develop a better understanding of Aboriginal and Torres Strait Islander Peoples' history, culture and lived experience.

It is strongly recommended that teachers examine resources on topics related to Aboriginal and/or Torres Strait Islander Cultures and Peoples to assess their suitability for their own specific class and school context. It is also recommended that teachers know and follow the guidelines laid down by the relevant educational authorities and local Elders or community advisors regarding content about all First Nations Peoples.

All activities in this resource have been written with the safety of both teacher and student in mind. Some, however, involve physical activity or the use of equipment or tools. **All due care should be taken when performing such activities**. To the maximum extent permitted by law, the author and publisher disclaim all responsibility and liability for any injury or loss that may be sustained when completing activities described in this resource.

The Publisher acknowledges ongoing discussions related to gender-based population data. At the time of publishing, there was insufficient data available to allow for the meaningful analysis of trends and patterns to broaden our discussion of demographics beyond male and female gender identification.

Contents

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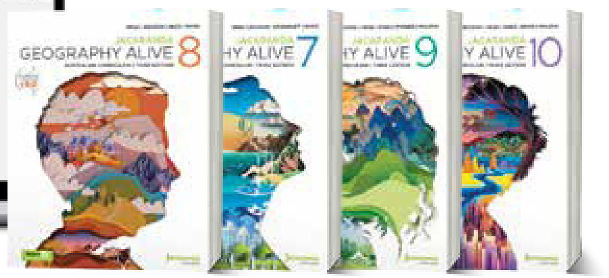
NEW FOR
AUSTRALIAN CURRICULUM V9.0



JACARANDA
GEOGRAPHY ALIVE 8 AUSTRALIAN CURRICULUM
THIRD EDITION

Developed by teachers for students

Tried, tested and trusted. Every lesson in the new *Jacaranda Geography Alive* series has been carefully designed to support teachers and help students evoke curiosity through inquiry-based learning while developing key skills.

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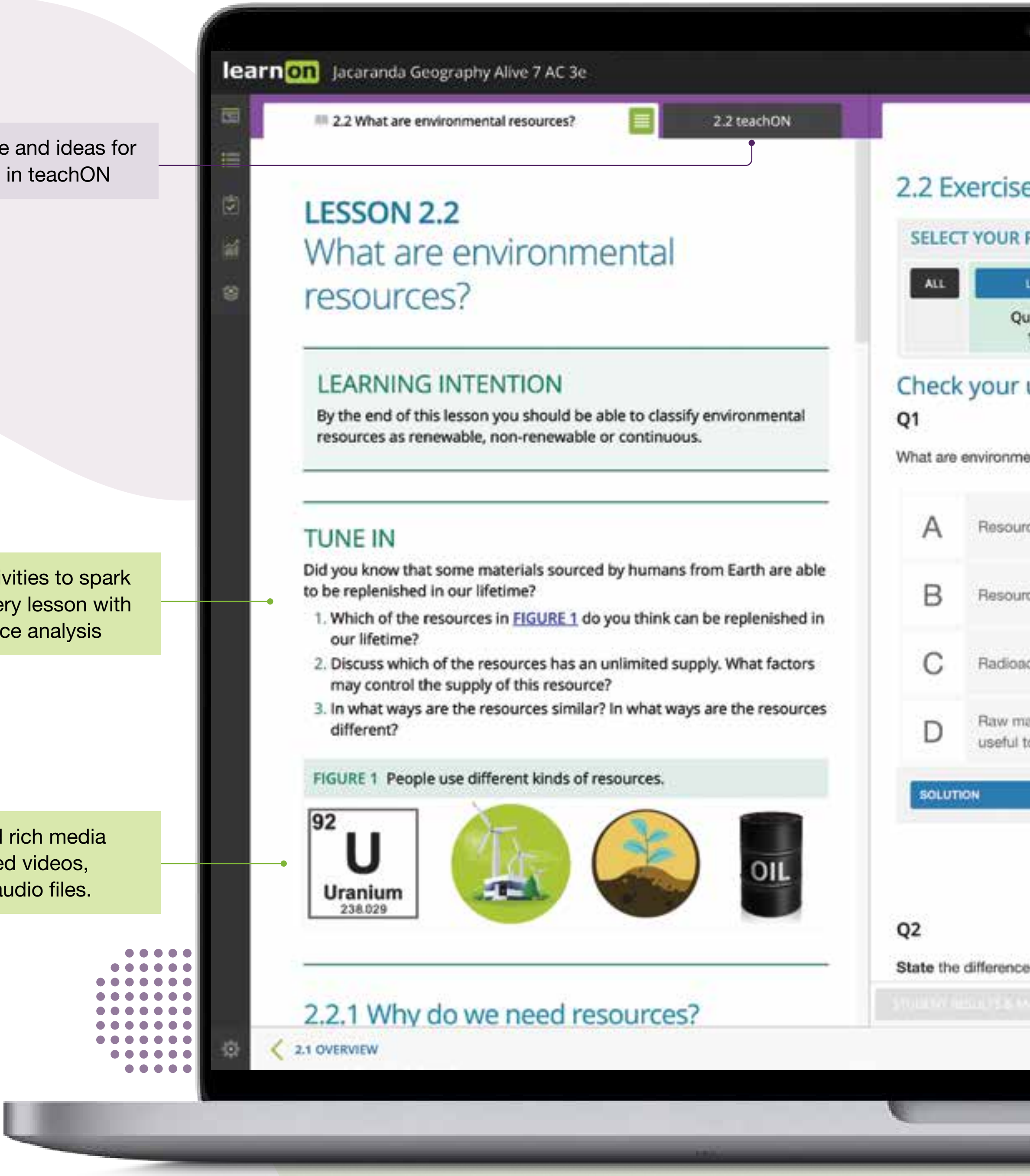
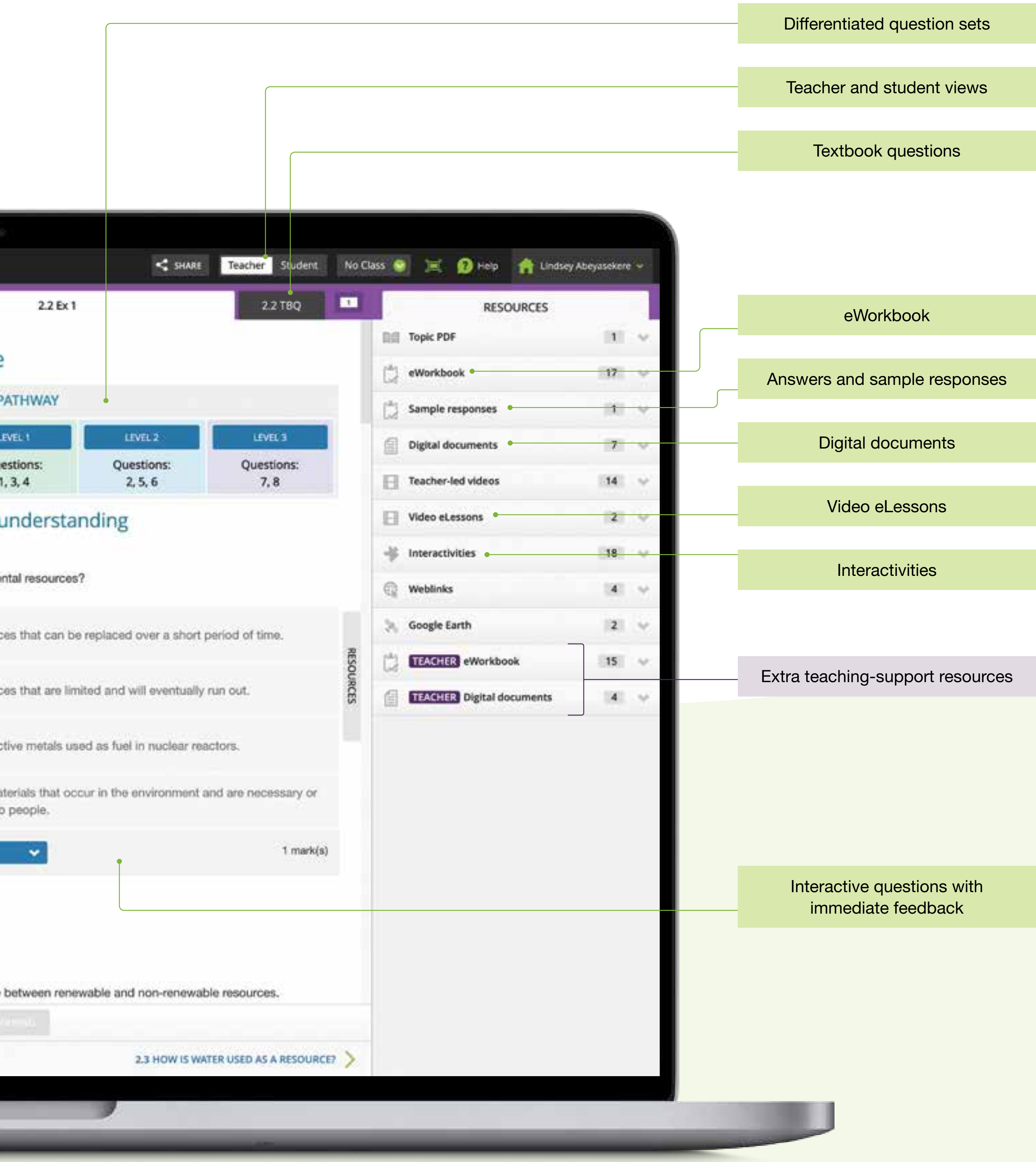
Reading content and rich media including embedded videos, interactivities and audio files.



powerful learning tool, learnON

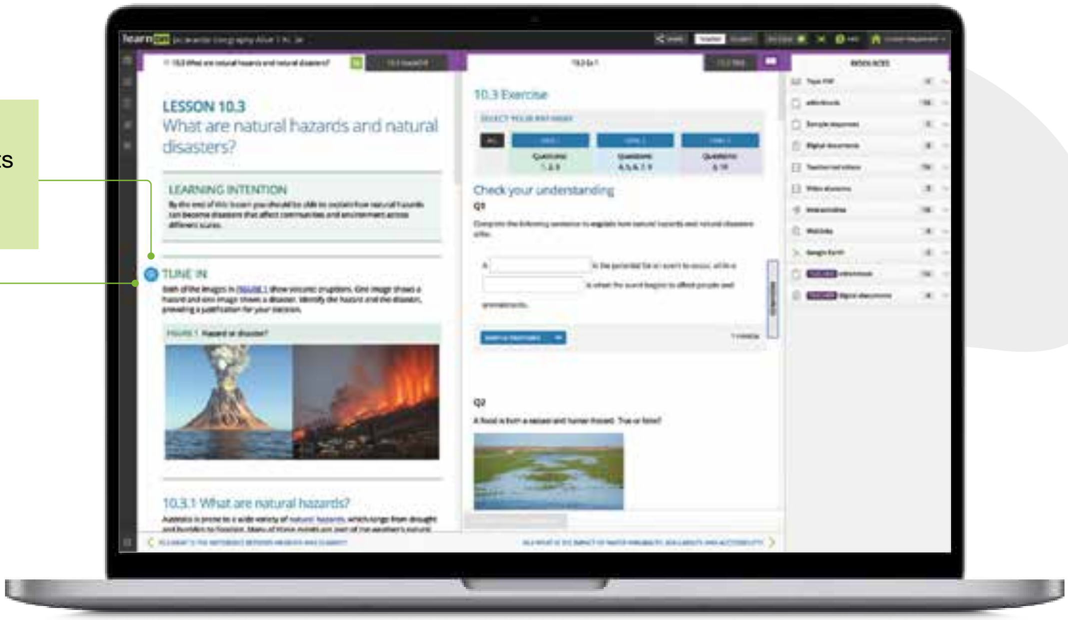


Get the most from your online resources

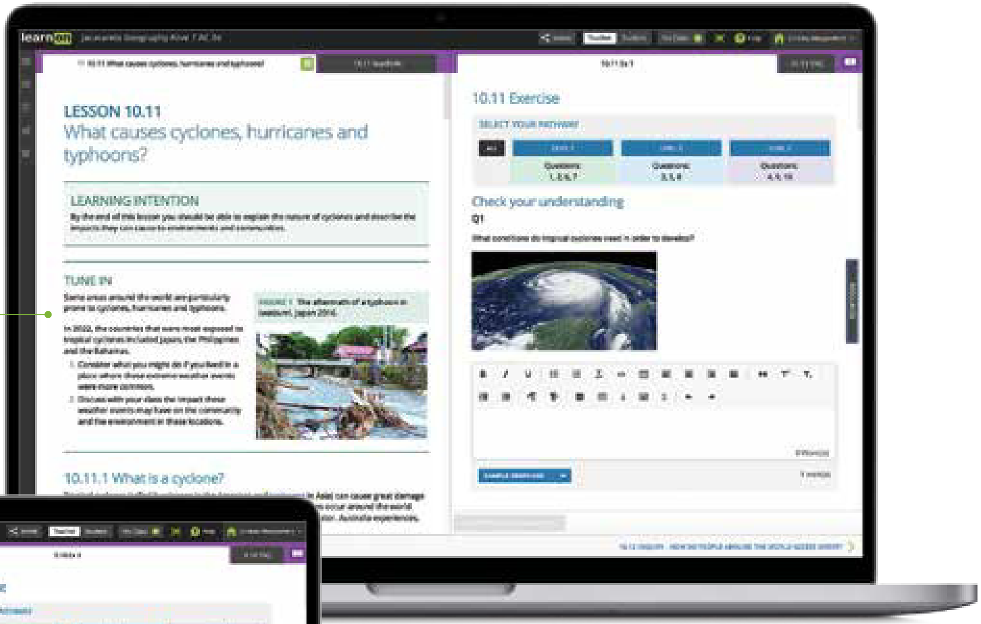
Online, these new editions are the **complete package**

Trusted Jacaranda theory, plus tools to support teaching and make learning more engaging, personalised and visible.

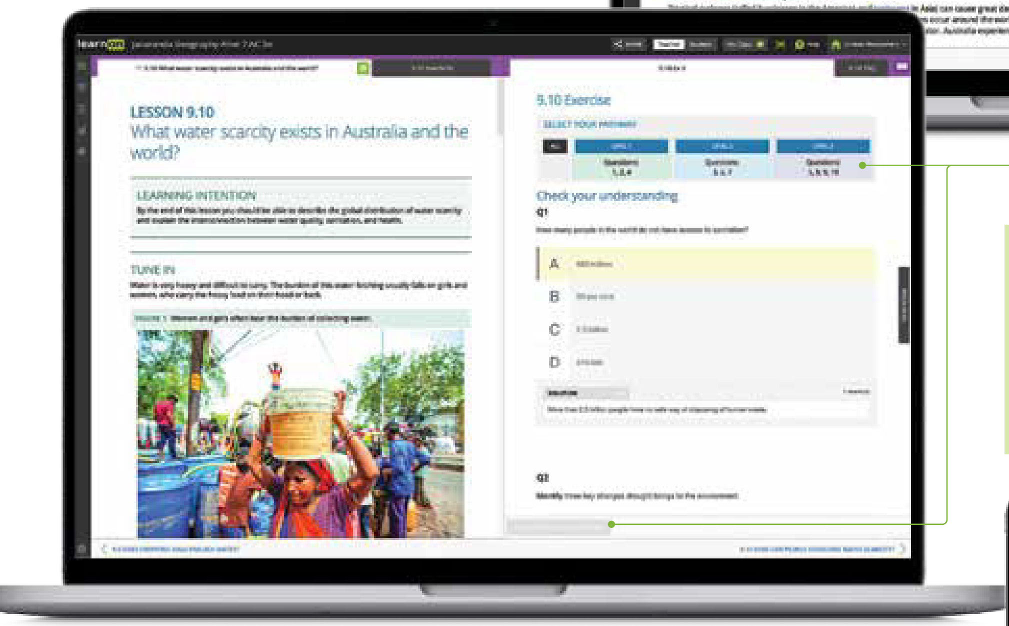
Embedded interactivities and videos enable students to explore concepts and learn deeply by ‘doing’.



New teaching videos are designed to help students learn concepts by having a ‘teacher at home’, and are flexible enough to be used for pre-and post-learning, flipped classrooms, class discussions, remediation and more.

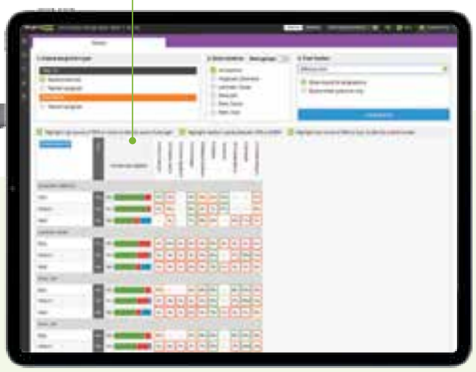


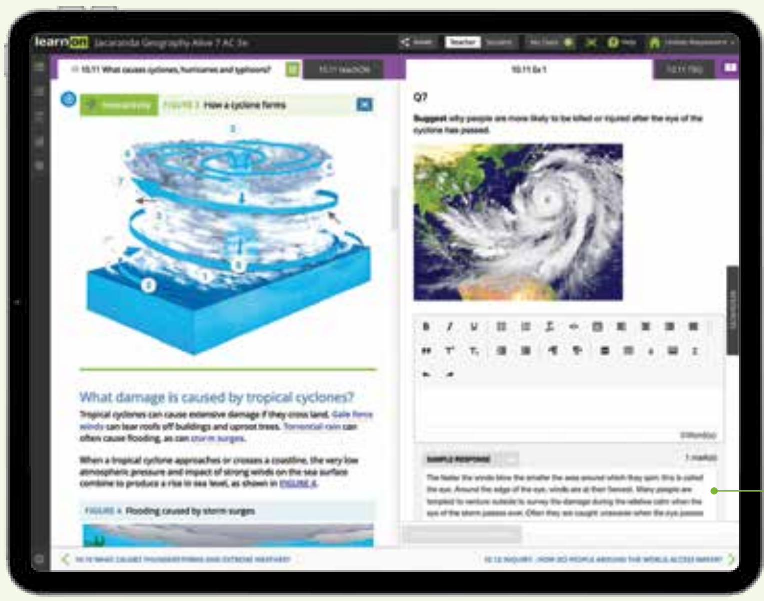
Brand new! Tune in activities to spark interest and kick off every lesson with discussion and source analysis



Three differentiated question sets, with immediate feedback in every lesson, enable students to challenge themselves at their own level.

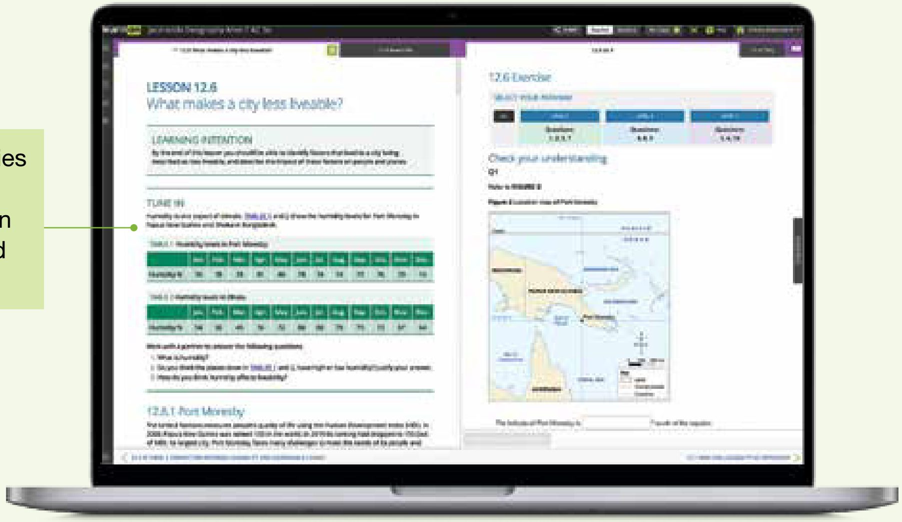
Instant reports give students visibility into progress and performance.





Every question has immediate, feedback to help students overcome misconceptions as they occur and get unstuck as they study independently — in class and at home.

TUNE IN lesson starters



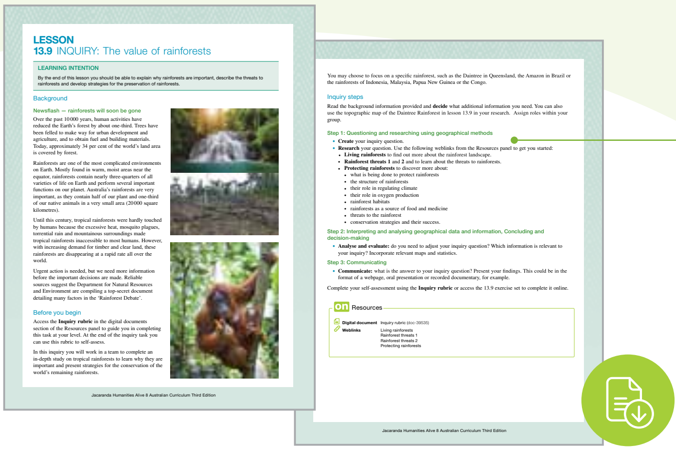
New Tune In activities spark interest and kick off every lesson with discussion and source analysis.

Skill development

New skill activities provide opportunities to develop and build crucial Geography skills using research, collaboration and analysis.

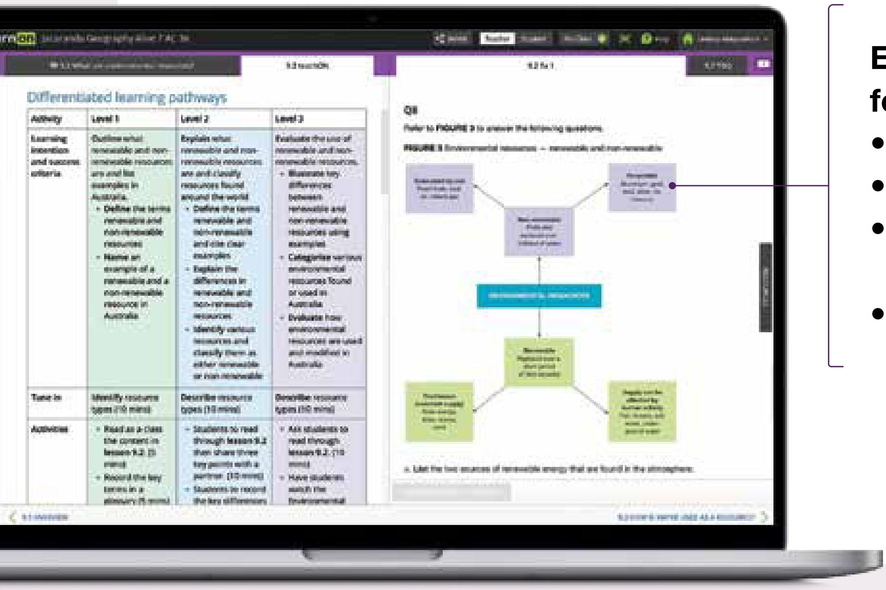
SkillBuilders support and strengthen skill development using our Tell me, Show me, Let me do it approach.

Inquiry projects



New Inquiry lessons use project-based learning and a clear skill structure for a deep dive into every topic while practising the curriculum-specific skills.

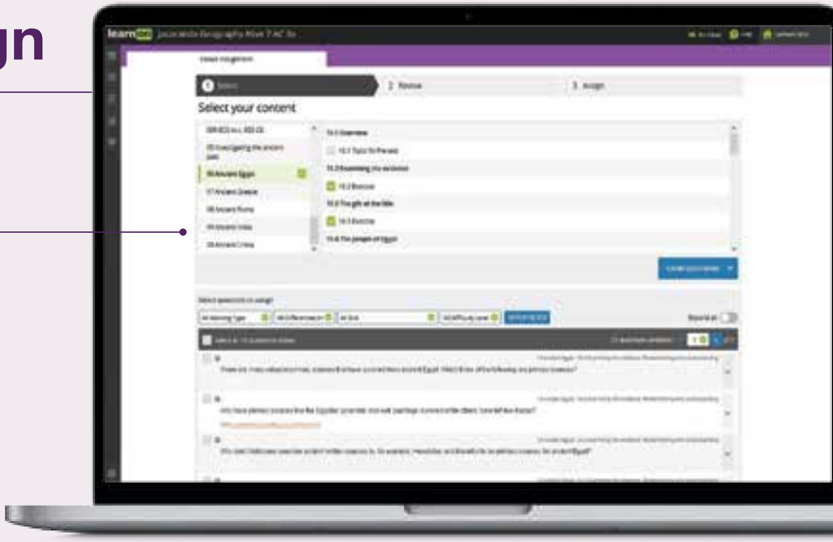
A wealth of teacher resources



Enhanced teaching-support resources for every lesson, including:

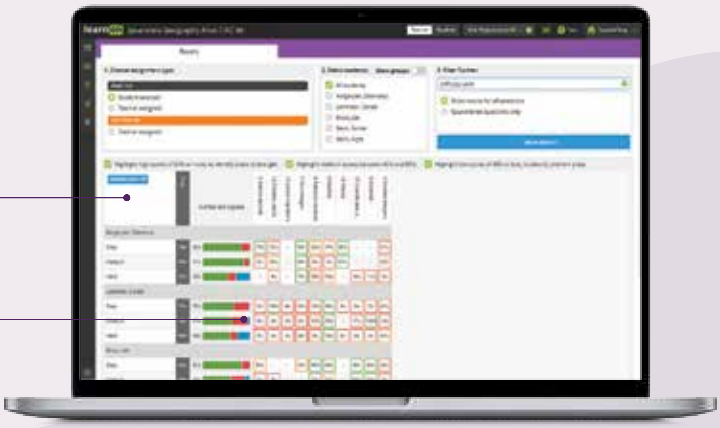
- work programs and curriculum grids
- practical teaching advice
- three levels of differentiated teaching programs
- quarantined topic tests (with solutions)

Customise and assign



An inbuilt testmaker enables you to create custom assignments and tests from the complete bank of thousands of questions for immediate, spaced and mixed practice.

Reports and results



Data analytics and instant reports provide data-driven insights into progress and performance within each lesson and across the entire course.

Show students (and their parents or carers) their own assessment data in fine detail. You can filter their results to identify areas of strength and weakness.

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Understanding cognitive verbs

Cognitive verbs in the Australian Curriculum

The Australian Curriculum aims to develop students' disciplinary knowledge, skills, understanding and general capabilities across the curriculum. Students are also expected to progressively develop their thinking skills.

In the Australian Curriculum, cognitive verbs are used as signposts for this depth of thinking. Cognitive verbs signify different types of thinking and are already used in the classroom by many teachers and students.

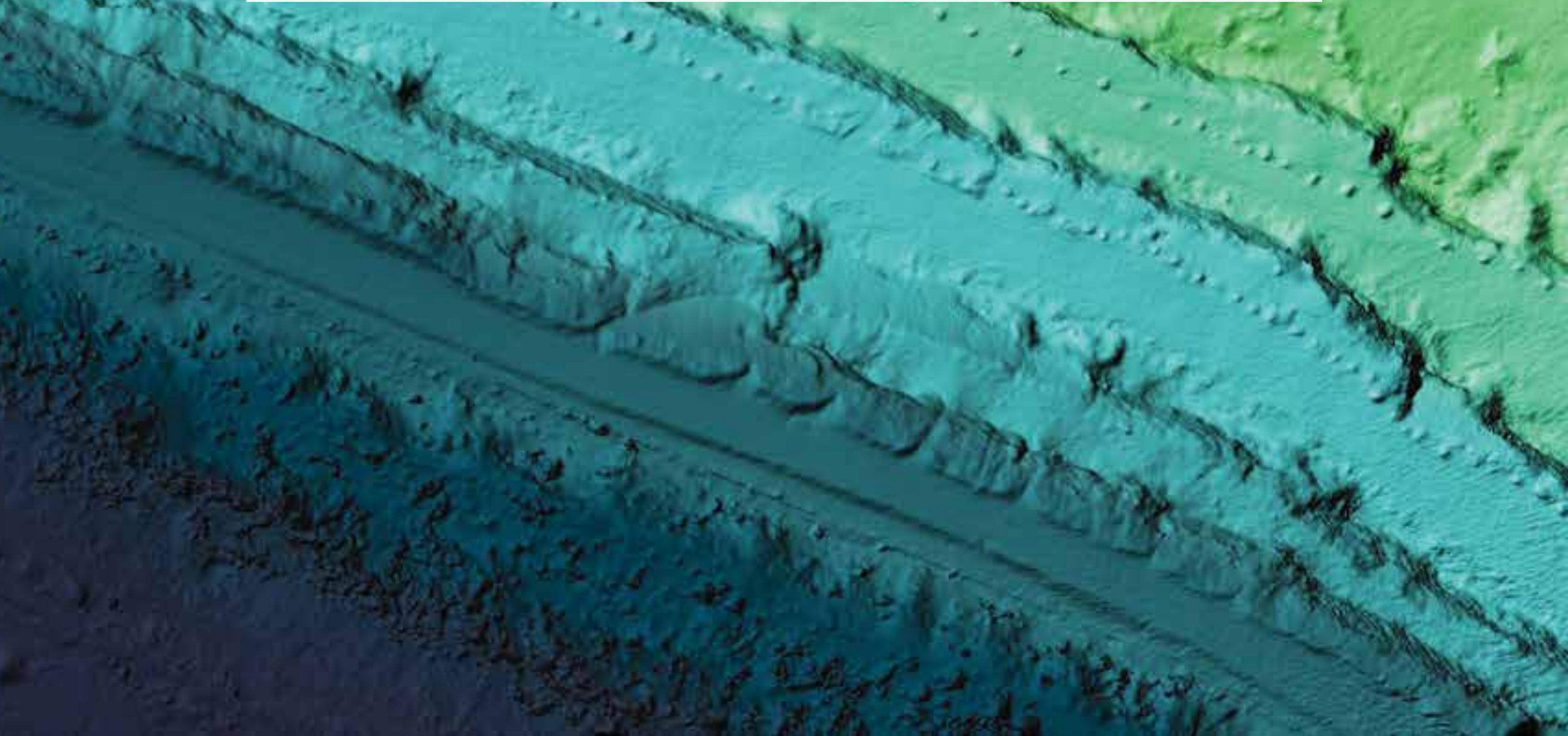
Questions within Jacaranda resources use these cognitive verbs to support students in cognitive verb 'thinking'. The following list describes the cognitive verbs that are frequently used in Years 7 and 8.

Cognitive verb	Description
analyse	considering something in detail, finding meaning or relationships and identifying patterns. In an analysis you may reorganise ideas and find similarities and differences.
apply	using knowledge and understanding in order to solve a problem or complete an activity. This may involve applying a familiar concept to an unfamiliar situation.
compare	recognising how things are similar and dissimilar. Concepts or items are generally grouped before a comparison is made.
decide	selecting from available options. This may involve considering criteria on which to base your selection.
describe	giving an account of a situation, event, pattern or process. A description may require a sequence or order.
develop	bringing something to a more advanced state. Processing and understanding are required in order to develop an idea or opinion.
evaluate	making a judgement using a set of criteria. This may include considering strengths and limitations of something in order to make a judgement on a preferred option.
examine	considering the information given and recognising key features. This sometimes requires making a decision.
explain	making an idea, concept or relationship between two things clear by giving in-depth information. Explanations may include details of who, what, when, where, why and how.
identify	recognising and showing a particular part or feature of something. This might also include showing what or who something or someone is.
interpret	gaining meaning from text, graphs, data or other visuals. An interpretation includes stating what something might mean.
select	choosing the most suitable option from a number of alternatives. This might require some consideration of context.

Source: Adapted from the QCAA Cognitive Verbs.

1 Geography concepts and skills

LESSON SEQUENCE



LESSON
1.1 Overview

Hey students! Bring these pages to life online

Watch videos | Engage with interactivities | Answer questions and check results

Find all this and MORE in jacPLUS

1.1.1 Introduction

When you study Geography, you are starting to build the knowledge and skills that will be needed by you and your community now and into the future. The concepts and skills that you will use will not only help you in Geography but they can also be applied to everyday situations, such as finding your way from one place to another. Studying Geography may even help you in a future career here in Australia or somewhere overseas.

Throughout your study of Geography you will cover topics that will give you a better understanding of the world around you — both the local and global environment. You will investigate issues that need to be addressed now and also options for the future.

FIGURE 1 Geography is the study of the world around you.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-10742)

Video eLesson Geography concepts and skills (eles-6108)

LESSON
1.2 Concepts in Geography

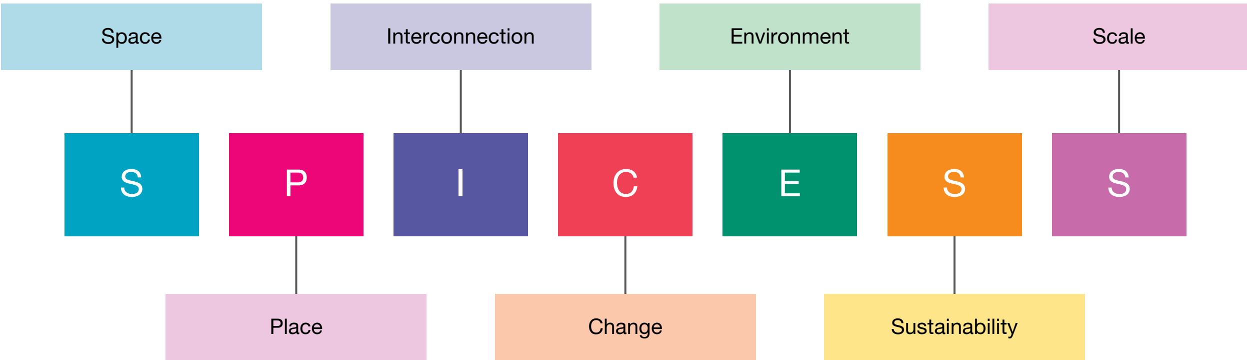
LEARNING INTENTION

By the end of this lesson you should be able to identify, explain and apply the seven Geography concepts using the acronym SPICESS.

1.2.1 Geographical concepts: SPICESS

Geographical concepts help you to make sense of your world. By using these concepts you can investigate and understand the world you live in, and try to imagine a different world. The concepts help you to think geographically. There are seven major concepts: *space, place, interconnection, change, environment, sustainability* and *scale*.

FIGURE 1 A way to remember these seven concepts is to think of the acronym SPICESS.



You will use the seven concepts to investigate two units: *Landscapes and landforms* and *Changing nations*.

1.2.2 What is space?

The concept of space is about where things are located and distributed on the surface of the Earth, and how the space is organised and managed by people.

When referring to Space in Geography we can have absolute or relative location. Absolute location is the unique location of a site or geographical feature. For example, the absolute location of Broken Hill is at 31.95° South latitude and 141.45° East longitude. Relative location is the location of a place or feature in relation to other places. It can be described by direction and distance from other places and features.

A place can be described by its absolute location (latitude and longitude) or its relative location (in what direction and how far it is from another place).

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.

- Developing Australian Curriculum concepts > **Space**

1.2.3 What is place?

The world is made up of places, so to understand our world we need to understand its places by studying their variety, how they influence our lives and how we create and change them.

Places may be natural (such as an undisturbed wetland) or highly modified (like a large urban conurbation).

Places provide us with the services and facilities we need in our everyday life. The physical and human characteristics of places, their location and their environmental quality can influence the quality of life and wellbeing of people living there.

FIGURE 2 The Paraisópolis favela (slum), home to 60 000 people, is situated next to the gated complexes of the wealthy Morumbi district of São Paulo in Brazil.

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.

- Developing Australian Curriculum concepts > **Place**

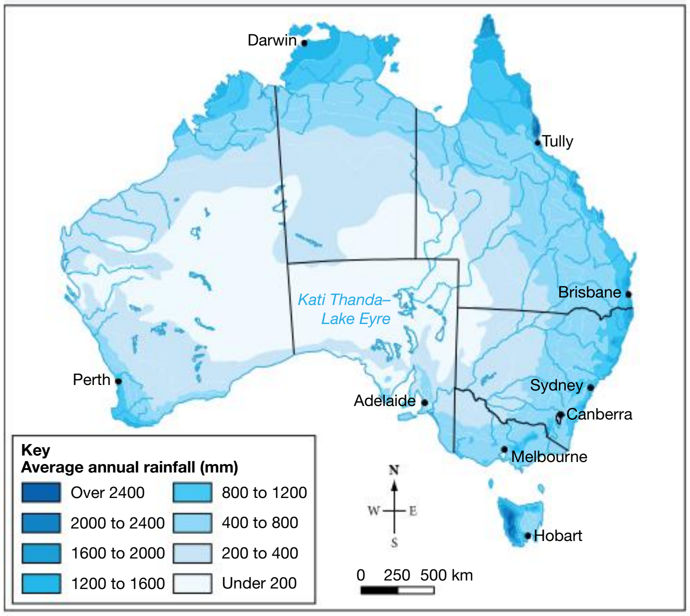
1.2.4 What is interconnection?

int-8993

People and things are connected to other people and things in their own and other places. Understanding these connections helps us to understand how and why places are changing.

An event in one location can lead to change in a place some distance away.

FIGURE 3 Distribution of annual rainfall in Australia



Source: MAPgraphics Pty Ltd, Brisbane

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- Developing Australian Curriculum concepts > **Interconnection**

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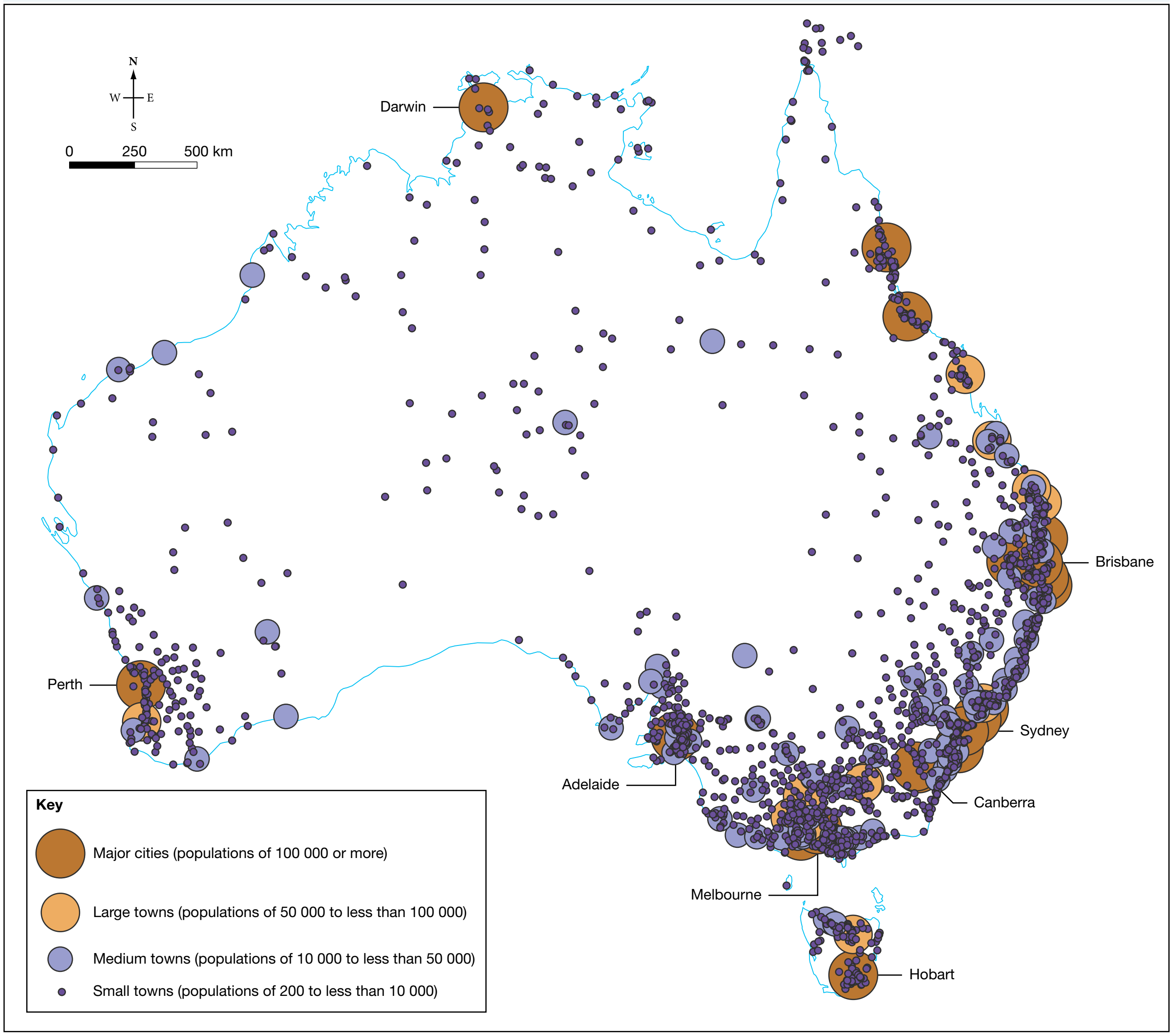
FIGURE 4 Australia's population distribution and density



Source: Australian Bureau of Statistics

1.2.5 What is change?

The concept of change is about using time to better understand a place, an environment, a spatial pattern or a geographical problem.

Some changes can be fast and easily observed, but others are very slow. For example, cities can expand outwards over a number of years. Similarly, landforms generally change very slowly, as with the formation of mountains. But some landscape change can be very fast, as is the case with landslides, volcanic eruptions and deforestation.

Explore more with myWorldAtlas

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- Developing Australian Curriculum concepts > **Change**

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FIGURE 5(a) Landscape before deforestation

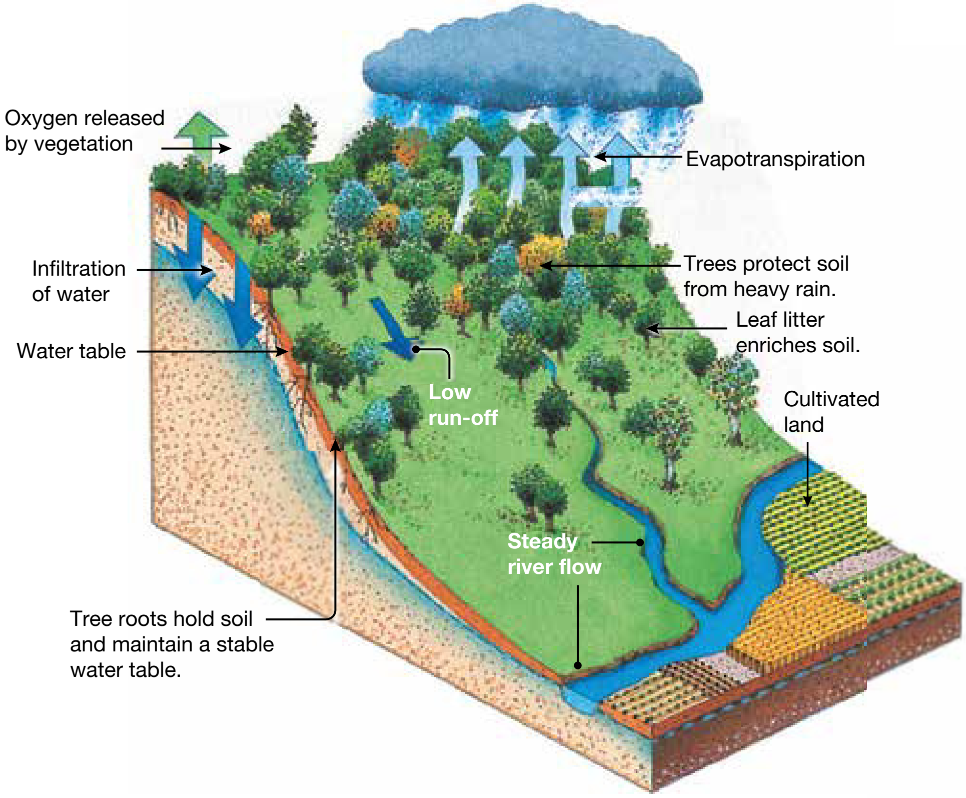
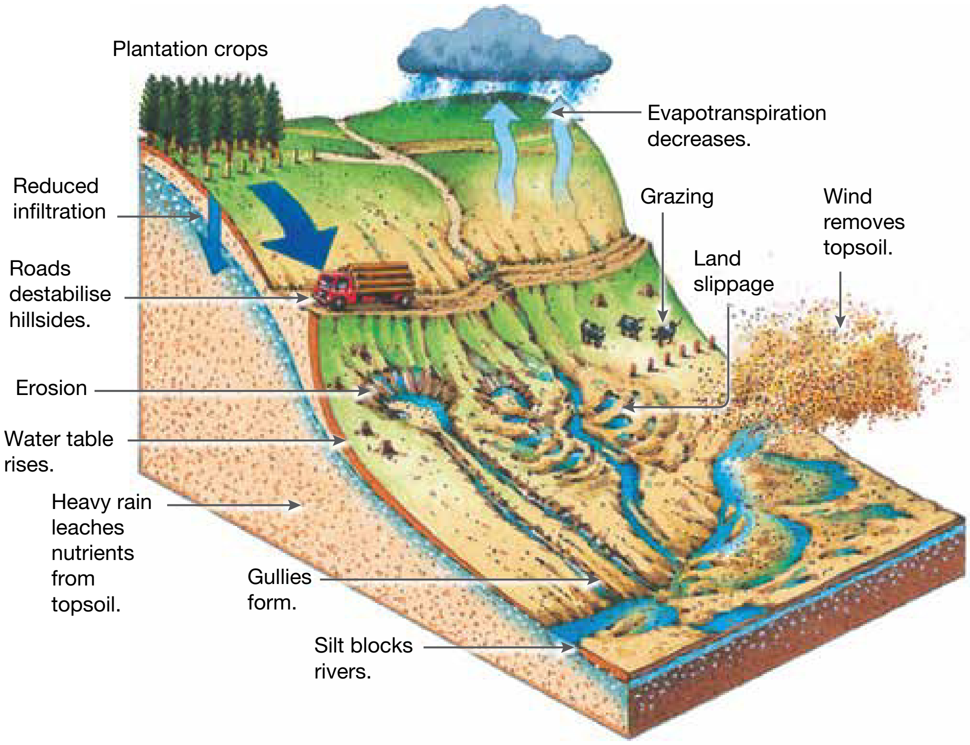
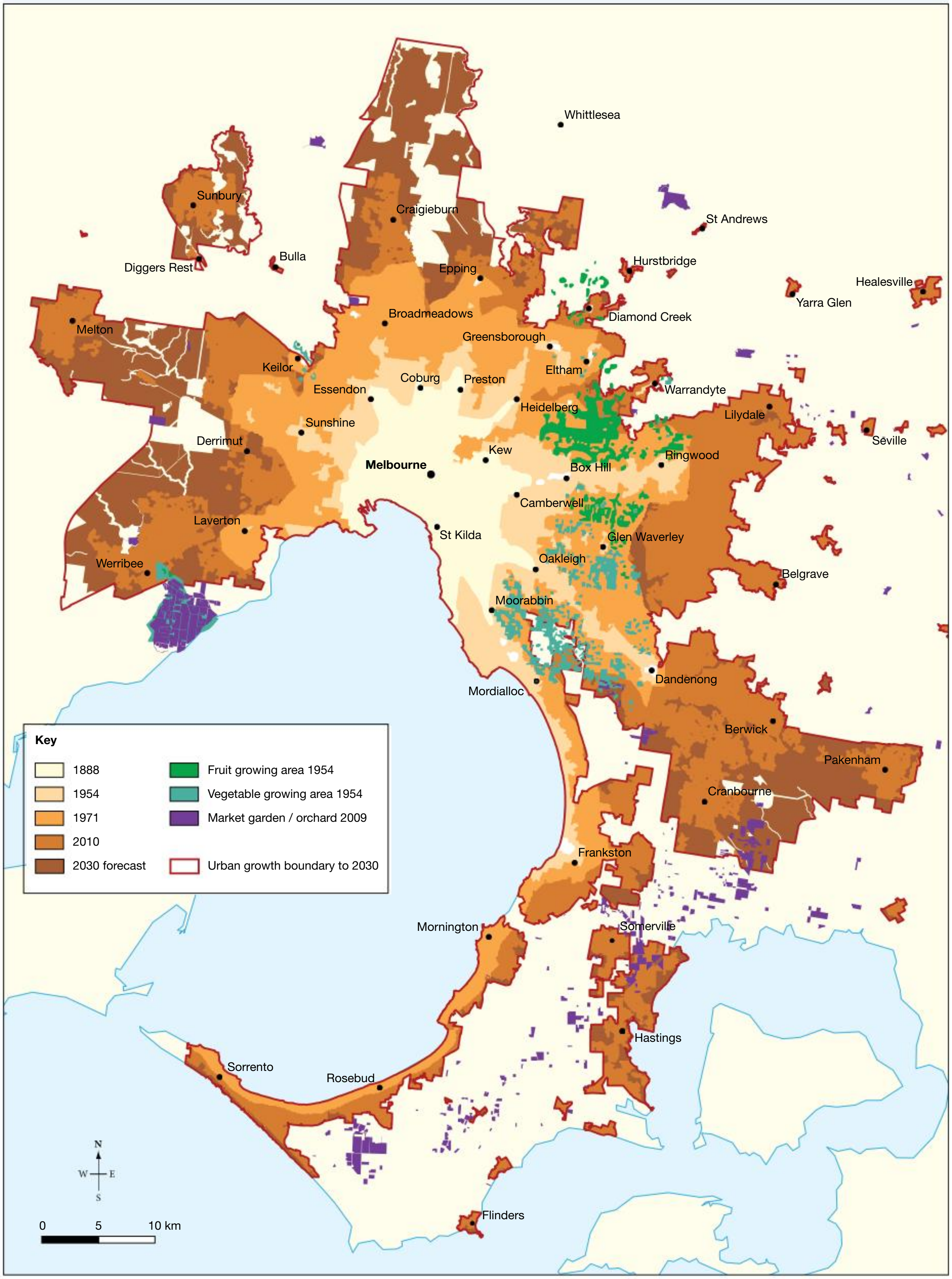


FIGURE 5(b) Landscape after deforestation



int-7827

FIGURE 6 Melbourne's urban sprawl



Source: Various Victorian planning studies and current land use mapping. Map produced by Spatial Vision 2019.

1.2.6 What is environment?

People live in and depend on the environment, so it has an important influence on our lives.

The environment, defined as the physical and biological world around us, supports and enriches human and other life by providing raw materials and food, absorbing and recycling wastes, and being a source of enjoyment and inspiration to people.

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.

- Developing Australian Curriculum concepts > **Environment**

1.2.7 What is sustainability?

Sustainability is about maintaining the capacity of the environment to support our lives and those of other living creatures.

Sustainability is about the interconnection between the human and natural world and who gets which resources and where, in relation to conservation of these resources and prevention of environmental damage.

FIGURE 7 Uranium mining in Colorado, United States. Many deserts contain valuable mineral deposits.

FIGURE 8 The Vatican is the world's smallest independent state. In 2008, more than 2000 photovoltaic panels were fixed to the roof of one of the city state's main buildings — the roof of the Paul VI Hall — enabling the Vatican to cut its carbon dioxide emissions by about 225 tonnes per year. The 2400 panels heat, light and cool the hall and several surrounding buildings, producing 300 kilowatt hours (MWh) of clean energy per year.

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.

- Developing Australian Curriculum concepts > **Sustainability**

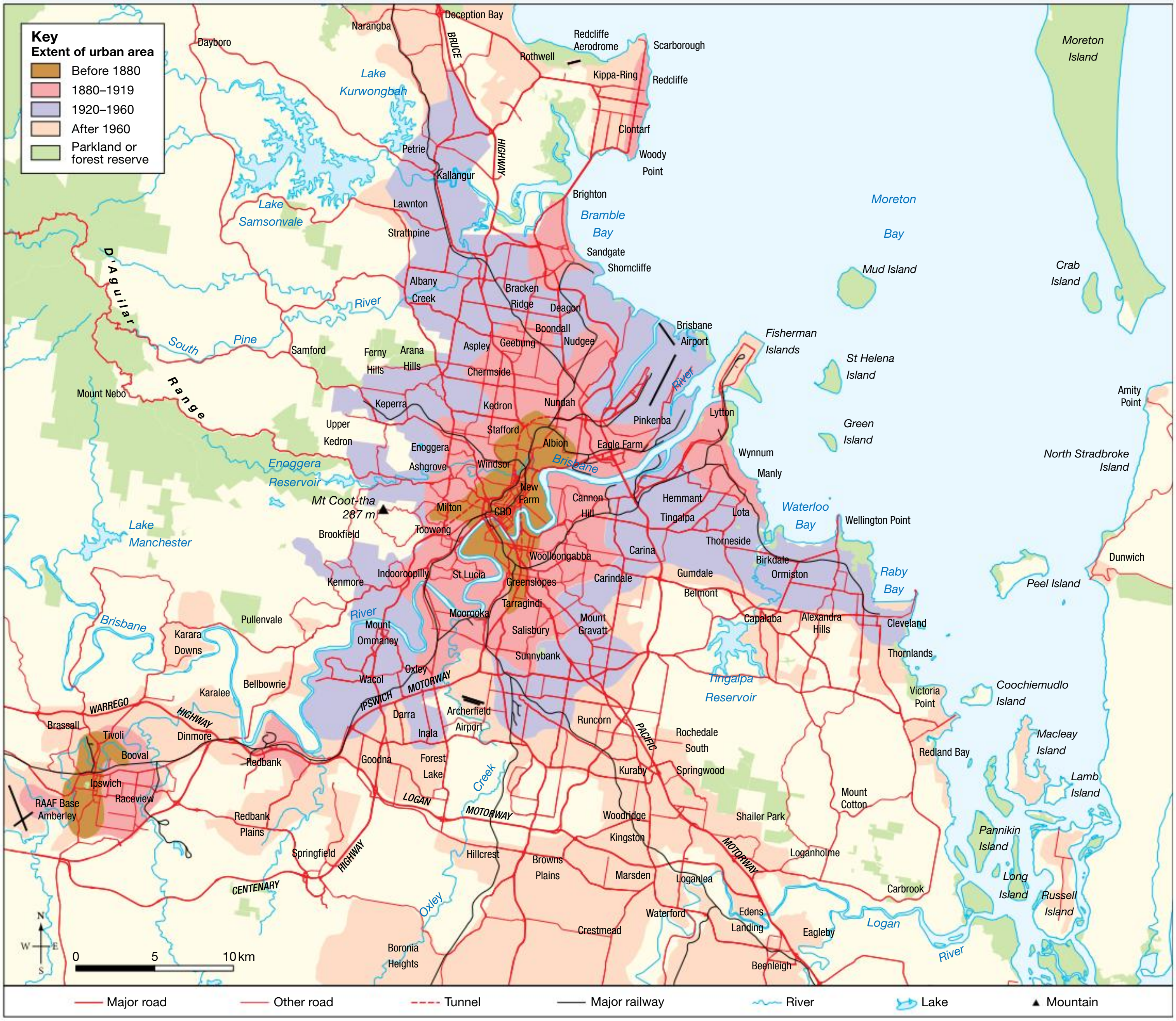
1.2.8 What is scale?

When we examine geographical questions at different spatial levels we are using the concept of scale to find more complete answers.

Scale can be from personal and local to regional, national or global. Looking at things on a range of scales provides a deeper understanding of geographical issues.

int-8994

FIGURE 9 Brisbane, Queensland. Building sustainable communities means we have to work at various scales.



Source: MAPgraphics / ABS — Urban Centre and Locality (UCL) ASGS Edition 2011 Digital Boundaries data / OpenStreetMap (Roads)

Ways to improve sustainability at the local scale include:

- reducing the ecological footprint
- protecting the natural environment
- increasing community wellbeing and pride in the local area
- changing behaviour patterns by providing better local options
- encouraging compact or dense living
- providing easy access to work, play and schools.

Ways to improve sustainability at the city scale include:

- building strong central activities areas (either one major hub or a number of specified activity areas)
- reducing traffic congestion
- protecting natural systems
- avoiding suburban sprawl and reducing inefficient land use
- distributing infrastructure and transport networks equally and efficiently to provide accessible, cheap transportation options
- promoting inclusive planning and urban design
- providing better access to healthy lifestyles (e.g. cycle and walking paths)
- improving air quality and waste management
- using stormwater more efficiently
- increasing access to parks and green spaces
- reducing car dependency and increasing walkability
- promoting green space and recreational areas
- demonstrating a high mix of uses (e.g. commercial, residential and recreational).

FIGURE 10 Street art in a Brisbane suburb

FIGURE 11 A glimpse of the CBD from the Brisbane Botanical gardens

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.

- Developing Australian Curriculum concepts > **Scale**

LESSON
1.3 Skills used in Geography

LEARNING INTENTION

By the end of this lesson you should be able to write a definition of Geography, explain what geographers do, and identify the different skills used in Geography.

1.3.1 Skills for work

Many questions come up during a typical Geography class, such as those in **TABLE 1**. These questions need to be answered in the real world by people in a wide variety of occupations. They all have links with Geography.

TABLE 1 Examples of occupations that use Geography

Question	Occupations/organisations that try to answer these questions
How high is Mount Everest? How do we know?	Surveyor, cartographer
How can we protect our parks and wildlife?	Park ranger, planner, environmental manager
Where should we establish a new suburb for our future population?	Urban planner, demographer
How can we prepare for future droughts and floods?	Civil engineer
Does our town really have enough water? Should we build a new dam? Where should we build a new dam?	Coastal engineer, hydrologist, cartographer
Should a boat marina be built at location X or at location Y?	Oceanographer
Do we have good quality drinking water?	Chemist, hydrologist
How do countries such as India and China deal with their air pollution problems?	Environmental scientist/manager
How do we provide aid to other countries?	Air Force, Navy, army officer; Red Cross, World Vision and other aid agencies
How do we build sustainable housing?	Architect, landscape architect, civil engineer/ construction manager, town planner, real estate salesperson

Do you know much about the occupations mentioned in **TABLE 1**? Are any of interest to you? The first step in thinking about your future is to consider questions such as:

- Who am I?
- What are my interests?
- What do I enjoy doing?
- What am I good at?
- What would I like to do when I leave school?

Geography careers on the move

A great part of studying Geography is being able to explore the many occupations and areas that it opens up. **TABLE 2** lists some occupations that you might not have thought studying Geography could lead you into.

TABLE 2 Would I enjoy

... working Indoors?	... working outdoors?	... helping people?
 • Land economist • Landscape designer • Real estate salesperson • Geoscience technician • Travel consultant	 • Surveyor • Mining engineer • Geologist • Landscape architect • Cartographer	 • Park ranger • Paramedic • Navy officer • Firefighter • Tour guide
... designing new places to live?	**... improving people's wellbeing?**	**... doing research?**
 • Urban planner • Architect • Landscape architect • Horticulturist	 • Natural resource manager • Demographer	 • Meteorologist • Anthropologist • Geophysicist • Hydrographer • Environmental scientist

1.3.2 Skills used in studying Geography

In addition to the concepts you study in Geography (SPICESS) there is a range of essential practical skills that you will learn, practise and master as you study Geography. These can be categorised into the four core Geography skills:

Questioning and researching using geographical methods

Investigating using geographical methods involves applying geographical concepts to develop questions and using primary research or fieldwork to gain a greater understanding of a concept or issue. This year your fieldwork should involve gathering information from both primary sources (e.g. information you observe and record) and a range of secondary sources (e.g. information obtained from maps, atlases and textbooks), evaluating them for relevance, reliability and bias. In Geography we look at information from a range of perspectives, and use ethical protocols assess reliability and worth. You will be examining the processes that shape our world and the ways in which environmental and human processes determine the world around us.

Interpreting and analysing geographical data and information

In Geography this year you will interpret data using both quantitative methods (measurable information) and qualitive methods (observations and descriptions) to find similarities, patterns and differences in sources studied. You will also be expected to predict trends and discuss relationships by identifying the key aspects of data presented to you in a variety of forms (e.g. a range of different types of maps, tables, graphs and charts). In Year 8 Geography this may involve analysing information on population changes and levels of urbanisation across the globe. You will also need to interpret maps and make spatial associations between geomorphological hazards and the underlying make-up of the lithosphere.

The SkillBuilders related to this skill that you will use at Year 8 level are:

- Recognising land features
- Reading contour lines on a map
- Using latitude and longitude
- Calculating distance using scale
- Drawing simple cross-sections
- Interpreting an aerial photo
- Understanding thematic maps
- Comparing population profiles
- Reading and describing basic choropleth maps
- Drawing a line graph using Excel
- Drawing a precis map
- Creating and reading pictographs
- Constructing a basic sketch map
- Creating and reading compound bar graphs.

Concluding and decision-making

In Geography you will learn to justify conclusions and propose strategies by analysing data, information and perspectives from a variety of sources. By considering environmental, economic and social factors you will make assessments about the interconnectedness of issues relating to population, urban environments and the geomorphological processes that shape our world. You will be expected to make conclusions about how best to manage the growth of urban settlements and the sustainability of resources from both a human and more holistic environmental perspective.

The SkillBuilders related to this skill that you will use at Year 8 level are:

- Comparing population profiles
- Creating and describing complex overlay maps
- Creating and reading compound bar graphs.

Communicating

Communicating your ideas and justifying your conclusions are key skills you will develop in Geography. Using geographical concepts and knowledge and a range of digital and non-digital formats you will seek to express your thoughts and ideas on a wide range of concepts and issues. When communicating in Geography you need to ensure that you consider your audience, you acknowledge your sources and you choose appropriate methods of communication to ensure your message is clear and well presented. In Year 8 you will be expected to explore new ways of presenting information and further develop skills acquired in earlier years.

The SkillBuilders related to this skill that you will use at Year 8 level are:

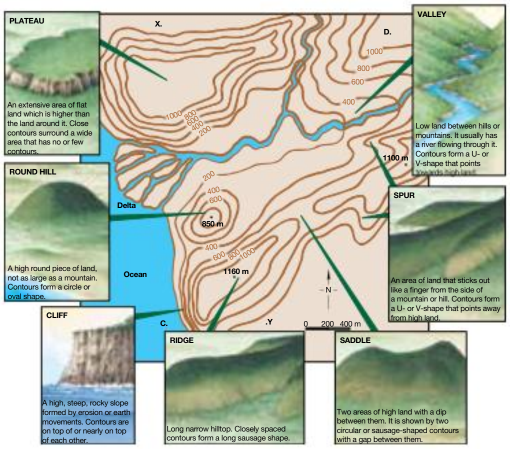
- Interpreting an aerial photo
- Using positional language
- Constructing a field sketch
- Drawing a precis map
- Describing photographs
- Constructing a basic sketch map.

LESSON
1.4 SkillBuilder: Recognising land features

online only

What are land features?

Land features are landforms with distinct shapes, such as hills, valleys and mountains. You recognise these as you look around your natural environment. On topographic maps you recognise land features from the patterns formed by the contour lines.



Go online to access:
- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

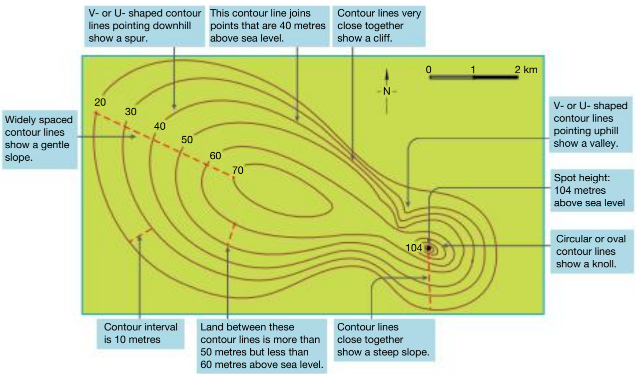
Digital doc Topographic map of Yarra Yarra Creek Basin (doc-31343)
Video eLesson SkillBuilder: How to recognise land features (eles-1648)
Interactivity SkillBuilder: Recognising land features (int-3144)

LESSON
1.5 SkillBuilder: Reading contour lines on a map

online only

What are contour lines?

Contour lines drawn on a map join all places of the same elevation (height). These lines are usually brown and have a number written on them to indicate height above sea level. Contour maps are used to show the relief (shape) of the land and the heights of the landscape.



Go online to access:
- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

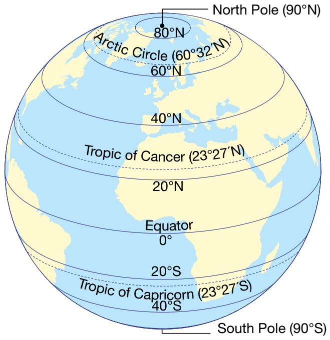
Video eLesson SkillBuilder: Reading contour lines on a map (eles-1651)
Interactivity SkillBuilder: Reading contour lines on a map (int-3147)

LESSON
1.6 SkillBuilder: Using latitude and longitude

online only

What are latitude and longitude?

Latitude and longitude are imaginary grid lines encircling the Earth. They can be drawn over a map to help us locate a place. The lines that run parallel to the equator are called parallels of latitude. Lines of longitude run from north to south from the North Pole to the South Pole.



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- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

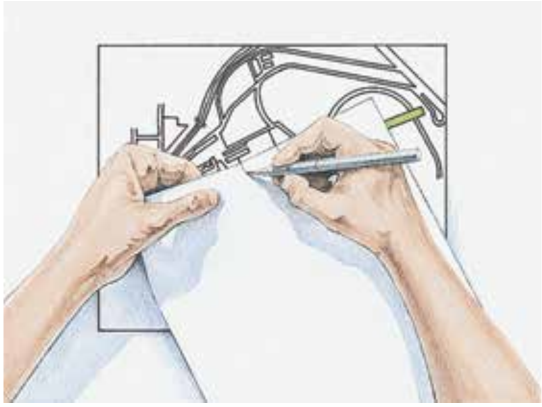
Video eLesson SkillBuilder: Using latitude and longitude (eles-1652)
Interactivity SkillBuilder: Using latitude and longitude (int-3148)

LESSON
1.7 SkillBuilder: Calculating distance using scale

online only

What does it mean to calculate distance using scale?

Calculating distance using scale involves working out the actual distance from one place to another using a map. The scale on a map allows you to convert distance on a map or photograph to distance in the real world — what it represents on Earth's surface. A linear scale is the easiest to use, but sometimes the distance being measured between places is not straight.



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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

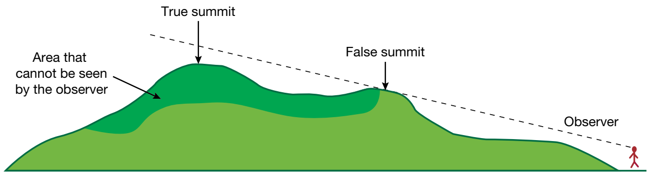
Video eLesson SkillBuilder: Calculating distance using scale (eles-1653)
Interactivity SkillBuilder: Calculating distance using scale (int-3149)

LESSON
1.8 SkillBuilder: Drawing simple cross-sections

online only

What are cross-sections?

A cross-section is a side-on, or cut-away, view of the land as if it had been sliced through by a knife. It is like taking a vertical slice of the landscape and looking at it side-on. Cross-sections provide us with an idea of the shape of the land. We can use contour lines on topographic maps to draw a cross-section between any two points. Cross-sections also indicate heights at a range of points.



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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

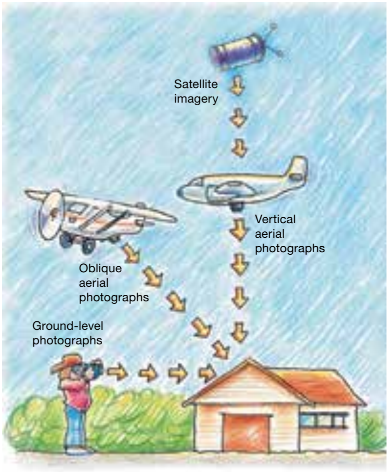
Video eLesson SkillBuilder: Drawing simple cross-sections (eles-1655)
Interactivity SkillBuilder: Drawing simple cross-sections (int-3151)

LESSON
1.9 SkillBuilder: Interpreting an aerial photo

online only

What are aerial photos?

Aerial photographs are those that are taken from above the Earth from an aircraft. Aerial photos, either oblique or vertical, record how a place looks at a particular moment in time. Greater detail of a place can be captured than in a photo taken from ground level. Some aerial photos are also satellite compilations; that is, created by a number of images transmitted from the satellite.



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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Interpreting an aerial photo (eles-1654)
Interactivity SkillBuilder: Interpreting an aerial photo (int-3150)

LESSON
1.10 SkillBuilder: Understanding thematic maps

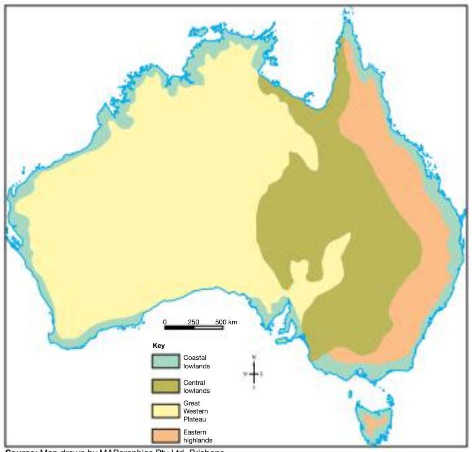
online only

What is a thematic map?

A thematic map is a map drawn to show one aspect; that is, one theme. For example, a map may show the location of vegetation types, hazards or weather. Parts of the theme are given different colours or, if only one idea is conveyed, symbols may show location.

Go online to access:

- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

on Resources

Video eLesson SkillBuilder: Understanding thematic maps (eles-1658)

Interactivity SkillBuilder: Understanding thematic maps (int-3154)

LESSON
1.11 SkillBuilder: Comparing population pyramids

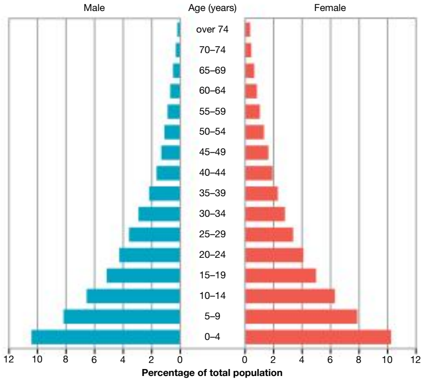
online only

What is a population pyramid?

A population pyramid is a bar graph that provides information about the age and gender of a population. The bars identify the proportion of a country's population within a particular age group. The graph is split to show information about males and females. The shape of the population pyramid tells us about a particular population.

Go online to access:

- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).



on Resources

Video eLesson SkillBuilder: Comparing population profiles (eles-1704)

Interactivity SkillBuilder: Comparing population profiles (int-3284)

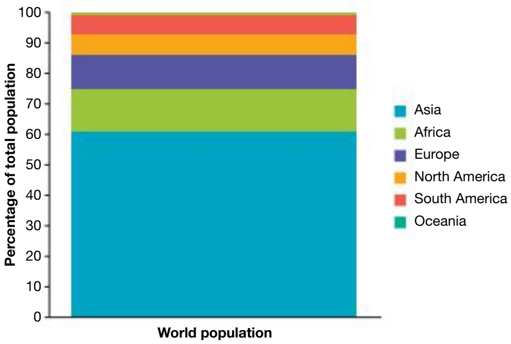
Weblink Population pyramid

LESSON
1.12 SkillBuilder: Creating and reading compound bar graphs

online only

What are compound bar graphs?

A compound bar graph is a bar or series of bars divided into sections to provide detail of a total figure. These bars can be drawn vertically or horizontally. The height or length of each section represents a percentage, with the total length of the bar representing 100 per cent.



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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Creating and reading compound bar graphs (eles-1705)

Interactivity SkillBuilder: Creating and reading compound bar graphs (int-3285)

LESSON
1.13 SkillBuilder: Reading and describing basic choropleth maps

online only

What is a basic choropleth map?

A basic choropleth map is a shaded or coloured map that shows the density or concentration of a particular aspect of an area. The key/legend shows the value of each shading or colouring. The darkest colours show the highest concentration, and the lightest colours show the lowest concentration.

Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

Go online to access:

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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Reading and describing basic choropleth maps (eles-1706)

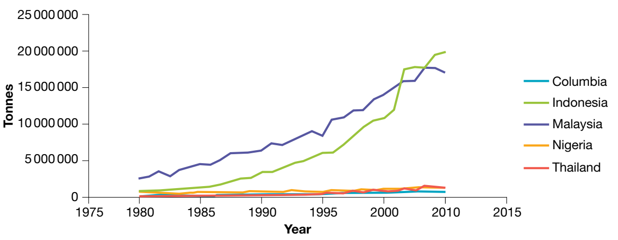
Interactivity SkillBuilder: Reading and describing basic choropleth maps (int-3286)

LESSON
1.14 SkillBuilder: Drawing a line graph using Excel

online only

What is a line graph?

A line graph is a clear method of displaying information so it can be easily understood. Using a digital means of drawing a line graph enables you to show multiple data sets clearly.



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- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Drawing a line graph using Excel (eles-1662)

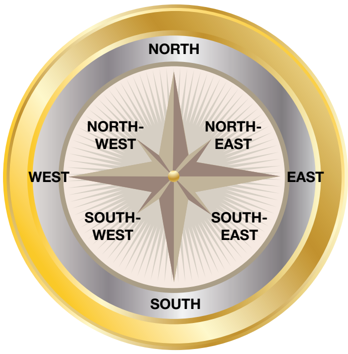
Interactivity SkillBuilder: Drawing a line graph using Excel (int-3158)

LESSON
1.15 SkillBuilder: Using positional language

online only

What is positional language?

Positional language uses compass points to locate places and provide directions between places. North, north-east, east, south-east, south, south-west, west, and north-west are shown on an 8-point compass. We can use positional language to describe the location of one feature in relation to another.



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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Using positional language (eles-1649)

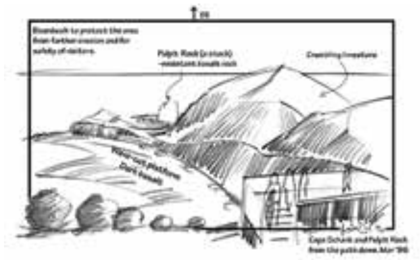
Interactivity SkillBuilder: Using positional language (int-3145)

LESSON
1.16 SkillBuilder: Constructing a field sketch

online only

What are field sketches?

Field sketches are drawings completed during fieldwork — geography outside the classroom. Field sketches allow a geographer to capture the main aspects of landscapes in order to edit the view, focusing on the important features and omitting the unnecessary information.



Go online to access:

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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Completing a field sketch (eles-1650)

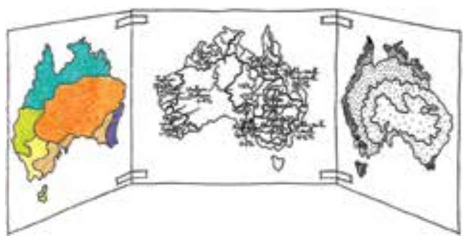
Interactivity SkillBuilder: Constructing a field sketch (int-3146)

LESSON
1.17 SkillBuilder: Creating and describing complex overlay maps

online only

What is a complex overlay map?

A complex overlay map is created when one or more maps of the same area are laid over one another to show similarities and differences between the mapped information. Traditionally, the second map is on tracing paper that is attached to the original page. Complex overlay maps show relationships between factors — the similarities and the differences in a pattern.



Go online to access:

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- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Creating and describing complex overlay maps (eles-1656)

Interactivity SkillBuilder: Creating and describing complex overlay maps (int-3152)

LESSON
1.18 SkillBuilder: Drawing a précis map

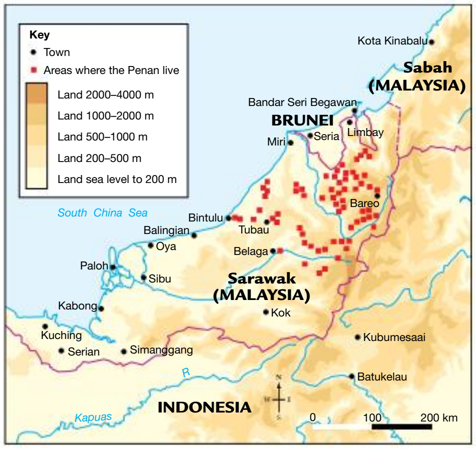
online only

What is a précis map?

A précis map is a simplified map — the cartographer has decided which details to leave in and which to leave out. It is different from a sketch map, which includes all the main features.

Go online to access:

- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).



Resources

Video eLesson SkillBuilder: Drawing a précis map (eles-1657)

Interactivity SkillBuilder: Drawing a précis map (int-3153)

LESSON
1.19 SkillBuilder: Creating and reading pictographs

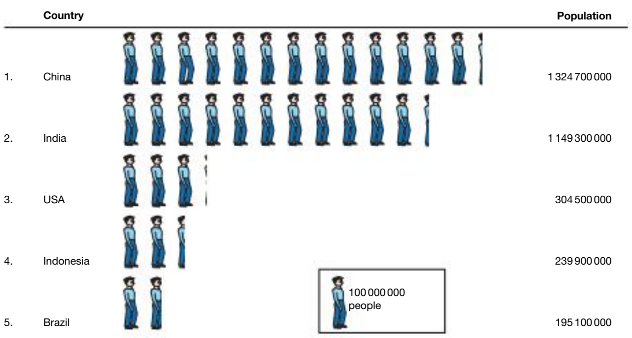
online only

What is a pictograph?

A pictograph is a graph drawn using pictures to represent numbers, instead of bars or dots that are traditionally used on graphs. A pictograph is a simple way of representing data and conveying information quickly and efficiently in a different format.

Go online to access:

- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).



Resources

Video eLesson SkillBuilder: Creating and reading pictographs (eles-1659)

Interactivity SkillBuilder: Creating and reading pictographs (int-3155)

LESSON
1.20 SkillBuilder: Describing photographs

online only

What is meant by 'describing photographs'?

A description is a brief comment (up to a paragraph) on a photograph, identifying and communicating features from a geographic point of view. As geographers, we use our understanding of the world to interpret the image and tell others about the main features or information the photograph reveals.

Go online to access:
- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

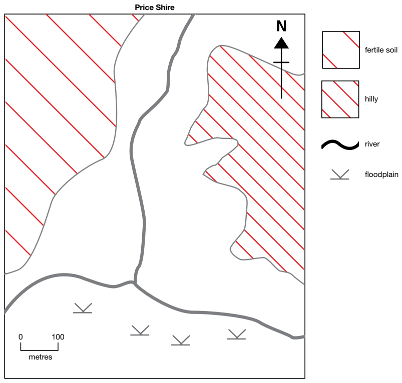
Video eLesson SkillBuilder: Describing photographs (eles-1660)
Interactivity SkillBuilder: Describing photographs (int-3156)

LESSON
1.21 SkillBuilder: Constructing a basic sketch map

online only

What is a basic sketch map?

A basic sketch map is a map drawn from an aerial photograph or developed during field work that identifies the main features of an area. Basic sketch maps are used to show the key elements of an area, so other more detailed characteristics are not shown.



Go online to access:
- an overview of the skill and its application in Geography (Tell me)
- a video and a step-by-step process to explain the skill (Show me)
- an activity and interactivity for you to practise the skill (Let me do it).

on Resources

Video eLesson SkillBuilder: Constructing a basic sketch map (eles-1661)
Interactivity SkillBuilder: Constructing a basic sketch map (int-3157)

LESSON
1.22 Review

Hey students! Now that it's time to revise this topic, go online to:

Review your results | **Watch teacher-led videos** | **Practise questions with immediate feedback**

Find all this and MORE in jacPLUS

1.22.1 Key knowledge summary

1.2 Concepts in Geography

- The acronym SPICESS helps you remember the seven geographical concepts:
  - Space
  - Place
  - Interconnection
  - Change
  - Environment
  - Sustainability
  - Scale.

1.3 Skills used in Geography

- Many occupations are linked to the study of Geography.
- New jobs are developing in the spatial sciences that use geographical tools such as GPS, GIS, satellite imaging and surveying.
- You will learn, practise and master a range of essential practical skills, including:
  - questioning and researching using geographical methods
  - interpreting and analysing geographical data and information
  - concluding and decision-making
  - communicating.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-10742)
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LESSON
1.4 SkillBuilder: Recognising land features

LEARNING INTENTION

By the end of this lesson you will be able to recognise and describe the major land features on a topographic map.

1.4.1 Tell me

What are land features?

Land features are landforms with distinct shapes, such as hills, valleys and mountains. You recognise these as you look around your natural environment. On topographic maps you recognise land features from the patterns formed by the contour lines.

Why is it useful to recognise land features?
By recognising land features, we understand our natural environment. This is useful for a wide range of activities including:
- planning housing estates, freeway routes and reservoirs
- organising outdoor recreational pursuits such as orienteering, trail-biking and flying
- managing hazards such as flooding.

Recognising land features on a map involves identifying the shapes created by the pattern of contours.

1.4.2 Show me

How to recognise a land feature

By reading the contour lines on a map, an understanding of the shape of the land is obtained. Land features are identified from the contour lines.

You will need:

- a topographic map.

Procedure

Use the contour lines to identify land features.

Step 1

Look at the contour lines on **FIGURE 1**. You will see that sometimes the lines are close together and sometimes the lines are further apart. Identify two areas where this is the case.

Step 2

Using your hand, create the shape of a hill. For every 50 metres increase of the hill slope, move your hand higher and at each step visualise that this is the next contour line on a map.

Try this for some other landforms that you are familiar with, such as a valley or a beach cliff.

Did you recognise that if the contours are close together then the shape of the land is steep, and if the contours are further apart then the land is flatter?

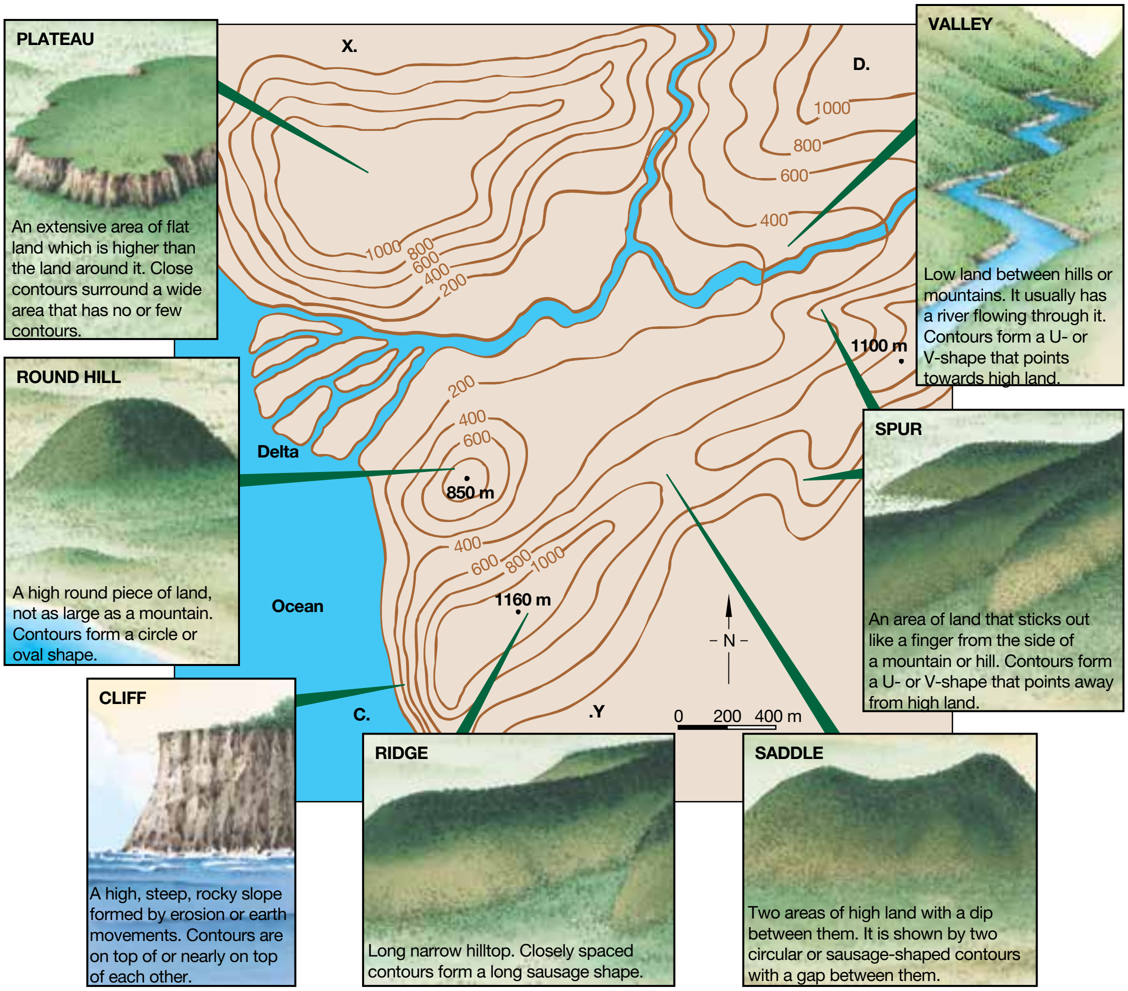
Step 3

Landforms have distinctive shapes with contours, which a geographer recognises on a topographic map as a particular land feature. Use **FIGURE 1** as a guide to understanding the shapes on maps as land features. Create your own hand models of the shape of each land features.

Model

FIGURE 1 shows a simple topographic map including a spur, cliff, valley and plateau. These land features are identified by the way the contour lines come together to create shapes on the map.

FIGURE 1 Landforms matched to a topographic map



on Resources

- **Digital document** Topographic map of Yarra Yarra Creek Basin (doc-31343)
- **Video eLesson** SkillBuilder: How to recognise land features (eles-1648)
- **Interactivity** SkillBuilder: Recognising land features (int-3144)

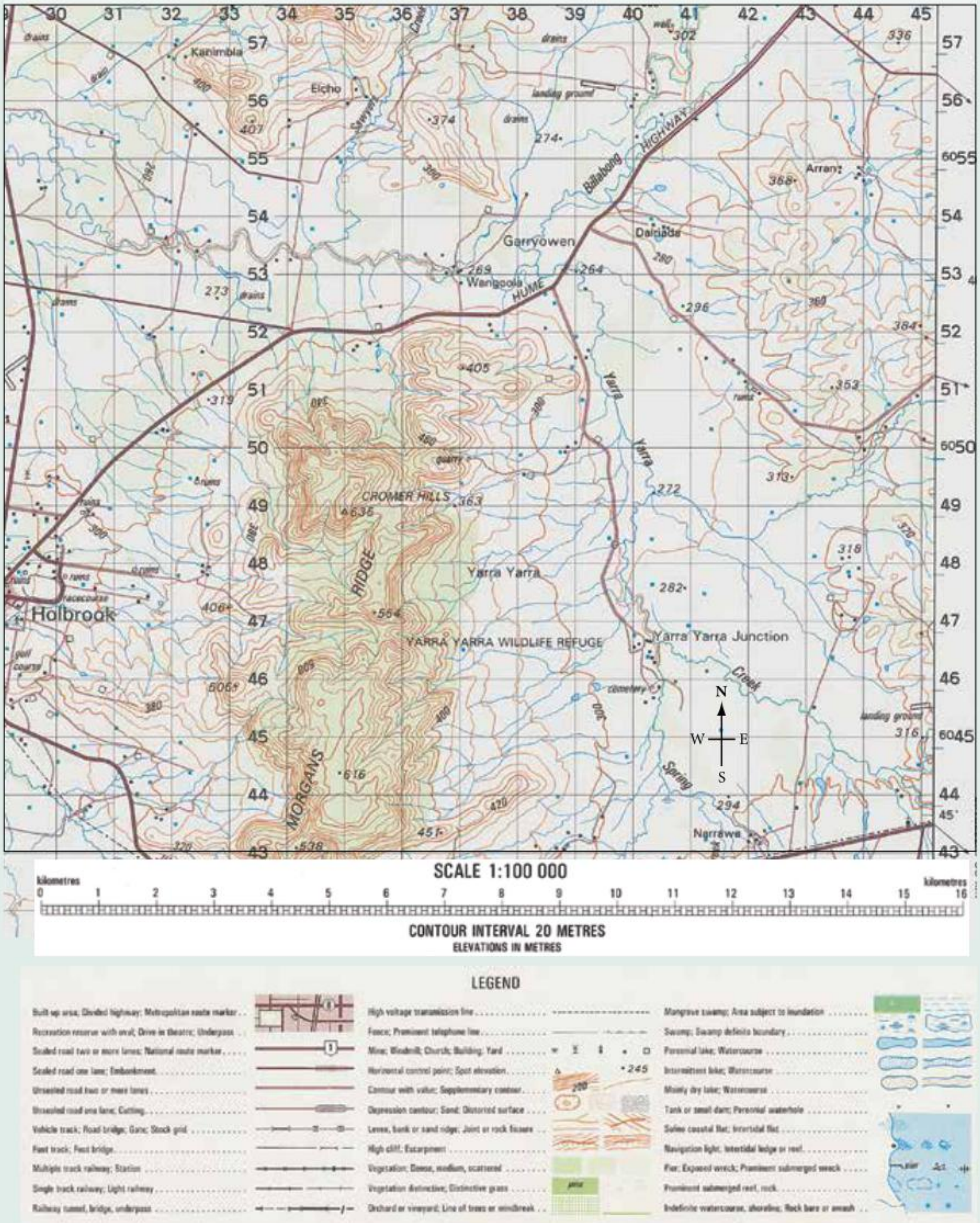
1.4.3 Let me do it

Complete the following activities to practise this skill.

1.4 ACTIVITIES

1. Use **FIGURE 2**, the map of Yarra Yarra Creek Basin, New South Wales, to identify the following landforms.

FIGURE 2 Topographic map of Yarra Yarra Creek Basin



Source: Spatial Vision

- Ridge
- Wide valley
- Very steep slope
- Spot height of 635 metres
- Spur
- Plateau
- Saddle

HASS skills: Analysing

2. Apply your skills to answer the following questions.
   a. Which slope of Morgans Ridge would be the most difficult to climb?
   b. What two natural features can be seen from Morgans Ridge to the east?
   c. What are the heights of the peaks on Morgans Ridge?
   d. Can you see the town of Holbrook from Wangoola? Explain your answer.
   e. What land features form part of Morgans Ridge?

HASS skills: Analysing

Checklist

I have:
- identified patterns in contour lines
- recognised the major land features on a topographic map.

LESSON
1.5 SkillBuilder: Reading contour lines on a map

LEARNING INTENTION

By the end of this lesson you will be able to explain what contour lines are and why they are useful. You will also be able to read contour lines on a topographic map.

1.5.1 Tell me

What are contour lines?

Contour lines drawn on a map join all places of the same elevation (height). These lines are usually brown and have a number written on them to indicate height above sea level. Contour maps are used to show the relief (shape) of the land and the heights of the landscape. Land heights are identified from aerial photography. Natural features, such as rivers, lakes and beaches, and human features, such as towns, roads and power lines, are added to the map to complete the landscape picture. Symbols provided in a legend (or key) or labels on the map add information to complete the image of the environment.

Why are contour lines useful?

It is not possible to see an entire area when in the environment, so maps with contour lines show the relief of the land and help people to identify features. They are also useful because they tell us the actual height above sea level of particular locations on a map. Contour lines are used by many people, and for various purposes, such as:

- organising a hike
- land-use planning of roads, airports, train lines and power-line routes
- identifying slopes for building sites
- planning decisions
- leisure activities; for example, working out where the best rapids on a river might be or where to launch or land a hang-glider.

Reading contour lines on a map involves:

- identifying a contour line
- finding its number (metres above sea level)
- determining the contour interval
- checking spot heights.

1.5.2 Show me

How to read contour lines

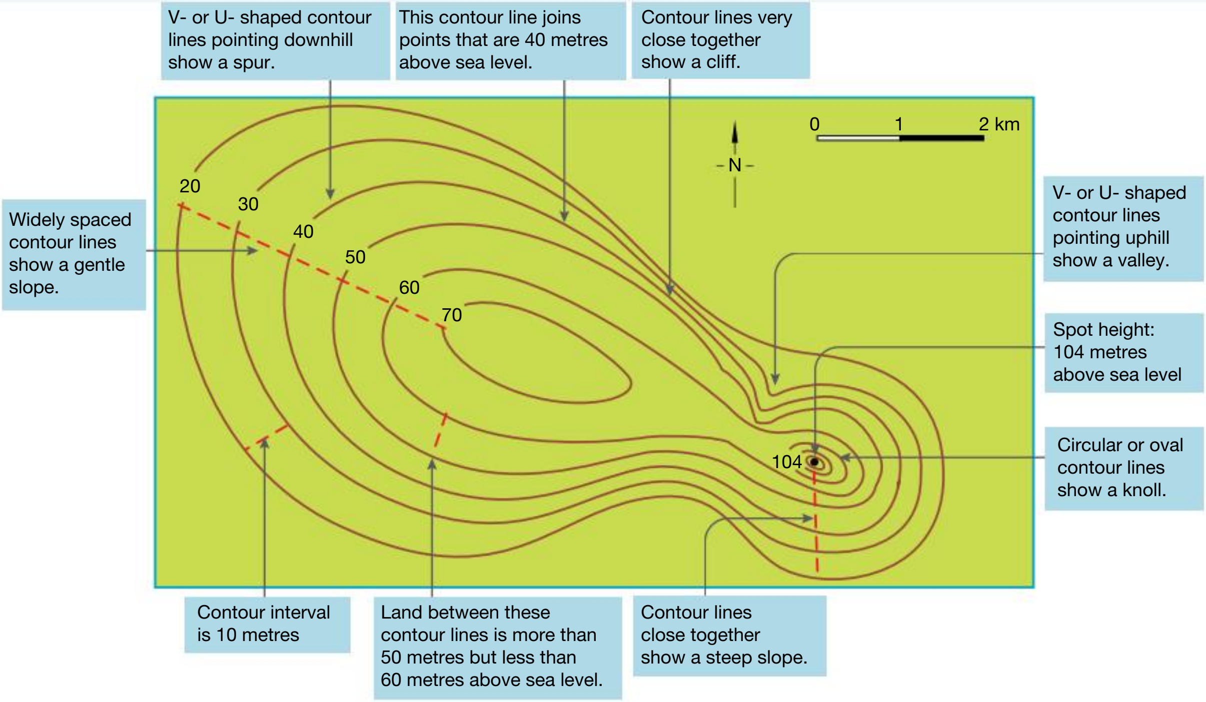
You will need:

- a contour (topographic) map.

Model

The contour lines (brown lines) on the simple topographic map shown in **FIGURE 1** join places of the same height above sea level. The contour lines are drawn at 10-metre intervals. The highest point is identified by a spot height of 104 metres. Landscape features such as steep or gentle slopes, cliffs, valleys, spurs and knolls can be identified using the contour lines on the map.

FIGURE 1 How contour lines show the shape of the land



Procedure

Step 1

To find the height of a particular area of land, identify a contour line in **FIGURE 1** and follow the line to find the number that states the height above sea level (in metres).

Step 2

Spot heights are dots that indicate the exact height at the highest point of a hill or the lowest point of a depression. For example, the hill in **FIGURE 1** is exactly 104 metres above sea level at its peak. This spot is higher than the last contour line (in this case 100 m), but lower than the height at which the next contour line would be drawn (110 m).

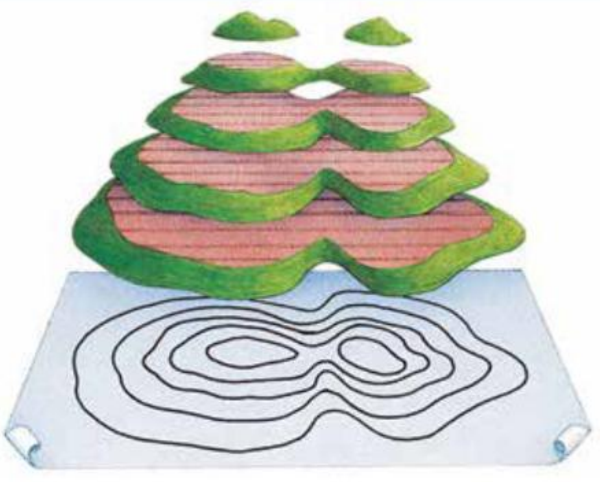
If the contour interval shown in **FIGURE 2** is 20 metres, what height could the land be on these hilltops?

Step 3

The contour interval of a map is the difference in metres between each of the contour lines. This interval is consistent across a map.

If the contour lines are too close and the numbers can't easily be written, it is left to the reader to use the contour interval to calculate heights. The contour interval is often written in the legend as a guide. Check your understanding by considering the landscape shown in **FIGURE 2**. With a contour interval of 20 metres, what would be the height of the land at the top of the contour immediately beneath the hilltops?

FIGURE 2 A topographic map represents a three-dimensional landscape on a flat surface.



Resources

Video eLesson SkillBuilder: Reading contour lines on a map (eles-1651)
Interactivity SkillBuilder: Reading contour lines on a map (int-3147)

1.5.3 Let me do it

Complete the following activity to practise this skill.

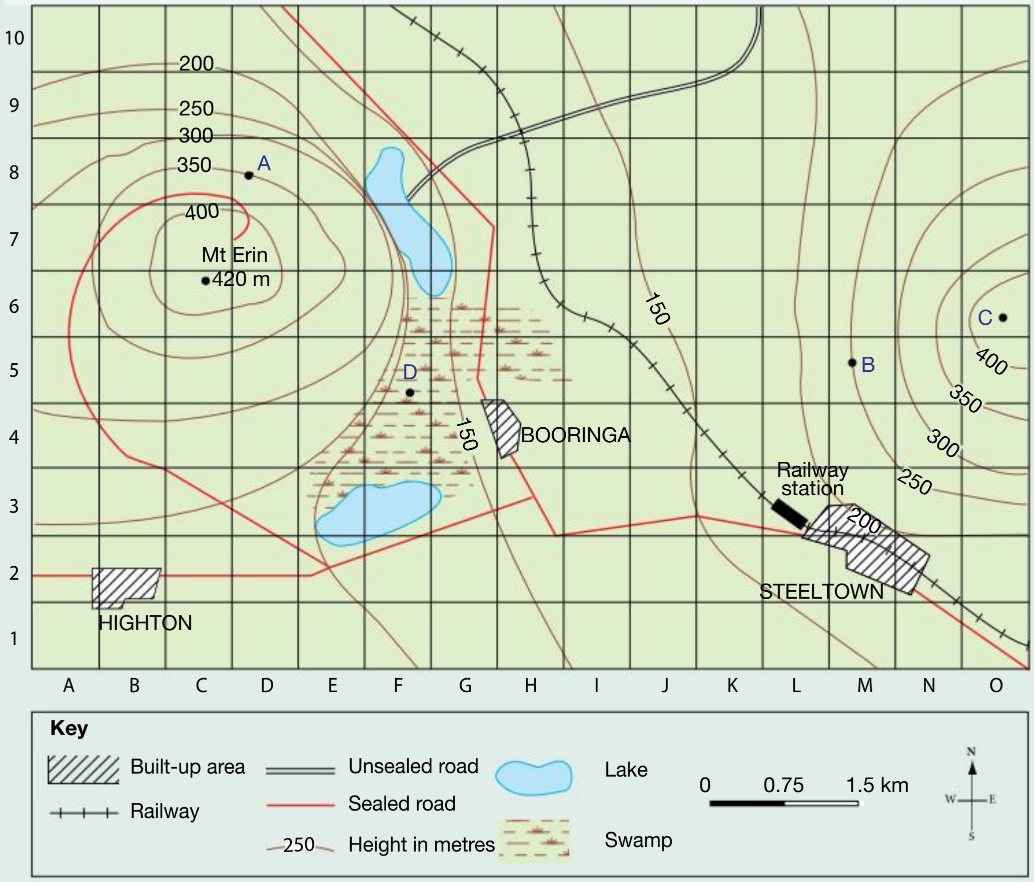
1.5 ACTIVITY

Study **FIGURE 3** and apply your skills in reading contour lines to answer the following questions.

a. What contour heights does the road from Highton to Booringa cross?
b. Does the railway line follow fairly even land or does the train have to climb a steep slope?
c. What is the contour interval on this map?
d. What is the maximum height of Mount Erin at its peak?
e. How would we know that Mount Erin is a hill if it was not labelled so?

HASS skills: Analysing

FIGURE 3 A simple topographic map of Mount Erin and surrounding areas



Source: MAPgraphics Pty Ltd, Brisbane

Checklist

I have:

- understood contour lines
- understood contour intervals
- understood spot heights.

LESSON
1.6 SkillBuilder: Using latitude and longitude

LEARNING INTENTION

By the end of this lesson you will be able to:
- explain the difference between latitude and longitude
- accurately read parallels of latitude
- accurately read meridians of longitude.

1.6.1 Tell me

What are latitude and longitude?

Latitude and longitude are imaginary grid lines encircling the Earth. They can be drawn over a map to help us locate a place.

The lines that run parallel to the equator are called parallels of latitude. Each line is measured in degrees north (N) and south (S) of the equator (0°). The equator divides the Earth into two parts — the northern hemisphere and the southern hemisphere. The latitude at the North Pole is 90°N, and the latitude at the South Pole is 90°S. All places have a latitude reading somewhere between 0° and 90°N, or 0° and 90°S.

Lines of longitude run from north to south from the North Pole to the South Pole. These are called meridians of longitude and are also measured in degrees. The Prime (or Greenwich) Meridian (0°) runs through Greenwich Observatory near London, England. Places are either east (E) or west (W) of this line. All places have a longitude reading somewhere between 0° and 180°E, or 0° and 180°W.

FIGURE 1 The parallels of latitude

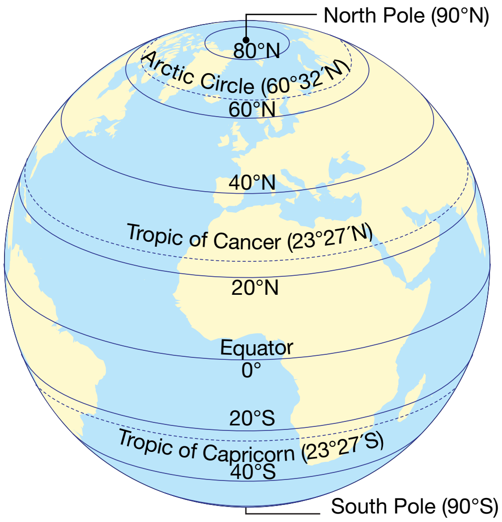
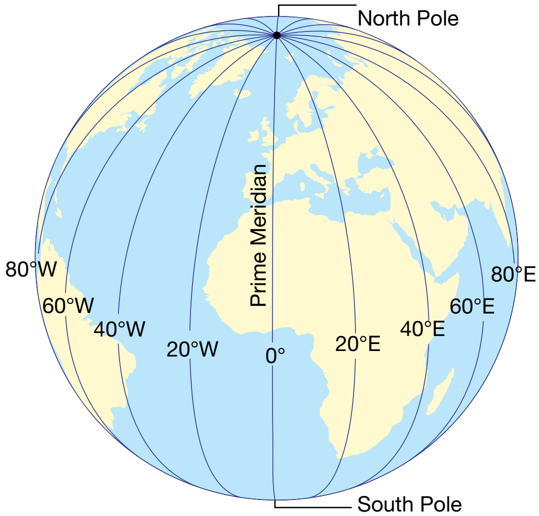


FIGURE 2 The meridians of longitude



How are latitude and longitude useful?

Latitude and longitude are used to give the precise location of a place in an atlas, on a globe, or on a map showing a large region. Lines of latitude and longitude form a grid pattern on a map and this makes identifying the location of a place easy. A gazetteer index lists latitude and longitude readings of all places featured in an atlas.

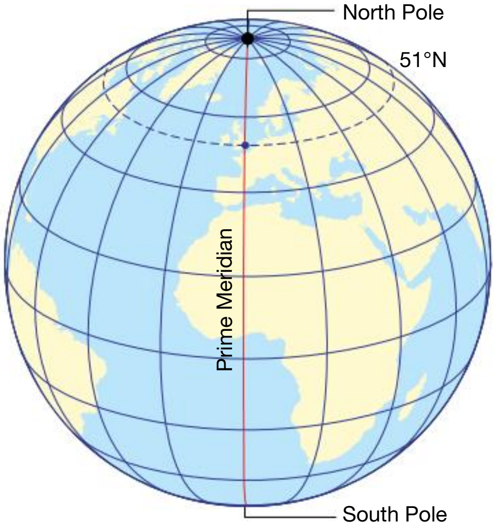
Latitude and longitude are useful for identifying exact locations in a range of situations, including :

- sailing on the open ocean
- flying across vast expanses
- gaining a GPS reading
- viewing Google Earth
- studying maps to plan a touring holiday.

Using latitude and longitude accurately involves:

- identifying the precise location of a place
- accurately reading parallels of latitude
- accurately reading meridians of longitude
- writing the reading correctly.

FIGURE 3 Latitude and longitude lines form a grid pattern



1.6.2 Show me

How to use latitude and longitude

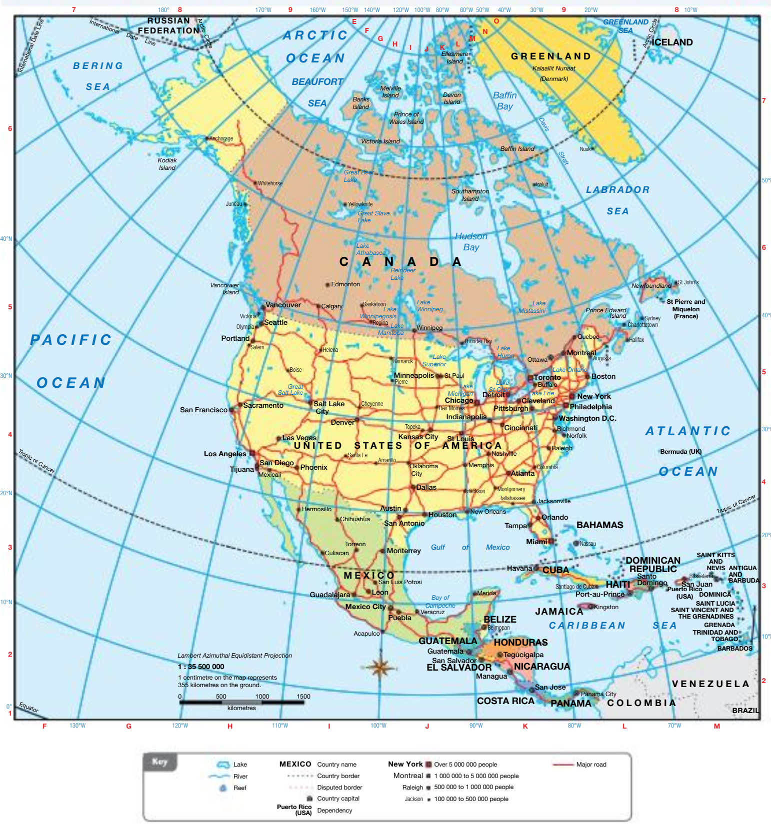
You will need:

- a map with a latitude and longitude grid
- a ruler.

Model

Philadelphia in the United States is located at 40°00′N 75′°10′W. Further east, on the coast, is Boston at 42°20′N 71°05′W. Dallas, in the central south of the country, is at 32°47′N 96°48′W. On the west coast, Los Angeles is at 34°00′N 118°15′W and San Francisco is at 37°45′N 122°27′W.

FIGURE 4 North and Central America



Source: Spatial Vision

Procedure

Step 1

Determine the place for which you want to give a latitude and longitude reading.

Step 2

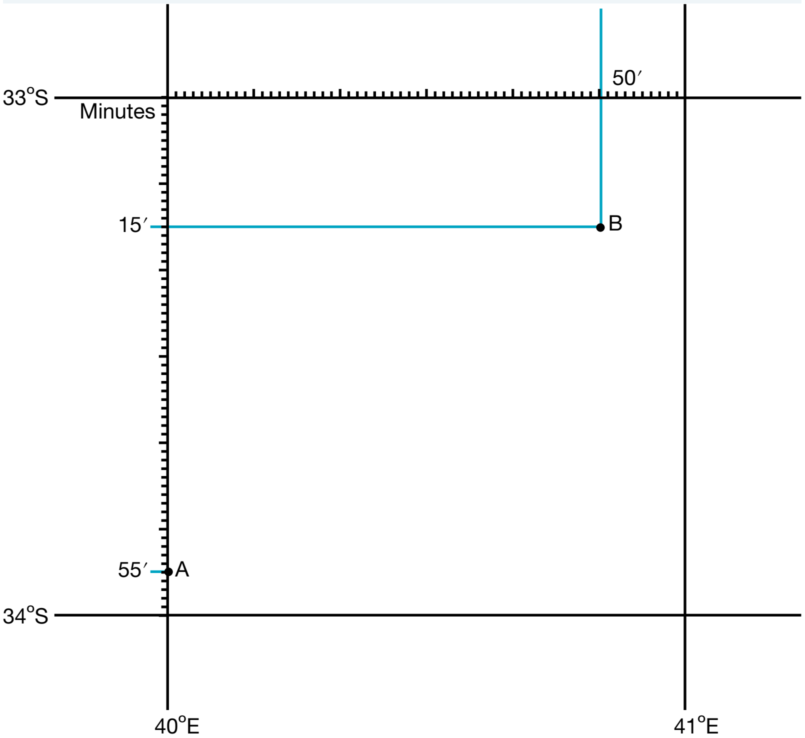
Begin with the parallels of latitude. Determine the degrees on the line closest to the location. For example, in **FIGURE 4** Philadelphia is at 40°N — it is exactly on the line of latitude and north of the equator. The equator (0°) is shown in the bottom left corner of **FIGURE 4** but due to the Earth's curve, it cannot be seen across the entire map because it dips below the area shown. Not all parallels of latitude are drawn on a map, so you will often have to work out what the closest line of latitude is. For example, in **FIGURE 4**, we can see that Dallas is located at 33°N.

You may have noticed in **FIGURE 4** that an additional parallel of latitude has been drawn and labelled the Tropic of Cancer. This line is at 23.5°N. A similar line is found at 23.5°S and is known as the Tropic of Capricorn. It passes through northern Australia just near Rockhampton. It is between these two lines that the sun moves and determines our seasons.

Step 3

Each degree on the grid is made up of 60 minutes (see **FIGURE 5**). It is likely that a place is not situated exactly on the degree line, so you will need to determine a minute reading as well. This becomes especially evident in smaller-scaled maps. Calculate the minutes for the place you are identifying. It is often a good idea to place a ruler on the map or use a finger to follow a line so that your eyes don't inadvertently cross to another grid square.

FIGURE 5 Showing minutes of a degree



Step 4

Combine the readings to obtain a precise latitude for place. Place A in **FIGURE 5** is at 33°55′S. (The 'S' indicates that this place is south of the equator.)

Step 5

Longitude is determined in a similar manner. Find the north–south line (meridian) closest to the place. Take the line reading and then the degrees reading. For example, in **FIGURE 4** Philadelphia is at 75°W. The 'W' indicates it is west of the Prime Meridian. The Prime Meridian is not shown on **FIGURE 4** but the numbering on the meridians at both the top of the map and the bottom of the map indicate that the Prime Meridian is off the map to the right. On a more detailed map, a minute reading could also be obtained.

FIGURE 6 A sample from the gazetteer index of an atlas

Van Diemen, Cape **80 C9** 11.10 S 130.22 E
Van Diemen Gulf **80 C9**
Vanern, Lake **114 G4**
Vanersborg **114 G4** 58.23 N 12.19 E
Vangunu, island **89 G3**
Vanimo **88 D3** 2.40 S 141.17 E
Vannes **116 C4** 47.40 N 2.44 W
Van Rees Range **88 C3**
Vanrhynsdorp **126 B1** 31.36 S 18.45 E

Latitude
Longitude

Step 6

When combining the grid readings, latitude always comes first. A useful tip is to remember that 'latitude' comes before 'longitude' alphabetically. In **FIGURE 4**, Philadelphia is at 40°N 75°W. In **FIGURE 5**, place B is at 33°15′ S 40°50′ E. Check that you can find these two places.

Step 7

In the gazetteer index of an atlas, the reading for Philadelphia is listed as 40°00′ N 75°10′ W. Have a look in an atlas gazetteer index (usually in the back of the atlas) because the places are all identified by latitude and longitude. With a partner, test each other by naming and looking up locations on a map and practising giving their latitude and longitude.

on Resources

Video eLesson SkillBuilder: Using latitude and longitude (eles-1652)
Interactivity SkillBuilder: Using latitude and longitude (int-3148)

1.6.3 Let me do it

Complete the following activities to practise this skill.

1.6 ACTIVITIES

1. Using **FIGURE 1(b)** in section 1.10.2, give the latitude and longitude readings at the centre of the listed deserts to complete the table below.

Desert	Latitude and longitude reading
Gibson	
Tanami	
Simpson	
Great Sandy	

Geography concepts: Space, Place

2. Apply your skills in using latitude and longitude to answer the following questions.
   a. Which desert can be found at 22°S 133°E?
   b. This South Australian desert can be found at 29°S 141°E. What is its name?
   c. Give a latitude and longitude reading such that a person would find themselves at Davenport Range.
   d. If you were to travel the full length of the Great Dividing Range, at what latitude and longitude would you begin and finish?
   e. Which range extends furthest east — Hammersley, Carnarvon or Robinson? Give the latitude and longitude reading at its most easterly point.
   f. Use the following checklist to assess your development of this skill. Can you tick all the items? If not, with a partner, continue your practice of looking up or providing readings for locations in your atlas until you feel confident in your skills. **Geography concepts: Space, Place**

Checklist

I have:

- identified the precise location of a place
- accurately read parallels of latitude
- accurately read meridians of longitude
- written the readings correctly.

LESSON
1.7 Calculating distance using scale

LEARNING INTENTION

By the end of this lesson you will be able to calculate distance measured with a ruler on a map to an actual distance by using a linear scale.

1.7.1 Tell me

What does it mean to calculate distance using scale?

Calculating distance using scale involves working out the actual distance from one place to another using a map. The scale on a map allows you to convert distance on a map or photograph to distance in the real world — what it represents on Earth's surface. A linear scale is the easiest to use, but s ometimes the distance being measured between places is not straight.

Why is calculating distance using scale useful?

Calculating distance by using scale provides a spatial understanding of an area. If you go to an unfamiliar place for a holiday and the tourist information map does not have a scale, it is very difficult for you to know how far it is between places on the map and therefore how long it might take to walk or drive between them. Maps and photographs often show large areas of the Earth on a page. Many people use maps or photographs to gather information and need to understand the distances between places. Examples of people who calculate distance by using scale include:

- architects
- town planners
- engineers
- pilots
- farmers
- tourists.

A good calculation of distance using scale involves accurately converting a ruler-measured distance on a map to an actual distance by using a linear scale.

1.7.2 Show me

How to calculate distance using scale

You will need:

- a map or photograph with a linear scale
- a piece of paper with a straight side for marking places
- a light grey pencil
- a piece of string
- a pencil.

Model

The linear scale of the **FIGURE 1** map is shown in the lower left corner. The shaded Bedouin lands are seen in the key/legend. The Sahara Desert, where the Bedouin people live, is approximately 5250 km from west to east and, on average, 1900 km from north to south.

Procedure

To calculate the distance between places or around places, it is easiest if you have a map or photograph that has a linear scale as shown in **FIGURE 1**.

FIGURE 1 Desert areas inhabited by the Bedouin people

Source: MAPgraphics Pty Ltd, Brisbane

Step 1

Determine the two places between which you want to know the distance. If it is a straight-line distance between the two places — the distance 'as the crow flies' — then your paper edge must be long enough to go between these points. If not, and the distance is winding, then you will need to learn to bend your paper (jump to **step 4**) or use a piece of string (jump to **step 8**).

Step 2

Place the straight edge of the piece of paper between the two places. Mark the two extremities of the distance on the edge. Label the place names at each end if working from a map.

Step 3

Place this marked edge of paper onto the linear scale drawn on the map. One end of the markings must be at 0. Read off the distance on the scale. If the distance is longer than the scale bar on the map, mark your paper edge where the scale bar ends and move this new mark to 0, repeating as often as required. If you have to do this you will need to add the distances together to find the total distance between the named places. Don't forget to add the unit of measurement (for example, metres or kilometres).

FIGURE 2 Measuring straight distances with a scale

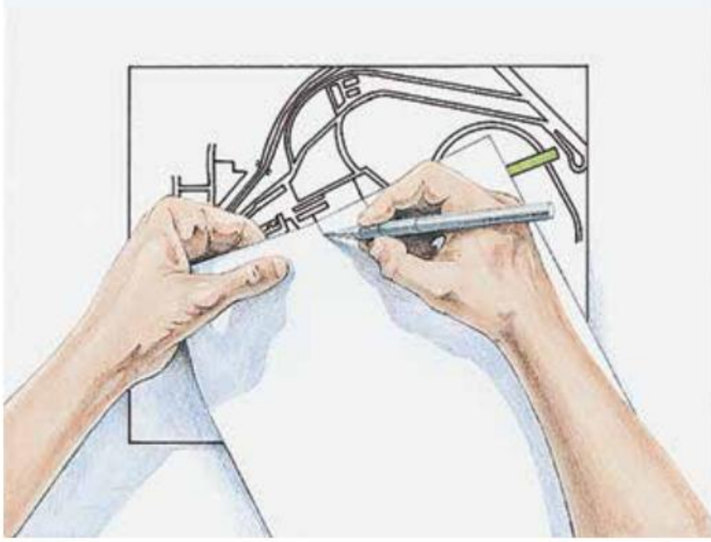
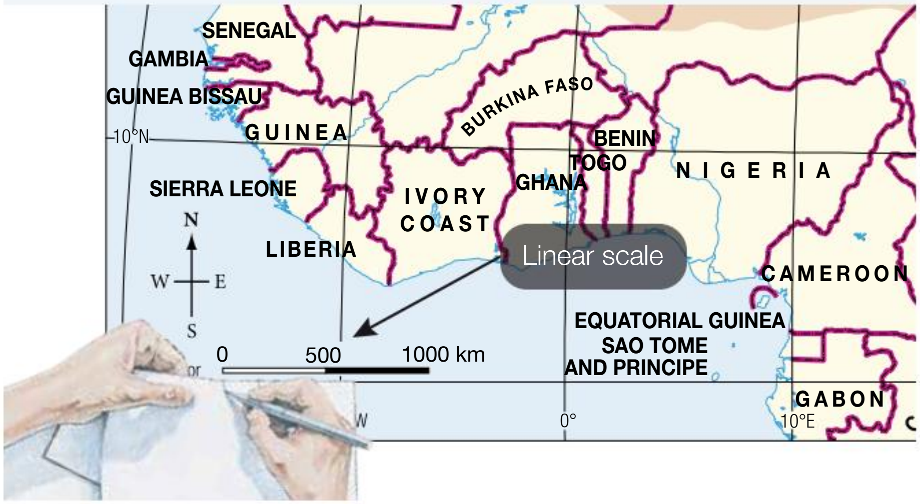


FIGURE 3 Converting the paper edge markings to a ‘real’ distance



Step 4

If the distance is winding rather than straight — perhaps you are following a road through hills, or a river winding its way downstream, or a hiking track across a ridge — begin by placing the edge of the paper against the starting point, marking the edge with the place name.

Step 5

Move the paper carefully so the edge follows the curve on the map. Use your pencil to apply light pressure while you adjust the paper edge to the curve.

Step 6

Mark and label the end point on your paper.

Step 7

Place the paper along the linear scale and read off the distance between your two places as you did in **step 3**. Don’t forget to add the unit of measurement (for example, metres or kilometres).

Step 8

The technique using a piece of string is risky — if you let go of the piece of string, you’ll have to start again! Place one end of the string at your starting point and bend the string around the winding distance.

Mark the total distance carefully and place the string against the linear scale to calculate the total distance between the two places. One end

FIGURE 4 Measuring curved distances with a scale using a paper edge

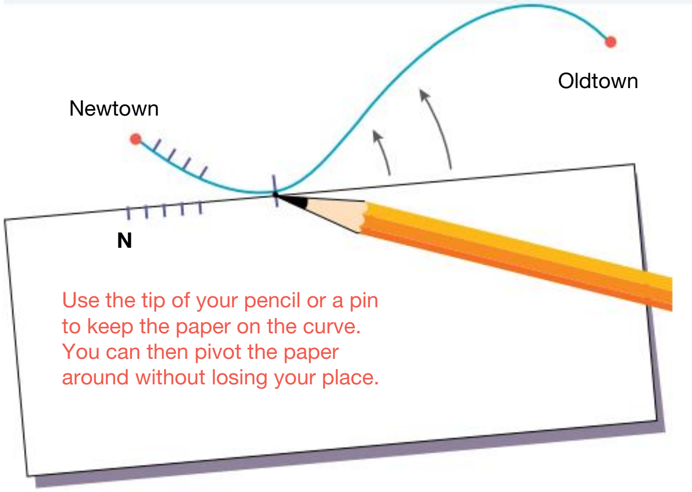
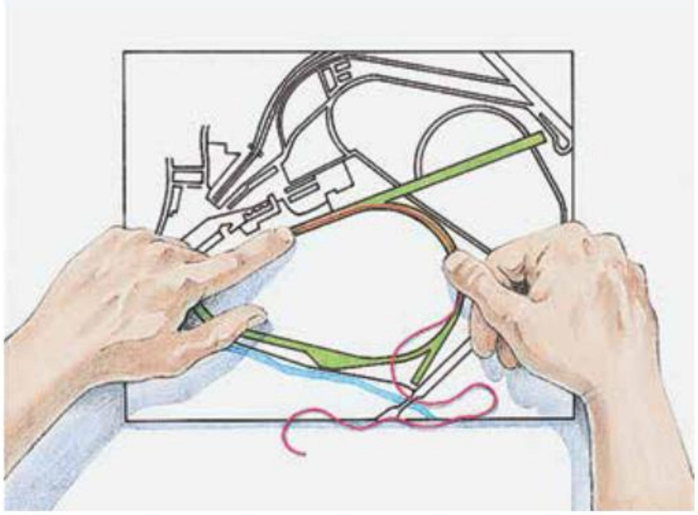


FIGURE 5 Measuring curved distances with a scale using a piece of string



of the string must be at 0. Read off the distance on the scale. If the distance is longer than the scale bar on the map, mark the string or hold it carefully where the scale bar ends and move this new mark to 0, repeating as often as required. If you have to do this, you will need to add the distances together to find the total distance between the named places. Don't forget to add the unit of measurement (for example, metres or kilometres).

on Resources

Video eLesson SkillBuilder: Calculating distance using scale (eles-1653)
Interactivity SkillBuilder: Calculating distance using scale (int-3149)

1.7.3 Let me do it

Complete the following activity to practise this skill.

1.7 ACTIVITY

Using **FIGURE 1(b)** in section 1.10.2, complete the following. Tick off the checklist when you feel confident in your development of this skill.

a. How far is it from the west to the east of the Great Victoria Desert?
b. How far is it between the Central Desert and the Simpson Desert?
c. Calculate the distance around the Tanami Desert.
d. What is the distance around the area designated as 'arid zone'?
e. What length of 'arid zone' boundary is also on the coast of Australia?

Geography concept: Scale

Checklist

I have:
- accurately converted a distance measured with a ruler on a map to an actual distance by using a linear scale.

LESSON
1.8 SkillBuilder: Drawing simple cross-sections

LEARNING INTENTION

By the end of this lesson you will be able to complete a simple cross-section using a topographic map.

1.8.1 Tell me

What are cross-sections?

A cross-section is a side-on, or cut-away, view of the land as if it had been sliced through by a knife. It is like taking a vertical slice of the landscape and looking at it side-on. Cross-sections provide us with an idea of the shape of the land. We can use contour lines on topographic maps to draw a cross-section between any two points. Cross-sections also indicate heights at a range of points.

Why are cross-sections useful?

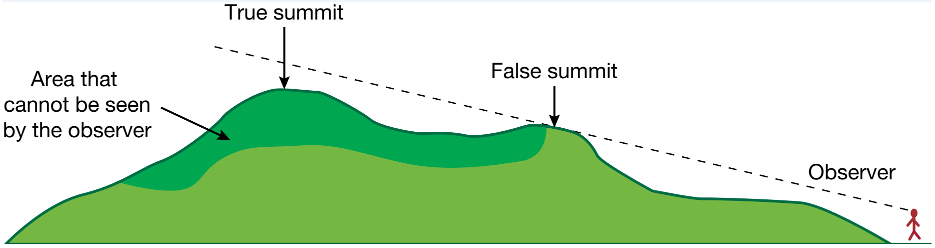
Cross-sections help us visualise the shape of the land between any two points. They are useful because sometimes it is difficult to visualise what topography (the shape of the land) is like when looking at a topographic map. Also, they help us determine if a landform will block the view of other landforms; for example, if a high hill obscures the view of the valley beyond and the lower range of hills. Cross-sections are also useful for:

- showing the changing shape of the land
- planning a walk or hike in a mountainous area
- planning constructions, such as houses, on sloping blocks.

A good cross-section has:

- been drawn in pencil
- ruled axes
- labelled axes
- used small dots
- created a smooth curve
- labelled features, if necessary
- a title.

FIGURE 1 Working with cross-sections



1.8.2 Show me

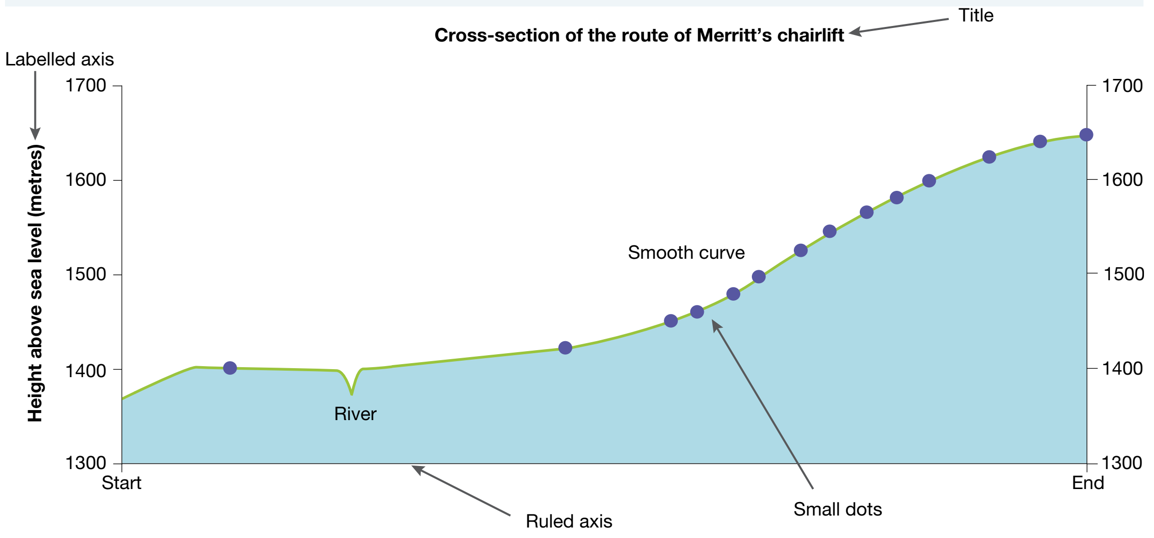
How to complete a cross-section

You will need:

- a topographic map of the region being considered
- a piece of paper with a straight side for marking the contours
- another sheet of paper, or graph paper, to draw the cross-section on
- a light grey pencil
- a ruler
- an eraser.

Model

FIGURE 2 A completed cross-section of Merritt's chairlift route



Procedure

Step 1

Determine the two points between which you want to create a cross-section. Your paper edge must be long enough to reach from one point to the other.

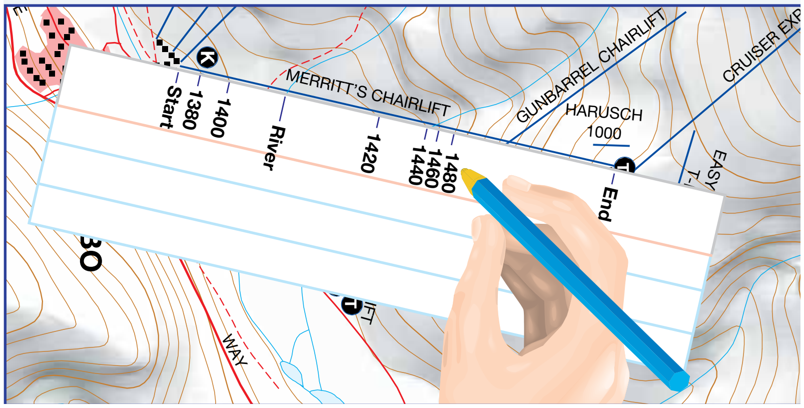
Step 2

Place the straight edge of a piece of paper between the two points. Mark the two extremities of your cross-section on the edge. Label these 'start' and 'end' or use place names/grid references from the map.

Step 3

On the paper, m ark where each contour line touches the edge and write the height of the contour line beside each mark. It may be necessary to lift the paper edge or follow the contour line to find a number. Hold your paper firmly and lift the edges to prevent moving it off the line of the cross-section. When you have completed all the contour markings you can lift the paper away from the map.

FIGURE 3 Marking up the paper edge where each contour touches the page



Step 4

On another sheet of paper, use your ruler to draw an axis onto which to transfer your markings. The horizontal (base) line should be as long as your cross-section from 'start' to 'end'. The vertical scale needs to give a realistic impression of the slopes and landforms. For this exercise, use one centimetre to represent 100 metres.

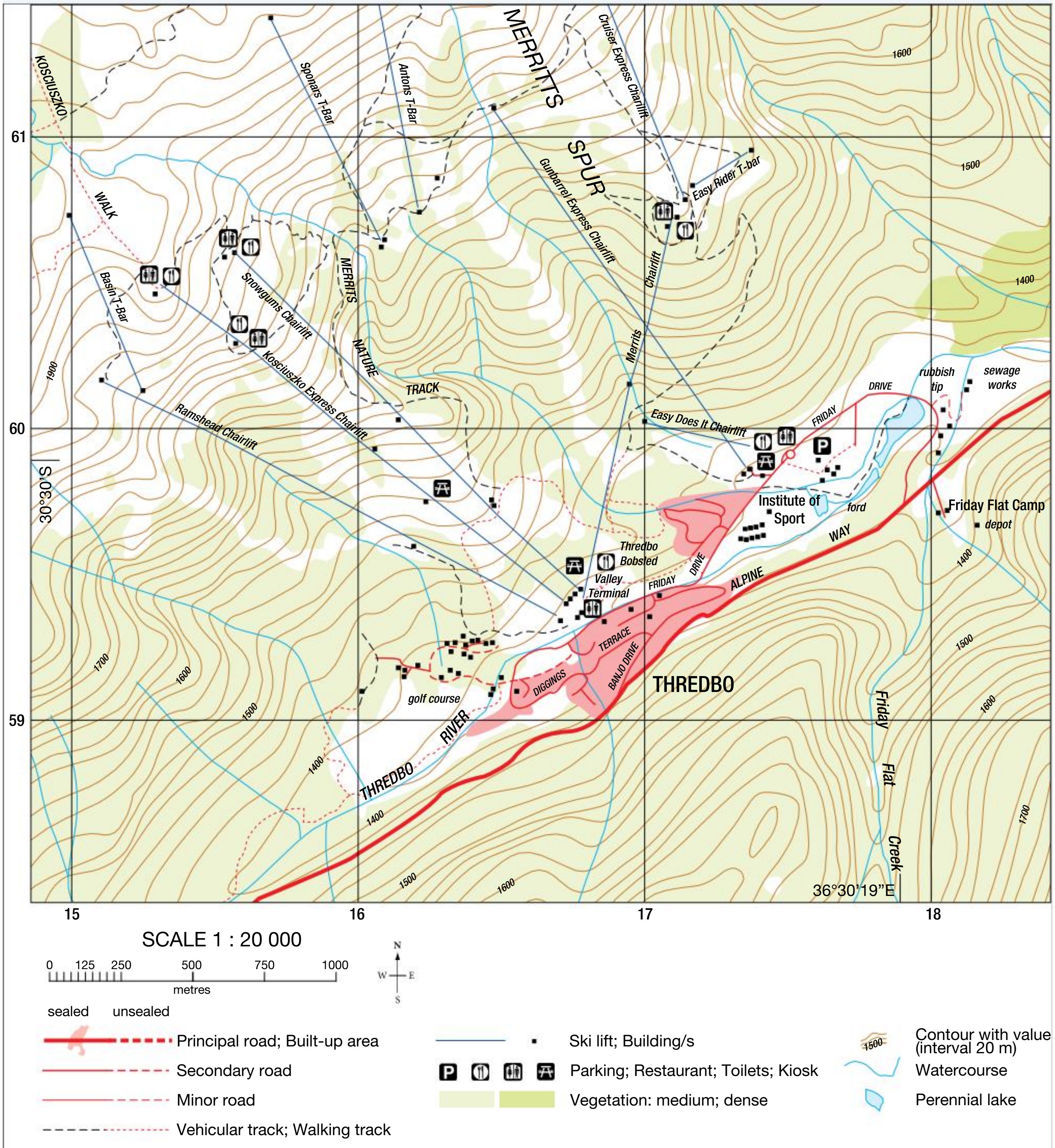
Step 5

Place the marked edge of the paper along the base axis. At each contour marking, find the appropriate height according to the vertical scale and put a small dot directly above the contour marked on the edge of the paper.

Step 6

Join the dots with a smooth line to show the slope of the land. Notice that a notch has been used to show where a river is located on the cross-section, and that the river has been labelled. Other features can be marked similarly when preparing the cross-section, if required.

FIGURE 4 Topographic map of Thredbo, New South Wales

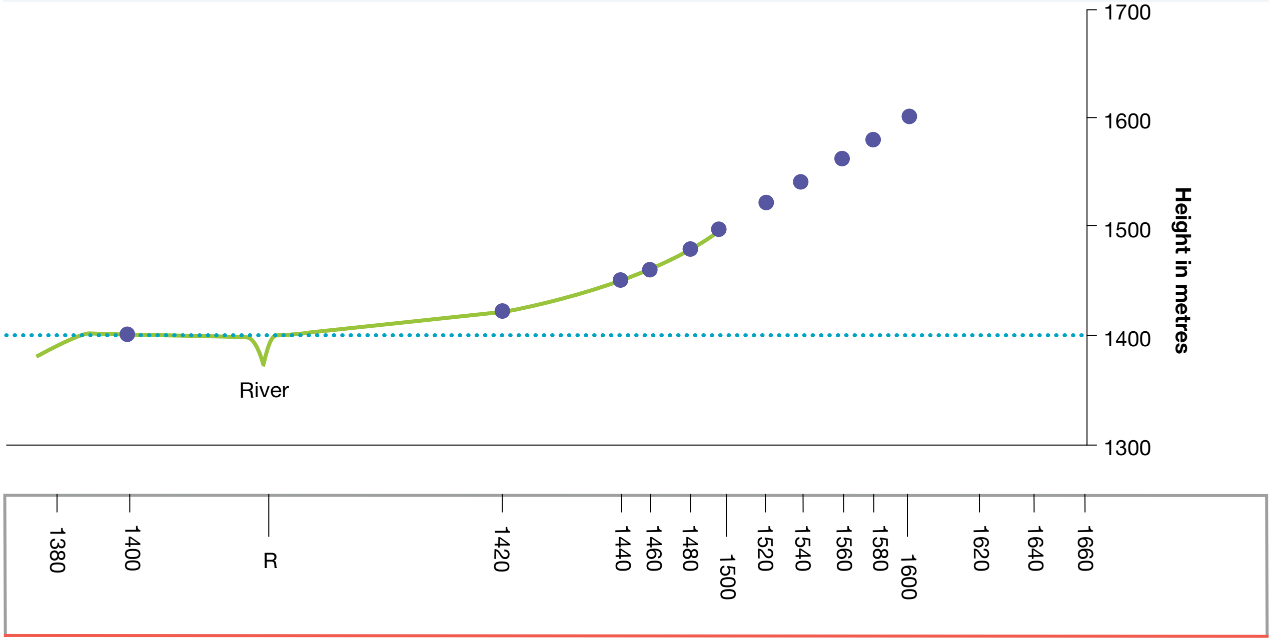


Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

Step 7

Complete the cross-section with the geographic conventions of a title and labelling of the axis. Shade the area below the line of your cross-section.

FIGURE 5 Drawing the curve of the cross-section



on Resources

Video eLesson SkillBuilder: Drawing simple cross-sections (eles-1655)

Interactivity SkillBuilder: Drawing simple cross-sections (int-3151)

1.8.3 Let me do it

Complete the following activities to practise this skill.

1.8 ACTIVITIES

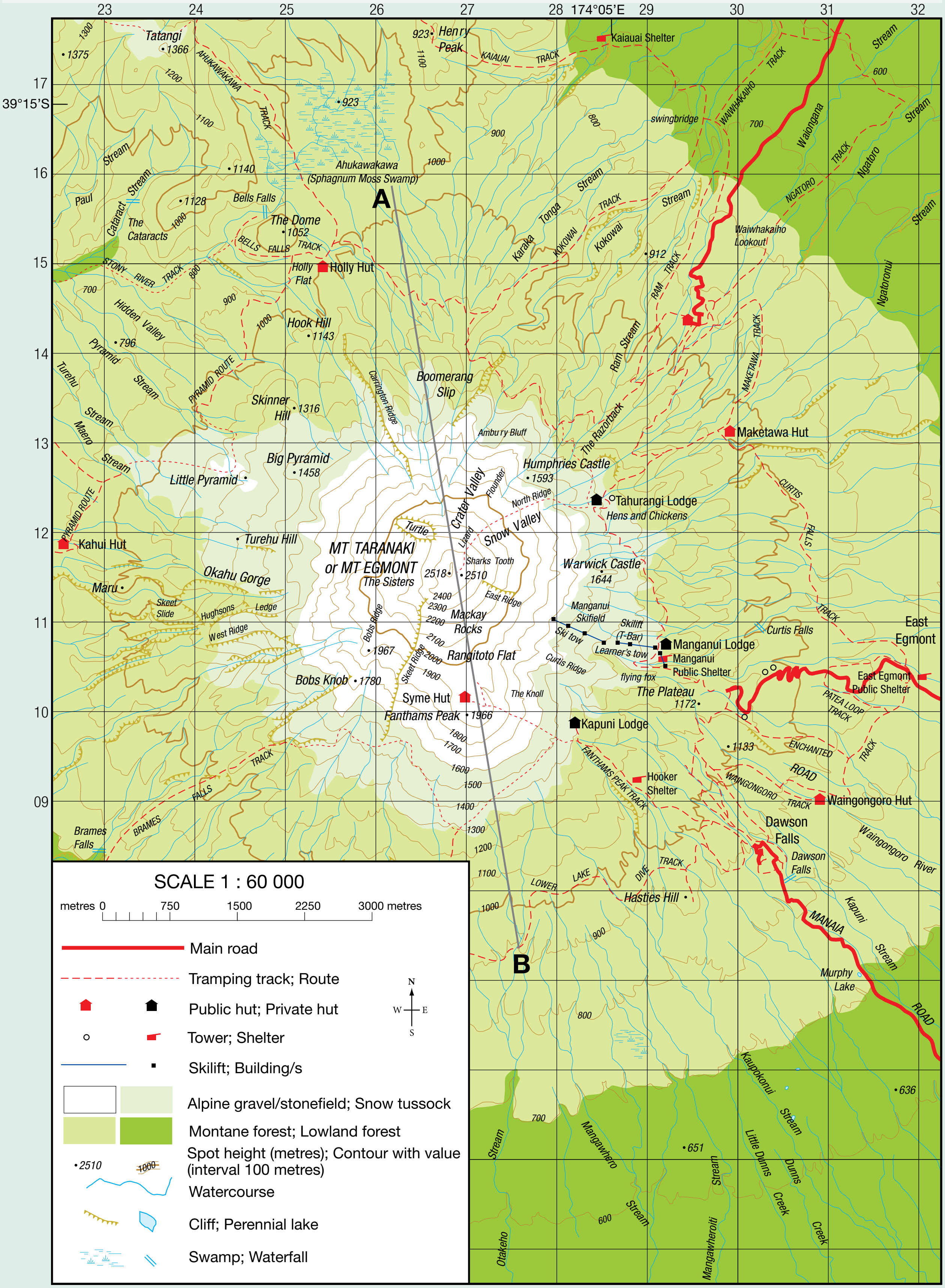
1. Using **FIGURE 6**, complete a cross-section along the line A–B. Use the checklist to ensure you have correctly completed all aspects of the task. **HASS skills: Analysing**
2. Use your cross-section to answer the following questions.
   a. Based on your cross-section, which side of Mount Taranaki would be the easiest to walk up? Why?
   b. How high is Mount Taranaki at its peak?
   c. How many watercourses are shown on the cross-section?
   d. Describe the vegetation cover of Mount Taranaki along the cross-section.
   e. What type of land feature is Mount Taranaki? **HASS skills: Evaluating**

Checklist

I have:

- used pencil
- ruled the axis
- used small dots
- created a smooth curve
- labelled the axis
- included a title.

FIGURE 6 Topographic map of Mt Taranaki, New Zealand



Source: Topographic Map 273-09 Egmont. Crown Copyright Reserved. Map drawn by MAPgraphics Pty Ltd, Brisbane

LESSON
1.9 SkillBuilder: Interpreting an aerial photo

LEARNING INTENTION

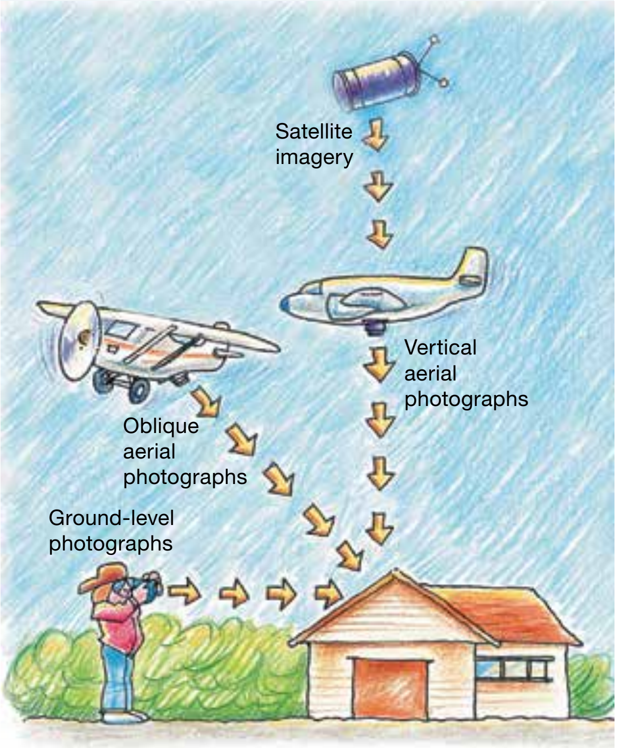
By the end of this lesson you will be able to:
- explain why aerial photographs are useful
- interpret shapes, sizes, tones, patterns and textures on a vertical aerial photograph
- write a detailed description of the vertical aerial photograph.

1.9.1 Tell me

What are aerial photos?

Aerial photographs are those that are taken from above the Earth from an aircraft. Aerial photos, either oblique or vertical, record how a place looks at a particular moment in time. Greater detail of a place can be captured than in a photo taken from ground level. Some aerial photos are also satellite compilations; that is, created by a number of images transmitted from the satellite.

FIGURE 1 Cartographers use different types of photographs



Vertical aerial photos are taken from directly above; that is, looking straight down on objects. Specially equipped aircraft take these photos. These photos are often referred to as a 'bird's eye' view. This is the view from which maps are drawn. When you look at one of these photos, there is a similarity to a plan drawing. For example, Katherine Gorge in **FIGURE 2** is so deep and narrow that it appears as a thin line 'snaking' through the rock formation.

Oblique aerial photos are those taken at an angle from an aircraft. These photos show the height and shape of objects better than vertical aerial photos, but some of the objects in the background can be hidden.

Objects in the foreground appear larger than those in the background. For example, in the oblique aerial photograph in **FIGURE 3** showing rock formations in Purnululu National Park in the Kimberley region of Western Australia, the sandstone domes appear larger in the foreground than in the background.

FIGURE 2 Vertical aerial photograph of Katherine Gorge

Source: © MAPgraphics Pty Ltd, Brisbane

FIGURE 3 Oblique aerial photo of rock formations in Purnululu National Park

Why are aerial photos useful?

Aerial photos can reveal details that are not recorded on maps. They make it easier to see landforms with distinct shapes, different landscapes, land uses, specific places and spatial patterns of the environment. Aerial photos from different time periods can show how a place has changed over time (see **FIGURE 4**).

FIGURE 4 Satellite images of Banda Aceh, Indonesia (a) before, (b) two days after and (c) four years after the tsunami on 28 December 2004

Source: Geoimage Pty Ltd © DigitalGlobe 2009

Interpretation of aerial photos provides a rich source of data for understanding the environment. We can obtain much information about a place by carefully analysing and interpreting an aerial photograph. We also need to be able to describe aerial photo to others. Some groups that use aerial photos are:

- urban developers
- firefighters
- search and rescue organisations
- transport authorities
- agronomists (people who manage land and crops).

Interpreting an aerial photograph involves:

- identifying key features by recognising elements such as shapes, colours, patterns and textures
- describing the main aspects in detail.

1.9.2 Show me

How to interpret a vertical aerial photo

You will need:

- a vertical aerial photo.

Model

The small Australian country town shown in **FIGURE 5** is predominantly a rectangular shape with a grid road system. A major road becomes a divided road as it passes through the town centre. Beside this road is the main shopping strip. The houses are on quite large blocks of land and most gardens have trees. Backyard swimming pools are scarce. The local bowling club can be found in the south-east of town. There appears to be some expansion of the town toward the west. This aerial photograph was taken either in summer when the land is dry or the town is in a low rainfall environment.

Procedure

To identify features on an aerial photograph, such as that in **FIGURE 5**, you need to apply the elements of interpreting an aerial photograph — shapes, size, tone, patterns and texture.

FIGURE 5 Vertical aerial photograph

Source: © Aerial Impressions

Step 1

First, let's consider 'shape' and 'size'. Objects from a vertical viewpoint have obvious shapes. Buildings appear as blocks (you are looking at the roof only). Small blocks are houses; larger blocks are factories if a number are grouped together; single, larger blocks are generally public buildings such as schools, halls and shopping centres. Oval or round shapes are sporting grounds/tracks. Can you imagine a golf course from above? Its size is large; its shape indicates green grass and rows of trees dividing the fairways. Look around the aerial photograph in **FIGURE 5** and identify the trees in the median strip of the major road.

Step 2

'Texture' and 'tone' are gained from the objects themselves in the course of the photography. Texture indicates whether the object has a degree of smoothness or whether it is rough. A mown oval will appear as 'smooth and green'; a forest will appear as 'lumpy and various greens' according to the size and species of trees in the forest; farmland sown to different crops and with some land ploughed will appear as a mosaic of colours.

Tone is the reflection of light from objects to the camera.

- Water glistens when clear, but appears brown when in flood.
- The deeper the water, the darker the colour.
- Sealed highways reflect light in comparison to the dirt of rural tracks. **FIGURE 5** shows a range of differently sized and surfaced roads.
- Sandy beaches glow a cream colour compared to the dark colour of bare soil.

Step 3

'Pattern' is what a geographer delights in observing, as they try to understand the world around them. This involves discovering key patterns in the aerial photograph. Towns generally have a series of roads in a grid pattern. Rivers, as a natural feature, wind their way through an environment. Irrigation channels and railway lines built by humans appear as straight lines. **FIGURE 5** shows how readily the boundary can be identified in this rural environment.

Resources

Video eLesson SkillBuilder: Interpreting an aerial photo (eles-1654)
Interactivity SkillBuilder: Interpreting an aerial photo (int-3150)

1.9.3 Let me do it

Complete the following activities to practise this skill.

1.9 ACTIVITIES

1. Study the vertical aerial photo of Villarrica volcano, Chile (**FIGURE 6**). Use the steps in section 1.9.2 'Show me' to identify key shapes, sizes, patterns and textures. Expand the size of this aerial photo and, using the Paint program (or similar software), label the following features:
   - the central vent
   - snow covered area
   - mud and/or lava flows
   - lakes
   - barren land
   - forested areas
   - a coastal settlement. **Geography concept: Environment**
2. Apply your skills in interpreting aerial photos to answer the following questions about **FIGURE 6**.
   a. Why do you think the mountain peak is covered in snow?
   b. What is the source of the water in the lakes?
   c. Suggest why some of the land is bare.
   d. How do you know that small areas of land near the base of the volcano are used for agriculture?
   e. By its shape, what type of volcano is Mount Villarrica? **HASS skills: Evaluating**
3. Write a detailed description of the aerial photograph, including your interpretation of the shapes, sizes, tones, patterns and textures in the image. Use the checklist to ensure you have covered all aspects of this task. **HASS skills: Communicating and reflecting**

Checklist

I have:
- interpreted shapes, sizes, tones, patterns and textures on a vertical aerial photograph
- written a detailed description of the vertical aerial photograph.

FIGURE 6 Villarrica volcano, Chile

Source: © NASA Earth Observatory image by Jesse Allen and Robert Simmon, using EO–1 ALI data provided courtesy of the NASA EO–1 team.

LESSON
1.10 SkillBuilder: Understanding thematic maps

LEARNING INTENTION

By the end of this lesson you will be able to:
- explain what a thematic map is, and why they are useful
- interpret shapes, sizes, tones, patterns and textures on a vertical aerial photograph write a detailed description of the vertical aerial photograph.

1.10.1 Tell me

What is a thematic map?

A thematic map is a map drawn to show one aspect; that is, one theme. For example, a map may show the location of vegetation types, hazards or weather. Parts of the theme are given different colours or, if only one idea is conveyed, symbols may show location.

Why are thematic maps useful?

Thematic maps are used to identify and represent a single feature. Because no additional clutter is presented on the map, the reader can focus on one feature only.

Thematic maps are useful for:
- focusing the viewer's attention on a single feature
- highlighting the significance of a single feature
- comparing different areas of a map in terms of the existence of a feature.

A good description of a thematic map:
- utilises the title to identify the theme
- applies the key/legend in order for readers to understand the colouring and/or symbols
- identifies and communicates the key theme and features.

1.10.2 Show me

How to understand a thematic map

You will need:

- a thematic map
- an atlas.

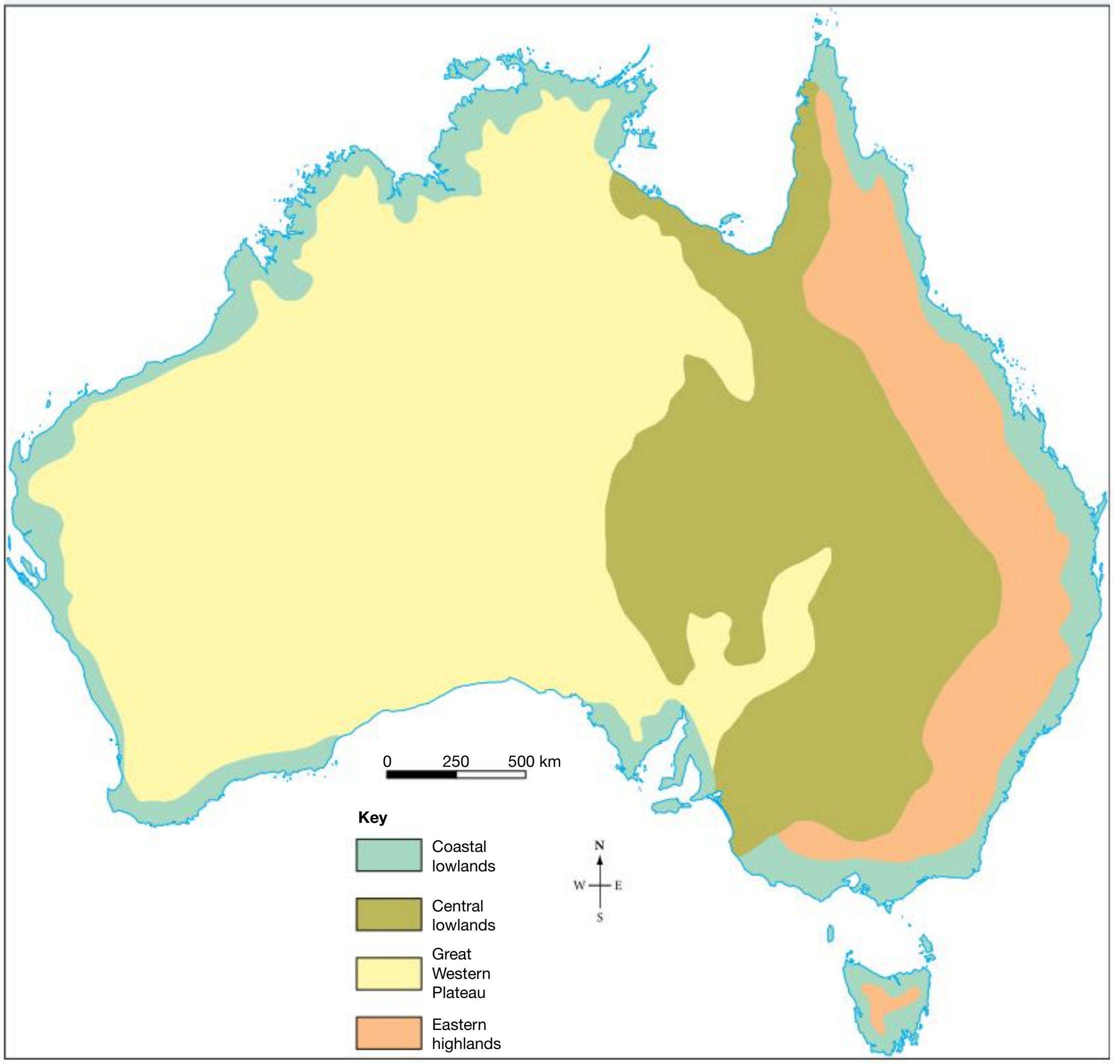
Model

FIGURE 1(a) shows four major landform regions. It is a simplified version of the natural features map shown in **FIGURE 1(b)**. Much of Australia is dominated by the Great Western Plateau, particularly in the west of the country. Following the coastline are the coastal lowlands, except around the Great Australian Bight and near the Victorian/South Australian border. The eastern highlands run parallel to the east coast from the northern tip of Australia to the south. The central lowlands run from the Gulf of Carpentaria to the Victorian/South Australian border.

Procedure

To understand a thematic map, you must be prepared to follow a planned approach to its study.

FIGURE 1(a) Thematic map of the major landform regions of Australia



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

Step 1

Read the title of the thematic map. What part of the world does the map show? When was the data gathered? What is the theme? In **FIGURE 1(a)**, the theme is 'major landforms in Australia'.

Step 2

Check that the map was put together by a reliable authority. Who is the source of the map? Sometimes textbooks don't state the source, but you can usually find this information by looking at the list of acknowledgements in the book.

Step 3

Read the key/legend to understand the colours and/or symbols that are used. In **FIGURE 1(a)**, four different colours are used to represent each of the four major landforms.

FIGURE 1(b) Topographic map of the natural features of Australia

Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

To interpret the colours you need to comment on where the various colours or symbols occur. Can you discuss the map by continent, or by region? An atlas may be useful to help you identify regions or places. In **FIGURE 1(a)**, the eastern highlands stretch from the north of Australia to the south, parallel to the coastline.

Step 4

You also need to discuss the colours or symbols that appear only in small areas of the map. In **FIGURE 1(a)**, the central lowlands reach to the coast near the Victorian/South Australian border and the Great Western Plateau meets the coast in the Great Australian Bight.

on Resources

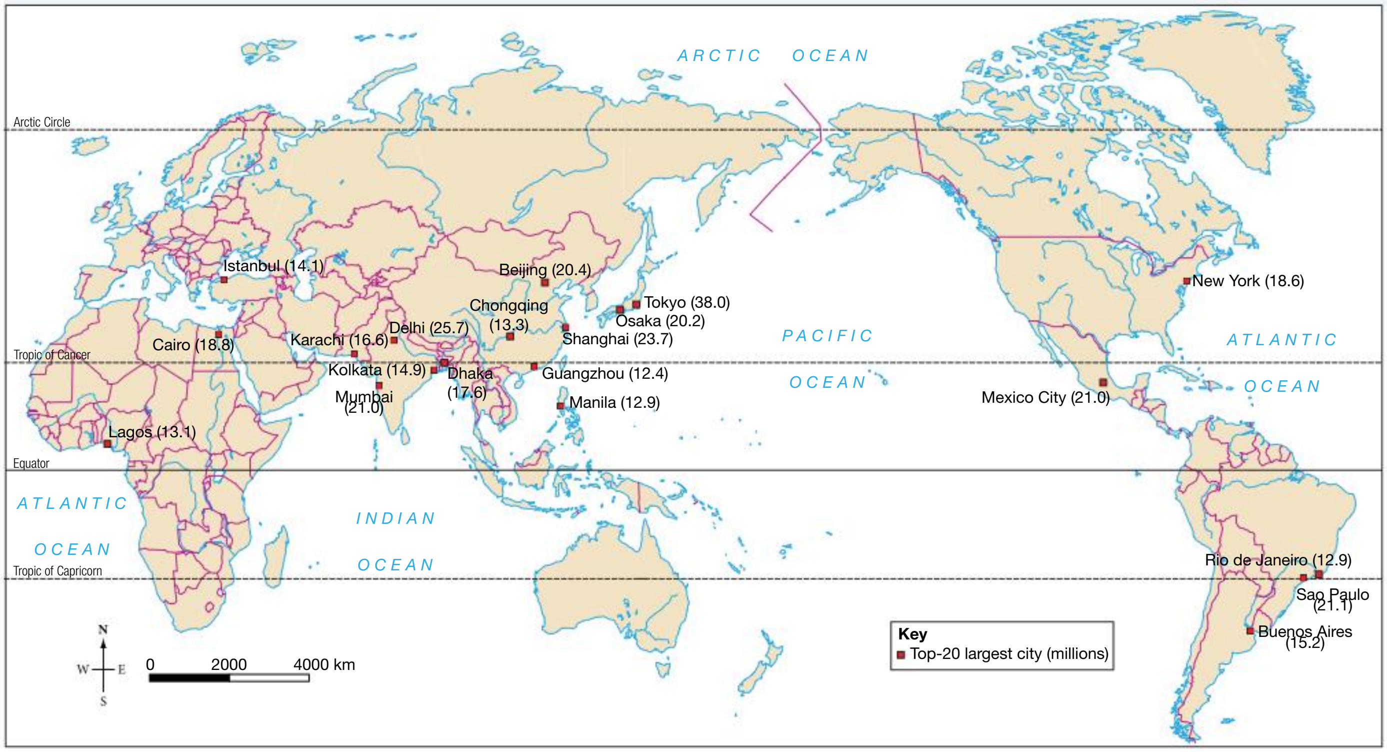
Video eLesson SkillBuilder: Understanding thematic maps (eles-1658)

Interactivity SkillBuilder: Understanding thematic maps (int-3154)

1.10.3 Let me do it

Complete the following activities to practise this skill.

FIGURE 2 The world's 20 largest cities



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane. Data from United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, CD-ROM Edition.

1.10 ACTIVITIES

1. Using **FIGURE 2**, describe the locations of the world's 20 largest cities. Use the checklist to ensure you cover all aspects of the task. **Geography concept: Place**
2. Apply your skills by answering the following questions.
   a. What is the title of the map in **FIGURE 2**?
   b. What theme is being shown in **FIGURE 2**?
   c. On which continent are most of the 20 largest cities located?
   d. Which continents contain none of the 20 largest cities?
   e. How many people live in the three largest cities in South America? **HASS skills: Analysing**

Checklist

I have:

- utilised the map title to identify the theme
- applied the key/legend in order to understand the colouring and/or symbols
- identified and communicated the key theme and features.

LESSON
1.11 SkillBuilder: Comparing population profiles

LEARNING INTENTION

By the end of this lesson you will know what a population profile is, why they are useful and be able to compare two population profiles from different countries.

1.11.1 Tell me

What is a population profile?

A population profile, sometimes called a population pyramid, is a bar graph that provides information about the age and gender of a population. The bars identify the proportion of a country's population within a particular age group. The graph is split to show information about males and females. The shape of the population profile tells us about a particular population.

Why are population profiles useful?

Population profiles help us to interpret and understand a list of statistics. Any patterns are easily identified and compared. A triangular shape that is widest at the base, as in **FIGURE 1**, tells us that the population is growing rapidly. A square shape, as in **FIGURE 2**, indicates that population growth is slow. An inverted triangle, as in **FIGURE 3**, tells us that there is negative growth — that is, the population is decreasing.

FIGURE 1 Population profile of Niger, 2009

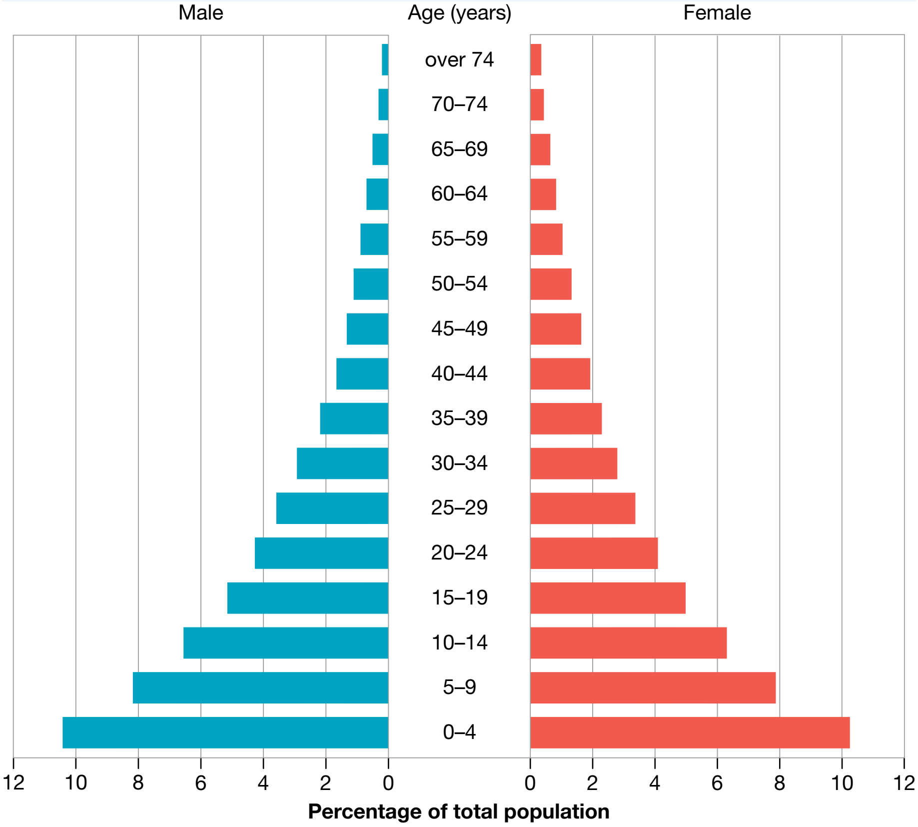


FIGURE 2 Population profile of Germany, 2009

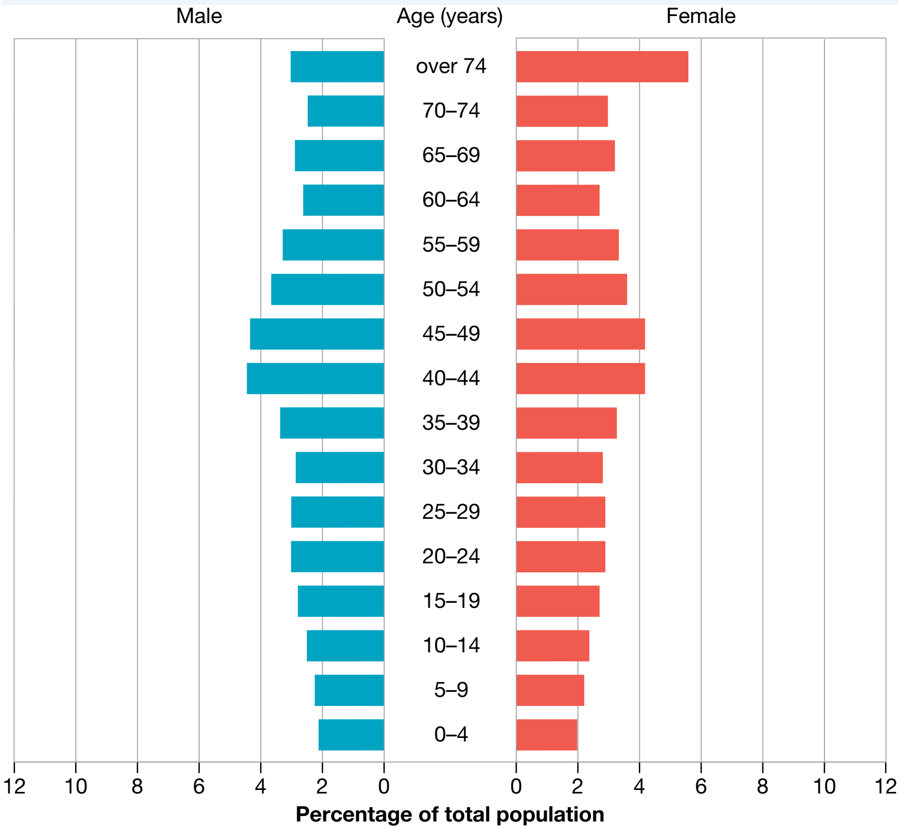
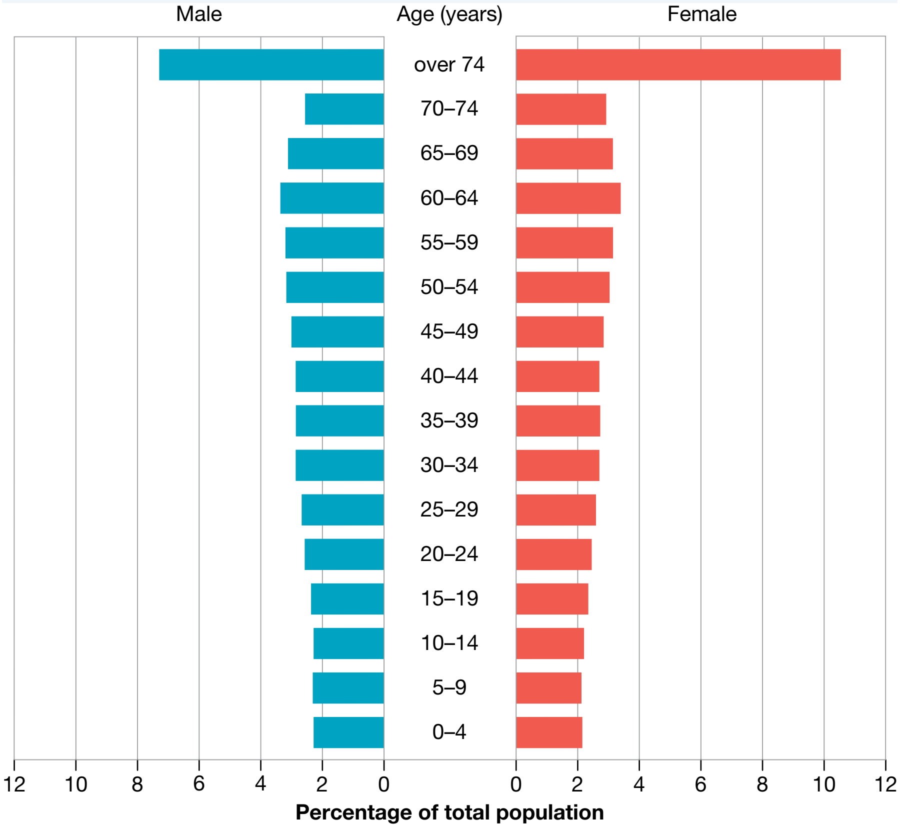


FIGURE 3 Population profile of Germany, 2050



A population profile is used to show us the structure of a population.

- If the lower bars of the profile are wide, the population is young (that is, there is a larger proportion of young people than older people in the population).
- If the upper bars of the profile are wide, the population is ageing.
- Comparisons can be made of the numbers of males and females within a population.
- Exceptions, particularly indents, in the shape may be due to significant events, such as war, disease, emigration or natural disasters.
- Expansions in the shape may be due to factors such as immigration, changes in birth control laws or the ending of a war.

Population profiles are useful for:

- comparing populations of different countries or places
- planning future urban developments
- determining the facilities required in an area; for example, a widening in the bars showing the 5–14 years age group means more schools will be needed, while a widening in the bars showing the 60+ years age group means aged care facilities will be required
- planning by governments for services for the future.

A clear comparison of population profiles has:

- identified the countries to be compared
- considered the three categories of level of dependence (see **Step 2** of the following Procedure)
- provided quantification (numbers) from the population profile
- compared male populations with female populations.

1.11.2 Show me

How to compare population profiles

You will need:

- two population profiles to compare — these can be for the same place at different times, or for two different places at the same time, such as in **FIGURES 4(a)** and **(b)**.

Model

In **FIGURE 4(a)**, Indonesia's profile does not fit a triangular shape; it is not very wide at the bottom, suggesting that it has relatively fewer young people and an ageing population. The profile of Vanuatu is widest at the base (the 0–4 years age group) and tapers in a triangular shape, indicating that it has a youthful population. Vanuatu will have to consider the needs of its population carefully in the future.

In Vanuatu, 41.8 per cent of the population can be regarded as dependent (very young or very old), but in Indonesia the dependent population makes up 32.5 per cent of the population. People in Vanuatu's population can be expected to live into their 70s, whereas those in Indonesia can expect to live into their 80s.

In Vanuatu, the gender balance is skewed to males (the bars show that the male population is slightly larger than that of females in most age groups), whereas in Indonesia the numbers are more evenly balanced (although the proportion of females increases in the 60+ years age group).

Procedure

Step 1

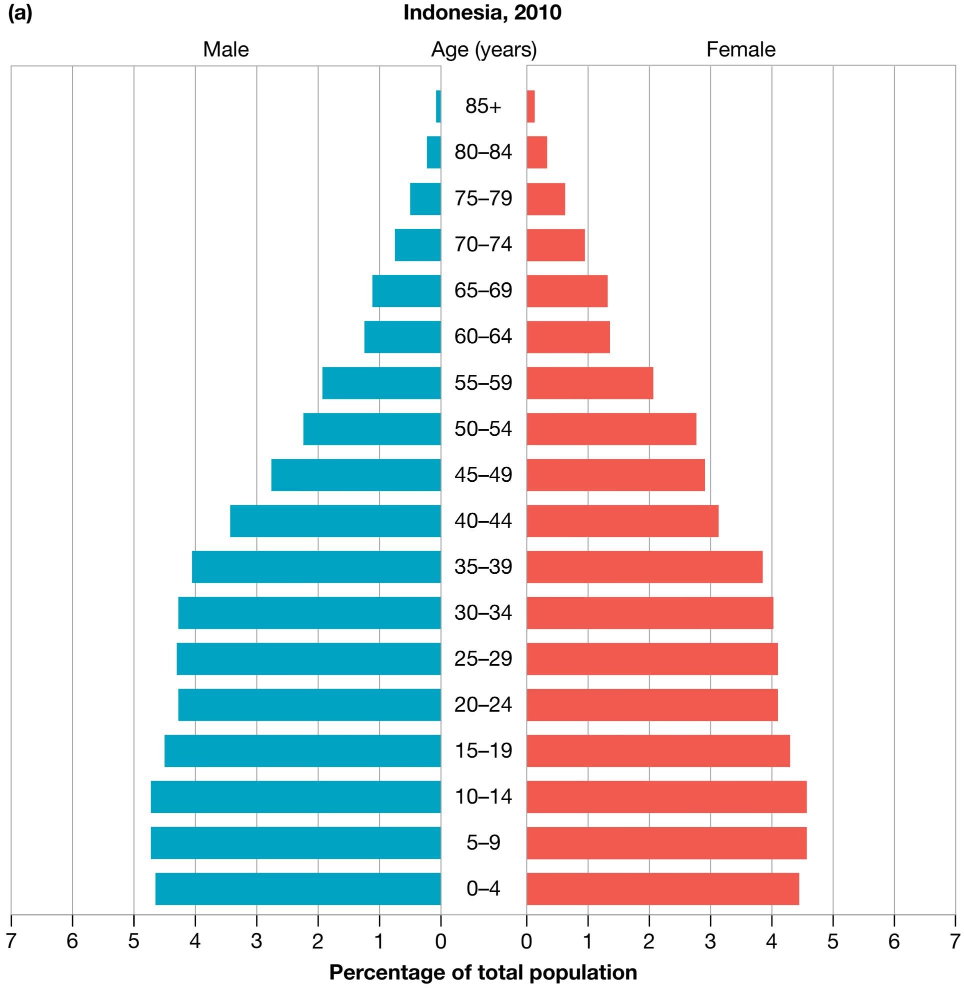
To complete a comparison of population profiles, you must have two or more population profiles for the same place at different times, or for different places at the same time. For this example, we will use the population profiles for Indonesia and Vanuatu shown in **FIGURES 4(a)** and **(b)**.

Step 2

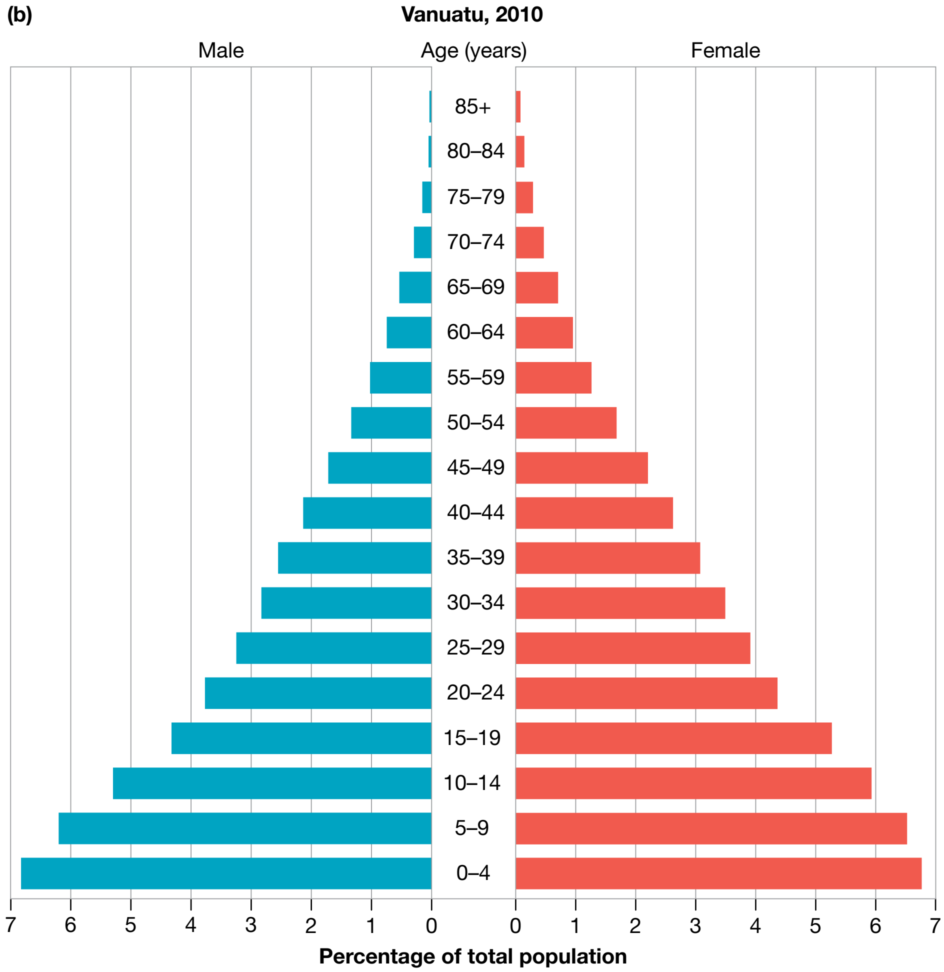
Populations can be broadly grouped into three categories according to the level of dependence of the age group:

- children (0–14 years) — dependent population, that is, those that need others to provide their basic needs
- adults (15–64 years) — economically productive and independent, that is, the workforce of a population
- aged (65 years and over) — economically inactive and dependent, that is, no longer earning money and therefore relying on other means of support such as pensions or savings.

FIGURE 4 Population profiles of (a) Indonesia and (b) Vanuatu, 2010



(b)



A population is considered to be old when less than 30 per cent of the population is younger than 15 years and more than 6 per cent is aged 65 years and over. A population is considered to be young when more than 30 per cent of the population is younger than 15 years and less than 6 per cent is aged 65 years and over.

For each population profile, calculate the percentage of males and females in each of the three categories described above. You can do this by using the **Population pyramid** weblink in the Resources panel and selecting the country and year that you want to research. Calculate the total population in each of the three categories of dependence. What does this tell you about the population in each of the population profiles?

Step 3

Look for patterns revealed by each population profile. Look at the gender structure — the number of males and females — of the graph. Is it in balance, that is, are there as many males as females? Often there are more females than males in the older age groups because females tend to have a longer lifespan. Migration can result in the movement of one gender more than another. War can affect the gender structure because a higher proportion of men may be killed. However, after a war, more births are likely to occur. Government policies such as the one-child policy of China, which was put into effect in 1979, but became less restrictive in 2016, where males are favoured, has changed the gender balance in affected countries. Write a statement about the balance of the population profiles.

Are the profile shapes for Indonesia and Vanuatu similar? If not, at what age groups do the variations appear? Write a few statements to summarise your findings. Some key points you could cover include Vanuatu's economic development and Indonesia's mass education and family planning programs of the 1990s.

Step 4

Consider any unusual aspects. Traditionally, population profiles were called population pyramids because they were shaped like a pyramid or triangle — wide at the base and narrow at the top. Are there any indents (places where the graph narrows unexpectedly) or extended age groupings? Can you suggest why these might occur? Historical and economic events are an important consideration. A country's history — for example, conflicts or natural disasters — can often explain unusual changes. When economic times are tough, fewer children are born; when economic times are good, parents feel they have the finances to support larger families. You will need to research the history of a country to gain information that will allow you to make an accurate interpretation of its population figures.

on Resources

Video eLesson	SkillBuilder: Comparing population profiles (eles-1704)
Interactivity	SkillBuilder: Comparing population profiles (int-3284)
Weblink	Population pyramid

1.11.3 Let me do it

Complete the following activities to practise this skill.

1.11 ACTIVITIES

1. a. Using the **Population pyramid** weblink in the Resources panel find the current year population profile for South Africa and compare it with the current year population profile for Thailand by writing a paragraph about population structure (using the steps in section 1.11.2 'Show me' to help you). Use the following checklist to ensure you cover all aspects of the task.
   b. Spend some additional time on the website looking at the changes in population pyramids over time for other countries. It is amazing what you will discover! **Geography concept: Change**
2. Apply your skills by answering the following questions.
   a. What percentage of people in Thailand are aged less than 10 years? Compare this with the figure for South Africa.
   b. In which country, South Africa or Thailand, is a female most likely to live longest?
   c. Which population profile is narrowest in the 0–4 years age group?
   d. At what point does the population structure for South Africa take on a pyramid shape?
   e. Which country, South Africa or Thailand, is likely to have more people in the workforce in 2025? Give reasons for your answer. **HASS skills: Analysing**

Checklist

I have:

- identified the countries to be compared
- considered the three categories of level of dependence
- provided quantification (numbers) from the population profile
- identified and utilised male population and female population numbers
- compared the total populations in each gender.

LESSON
1.12 SkillBuilder: Creating and reading compound bar graphs

LEARNING INTENTION

By the end of this lesson you will know what a compound bar graph looks like and what they are used for. You will also be able to create and interpret a compound bar graph.

1.12.1 Tell me

What are compound bar graphs?

A compound bar graph is a bar or series of bars divided into sections to provide detail of a total figure. These bars can be drawn vertically or horizontally. The height or length of each section represents a percentage, with the total length of the bar representing 100 per cent.

Why are compound bar graphs useful?

Compound bar graphs allow us to see at a glance the various components that make up the total. For example, it might show the origin of tourists arriving in a country. In this case, each part of the compound bar would allow the reader to visually interpret what percentage of tourists came from each country of origin.

Compound bar graphs are useful for:
- showing the proportion of sectors within a total
- comparing sets of data between places
- comparing sets of data over time
- accurate interpretation of comparisons.

A good compound bar graph has:
- been drawn in pencil
- ruled lines to clearly represent and communicate data
- used colour according to a key
- a scale
- provided the source of the data
- a clear title.

A good interpretation of a compound bar graph has clearly represented and communicated the data.

1.12.2 Show me

How to create and interpret a compound bar graph

You will need:

- a set of data including parts that make up a total figure of 100 per cent
- a piece of paper on which to draw a graph, preferably graph paper
- a light grey pencil
- a ruler
- coloured pencils
- a calculator.

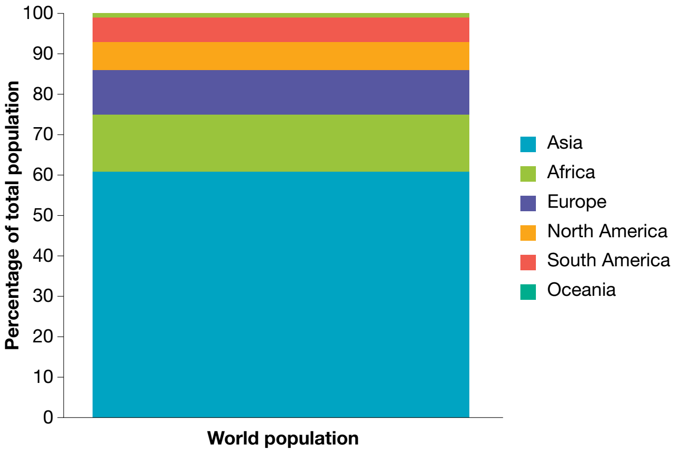
Model

FIGURE 1 clearly shows that the greatest percentage (60 per cent) of the world's population lived in Asia in 2011. Africa was the second most populated continent, with 15 per cent of the population. Europe was home to fewer people than Africa, with 11 per cent of the population. North and South America combined contained fewer people (14 per cent) than Africa. Oceania, including Australia, was home to a very small percentage of the world's population (0.5 per cent).

TABLE 1 World population, 2011

Region	Population	Percentage of total
Asia	4 140 336 501	60.7
Africa	994 527 534	14.6
Europe	738 523 843	10.8
North America	528 720 588	7.7
South America	385 742 554	5.7
Oceania	36 102 071	0.5
Total	**6 823 953 091**	**100**

FIGURE 1 Compound bar graph illustrating the 2011 world population figures from **TABLE 1**



Procedure

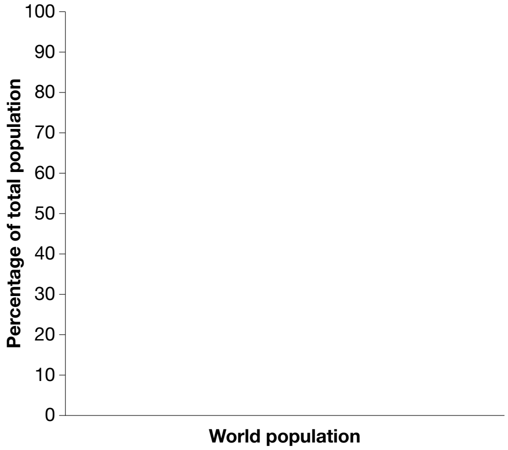
To complete a compound bar you must have a set of data that totals 100 per cent, with detailed information as to how that total is made up.

Step 1

Decide on a width (x-axis) and length (y-axis) for the bar graph — this will depend on the amount of space available and the complexity of the data being graphed. The x-axis width is not particularly important, but it is easier if the length is easily divided into hundredths (where each division equals 1 per cent). The easiest length to work with is 10 centimetres (100 millimetres). This means that each millimetre represents 1 per cent, or 10 millimetres represents 10 per cent.

Draw your y-axis 10 centimetres long. Add a scale alongside the axis (see **FIGURE 2**).

FIGURE 2 Draw your y-axis so that the total length represents 100 per cent.



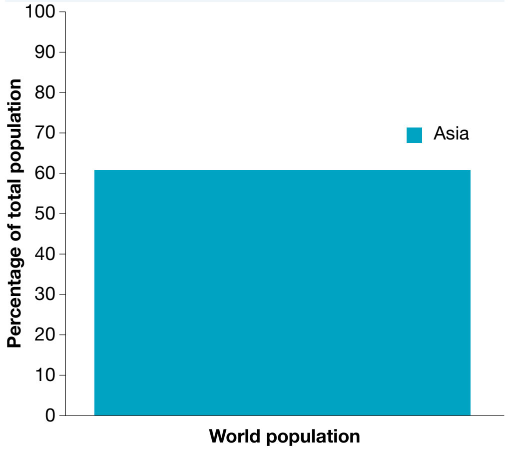
Step 2

Look at the set of data and use a calculator to convert the data into percentages of the total, if necessary. To do this, divide the figure for any part (for example, from **TABLE 1**, Oceania's population, 36 102 071) by the total figure (total world population, 6 823 953 091) and multiply the result by 100. Check your data before beginning to graph. The percentages you have should add up to 100 per cent (see **TABLE 1**). You don't want to finish colouring your bar and find that one data piece won't fit.

Step 3

Since this is a compound graph, all numbers compound (add onto) one another. Mark on your graph the length of the section of bar representing your first piece of data as a percentage. For example, 60.7 per cent = 60.7 millimetres if your total bar length is 100 millimetres.
Colour this segment and add a key near your graph, with appropriate labelling (see **FIGURE 3**). Data will usually be graphed in order from the largest to the smallest.

FIGURE 3 Colour the first section of your bar, representing the first (and largest) piece of data, and add a key.



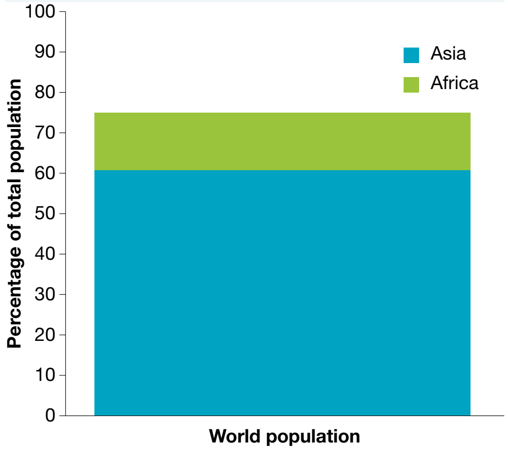
Step 4

Add the next percentage to the percentage for the first piece of data. In this example, add 14.6 per cent to the previous 60.7 per cent and you have a total of 75.3 per cent — this indicates where the next segment of the bar will end. Draw a line where this percentage is represented on your bar (75.3 per cent = 75.3 millimetres if your total bar length is 100 millimetres). Shade the segment in a different colour and add this colour to the key.

Step 5

Repeat Step 4 until you have completed the graphing, colouring and key. Don't forget to give your compound bar graph a title and state the source of your data under the graph (see **FIGURE 1** for the final graph).

FIGURE 4 Colour the second section of your bar. A add the new colour to the key.



Step 6

Now you can interpret the information displayed in your compound bar graph. Write a description of the information it shows about world population. Begin with a comment on the most obvious feature — the colour that fills the largest section of the bar. In this example, you would state that the greatest percentage of the world's people (60.7 per cent) live in Asia. Now consider each of the other coloured sections of the compound bar and comment on how these colours (and therefore the data) relate to one another. For example, the combined population of North and South America (13.4 per cent) is smaller than that of Africa. The model text accompany ing **FIGURE 1** gives a sample description of the data.

on Resources

Video eLesson SkillBuilder: Creating and reading compound bar graphs (eles-1705)

Interactivity SkillBuilder: Creating and reading compound bar graphs (int-3285)

1.12.3 Let me do it

Complete the following activities to practise this skill.

1.12 ACTIVITIES

1. Using the data provided in **TABLE 2**, create compound bar graphs to show the proportion of the world's urban population by continent in 2000, and as predicted for 2030. *Hint:* The numbers you need to create the graph are percentages, which you will need to calculate. Use the checklist to ensure you complete all aspects of the task correctly.

TABLE 2 Global urban population in 2000, and predicted urban population 2030

Continent	Urban population 2000 (millions)	Predicted urban population 2030 (millions)
North America	248	344
Latin America and the Caribbean	394	585
Oceania	22	34
Europe	515	573
Asia	1392	2703
Africa	288	744
Total	**2859**	**4983**

Source: United Nations, Department of Economic and Social Affairs, Population Division (2012). *World Urbanization Prospects: The 2011 Revision*

HASS skills: Organising and constructing

2. Carefully analyse your two completed compound bar graphs to answer the following questions.
   a. i. Which continent had the second highest proportion of people living in urban areas in 2000?
      ii. What ranking is that continent expected to have in 2030?
   b. Which continent is predicted to have the greatest increase in urban population by 2030?
   c. What do you notice about the expected *change* in the urban population of Europe between 2000 and 2030?
   d. Compare the expected *change* in the urban population in Asia and Africa between 2000 and 2030.
   e. Give two other interesting facts your two compound graphs show about the expected *changes* to the world's urban population between 2000 and 2030.

HASS skills: Analysing

Checklist

I have:

- drawn in pencil
- ruled lines to clearly represent and communicate the data
- coloured according to a key
- included a scale
- provided the source of the data
- included a clear title
- clearly represented and communicated the data in my interpretation.

LESSON
1.13 SkillBuilder: Reading and describing basic choropleth maps

LEARNING INTENTION

By the end of this lesson you will be able to read, understand and describe a basic choropleth map.

1.13.1 Tell me

What is a basic choropleth map?

A basic choropleth map is a shaded or coloured map that shows the density or concentration of a particular aspect of an area. The key/legend shows the value of each shading or colouring. The darkest colours show the highest concentration, and the lightest colours show the lowest concentration.

Why are basic choropleth maps useful?

A basic choropleth map is used to show particular aspects in a pictorial way. They allow the viewer to quickly identify where the values are highest (darkest) and lowest (lightest) and note any patterns over space. However, the information is based on averages and precise data is not given for a particular place or region within the map. Areas can contain within them wide variations from the average value mapped. An atlas will have a wide range of choropleth maps.

Basic choropleth maps are useful for showing:
- differences between the highest and lowest concentrations of aspects
- average rainfall across a country
- average population densities per region
- average wealth per country
- average number of cars per household in local council areas.

A good description of a basic choropleth map is achieved if:
- an overall pattern is described
- the highest concentration is identified
- the lowest concentration is identified
- any anomalies are stated
- quantification is used wherever possible.

1.13.2 Show me

How to read and describe a basic choropleth map

You will need:
- a basic choropleth map.

Model

The population density across Brazil (see **FIGURE 1**) varies considerably from the coast to the inland regions. The population density is greatest (more than 100 people per square kilometre) along the Atlantic Ocean coast, especially in the largest cities. For a distance of about 700 kilometres from the coast, the population density is generally around 50 people per square kilometre. The large inland area of Brazil has a low population density of fewer than 10 people per square kilometre.

Procedure

Step 1

Read the title of the map to get an impression of what the map is going to show you. Check that the source of the information is a recognised authority. If the source is not stated, check the list of acknowledgements for the textbook to find out where the information came from.

Step 2

Read the key/legend. Check the units of measurement that are used. Think about the divisions that are used for colours. The darker the colour, the more intense or higher the value; similarly, the paler the colour, the less intense or lower the value. Cast your eye over the map, taking in the colours and trying to work out any general patterns that emerge.

FIGURE 1 Population density in Brazil

Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

Step 3

To interpret the colours, you need to comment on where the darkest colours or the more intense/higher values occur. Can you discuss the map by continent, or by region? For example, the highest density of people in Brazil occurs in the cities, such as São Paulo and Fortaleza, on the Atlantic Ocean coastline.

Step 4

To further interpret the colours, you need to comment on where the lightest colours or the least intense/lower values occur. Can you discuss the map by continent, or by region? For example, the lowest density of people in Brazil occurs in the large inland region, especially along and around the Amazon River and its tributaries.

Step 5

Are there any coloured areas that stand out from the rest as being unusual? That is, is there a colour among a mass of another colour that isn't expected? This is referred to as an anomaly, and needs to be discussed. Identify the place that is different from the surrounding area. For example, the population densities around Brasilia and Goiania are unusual because these appear to be isolated clusters of higher populations, whereas most of the surrounding area contains fewer than 10 people per square kilometre.

on Resources

Video eLesson SkillBuilder: Reading and describing basic choropleth maps (eles-1706)

Interactivity SkillBuilder: Reading and describing basic choropleth maps (int-3286)

1.13.3 Let me do it

Complete the following activity to practise this skill.

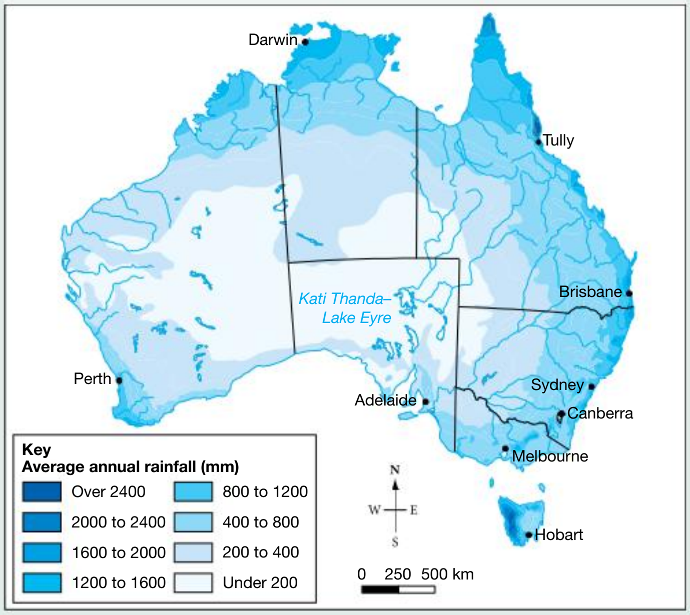
1.13 ACTIVITY

Read and interpret **FIGURE 2**, a basic choropleth map of Australia's annual rainfall distribution, by answering the following questions. Use the checklist to ensure you cover all aspects of the task.

a. Which region(s) of Australia has a pattern indicating the highest rainfall? Provide statistics or numbers (quantification) in your answer, such as percentage (%), size or area (square kilometres, km^2).
b. Which region(s) of Australia has a pattern indicating the lowest rainfall? Include quantification in your answer.
c. Are there any *places* that do not fit the expected pattern? State the locations of these anomalies.
d. Which Australian state receives the most rainfall?
e. Give two reasons for why large parts of Australia have low rainfall.

Geography concept: Interconnection

FIGURE 2 The distribution of annual rainfall in Australia



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

Checklist

I have:

- described an overall pattern
- identified the highest concentration
- identified the lowest concentration
- stated any anomalies
- used quantification wherever possible.

LESSON
1.14 SkillBuilder: Drawing a line graph using Excel

1.14.1 Tell me

What is a line graph?

A line graph is a clear method of displaying information so it can be easily understood. It is best used to show changes in data over time.

A line graph can be drawn by hand. In this SkillBuilder, you will develop your skills in constructing a line graph using Excel, which is a spreadsheet program. Using a digital means of drawing a line graph enables you to show multiple data sets clearly.

Why are line graphs useful?

A line graph is useful to help analyse data quickly and also to compare data. **FIGURE 1** shows five data sets and you can quickly see which two countries are the top producers of palm oil.

A good line graph has:

- time shown on the horizontal axis
- axes labelled
- a key, if necessary
- a clear title
- shown the source of the data.

1.14.2 Show me

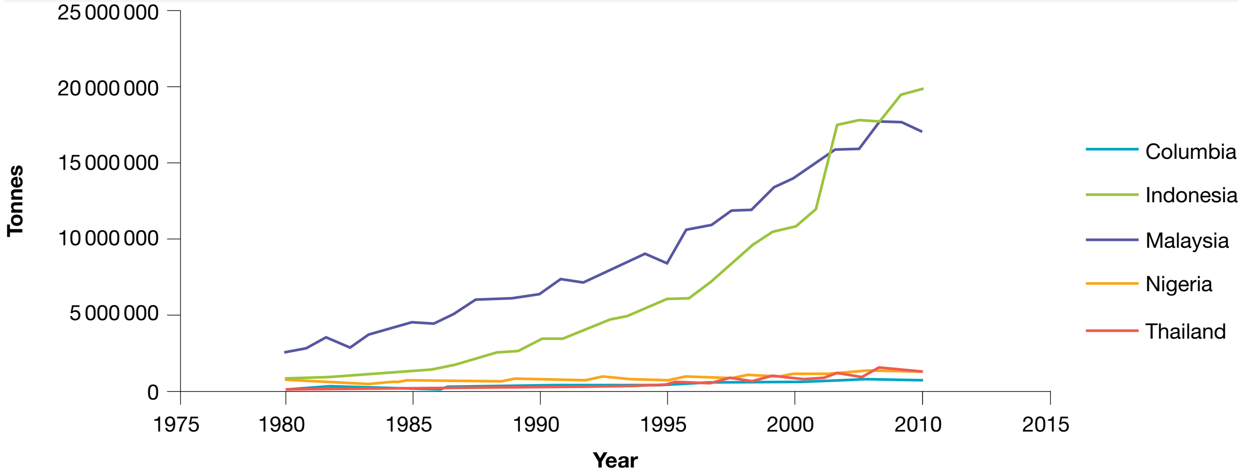
How to draw a line graph using Excel

You will need:

- Excel software
- a set of data.

Model

FIGURE 1 Production of palm oil for the top five producers (1980–2010)



Source: Food and Agriculture Organization of the United Nations 2012 FAOSTAT, http://faostat3.fao.org/home/ index.html

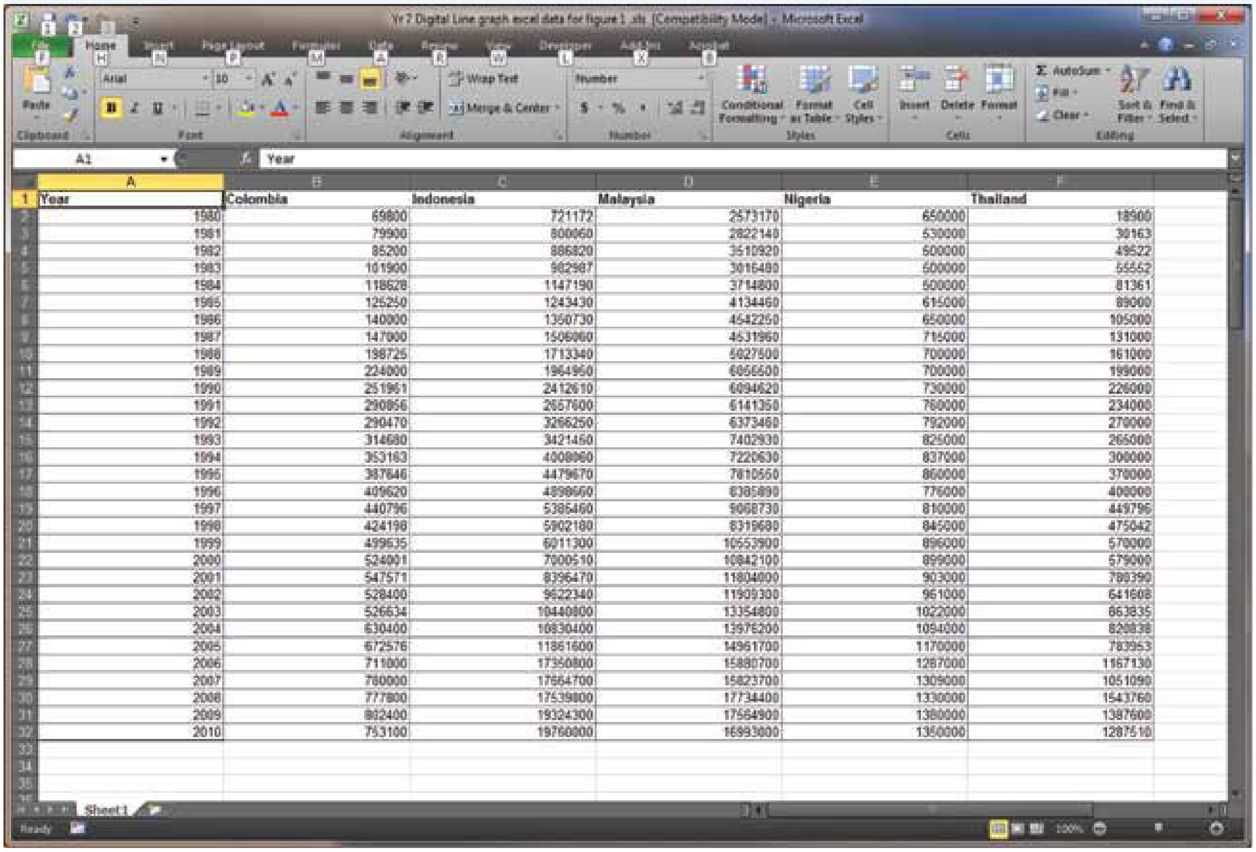
Procedure

Step 1

Enter the data into the Excel worksheet. Put time (hours, days, months or years) in column A and the other variable in column B. Do not leave blank rows or columns. Make sure each column has a heading to describe the data.

If there is more than one set of data, list the second data set in column C, and so on.

FIGURE 2 Data for the top five producers of palm oil (1980–2010) is entered in separate columns of an Excel worksheet.



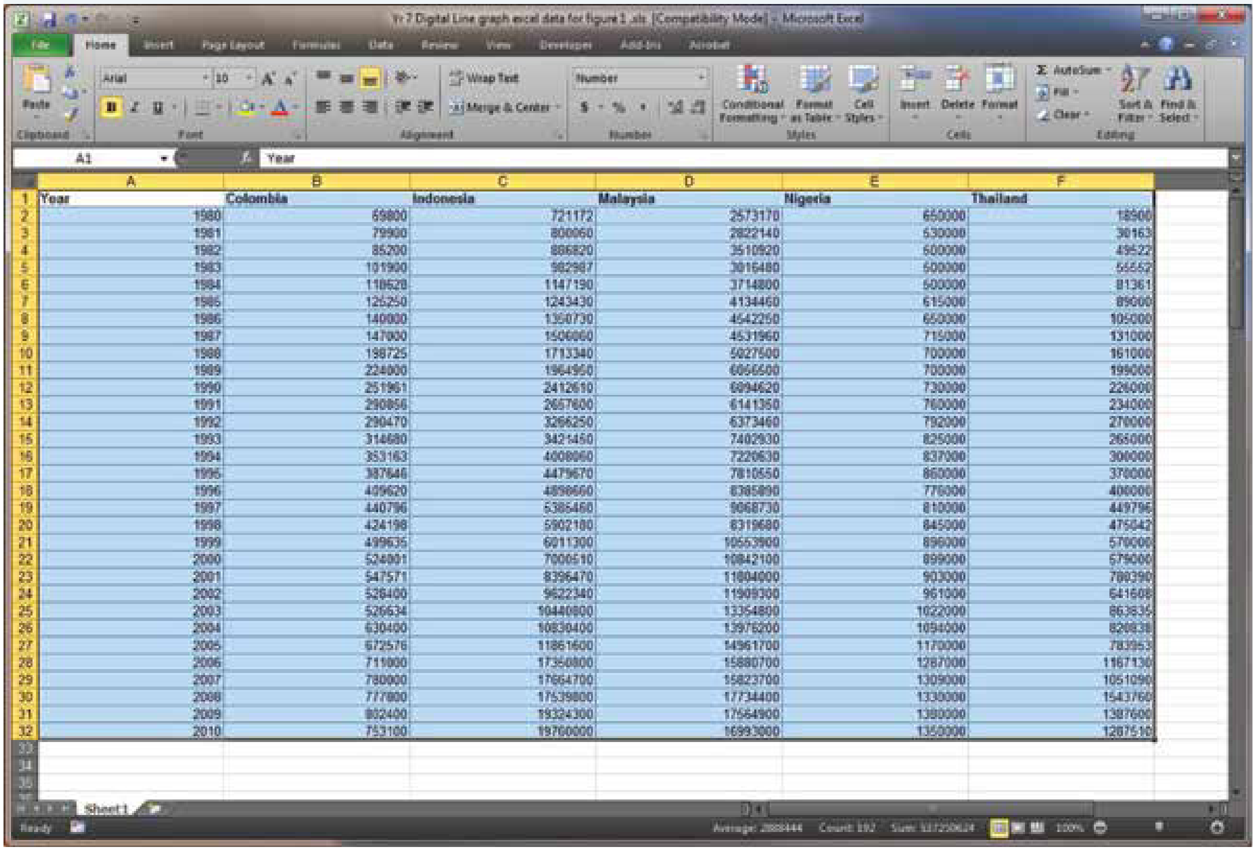
Year	Colombia	Indonesia	Malaysia	Nigeria	Thailand
1980	69800	721172	2573170	650000	18900
1981	79900	800060	2822140	530000	30163
1982	85200	886820	3510920	500000	49522
1983	101900	982987	3016480	500000	55552
1984	118628	1147190	3714800	500000	81361
1985	125250	1243430	4134460	615000	89000
1986	140000	1350730	4542250	650000	105000
1987	147000	1506060	4631960	715000	131000
1988	198725	1713340	5027500	700000	161000
1989	224000	1964950	6056500	700000	199000
1990	251961	2412610	6094620	730000	226000
1991	290856	2657600	6141350	760000	234000
1992	290470	3266250	6373460	792000	270000
1993	314680	3421450	7402930	825000	265000
1994	353163	4008060	7220630	837000	300000
1995	387646	4479670	7810550	860000	370000
1996	409620	4898660	8385890	776000	400000
1997	440796	5385460	9068730	810000	449796
1998	424198	5902180	8319680	845000	475042
1999	499635	6011300	10553900	896000	570000
2000	524001	7000510	10842100	899000	579000
2001	547571	8396470	11804000	903000	780390
2002	528400	9622340	11909300	961000	641608
2003	526634	10440800	13354800	1022000	663835
2004	630400	10830400	13976200	1094000	820838
2005	672576	11861600	14961700	1170000	783953
2006	711000	17350800	15880700	1287000	1167130
2007	780000	17664700	15823700	1309000	1051090
2008	777800	17539800	17734400	1330000	1543760
2009	802400	19324300	17564900	1380000	1387600
2010	753100	19760000	16993000	1350000	1287510

Step 2

Drag- select with the mouse button to highlight the cells containing the data to be included in your line graph.

Note: Make sure you select any column and row details (headings) that you want included in the graph.

FIGURE 3 The required data (all values in the example shown here) is selected.

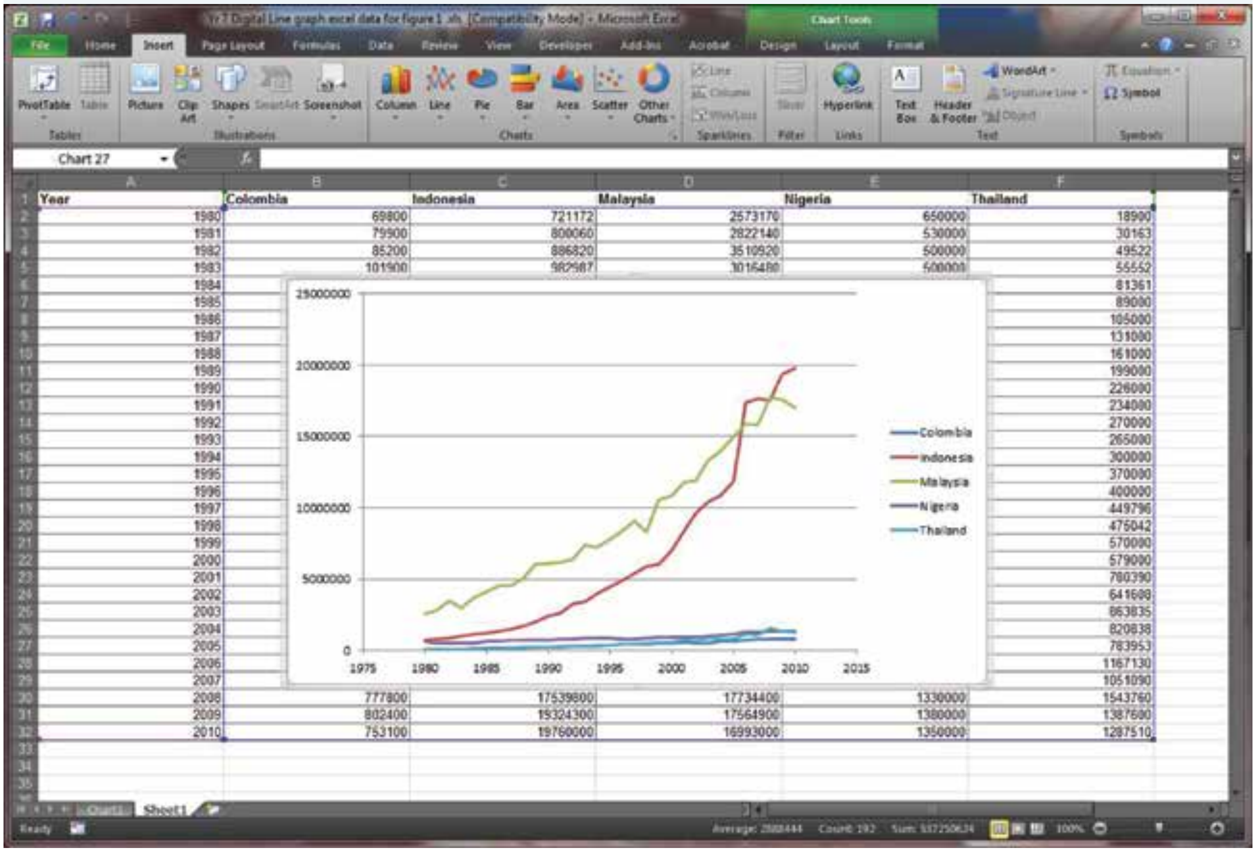


Year	Colombia	Indonesia	Malaysia	Nigeria	Thailand
1980	69800	721172	2573170	650000	18900
1981	79900	800060	2822140	630000	30163
1982	85200	886820	3510920	600000	49522
1983	101900	982987	3016480	500000	55552
1984	118628	1147190	3714800	500000	81361
1985	125250	1243430	4134460	615000	89000
1986	140000	1350730	4542250	650000	105000
1987	147000	1506060	4531960	715000	131000
1988	198725	1713340	5027500	700000	161000
1989	224000	1964950	6066500	700000	199000
1990	251961	2412610	6094620	730000	226000
1991	290856	2657600	6141350	760000	234000
1992	290470	3266250	6373460	792000	270000
1993	314680	3421450	7402930	825000	266000
1994	353163	4008060	7220630	837000	300000
1995	387646	4479670	7810550	860000	370000
1996	409620	4898660	8385890	776000	400000
1997	440796	5386460	9068730	810000	449796
1998	424198	5902180	8319680	845000	475042
1999	499635	6011300	10553900	896000	570000
2000	524001	7000510	10842100	899000	579000
2001	547571	8396470	11804000	903000	780390
2002	528400	9622340	11909300	961000	641608
2003	526634	10440800	13354800	1022000	863835
2004	630400	10830400	13976200	1094000	820838
2005	672576	11861600	14961700	1170000	783953
2006	711000	17360800	15880700	1287000	1167130
2007	780000	17664700	15823700	1309000	1051090
2008	777800	17539800	17734400	1330000	1543760
2009	802400	19324300	17564900	1380000	1387600
2010	753100	19760000	16993000	1350000	1287510

Step 3

Click on the 'Insert' tab, then click on a category in the 'Charts' section to open a drop-down list of available graph types. Hover your mouse pointer over a graph type to bring up a description of the graph. Click on the 'Scattergraph' category and select the 'Scatter with Straight Lines' option. A line graph is created and placed on your worksheet. You can change the graph style using the tabs within the 'Chart Tools' section.

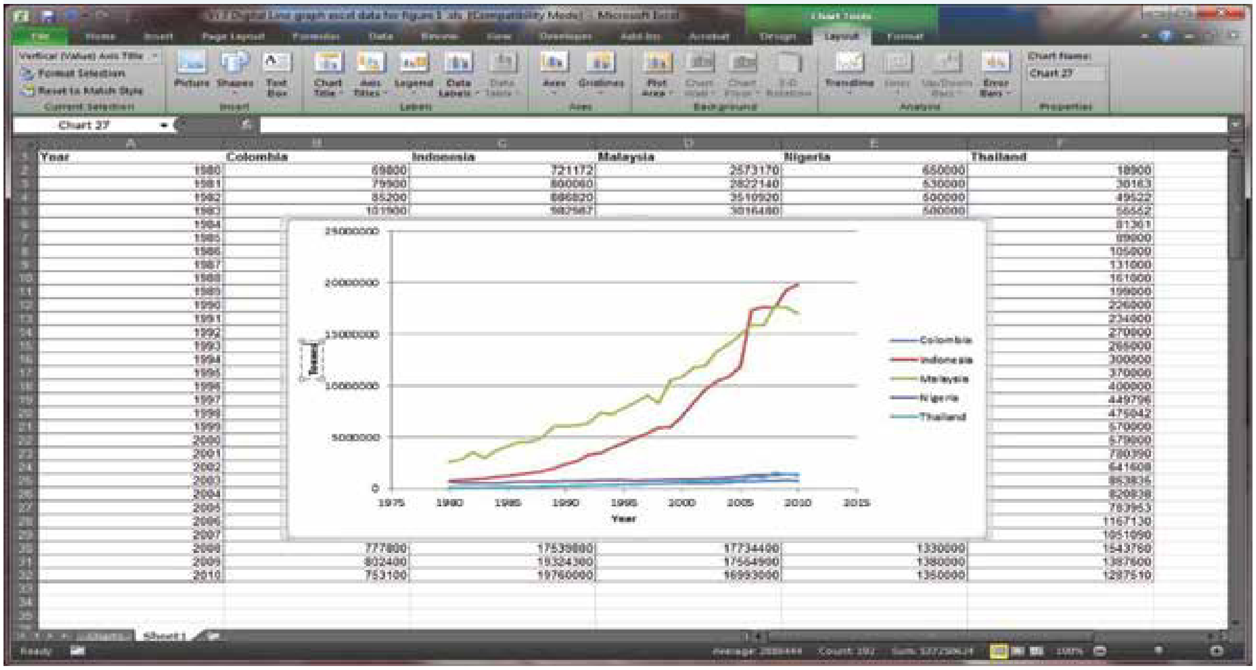
FIGURE 4 Select the 'Scatter with Straight Lines' option to produce a graph with a line for each of the variables in your data set.



Step 4

Label the axes. Click on the ‘Layout’ tab within the ‘Chart Tools’ section. Select ‘Axis Titles’ and enter the axis names for the horizontal and vertical axes.

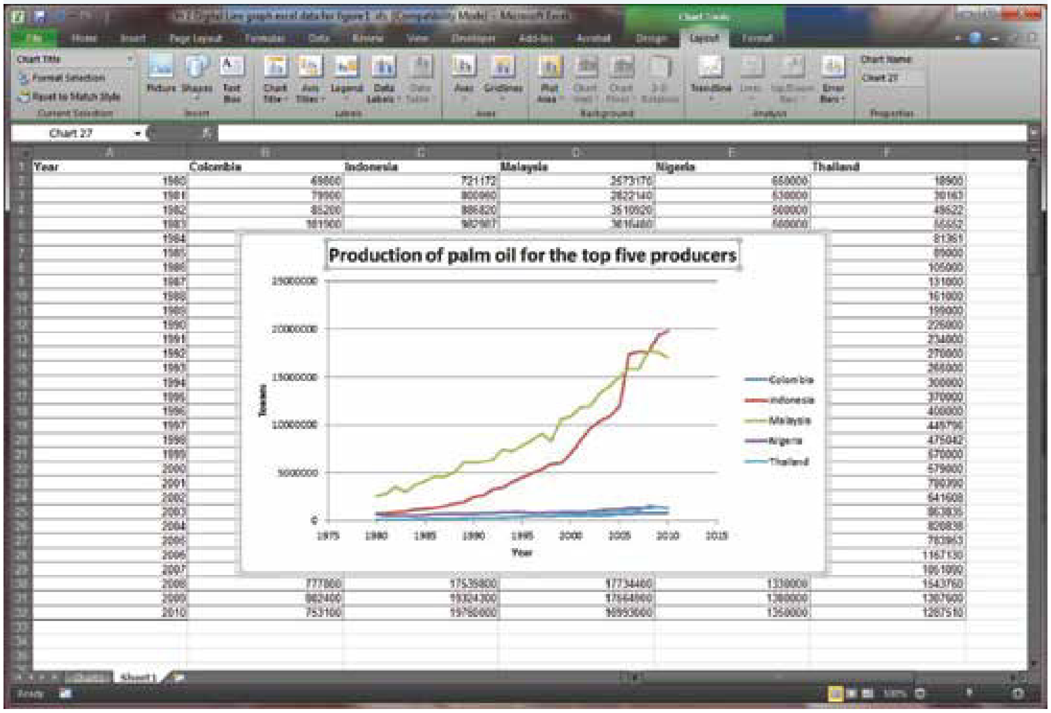
FIGURE 5 Label the axes on your graph.



Step 5

To add a title to the line graph, click on the ‘Layout’ tab within the ‘Chart Tools’ section. Select ‘Chart Title’ and choose the option ‘Above Chart’ for placement of your title. Type an appropriate title for your graph in the text box that appears.

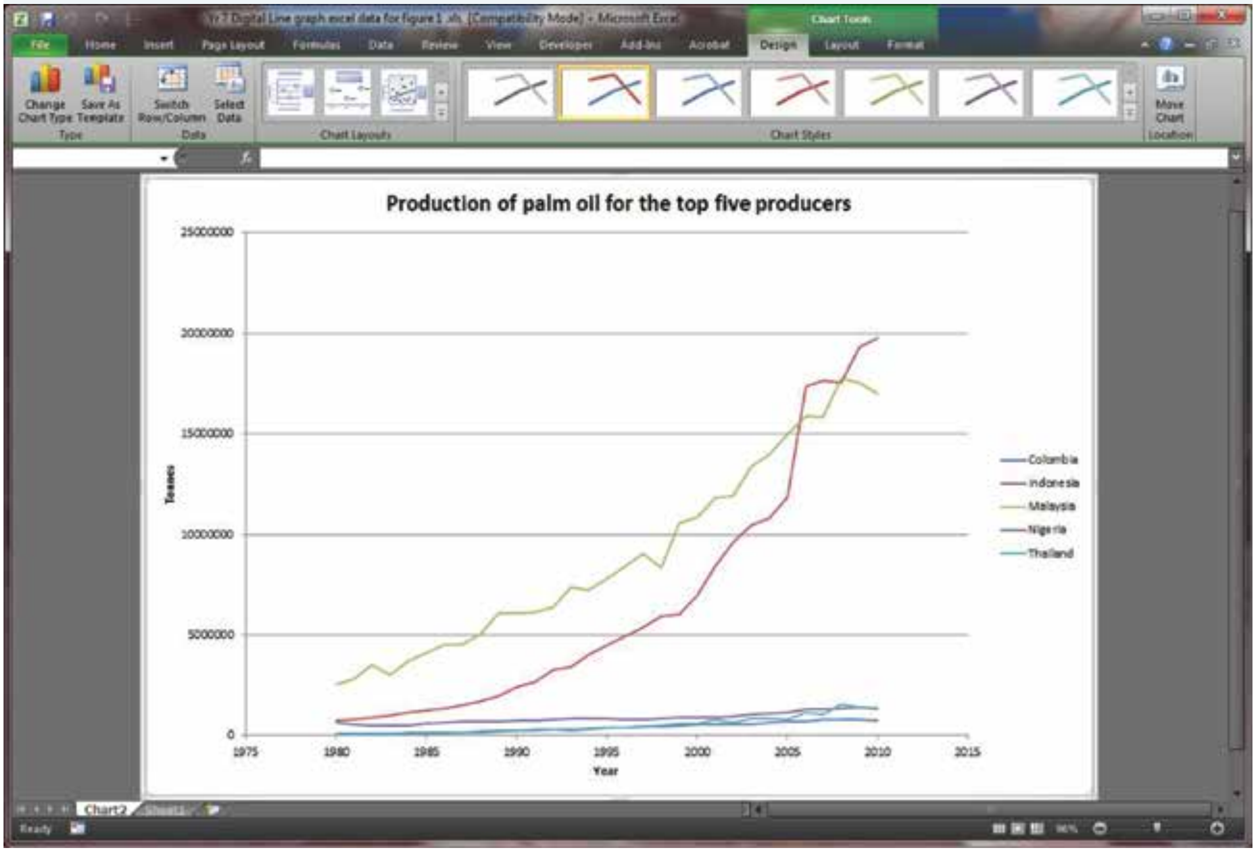
FIGURE 6 Add a title to your graph.



Step 6

Select the ‘Design’ tab within the ‘Chart Tools’ section. Click on the ‘Move Chart’ button on the right. This places your chart on a new page within your spreadsheet.

FIGURE 7 Move your graph onto its own page within the spreadsheet.

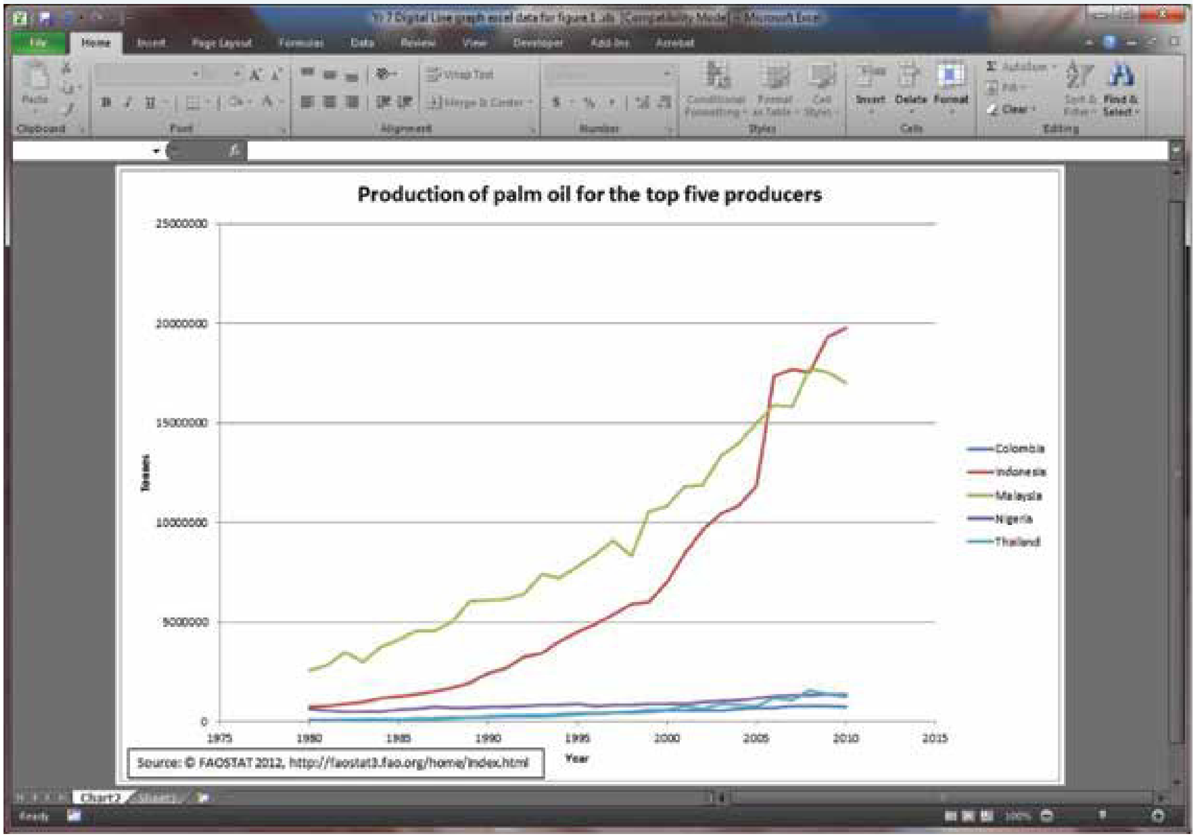


Step 7

Add the source of the data. One way to add this kind of extra information is to use a text box.

Select the chart. Click on the 'Insert' tab and select 'Text Box'. Drag your cursor to draw a text box of an appropriate size, and enter the details of the source of your data. Format your text to a suitable size and style, and move the text box to an area where it does not interfere with the reading of the graph.

FIGURE 8 Include source details for the data you have used in your graph.



on Resources

Video eLesson Drawing a line graph using Excel (eles-1662)

Interactivity Drawing a line graph using Excel (int-3158)

1.14.3 Let me do it

Complete the following activities to practise this skill.

1.14 ACTIVITIES

1. Use the data shown in **TABLE 1** to create a line graph using Excel.
2. Analyse your graph to answer the following questions.
   a. What unit of measurement is used in this graph?
   b. Describe the general trend of palm oil production from 1985 to 2010.
   c. Suggest two possible causes for the change in palm oil production in 1998.
   d. What has happened to palm oil production since 2008?

Checklist

I have:

- shown time on the horizontal axis
- labelled the axes
- included a key, if necessary
- provided a clear title and source information.

TABLE 1 Palm oil production in Malaysia, 1980–2010

Year	Tonnes of palm oil produced
1985	4 134 460
1986	4 542 250
1987	4 531 960
1988	5 027 500
1989	6 056 500
1990	6 094 620
1991	6 141 350
1992	6 373 460
1993	7 402 930
1994	7 220 630
1995	7 810 550
1996	8 385 890
1997	9 068 730
1998	8 319 680
1999	10 553 900
2000	10 842 100
2001	11 804 000
2002	11 909 300
2003	13 354 800
2004	13 976 200
2005	14 961 700
2006	15 880 700
2007	15 823 700
2008	17 734 400
2009	17 564 900
2010	16 993 000

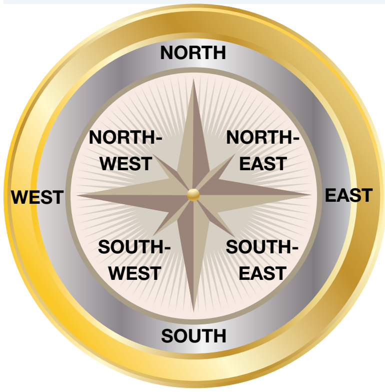
LESSON
1.15 SkillBuilder: Using positional language

1.15.1 Tell me

What is positional language?

Positional language uses compass points to locate places and provide directions between places. A magnetic compass will always point to north. All other directions are taken from this reference point. An 8-point compass — with points north, north-east, east, south-east, south, south-west, west, and north-west — is standard in most Geography books and atlases. A 16-point compass provides even further detail.

FIGURE 1 An eight-point compass



Why is positional language useful?

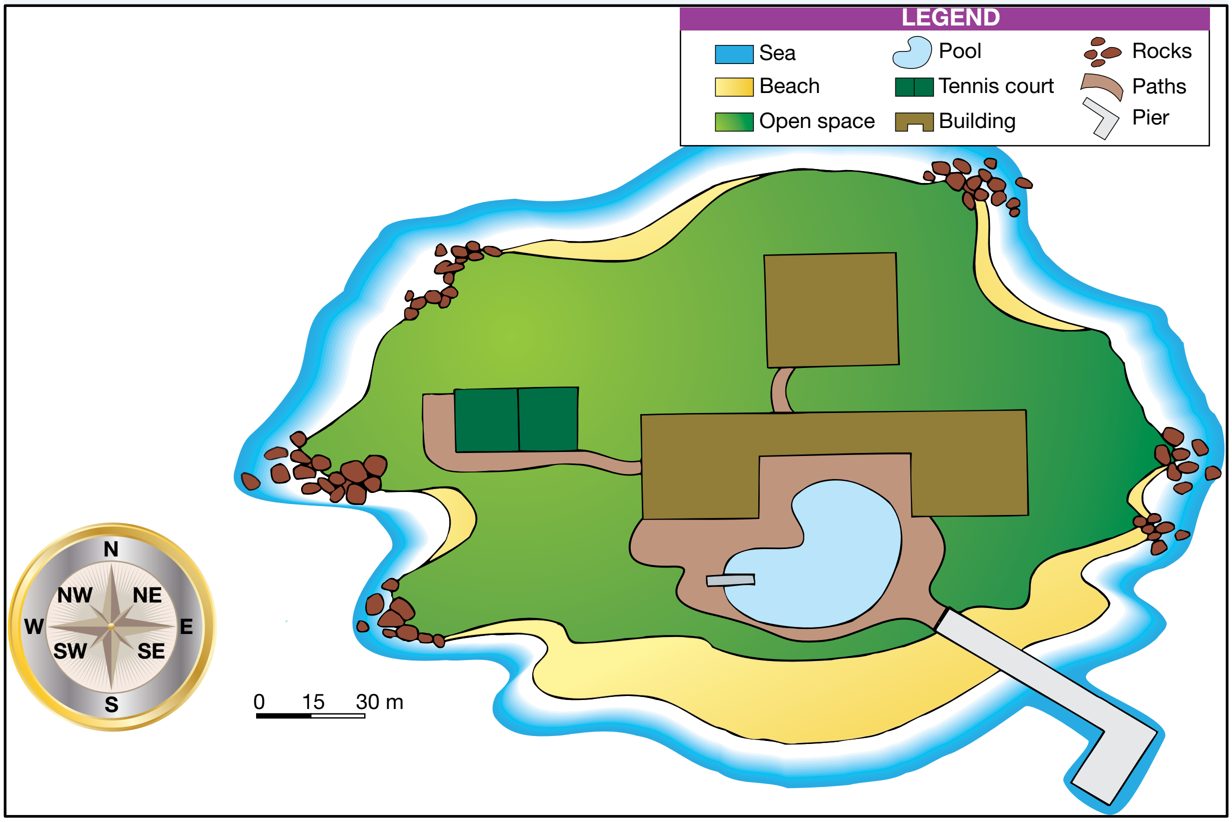
Positional language allows geographers to be accurate when giving directions and locations of places. It avoids the confusion that can occur with positioning if words such as left and right, up and down, top and bottom are used. No matter what direction you are facing, compass direction always remains the same, based around north.

1.15.2 Show me

How to use positional language

Model

FIGURE 2 A cartographer's map of Holiday Island



As we check in at the main building for our stay on Holiday Island, a guide explains the features of the holiday resort.

'You arrived at the pier, which is to our south-east. On the way to this building you passed the paved poolside area, which is now to your south. There are four beach areas — the largest is to the south, a small moon-shaped beach is to the west-south-west and the other beaches are to the north-north-west and north-east across the open spaces. To the . . . '

You will need:

- a map (use **FIGURE 3**)
- a pencil
- tracing paper.

Procedure

Practise using the positional language of a 16-point compass with any type of map, such as in an atlas, a street map, a topographic map, a plan, a sketch, or an image such as aerial or oblique photos and satellite images.

Step 1

On the piece of tracing paper, draw a simple 16-point compass based on **FIGURE 1**. You will need to add the following points: NNE, ENE, NNW, WNW, SSE, ESE, SSW, WSW. Ensure that you mark the centre of the compass with a dot.

Step 2

Place the centre of the 16-point compass (the dot) on the point of origin from which a direction is being given. Ensure that north is in the vertical position. On all maps/images, unless an indicator determines otherwise, north is assumed to be vertical (i.e. pointing to the top).

For example, to discover that place A is north-north-west of place B, the direction is taken from place B, so the centre of the compass should be on place B.

Step 3

Read the compass direction from the centre dot to the place identified and write down that direction.

Step 4

The placement of the centre of the compass must be moved for each individual direction required.

on Resources

Video eLesson How to use positional language (eles-1649)
Interactivity Using positional language (int-3145)

1.15.3 Let me do it

Complete the following activities to practise this skill.

1.15 ACTIVITIES

1. The completed example in **TABLE 1** uses the map in **FIGURE 3** to show directions from one place to another place.

   In this example, you are at Kakadu National Park and you want to give a direction so that someone arrives at Litchfield National Park.

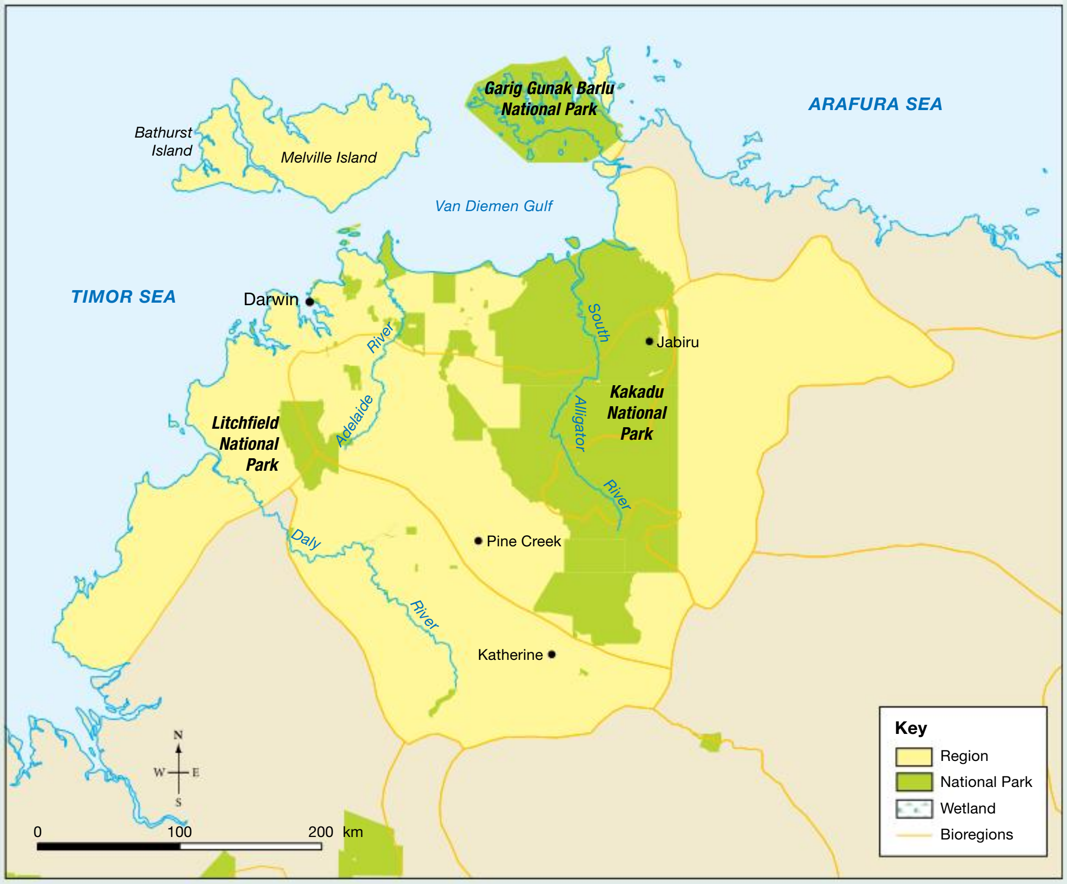
   Copy the table below into your workbook. Using the map and your tracing paper compass, create five more examples of positional language in the table. Ensure that you use a range of directions from your 16-point compass.

TABLE 4 Examples of positional language

Place of origin	Place of arrival	Direction
Kakadu National Park	Litchfield National Park	West

Ask a class member to check your directions.

FIGURE 46 Map of Kakadu National Park



Source: Spatial Vision

2. Apply your skills to answer the following questions.
   a. In which direction from Katherine would you need to fly to get to Kakadu National Park?
   b. In what direction is Jabiru in Kakadu National Park from Darwin?
   c. In what direction is Jabiru from Pine Creek?
   d. If I was to drive from Katherine in a north-west direction, would I arrive in Jabiru or Darwin?
   e. I want to drive from Pine Creek to Jabiru. Describe the directions in which I would need to travel while on the road.

Checklist

I have:

- drawn and labelled an accurate 16-point compass
- used the compass to indicate direction using positional language.

LESSON
1.16 SkillBuilder: Constructing a field sketch

1.16.1 Tell me

What are field sketches?

Field sketches are drawings completed during fieldwork — Geography outside the classroom. Field sketches allow a geographer to capture the main aspects of landscapes in order to edit the view, focusing on the important features and omitting the unnecessary information. Field sketches are free-hand drawings with annotations. Colour may be added but is not a requirement. A field sketch aids our sense of observation and allows us to record and interpret environments.

Why are field sketches useful?

Field sketches capture the important information. You might think it is easier to take an image on your phone or with a camera, but you are then capturing the non-relevant data as well. By making a drawing in the field you are interpreting the environment, analysing the landscape and highlighting a geographical understanding of what you see by careful and clear labelling.

A good field sketch has:

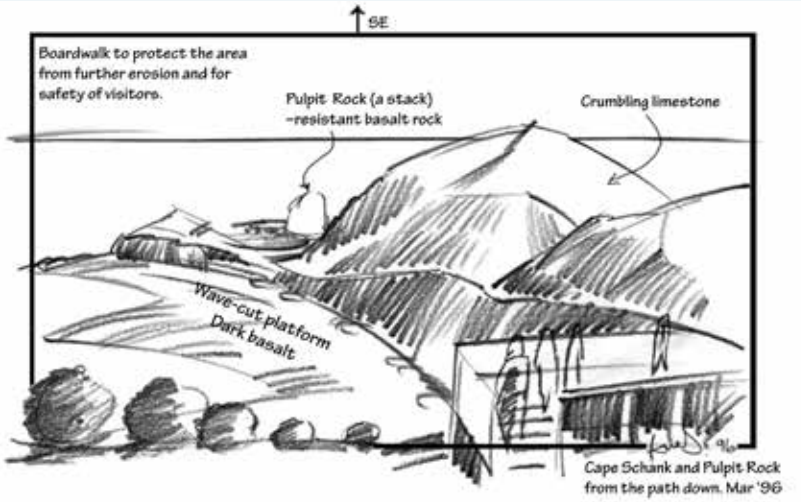
- been completed on plain paper
- been drawn in pencil
- a title
- a date
- labels of key features
- an indicator to show direction
- shading.

1.16.2 Show me

How to construct a field sketch

Model

FIGURE 1 Field sketch of Cape Schanck



Source: © Geography Teachers' Association of Victoria Inc. *Interaction*, journal of the GTAV, June 1998. Illustration redrawn by Harry Slaghekke.

You will need:

- plain paper
- a clipboard
- a grey pencil (soft)
- a ruler
- an eraser.

Procedure

FIGURE 1 is an example of a coastal field sketch. Obviously, to complete a coastal field sketch you need to be in a coastal environment, but any environment can be sketched — natural or human-altered. You can choose an environment near you.

Step 1

Choose the field of view to be sketched; that is, 'from this tree to that bend in the stairs'. Make yourself comfortable because you'll need to stay in the one place while you complete the sketch.

Step 2

Partly close your eyes so that you are peeking at the world — all the small details will disappear and your eyes will focus on the main outlines, which are the first parts to be drawn. Practise viewing the environment.

Step 3

Attach your paper securely to the clipboard because wind plays havoc with field sketching! Using a pencil, draw a border (frame) in which you are going to sketch. Always draw in pencil and keep your eraser handy.

Step 4

Draw in the horizon as a baseline; that is, where the land meets the sky.

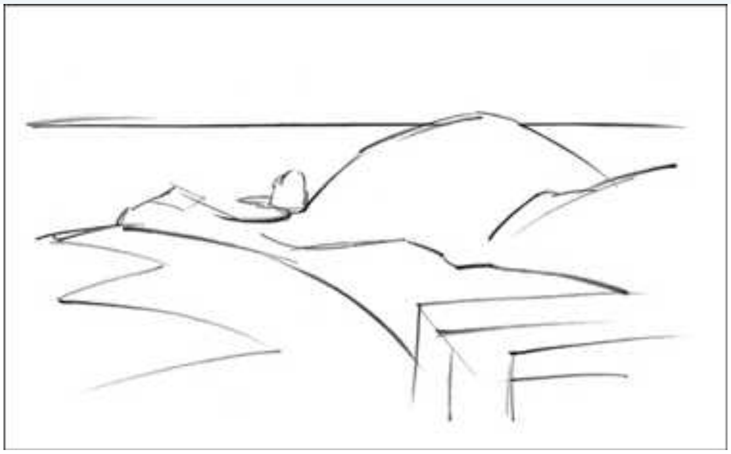
Step 5

Divide your sketch horizontally into three portions: background, middle- ground and foreground (what is closest to you).

Step 6

Peek at the landscape through partly closed eyes and now add the main outlines to your sketch. Start with main features in the background (most distant), then middle-ground and lastly foreground. There will be a few shapes on your page, but no detail (see **FIGURE 2**).

FIGURE 2 Initial outline



Source: © Geography Teachers' Association of Victoria Inc. *Interaction*, journal of the GTAV, June 1998. Illustration redrawn by Harry Slaghekke.

Step 7

Using this base you can now add details and shading. Identify those aspects that are relevant to your study. In this coastal example, there are natural features — a wave-cut platform, a stack, a headland and limestone ridges — and a human feature, the boardwalk.

FIGURE 3 Further detail shading

Source: © Geography Teachers' Association of Victoria Inc. *Interaction*, journal of the GTAV, June 1998. Illustration redrawn by Harry Slaghekke.

Step 8

Annotate (label) your sketch to draw attention to the landscape features. Ask yourself what the connection is between the natural features and the human-altered features. Can your labelling assist in making this interconnection clear to those who view your field sketch?

Step 9

Add the finishing touches.

- On the border, add a direction indicator as to which way you are looking at the landscape.
- Title your sketch — identify the place with as much detail as possible.
- Date your drawing.

FIGURE 1 shows the completed field sketch with all features added.

on Resources

Video eLesson	Constructing a field sketch (eles-1650)
Interactivity	Constructing a field sketch (int-3146)

1.16.3 Let me do it

Complete the following activities to practise this skill.

1.16 ACTIVITIES

1. Your teacher may take the class into the school grounds and ask you to do a field sketch of an area within the school boundary, or you may be able to view an *environment* beyond the fence line.
   OR
   At home, select a street view or a garden view and complete an annotated field sketch. Use the checklist to ensure you cover all aspects of the task.
2. Study your field sketch and consider the *environment* to answer the following questions.
   a. What natural features have been labelled in the field sketch?
   b. What human-altered features have been labelled in the field sketch?
   c. Is there any *interconnectedness* between the natural *environment* and human activities?
   d. How do your five senses respond to this *environment*?
   e. How might this *place change* in the future?

Checklist

I have:

- drawn a border
- added a compass direction
- titled the sketch
- dated the sketch
- shaded to give depth
- clearly labelled the significant aspects.

LESSON
1.17 SkillBuilder: Creating and describing complex overlay maps

1.17.1 Tell me

What is a complex overlay map?

A complex overlay map is created when one or more maps of the same area are laid over one another to show similarities and differences between the mapped information. All maps must be at the same scale. Laid over a base map with information that is consistent (for example, landforms), traced copies of maps showing variables (for example, population) allow you to see the elements underneath. Traditionally, the second map is on tracing paper that is attached to the original map.

Why are complex overlay maps useful?

Complex overlay maps are analysed to show relationships between factors — the similarities and the differences in a pattern. They are useful when looking for the degree to which features are arranged in a similar pattern. In a complex overlay map there may be three or more layers, allowing three or more variables to be compared. Complex overlay maps also help you work out between which features there is the strongest or weakest relationship or interconnection.

In today's world of computers, geographic information system (GIS) programs do this task. Digitally, layers can be turned 'off' and 'on' to show the interconnection between factors in a distribution pattern.

Complex overlay maps are useful for:

- town planners to see new settlement patterns overlaid on the land's shape
- construction engineers to see original buildings and the interconnection of extensions to a building
- logistic engineers to overlay the distribution of a number of features to identify similarities
- farmers to seek alternative planting rotations with an increased knowledge of the features involved, such as soil types, rainfall and topography.

A good series of complex overlay maps has:

- been drawn in pencil first, then coloured
- been drawn in light colours, so that the base map remains clear
- a key on each overlay, offset so each can be seen
- been accurately taped together so the maps overlap exactly
- labelled features, if necessary
- included BOLTSS.

A clear description of complex overlay maps has:

- identified and communicated key features
- clearly represented and communicated the data.

1.17.2 Show me

How to create and describe a complex overlay map

You will need:

- three maps of the same region at the same scale showing different information (one to be a base map)
- one of these maps to act as a base map
- two pieces of tracing paper, at least as large as the base map
- a light grey pencil and coloured pencils
- a ruler
- an eraser
- adhesive tape.

Model

FIGURE 1 An illustration of a completed complex overlay map showing Australia's seasonal rainfall patterns (left), drainage catchments (centre) and average annual rainfall (right)

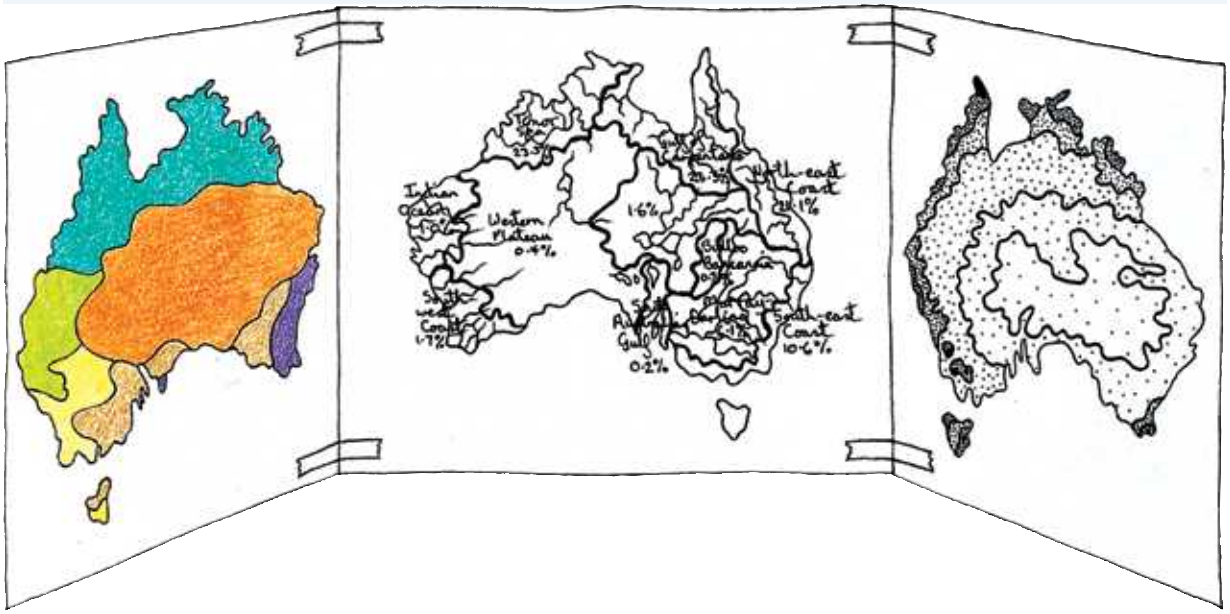


FIGURE 1 shows a map of Australia's drainage catchments used as the base map (centre) in a complex overlay. Taped to this on tracing paper is a map of Australia's average annual rainfall (shown at right in **FIGURE 1**), attached so as to be able to fold onto the base map. Taped to the opposite side of the base map is a map of Australia's seasonal rainfall patterns (shown at left in **FIGURE 1**). This is also attached so as to be able to fold onto the base map. Additional layers could be added by taping further maps (drawn on tracing paper) to the top and bottom of the base map.

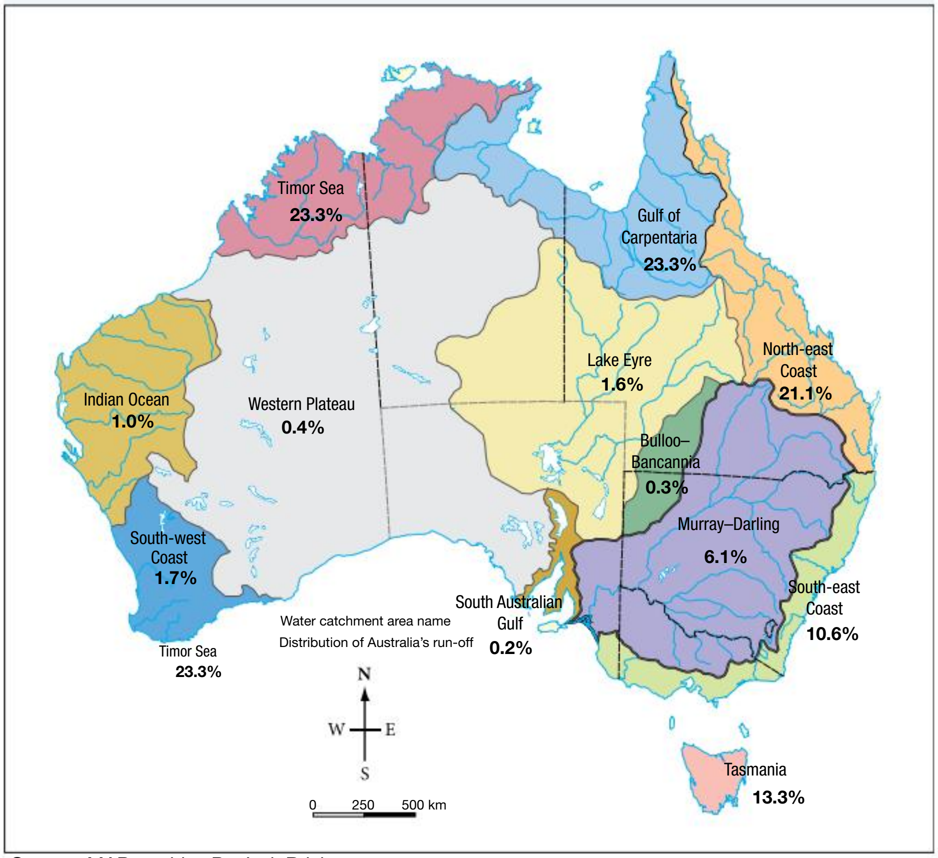
This series of map overlays provides an example of interconnection; in this case, the interconnection between annual rainfall and seasonal rainfall, between annual rainfall and drainage catchments, and between seasonal rainfall and drainage catchments.

Further analysis is required to show areas that are not connected and areas that are sometimes related, but not always. For example, the Murray–Darling Basin drainage catchment has a wide range of seasonal rainfall patterns across its area, varying from uniform rainfall to arid zones.

Procedure

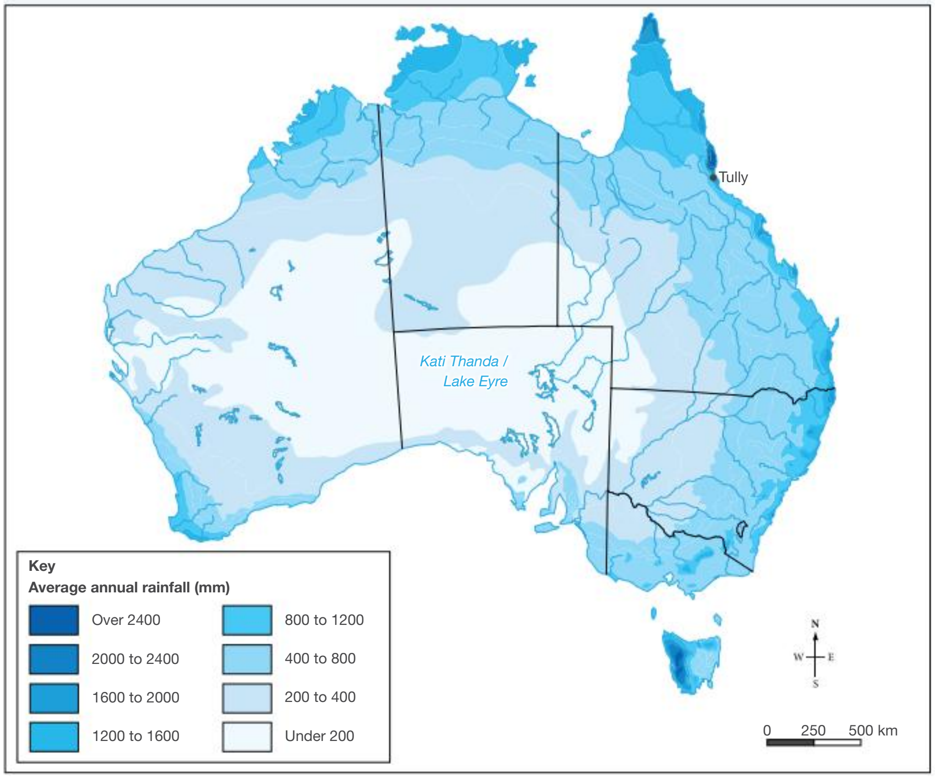
To complete and describe complex overlay maps you must have two or more maps of the same place and at the same scale with different information. For this example, we will use maps showing Australia's drainage catchments (**FIGURE 2a**), Australia's average annual rainfall (**FIGURE 2b**) and Australia's seasonal rainfall patterns (**FIGURE 2c**).

FIGURE 2(a) Australia's drainage catchments



Source: MAPgraphics Pty Ltd, Brisbane

FIGURE 2(b) Australia's average annual rainfall



Source: Bureau of Meteorology, 2003, on the Australian Water Map, Earth Systems Pty Ltd

Step 1

Select the base map — this will show information that is unlikely to vary. In this instance, it is the drainage catchments. You may need to trace the base map if it appears in a book, because it might not be possible to stick other maps to the original.

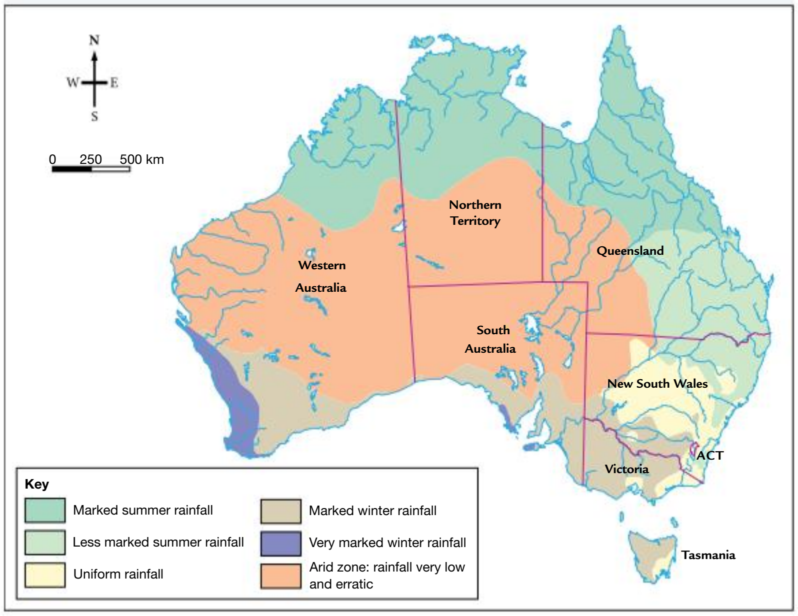
Step 2

Trace each of the other maps onto separate sheets of tracing paper. Don't forget to include BOLTSS on your maps. Each map should have its own title, its own key and its own source. The scale and north pointer need to appear only on the base map.

Step 3

Using adhesive tape, hinge the maps to fold on top of each other so that the map outlines (coastlines) match up. Alignment is very important, so choose obvious borders to line up. **FIGURE 3** shows the second map hinged to the right of the base map. **FIGURE 4** shows the third map added, hinged to the left of the base map.

FIGURE 2(c) Australia's seasonal rainfall patterns



Source: MAPgraphics Pty Ltd, Brisbane

FIGURE 3 Hinged map (first overlay) over base map

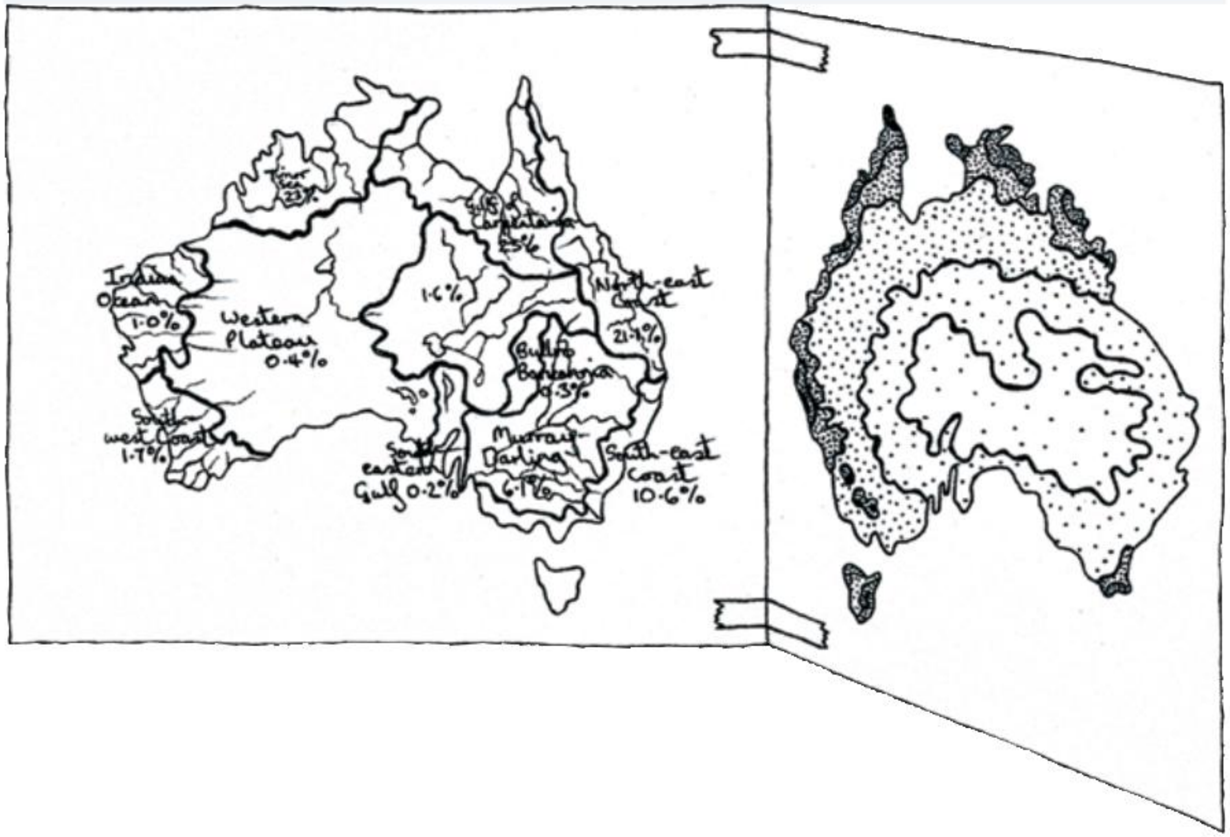
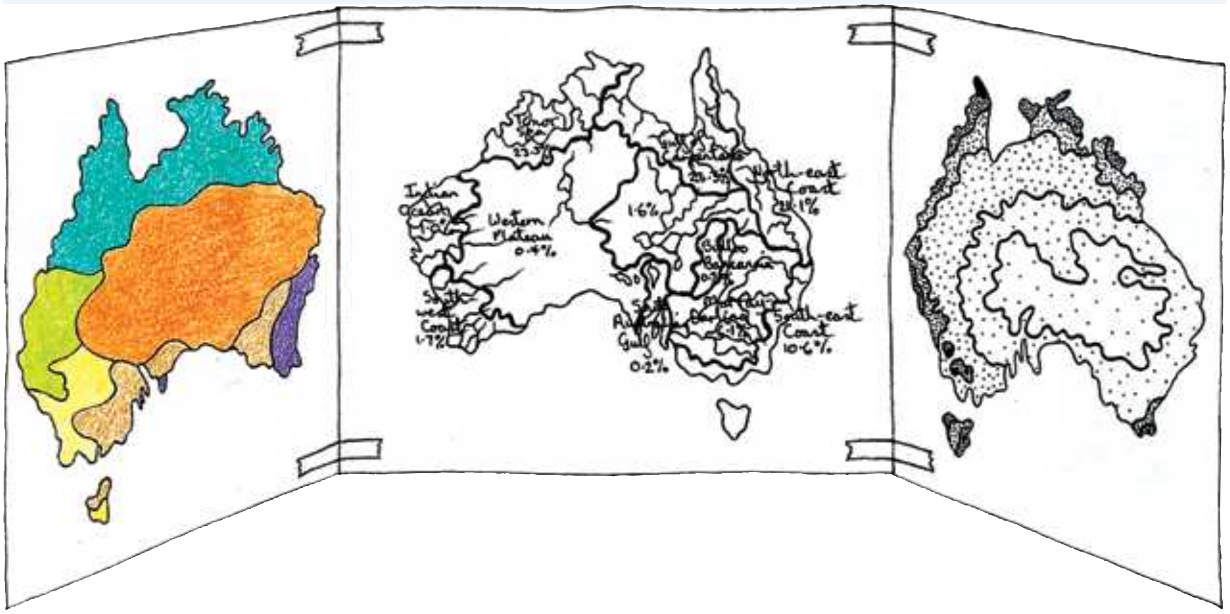


FIGURE 53 Two maps hinged to a base map, forming a complete overlay map shown prior to folding



Step 4

You are now able to lift each map separately from the others to see the information individually, or view two or more maps combined.

Step 5

To analyse the information that the overlay maps show, you should comment on where there is a relationship or interconnection of features. Lay any two maps together and identify any similar patterns. Write a sentence about these similarities. Then lay all three maps together, identify any similar patterns and write a sentence about these. An example is that the area with less than 400 mm of rainfall forms the arid zone, with erratic rainfall across the Western Plateau and Lake Eyre catchments.

Step 6

Next, look for significant differences across two maps. Write a sentence about these differences. Then look for significant differences across the three maps and write a sentence about these. For example, the very marked winter rainfall in south-west Western Australia does not produce greater annual rainfall than that in western Tasmania and near Tully, Queensland.

Step 7

Now go through the process again looking for unusual occurrences; that is, where things appear random and show no interconnection. An example is that the Murray–Darling Basin drainage catchment has a wide range of seasonal rainfall patterns across its area, varying from uniform rainfall to arid zones.

on Resources

Video eLesson	Creating and describing complex overlay maps (eles-1656)
Interactivity	Creating and describing complex overlay maps (int-3152)

1.17.3 Let me do it

Complete the following activities to practise this skill.

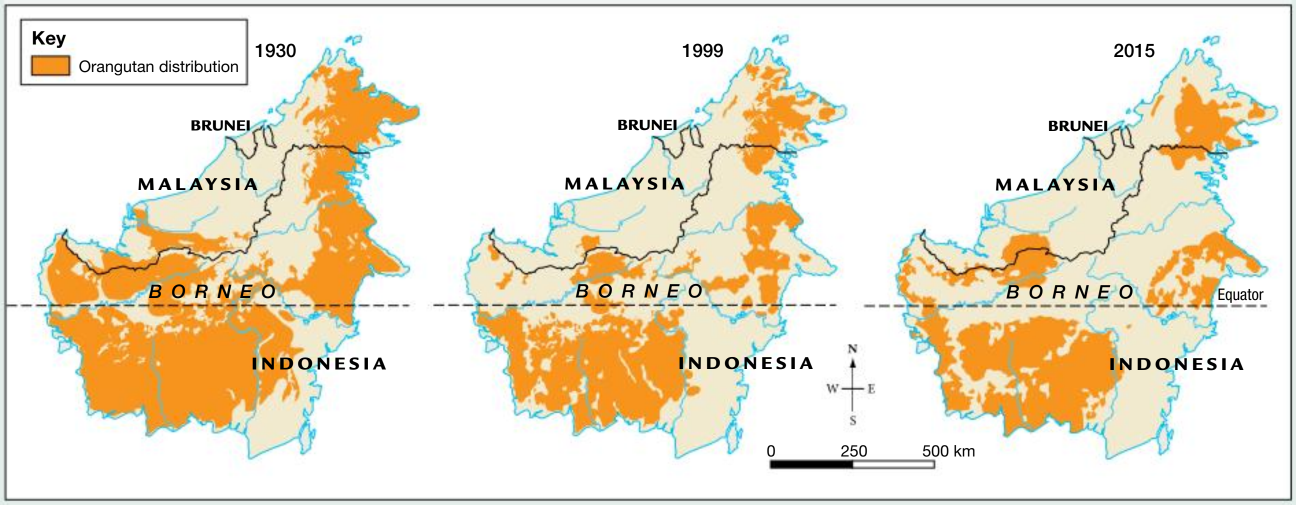
1.17 ACTIVITIES

1. Use **FIGURE 5**, which shows the topography of Borneo, and **FIGURES 6** and **7**, which show orangutan distribution in 2015 and rainforest distribution in 2020. Create an overlay map to show the ***interconnection*** between topography, rainforest distribution and orangutan distribution. Use the checklist to ensure you cover all aspects of the task correctly.
   Note: You will need to make your base map (from **FIGURE 5**) to the same scale as **FIGURE 6** and **7**. To do this, draw a 3 × 3 grid over the base map, then draw a smaller 3 × 3 grid on a piece of paper — this new grid should be the same size as **FIGURES 6** and **7**. Working one grid square at a time, sketch a copy of the base map into the new smaller grid.
2. Apply your skills in describing a complex overlay map by answering the following questions.
   a. Is there a pattern (relationship or ***interconnection***) between the location of the highest land and rainforest distribution in Borneo?
   b. Is there a pattern (relationship or ***interconnection***) between the location of rainforests and the distribution of orangutans in Borneo?
   c. Are there any areas in Borneo where there is no relationship between rainforest distribution and orangutan numbers?
   d. On what type of land might rainforests be found in the future?
   e. Between which of the following two features is the strongest relationship?
      - High land and rainforest distribution
      - High land and distribution of orangutans
      - Rainforest distribution and the orangutan population.
   f. What would explain this strong relationship?

FIGURE 5 Topography of Borneo

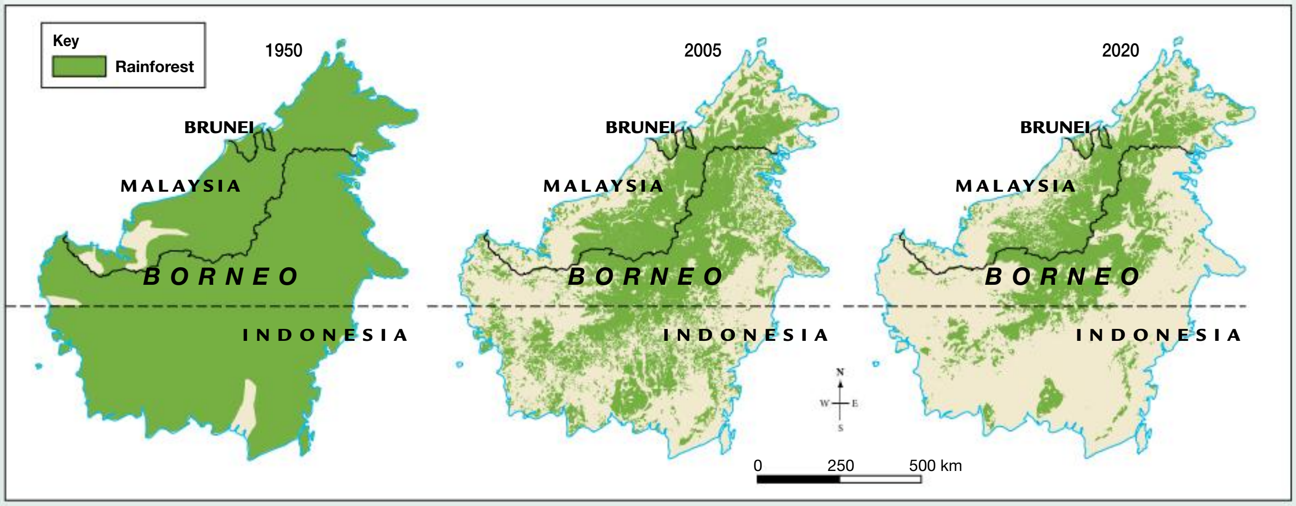
Source: Spatial Vision

FIGURE 6 Orangutan distribution in Borneo, 1930–2015



Source: IUCN Red list

FIGURE 7 Rainforest distribution in Borneo, 1950–2020



Source: Spatial Vision

Checklist

In creating my complex overlay map, I have:

- drawn in pencil first, then coloured
- used light colours, so that the base map remains clear
- placed a key on each overlay, but offset it so each can be seen
- created hinges with adhesive tape at appropriate spots
- labelled features, if necessary
- included BOLTSS.

In describing my complex overlay map, I have:

- identified and communicated key features
- clearly represented and communicated the data.

LESSON
1.18 SkillBuilder: Drawing a précis map

1.18.1 Tell me

What is a précis map?

A précis map is a simplified map — the cartographer has decided which details to leave in and which to leave out. It is different from a sketch map, which includes all the main features.

Why are précis maps useful?

A précis map is a summary of an area. There may be just one feature shown, such as rainforest. Sometimes more features are shown, such as vegetation, urban areas and roads.

They are useful for:

- identifying a particular feature or features, such as rainforests or residential/industrial areas of a city
- close examination of a particular feature
- focusing the reader's attention on a feature, such as the distribution of a plant species
- showing or including detail not visible on a satellite image or aerial photograph.

A good précis map has:

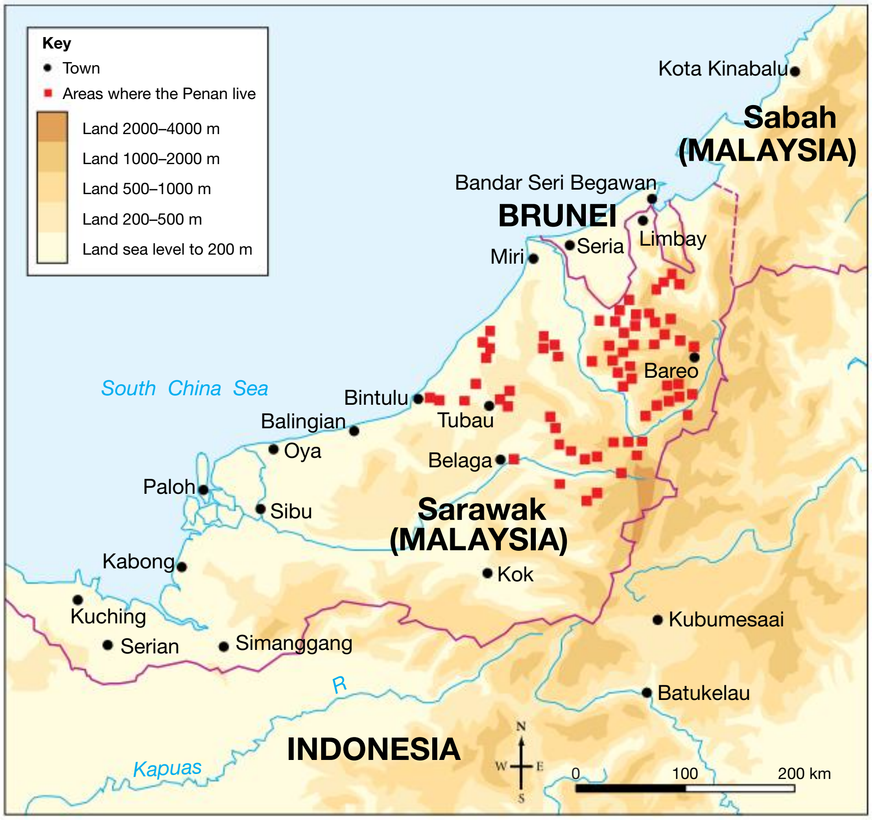
- been neatly presented
- been drawn in pencil
- been coloured or shaded and includes a key
- accurately shown a feature or features
- included BOLTSS.

1.18.2 Show me

How to draw a précis map

Model

FIGURE 1 Précis map showing Sarawak, in Malaysian Borneo.

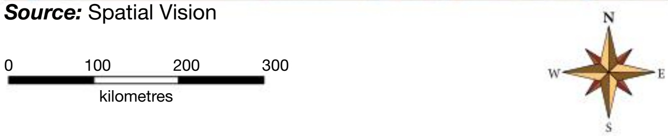


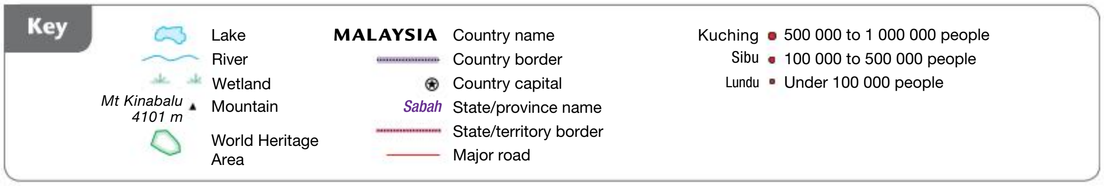
Source: MAPgraphics Pty Ltd, Brisbane

FIGURE 1 shows four aspects — the height of the land, the major towns, the rivers and the areas where the Penan people live. The cartographer has elected to omit aspects such as transport systems and vegetation. The areas in which the Penan people live have been drawn as symbols and in no way depict the boundaries of their locations. **FIGURE 1** is a précis of the complex map in **FIGURE 2**.

FIGURE 2 Complex map showing Sarawak, in Malaysian Borneo

Source: Spatial Vision





You will need:

- a map of the region being considered
- a light grey pencil
- coloured pencils
- a ruler
- an eraser.

Procedure

Step 1

Determine the area that you want to use to create a précis map. In **FIGURE 57** this has been done by removing details for surrounding countries, so that only Sarawak is detailed.

Step 2

Rule a border on your page within which to create your map. Make this the same size as the original to avoid having to scale your drawing.

Step 3

Identify the feature/s and their extent that you are going to include on your précis map. In **FIGURE 1**, the cartographer has chosen to leave in land heights, rivers and towns, and has chosen to leave out roads and vegetation.

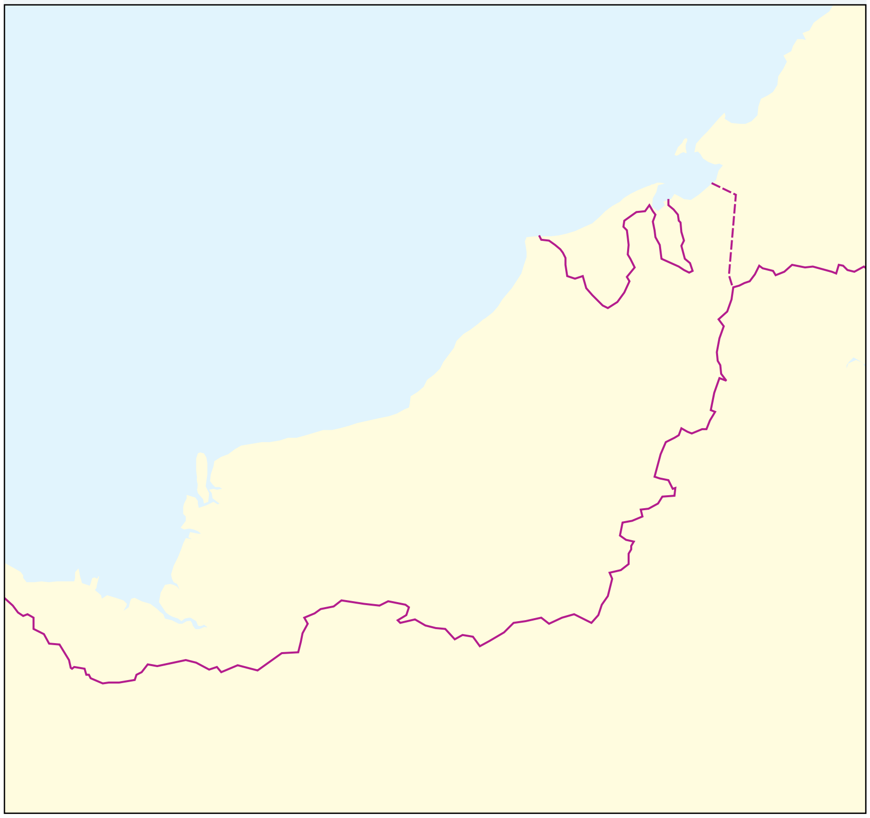
Step 4

Create a colour-coded key for each feature and place it next to or below the map.

Step 5

Within the border that you created in **Step 2**, draw an outline of the area that is to be mapped. Retain the scale of the original map that you are using.

FIGURE 3 Setting up the base map for the précis map



Step 6

Individually, take each of the features that you identified in **Step 3** and mark on your map, in a generalised way, the area that it covers. When you have completed one feature, colour it before moving to the next feature and mark your key appropriately (see **FIGURES 4, 5, 6** and **7**). It will prevent confusion if you complete the colouring as you go, rather than leaving it all until the end.

FIGURE 4 Land heights have been added to the base map.

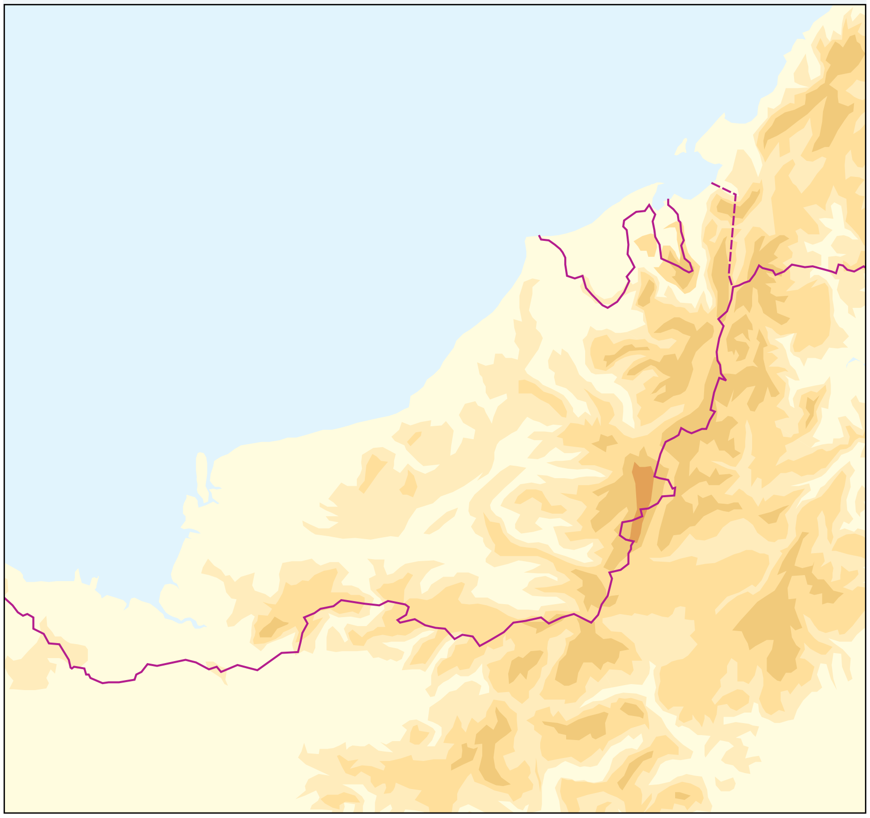


FIGURE 5 Rivers have been added to the base map.

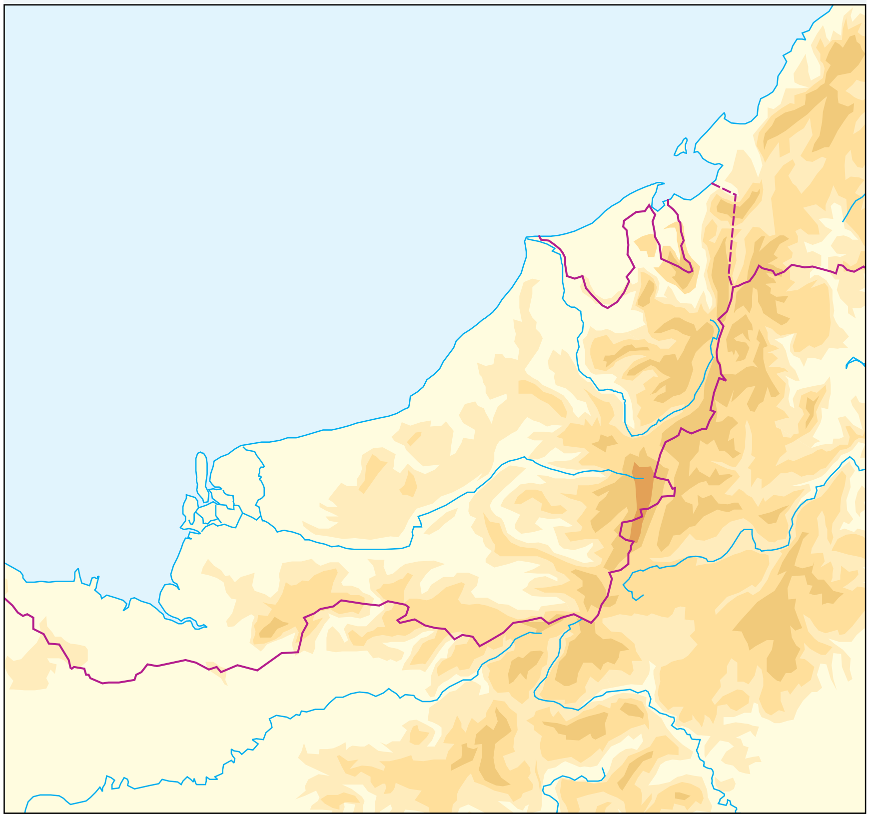
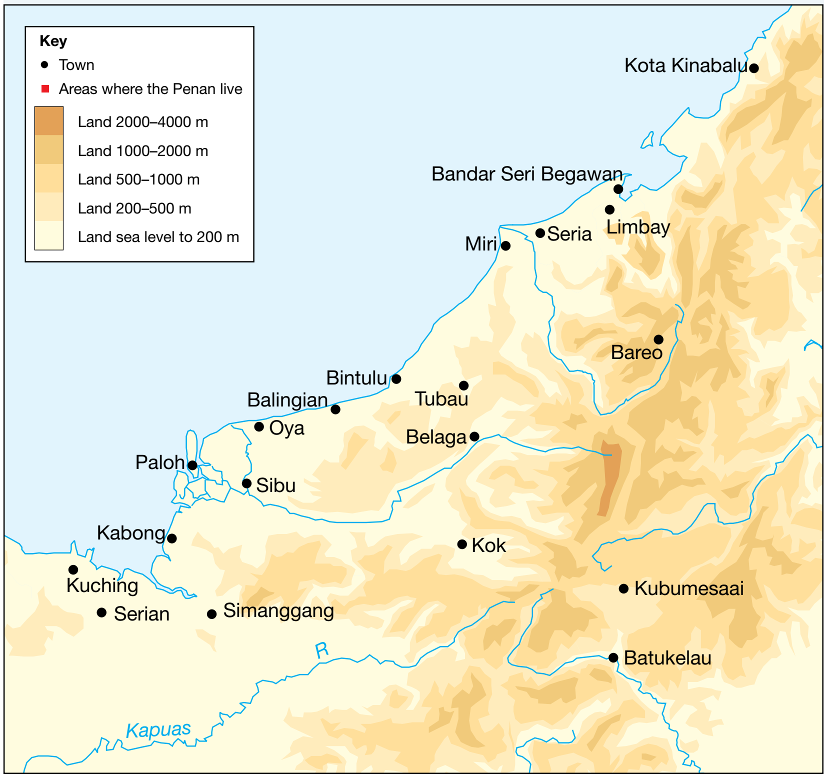


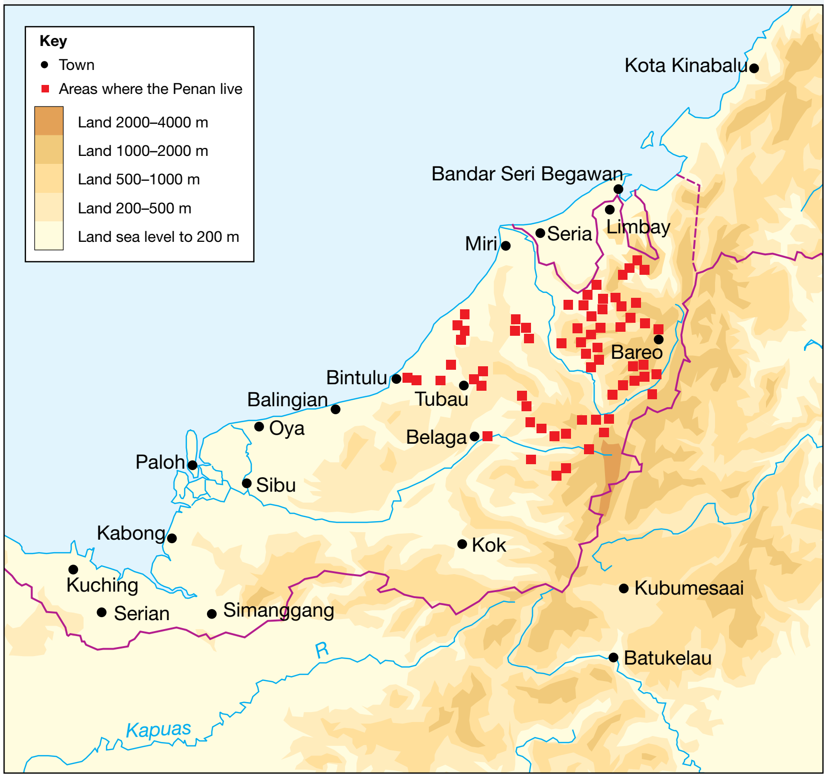
FIGURE 6 Towns have been added to the base map.



Step 7

Complete the précis map with BOLTSS.

FIGURE 7 The locations of Penan lands have been added to the base map.



on Resources

Video eLesson Drawing a précis map (eles-1657)
Interactivity Drawing a précis map (int-3153)

1.18.3 Let me do it

Complete the following activities to practise this skill.

1.18 ACTIVITIES

1. Refer to the map of the Amazon shown in **FIGURE 8**. On a separate piece of paper, create a précis map showing only the levels of deforestation. Map the outline and include the borders of countries. To show levels of deforestation, you should include the areas of undisturbed natural forest (low or no threat), undisturbed natural forest (under threat) and disturbed forest. Ensure that you complete the conventions of good mapping (include BOLTSS). Use the checklist to ensure that you cover all aspects of the task.
2. Use your completed précis map to answer the following questions.

FIGURE 8 The Amazon Basin

Source: MAPgraphics Pty Ltd, Brisbane

a. What level of deforestation dominates the Amazon Basin?
b. Is there more area of forest under threat than there is deforested area?
c. Is there a greater area of forest under threat than there is not threatened?
d. In which area of the Amazon Basin is the majority of the least disturbed forest?
e. Describe the regions of the Amazon Basin where you would be most likely to see evidence of deforestation.

Checklist

I have:

- presented the information neatly
- drawn in pencil
- coloured/shaded with a key
- accurately shown a feature or features
- included BOLTSS.

LESSON
1.19 SkillBuilder: Creating and reading pictographs

1.19.1 Tell me

What is a pictograph?

A pictograph is a graph drawn using pictures to represent numbers, instead of the bars or dots that are traditionally used on graphs. Data can be drawn vertically or horizontally. Each picture is given a value.

Why are pictographs useful?

A pictograph is a simple way of representing data and conveying information quickly and efficiently in a different format. It is very visual for the reader.

Pictographs are useful for:
- simplifying data
- showing differences between data
- presenting data.

A good pictograph has:
- been drawn in pencil
- used clear and simple pictures or graphics of the same size.

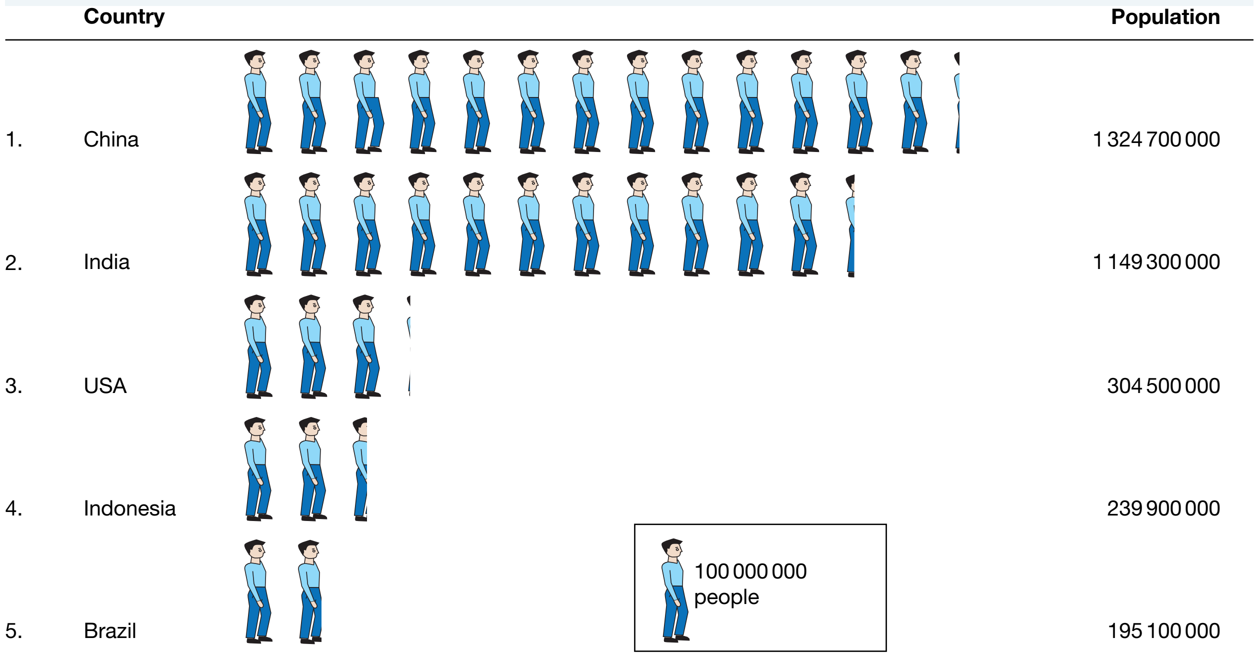
1.19.2 Show me

How to create and read a pictograph

Model

FIGURE 1 is a pictograph that shows that the populations of China and India are large in comparison to those of other countries. The populations of the United States and Indonesia appear to be similar, but the key shows that each complete symbol (person) represents 100 million people, so in fact there is a large difference in the population sizes. Indonesia's population is almost 250 million, while that of the United States is over 300 million.

FIGURE 1 Top five countries by population, 2008



You will need:

- a basic set of data
- a piece of paper on which to draw the pictograph
- a light grey pencil
- coloured pencils
- a ruler.

Procedure

To complete a pictograph you need a small set of data on one theme to graph.

Step 1

Decide on a simple picture to represent the data that you are going to graph. For example, you might decide to use stick figures to represent numbers of people, fish if your data is about fishing, or dollar signs if your data concerns money.

Step 2

Consider the data and determine a number that each picture should represent. In **FIGURE 1**, the drawing of one person is equivalent to 100 000 000 people in a population. Choose a scale that will not require too many pictures for each part of the graph, and check what the size of the graph will be when your representations are included. The pictograph must fit on the page or in the space you have available.

Step 3

Draw lines on your page, equal distances apart, to represent each variable (for example, country or year) for which you have data. On these lines you need to draw the appropriate number of pictures.

Step 4

Spend some time doing calculations to determine how many pictures you need to represent each number. Notice in **FIGURE 1** that ‘part people’ are used. For example, half a person in the pictograph would represent 50 000 000 people. Think about how your pictograph will show ‘parts of the whole’ to represent the data you are plotting.

Step 5

Complete your pictograph with its drawings. Ensure that the key is in place and that the pictograph has a clear title.

Step 6

Reading a pictograph requires you to carefully analyse the data provided. Check the title and the key, and determine the numbers represented by the graph. Write a few sentences summarising what the pictograph tells you. For example, **FIGURE 1** shows that the populations of China and India are large in comparison to those of other countries.

on Resources

Video eLesson SkillBuilder: Creating and reading pictographs (eles-1659)

Interactivity SkillBuilder: Creating and reading pictographs (int-3155)

1.19.3 Let me do it

Complete the following activities to practise this skill.

1.19 ACTIVITIES

1. Use the data below to draw a pictograph of the 10 cities with the largest populations. Use the checklist to ensure you complete the task correctly.

Rank	City	Country	Population (rounded figures, 2011)
1	Tokyo	Japan	35.7 million
2	Mexico City	Mexico	19.0 million
2	Mumbai	India	19.0 million
2	New York City	United States	19.0 million
5	São Paulo	Brazil	18.8 million
6	Delhi	India	15.9 million
7	Shanghai	China	15.0 million
8	Kolkata	India	14.8 million
9	Dhaka	Bangladesh	13.2 million
10	Jakarta	Indonesia	13.2 million

2. Apply your skills to answer the following questions.
   a. What did you immediately notice when you first looked at your completed pictograph?
   b. Which cities did you not expect to see on this list? Why?
   c. Which country did you think would contain one of the 10 cities with the highest populations, but does not?
   d. How much larger is Tokyo than Mexico City?
   e. Sydney is Australia's largest city (5.7 million in 2019). Add Sydney to your pictograph. What do you notice?

Checklist

I have:

- drawn in pencil
- used clear and simple pictures or graphics of the same size.

LESSON
1.20 SkillBuilder: Describing photographs

1.20.1 Tell me

What is meant by ‘describing a photograph’?

A description is a brief comment (up to a paragraph) on a photograph, identifying and communicating features from a geographic point of view. Sometimes it is necessary to infer information from a photograph; for example, a cloud of dust in an image may tell us that the climate is dry, or that the place is experiencing drought, or that some movement disturbed the soil at the time the photograph was taken.

Why is describing photographs useful?

Photographs record the details of a place at a particular moment in time. As geographers, we use our understanding of the world to interpret the image and tell others about the main features or information the photograph reveals.

Photographs are also useful for:
- comparing features before and after a disaster
- showing land features when planning town expansions
- explaining about a place and the way people use space
- revealing the living conditions of people on the other side of the world.

A good description of a photograph:
- includes an overview of the main features
- has considered the angle of photography — aerial, oblique or ground
- has tried to identify the place in the photograph
- notes other relevant information from the photograph
- acknowledges the anomalies in the image (those things that seem out of place)
- includes any written information that came with the photograph
- has considered the time of the day and the date when the photograph was taken
- has looked for visual clues of *scale* (e.g. comparisons with people or building heights)
- clearly communicates what you want the viewer to notice or see in the photograph
- has considered whether there is evidence of bias from the photographer, especially with the size of the image.

1.20.2 Show me

How to interpret photographs

Model

FIGURE 1 is a ground-level photograph of a city, which shows a mix of traditional buildings of about 10 storeys in height and modern sky scrapers of at least double that height. You can see an inner-urban area with traffic lights, street vendors and one-way streets. A lone tree is struggling to grow in the shade of the buildings. Some of the people may be tourists, as the man in the light-coloured shirt seems to be looking around as he walks. It appears to be a warm day, because people are wearing short-sleeved shirts and sunglasses, and some buildings are casting shadows onto others. You can tell that people are at work in these offices, because the lights are on in many levels of the buildings. The street name (W 56 St) tells the viewer that this is a street in New York. It is likely that the photograph was taken within the last 15 years, because the man in the foreground wears earphones and is listening to music while he walks.

FIGURE 1 A modern city environment

You will need:

- a photograph of a built or natural environment.

Procedure

To interpret a photograph, you must have a geographic photograph of a place. Begin by using the 'See, Think, Wonder' technique.

Step 1

See

What can you see? Look for all the main details. What takes up most of the space? Look for all the small details. What are you wanting or needing to point out in this image? Do not try to explain anything. Make a list of the things that you can see. In **FIGURE 1**, this list would include high-rise buildings, traffic on the roads, pedestrians, street signs and more.

Step 2

Think

What do you think is happening? What do you think about it? Make a list of what you think. In **FIGURE 1**, you might think it is early morning and workers and tourists are in the street, going about their daily activities. Perhaps you think that the high-rise buildings contain offices within which people are beginning their work for the day.

Step 3

Wonder

What is the mystery? What do you wonder about this image? For example, in **FIGURE 1**, why are all the streets one way? Make a list of what you wonder about.

Step 4

Is there any information with the photograph? For example, information might be given about the photographer or when the image was taken. Does the photograph appear with an article?

Step 5

Have you determined where the place is? Can you suggest in which region of the world the photograph is taken, even if the exact country or place is difficult to decide? As you develop your geographic understanding, you will gain impressions from images. In **FIGURE 1**, the street name (using numbering) on the sign indicates that this is a city in the United States, probably New York.

Step 6

What does the light in the image indicate about the time of day when the photograph was taken? Are there any shadows? Are there any indications as to whether the sun is high in the sky, rising in the early morning, or setting in the evening? This might tell you about the activities of people at a particular time of day. In **FIGURE 1**, the light comes from an angle and so appears to be the light of early morning.

Step 7

Is this a recent or an old photograph? Clothes, cars and other items in the image, such as appliances, can help to date the photograph. Sometimes photographs have dates embedded in the corner of the image. **FIGURE 1** shows a man walking with earphones in, listening to a personal media player. This technology has only been widely available for around 15 years.

Step 8

At what angle is the photograph taken — aerial, oblique or ground? Think about why the photographer may have used this angle. Does the background information add to your understanding of the photograph? Think about the things that you cannot see. For example, what types of office work might happen in the buildings in **FIGURE 1**?

Step 9

Do you need to make a statement about the height of any objects in the photograph? Is there an item from which you can reference height? In **FIGURE 1**, each floor of a building represents about four metres.

Step 10

Ask yourself whether you think the photographer may be using bias in the photograph; that is, has the photographer unfairly influenced the image? Is it likely that left and right or top and bottom of this image show the same scene, or has the photographer selected these elements to tell a particular story? In **FIGURE 1**, bias does not seem to be apparent. The photographer has included what the eye can see. Look at **FIGURES 2 (a)** and **(b)** — is the story the same in both images?

FIGURE 2 (a) appears to be a scene of a peaceful rural or parkland environment. When the full image is shown in **FIGURE 2 (b)**, it becomes apparent that this place is part of a very urban space, in the centre of a large city.

FIGURE 2 (a) A peaceful rural environment? (b) Central Park, New York City

(a)

(b)

Resources

Video eLesson	Describing photographs (eles-1660)	
Interactivity	Describing photographs (int-3156)	
Weblink	Kibera slum	

1.20.3 Let me do it

Complete the following activity to practise this skill.

1.20 ACTIVITY

Use the **Kibera slum** weblink in the Resources panel to look at the photograph of the Kibera slum in Nairobi, Kenya. Using the online zoom tool, explore the details of the photograph. Interpret the image by answering the following questions. Use the checklist to ensure you cover all aspects of the task.

a. What activities are being carried out in the slum?
b. Describe the buildings in the slum, including size, construction techniques, building materials and density of buildings.
c. Describe the possible movement of people through the slum.
d. In the left foreground is a water tank. This seems unusual in this environment. Can you suggest what might be happening in this community?
e. What additional information would you like to have about this place, especially considering the presence of the multistorey buildings in the background?
f. Write a paragraph of text to describe the Kibera slum, following the steps outlined in the Procedure.

Checklist

I have:

- included an overview of the main features
- considered the angle of photography — aerial, oblique or ground
- tried to identify the place in the photograph
- noted other relevant information from the photograph
- acknowledged the anomalies in the image (those things that seem out of place)
- included any written information that came with the photograph
- considered the time of the day and the date when the photograph was taken
- looked for visual clues of *scale* (e.g. comparisons with people or building heights)
- clearly communicated what I want the viewer to notice or see in the photograph
- considered whether there is evidence of photographer bias, especially with the size of the image.

LESSON
1.21 SkillBuilder: Constructing a basic sketch map

1.21.1 Tell me

What is a basic sketch map?

A basic sketch map is a map drawn from an aerial photograph or developed during fieldwork. It identifies the main features of an area and is different from a précis map, in which the cartographer opts to include or leave out certain features.

Why are basic sketch maps useful?

Basic sketch maps are used to show the key elements of an area, so other more detailed characteristics are not shown.

They are useful for:

- summarising an idea for presentations about a feature
- identifying and communicating key features or characteristics of an area.

A basic sketch map has:

- been drawn in pencil
- not tried to show everything in great detail
- been coloured using a key
- included BOLTSS.

1.21.2 Show me

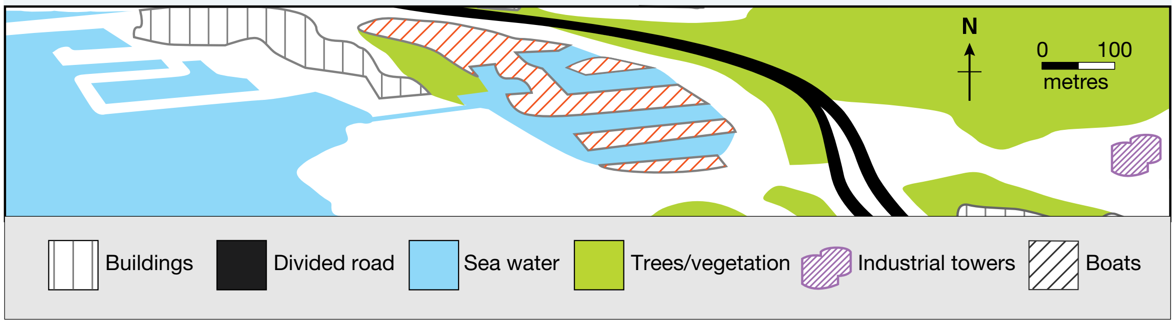
How to construct a basic sketch map

You will need:

- an aerial photograph
- a piece of paper on which to draw the map
- a light grey pencil
- coloured pencils
- a ruler
- an eraser.

Model

FIGURE 1 Sketch map of Darwin, Northern Territory, showing base features



Procedure

To complete a basic sketch map from an aerial photograph of a place, complete the following steps.

FIGURE 2 Aerial photograph of Darwin, Northern Territory

Step 1

Determine the relevant area of the aerial photograph that you want to use to make a basic sketch map.

FIGURE 3 The area for the sketch map is identified.

Step 2

Rule a border on your page within which to create your map. Keep the border the same size as the area of the photograph you are planning to draw, to avoid scale issues.

Step 3

Identify the feature(s), and their extent, that you are going to transfer onto your basic sketch map. Look for both natural and human features. In **FIGURE 3**, we can identify buildings, a divided road, sea water, trees and vegetation, industrial towers, and boats.

Step 4

Create a colour-coded key for each feature and place it near the map. If you want to use appropriate symbols, choose those too. For example, a red cross might be a suitable symbol to represent a hospital. You can add to your key as you go.

Step 5

Inside the border, draw an outline of the base features of the area, such as rivers, coastlines and major roads. These will guide your colouring.

Step 6

Individually, take each of the features that you have identified and mark on your base map the approximate area that it covers. When you have completed one feature, colour it before moving to the next feature. This will prevent confusion with colouring other features.

Step 7

You may wish to label some significant features of the sketch map. This shoud be done neatly and horizontally.

Step 8

Complete the simplified sketch map with BOLTSS.

on Resources

Video eLesson	Constructing a basic sketch map (eles-1661)
Interactivity	Constructing a basic sketch map (int-3157)

1.21.3 Let me do it

Complete the following activities to practise this skill.

1.21 ACTIVITIES

1. Using the aerial photograph of Darwin shown in **FIGURE 2**, complete a basic sketch map of the city and its *environments*. Use the checklist to ensure you have completed the task correctly.
2. Use your sketch map to answer the following questions.
   a. Describe the natural *environment* of Darwin. Mention the base features that you used to make your sketch.
   b. What type of buildings make up the greatest proportion of the built *environment* of Darwin?
   c. Suggest two reasons for the focus of the city on marine activities.
   d. There is vacant land to the right of the coastal road. On your sketch map, shade the land use that might appear here in 20 years' time. Justify your shading using labelling placed on your sketch map.
   e. How does this city compare to the *place* in which you live?

Checklist

I have:
- drawn in pencil
- not tried to show everything in great detail
- used colour with a key
- included BOLTSS.

2 Landforms and landscapes

LESSON SEQUENCE

LESSON
2.1 Overview

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How do human and natural processes shape environments and what impact does this have on the way people manage changing landscapes?

2.1.1 World landscapes and landforms

Landscapes are the visible features of the land, ranging from the icy landscapes of polar regions and lofty mountain ranges of Nepal through the grasslands of Tanzania and the forests of Brazil to the deserts of central Asia and the coastal plains. Shaped by physical processes over millions of years, they have been overlaid by the presence of humans.

FIGURE 1 Wave Rock is a natural rock formation near the town of Hyden, in the south-west of Western Australia.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-13441)

Video eLesson World landscapes and landforms (eles-1623)

LESSON
2.2 Why do landscapes vary?

LEARNING INTENTION

By the end of this lesson you should be able to identify and classify different environments as part of either the natural or built environment.

You should be able to explain how people might use the environment and classify people's impact on environments as either positive or negative.

TUNE IN

Did you know the Earth has many different types of landscapes and that there are also variations within landscapes?

FIGURE 1 At 8848 metres, Mount Everest in the Himalayas is the highest mountain on Earth.

1. Brainstorm a list of different types of landscapes.
2. What factors do you think influence the formation of landscapes?
3. Select one of the landscapes you identified and suggest:
   a. how people could have a positive impact on this landscape
   b. how people could have a negative impact on this landscape.

2.2.1 Types of landscapes

There are many different landscapes across the Earth, and similarities can be observed within regions. Differences in landscapes are influenced by factors such as climate, geographical features (including mountains and rivers), latitude, the impact of humans, and where the landscapes are located.

FIGURE 2 The Ngilgi cave formations in Western Australia are protected. They are considered to be of both historical and cultural significance.

FIGURE 3 The Great Barrier Reef in Queensland is a protected marine environment made up of more than 3000 individual reefs.

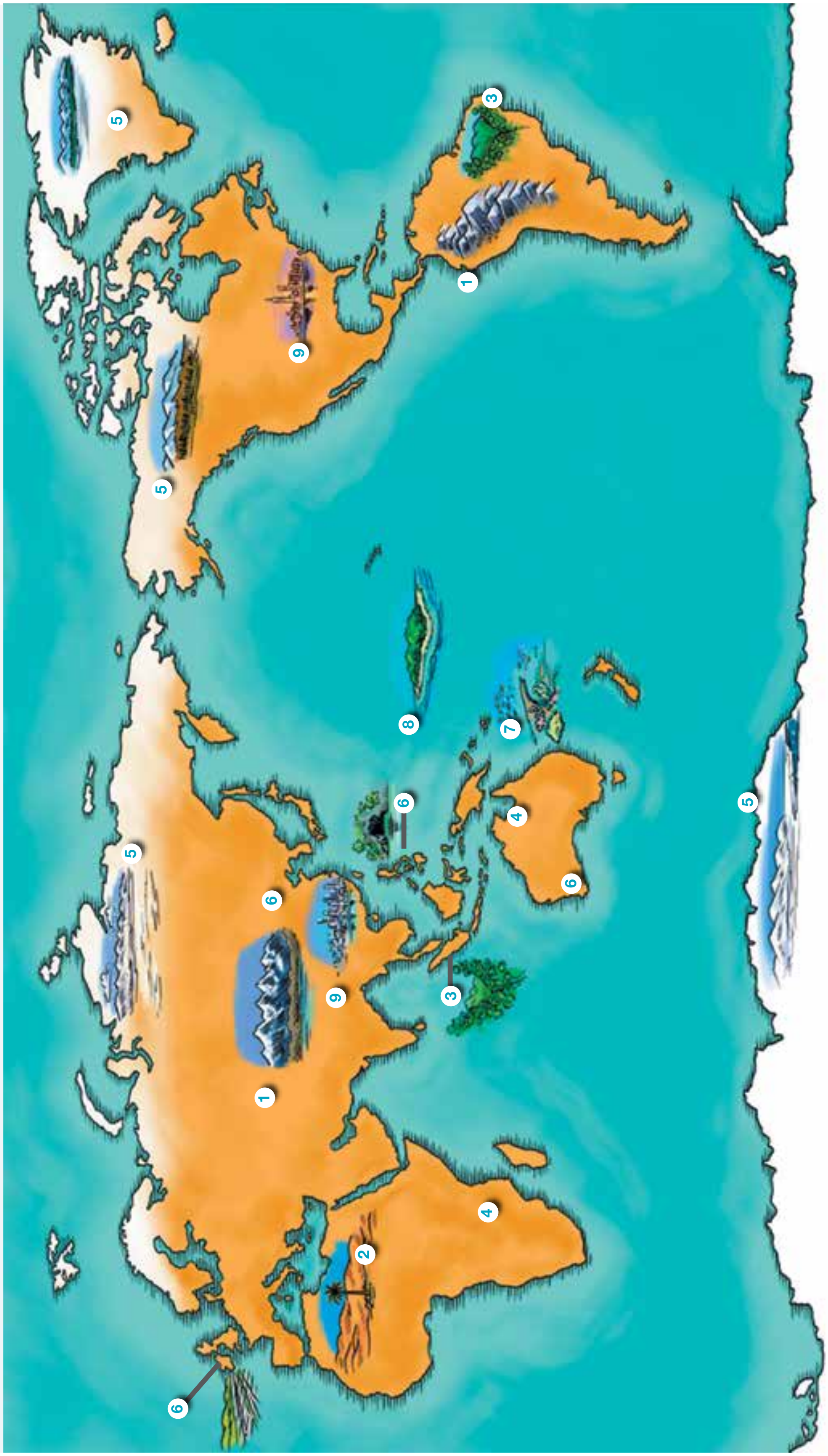

FIGURE 4 Selected world landscapes

int-3604

1. Mountains rise above the surrounding landscape. They often have steep sides and high peaks and are the result of processes operating deep inside the Earth. Some reach high into the atmosphere, where it is so cold that snow is found on their peaks.
2. Deserts are areas of low rainfall; they are an arid or dry environment. They can experience temperature extremes: hot by day and freezing at night. However, not all deserts are hot. Antarctica is the world's largest desert, and the Gobi Desert, located on a high **plateau** in Asia, is also a cold desert.
3. Rainforests are the most diverse landscapes on Earth. They are found in a variety of climates, ranging from the hot wet tropics to the cooler temperate areas. The lush vegetation found in these regions depends on a high level of rainfall. Over 50 per cent of all known plant and animal species are found within them. In addition, many of our foods and medicines come from rainforests.
4. Grasslands, or savannas, are sometimes seen as a transitional landscape found between forests and deserts. They contain grasses of varying heights and coarseness, and small or widely spaced trees. They are often inhabited by grazing animals.
5. Polar regions and tundra can be found in polar and alpine regions. Characterised by **permafrost**, they are too cold for trees to grow. Vegetation such as dwarf shrubs, grasses and lichens have adapted to the extreme cold and short growing season. **Glaciers** often carve spectacular landscape features as they move down the mountains under the influence of gravity.
6. Karst landscapes form when mildly acidic water flows over soluble rock such as limestone. Small fractures form, which increase in size over time and lead to underground drainage systems developing. Common landforms include limestone pavements, disappearing rivers, reappearing springs, sinkholes, caves and karst mountains. Around 25 per cent of the world's population obtains water from karst **aquifers**.
7. Aquatic landscapes cover around three-quarters of the Earth and can be classified as freshwater or marine. Marine landscapes are the saltwater regions of the world, and include oceans and coral reefs. Freshwater landscapes are found on land, and include lakes, rivers and wetlands.
8. Islands are areas of land that are completely surrounded by water. They can be continental or oceanic. Continental islands lie on a continental shelf — an extension of a continent that is submerged beneath the sea. Oceanic islands rise from the ocean floor and are generally volcanic in origin. A group or chain of islands is known as an archipelago.
9. Human or built landscapes are those that have been altered or created by humans.

plateau an extensive area of flat land that is higher than the land around it. Plateaus are sometimes referred to as tablelands.
permafrost a layer beneath the surface of the soil where the ground is permanently frozen
glacier a large body of ice, formed by an accumulation of snow, that flows downhill under the pressure of its own weight
aquifer a body of permeable rock below the Earth's surface that contains water, known as groundwater

Resources

Interactivity Landscapes galore (int-3102)

Google Earth Mount Everest

2.2 SKILL ACTIVITY: Communicating

Scenario

A marketing agency has invited teams of students to create television commercials for a tourism campaign highlighting the landscapes shown in **FIGURE 4**. The aim of the commercials is to provide interesting and accurate information to convince the audience (potential tourists aged from 20–25) to visit different landscapes.

You can present your commercial as a PowerPoint showing what you would include or as an oral presentation with visual aids.

Before the presentation

Select a location somewhere in the world that contains one of the landscapes and **conduct research** on its features.

Your presentation must cover at least four of the following:
- location
- climate
- striking natural features
- unique or interesting animal and/or plant species
- specific cultural or historical human aspects.

During the presentation

Ensure you use geographical language to **describe** the landscape of your chosen place.

Keep in mind who your audience is and adapt your language choices to suit them.

Only include information that will persuade the audience to travel to the place.

2.2 Exercise

learnon

2.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3, 7	4, 5, 8	6, 9, 10

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Check your understanding

1. What is the difference between the terms ‘natural’ and ‘built’ environment?
   A. Natural environments are created or altered by humans whereas built environment are not.
   B. Built environments are created or altered by humans whereas natural environments are not.
   C. There is no difference as neither of them are altered by humans.
   D. Natural environments are larger than built environments.
2. Altitude, latitude, geographical features and climate are examples of factors that do not make landscapes different. True or false?
3. Which four of the following are human or built environments?
   A. Forests
   B. Zoos
   C. Camping grounds
   D. Caravan parks
   E. Grasslands
   F. Farms
4. **Explain** why you think people change landscapes.
5. **Select** two of the landscapes featured in this lesson and **explain** how they are different.

Apply your understanding

Communicating

6. Copy the following table into your workbook.

Characteristics	How it formed	How people use it	Positive impacts	Negative impacts	Human impacts both positive and negative

   a. **Select** one of the landscape types described in this lesson and complete the table, **stating** the positive and negative aspects of human use.
   b. Which list is larger — the positive impacts or negative impacts?
   c. Review the column of negative impacts. **Select** three of these impacts and propose a way in which the environment could be used more sustainably.
7. **Describe** how the scale of the following landscapes might differ around the world: deserts, polar regions, aquatic landscapes and islands.
8. Which of the featured landscapes would you like to know more about? **Create** a list of questions that you would like to have answered.

Concluding and decision-making

9. **Explain** why you think rainforests are described as ‘the most diverse landscapes on Earth’.
10. **Identify** the featured landscape that you think would be the least diverse. **Justify** your answer.

LESSON
2.3 What processes shape landscapes?

LEARNING INTENTION

By the end of this lesson you should be able to explain the processes that have shaped the Earth and explain how soil is formed. You should also be able to define the key terms weathering, erosion, deposition, tectonic forces and transportation.

TUNE IN

Processes are at work to continuously sculpt and change the landscape. In the future, the Earth's surface will look very different from the way it looks today.

FIGURE 1 The Grand Canyon has formed over millions of years.

1. What actions or steps do you think have produced the Grand Canyon?
2. Describe how you think this landscape looked one million years ago.
3. Explain how this landscape might change over the next one million years.

2.3.1 Are all processes natural?

A variety of natural processes shape and reshape not only the surface of the Earth but also what lies beneath it. Natural processes include uplift, such as that caused by tectonic activity, **erosion**, **deposition** and **weathering**. People change the landscape when they clear land for agriculture or build cities and road networks. Sometimes they alter the course of a river or trap its flow behind the walls of a dam.

erosion the wearing away and removal of soil and rock by natural elements, such as wind and water, and by human activity
deposition the laying down of material carried by rivers, wind, ice and ocean currents or waves
weathering the breaking down of bare rock (mainly by water freezing and cooling as a result of temperature change) and the effects of climate

2.3.2 The role of tectonic forces

The Earth's surface, or crust, is split into a number of plates, which fit together like a giant jigsaw puzzle. These plates sit on a layer of semi-molten material in the Earth's **mantle** — the layer of the Earth between the crust and the core. Heat from the Earth's core creates **convection currents** within the mantle, causing the plates to move. Most of the Earth's great mountain regions were formed as a result of this movement.

When two plates collide, one plate often slides under the other, in a process known as subduction, and it becomes part of the mantle. Other rocks are forced upwards and bent or folded. Large mountain ranges that were formed in this way include the Himalayas in Asia and the Rocky Mountains in North America. You will find more information on how mountains are formed in topic 4.

2.3.3 How is the landscape worn away?

Erosion is the wearing away of the Earth's surface by natural elements such as wind, water, ice and human activity. The landscape is further eroded when agents such as wind, water and ice **transport** these materials to new locations. Eventually, transported material is deposited in a new location. Over time, this material can build up and new landforms result. The Grand Canyon in Arizona in the United States (**FIGURE 1**) is an example of these elements at work. Here the Colorado River has cut deep channels into the landscape to form the Grand Canyon. These processes work more quickly on softer rocks.

Human activity also contributes to erosion. Deforestation, agriculture, urban sprawl, logging and road construction all alter the natural balance and increase erosion by as much as 40 per cent in some areas. Vegetation not only provides valuable habitat for native animals but is also vital for binding the soil together. Once vegetation is removed, it is more easily broken down and removed by wind and water. When topsoil is removed, plants are unable to obtain the nutrients they need for growth. Sometimes wide, deep channels, known as gullies, form (see **FIGURE 2**).

mantle the layer of the Earth between the crust and the core
convection current a current created when a fluid is heated, making it less dense and causing it to rise through surrounding fluid and sink if it is cooled; a steady source of heat can start a continuous current flow
transport the movement of eroded materials to a new location by elements such as wind and water

FIGURE 2 Note the scale of this gully compared to the people.

int-7830

tlvd-10611

FIGURE 3 After tectonic forces cause a section of the Earth to be raised (uplifted), other processes take over and resculpt the landscape.

1 Weathering is the breakdown of rocks due to the action of rainwater, temperature change and biological action. The material is not transported (removed).

It can be physical, chemical or biological.

2 Erosion is the process whereby soil and rocks are worn away and moved to a new location by agents such as wind, water or ice.

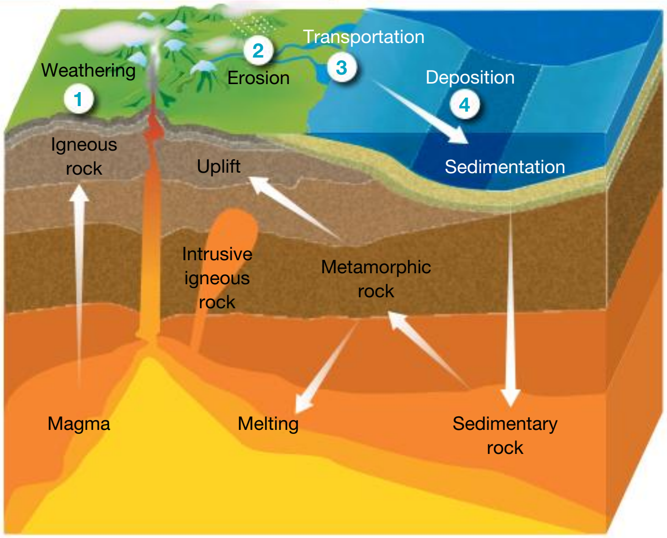
3 Transportation is the process that moves eroded material to a new location – examples include soil carried by the wind, sediment or pebbles in a stream.

4 Deposition – materials moved by wind and water eventually come to a halt. Over time new landforms are built. Sand dunes and beaches are common landforms associated with deposition.

Physical – occurs where water is continually freezing and thawing. The water penetrates cracks and holes in the rocks. As water freezes it expands, making the cracks larger. Over time the rock breaks apart.

Chemical – some rocks, such as limestone, contain chemicals that react with water, causing the limestone to dissolve.

Biological – living organisms such as algae produce chemicals that break down rocks. They can also be forced apart by plant roots.



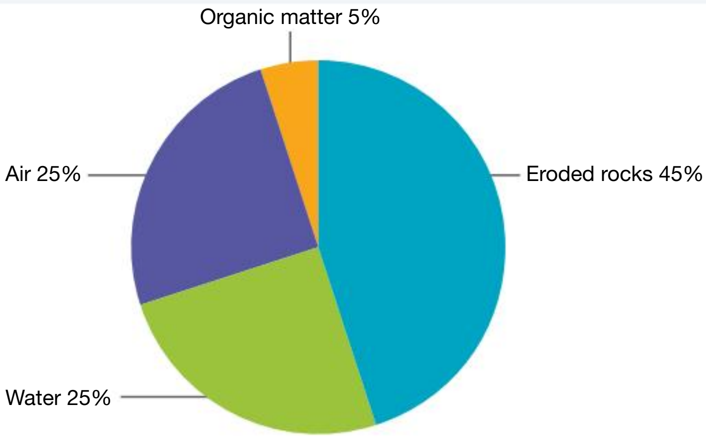
2.3.4 What is soil?

Formed as a result of the processes of weathering and erosion, soil is the basis of all life on Earth, providing the nutrients for plant growth and enabling people to grow crops and raise livestock.

The composition of soil is shown in **FIGURE 4** and the factors that influence soil formation are shown in **FIGURE 5**.

Australia generally has poor soils when compared with those found on other continents such as North America and Europe. Australian soils are generally low in nutrients and, in some areas, especially arid zones, they have a high salt content. Patches of good soil, though, are scattered throughout the continent.

FIGURE 4 While the composition of soil varies widely across the Earth, an average soil will have these characteristics.

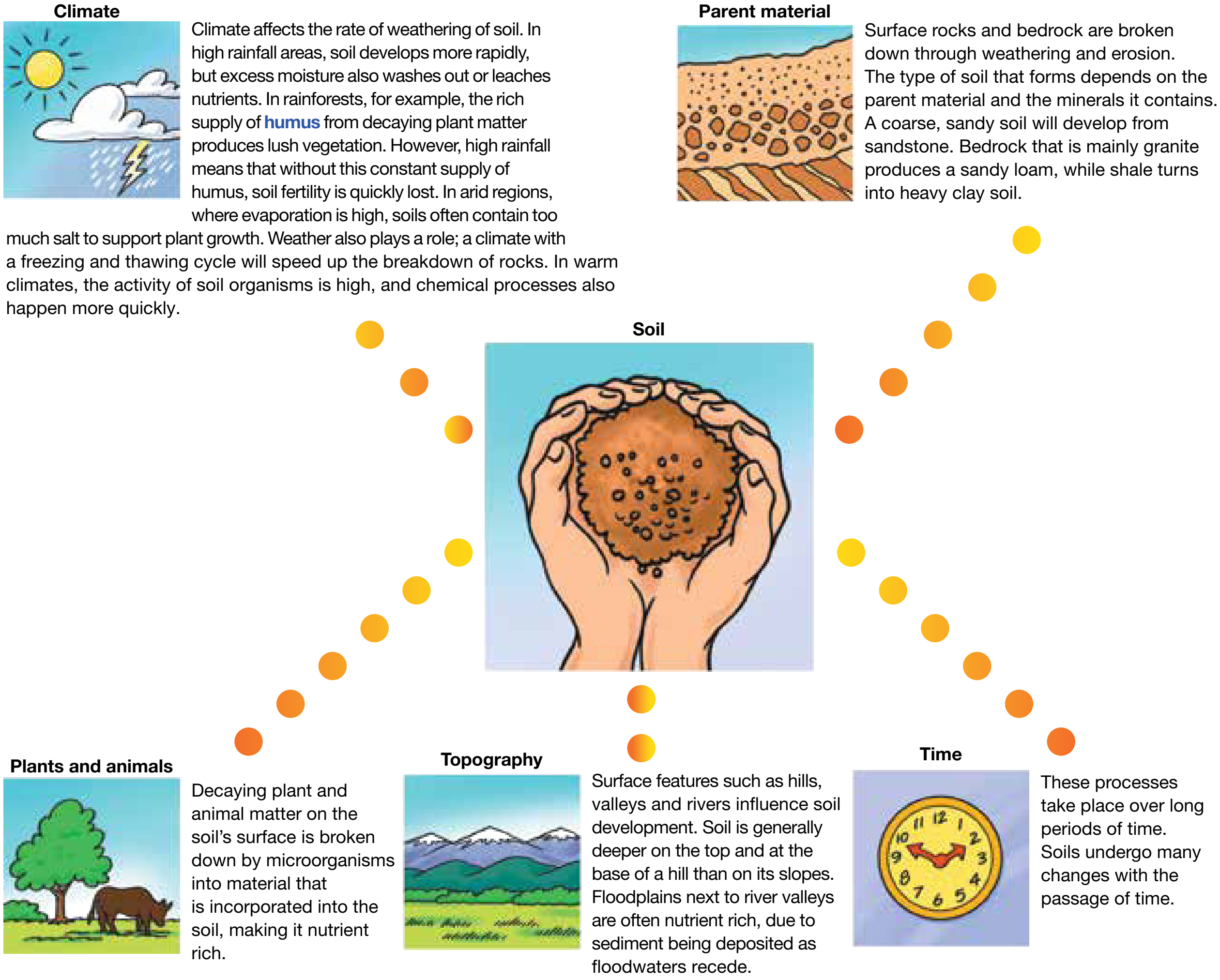


How is soil formed?

Factors that influence soil formation are shown in **FIGURE 5**.

int-7831

FIGURE 5 Influences on soil formation



For example, there is:

- volcanic soil on the Darling Downs in Queensland and around Orange in New South Wales
- alluvial soil in river valleys such as around the Clarence River in New South Wales and Margaret River in Western Australia.

In many parts of Australia, it takes more than 1000 years for natural processes to produce 3 centimetres of soil.

humus nutrient-rich dark organic matter, created by decaying animal and plant matter

on Resources

Weblink Soil formation

Google Earth Grand Canyon

2.3 SKILL ACTIVITY: Questioning and researching, Communicating

Work with a partner to complete this task.

Use the internet to find an image of the MacDonnell Ranges or a mountain range that you find interesting. You and your partner will need to agree on the chosen landscape feature.

Your task is to create a presentation to:
- **explain** how physical processes have shaped and changed the landscape over time
- **describe** the traditional Dreaming creation story associated with your landscape and **explain** its significance to First Nations Peoples of Australia.

1. **Create** a physical or virtual model of your landform.
2. Copy and paste an image of your created landform into a Word document.
3. Using geographical language, annotate your image or model with accurate and explicit information about the mountain range's location and how it was formed.
4. Add further annotations to **describe** how your landform has changed over time and the processes that have resulted in these changes.
5. **Predict** how this landform might look in the future.
6. Add additional diagrams and annotations to **illustrate** the Dreaming creation story of First Nations Peoples.
7. **Explain** the significance of your chosen landscape or landform feature to First Nations Peoples of Australia.
8. Share your findings with the rest of the class.

FIGURE 6 The MacDonnell Ranges in the Northern Territory have formed over millions of years.

2.3 Exercise

learnon

2.3 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4, 5, 7	8, 10	3, 6, 9, 11

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Soil is the thin layer of material on the surface of the Earth in which plants can grow.
   b. Australia generally has superior soils when compared with those found on other continents such as North America and Europe.
   c. When one tectonic plate slips under another it is known as subduction.
   d. The breakdown of rocks (weathering) is only a physical process.
   e. Soil is generally shallower on the top and at the base of a hill than on its slopes.
   f. Erosion processes work more quickly on softer rocks.
2. Why is soil important?
   A. It is the basis for plant growth, which feeds both people and animals.
   B. It is not important.
   C. 75 per cent of mammals eat soil as their main source of nutrition.
   D. It protects the Earth from damage from the sun.
3. **Consider** the natural processes at work shaping the Earth and complete the following passage.
   ______________________ refers to the process of eroded or weathered material being moved to new locations by agents such as wind, water and ice. _____________________ refers to materials being dropped in new locations and may result in the new landforms being created.
4. __________________ is the process whereby soil and rocks are worn away and moved to a new location by agents such as wind, water or ice.
   ____________________ refers to the breakdown of rocks due to the action of rainwater, temperature change and biological action.
5. **Identify** any human factors that might contribute to erosion.
   A. Conservation
   B. Deforestation
   C. Urban sprawl and road construction
   D. Planting trees and shrubs
   E. Logging

Apply your understanding

Communicating

6. **Explain** how and why human activity might contribute to weathering and erosion.
7. Using terms such as uplift, erosion, deposition, weathering and transportation, **explain** the interconnection between physical processes and the environment.
8. In your own words, **explain** how soil is formed and why it is not uniform across the surface of the Earth.
9. Using examples, **describe** two different ways that mountain ranges can be formed.
10. Australia is an ancient landmass. **Identify** which processes described in this lesson are currently shaping Australia's landforms. **Justify** your answer.

LESSON
2.4 What landscapes form underground?

LEARNING INTENTION

By the end of this lesson you should be able to explain how a karst landscape is formed.

TUNE IN

Did you know that the rocks that make up the karst landscape are composed of limestone and dolomite; both are carbonate rocks (a subclass of sedimentary rocks). They are highly susceptible to a form of chemical weathering known as oxidation (a chemical reaction that causes rocks to break down due the presence of water, oxygen or acid).

FIGURE 1 Lake Cave, Margaret River, Western Australia

1. How do you think sedimentary rocks were formed?
2. You can see oxidation at work when you cut an apple and it turns brown. What do you think is causing oxidation?
3. Brainstorm how you think the structures shown in **FIGURE 1** were formed.

2.4.1 What is karst?

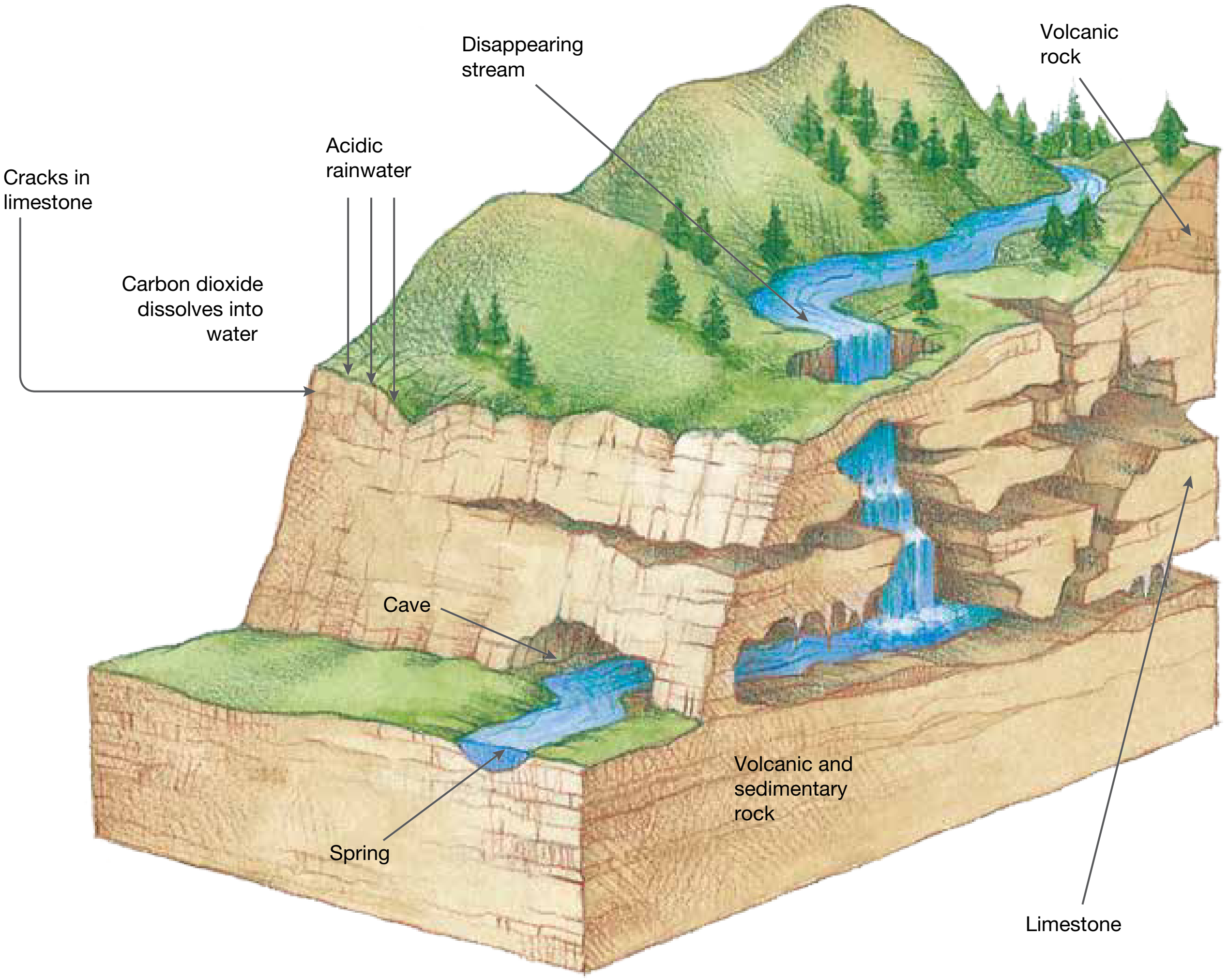
Apart from rivers and streams that flow across the surface of the Earth, vast networks of rivers also exist under the ground. The result is a network of caves and channels that carve a very different landscape, known as karst.

Karst is a landscape formed by water dissolving bedrock (solid rock beneath soil) over hundreds of thousands of years (see **FIGURE 1**). On the surface of the Earth, sinkholes (holes in the Earth's surface), vertical shafts (tunnels), and fissures (cracks) will be evident. Rivers and streams may seem to simply disappear, but intricate drainage networks are underground, complete with caves, rivers, **stalactites** and **stalagmites** (see **FIGURE 2**).

stalactite a feature made of minerals, which forms from the ceiling of limestone caves, like an icicle. They are formed when water containing dissolved limestone drips from the roof of a cave, leaving a small amount of calcium carbonate behind.
stalagmite a feature made of minerals found on the floor of limestone caves. They are formed when water containing dissolved limestone deposits on the cave floor and builds up.

tlvd-10612

FIGURE 2 Formation of a karst landscape



Karst topography makes up about 10 per cent of the Earth's surface; however, a quarter of the world's population depends on karst environments to meet its water needs.

2.4.2 How are karst landscapes formed?

Water becomes slightly acidic when it comes into contact with carbon dioxide in the atmosphere (as it does when raindrops form) or when it filters through organic matter in the soil and **percolates** into the ground. Acidic water is able to dissolve soluble bedrock, such as limestone and dolomite. This creates cracks or fissures, allowing more water to penetrate the rocks.

When the water reaches a layer of non-dissolving rocks, it begins to erode sideways, forming an underground river or stream. As the process continues, the water creates hollows, eventually creating a cave. Some karst landscapes contain aquifers that are capable of providing large amounts of water.

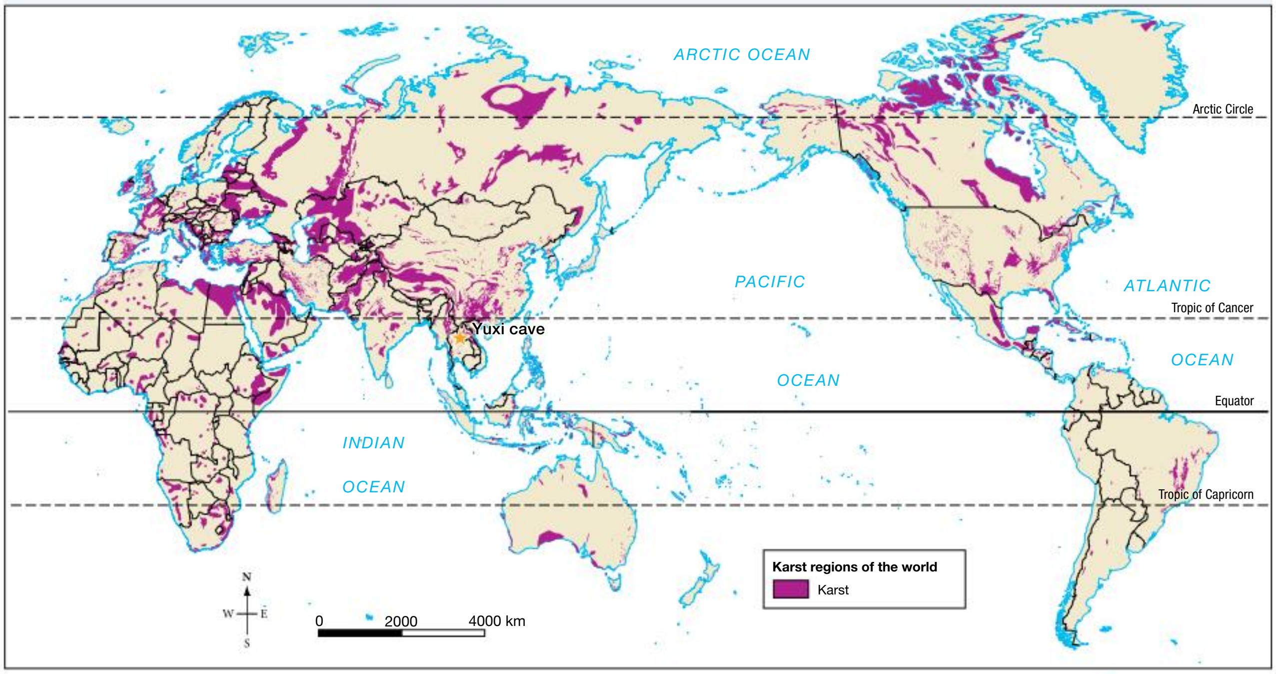
percolate filter through porous material such as soil

2.4.3 Where are karst landscapes found?

Karst landscapes are found all over the world, as shown in **FIGURE 3**, in locations where mildly acidic water is able to dissolve **soluble** bedrock such as limestone and dolomite.

soluble able to be dissolved in water

FIGURE 3 Karst regions of the world



Source: World Map of Carbonate Rock Outcrops v3.0.

In tropical regions, where rainfall is very high, karst mountains sometimes develop. This is because the high rainfall levels wear away the soluble rock much faster than rock is worn away in karst areas with lower rainfall. Examples of tropical karst mountains include the peaks of Ha Long Bay in Vietnam and the Guilin Mountains in China.

The Earth's largest arid limestone karst cave system is located on Australia's Nullarbor Plain, covering 270 000 square kilometres. It extends 2000 kilometres from the Eyre Peninsula in South Australia to Norseman in the Goldfields–Esperance region of Western Australia, and from the Bunda Cliffs on the Great Australian Bight in the south to the Victoria Desert in the north.

The extensive cave system provides a unique habitat for a variety of native flora and fauna. Within the caves are fossils that can reveal much about our distant past; indeed, fossils of thylacines (Tasmanian tigers) have been found in the cave systems south of Perth. These caves are also often important First Nations heritage sites.

on Resources

Interactivity Underground wonders (int-3103)

2.4 SKILL ACTIVITY: Questioning and researching, Communicating

Examples of karst landscapes in Australia include Buchan, Naracoorte, Jenolan, Labertouche, Princess Margaret Rose, Judbarra, Abercrombie caves and the Nullarbor Plain.

1. Working with a partner, **investigate** one of these environments and **create** an annotated visual display.

   Show the location of your karst environment on a map and include:
   - the scale
   - features
   - land use
   - any concerns or threats to the environment.

   Include information on what is being done to ensure the sustainable management of the place and the significance of this place to First Nations Peoples.
2. **Communicate** your findings with the rest of the class in a brief presentation.

2.4 Exercise

learnon

2.4 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 6	4, 5, 8	3, 7, 9, 10

Check your understanding

1. How are karst landscapes formed?
   A. Chemical reaction
   B. Transportation
   C. Uplift
   D. All of the above
2. Karst topography makes up about ______ per cent of the Earth's surface.
3. **Identify** two reasons why karst landscapes should be preserved.
   A. For their natural beauty
   B. 25 per cent of the world's population depends on karst aquifers as a water supply.
   C. 90 per cent of the world's tourist attractions are found in karst landscapes.
   D. 99 per cent of the world's population depends on karst aquifers as a water supply.
4. Karst landscapes are predominantly found underground. **Identify** evidence on the surface of the Earth that might indicate the existence of a karst landscape.
5. **Describe** the global distribution of karst landscapes.

Apply your understanding

Communicating

6. The world's largest arid limestone karst system is found on the Nullarbor Plain, Australia.
   a. The Nullarbor Plain is an example of a desert landscape. **Propose** how an environment formed by water can occur in this location.
   b. **Describe** how you think this landscape would be different if it were located in Australia's tropical north.
7. **Explain** how the karst landscape can provide us with a link to our distant past.
8. **Explain** how the karst landscape can provide a quarter of the world's population with water.

Concluding and decision-making

9. Karst is often described as a 'hidden landscape'. **Identify** reasons for this description.
10. **Propose** a reason for the absence of 'discovered' karst landscapes in Antarctica.

LESSON
2.5 What are the landforms and landform regions of Australia?

LEARNING INTENTION

By the end of this lesson you should be able to identify the key features of the Australian landscape and describe the processes that have shaped it.

TUNE IN

Many of Queensland's mountain peaks were formed by volcanic activity around 20 million years ago. The Glasshouse Mountains, north of Brisbane, are volcanic plugs. Over millions of years the volcano that once surrounded the plug has been worn away by weathering and erosion.

1. What do you think led to the formation of the volcanic plug?
2. Distinguish between weathering and erosion.
3. Why do you think the weathering and erosion wore away the volcano but not the plug?

FIGURE 1 The Glasshouse Mountains, Queensland

2.5.1 What processes have shaped Australasia?

The tectonic forces of folding, faulting and volcanic activity have created many of Australia's major landforms. Other forces that work on the surface of Australia, and give our landforms their present appearance, are weathering, mass movement, erosion and deposition.

Australia is an ancient landmass. The Earth is about 4600 million years old, and parts of the Australian continent are about 4300 million years old.

Over millions of years, Australia has undergone many changes. Mountain ranges and seas have come and gone. As mountain ranges eroded, sediments many kilometres thick were laid down over vast areas. These sedimentary rocks were then subjected to folding, faulting and uplifting. This means that the rocks that make up the Earth's crust have buckled and folded along areas of weakness, known as faults. Sometimes, fractures or breaks occur, and forces deep within the Earth cause sections to be raised, or uplifted. Over time the forces of weathering and erosion have worn these down again. Erosion acts more quickly on softer rocks, forming valleys and bays. Harder rocks remain as mountains, hills and coastal headlands.

Because it is located in the centre of a **tectonic plate**, rather than at the edge of one, Australia currently has no active volcanoes on its mainland, and has very little tectonic lift from below. This means its raised landforms such as mountains have been exposed to weathering forces for longer than mountains on other continents and are therefore more worn down.

About 33 million years ago, when Australia was drifting northwards after splitting from Antarctica, the continent passed over a large **hotspot**. Over the next 27 million years, about 30 volcanoes erupted while they were over the hotspot.

tectonic plate one of the slow-moving plates that make up the Earth's crust. Volcanoes and earthquakes often occur at the edges of plates.
hotspot an area on the Earth's surface where the crust is quite thin and volcanic activity can sometimes occur, even though it is not at a plate margin

The oldest eruption was 35 million years ago at Cape Hillsborough, in Queensland, and the most recent was at Macedon in Victoria around 6 million years ago. Over millions of years, these eruptions formed a chain of volcanoes in eastern and south-eastern Australia, known today as the Great Dividing Range (see **FIGURE 2**). At present, the hotspot that caused the earlier eruptions is probably beneath Bass Strait.

The present topography of much of Australia results from erosion caused by ice. For example, about 290 million years ago a huge icecap covered parts of Australia. After the ice melted, parts of the continent subsided and were covered by **sediment**, forming sedimentary basins (a low area where sediments accumulate) such as the Great Artesian Basin. On a smaller scale, parts of the Australian Alps and Tasmania were also eroded by glaciers during the last ice age.

sediment material carried by water

FIGURE 2 Relief map of Australia. The Great Dividing Range stretches from north of Cairns in Queensland to Mount Dandenong near Melbourne in the south.

Source: ©WorldSat International, 2017

Rivers and streams are another cause of erosion, having carved many of the valleys in Australia's higher regions.

When streams, glaciers and winds slow down, they deposit or drop the material they have been carrying. This is called deposition. Many broad coastal and low-lying inland valleys have been created by stream deposition. These areas are called floodplains.

2.5.2 Australia's landform regions

The topography of Australia can be divided into four major regions (see **FIGURE 3**).

Coastal lowlands

int-3606

The coastal lowlands around Australia's edge are narrow and fragmented. The plains often take the form of river valleys, such as the Hunter River Valley.

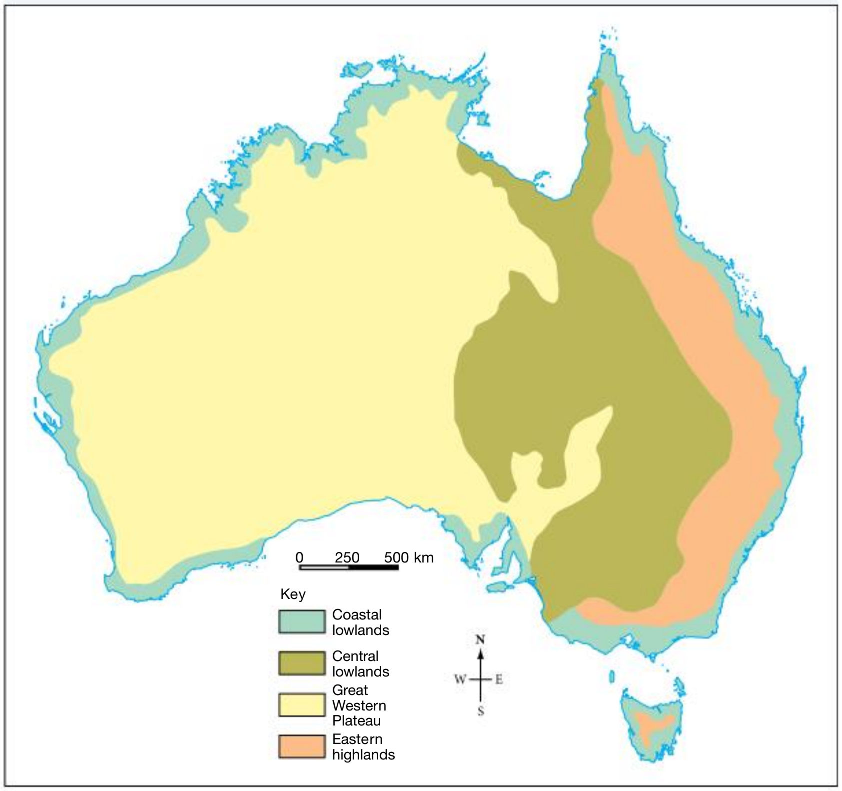
Eastern highlands

The eastern highlands region, which includes the Great Dividing Range, is mainly a series of tablelands and plateaus. Most of the area is very rugged, because rivers have cut deep valleys. It is the source of most of Australia's largest rivers, including the Fitzroy, Darling and Murray. The highest part is in the south-east, where a small alpine area is snow-covered for more than half the year.

Central lowlands

The central lowlands are a vast area of very flat, low-lying land that contains three large **drainage basins**: the Carpentaria Lowlands in the north, the Lake Eyre Basin in the centre (see **FIGURE 4**) and the Murray–Darling Basin in the south.

FIGURE 3 Australia's four major landform regions



Source: MAPgraphics Pty Ltd Brisbane

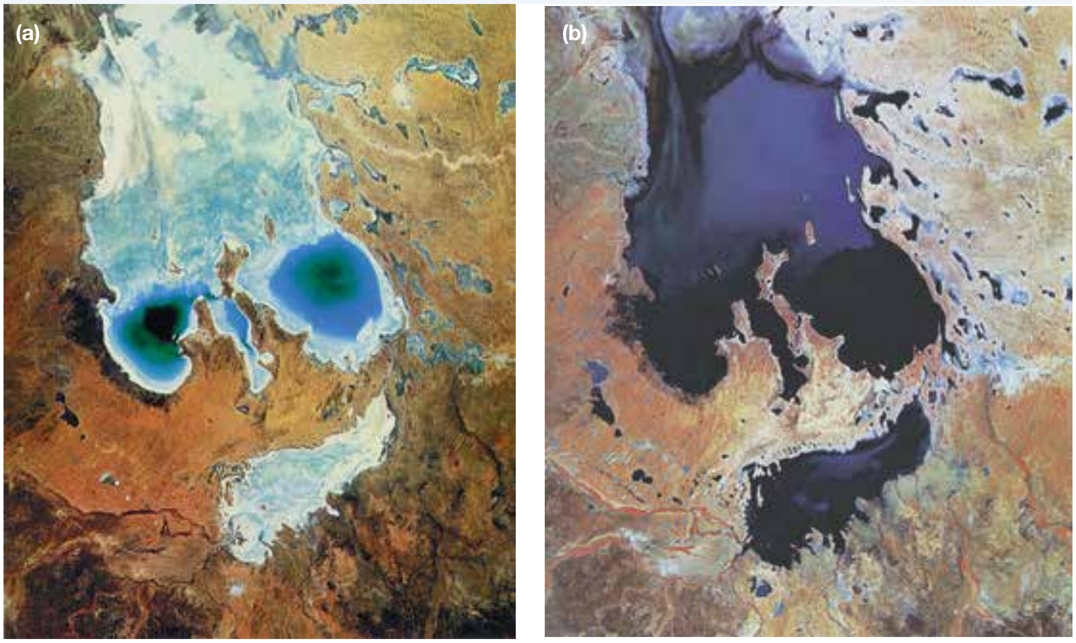
Great Western Plateau

The Great Western Plateau is a huge area of tablelands, most of which are about 500 metres above sea level. It includes areas of gibber (or stony) desert and sandy desert. There are several rugged upland areas, including the Kimberley and the MacDonnell Ranges.

drainage basin an area of land that feeds a river with water; or the whole area of land drained by a river and its tributaries

int-9006

FIGURE 4 Kati Thanda–Lake Eyre, the lowest point on the Australian mainland, is part of the Great Artesian Basin. It is 15 metres below sea level. Once a freshwater lake, the region is now the world's largest salt pan. The evaporated salt crust shows white in the satellite image (a) below. The lake fills with water only three or four times each century, transforming it into a haven for wildlife. Deep water is shown as black in image (b) below.



CASE STUDY: Water issues in the Murray–Darling Basin region

The Murray–Darling Basin covers about one million square kilometres, and more than 20 major rivers flow into it. It has a wide variety of landscapes, ranging from alpine areas in the south-east to plains in the west. The basin produces 43 per cent of Australia's food and over 40 per cent of Australia's total agricultural income.

The Murray–Darling Basin is the largest and most important drainage basin in Australia, covering one-seventh of the continent. However, the amount of water flowing through it in one year is about the same as the *daily* flow of the Amazon River.

FIGURE 5 Aerial view of the Murray River, where it enters the Coorong and Lake Alexandrina in South Australia

The basin is facing severe problems:

- Only about 20 per cent of the water flowing through the basin ever reaches the sea. The rest is diverted for agriculture, industry and domestic use.
- The Murray supplies about 50 per cent of Adelaide's drinking water. The quality of the water continues to decline, mainly because of salinity levels.
- Approximately 50 to 80 per cent of the wetlands in the basin have been severely damaged or destroyed, and more than a third of the native fish species are threatened with extinction. The number of water birds in the basin has halved.

- River system inflows vary from year to year. The long-term average is 9030 GL. In 2018, inflows were around 2740 GL, among the lowest on record.
- An estimate of weather trends shows that the flow to the Murray River mouth may be reduced by a further 25 per cent by 2030. However, with the added problem of climate change, it is predicted that precipitation in the Murray–Darling catchment will decrease, so that the reduction in flow to the mouth could be as high as 70 per cent.

2.5.3 How does water flow across the land?

Permanent rivers and streams flow in only a small proportion of the Australian continent. Australia is in fact the driest of all the world's inhabited continents. It has:

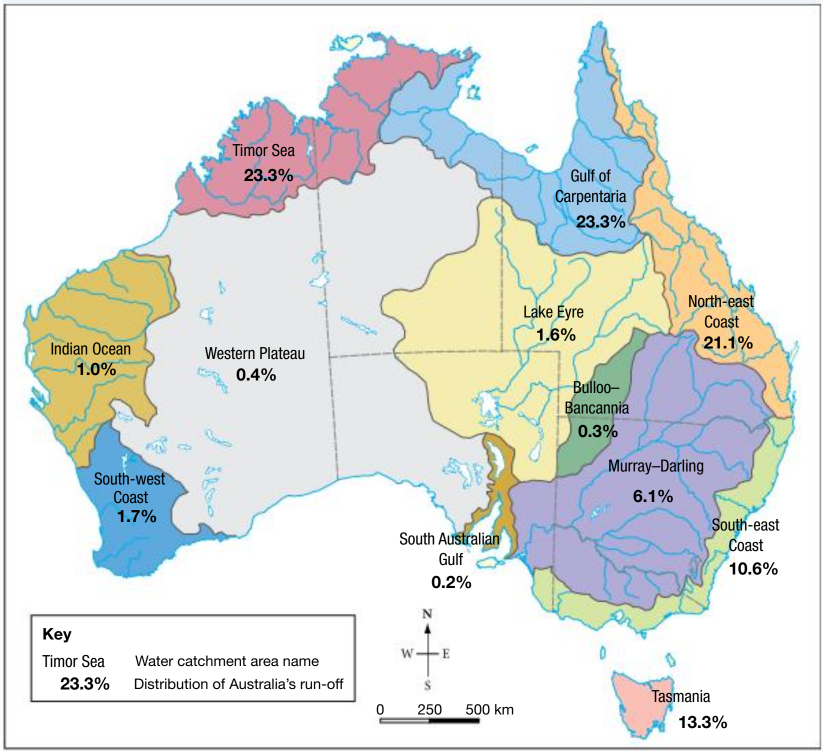
- the least amount of run-off
- the lowest percentage of rainfall as run-off
- the least amount of water in rivers
- the smallest area of permanent wetlands
- the most variable rainfall and stream flow.

Australia has many lakes and drainage basins (see **FIGURES 7** and **8**). Many of our lakes hold little water compared with those found on other continents. The largest drainage basins are in the tropical north of Australia and they are far from our major population centres.

The Ord River Scheme in Western Australia was constructed near Kununurra to try to utilise some of the water that flowed into the Timor Sea. The Ord River dam can hold up to 5641 gigalitres, which is the equivalent of 11.2 Sydney Harbours. The water in the Ord River Scheme provides irrigation for farms throughout the region. It has created land suitable for a range of crops where previously only cattle ranches were economically viable. This is controversial, however, because some see the scheme as a waste of money and an environmental disaster. Others see the scheme as a potential bread basket for Western Australia and a provider of thousands of jobs and export dollars.

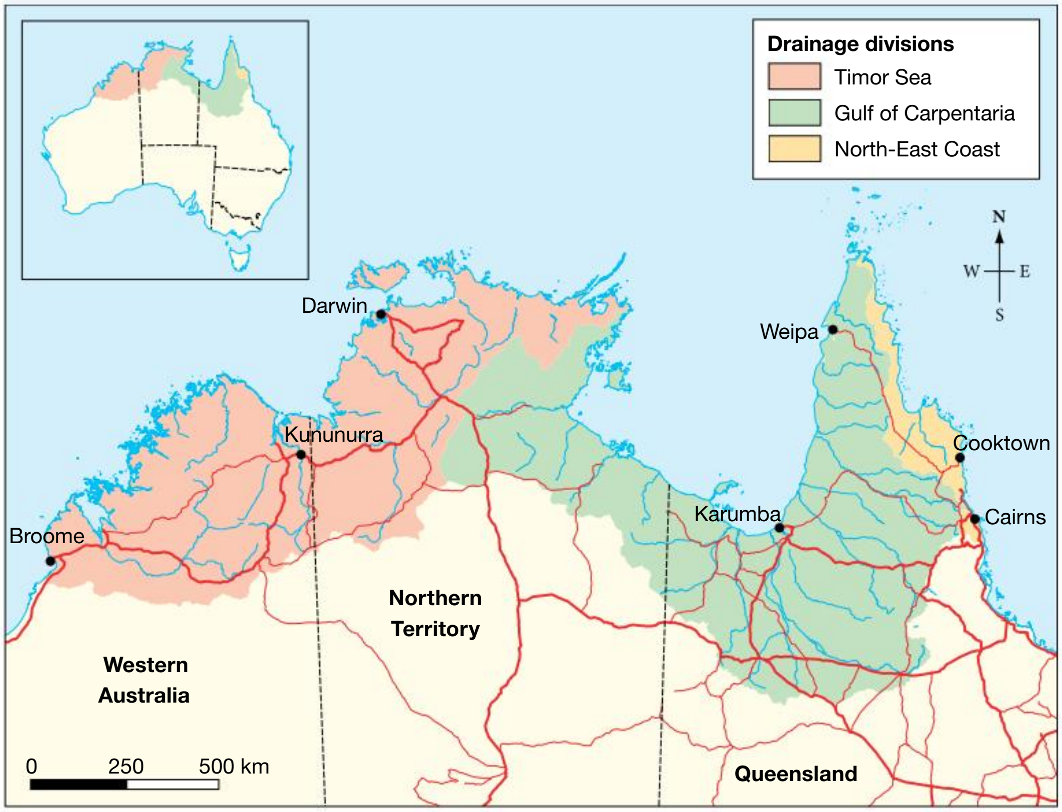
FIGURE 6 Lake Argyle

FIGURE 7 Australia's drainage basins



Source: MAPgraphics Pty Ltd Brisbane

FIGURE 8 The Northern Australian drainage basins



Source: Department of Sustainability and the Environment

on Resources

Google Earth Kununurra
Murray–Darling River

SkillBuilders to support skill development

- 2.10 SkillBuilder: Understanding thematic maps

2.5 SKILL ACTIVITY: Questioning and researching using geographical methods, Communicating

Divide your class into five groups and assign groups 1 to 4 one of Australia's landform regions to investigate. Collectively **compile** a list of landforms that are found in each region, have each member of the group **investigate** a different landform and prepare a series of PowerPoint slides that show the following:

a. the landform
b. where it is located
c. how it was formed
d. its importance to First Nations Peoples
e. reasons why it is or is not a popular place that people want to visit.

Group 5 should use their atlas to **locate** the highest mountains in each Australian state and territory.
a. What is the height of this mountain?
b. Where is it located?
c. How has it changed over time?
d. Its importance to First Nations Peoples — what creation story explains its formation?

Groups should work collaboratively online using Google Slides or a similar program to put their presentation together for viewing by the rest of the class.

2.5 Exercise

learnon

2.5 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 4, 6	2, 3, 8	5, 7, 9, 10

Check your understanding

1. Circle the correct options to complete the passage below.
   The Murray–Darling Basin covers **one-seventh** / **one fifth** of the Australian continent and is the largest drainage basin in Australia. It covers about **one** / **two** million square kilometres and is fed by more than **10** / **20** / **30** major rivers. The basin produces **25** / **43** / **62** per cent of Australia's food and over **40** / **60** / **90** per cent of Australia's agricultural income, making it the most important drainage basin in Australia.
2. Complete the following passage.
   Folding, faulting and uplift are processes that occur as a result of ____________________ activity. Pressures deep within the Earth's ____________________ cause the rocks that make up its ____________________ to buckle and fold, in much the same way that an aluminium can does when squeezed. Sometimes breaks occur or fractures develop, known as ____________________, and blocks or sections of the crust are pushed upwards, known as ____________________.
3. Australia is so low in altitude and flat compared with other continents because the continent is located in the middle of a tectonic plate, has no active volcanoes and very little tectonic uplift from below. True or false?
4. **Describe** some of the physical changes Australia's landmass has undergone.
5. **Describe** the major characteristics of Australia's four main landform regions.

Apply your understanding

Interpreting and analysing geographical data and information

6. Use your atlas to find the Cape Hillsborough and Macedon volcanoes, or refer to **FIGURE 2**.
   a. Calculate the distance between them.
   b. Use the information in this lesson to work out the rate at which the Australian landmass is moving.
   c. How far has Australia moved over the Bass Strait hotspot? Now calculate where under Bass Strait this hotspot might now lie.
   d. Use the information in this lesson to **explain** why this hotspot has changed its location over time.
7. It is said that the amount of water that flows down the Amazon River in a day is more than flows down the Murray in a year.
   a. **Consider** what this tells you about how dry Australia's climate is.
   b. **Describe** how this might affect the environment around the Murray River.
8. **Describe** the role of the Bass Strait hotspot in creating the landforms on Australia's east coast.
9. **Describe** how Kati Thanda–Lake Eyre has changed over time. **Identify** a reason for these changes.

Communicating

10. Approximately 80 per cent of the water flowing through the Murray–Darling Basin is diverted.
    a. **Identify** what this water is used for.
    b. **Predict** what impact this might have on people and the environment.

LESSON
2.6 What are deserts like in Australia and China?

LEARNING INTENTION

By the end of this lesson you should be able to describe the global distribution of deserts; identify, and make comparisons between, important desert landscapes in Australia and China; and explain why Uluru is an iconic Australian landmark.

TUNE IN

The actions of wind, and sometimes water, shape the rich variety of landscapes found in the desert regions of the world. Deserts may be hot or cold, and subject to temperature extremes.

1. What processes do you think created the landscape shown in **FIGURE 1**?
2. How can some deserts be hot, while others are cold?
3. Work with a partner to brainstorm a list of characteristics that define the desert landscape.
4. As a class, create a combined list of the characteristics of deserts.

FIGURE 1 While the extreme conditions make it difficult for people to survive, there are many desert locations around the world where people can and do live.

2.6.1 What defines a desert?

A desert is a hot or cold region with little or no rainfall. Around one-third of the Earth's surface is desert and they are home to about one billion people.

TABLE 1 Rainfall levels in different types of deserts

Rainfall (mm/year)	Type of desert	Examples
< 25	Hyper-arid	Namib; Arabian
25–200	Arid	Mojave
200–500	Semi-arid	Parts of Sonoran Desert

FIGURE 2 Although they receive little rainfall, most deserts receive some form of **precipitation**. Rain usually occurs as a few heavy storms that last a short time and can be so intense that normally dry rivers overflow their banks.

Hot deserts

Most of the world's hot deserts are located between the Tropic of Cancer and the Tropic of Capricorn (see **FIGURE 3**). They have very hot summers and warm winters. Temperature extremes are common, because cloud cover is rare, and humidity is very low; this means there is nothing to block the heat of the sun during the day or prevent its loss at night. Temperatures can range between around 45 °C and –15 °C in a 24-hour period.

precipitation the different forms in which moisture is returned to the Earth from the atmosphere, most commonly in the form of rain, hail, sleet and snow

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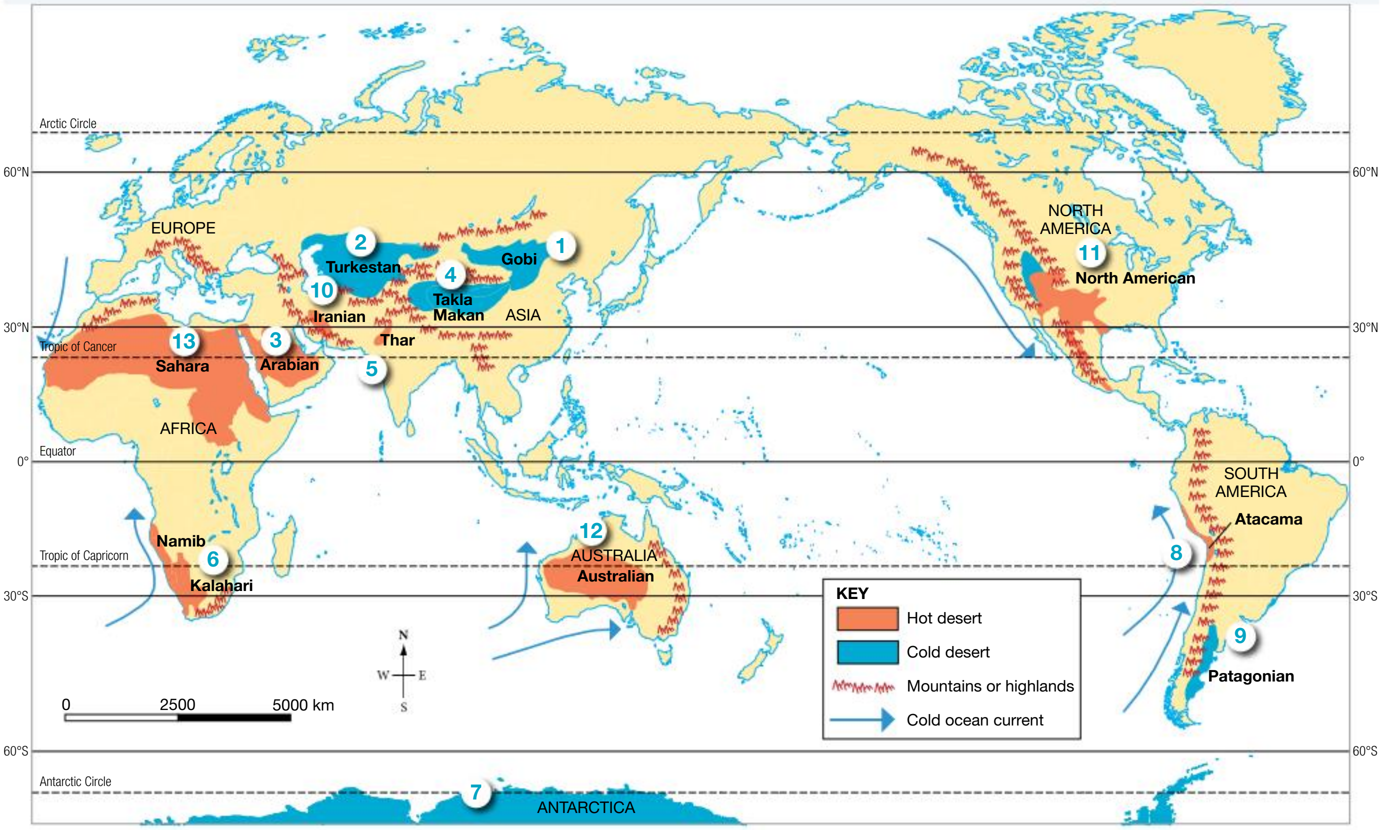
FIGURE 3 The distribution of the world's deserts



Source: MAPgraphics Pty Ltd, Brisbane

1 **Gobi Desert:** Asia's biggest desert, the Gobi, is a cold desert. It sits around 900 metres above sea level and covers an area of some 1.2 million square kilometres. Its winters can be freezing.

2 **Turkestan Desert**: The cold Turkestan Desert covers parts of south-western Russia and the Middle East.

3 **Arabian Desert:** This hot desert is as big as the deserts of Australia. Towards its south is a place called Rub al-Khali (meaning 'empty quarter'), which has the largest area of unbroken sand dunes, or ergs, in the world.

4 **Takla Makan Desert**: The Takla Makan Desert is a cold desert in western China. Its name means 'place of no return'. The explorer Marco Polo crossed it some 800 years ago.

5 **Thar Desert:** The Thar Desert is a hot desert covering north-western parts of India and Pakistan. Small villages of around 20 houses dot the landscape.

6 **Kalahari and Namib deserts:** The Namib Desert extends for 1200 kilometres down the coast of Angola Namibia and South Africa. It seldom rains there, but an early-morning fog often streams across the desert from the ocean. The dew it leaves behind provides moisture for plants and animals. It joins the Kalahari Desert, which is about 1200 metres above sea level.

7 **Antarctic Desert**: The world's biggest and driest desert, the continent of Antarctica is another cold desert. Only snow falls there, equivalent to about 50 millimetres of rain per year.

8 **Atacama Desert**: The Atacama Desert is the driest hot desert in the world. Its annual average rainfall is a tiny 0.1 millimetre.

9 **Patagonian Desert:** The summer temperature of this cold desert rarely rises above 12 °C. In winter, it is likely to be well below zero, with freezing winds and snowfalls.

10 **Iranian Desert:** Two large deserts extend over much of central Iran. The Dasht-i-Lut is covered with sand and rock, and the Dasht-i-Kavir mainly in salt. Both have virtually no human population.

11 **North American deserts**: The desert region in North America is made up of the Mojave, Sonoran and Chihuahuan deserts (all hot deserts) and the Great Basin (a cold desert). The Great Basin's deepest depression, Death Valley, is the lowest point in North America.

12 **Australian deserts**: After Antarctica, Australia is the driest continent in the world. Its deserts are generally flat lands, often vibrant in colour.

13 **Sahara Desert**: The largest hot desert in the world, the Sahara covers around 9 million square kilometres across northern Africa over 12 countries. Only a small part is sandy. It is the sunniest place in the world.

Cold deserts

Cold deserts lie on high ground generally north of the Tropic of Cancer and south of the Tropic of Capricorn (see **FIGURE 3**). They include the polar deserts. Any precipitation falls as snow. Winters are very cold and often windy; summers are dry and cool to mild.

2.6.2 Desert dwellers

Many of the people who live in desert regions ae nomadic and move with the seasons, obtaining their needs from the land or trade. In several parts of the world, nomadic tribes herd animals. The harsh climate and lack of water make it difficult for large cities to develop, although they can develop in coastal areas where permanent rivers provide a reliable water supply.

2.6.3 Comparing deserts in China and Australia

FIGURE 3 shows that deserts exist in many different parts of the globe: the subtropics; interior of continents; on the leeward side of mountain ranges; along the coast; and in polar regions. The only common factor is their low rainfall. The Gobi Desert is an example of both a rain-shadow desert (**FIGURE 4**) and an inland desert. While the deserts in Australia are also rain-shadow deserts, cold ocean currents (**FIGURE 5**) have played a significant role in in their formation. Look back at the map in **FIGURE 3**. What factors do you think led to their formation?

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FIGURE 4 The formation of rain-shadow deserts

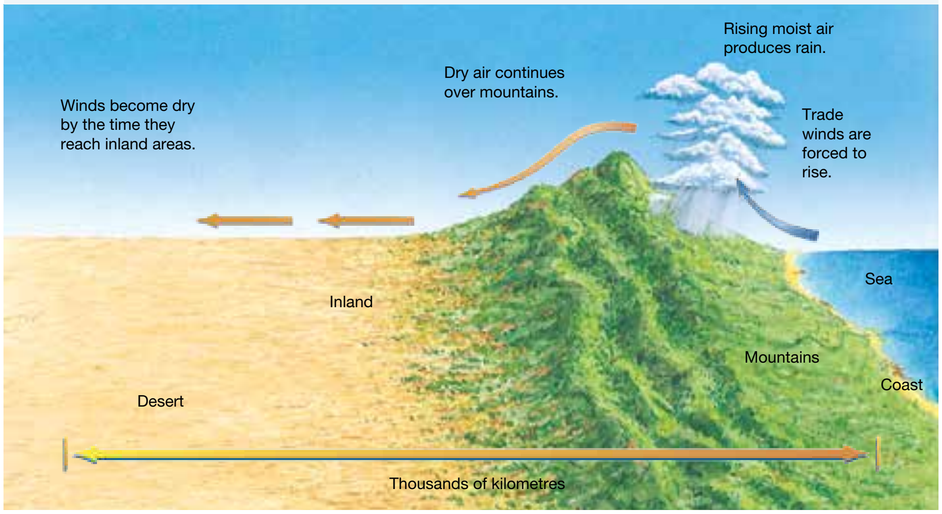

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FIGURE 5 The formation of coastal deserts

The Gobi Desert

The Gobi Desert (**FIGURE 6**) is the second largest desert in Asia and the sixth largest in the world, covering parts of both North-western China and Southern Mongolia. It is classified as a cold desert.

The Gobi Desert is a rain-shadow desert, as it lies on the leeward side of the Tibetan Plateau and the Himalayan Mountains prevent precipitation from the Indian Ocean from reaching it. Its location away from the coast and in the high latitudes (approximately 43 degrees north of the Equator) means that winter temperatures can drop as low as –40 °C, at the height of summer the temperature can reach as high as 45 °C, though this is rare.

FIGURE 6 The Gobi Desert is an example of a cold desert.

The landscape in the Gobi Desert is varied, with sand covering only about 5 per cent. The most common landscape is the grassy plains that are exposed when the land is not covered in snow. The region is home to one of the Earth's most important paleontological sites; the cold conditions have led to the discovery of well-preserved fossils that are thought to be more than 88 million years old.

Australian deserts

Australia is the world's driest inhabited continent, with around 70 per cent classified as arid or semi-arid. However, only about 18 per cent of the continent is classified as true desert.

Lying predominantly between the Equator and the Tropic of Capricorn, Australian deserts are classified as hot deserts, as they receive less than 250 mm of rainfall each year and temperatures can soar past 50 °C. Humidity levels are low, with the average humidity lying between 10 to 20 per cent.

- Australian deserts, such as the Simpson Desert, are the result of a combination of factors. Australian deserts are rain-shadow deserts (**FIGURE 4**); the Great Dividing Range prevents warm moisture-laden air from the east coast reaching the interior of the continent.
- Cold ocean currents along the west coast contain little moisture and the winds are essentially dry as they move to the interior of the continent (**FIGURE 5**).

FIGURE 7 Uluru is an **inselberg** that rises above the surrounding desert landscape. To the Anangu People it is a significant landmark created during The Dreaming and seen as the resting place for generations of ancient spirits.

The Australian desert landscape is varied, including sandy deserts, grassy plains and stony areas (gibber plains). The climatic conditions of Australia's deserts have resulted in the preservation of fossil remains.

2.6.4 What processes shape desert landforms?

Sand covers only about 20 per cent of the world's deserts. Sand is the product of millions of years of erosion of other landforms such as rock and plateaus that, over time, are worn away by extremes of temperature, wind and water.

inselberg an isolated hill, knob, ridge, outcrop or small mountain that rises sharply from the surrounding landscape

The landforms and patterns of a desert are created by several natural processes. The unprotected land surfaces are prone to erosion. After heavy rain, often a long distance from the desert floodplains, erosion of ancient river channels can be major. Extreme temperatures, along with strong winds and the rushing water that can follow a desert rainstorm, cause rocks to crack and break down into smaller fragments. This process is called weathering.

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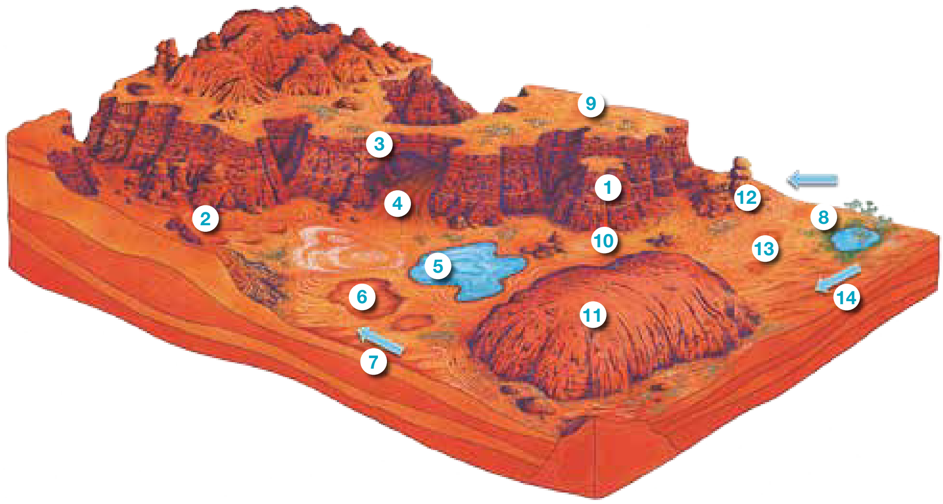
FIGURE 8 A variety of landforms are found in the desert. They result from the actions of wind and water. Can you pick the landforms created by erosion and those created by deposition?



1. A butte is the remaining solid core of what was once a mesa. It often is shaped like a castle or a tower.
2. Crescent-shaped barchan dunes are produced when sand cover is fairly light.
3. An arch, or window, is an opening in a rocky wall that has been carved out over millions of years by erosion.
4. An alluvial fan is the semicircular build-up of material that collects at the base of slopes and at the end of wadis after being deposited there by water and wind.
5. A playa lake may cover a wide area, but it is never deep. Most water in it evaporates, leaving a layer of salt on the surface. These salt-covered stretches are called saltpans.
6. Clay pans are low-lying sections of ground that may remain wet and muddy for some time.
7. The rippled surface on transverse dunes is the result of a gentle breeze blowing in one direction.
8. An oasis is a fertile spot in a desert. It receives water from underground supplies.
9. A mesa is a plateau-like section of higher land with a flat top and steep sides. The flat surface was once the ground level, before weathering and erosion took their toll.
10. Sand dunes often start as small mounds of sand that collect around an object such as a rock. As they grow larger, they are moved and shaped by wind.
11. An inselberg is a solid rock formation that was once below ground level. As the softer land around it erodes, it becomes more and more prominent. Uluru is an inselberg.
12. A chimney rock is the pillar-like remains of a butte.
13. Star dunes are produced by wind gusts that swirl in from all directions.
14. Strong winds blowing in one direction form longitudinal dunes.

Erosional landforms

Most erosion in deserts is caused by wind, and at times running water. Although deserts are areas of low rainfall, they sometimes experience heavy downpours and may receive several years of rain in one such event. Fast-flowing water carves deep channels into the ground forming deep gullies or the walls of a plateau (see **FIGURE 8**). An inselberg such as Uluru is an example of an erosional landform (see **FIGURE 7**).

Erosion can also result from the action of wind and from chemical reactions. Some rock types, such as limestone, contain compounds that react with rainwater and then dissolve in it. Wind is a very important agent of transport and deposition and can change the shape of land by abrasion — the wearing down of surfaces by the grinding and sandblasting action of windborne particles.

Depositional landforms

Materials carried along by rushing water and wind must eventually be put down. Over time these materials build up, forming different shapes and patterns in the desert. This process is called deposition.

Depositional landforms in deserts include alluvial fans and sand dunes (see **FIGURE 8**).

2.6 SKILL ACTIVITY: Communicating

The significance of Lake Mungo

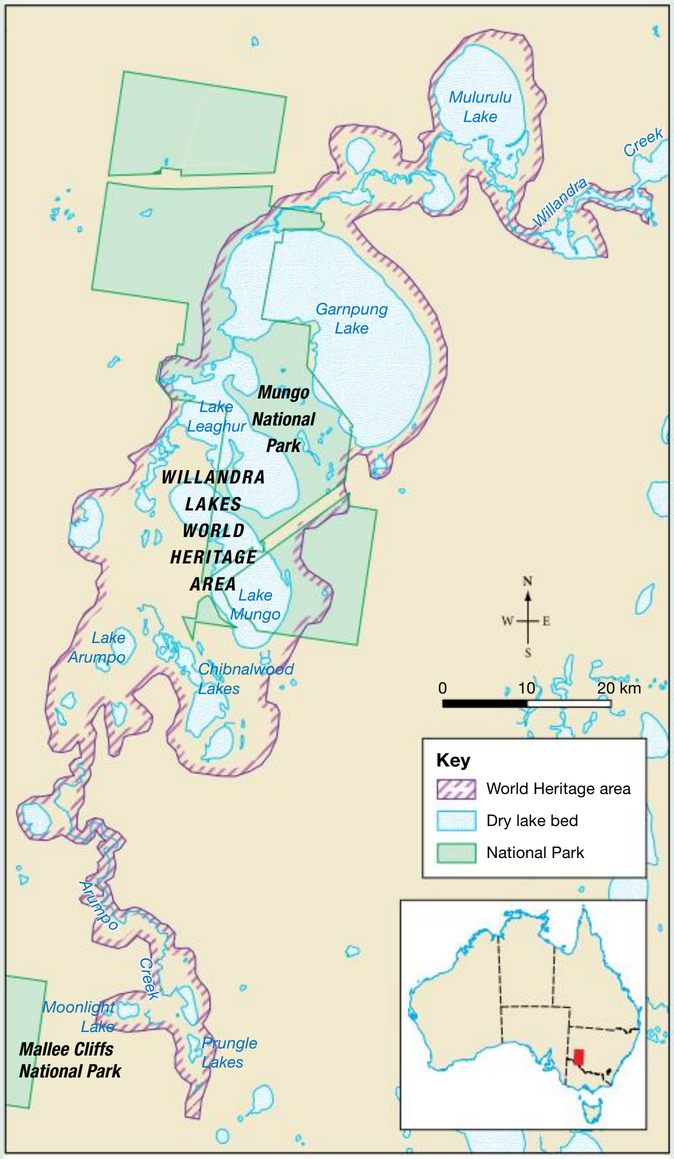
The hot dry climate of Australia's deserts has meant that much of our distant past has been preserved. At Lake Mungo in the Willandra Lakes Region of New South Wales, for example, evidence of continuous human settlement by Australia's First Nations Peoples has been discovered.

The Willandra Lakes region is a World Heritage Area. It is important because of its archaeology and geomorphology. It is culturally significant to Australia's First Nations Peoples.

Use the internet to **investigate** the following:

1. How has Lake Mungo changed over time? Begin with its formation through to the present day. Use the **Timeline maker** weblink to **communicate** your findings.
2. **Create** a poster to **explain** what World Heritage listing means and why this place is culturally significant to First Nations Peoples.

FIGURE 9 Location of Willandra Lakes, including Lake Mungo



Source: Spatial Vision

FIGURE 10 Traditional custodians clean fossilised footprints at Lake Mungo.

on Resources

Interactivity Location of Willandra Lakes, including Lake Mungo (int-3615)

2.6 Exercise

learnon

2.6 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4, 5	3, 7, 8, 9	6, 10

Check your understanding

1. **Identify** the sunniest place in the world from the following list.
   A. Antarctica
   B. Australian Desert
   C. Sahara Desert
   D. Namib Desert
2. Refer to the **FIGURE 3** map and **identify** two deserts in the Asia–Pacific region.
   A. Patagonian
   B. Thar
   C. Australian
   D. Iranian
   E. Gobi
   F. Arabian
3. **Determine** if the following statements are true or false.
   a. Hot deserts are located between the tropics of Cancer and Capricorn.
   b. Cold deserts are found only at high altitudes.
   c. Hot deserts are always hot.
   d. Cold deserts are always cold.
   e. In cold deserts precipitation falls as snow.
4. **Describe** the climate conditions that are needed for hot and cold deserts to form.
5. **Identify** the major line of latitude on which Australian deserts are located.

Apply your understanding

Communicating

6. The Gobi Desert is a land of climate extremes. **Justify** the classification of the Gobi Desert as a cold desert.
7. **Describe** why Uluru is considered an iconic Australian landmark.
8. **Explain** the factors that have resulted in the formation of Australia's desert region.
9. **Compare** the characteristics of the Gobi Desert and the Australian desert region.
10. **Discuss** reasons that account for the rich source of well-preserved fossil remains in desert regions.

LESSON
2.7 How do the savanna grasslands of Australia and Africa compare?

LEARNING INTENTION

By the end of this lesson you should be able to describe the distribution of grasslands, explain the characteristics of grasslands and compare Australia's grasslands with those in the Serengeti.

TUNE IN

Indigenous communities use fire sticks to light fires, referred to as 'cool burns' as a method of land management. Only small areas are burnt, and careful attention is paid to the condition of the grass, temperature and winds. Fires are low and lit in the early morning or late afternoon when it is cooler to help prevent them from getting out of control. The dry undergrowth is burnt, reducing fuel load. The practice helps encourage new growth and maintains the grassland.

1. Discuss with a partner the benefits of landscape burning.
2. It has been suggested that more selective burning of bushland should take place during winter to reduce the threat of bushfires in summer. Brainstorm a list of advantages and disadvantages of this suggestion.

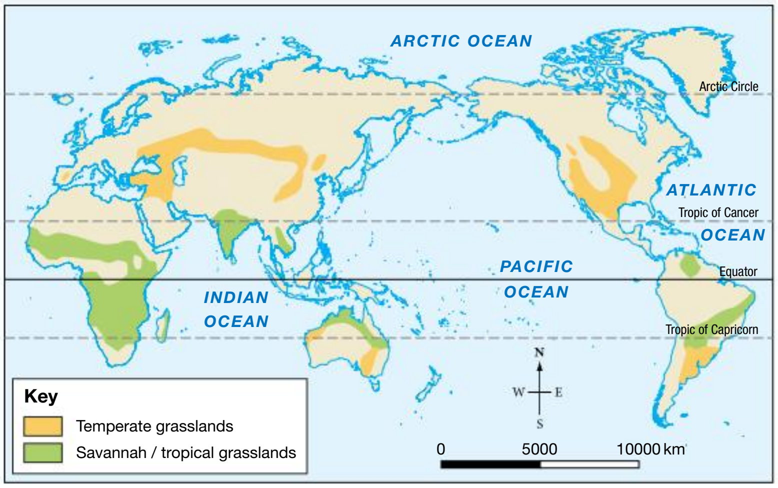
FIGURE 1 A cool burn

2.7.1 What are grasslands?

FIGURE 2 shows the location of both temperate and tropical grasslands that are often referred to as savannas (or savannahs). Grasslands are a landscape dominated by an almost continuous cover of grass. They are often referred to as a transitional landscape as they lie between rainforests and deserts. Rainfall is too high for the landscape to be classified as a desert but not high enough to support the tall trees and vegetation found in a rainforest.

Grasslands have sometimes been described as looking 'like a park', due to the absence of trees. When present, trees are scattered and often 'flat topped' or little more than stunted shrubs. Where water flows through the landscape in rivers or streams, narrow strips of forest referred to as 'gallery forests' may develop.

FIGURE 2 Grasslands are found on every continent except Antarctica.



Source: Based on data from Geography Teachers Associations of NSW. Map redrawn by Spatial Vision.

The ecosystem is maintained by grazing animals and Indigenous communities have used fire as a method of maintaining this landscape. Fire prevents the growth of trees and encourages the growth of grass, which in turn attracts grazing animals. Grasslands exist in a delicate state of balance and can easily be converted to desert if not managed carefully.

Climate in savanna grasslands varies; however, there are three main characteristics:
- wet summer — the wet
- dry winters — the dry
- hot all year round.

2.7.2 The Serengeti grasslands

The Serengeti is a savanna grassland located in northern Tanzania and southwestern Kenya. The grassland ecosystem is supported by rich volcanic soils; the mass migration of animals has had a positive ecological impact on the area.

Indigenous communities such as the Maasai traditionally lived a nomadic lifestyle as cattle herders and subsisting off their herds and the land. They believed that sedentary agriculture is damaging to the environment.

Today the lifestyle of the Maasai is threatened by restrictions imposed upon them due to drought; the government places limits on how land can be used within a national park. The tourism industry operates under strict controls (**FIGURE 3**).

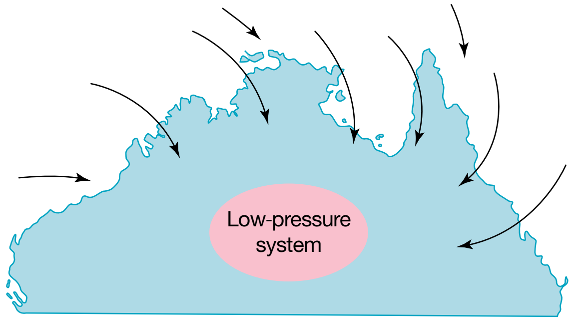
FIGURE 3 The lifestyle of the Maasai and the opportunity to go on a wildlife safari has resulted in a massive influx of tourists into the Serengeti.

2.7.3 Australian grasslands

Australia's top end, stretching from Broome on the west coast to Townsville on the east coast, is a tropical grassland or savanna landscape. First Nations Peoples have maintained the grassland environment for thousands of years, relying on fire to regenerate the grasslands by using cool burns (see **FIGURE 1**) to encourage new plant growth. There is a distinct wet season that corresponds with the monsoon season (**FIGURE 4**). The lives of First Nations Peoples in northern Australia are governed by changes that occur during and between the wet and dry seasons.

tlvd-10614

FIGURE 4 Australia's wet and dry seasons are the result of air movements and pressure systems.

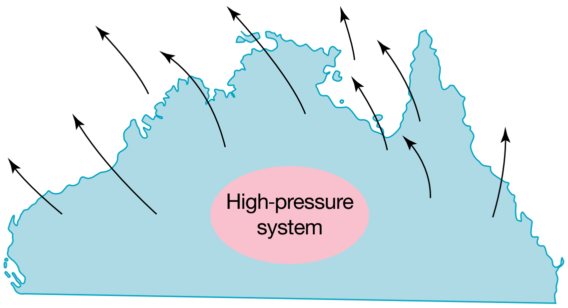


In summer

- The land heats up; the air is hot and light.
- Hot air rises and cools, creating a low-pressure system.
- Air moves in from over the ocean to replace the rising air.
- This air is wet and brings rain to northern Australia.

a. Summer months

⟶ Major wind direction



In winter

- The land cools down.
- The air is heavy and sinks, creating a high-pressure system.
- The air is dry as it has passed over the interior of the continent.
- Dry air moves to the north, bringing dry weather to northern Australia.

b. Winter months

⟶ Major wind direction

2.7 SKILL ACTIVITY: Interpreting and analysing geographical data and information, Communication

TABLES 1 and **2** contain the climate statistics for Cloncurry in Australian and Serengeti National Park in Tanzania. The lives of Indigenous communities are often governed by the climatic changes that take place throughout the year.

TABLE 1 Cloncurry Australia 21°S

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp °C	31	30	29	26	22	19	18	20	23	27	30	31
Rain mm	112	108	61	18	13	15	8	3	8	13	33	69

TABLE 2 Serengeti National Park Tanzania 2°S

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp °C	28	28	28	26	25	25	25	26	27	28	27	27
Rain mm	81	100	121	137	68	23	9	19	34	51	100	97

1. **Create** climate graphs, using geographic conventions, for both Cloncurry and Serengeti National Park.
2. Both places have a wet and a dry season. **Explain** what you understand by the terms wet and dry season.
3. The lives of the people in the Northern Territory recognise six seasons and their lives are governed by these seasons. Use the **Ngurrungurrudjba** weblink in the Resources panel to learn more about the way First Nations Peoples recognise changes in the environment. **Create** a calendar of seasons, or annotate your climate graph to show what occurs in each season.

on Resources

Weblinks Serengeti
Ngurrungurrudjba

2.7 Exercise

learn**on**

2.7 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 3, 7, 9	2, 4, 6	5, 8, 10

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- Access sample responses
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Check your understanding

1. Refer to **FIGURE 2**. The largest area of grasslands is found in
   A. Africa
   B. Australia
   C. Europe
   D. Antarctica.
2. **Identify** which continent does not have any grasslands.
   A. Europe
   B. Asia
   C. Antarctica
   D. Africa
3. The Maasai people live in the top end of Australia. True or false?
4. **Explain** why grasslands are described as a transitional landscape.
5. Which of the following statements is true?
   A. The Serengeti is hotter and wetter than Australia's grasslands.
   B. The Serengeti is cooler and drier than Australia's grasslands.
   C. The Serengeti is hotter and drier that Australia's grasslands.
   D. The Serengeti is cooler and wetter than Australia's grasslands.

Apply your understanding

Communicating

6. **Explain** why there are few trees in grasslands.
7. **Define** the term 'gallery forest'.
8. **Propose** a reason why gallery forests are usually found along watercourses, even when the watercourse is dry.
9. **Identify** the threats faced by the Maasai people of the Serengeti.

Interpreting and analysing geographical data and information

10. Refer to **FIGURE 4**. **Explain** the relationship between pressure systems and the climate of northern Australia.

LESSON
2.8 What makes a rainforest?

LEARNING INTENTION

By the end of this lesson you should be able to describe the characteristics and distribution of rainforests. Additionally, you should be able to explain the importance of rainforests.

TUNE IN

Did you know that rainforests have been described as the 'Earth's lungs' and play a key role in regulating the global climate?

1. What do you understand by the terms 'Earth's lungs' and 'regulators of global climate'?
2. Describe what you can see in **FIGURE 1.**
3. What message do you think **FIGURE 1** is sending?

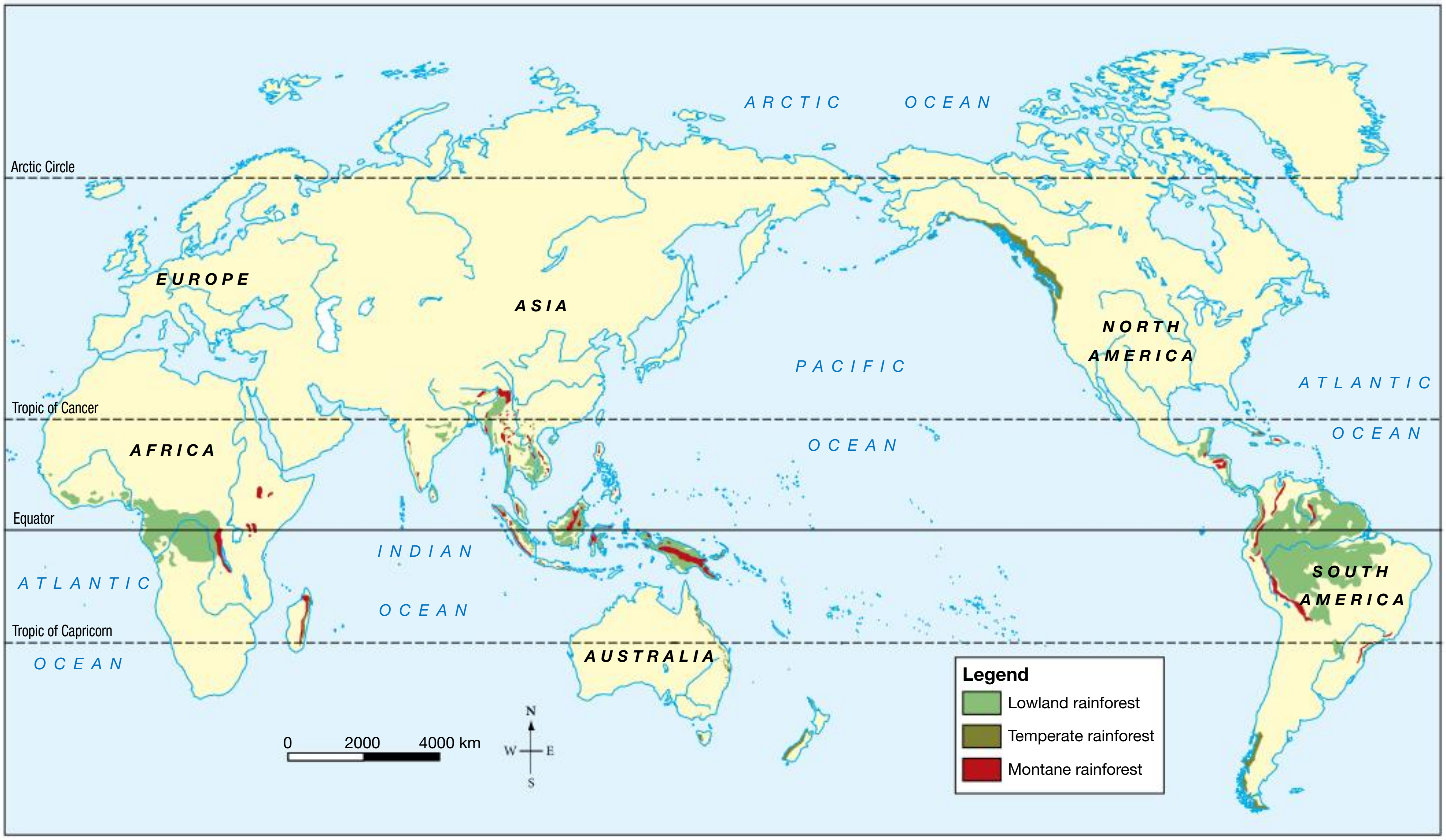
FIGURE 1 The global climate is linked to our rainforests.

2.8.1 Where are the world's rainforests?

Rainforests grow in areas that are constantly wet. More than 1300 millimetres of rain spread evenly throughout the year is needed to support the rainforest ecosystem.

int-7852

FIGURE 2 World rainforest types

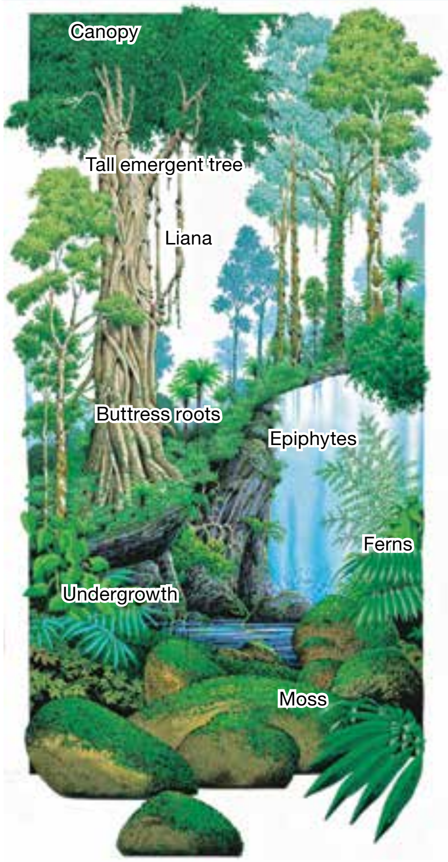


Source: MAPgraphics Pty Ltd Brisbane

Tropical rainforests are found where there are both high temperatures and high rainfall. These conditions stretch from the Equator to the Tropic of Capricorn (in the south) and the Tropic of Cancer (in the north).

Tropical rainforests that occur in the mountains more than 1000 metres above sea level are called montane rainforests, whereas those growing below 1000 metres are known as lowland rainforests. Temperate rainforests, on the other hand, are located between the tropics and the polar regions in what is known as the **temperate zone**.

FIGURE 3 Layers in a tropical rainforest



2.8.2 The rainforest ecosystem

Rainforests are unique **ecosystems** consisting of four different layers — the emergent, canopy, understory and forest floor (**FIGURE 3**). Each layer can be identified by its distinct characteristics.

Emergents

These are the tallest trees, ranging in height from 30 to 50 metres. They are so named because they rise up or emerge out of the forest canopy. Huge crowns of leaves and abundant animal life thrive on plenty of available sunlight.

Canopy

This describes the array of treetops that form a barrier between the sunlight and the underlying layers. Their height can vary from 20 to 45 metres. This layer contains a distinct **microclimate** and supports a variety of plants and animals. The taller trees host special vines called lianas that intertwine the branches. Other plants called epiphytes use the tree trunks and branches as anchors in order to capture water and sunlight.

Understorey

This layer contains a mixture of smaller trees and ferns that receive only about five per cent of the sun's energy. Many animals move around in the darkness and humidity, using the vines as highways.

Forest floor

This bottom layer is dominated by a thick carpet of leaves, fallen trees and huge buttress roots that support the giant trees above. Rainforest soils give the impression of being fertile because they support an enormous number of trees and plants.

However, this impression is wrong, as the soil in rainforests is generally poor. Leaves and other matter are recycled by the many organisms to create a living **compost**. The roots of trees must 'snatch' these nutrients from the soil before heavy rains wash them away and they are lost through a process called **leaching**.

Larger animals also roam through this layer in search of food.

temperate zone describes the relatively mild climate experienced in the zones between the tropics and the polar circles

ecosystem an interconnected community of plants, animals and other organisms that depend on each other and on the non-living things in their environment

microclimate specific atmospheric conditions within a small area

compost a mixture of various types of decaying organic matter such as dung and dead leaves

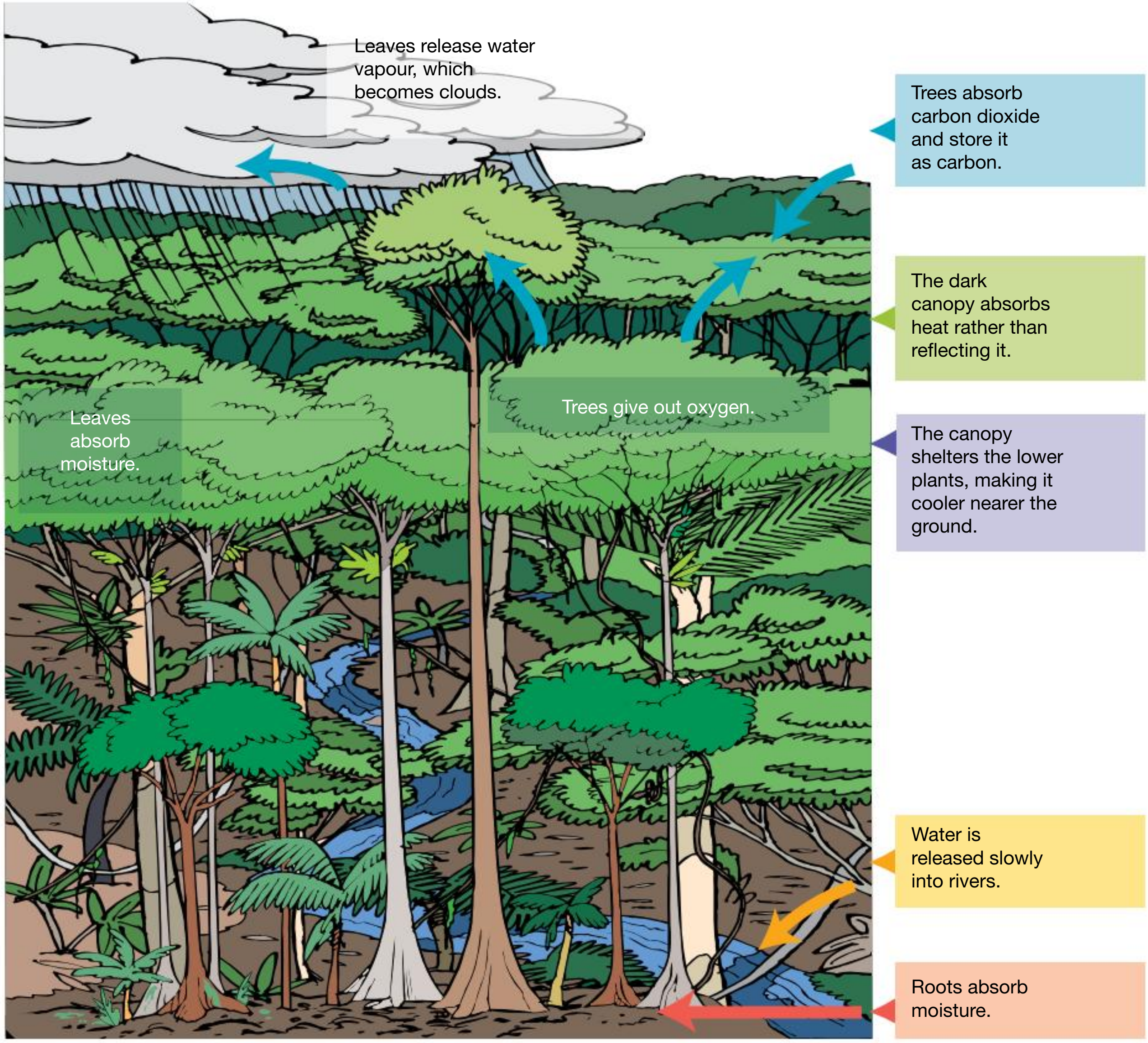
leaching a process that occurs in areas of high rainfall, where water runs through the soil, dissolving minerals and carrying them into the subsoil. The process can be compared to a coffee pot in which water drips through the grounds.

2.8.3 Amazing rainforests

Most of us use rainforest products every day. More importantly, however, rainforests help control the world's climate and our oxygen supply (see **FIGURE 4**). So the next time you eat chocolate, treat your asthma, play a guitar or even take a deep breath, you should thank a rainforest.

tlvd-10679

FIGURE 4 Rainforests play a vital role in controlling the world's climate and oxygen supply. Scientists believe that half of the world's oxygen is produced by the Amazon rainforest alone.



- At least 50 million indigenous peoples live in rainforests worldwide. From the Kuna people of Panama and the Yanomami of Brazil to the Baka people of Cameroon and the Penan of Borneo (Indonesia), these people have traditionally lived a way of life that has little impact on their forest home.
- Rainforest trees are generally hardwood trees, making them resistant to decay and attractive for building. Well-known rainforest timbers are mahogany, teak, ebony, balsa and rosewood. Rosewood is particularly interesting, as it is considered the best timber in the world for guitar making. In many tropical countries, people also collect timber as fuel for cooking or heating.

- Chocolate first came from the cacao tree native to the Amazon rainforest. Today the chocolate you eat is most likely to come from cacao plantations in West Africa.
- Most of the fruits and nuts mentioned here are now grown by farmers rather than harvested directly from the forest, but it was in the rainforests that they originated.
- Brazil and cashew nuts, cinnamon, ginger, pepper, vanilla, bananas, pineapples, coconuts, paw-paws, mangoes and avocados were all originally rainforest plants.
- The gum used in chewing gum comes from a rainforest plant, as does the tree that produces rubber.
- More than 7000 modern medicines are made from rainforest plants. They can be used to treat problems from headaches to killer diseases like malaria. They are used by people who suffer from multiple sclerosis, Parkinson's disease, leukaemia, asthma, acne, arthritis, glaucoma, diabetes, dysentery and heart disease, among many others.
- The cacao tree is a source of compounds used to lower cholesterol, blood sugar levels and the risk of heart disease.
- Tree frogs from Australia give off a chemical that can heal sores, and a similar chemical from a South American frog is used as a powerful painkiller.
- Quinine, a key ingredient in the treatment of malaria, comes from the cinchona tree.
- The poisonous venom from an Amazonian snake is used to treat high blood pressure.
- Twenty-five per cent of all cancer-fighting drugs originate in the rainforest.

FIGURE 5 Many of the foods we eat come from rainforests.

FIGURE 6 Only one per cent of known rainforest plants and animals have been analysed for their medicinal potential.

2.8.4 Where have our rainforests gone?

Rainforests have the potential to provide a wide variety of useful resources. The temptation to use these pristine areas is often too difficult for people to resist, especially if they live in poverty. As a result, all around the world, rainforests are being destroyed for economic gain (see **FIGURE 7**).

- Around 31 per cent of the Earth's surface is covered by rainforests.
- Only 18 per cent of the Earth's rainforests are protected from deforestation.
- More than 8 million hectares of forest were lost between 1990 and 2020.
- Globally, around 2400 trees are cut down each minute — enough to fill one soccer field.
- NASA estimates that in 100 years there may be no rainforests left.

Factors causing deforestation

Agricultural production — removal of forest for plantation crops such as soy and palm oil, agricultural pasture, settlements and infrastructure. Beef and soy production account for more than two-thirds of deforestation.

Forest fires — millions of hectares are lost each year. Degraded forests are more prone to uncontrolled natural fires. Fires are also deliberately lit to clear the area for other uses.

Illegal and unsustainable logging — rainforest trees produce hardy timber that is in demand for commercial use in international markets.

Fuelwood harvesting — over-harvesting as a cheap source of fuel for locals living in poverty or for the commercial use in the production of charcoal.

Mining — mineral resources are abundant in rainforest regions. The land is cleared to extract these resources and build roads and other infrastructure to gain access to mines.

Climate change — climate change reduces rainfall and increased temperatures dry out the rainforest, increasing the risk of fire and further reducing rainfall.

FIGURE 7 Illegal gold mining in the Amazon not only destroys the rainforest but also contaminates rivers with mercury.

on Resources

Interactivities Deforestation dilemma (int- 3113)
Our living green dinosaurs (int- 3112)
Protecting or plundering rainforests (int- 3114)

2.8 SKILL ACTIVITY: Questioning and researching, Communicating

More than 3 million species call rainforests home, making them the most biodiverse places on Earth.

1. As a class, **brainstorm** a list of plants, animals, insects, amphibians and so on that are found in the rainforest. You might need to use the internet to help you.
2. Have each member of the class select a different species to **investigate**.
   a. Find an image of your species.
   b. **Annotate** your image to **explain** the characteristics of the species shown.
   c. **Create** a class collage to showcase your collective findings.

2.8 Exercise

learnon

2.8 Exercise

Learning pathways

■ LEVEL 1 1, 2	■ LEVEL 2 3, 4	■ LEVEL 3 5, 6

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Check your understanding

1. Rainforests thrive in locations that receive ____________ of rainfall evenly spread throughout the year. This is most commonly experienced in the equatorial regions of the planet, where climatic conditions are moist and warm all year round.
2. **Compare** montane and lowland rainforests by inserting the correct type into the spaces.
   ____________ rainforests are found at altitudes below 1000 metres. Trees are tall and include a greater variety of fruiting trees.
   ____________ rainforests are found at an altitude of 1000 metres or higher. These rainforests are not as threatened as others.
3. **Compare** the different layers of rainforest environments by matching each layer with the amount of light it receives.

Emergent and canopy	
Understorey	
Forest floor	

   - Dark
   - Dark, only 5 per cent of the sun's light and energy
   - Plenty of sunlight available
4. Why are rainforests sometimes called 'the lungs of the Earth'?
5. What percentage of deforestation is caused by agriculture in the Amazon?
   A. 20%
   B. 30%
   C. 55%
   D. 77%
   E. 90%

Apply your understanding

6. Refer to **FIGURE 2**. **Describe** the distribution of rainforests around the world. On which continents and between which latitudes are they found?
7. a. What name is given to the tallest trees in the rainforest?
   b. Why do you think they were given this name?
8. **Describe** the distribution of rainforests around the world. Think about in which continents and between which latitudes they are found, the size and scale of them, and whether they are continuous or scattered.
9. Many rainforest environments are located in developing countries. Why does this make the problem of rainforest destruction harder to solve?
10. Soils in the rainforest are generally poor but they support a diverse range of dense vegetation. **Explain** why the rainforest is able to support so much vegetation, but cannot sustain agricultural production without the addition of fertilisers.

LESSON
2.9 INQUIRY: The value of rainforests

LEARNING INTENTION

By the end of this lesson you should be able to explain why rainforests are important, describe the threats to rainforests and develop strategies for the preservation of rainforests.

Background

Newsflash — rainforests will soon be gone

Over the past 10 000 years, human activities have reduced the Earth's forest by about one-third. Trees have been felled to make way for urban development and agriculture, and to obtain fuel and building materials. Today, approximately 34 per cent of the world's land area is covered by forest.

Rainforests are one of the most complicated environments on Earth. Mostly found in warm, moist areas near the equator, rainforests contain nearly three-quarters of all varieties of life on Earth and perform several important functions on our planet. Australia's rainforests are very important, as they contain half of our plant and one-third of our native animals in a very small area (20 000 square kilometres).

Until this century, tropical rainforests were hardly touched by humans because the excessive heat, mosquito plagues, torrential rain and mountainous surroundings made tropical rainforests inaccessible to most humans. However, with increasing demand for timber and clear land, these rainforests are disappearing at a rapid rate all over the world.

Urgent action is needed, but we need more information before the important decisions are made. Reliable sources suggest the Department for Natural Resources and Environment are compiling a top-secret document detailing many factors in the 'Rainforest Debate'.

Before you begin

Access the **Inquiry rubric** in the digital documents section of the Resources panel to guide you in completing this task at your level. At the end of the inquiry task you can use this rubric to self-assess.

In this inquiry you will work in a team to complete an in-depth study on tropical rainforests to learn why they are important and present strategies for the conservation of the world's remaining rainforests.

You may choose to focus on a specific rainforest, such as the Daintree in Queensland, the Amazon in Brazil or the rainforests of Indonesia, Malaysia, Papua New Guinea or the Congo.

Inquiry steps

Read the background information provided and **decide** what additional information you need. You can also use the topographic map of the Daintree Rainforest in lesson 2.9 in your research. Assign roles within your group.

Step 1: Questioning and researching using geographical methods

- **Create** your inquiry question.
- **Research** your question. Use the following weblinks from the Resources panel to get you started:
  - **Living rainforests** to find out more about the rainforest landscape.
  - **Rainforest threats 1** and **2** and to learn about the threats to rainforests.
  - **Protecting rainforests** to discover more about:
    - what is being done to protect rainforests
    - the structure of rainforests
    - their role in regulating climate
    - their role in oxygen production
    - rainforest habitats
    - rainforests as a source of food and medicine
    - threats to the rainforest
    - conservation strategies and their success.

Step 2: Interpreting and analysing geographical data and information, Concluding and decision-making

- **Analyse and evaluate:** do you need to adjust your inquiry question? Which information is relevant to your inquiry? Incorporate relevant maps and statistics.

Step 3: Communicating

- **Communicate:** what is the answer to your inquiry question? Present your findings. This could be in the format of a webpage, oral presentation or recorded documentary, for example.

Complete your self-assessment using the **Inquiry rubric** or access the 2.9 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39535)

Weblinks Living rainforests
Rainforest threats 1
Rainforest threats 2
Protecting rainforests

LESSON
2.10 Investigating topographic maps — Features of the Daintree rainforest

LEARNING INTENTION

By the end of this lesson you should be able to locate and describe the features of the Daintree rainforest on a topographic map.

2.10.1 Daintree rainforest

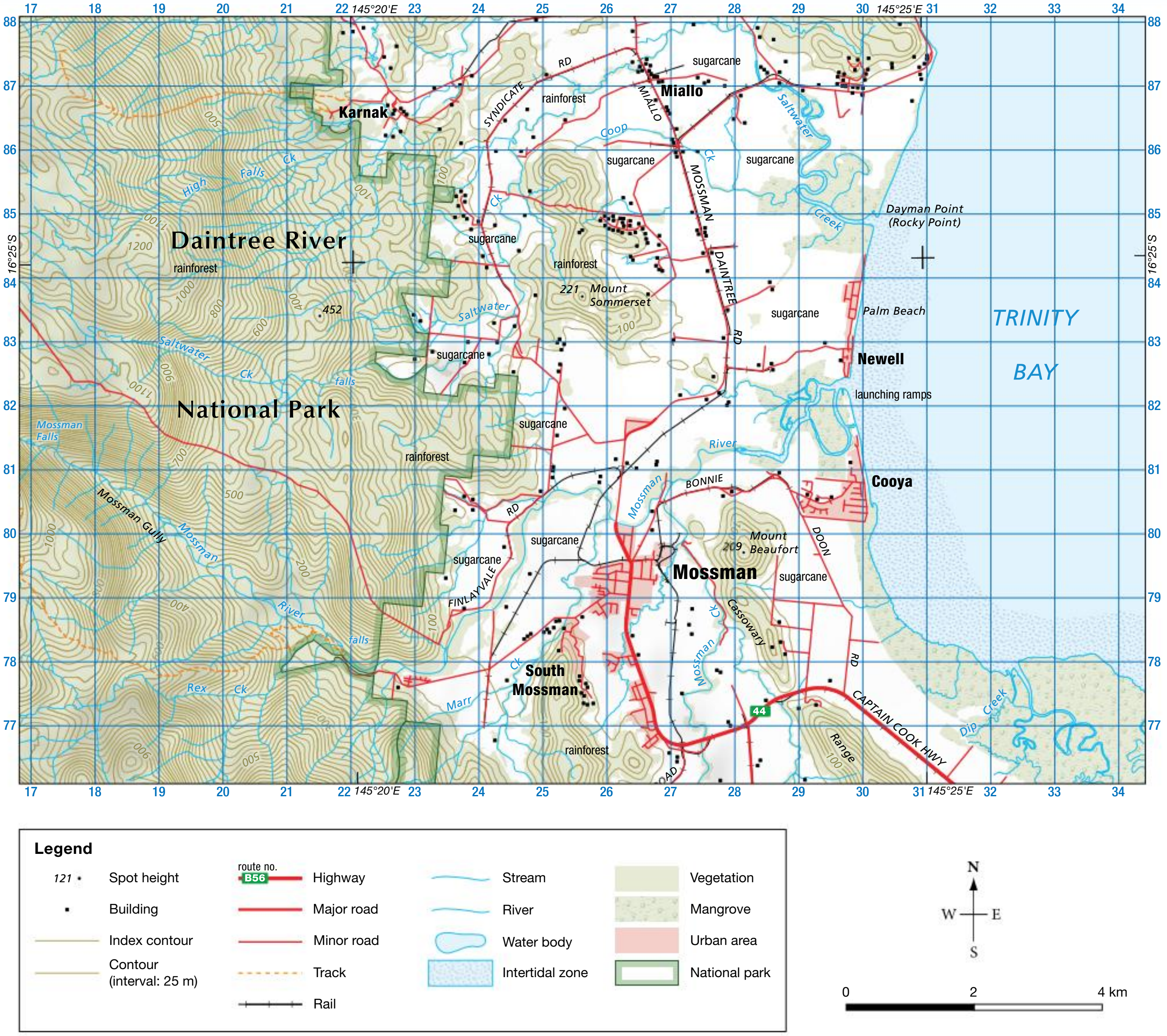
The Daintree rainforest, located in the Daintree National Park in far north Queensland, is one of the oldest surviving rainforests on Earth. It holds such significance to the biological diversity and geological history of Australia that it was recognised as a World Heritage Area in 1988.

This area forms part of the Wet Tropics of Queensland, which stretches along the northeast coast of Australia for 450 kilometres.

FIGURE 1 The Daintree area of northern Queensland: (a) A mangrove on the mudflats of Cooya Beach; (b) Newell beach; (c) Mossman Gorge

int-8410

FIGURE 2 Topographic map extract of the south-eastern section of the Daintree River National Park



Source: Map redrawn by Spatial vision, based on information taken from QSpatial, State of Queensland (Department of Natural Resources, Mines and Energy, Department of Environment and Science), http://qldspatial.information.qld.gov.au/catalogue/

on Resources

eWorkbook	Investigating topographic maps — Features of the Daintree rainforest (ewbk-10753)
Digital document	Topographic map of Daintree River National Park (doc-36254)
Video eLesson	Investigating topographic maps — Features of the Daintree rainforest — Key concepts (eles-6109)
Interactivity	Investigating topographic maps — Features of the Daintree rainforest (int-8410)

FIGURE 3 The Mossman River winds through the Daintree Rainforest.

2.10 Exercise

learnon

2.10 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 4	2, 5	3, 6

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1. According to **FIGURE 2**, the most common type of farming to occur in the area is ______________________________.
2. **Identify** the features found at the following locations.
   a. GR262792
   b. GR332775
   c. GR311788
   d. GR307760
3. **Describe** what the landscape would look like if you were at the following locations.
   a. GR195768
   b. GR335765
   c. GR272867
4. **State** the six-figure grid references for:
   a. Dayman Point
   b. Port of Mossman
   c. Miallo.
5. **Identify** which features shown on the map provide evidence that this is a rainforest landscape.
6. **Explain** three ways that humans have had an impact on this rainforest environment.

LESSON
2.11 What cultural significance do landscapes have for First Nations Peoples of Australia?

LEARNING INTENTION

By the end of this lesson you should be able to explain the cultural significance of landscapes.

TUNE IN

First Nations Peoples are recognised as the first Australians. Evidence of their presence in Australia is found across the continent in archaeological records and their cultural heritage has been passed down through the generations.

FIGURE 1 This rock art depicting a cloud or rain spirit was found in Western Australia's Kimberley region.

1. What do you understand by the term 'rock art'?
2. Working with a partner:
   a. Develop a shared understanding of where this image may have been found and what you can see.
   b. What element of First Nations Peoples do you think is depicted in this rock art?
3. Share your thoughts with the rest of the class.

2.11.1 The Australian context

Landscapes are the product of processes that have operated for millions of years. While all humans have come to realise the importance of the landscape and the role it plays in our lives, First Nations Peoples of Australia have always known that it is important to work alongside nature rather than always seek to change and exploit it.

They rely on and nurture the plants, animals and the environment for their survival, and so have an understanding of the complex nature of Australia's varying landscape.

Europeans, on the other hand, arrived in 1788 and occupied areas of Australia. They had a very different view of the landscape, based on ideas they brought with them from Britain. They sought to change the landscape and adapt it to meet their needs. They established permanent settlements and depended on farming introduced species to provide for their needs.

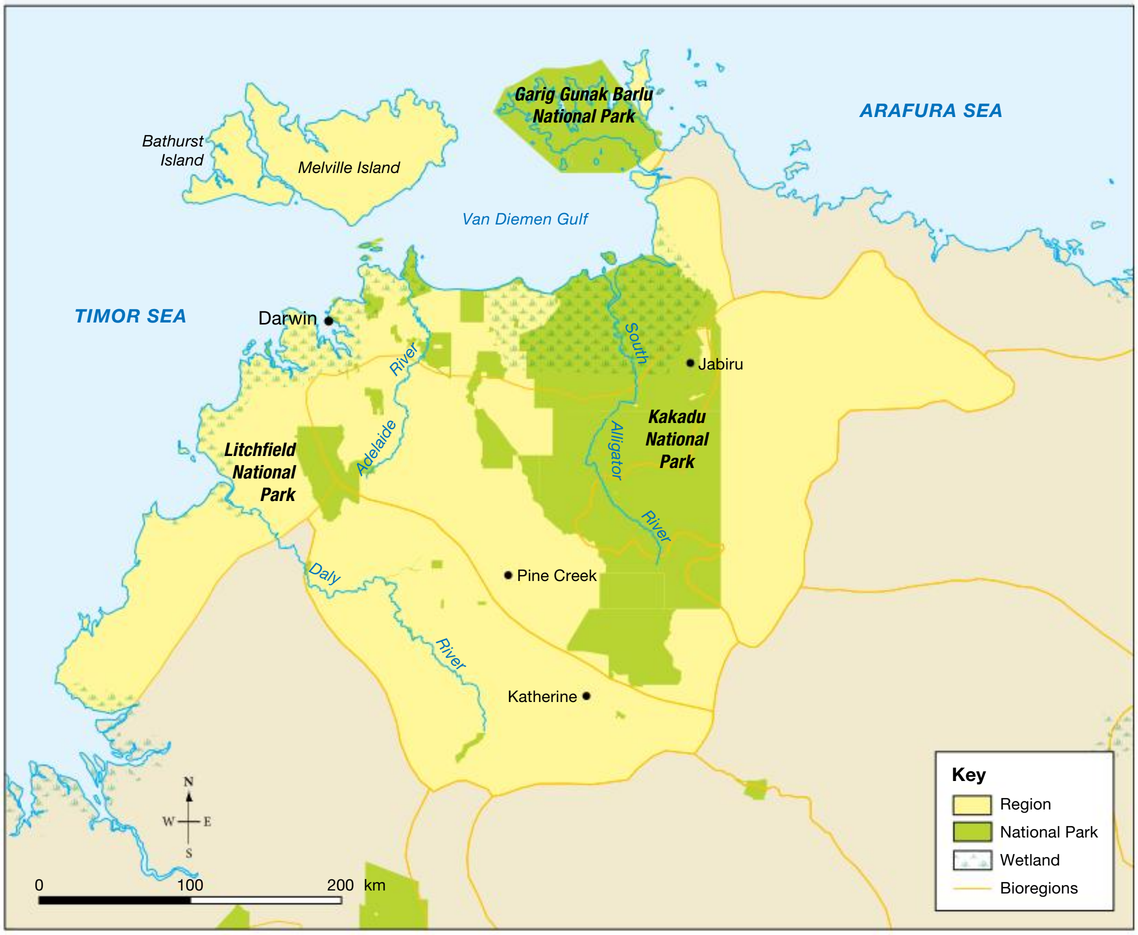
The perspective of First Nations Peoples of Australia is one of belonging to the landscape, while the European perspective is based on the idea of owning land.

2.11.2 Kakadu — Australia's first World Heritage Area

Kakadu National Park, as seen in **FIGURE 2**, covers an area of approximately 20 000 square kilometres of the Northern Territory — an area roughly a third the size of Tasmania. It stretches 200 kilometres from north to south, and spans 100 kilometres from east to west. Within the boundaries of the park are vast uranium deposits. Kakadu is unique in that it is recognised for both its natural beauty and its cultural value.

int-3609

FIGURE 2 Map of Kakadu National Park



Source: Spatial Vision

2.11.3 Kakadu and its resources

More than 200 000 tourists visit Kakadu National Park annually. Kakadu is a UNESCO World Heritage List site that is recognised for both its cultural and natural importance. Culturally, the area features some of the oldest rock art in the world, with Bininj/Mungguy paintings dating back 20 000 years. It is believed that Kakadu has been home to the Bininj and Mungguy peoples for over 65 000 years. The natural heritage of the area includes diverse native plant and animal species, vast wetlands, steep gorges and waterfalls (see **FIGURE 4**).

FIGURE 3 Consider how the Kakadu landscape is viewed and valued

1. More than 7000 sites preserve Bininj/Mungguy heritage; the rock art of Kakadu is one of the oldest and longest running accounts of culture on Earth.

2. Kakadu is home to a variety of plant and animal species that are unique to this region.

3. The land provides food such as wallabies and fruit; the rivers, fish and turtles; and the wetlands, bulbs and waterfowl.

4. Culture, traditions and nature are all linked, and connect people to their Country. People are responsible for looking after the land; they do not own it.

10. When Kakadu became a National Park, three possible uranium mining areas – Jabiluka, Ranger and Koongarra – were excluded from the park, even though they were surrounded by it. The Jabiluka mine site began development but has never been mined because of successful protests by the Mirarr people. Koongarra was added to the National Park in 2013 after campaigning by a senior Traditional Owner of the Djok clan. The Ranger mine is due to close at the end of 2020.

5. First Nations land management is very different to European farming; European settlers did not understand.

6. European land management involves ownership: building fences, restricting access and extracting resources to make a profit.

9. The region is remote, so there was much less European colonisation of the area, and little commercial interest until Uranium was found.

8. Native flora and fauna have been affected and some small native mammals have become extinct.

7. Europeans brought in new rules, religion, laws and diseases that affected the human experience and natural cycles of the landscape.

Kakadu also has vast deposits of uranium ore, which is a potentially valuable export for Australia. Opponents of uranium mining are concerned about the possibility that Australia's uranium could be processed and used to make nuclear weapons. Others fear the effects of mining on the environment and the potential for a devastating pollution event. Health studies on the First Nations population living in the vicinity of the mine have found that stillbirth rates are double the rate seen in women living in other parts of the Top End. Cancer rates were also 50 per cent higher.

FIGURE 4 Jim Jim Falls at Kakadu is a popular tourist destination.

The Ranger uranium mine has been operating since 1980 and lies within the boundaries of Kakadu National Park. Three kilometres downstream from the mine, the Mirrar people (a local First Nations community) swim and fish. Since the mine opened, there have been more than 200 leaks and spills, and the mine has generated some 30 million tonnes of liquid radioactive waste (see **FIGURE 5**). Uranium mining ended in 2012, but the processing of stockpiled ore continued until January 2021. The owners of the mining lease will continue to rehabilitate the area beyond its lease expiry date in 2026. The final cost of returning the site to its original state is expected to cost up to $2.2 billion.

on Resources

Google Earth Mount Everest
Kakadu

2.11 SKILL ACTIVITY: Interpreting and analysing geographical data and information, Concluding and decision-making

Review the information in this lesson related to Kakadu and its resources, and carefully study both **FIGURES 5** and **6**.

FIGURE 5 Timeline of major breaches at the Ranger uranium mine since 2002

2002 — Uranium levels 4000 times higher than acceptable standard for drinking water detected

2004 — Uranium levels 400 times higher than acceptable standard for drinking water detected

2005 — Mine operators fined by EPA for contaminating local waters

2009 — Reported that 100 000 litres of contaminated water leaking into local waters daily

2011 — Processing operations halted during wet season when heavy rain filled the tailings dam, which holds rock and materials from the mining process

2013 — Six-month shutdown after 1 million litres of radioactive sulfuric acid spilled when a leach tank collapsed

2015 — Weed control fire escapes the mine site and threatens rock art dating from between 50 000 years ago and first contact with Europeans

FIGURE 6 Aerial view of the rehabilitation and vegetation regrowth on the Jabiluka mine site from 2006 to 2018.

1. Referring to **FIGURE 5**, **describe** the impact of breaches at the Ranger Uranium mine on both people and the environment.
2. Annotate a diagram of **FIGURE 6**:
   a. **Describe** the changes that have taken place to the landscape at the Ranger Uranium mine from 2006 to 2018.
   b. Add an additional image and annotation to **predict** what the landscape might look like today.
3. **Determine** if you think the Kakadu region be completely restored. Use evidence to support your conclusion.

2.11 Exercise

learnon

2.11 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 2, 3, 5, 6	4, 8	7, 9, 10

Check your understanding

1. Refer back to the information about Kakadu National Park.
   a. **Identify** the location of Kakadu National Park.
      A. Northern Territory
      B. New South Wales
      C. Queensland
      D. Western Australia
   b. **Select** the option that best explains why Kakadu National Park is important.
      A. Most of Australia sources water from there.
      B. It has cultural significance.
      C. Most of Australia sources fish from there.
      D. It is not important.
2. **Consider** the Australian landscape and the way it is viewed by First Nations Peoples and non-Indigenous Australians.
   Identify whether the following statements are true or false.
   a. First Nations Peoples of Australia see the land as something to farm and develop, whereas the European tradition views people as custodians of the land.
   b. First Nations Peoples of Australia look after the land as a community, whereas the European tradition is that people live on and own one specific piece of land.
   c. First Nations Peoples of Australia, exploited the land, whereas the European tradition involved careful management of the land and its resources.
3. Where are the more densely populated regions of Australia?
   A. Coastal regions
   B. Inland regions
   C. Population is evenly distributed across Australia.
   D. Forest regions
4. **Describe** the interconnection that First Nations Peoples of Australia have with the landscape. What evidence of this interconnection is found in this lesson?
5. **Consider** the resources in the Kakadu region.
   a. **Explain** what is uranium is used for and why it is considered a valuable resource.
   b. What risks does uranium mining pose in the Kakadu region?

Apply your understanding

Communicating

6. Think about your personal values and beliefs and **analyse** how they might be similar or different to those reflected in **FIGURE 3**.
7. Think back to section 2.7.3 on mining in the Kakadu region.
   a. **Predict** three possible impacts on the landscape if a new uranium mine was opened in the Kakadu region.
   b. Do you think changes would have a large-scale or a small-scale impact? **Explain**.
8. **Predict** what pressures decision-makers in Australia might face in future when balancing the needs of the different groups who have an interest in Kakadu's resources.
9. **Explain** how we have such an extensive knowledge of Bininj and Mungguy peoples' culture, history and beliefs.
10. **Propose** one argument for and one argument against granting leases to mine resources such as uranium in the Kakadu region.

LESSON
2.12 Why do we preserve and manage landscapes?

LEARNING INTENTION

By the end of this lesson you should be able to explain why landscapes need to be protected.

TUNE IN

Did you know that Australia's Gondwana Rainforest is made up of 50 separate reserves and national parks? Comprising 366 000 hectares of remnant rainforest across Queensland and New South Wales. Within these rainforests are fossil records dating back to the supercontinent Gondwanaland. It is on the World Heritage List because it has high conservation value for both its natural beauty and cultural significance.

FIGURE 1 Crystal Falls in Australia's Gondwana Rainforest

1. What do you understand by the concept of World Heritage listing?
2. Why do you think the Gondwana Rainforest comprises so many reserves and national parks?
3. Brainstorm a list of the types of evidence from Australia's past that might be found in the Gondwana Rainforest.
4. Have a class discussion about whether the Gondwana Rainforest should be preserved.

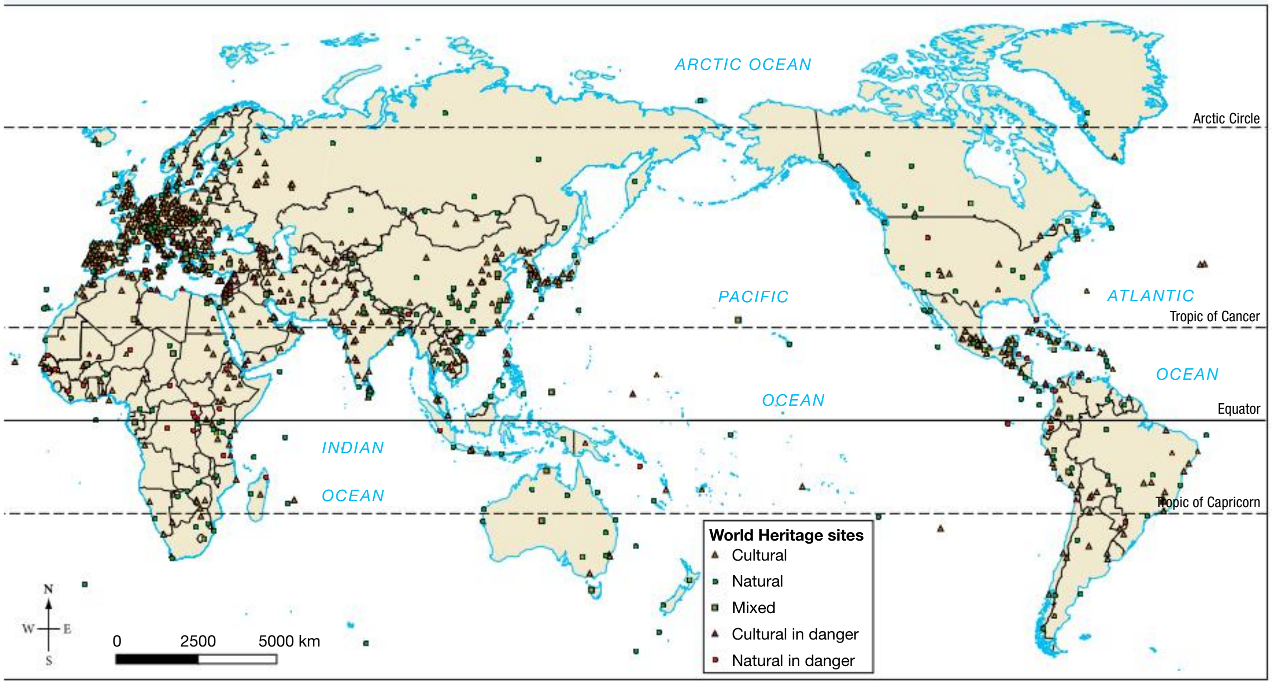
2.12.1 The World Heritage Convention

Worldwide, people recognise the value of landscapes and the need to protect their natural beauty and cultural heritage, and to manage their resources sustainably. Landscapes are easily damaged or destroyed, but are difficult to recreate and repair. The key is to ensure that they are carefully managed so the landscapes we value today are still present in the future.

From the middle of the twentieth century, concern grew about the need to protect areas of both cultural and natural significance (see **FIGURE 2**).

int-7833

FIGURE 2 The World Heritage List includes 1092 sites of significance.



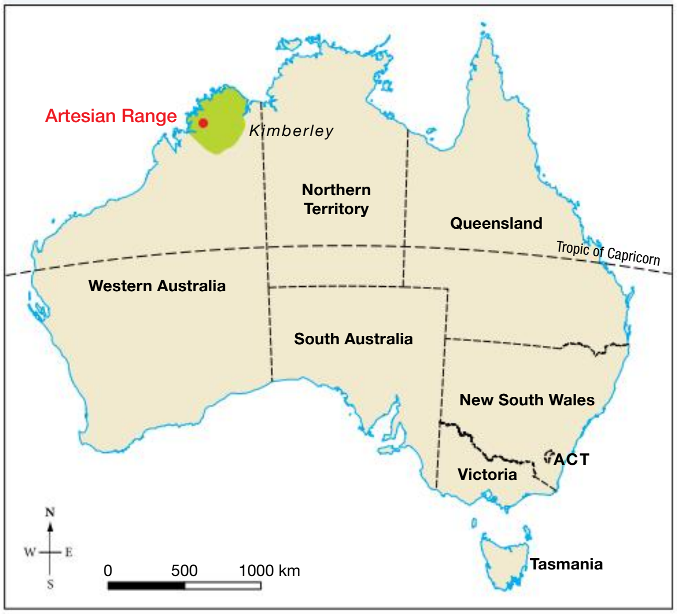
Source: Copyright © 1992–2019 UNESCO/World Heritage Centre. All rights reserved.

2.12.2 The Artesian Range

The Artesian Range is a unique part of the Australian landscape. It has been described as a lost world, a modern-day Noah's Ark, and our last opportunity to protect and preserve a part of the Australian mainland that has had little contact with modern civilisation. Within its hidden valleys and canyons lies a diverse range of flora and fauna. The rich tropical rainforests and woodlands provide vital habitats for some of Australia's most endangered wildlife.

The Artesian Range covers 1800 square kilometres (see **FIGURE 3**). It is largely inaccessible; the only way in is by helicopter or boat. It is a maze of hidden valleys and canyons, rocky ranges and plateaus, towering **escarpments**, wide valleys and deep gorges (see **FIGURE 4**). Its sandstone ranges were formed as a result of tectonic plate activity. These rock formations date back some 1.8 million years.

FIGURE 3 The Artesian Range covers 1800 square kilometres of the Kimberley region.



Source: Spatial Vision

Although it is difficult for humans to reach the area, exotic species such as donkeys, horses, pigs and cats have gradually invaded the Kimberley. And while fire is a natural part of the landscape, changing fire patterns and the increasing number of late-season wildfires are also a threat to the Artesian Range.

escarpment a steep slope or long cliff formed by erosion or vertical movement of the Earth's crust along a fault line

Australian Wildlife Conservancy (AWC), an independent non-profit organisation funded by donations, has now secured the land and manages it for conservation. AWC undertakes fire management, feral animal control, and biological surveys and monitoring, protecting the full length of the Artesian Range.

FIGURE 4 The Artesian Range is a rugged and largely inaccessible landscape, renowned for its natural beauty and unique wildlife.

on Resources

Weblink World Heritage list

2.12 SKILL ACTIVITY: Questioning and researching, Communicating

Use the **World Heritage list** weblink to **investigate** a World Heritage site in more detail.

Select a heritage site from one of the countries listed on the website.

Prepare a visual presentation of your chosen site that includes the following information:

- Show the location of your chosen site on a map that conforms to geographic conventions.
- **Illustrate** the importance of the site.
- **Identify** any threats to your site.
- **Explain** the strategies being used to protect your site.
- **Evaluate** these strategies
  - How successful have these strategies been?
  - Is enough being done?
  - Are any modifications needed?

2.12 Exercise

learnon

2.12 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3, 5, 6	4, 8	7, 9, 10

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- Receive immediate feedback
- Access sample responses
- Track results and progress

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Check your understanding

1. a. Where in Australia is the Artesian Range located?
   A. North-east coast of Australia
   B. North-west coast of Australia
   C. South-west coast of Australia
   D. South-east coast of Australia

   b. Suggest why the Artesian Range is unique.
2. Why has the Artesian Range been largely inaccessible to people?
   A. Steep escarpments
   B. Thick forests
   C. Woodlands
   D. There are no roads leading into the area
   E. All of the above
3. **Identify** two management strategies used by the Australian Wildlife Conservancy (AWC) to manage and conserve the Artesian Range.
   A. Increasing tourist numbers
   B. Fire management
   C. Native animal control
   D. Biological surveys
   E. Diverting water for public use
4. **Explain** why it is important to protect sites that have cultural or natural significance.
5. **Determine** if you think invasive species or wildfires pose the greatest risk to the Artesian Range. **Justify** your answer.

Apply your understanding

Communicating

6. **Explain** how exotic species such as cats, foxes and camels have been able to become established in the Artesian Range when it is difficult for people to enter the region.

Concluding and decision-making

7. **Evaluate** the ways in which the community demonstrates the value it places on cultural diversity and why this is important to the community.
8. The Artesian Range has been described as a ‘modern-day Noah’s Ark’. **Explain** what you understand by this description.
9. **Describe** the processes that have led to the formation of the Artesian Range and its different landscape features.
10. Uluru is considered to have both cultural and natural significance. **Propose** a reason for this classification.

LESSON
2.13 Review

Hey students! Now that it's time to revise this topic, go online to:

Review your results

Watch teacher-led videos

Practise questions with immediate feedback

Find all this and MORE in jacPLUS

2.13.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

2.2 Why do landscapes vary?

- Landscapes are influenced by factors such as climate, geographical features and latitude.
- The type of landscape that develops is determined by the mix of these factors.
- There are variations within landscapes and they are impacted by human activity.

2.3 What processes shape landscapes?

- Landscapes are continually changing; tectonic forces are at work to build landscapes, and processes such as weathering and erosion wear them away.
- Human activity such as deforestation increases the rate of erosion.
- Soil varies across landscapes and ultimately determines the type of vegetation that a landscape can support.

2.4 What landscapes form underground?

- Karst landscapes are found all over the world, predominantly in tropical regions.
- Karst landscapes form where slightly acidic water filters through soluble bedrock, such as limestone, forming hollows and caves beneath the surface of the Earth.
- The largest arid limestone karst cave system is located on Australia's Nullarbor Plain.

2.5 What are the landforms and landform regions of Australia?

- Australia is an ancient landscape and has undergone many changes over millions of years.
- Tectonic forces have uplifted the land, creating mountain ranges. The landscape was been worn away and sculpted by the processes of weathering, erosion and deposition.
- Australia has also migrated, so that its climate and vegetation are vastly different from what they were millions of years ago.

2.6 What are deserts like in Australia and China?

- Desert landscapes are areas of low precipitation and can be either hot or cold.
- Approximately one-third of the Earth's surface is classified as arid or semi-arid.
- Latitude and topography play a role in determining where deserts are located.

2.7 How do the savanna grasslands of Australia and Africa compare?

- Grasslands are described as a transitional landscape as they are generally located between forests and deserts.
- Savana grasslands located in Africa are maintained by grazing animals and their migrations.
- First Nations communities maintain the savanna grasslands of northern Australia using fire.

2.8 What makes a rainforest?

- Rainforests are areas of very high rainfall and located between the Tropic of Cancer and the Tropic of Capricorn
- Rainforests are important regulators of global climate, produce oxygen medicine and the source of many of our foods and medicines.
- Rainforests are under threat due to exploitation and over-harvesting of their resources.

2.9 INQUIRY: The value of rainforests

- Inquiry into the importance of rainforests and strategies for their conservation

2.11 Investigating topographic maps — Features of the Daintree rainforest

- The Daintree Rainforest is located in far north Queensland.
- The Daintree region is a national park and a significant region with World Heritage status.

2.12 What cultural significance do landscapes have for First Nations Peoples of Australia?

- First Nations Peoples of Australia have been in Australia for over 60 000 years and have a close bond with the land.
- The Australian landscape is culturally significant to First Nations Peoples of Australia and their beliefs conflict with those of the European settlers.
- Addressing the competing needs of culture and resources involves striking a delicate balance.

2.13 Why do we preserve and manage landscapes?

- The World Heritage List ensures that places of natural and cultural significance are preserved and managed so they are not lost for future generations.
- Australia has several sites that are culturally significant and also considered natural wonders, such as the Artesian Range.
- The inaccessible nature of the Artesian Range has protected it from human activity; however, it is threatened by introduced species.

2.13.2 Key terms

aquifer a body of permeable rock below the Earth's surface that contains water, known as groundwater
compost a mixture of various types of decaying organic matter such as dung and dead leaves
convection current a current created when a fluid is heated, making it less dense and causing it to rise through surrounding fluid and sink if it is cooled; a steady source of heat can start a continuous current flow
deposition the laying down of material carried by rivers, wind, ice and ocean currents or waves
drainage basin an area of land that feeds a river with water; or the whole area of land drained by a river and its tributaries
ecosystem an interconnected community of plants, animals and other organisms that depend on each other and on the non-living things in their environment
erosion the wearing away and removal of soil and rock by natural elements, such as wind and water, and by human activity
escarpment a steep slope or long cliff formed by erosion or vertical movement of the Earth's crust along a fault line
glacier a large body of ice, formed by an accumulation of snow, that flows downhill under the pressure of its own weight
hotspot an area on the Earth's surface where the crust is quite thin and volcanic activity can sometimes occur, even though it is not at a plate margin
humus nutrient-rich dark organic matter, created by decaying animal and plant matter
inselberg an isolated hill, knob, ridge, outcrop or small mountain that rises sharply from the surrounding landscape
leaching a process that occurs in areas of high rainfall, where water runs through the soil, dissolving minerals and carrying them into the subsoil. The process can be compared to a coffee pot in which water drips through the grounds.
mantle the layer of the Earth between the crust and the core
microclimate specific atmospheric conditions within a small area
percolate filter through porous material such as soil
permafrost a layer beneath the surface of the soil where the ground is permanently frozen
plateau an extensive area of flat land that is higher than the land around it. Plateaus are sometimes referred to as tablelands.
precipitation the different forms in which moisture is returned to the Earth from the atmosphere, most commonly in the form of rain, hail, sleet and snow
sediment material carried by water
soluble able to be dissolved in water

stalactite a feature made of minerals, which forms from the ceiling of limestone caves, like an icicle. They are formed when water containing dissolved limestone drips from the roof of a cave, leaving a small amount of calcium carbonate behind.
stalagmite a feature made of minerals found on the floor of limestone caves. They are formed when water containing dissolved limestone deposits on the cave floor and builds up.
tectonic plate one of the slow-moving plates that make up the Earth's crust. Volcanoes and earthquakes often occur at the edges of plates.
temperate zone describes the relatively mild climate experienced in the zones between the tropics and the polar circles
transport the movement of eroded materials to a new location by elements such as wind and water
weathering the breaking down of bare rock (mainly by water freezing and cooling as a result of temperature change) and the effects of climate

2.13.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

How do human and natural processes shape environments and what impact does this have on the way people manage changing landscapes?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-10749)
Reflection (ewbk-10751)
Crossword (ewbk-10752)

Interactivity Introducing landforms and landscapes crossword (int-7595)

2.13 Review exercise

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Receive immediate feedback and access sample responses

Access additional questions

Track your results and progress

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Multiple choice

1. Distinguish between a natural and a human environment.
   A. Natural environments are altered by humans whereas built environments are not.
   B. Built environments are altered by humans whereas natural environments are not.
   C. There is no difference because neither of them are altered by humans.
   D. Natural environments are larger than built environments.
2. Select the statement that best explains how rivers and streams made physical changes to Australia's landmass.
   A. Through the process of folding, faulting and uplifting
   B. By transporting materials to new areas, creating floodplains and coastal landscapes
   C. By forming the Great Dividing Range
   D. None of the above

3. Why is soil important?
   A. It is not important.
   B. It is the basis for plant growth, which feeds both people and animals.
   C. 75 per cent of mammals eat soil as their main source of nutrition.
   D. It protects the Earth from damage from the sun.
4. Landscapes are in a state of continual change. Which two natural processes powered by water are most responsible for continually changing landscapes?
   A. Erosion and weathering
   B. Erosion and deposition
   C. Transportation and deposition
   D. Transportation and calcification
5. Which statements apply to savanna grasslands? Select two correct answers
   A. They have many trees.
   B. They have a distinct wet season and dry season.
   C. They are found on every continent.
   D. They are a transitional landscape.
6. Where is Kakadu National Park located?
   A. New South Wales
   B. Northern Territory
   C. Queensland
   D. Tasmania
7. What is the term used to describe the laying down of material carried by rivers, wind, ice and ocean currents or waves?
   A. Erosion
   B. Sediment
   C. Transport
   D. Deposition
8. Explain the importance of fire in maintaining savanna grasslands by combining two of the following statements.
   A. It clears out the undergrowth and encourages new plant growth.
   B. It creates new habitat for animals.
   C. It prevents trees from taking over, as saplings are burnt in the process.
   D. The soil becomes more fertile.

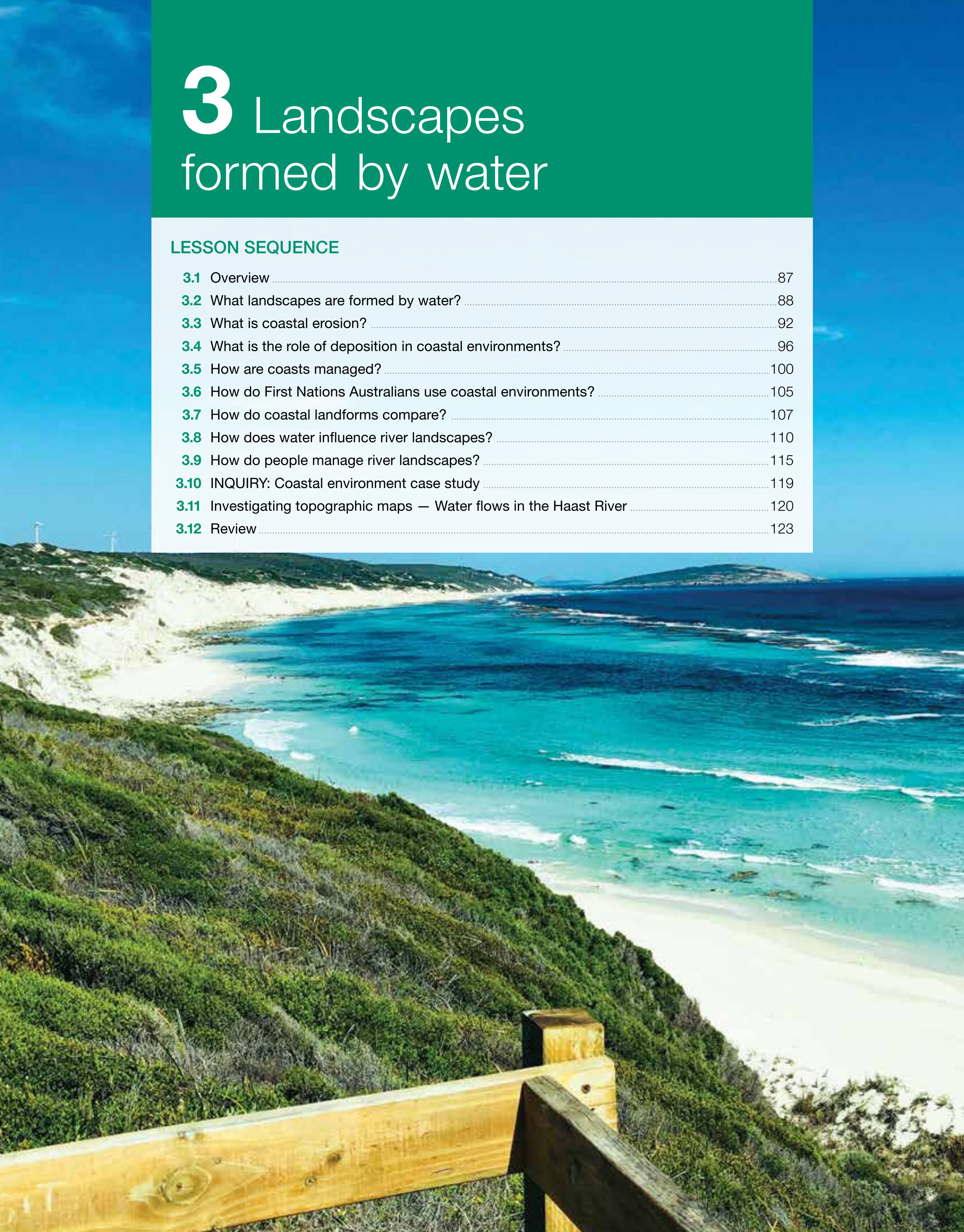
Short answer

Communicating

9. **Differentiate** between the terms erosion, deposition and transportation.
10. **Define** the term humus and explain why it is important.
11. **Propose** two reasons for the preservation of landscapes.
12. **Explain** how karst landscapes are formed.
13. **Identify** three factors that influence the formation of landscapes.

3 Landscapes formed by water

LESSON SEQUENCE



LESSON
3.1 Overview

Hey students! Bring these pages to life online

Watch videos

Engage with interactivities

Answer questions and check results

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How does water form and transform landscapes?

3.1.1 Introduction

Water is one of the most powerful agents in creating landscapes. If you have ever been caught outside in a heavy downpour, walked through a fast-flowing creek, or been dumped in the surf, then you have felt and seen the energy of flowing water. It can knock you off your feet, move buildings and carve huge holes in the Earth's surface. Landscapes created by water are found everywhere.

FIGURE 1 The Horizontal Falls are a natural phenomenon located in the Kimberley region of Western Australia.

on Resources

eWorkbook	Customisable worksheets for this topic (ewbk-13442)
Video eLesson	Landscapes sculpted by water (eles-1624)

LESSON
3.2 What landscapes are formed by water?

LEARNING INTENTION

By the end of this lesson you should be able to explain how water changes landscapes.

TUNE IN

Examine **FIGURE 1** and imagine the river water is flowing from right to left. Write three short sentences to describe the effect that the direction and speed of the moving water may have had on the soil and rocks in the Grand Canyon.

FIGURE 1 The Colorado River meandering through the Grand Canyon

3.2.1 How does water change landscape features?

A torrent of gushing water can shift rocks, remove topsoil or shape entire river valleys. Gentle rain can change the chemical structure of any surface material, sculpting the imposing coastal landforms we see around the world. In cold climates, compressed snow in glaciers works like a slow-moving bulldozer to erode land and create unique landscape features. Once fresh water has made its way to the ocean, the power of waves creates coastal landscape features.

Landscapes are predominantly changed or created by two processes: **erosion** and **deposition**. Through erosion, water can carve through rock — reducing once-mighty cliffs to lowly sea-stacks. Through deposition, water creates beaches, spits and sand dunes as it carries sand across the oceans of the world. In **FIGURE 2** you can see the power of water as it rushes over a rockface and carves pools in its hard surface. You may have seen pools of a similar shape carved by waves in rocky coastal landforms.

erosion the wearing away and removal of soil and rock by natural elements, such as wind and water, and by human activity

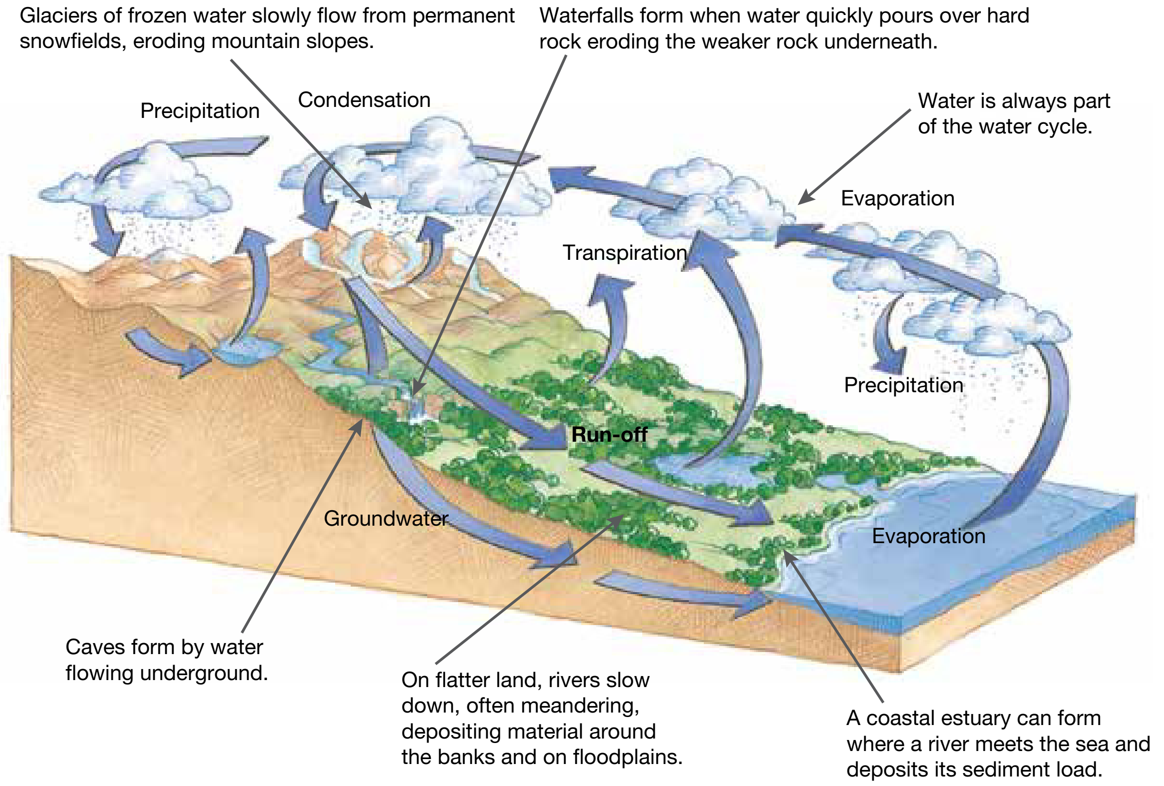
deposition the laying down of material carried by rivers, wind, ice and ocean currents or waves

FIGURE 2 How is the flow of water changing the landscape in this photograph?

int-7834

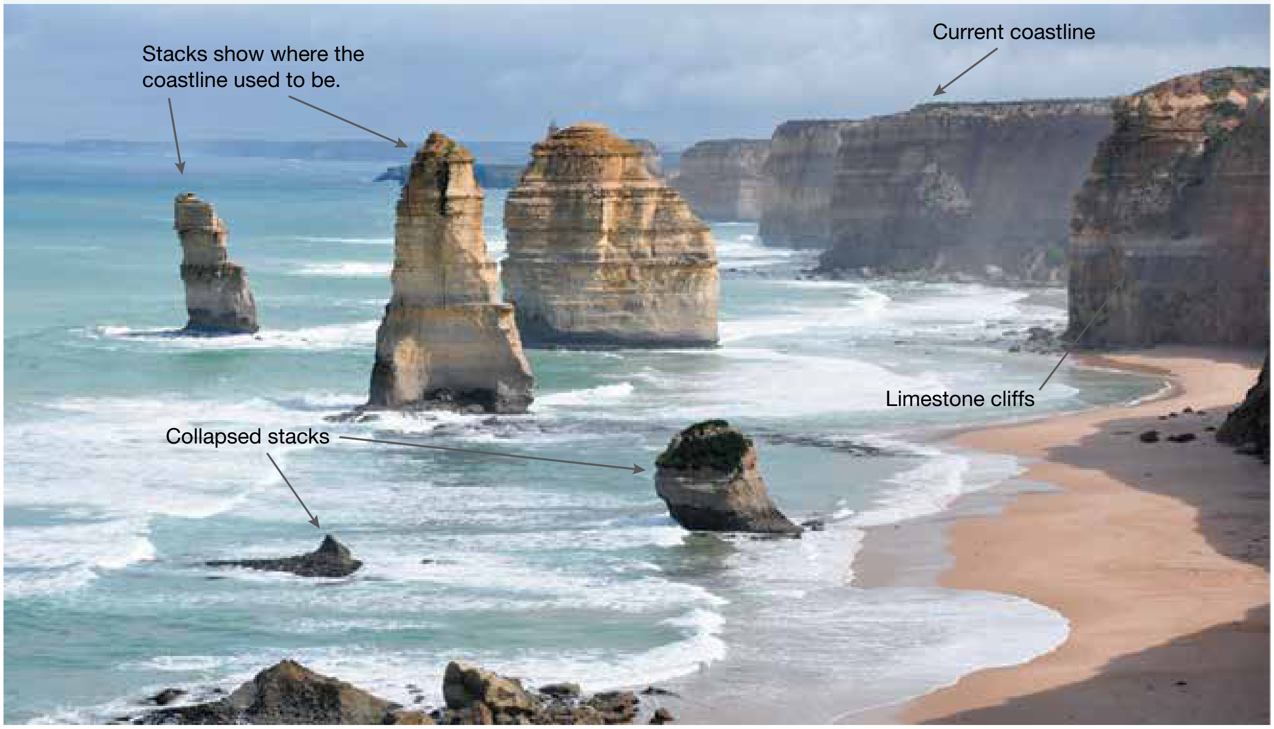
tlvd-10615

FIGURE 3 Water constantly moves over and through the Earth and through the air.



As water makes contact with landscapes, it can change the shape and size of its features or landforms (**FIGURES 2** and **3**). The coastal landscape that you see today is not the same as it was hundreds or thousands of years ago. **FIGURE 4** is a photo of the Twelve Apostles, located on the south-western coast of Victoria. The name suggests that there may once have been twelve pillars of rock, or stacks, visible along this stretch of coastline. In the foreground you can see the remnants of two quite recently collapsed stacks. Even these stacks were once joined to the cliffs as part of the mainland. This highly erodible coastline has been constantly altered by many years of rainfall and wave action on the soft limestone cliffs.

FIGURE 4 The Twelve Apostles in Port Campbell National Park, Victoria. How might the potential for erosion change along this coast if the waves were larger and it was high tide?



3.2 SKILL ACTIVITY: Questioning and researching using geographical methods

Create an annotated map which includes the following locations. You will need to use the internet to find each of these places.

a. The biggest glacier
b. The longest river
c. The biggest wave
d. The highest waterfall
e. The widest river
f. The biggest ocean
g. A world water fact of your choice

3.2 Exercise

learnon

3.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 4, 5	3, 9, 10	2, 6, 7, 8

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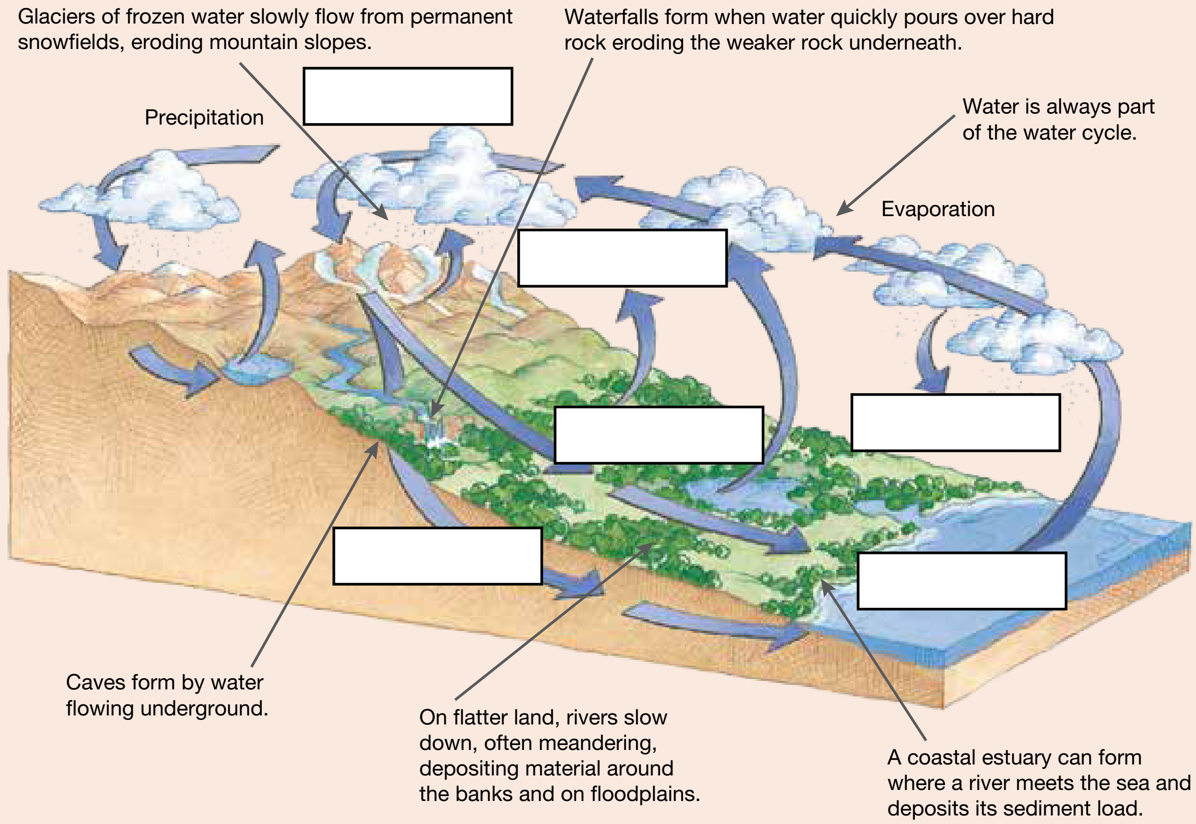
Check your understanding

1. Deposition is a more powerful process than erosion. True or false?
2. **Explain** how the water cycle and the formation of landscapes are interconnected.
3. Where would **FIGURES 2** and **4** be placed on the landscape depicted in **FIGURE 3**? **Explain**.



4. Place the following terms in the correct locations on the diagram below: transpiration, precipitation, evaporation, groundwater, run-off, condensation.
5. a. Which two natural processes powered by water are most responsible for continually changing landscapes?
   A. Erosion
   B. Transportation
   C. Deposition
   D. Transpiration
   b. **Identify** how these two processes are linked.

Apply your understanding

Concluding and decision-making

6. Many landscapes change rapidly; for example, the Twelve Apostles.
   a. **Describe** another example of a landscape that has been shaped by the power of water.
   b. **Propose** whether you think the changes to the landscape have been positive or negative.
   c. **Suggest** why people should try to stop the changes caused by water.

Interpreting and analysing geographical data and information

7. Water can be considered one of the most important architects of desert landscape features. After looking at the images in this lesson, try to **explain** how you think water can change the landscapes of arid or desert environments.
8. **Identify** three possible ways that people can change the flow of water, either across the surface of the Earth or along the coast. **Predict** how you believe this may alter landscape features. Examples may include the use of river water for irrigation or the construction of a marina.

Communicating

9. Think back to the last time you visited a coastal environment. What features were prominent in the environment you visited? **Suggest** what processes were responsible for the creation of these features.
10. Erosion and deposition are two processes that can transform coastal landscapes. **Describe** an additional way in which coastal landscapes can be changed.

LESSON
3.3 What is coastal erosion?

LEARNING INTENTION

By the end of this lesson you should be able to identify coastal features created by erosion and distinguish between the impact of wave action and running water.

TUNE IN

FIGURE 1 shows damage to houses caused by a powerful storm surge in the Sydney coastal suburb of Manly.

1. How has moving water affected the coast in this area?
2. Suggest what might protect these houses in the future.
3. Do you believe these houses should be rebuilt? Explain your answer.

FIGURE 1 Damage to houses in Manly, Sydney after a powerful storm surge

3.3.1 How do waves change an environment?

The coast is the zone or border between land and ocean. It is in this collision zone that the movement of sea water and the impact of the ocean on the land together create coastal landscapes. Coastal landscapes have landforms that are common to coastlines in different places around the world because they are built up or worn away in similar ways.

Before we investigate the different types of coastal landforms that exist, we need to first understand the processes which shape these landforms. Coastal erosion is mostly caused by the continued presence of waves in an environment. Waves are caused when the wind blows over the ocean. The size of a wave depends on the strength of the wind and the distance the wind has been blowing (referred to as the *fetch*). A strong wind and a long fetch will result in a powerful wave with a high degree of erosive potential. These waves are called **destructive waves** and they are involved in creating landforms by erosion. A gentle wind and a small fetch will create less powerful waves known as constructive waves. While these waves are not involved in erosion, they do create depositional landforms (see lesson 3.4).

Next time you are walking along a beach, stop to check whether the waves in this environment are constructive or destructive. You can do this by analysing the strength of the **swash** and **backwash**. As a wave hits the shore it sends water (as well as sand, shells and other debris) onto the beach. This is called the swash. Water is then pulled back into the ocean by gravity in what is known as the backwash. If the swash is more powerful than the backwash, the waves are constructive and you should see depositional landforms. If the backwash is more powerful than the swash, the waves are destructive and you should see more landforms which have been caused by erosion. The structure of constructive and destructive waves can be seen in **FIGURE 2**.

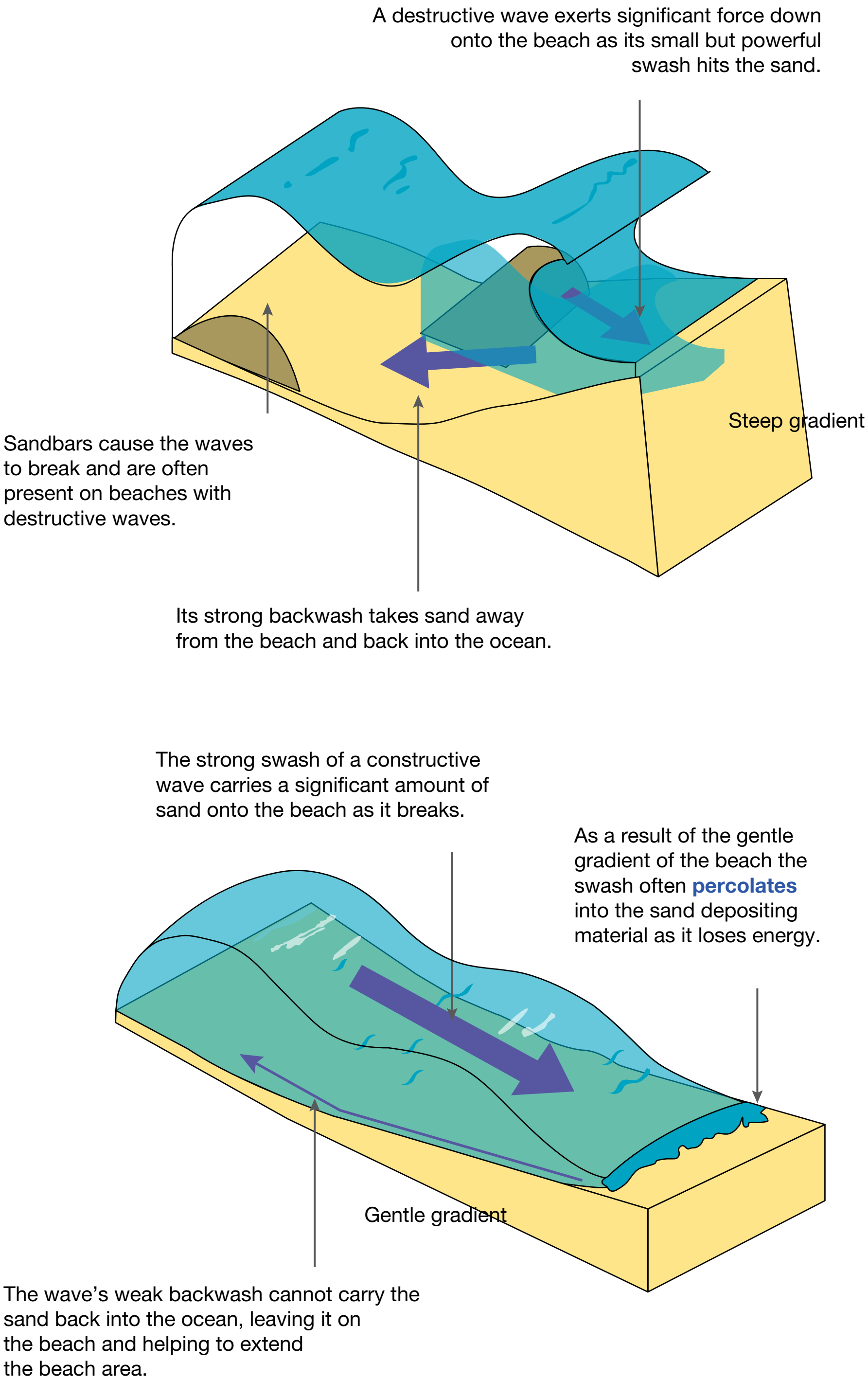
destructive wave a large powerful storm wave that has a strong backwash

swash the movement of water in a wave as it breaks onto a beach

backwash the movement of water from a broken wave as it runs down a beach returning to the ocean

int-7835

FIGURE 2 Comparing constructive and destructive waves



Coastal landforms are not solely created by the power of waves. Rainfall and constant strong winds can also influence the appearance of coastal landforms. For example, after a puddle of rain water evaporates, it leaves behind salts and minerals which can interact with rocks. This can lead to scarring of the rock surface and, over time, deep crevasses can be formed. Other physical processes can also greatly affect the coastal landscape; for example, the tectonic force of earthquakes and volcanoes; changing sea levels; and human activities such as building roads, ports and houses, and damming rivers.

percolate filter through porous material such as soil

Which coastal landscape features are created by erosion?

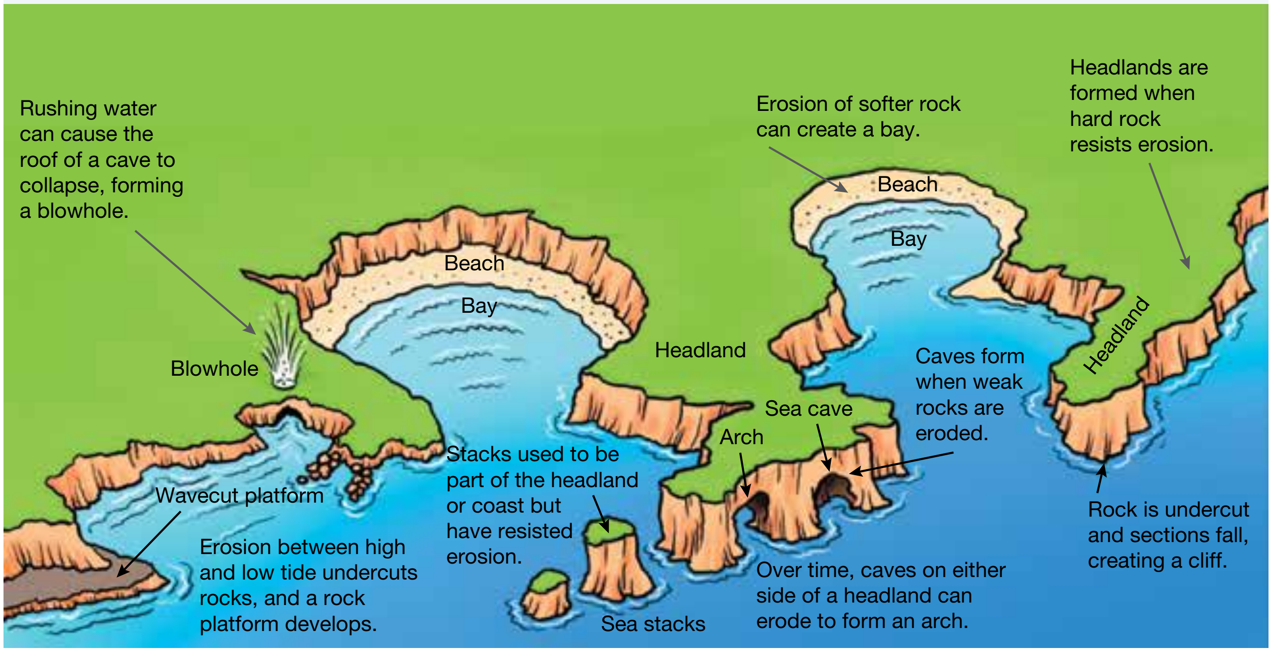
Features such as cliffs, headlands, bays, arches, caves, blow-holes and stacks are all landforms found along an eroding coastline (**FIGURE 3**). These features are formed by wave action and rainfall, which attack the cliffs and find points of weakness that are then eroded. Water running off a cliff face can carry eroded material into the sea below. When waves hit the cliff face, they undercut the base of the cliff to form a notch. As the notch increases in size it forms a cave and eventually the cliff gets undercut, becomes unstable and falls into the sea.

Destructive waves can also alter a sandy coastline. They can remove sand from a beach, destroy the vegetation on dunes, and remove management features designed to protect landscape features.

int-7836

tlvd-10616

FIGURE 3 Coastal landforms created by erosion



on Resources

Interactivity Coastal sculpture (int-3124)

Google Earth Twelve Apostles

3.3 SKILL ACTIVITY: Communicating

Create an annotated diagram that explains the difference between swash and backwash. An annotated diagram contains written descriptions that help the reader gain a deeper understanding of the information presented. **FIGURES 2** and **3** in this lesson are examples of annotated diagrams.

3.3 Exercise

3.3 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3, 7	5, 6, 8	4, 9, 10

Check your understanding

1. **Select** the correct term: A **beach** / **coast** / **river** / **cliff** is the zone or border between land and the ocean.
2. What are three physical processes that have influenced the creation of coastal landforms?
   A. Swash
   B. Construction
   C. Backwash
   D. Destructive waves
   E. Wind
   F. Damming rivers
3. **Identify** three human activities that have influenced the creation of coastal landforms.
   A. Road construction
   B. Constructive waves
   C. Swash
   D. Building houses
   E. Damming rivers
   F. Tsunamis
4. **Place** the following landforms in the order in which they would be created:
   a. arch, cave, headland, stack
   b. blowhole, cave, cliff.
5. **Explain** the difference between constructive and destructive waves.

Apply your understanding

Communicating

6. Find an image of a sandy coastline that has recently been affected by destructive waves. **Explain** the process that has occurred. Use the terms 'swash' and 'backwash' in your explanation.
7. **Identify** what the construction material that is deposited on a beach consists of.
8. Do you think people will still feel the same way about a coastal landscape such as the Twelve Apostles when only two or three are still standing? How might the changing landscape affect the value or pleasure people get from visiting this place? Write a short paragraph to **comment**.

Concluding and decision-making

9. Destructive waves are bad for all coastal environments and, as such, management techniques should be used to minimise their impacts. Do you agree or disagree with this statement? **Justify** your response.
10. Should we try to protect coastal landforms like the Twelve Apostles or should we simply let nature run its course? **Justify** your response.

LESSON
3.4 What is the role of deposition in coastal environments?

LEARNING INTENTION

By the end of this lesson you should be able to identify coastal features created by deposition and distinguish between constructive and destructive waves.

TUNE IN

The beaches at Reynisfjara in Iceland (**FIGURE 1**) are filled with striking black sand.

1. Why do you think this sand is black?
2. Where do you think the black sand has come from?

FIGURE 1 The black sand beaches of Reynisfjara, Iceland

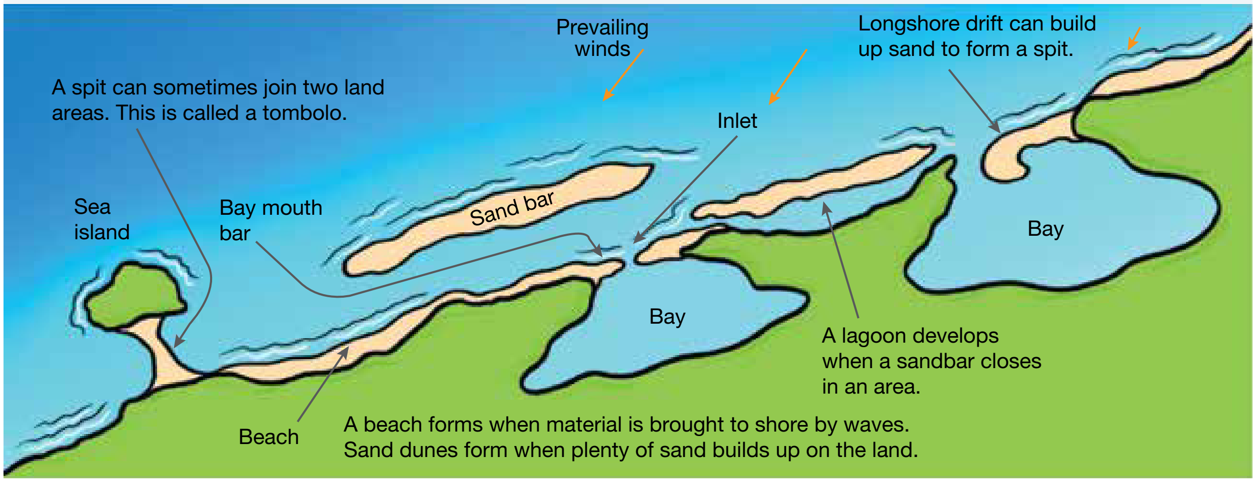
3.4.1 How are depositional coastal landforms formed?

As we learned in lesson 3.3, not all waves are destructive. Though they lack the sheer force of destructive waves, constructive waves still have an important role to play in the creation of coastal landforms. The movement of these waves towards the land is more likely to push material such as sand and shells and deposit them on the beach, building new coastal features.

A beach is a good example of a depositional coastal landform (**FIGURE 2**). Sand has been deposited and built up over a period of time. Constructive waves build coastal landscape features by repositioning wave-borne materials to also create spits, sand dunes and lagoons.

int-7837

FIGURE 2 Depositional landforms: coastal landforms created by deposition

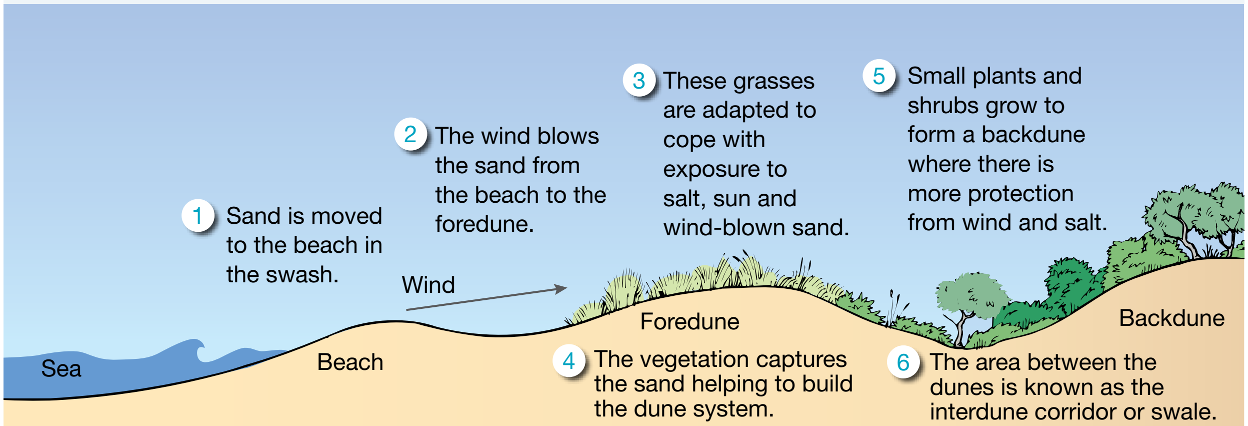


The coastal features created by deposition can be created only when material is brought onshore by the swash of constructive waves. The construction material is in the form of sand, shells, coral and pebbles. The source of the construction material may come from eroding cliffs, from an offshore source, or from rivers which, when they enter the sea, dump any material they were transporting.

This construction material is then shaped by prevailing winds. **FIGURE 3** illustrates the cross-section of a beach formed when there is plenty of sand being pushed onshore by the swash. This construction material is dried by the sun and blown inland to create dunes.

int-7838

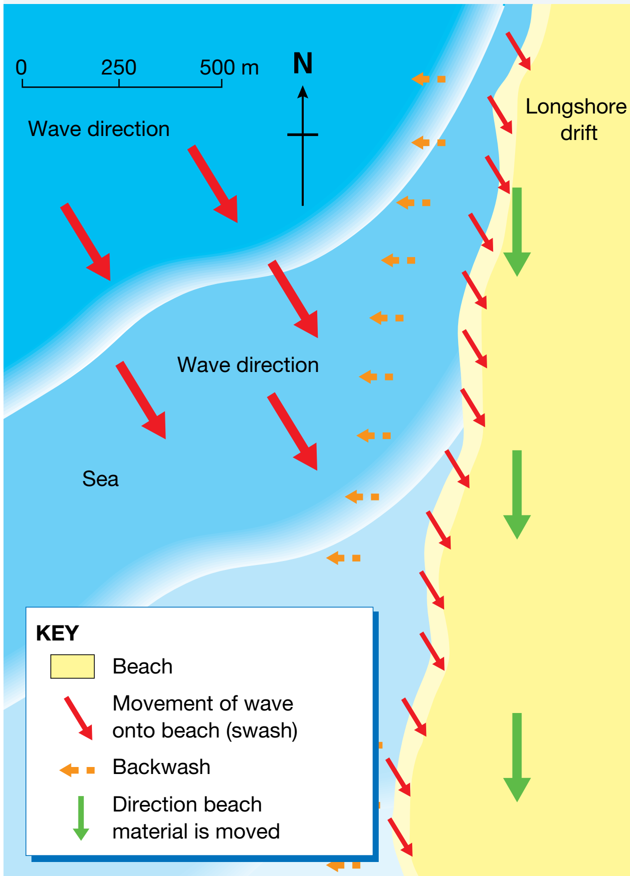
FIGURE 3 The formation of sand dunes



Beach material can also be shifted by waves, which get their energy from the wind. The wind influences or directs the angle that waves move towards the coast. Waves come from the direction of the **prevailing wind**. This means that waves often move towards the shore at an angle, and their swash pushes any material they are carrying onto the beach at an angle. As the backwash of the wave returns to the sea, its path takes the shortest possible route down the beach towards the water.

This action is known as **longshore drift**, and it is shown in **FIGURE 4**. Longshore drift moves material along the beach in a zigzag pattern that follows the direction of the prevailing wind. Longshore drift moves sand along the beach and creates spits and bars. If the prevailing wind changes direction, then so does the direction of longshore drift.

FIGURE 4 The process of longshore drift



prevailing wind the main direction from which the wind blows

longshore drift a process by which material is moved along a beach in the same direction as the prevailing wind

3.4.2 CASE STUDY: Cape Peron

A tombolo is a coastal depositional feature where a sand spit has joined an island to another island or to the mainland. One of the best examples of a tombolo in Western Australia is found at Cape Peron, south of Rockingham. Cape Peron and the surrounding islands are part of the Shoalwater Islands Marine Park.

At the end of the last ice age, some 10 000 years ago, Cape Peron was part of a limestone ridge which created high points in a north to south line along the coast. Sea levels rose, creating a chain of islands. Wave action slowly moved sand between the islands and a cuspate spit formed, connecting Cape Peron to the mainland. **Cuspate spits** form where wave action deposits material from two directions. In the last 2000 years, this process has slowly created a tombolo. Today, another island, Penguin Island, is slowly being joined to the coast by a sand bar. Tombolos tend to form in areas where the waves are constructive, and the area is sheltered from the prevailing winds. This is the case for Cape Peron and it is characterised by stretches of sandy beaches.

cuspate spits projections of a beach into an enclosed or semi-enclosed lagoon

Other parts of the marine park show evidence of erosion. Cape Peron has many erosive landform features such as cliffs, arches and collapsed bridges. These landforms tend to be more exposed to the prevailing winds and thus more destructive waves. To the west there are a number of offshore reefs and stacks. The eastern shore of Cape Peron is sheltered from storms and prevailing winds and is characterised by stretches of sandy beaches.

FIGURE 5 Coastal landforms at Cape Peron

SkillBuilders to support skill development

- 2.21 SkillBuilder: Constructing a basic sketch map

3.4 SKILL ACTIVITY: Communicating

In this activity, you will **create** a map which locates several depositional coastal landforms.

The format of the map is up to you — you can create a physical map or a digital map using the features of Google Maps.

Your map needs to include the following depositional landforms: a spit, a beach with dunes, a bay, a headland (point, cape or promontory) and an estuary. Find four examples of each landform and mark them on your map. Use an atlas or the internet to find each of the required locations.

FIGURE 6 Angel Road is a depositional landform connecting three small islands with the mainland in Japan.

3.4 Exercise

learnon

3.4 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 3, 5	2, 4, 7, 8, 9	6, 10

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Check your understanding

1. Where does beach building material come from? **Select** all possible answers from the options provided.
   A. Rivers
   B. Lakes
   C. Eroding cliffs
   D. Offshore
   E. Winds
2. The formation of sand dunes cannot happen unless there is plenty of sand in the swash to allow them to grow. Use the information in **FIGURE 3** to **provide** the evidence for you to agree or disagree with this statement.
3. **Select** the correct terms in the following sentences:
   Longshore drift moves material along the beach in a **circular** / **zigzag** pattern that follows the direction of the prevailing wind.
   Longshore drift moves sand along the beach and creates spits and **bars** / **bays** / **inlets**. If the prevailing wind changes direction, then so does the direction of longshore drift.
4. Weather is not involved the formation of sand dunes. True or false?
5. **Explain** two ways in which the wind can help shape beach environments.
6. **Suggest** four strategies that could be used at Cape Peron to reduce the impact of human activities on the natural environment.

Apply your understanding

Communicating

7. **Study FIGURE 4.**
   a. In which direction is sand moving on the beach?
   b. How will this beach change if the longshore drift continues in this direction?
   c. Redraw this diagram to show how the movement of sand along this beach would change this environment if the prevailing wind changed to come from the south-west.
8. **Describe** how coastal landforms are the result of interconnections between the sea and the atmosphere.
9. If it was a windy day, where on the beach or dune would it be best to take shelter? **Explain** your answer.
10. **Suggest** what might be some of the impacts on Cape Peron of the construction of a marina development in the area marked 'sandy beaches' on **FIGURE 6**.

LESSON
3.5 How are coasts managed?

LEARNING INTENTION

By the end of this lesson you should be able to identify strategies used to protect coastal environments. You should also be able to distinguish between soft engineering and hard engineering strategies and evaluate strategies for managing coastal erosion.

TUNE IN

The three images in **FIGURE 1** show different kinds of coastal management strategies.

FIGURE 1 Some examples of coastal management strategies

Working in pairs, study the images carefully and suggest purposes of each of these coastal management strategies.

3.5.1 How can a coast be managed?

It is possible to reduce or slow the change to coastal landscapes if we understand the **physical processes** and human activities that cause it. While it is not possible to change the speed and direction of the wind or the number of months each year when destructive waves reach a shoreline, it is possible to redistribute or trap the sand shifted by storm waves or longshore drift. It is also possible to protect coastal houses and roads using barriers to reduce the direct impact of waves.

Coastal management techniques are commonly divided into two main categories — hard engineering strategies and soft engineering strategies. **Hard engineering** strategies typically involve using physical structures to control the effects of natural processes. Sea walls, groynes, gabions and breakwaters are all examples of hard management techniques.

What is interesting about these kinds of strategies is that, over time, they can often create problems that are more severe than the ones which they were trying to solve. Let's use a seawall as an example.

As waves hit the shore in Seabird, Western Australia, they removed sand from the beach and decreased the stability of the dune system. Concerned that the dunes would eventually be washed away completely, the local shire decided to build a sea wall. Although the wall succeeded in protecting the dune, its presence inadvertently caused another management issue. As you can also see in the photograph, there is no sand in

physical processes continuing and naturally occurring actions such as wind and rain

hard engineering a coastal management technique that involves using physical structures to control the effects of natural processes front of the sea wall. Before the wall existed, waves did indeed remove sand from the beach and dune system. However, they also replenished the sand over time in a natural cycle. The presence of the wall has interrupted this natural cycle, eventually resulting in the complete loss of beach area in front of the wall. This is just one example of how hard engineering strategies can often cause long-term issues in coastal environments.

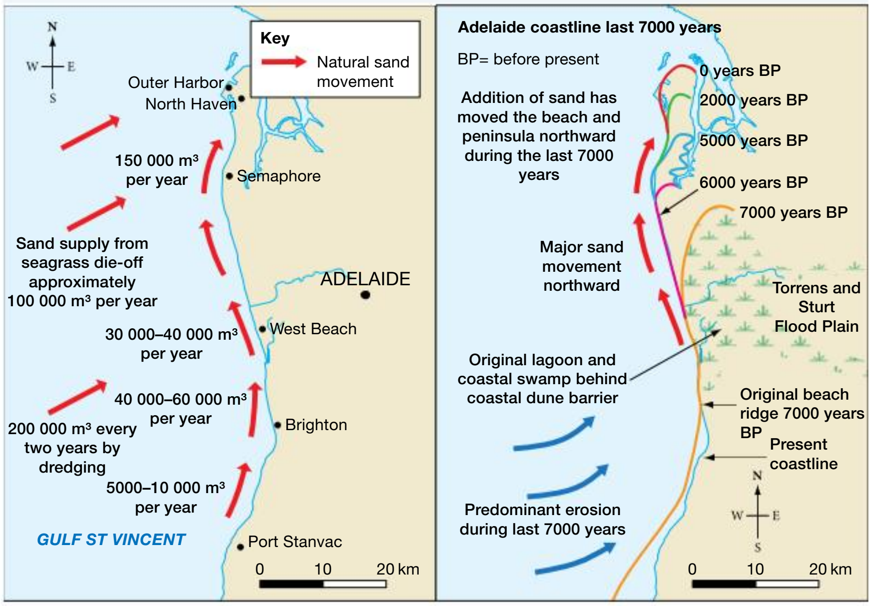
Due to the issues that often arise from hard engineering strategies, many of the strategies we see used today involve **soft engineering** techniques. Taking a more sustainable approach to coastal management, these strategies commonly use natural processes instead of permanent physical infrastructure. Instead of building a sea wall, the Shire of Gingin (responsible for the Seabird sea wall) could have revegetated the dune system to improve its stability. Dune revegetation is a common soft engineering strategy that involves planting natural grasses and shrubs. As these plants grow, their roots help bind the sand together, halting erosion.

3.5.2 CASE STUDY: Managing Adelaide's living beaches

The problem: The beautiful sandy beaches closest to Adelaide are under constant threat from erosion. **FIGURE 2** identifies the problem. For the past 7000 years the beaches south of Adelaide have been eroding, and the prevailing winds from the south-west have driven this material northwards.

This longshore drift has removed material from the south and relocated it in North Haven, where a **peninsula** has grown and a large dune system has been created. For the past 30 years the beaches in the south have been replenished by adding truckloads of sand. The plan is to find a better way to manage Adelaide's beaches by reducing the cost of moving sand.

FIGURE 2 The movement of sand northwards along the Adelaide Metropolitan coastline



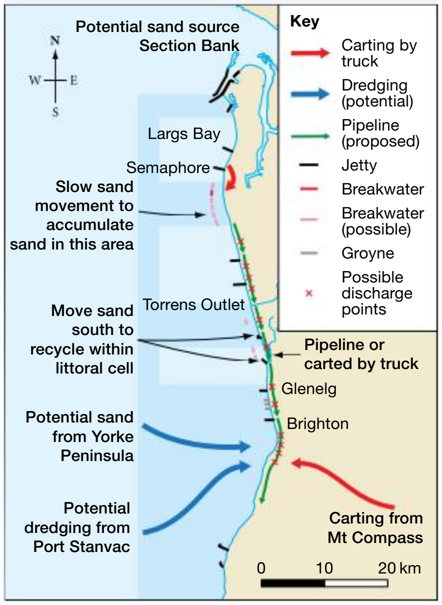
Source: Spatial Vision

The solution: Adelaide's Living Beaches Strategy. **FIGURE 3** illustrates the solution. Although sand will still need to be recycled from north to south, the plan is to use a pipeline instead of trucks to do most of the transportation. The pipeline will extend along the coast and will send sand back to the southern end of the beach. **FIGURE 4** shows sand being discharged at the southern end of the beach. A series of structures such as breakwaters and groynes will be built in several places to trap sand at important locations. Fewer trucks will be used, and it is expected that the cost of beach restoration will be reduced.

soft engineering a coastal management technique where the natural environment is used to help reduce coastal erosion and river flooding

peninsula land jutting out into the sea

FIGURE 3 Adelaide's Living Beaches Strategy



Source: Spatial Vision

FIGURE 4 Piping sand from north to south along Adelaide's beaches

3.5.3 Do coastal management strategies always work?

FIGURE 5 A groyne on Cottesloe Beach

An integrated strategy like the one designed for Adelaide's beaches has a better chance of protecting existing coastal landscapes (particularly the beaches) and structures built nearby, because it has taken into account the prevailing wind conditions, as well as the movement of sand.

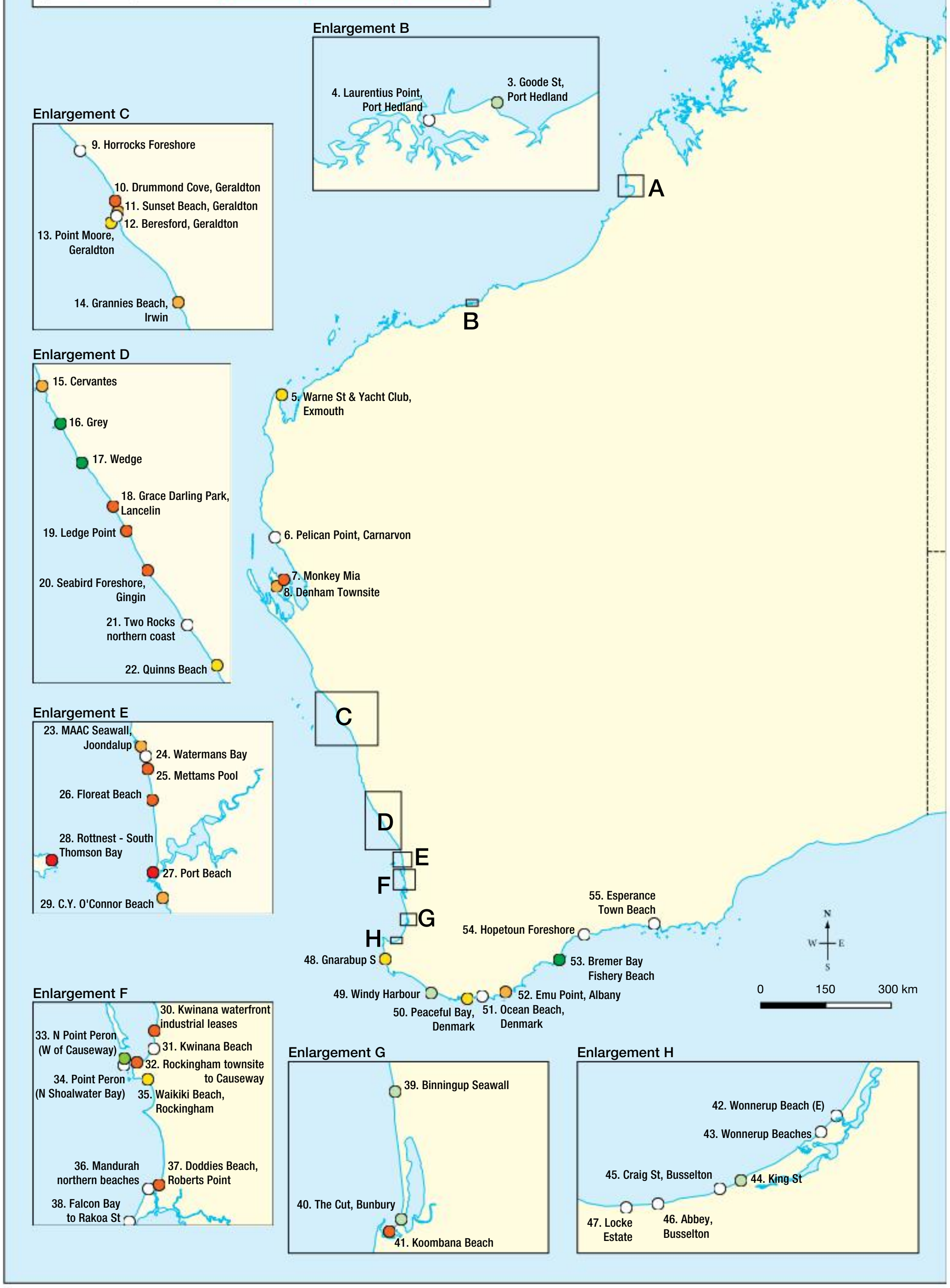
If a structure like the groyne in **FIGURE 5** is built on a beach, it will certainly trap sand on the side that interrupts the direct flow of the longshore drift. But this structure will also reduce the flow of sand to beaches further along the coast, on the other side of the groyne. Building a sea wall or breakwater may interrupt the flow of longshore drift and actually silt up the mouth of the harbour it is protecting. A sea wall can deflect the power of waves and increase erosion on an unprotected part of the nearby coast, or reduce the erosion of material from a cliff face that had been replenishing sand on the local beaches.

Coastal management is quite a tricky issue. Do you manage to protect the existing coastal landscape or do you manage to allow the action of wind and waves to create a naturally evolving landscape?

FIGURE 6 Western Australian coastal erosion hotspots and management importance

Coastal erosion hotspots and management importance

Colour	Rank	Management Importance 0-5 years	5-25 years	25+ years
(red)	1	High	High	High
(orange-red)	2	Medium	High	High
(orange)	3	Low	High	High
(yellow)	4	Medium	Medium	High
(white)	5	Low	Medium	High
(pale green)	6	Low	Medium	Medium
(light green)	7	Low	Low	High
(dark green)	8	Low	Low	Low



Source: Department of Transport, WA Government

3.5 SKILL ACTIVITY: Concluding and decision-making

Imagine that you own a holiday house that is built on coastal dunes within 15 metres of the beach. After a powerful storm, the beach in front of your house is eroded and your house is now only five metres from the sea. What are your options?

Propose a series of strategies that you could implement which may save your house from falling into the sea. Include diagrams to **illustrate** your plan.

3.5 Exercise

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3.5 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 3, 7	4, 5, 6, 9	2, 8, 10

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Check your understanding

1. Answer the following.
   a. How do groynes help to manage or protect a coastal landscape?
      A. They trap sand moving along the beach.
      B. They assist in the movement of sand along the beach.
      C. They help longshore drift.
      D. They stop destructive waves from pounding the beach.
   b. How do sea walls help to manage or protect a coastal landscape? **Select** all correct answers.
      A. They protect the coastline from destructive waves.
      B. They help anchor sand on the beach.
      C. They prevent longshore drift.
      D. They prevent structures such as cliffs and roads being undercut.
2. **Select** the correct terms in the following sentences:
   Strategies that involve using physical structures to control the effects of natural processes are known as **green** / **medium** / **hard** / **solid** / **soft** / **easy** engineering.
   Techniques that take a more sustainable approach to coastal management and commonly use natural processes instead of permanent physical infrastructure are known as **green** / **medium** / **hard** / **solid** / **soft** / **easy** engineering.
3. **Identify** the problem that sea walls usually attempt to solve.
4. **Describe** one situation in which you would use a hard management technique instead of a soft management technique.
5. **Describe** one situation in which you would use a soft management technique instead of a hard management technique.

Apply your understanding

Communicating

6. **Describe** what will happen to Adelaide's southern beaches if they stop being replenished with trucks of sand.

Interpreting and analysing geographical data and information

7. Refer to **FIGURE 2**. **Describe** the changes that have occurred to Adelaide's coastline over the past 7000 years.
8. Refer to **FIGURES 3** and **4**. **Describe** the changes the Living Beaches Strategy has made to the Adelaide coastline and the reasons for these changes.
9. Refer to **FIGURE 5** and **describe** the direction of the longshore drift in this image.
10. **Draw** a diagram to demonstrate how revegetation could be used instead of a sea wall.

LESSON
3.6 How do First Nations Australians use coastal environments?

LEARNING INTENTION

By the end of this lesson you should be able to explain how ancient shell middens provide an insight into First Nations Australian lifestyles and coastal management practices.

TUNE IN

Take a close look at this photograph of a fish trap used by First Nations Peoples on the Barwon River, NSW in the late 1800s.

1. How do you think the trap functioned?
2. Why is it unlikely for us to find many traps like these remaining today?

FIGURE 1 A fish trap used by First Nations Peoples on the Barwon River, NSW (approx. 1890)

3.6.1 How did First Nations Australians use coastal environments?

First Nations Australians have been using coastal environments for at least 65 000 years. During this time they learned to manage their resources and practised careful and deliberate environmental management techniques. Although the coastal environments we see in Australia today are dramatically different to those used by the First Australians, some archaeological evidence does still exist.

shell middens First Nations Australian archaeological sites where the debris associated with eating shellfish and similar foods has accumulated over time

Scattered across coastal environments throughout Australia are thousands of fascinating archaeological sites which allow us to examine First Nations Australian coastal land use. These sites are called **shell middens** and contain the remains of shellfish, bones and sometimes stone tools (see **FIGURE 2**). Shell middens can be found across Australia but are particularly common in New South Wales, Victoria and Tasmania. Shell middens are usually located in scrubland behind sand dunes or in other sheltered positions along a coastline. First Nations Australians used middens to both store and cook their food, as suggested by the presence of heavy amounts of ash and charcoal at these sites. We can use the carbon in these remains to establish the age of individual sites. The oldest Victorian shell midden is located at Cape Bridgewater and was used over 12 000 years ago!

FIGURE 2 Shell midden on the Tarkine coast, Tasmania

While shell middens provide us with important archaeological evidence, they are also an important reminder for all Australians of the long and rich history of First Nations Peoples in Australia.

Physical links to this heritage are rare in some parts of Australia, and shell middens provide us with tangible connections to the past. As shell middens are usually situated in delicate and dynamic coastal environments, it is vital that we preserve the historical and cultural significance of these sites.

3.6 SKILL ACTIVITY: Questioning and researching using geographical methods

Shell middens are one example of a First Nations Australian archaeological site. Use the internet to find another type of First Nations archaeological site in Australia. **Identify** and **describe** the site and **explain** why it is historically and culturally significant.

3.6 Exercise

learnon

3.6 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 3, 4, 7	5, 6	5, 8, 9, 10

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Check your understanding

1. In which locations are shell middens particularly common? **Select** all that apply.
   A. Tasmania
   B. New South Wales
   C. Queensland
   D. Western Australia
   E. Victoria
   F. South Australia
2. What evidence is there in the middens that suggests First Nations Australians cooked their food?
   A. Cutlery marks on the shells
   B. Charcoal and ash found around the middens
   C. Cooking utensils found among the shells
   D. All of the above
3. **Select** the correct terms in the following sentence: Victoria's oldest shell midden is located at **Tarkine** / **Cape Bridgewater** and is over **12 000** / **20 000** / **32 000** years old.
4. **Explain** what a shell midden is.
5. **Explain** why shell middens are important to preserve.

Apply your understanding

Communicating

6. Most shell middens are found within a few kilometres of a coastline. **Explain** why this location would make these sites vulnerable.
7. **Suggest** a way that we could protect and preserve shell middens.
8. **Suggest** how shell middens could be used to boost tourism in regional areas.
9. **Develop** a proposal to the local member for Cape Bridgewater that the shell midden site should be nominated as a location of cultural significance.

Concluding and decision-making

10. Some middens have been found far from current coastal areas. **Suggest** how this is possible.

LESSON
3.7 How do coastal landforms compare?

LEARNING INTENTION

By the end of this lesson you should be able to identify the processes that have created coastal landforms in different parts of the world.

TUNE IN

The images in **FIGURE 1** show similar landforms at different locations. The image on the left is an arch at a beach in Santa Cruz, USA (a coastal environment) and the image of the right is an arch in Lake Powell, USA (an inland environment).

FIGURE 1 Two different arch landforms

Do you think these landforms were created by the same processes? Justify your response.

3.7.1 How do coastal landforms differ?

Although coastal landforms can be similar in different parts of the world, they can also be very different. Some differences are climatic and some are geomorphic. Coastal landscapes are created by the interconnections between the sculpting power of the oceans, coastal topography and the material that is available to sculpt.

Limestone stacks, such as the Twelve Apostles in Victoria (see **FIGURE 3** in lesson 3.2), have been shaped by the power of the Southern Ocean. Similar stacks have been formed by the erosive power of the waters off the coast of Thailand (**FIGURE 2**) and along the Portuguese and Welsh coasts. We can also compare two regions that feature coastal lake environments — Gippsland Lakes in south-eastern Victoria and the Icelandic Vatnajökull glacier.

The Gippsland Lakes are a network of coastal lakes and lagoons fed by six rivers but they are often cut off from the sea by a barrier of silt. The Gippsland Lakes are at the mouth of the Mitchell, Avon, Thompson, Latrobe, Nicholson and Tambo Rivers. When there is little rainfall, the rivers flow slowly and deposit sediment in the lakes. This, along with the longshore drifting of the sea current in Bass Strait, creates lakes by moving sediment to seal the lakes with offshore barriers. After heavy rainfall the level of water in the Lakes rises and the barrier breaks, allowing access of fresh water to the sea and salt water into the Lakes. This lake system had an artificial entrance cut by humans in the late 1800s to allow fishing boats into and out of the Gippsland Lakes and to reduce the chance of algal blooms.

FIGURE 2 Ko Tapu rock near Phuket, Thailand

In south-eastern Iceland the melting Vatnajökull glacier (**FIGURE 3**) flows into the Atlantic Ocean through a glacial lake.

FIGURE 3 Jökulsárlón Glacier Lagoon, Iceland

This glacier once flowed directly into the sea, but a warming local climate has meant that the glacier's snout is now 1.5 kilometres inland. The melting ice has created the large 18-square-kilometre glacial lake named Jökulsárlón. Since the climate is cold and the sunshine has little heat, the large chunks of ice that fall from the glacier remain as slowly melting icebergs. These icebergs float in the lake until they become small enough to roll down a channel into the sea. During winter the lake freezes and traps the icebergs until the summer thaw.

Humans have created a narrow channel to link Jökulsárlón with the sea. This channel is designed to reduce the chance of summer floods and to protect the major highway that brings tourists to this beautiful place.

These two coastal lakes have formed in very different places, with different climates, but the geomorphic process of deposition has meant that human intervention has been required to allow their waters to flow into the sea.

3.7 SKILL ACTIVITY: Questioning and researching using geographical methods

1. a. Use the internet to collect at least six images of limestone stacks from different places in the world.
   b. Attach these images to a Google map to **create** a global distribution of limestone landscapes.
   c. **Describe** the similarities and differences between the images.

3.7 Exercise

3.7 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 9	3, 4, 5, 10	6, 7, 8

Check your understanding

1. What material are the Twelve Apostles and Ko Tapu rock both made from?
   A. Granite
   B. Sandstone
   C. Limestone
   D. Marble
2. Which two statements about climate and the entrance of the Vatnajökull glacier into the sea are true?
   A. The climate is getting warmer.
   B. The climate is getting cooler.
   C. The climate has not changed.
   D. The entrance to the glacier is unchanged.
   E. The glacier's snout has moved 1 kilometre inland.
   F. The glacier's snout has moved 1.5 kilometres inland.
   G. The glacier's snout has moved 2 kilometres inland.
3. **Describe** the way that the geological process of deposition has changed the Gippsland Lakes and Jökulsárlón.
4. **Explain** how the Gippsland Lakes area was formed.
5. The key similarity between the Gippsland Lakes and Jökulsárlón is that they are both coastal landscapes that have not changed over time. True or false?

Apply your understanding

Communicating

6. The Vatnajökull glacier is expected to have melted within 80 years. What might this place look like when there is no longer a glacier? **Draw** a sketch map to explain your answer.
7. Look at a map of the Gippsland Lakes. **Predict** how they might look if part of the barrier washes away during a huge storm. **Draw** a sketch map to **explain** your answer.
8. **Explain** how rainfall (or the lack of rainfall) can influence the appearance of the Gippsland Lakes region.
9. **Explain** how humans have changed the Gippsland Lakes region and Vatnajökull over time.

Concluding and decision-making

10. **Identify** the major threats to the two regions mentioned in this lesson. How can these regions be managed to avoid these threats?

LESSON
3.8 How does water influence river landscapes?

LEARNING INTENTION

By the end of this lesson, you should be able to identify the different phases of a river and describe the landform features that form from a river's source to its mouth.

TUNE IN

Many major cities are built near rivers, such as the Yarra River in Melbourne.

FIGURE 1 The Yarra River winds its way toward the city of Melbourne

Using the evidence provided by the image in **FIGURE 1**, brainstorm a list of the ways in which the people of Melbourne might use the Yarra River. Consider different groups within the population and share your brainstorm with the class.

3.8.1 Moving water

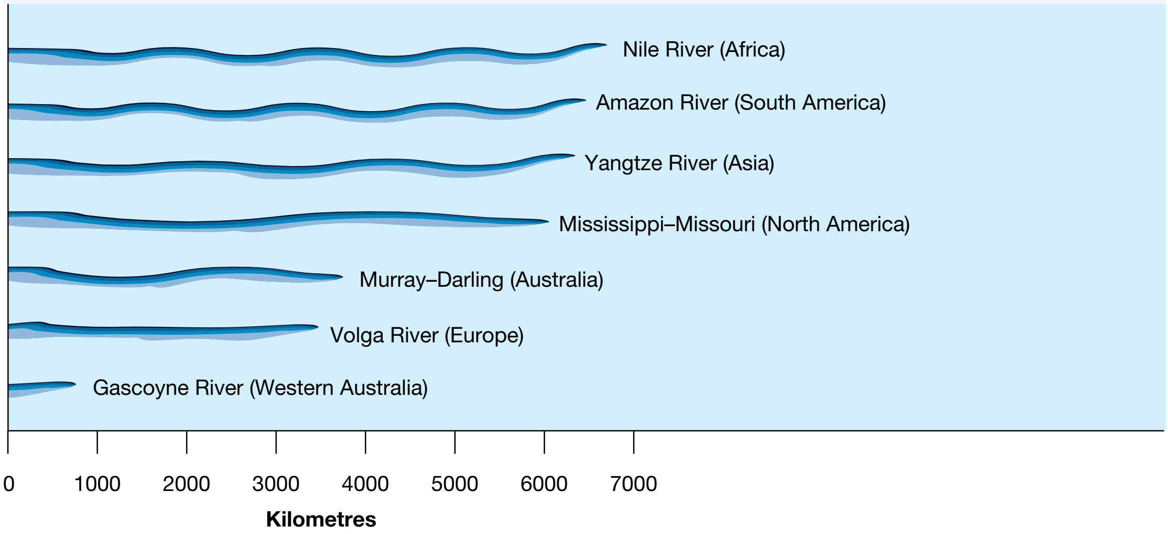
Erosion, transportation and deposition are the key processes through which rivers are able to sculpt landscapes. Some rivers, such as the Gordon River in Tasmania, are **perennial**; some, such as Coopers Creek in Queensland, are **intermittent**; others, such as the Colorado River in the United States, have eroded amazing landforms like the Grand Canyon.

Water is always on the move. It evaporates and becomes part of the water cycle; it rains and flows over the surface of the Earth and into streams that make their way to a sea, lake or ocean; and it soaks through the pores of rocks and soil into **groundwater**.

Groundwater is essential for keeping rivers flowing in dry months, as it is groundwater that stops many rivers from running dry.

perennial describes a stream that flows all year
intermittent describes a stream that does not always flow
groundwater water that seeps into soil and gaps in rocks

FIGURE 2 Rivers of the world: the longest river on each continent. How do each of these rivers compare to the Gascoyne River in Western Australia?



3.8.2 River systems and features

A river is a natural feature, and what we see is the result of the interaction of a range of inputs and processes. All parts of the Earth are related to the formation of river landscapes. This includes the lithosphere (rocks and soil), the hydrosphere (water), the biosphere (plants and animals) and the atmosphere (temperature and water cycle). Changes can happen quickly or over a very long period of time. Changes at one location along a river can have an effect at other locations along the river.

Water flows downhill, and the source (the start) of a river will be at a higher altitude than its mouth (the end). As the water moves over the Earth's surface, it erodes, transports and deposits material.

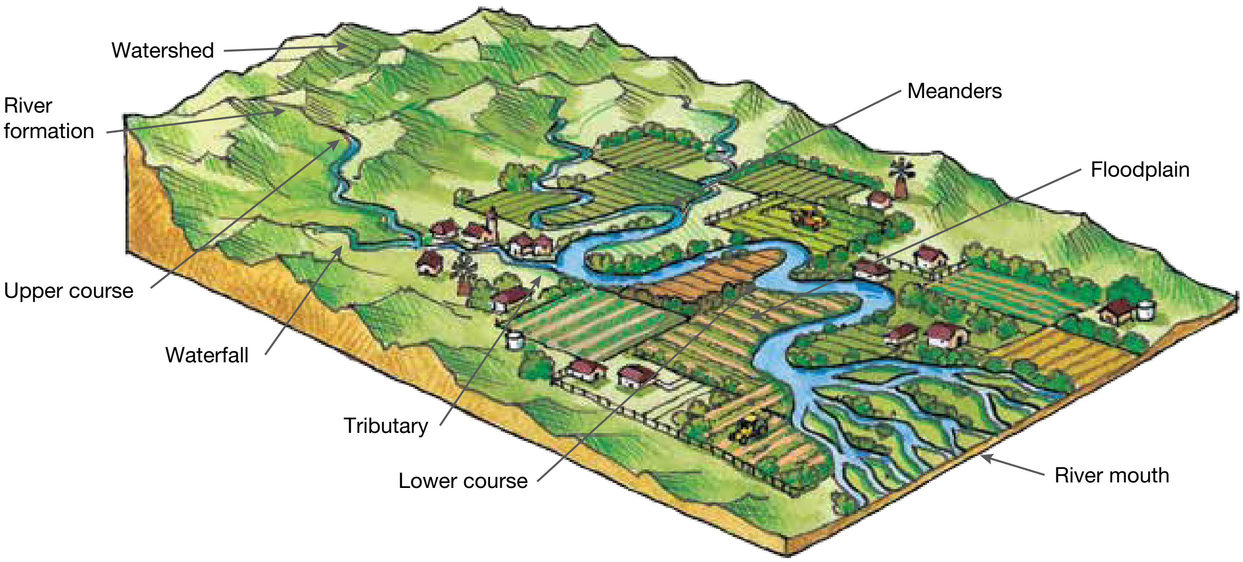
The volume of water and the speed of flow will influence the amount and type of work carried out by a river. A fast-flowing flooded river will erode enormous amounts of material and transport it **downstream**. As the speed or volume of the water decreases, much of the material it carries will be deposited. Rivers are commonly broken into three main sections — the upper, middle and lower course. Different processes and different types of landforms can be found in each section. Let's examine these sections more closely to see exactly how rivers work.

downstream nearer the mouth of a river, or going in the same direction as the current

int-7839

tlvd-10617

FIGURE 3 A river system

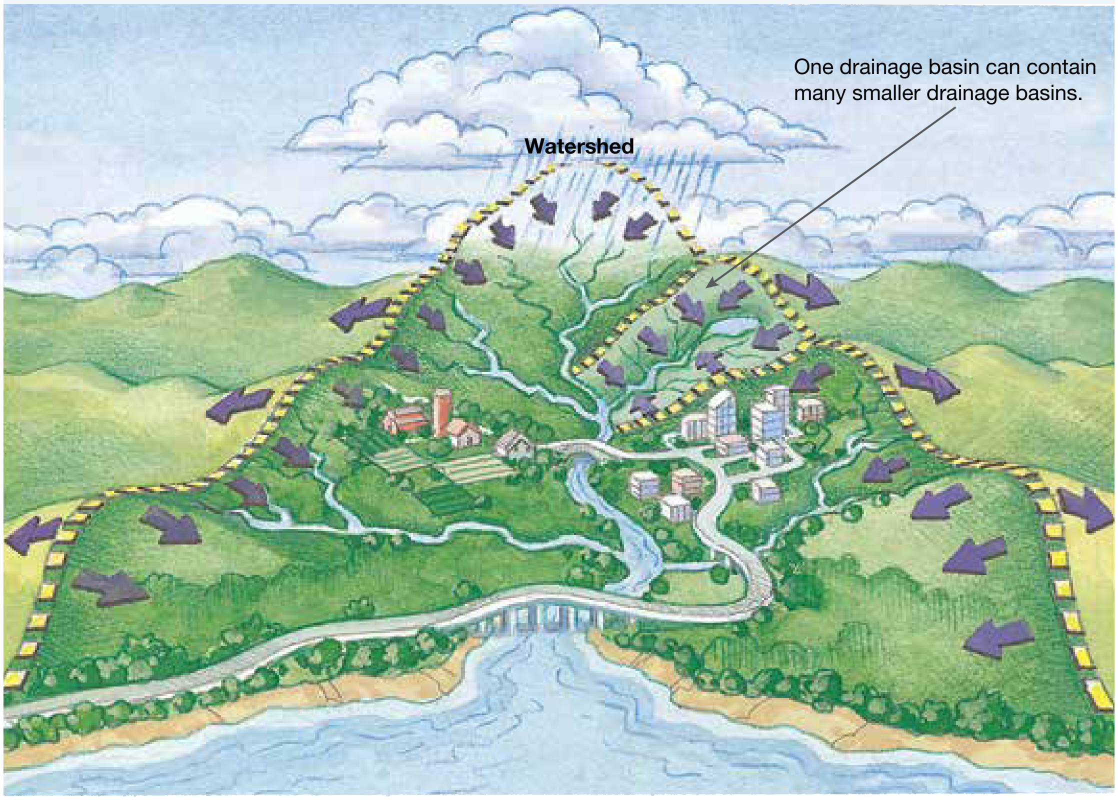


Upper course

A river gathers its water from a region known as a drainage basin or catchment (see **FIGURE 4**). The boundary of this region is identified by mountains, hills or any land that is higher than the surrounding area. This is often referred to as the **watershed** and it is the point that determines the direction of the river.

watershed an area or ridge of land that separates waters flowing to different rivers, basins or seas

FIGURE 4 The watershed and catchment, or drainage basin of a river system

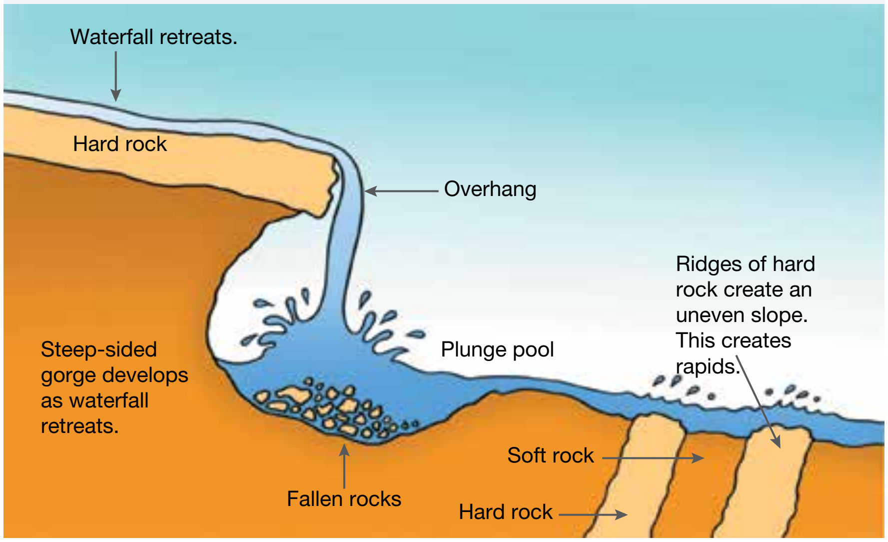


Within this region, water collects in small depressions in the ground (rills), which eventually become larger streams. Finally, these streams (also known as tributaries) combine to form the main trunk of the river itself.

Water moves quickly along the upper course of a river is it makes its way from areas of higher elevation to areas of lower elevation. The faster the flow of a river, the more power it has and the more erosion it causes.

It is common to see waterfalls, plunge pools and rapids along the upper course of a river.

FIGURE 5 A waterfall

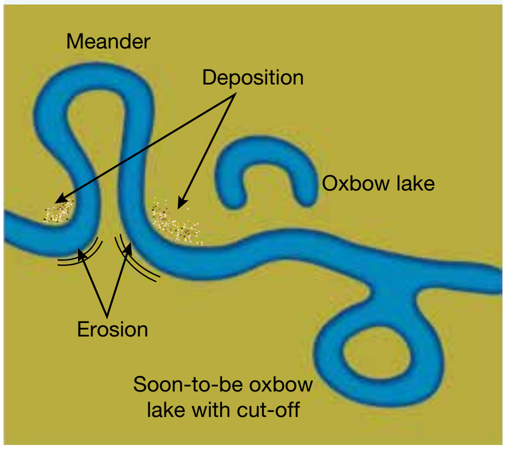


Middle course

A river will naturally follow the topography of the surrounding area. As the land flattens out, a river will stretch into long sweeping turns known as **meanders**. Here, the energy of the fast-flowing river we saw in the upper course is converted and allows the river to carve a new path through the flatter landscape of the middle course. Over time, a meandering river will change the path it follows, as some bends become more obvious and others disappear. A meander that has been cut off is called an oxbow lake. In Australia we call these billabongs.

During times of high rainfall, land on either side of the middle course can become inundated as the river struggles to contain excess water. Referred to as a **floodplain**, these areas are highly suitable for agriculture. As floodwaters subside, they leave behind the nutrient-rich sediment (alluvium) that the river had been transporting since it left the upper course.

FIGURE 6 The formation of a meander and oxbow lake



Lower course

As a river enters the lower course it slows down again, separating back into smaller streams called distributaries. The remaining sediment carried by the river is deposited in an area referred to as the delta. **River deltas** commonly take three main shapes: fan shaped, arrow shaped and bird-foot shaped. The shape of a delta is influenced by tides, waves and the volume of sediment and water carried by a river. Sometimes a river ends with a wide mouth where fresh water and salt water can mix. This is known as an **estuary**.

meander a winding curve or bend in a river

floodplain an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding

river delta a landform created by deposition of sediment that is carried by a river as the flow leaves its mouth and enters slower-moving or stagnant water. Can take three main shapes: fan shaped, arrow shaped and bird-foot shaped.

estuary the wide part of a river at the place where it joins the sea

DID YOU KNOW?

Australia has no major river deltas as a result of the strong ocean currents surrounding the continent.

3.8 SKILL ACTIVITY: Questioning and researching using geographical methods

A river finishes its long journey at the delta. Here, the river deposits the material which it has carried along its course, creating landscapes with nutrient-rich soils. Agricultural activity often takes place in these regions due to the high quality of the soil. However, life in the delta is not without its hazards, with floods frequently occurring in these regions.

1. **Research** river deltas around the world, paying closer attention to the positive and negatives aspects of living in a delta region.
2. When you have completed your research, **create** a table which **identifies** and **explains** the costs (negative) and benefits (positive) of living in a delta.

FIGURE 7 Farmers salvaging rice crops after a flood in Bangladesh

on Resources

Interactivity River carvings (int-3104)

Google Earth Mississippi Delta

3.8 Exercise

learn**on**

3.8 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
2, 3, 4, 6	1, 7	5, 8, 9, 10

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- Access sample responses
- Track results and progress

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Check your understanding

1. Which of the below statements is correct?
   A. The Nile River is 1.8 times longer than the Murray–Darling River.
   B. The Murray–Darling River is 1.8 times longer than the Nile River.
   C. The Nile River is 2.3 times longer than the Murray–Darling River.
   D. The Murray–Darling River is 2.3 times longer than the Nile River.
2. Study **FIGURE 5**. What feature, other than water, has to be present for waterfalls and rapids to form?
   A. Rapids
   B. Soft rock
   C. Bands of hard rock
   D. Heavy rainfall
3. Why do people settle and farm on floodplains? **Select** all possible answers.
   A. The land is flat.
   B. The land is steep.
   C. Regular flooding improves soil fertility.
   D. It is easy to sandbag during times of high river flow.
   E. A river is a source of water.
4. **Explain** how rivers are part of the water cycle.
5. Refer to **FIGURE 2** and compare the scale of Australia's longest river with the world's longest river.

Apply your understanding

Communicating

6. **Identify** a river that flows through the capital city in one state or territory in Australia. Describe its source, any tributaries, and its mouth.

Concluding and decision-making

7. **Propose** what you think will happen to deltas if sea levels rise.
8. **Predict** the changes that will occur to the waterfall in **FIGURE 5**. **Justify** your answer.
9. **Discuss** what changes will occur along a river if there is unusually high rainfall in its upper course. Think in terms of erosion and deposition.
10. Do you think that governments should stop people from living in floodplains? **Justify** your response.

LESSON
3.9 How do people manage river landscapes?

LEARNING INTENTION

By the end of this lesson you should be able to identify strategies for managing a river system and explain why managing a river system is complex, using the Mekong River in Vietnam as an example.

TUNE IN

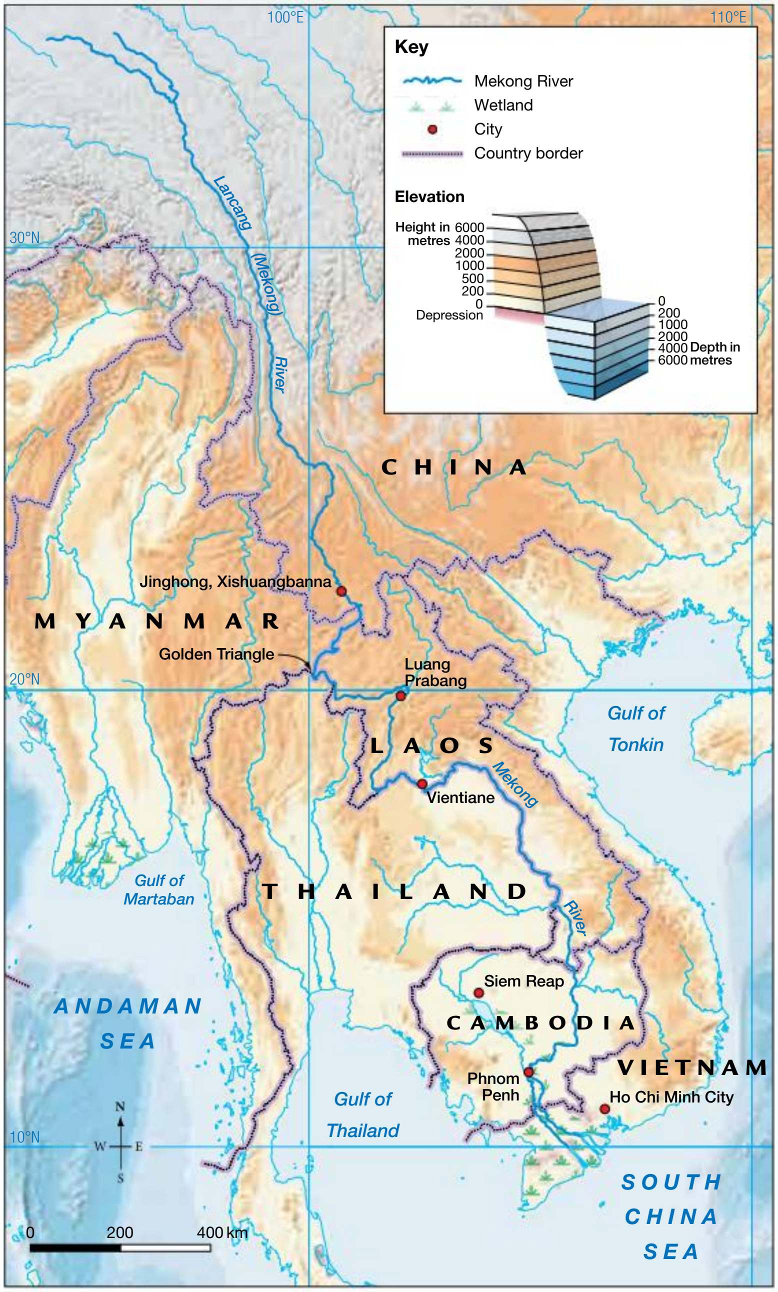
Have you ever shared a bedroom with a sibling or argued with a group of friends over whose turn it is to start at king in four-square?

There are times in our lives when we need to share resources and this can sometimes lead to disagreements.

As Figure 1 shows, the Mekong River flows through several countries in South-East Asia, meaning they all have to share the resource.

1. With so many countries sharing this important water resource, suggest some issues that might arise and lead to disagreements.
2. Discuss ways that you think the different countries could approach solving at least one of the issues you've identified.

FIGURE 1 The Mekong River winds its way through six South-East Asian countries, ending in the Mekong Delta in Vietnam.



Source: Based on data from Natural Earth and ETOPO1: doi:10.7289/V5C8276M. Map drawn by Spatial Vision.

3.9.1 The Mekong River

If you follow the Mekong River from beginning to end, it will take you on a fascinating journey through six South-East Asian countries! The source of the Mekong River is high in the Tibetan Plateau, an area which is the birthplace of several of Asia's most important rivers. From here, the Mekong River winds its way through Myanmar, Laos, Thailand and Cambodia, finally coming to its end in southern Vietnam. The Mekong is the twelfth longest river in the world and the third longest in Asia. Although the Mekong is a challenging river to navigate for large-scale aquatic vehicles, it remains a crucial trade route, linking countries in the region. The Mekong also provides irrigation for agriculture throughout the region.

The importance of the river

The Mekong is a vital economic and environmental asset, not only to Vietnam, but to other countries in the region.

- It enables the transportation of goods between and within countries.
- It supplies cities and communities with water for agricultural activity and household use.
- Parts of the river are used for the production of hydroelectric power.
- It is the second most biodiverse river in the world, sustaining important fishing industries.

FIGURE 2 Floating markets of Soc Trang, in the Mekong Delta

Floods

Flooding is a regular occurrence along the various sections of the Mekong River. The most significant impacts are felt in Vietnam, where the river branches out into the delta. While seasonal flooding is a dangerous but accepted way of life, large-scale flooding can have devastating impacts on communities in the Mekong Delta. The most recent flooding event occurred in 2020 after a succession of extreme weather events battered the region. Over 100 people died, and more than 200 000 houses were inundated or damaged during this disaster. An estimated 1 million livestock and poultry were killed, with thousands of hectares of agricultural land also affected.

As we have learned earlier in this topic, living in a floodplain or delta can have many positive and negative aspects for people in these areas. The Mekong River Commission estimates that the annual average value that flood waters provide for the region is between US$8 billion and US$10 billion. However, the organisation also estimates that the annual average cost of flooding events ranges between US$60 and 70 million. Although these figures show that floods provided an overall economic benefit, the human cost of flooding must also be considered.

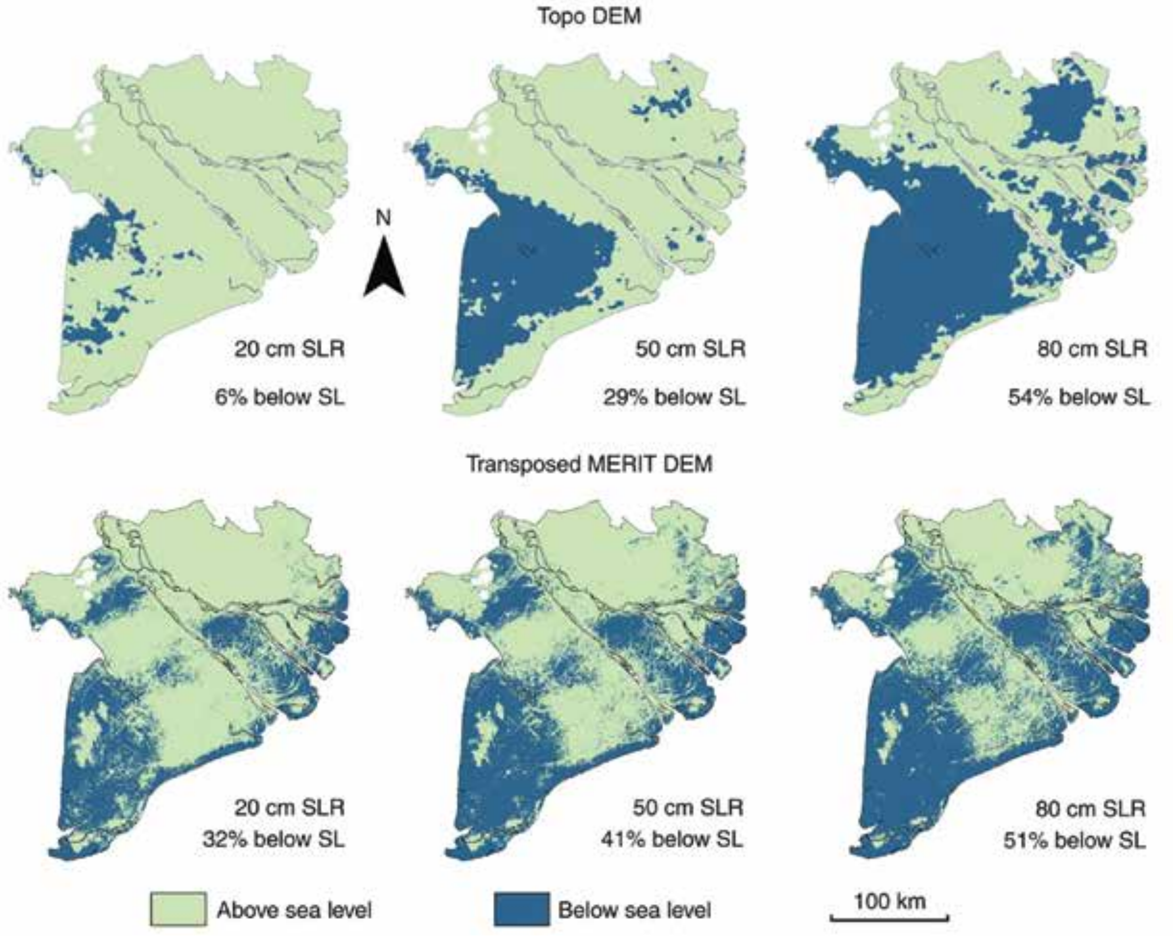
River management

As the Mekong River is a transboundary river, management of the river system is complex. A transboundary river is one which creates a number of international boundaries. Each country through which the river flows has an interest in the way in which the river is managed. This includes irrigation, damming and other flood mitigation strategies. The way in which one country might want to manage the Mekong will differ depending on the priorities of that country. For example, countries that contain the upper course of the river may want to harness the power of the river's fast-flowing waters, converting this power to hydroelectricity. Yet countries in the lower course would be focused on irrigation and other agricultural benefits provided by the river. As decisions made by each country will directly impact the others, management decisions need to be made through international cooperation or with the assistance of independent non-government organisations.

Management issues

- Transboundary rivers require complex inter-governmental management.
- Seasonal flooding creates consistent issues.
- Increased frequency and severity of extreme weather events.
- High population density in the Mekong Delta (20 per cent of Vietnam's population lives this region).
- Increasing use of dams in multiple countries along the Mekong's upper and middle courses.

FIGURE 3 This series of maps shows the potential impacts of sea-level rise on the Mekong Delta



3.9 SKILL ACTIVITY: Concluding and decision-making

Do you agree or disagree with the following statement? 'A strategy implemented in one part of the river will have an impact on another part of the river.'

As you find evidence from this lesson, place it in a table, or under subheadings. **Write** a conclusion based on your findings.

3.9 Exercise

learnon

3.9 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 6	3, 7, 8	4, 5, 9, 10

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Check your understanding

1. **Identify** the six countries through which the Mekong River flows.
   A. China
   B. Myanmar
   C. India
   D. Thailand
   E. Bangladesh
   F. Cambodia
   G. Laos
   H. Vietnam
   I. Indonesia
2. **Determine** whether the following statements are true or false.
   a. A transboundary river flows through only one country.
   b. Floods in the Mekong Delta always have a positive impact on the region's economy.
   c. The Mekong River is the second most biodiverse river in the world.
3. **Identify** three benefits that the Mekong River provides to the people of Vietnam.
   A. Water for agriculture
   B. Water sports
   C. Fisheries
   D. Method of transport for trade
4. Using the statistics provided, **calculate** the net economic impact of flooding in the Mekong Delta.
5. **Identify** who is responsible for managing the Mekong River system.

Apply your understanding

Communicating

6. **Explain** why flooding is a common occurrence along the Mekong River.

Concluding and decision-making

7. The resources provided by the Mekong are listed in this lesson. **Rank** these resources in order of importance and provide an **explanation** of your ranking.
8. **Discuss** why the management of a transboundary river is so complicated.
9. The impacts of flooding on residents of the Mekong Delta region could be avoided by relocating communities to other parts of Vietnam. **Identify** and **explain** two issues with this strategy.
10. If you were a farmer, would you choose to live in the Mekong Delta? **Explain** your response.

LESSON
3.10 INQUIRY: Coastal environment case study

LEARNING INTENTION

By the end of this lesson you should be able to describe and explain the coastal processes, threats and the management strategies of a particular coastal environment.

Background

For this inquiry, you will **investigate** and **evaluate** coastal processes and management strategies at a coastal location of your choosing. You can choose a coastal environment which is close to your home or perhaps one which you've visited before on a holiday. Use these steps to complete your inquiry activity.

Before you begin

Access the **Inquiry rubric** in the digital documents section of the Resources panel to guide you in completing this task at your level. At the end of the inquiry task you can use this rubric to self-assess.

Inquiry steps

Step 1: Questioning and researching using geographical methods

Choose any coastal environment to use as your case study. **Conduct research** on this location using these questions to guide your investigation:

- Where is your chosen location?
- What are the dominant coastal processes which occur at your location?
- **Describe** the extent of human activity at your location.
- **Identify** any existing or potential issues which could be caused by the observed coastal processes or by human activity.
- **Identify** any existing management strategies which are currently being used in your location.

Step 2: Interpreting and analysing geographical data and information

For this section, you will need to use your research data and your knowledge of the relationship between coastal processes and management strategies.

If there are management strategies being used at your location, **determine** the effectiveness of these strategies. In other words, have the strategies been successful? If so, what evidence supports your observations?

Step 3: Concluding and decision-making

If the existing management strategies have been unsuccessful, what strategies could potentially be used at your location to solve the issues which you have previously identified? **Consider** both hard and soft management techniques as possible solutions. **Explain** which strategies you would use and what impacts you would hope to see in the future.

Step 4: Communicating

Prepare a report about your chosen location, its coastal processes and threats, as well as existing coastal management strategies to mitigate these threats. The report can be in any appropriate format, such as a written report, slide show or video, and should include visual information such as photographs and maps. The report should also evaluate the effectiveness of the existing management strategies.

Complete your self-assessment using the **Inquiry rubric** or access the 3.10 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39539)

LESSON
3.11 Investigating topographic maps — Water flows in the Haast River

LEARNING INTENTION

By the end of this lesson you should be able to describe how water flows through a catchment by referencing a topographic map.

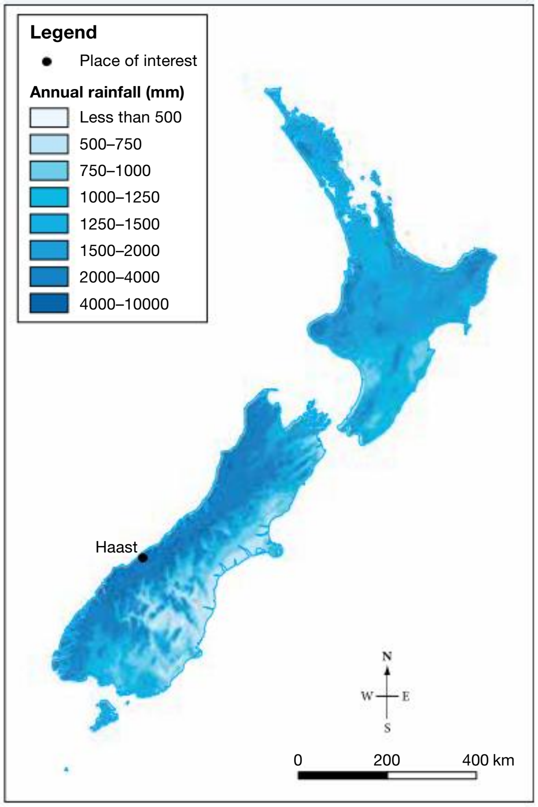
3.11.1 New Zealand's Haast region

Haast is a World Heritage site located on the west coast of the South Island of New Zealand. The region is untamed, with majestic mountains, pristine lakes and rugged coastlines.

The Haast River discharges as much as six cubic kilometres of water annually, and the catchment extends into the Southern Alps. There are some areas of seasonal and permanent snows and very high rates of run-off in the region due to the steep mountainous terrain.

FIGURE 1 The Gates of Haast

FIGURE 2 Annual rainfall, New Zealand



Source: WorldClim

int-9011

FIGURE 3 Topographic map extract of Haast, New Zealand

Source: LINZ Data Service. License: CC BY 3.0 NZ https://data.linz.govt.nz/license/attribution-3-0-new-zealand/

Resources

eWorkbook	Investigating topographic maps — Water flows in the Haast River (ewbk-10756)
Digital document	Topographic map of Haast, New Zealand (doc-39540)
Video eLesson	Investigating topographic maps — Water flows in the Haast River — Key concepts (eles-6032)
Interactivity	Investigating topographic maps — Water flows in the Haast River (int-9011)
Google Earth	Haast, New Zealand (gogl-0136)

3.11 Exercise

learnon

3.11 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
2, 4	1, 5	3, 6

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Check your understanding

1. a. **Examine FIGURE 3**. On a hike, what direction would you have to travel to get from:
   i. Mosquito Hill to the Haast Pass Highway
   ii. the hut in AR9030 to the hut on Cattle Track near Coppermine Creek
   iii. Buttress Point to the Haast Highway at Lake Paringa
   iv. Mt Browne to Haast Beach?
   b. **State** the spot height and area reference of:
   i. Mt Swindle
   ii. Plover Crag
   iii. Mosquito Hill.
2. **Identify** is the local relief in AR8057.
3. **Describe** the location of swamp areas found in the Haast region.

Apply your understanding

Interpreting and analysing geographical data and information

4. A tributary is a stream that flows into a larger river. **Explain** why there are so many tributaries that flow into the Haast River.
5. Examine **FIGURE 2**. **Explain** the reasons for a high volume of river flow in this area.
6. **Explain** how each of the following factors could affect water availability in the Haast region:
   a. latitude
   b. altitude
   c. topography
   d. climate change.

LESSON
3.12 Review

Hey students! Now that it's time to revise this topic, go online to:

Review your results

Watch teacher-led videos

Practise questions with immediate feedback

Find all this and MORE in jacPLUS

3.12.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

3.2 What landscapes are formed by water?

- Erosion and deposition are two processes through which water can shape landscapes.
- While all landscapes change over time, the rate of change seen in coastal landscapes, as well as other landscapes formed by water, can be relatively quick and dramatic.

3.3 What is coastal erosion?

- The coast is the zone between the land and the sea. The processes which occur in this zone determine the physical characteristics of that landscape.
- Waves are caused when the wind blows over the ocean; the size of a wave depends on the strength of the wind and the distance it has been blowing.

3.4 What is the role of deposition in coastal environments?

- Constructive waves are commonly involved in the creation of depositional landforms such as beaches, spits, sand dunes, lagoons and tombolos.
- The shape and appearance of depositional landforms are influenced by the strength and direction of the prevailing wind.
- Longshore drift is a process by which material is moved along a beach in the same direction as the prevailing wind.

3.5 How are coasts managed?

- Coastal processes need to be sufficiently understood before any management strategies can be developed and implemented.
- Coastal management strategies can be divided into hard and soft engineering strategies.
- Multiple coastal management strategies often need to be used simultaneously to achieve the best outcomes.

3.6 How do First Nations Australians use coastal environments?

- First Nations Australians have been using Australian coastal environments for at least 65 000 years.
- Shell middens provide archaeological evidence of First Nations Peoples' activity in coastal environments and are also a physical link to their culture and history.

3.7 How do coastal landforms compare?

- When comparing coastal environments from different locations, it is possible to see both similarities and differences in the landforms that are present in these environments and the way in which these landforms have been created.

3.8 How does water influence river landscapes?

- Rivers sculpt landscapes through the processes of erosion, transportation and deposition.
- Rivers can be perennial (flows consistently throughout the year) or intermittent (flows inconsistently throughout the year).
- Rivers consist of three sections — the upper, middle and lower course. Different processes and different types of landforms can be found in each section.

3.9 How do people manage river landscapes?

- People rely on rivers for a range of needs including agricultural, industrial, commercial, residential and recreational purposes.
- The human demand on rivers makes proper management essential.

3.10 INQUIRY: Coastal environment case study

- Many coastal locations use strategies to manage coastal processes with varying level of effectiveness.

3.11 Investigating topographic maps — Water flows in the Haast River

- The Haast River is situated in a World Heritage site located on the west coast of the South Island of New Zealand.
- The area has high water flow with the Haast River discharging as much as six cubic kilometres of water annually.

3.12.2 Key terms

backwash the movement of water from a broken wave as it runs down a beach returning to the ocean
cuspate spits projections of a beach into an enclosed or semi-enclosed lagoon
deposition the laying down of material carried by rivers, wind, ice and ocean currents or waves
destructive wave a large powerful storm wave that has a strong backwash
downstream nearer the mouth of a river, or going in the same direction as the current
erosion the wearing away and removal of soil and rock by natural elements, such as wind and water, and by human activity
estuary the wide part of a river at the place where it joins the sea
floodplain an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding
groundwater water that seeps into soil and gaps in rocks
hard engineering a coastal management technique that involves using physical structures to control the effects of natural processes
intermittent describes a stream that does not always flow
longshore drift a process by which material is moved along a beach in the same direction as the prevailing wind
meander a winding curve or bend in a river
peninsula land jutting out into the sea
percolate filter through porous material such as soil
physical processes continuing and naturally occurring actions such as wind and rain
prevailing wind the main direction from which the wind blows
perennial describes a stream that flows all year
river delta a landform created by deposition of sediment that is carried by a river as the flow leaves its mouth and enters slower-moving or stagnant water. Can take three main shapes: fan shaped, arrow shaped and bird-foot shaped.
shell middens First Nations Australian archaeological sites where the debris associated with eating shellfish and similar foods has accumulated over time
soft engineering a coastal management technique where the natural environment is used to help reduce coastal erosion and river flooding
swash the movement of water in a wave as it breaks onto a beach
watershed an area or ridge of land that separates waters flowing to different rivers, basins or seas

3.12.3 Reflection

Complete the following activities to reflect on your learning.

Revisit the inquiry question posed in the Overview:

How does water form and transform landscapes?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-10754)
Reflection (ewbk-10757)
Crossword (ewbk-10758)

Interactivity Landscapes formed by water crossword (int-7596)

3.12 Review exercise

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Multiple choice

1. A cave is formed by the process of:
   A. erosion.
   B. deposition.
   C. transpiration.
   D. condensation.
2. What is the main purpose of a 'groyne'?
   A. To hold the sand and grass area at the back of the beach
   B. To stop waves rushing onshore
   C. To take sand from further up the beach or another area, or to pump it from offshore
   D. To stop the sea from removing so much sand from the beach
3. What information can be shown by drawing a long profile of a river?
   A. The slope followed by the river
   B. The direction followed by the river
   C. The distance travelled by the river
   D. The speed at which the river travels

4. In which of the following places are glaciers found?
   - A. Greenland and Australia
   - B. New Zealand and Antarctica
   - C. Chad and the Himalayas
   - D. West Papua and Indonesia
5. What is the term that describes the movement of water in a wave as it breaks onto a beach?
   - A. Longshore drift
   - B. Swash
   - C. Watershed
   - D. Tributary
6. Which of the following is ***not*** a method used to protect beach areas from erosion?
   - A. Grommets
   - B. Sea wall
   - C. Sand renourishment
   - D. Rock walls
7. Identify which of the following is ***not*** a water feature that shapes the land.
   - A. Rain
   - B. Temperature
   - C. Glaciers
   - D. Oceans
8. Which country does the Mekong River ***not*** flow through?
   - A. China
   - B. Laos
   - C. Vietnam
   - D. Bangladesh
9. What is the name given to the smaller streams located toward the end of a river system?
   - A. Meanders
   - B. Tributaries
   - C. Distributaries
   - D. River deltas
10. Despite the risks of flooding, a high level of agricultural activity is often found in floodplains. Besides the availability of water, what is another reason that explains this pattern?
   - A. High human populations
   - B. High levels of nutrients in soils
   - C. High degree of sunlight
   - D. High diversity of plants and animals

Short answer

Communicating

11. Place each of the following features into the correct column of the table below: arch, beach, blowhole, cave, cliff, headland, lagoon, sand dune, spit, stack.

Features formed by erosion	Features formed by deposition

12. a. Why did First Nations Peoples of Australia tend to live near the coast?
    b. How have coasts been used since 1788?
13. a. What is the best way to avoid a rip current when swimming at the beach?
    b. **Identify** two ways in which a rip current looks different from surrounding water.
14. a. Refer to your fieldwork and explain the interconnection of physical processes and human activities.
    b. **Identify** three ways in which you can record data while in the field.
15. a. What information can be shown by drawing a long profile of a river?
    b. What information can be shown by drawing a cross-section of a river?
16. Match these features to the upper, middle or lower course of a river: V-shaped valley, floodplain, estuary, waterfall, meander, delta.
17. **Identify** at least one economic, one environmental and one social reason for devising strategies to manage a river.
18. Name two places where glaciers are found.

4 Geomorphic hazards

LESSON SEQUENCE

LESSON
4.1 Overview

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How do magma, water and tectonic plates change environments and what are the impacts on people and places?

4.1.1 Introduction

The forces that form and shape our planet come from deep within the Earth, and have been shaping landscapes for millions of years. The Earth is a very active planet — every day, many volcanoes are erupting somewhere, and even more earthquakes are occurring. In this topic we will explore the tectonic forces that shape the world. We will also study earthquakes, tsunamis and volcanoes, and the effects they have on people and places.

FIGURE 1 Mt Agung in Indonesia

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-13443)

Video eLesson Majestic mountains (eles-1626)

LESSON
4.2 What are plate tectonics?

LEARNING INTENTION

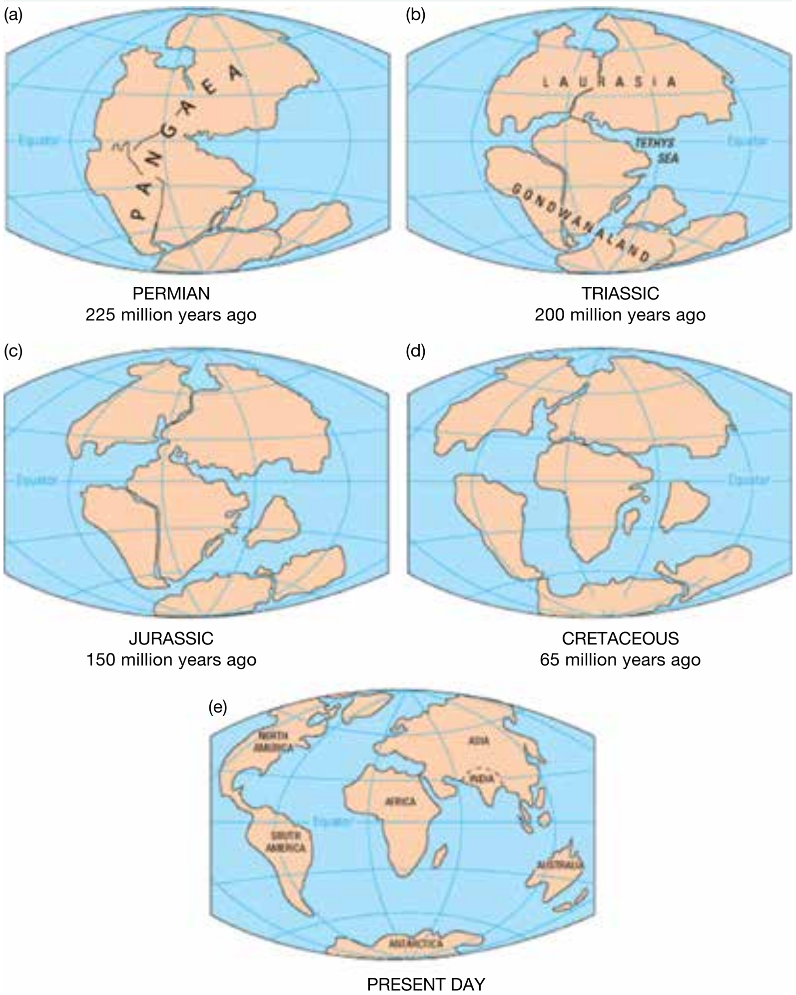
By the end of this lesson you should be able to define key terms 'continental plates' and 'continental drift' and explain the different ways continental plates can move. You should also be able to identify landforms that result from different types of plate movement and explain how continental drift and the movement of plates has led to the formation of mountains.

TUNE IN

Examine **FIGURE 1**. The continents used to be joined together in one landmass called Pangaea. Over time they moved and spread out into the formation that exists today.

tlvd-10618

FIGURE 1 Movement of the continents



In pairs, brainstorm and explain:

- Why you think the continents move.
- What evidence there might be to support this theory.
- Make a list of three to four questions that you want answered after looking at these images. See if you can answer them by the end of the topic.

4.2.1 Continental plates

The Earth's crust is cracked and is made up of many individual moving pieces called continental plates, which fit together like a jigsaw puzzle. These plates float on the semi-molten rocks, or magma, of the Earth's mantle.

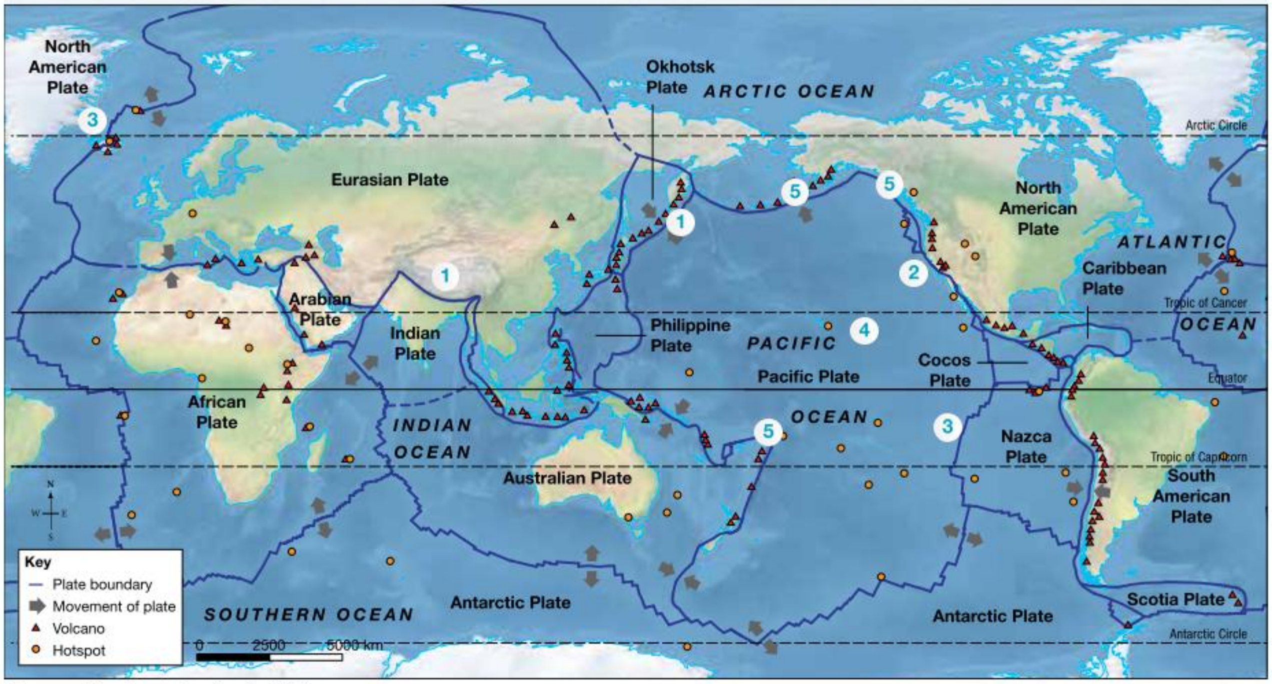
Enormous heat from the Earth's core, combined with the cooler surface temperature, creates **convection currents** in the magma. These currents can move the plates by up to 15 centimetres per year. Plates beneath the oceans move more quickly than plates beneath the continents. Scientific evidence shows that about 225 million years ago all the continents were joined.

convection current a current created when a fluid is heated, making it less dense, and causing it to rise through surrounding fluid and to sink if it is cooled; a steady source of heat can start a continuous current flow

int-9012

tlvd-10619

FIGURE 2 World map of plates, volcanoes and hotspots



Source: Map drawn by Spatial Vision

1 Convergent plates

When two continental plates of similar density collide, the pressure of the **converging plates** can push up land to form mountains. The Himalayas were formed by the collision of the Indian subcontinent and Asia. The European Alps were formed by the collision of Africa and Europe.

Oceanic and continental plates have different densities, so when they collide the thinner oceanic plate is subducted, meaning it is forced down into the mantle. Heat melts the plate and pressure forces the molten material back to the surface. This can produce volcanoes and mountain ranges. The Andes in South America were formed this way.

Subduction can also occur when two oceanic plates collide. This forms a line of volcanic islands in the ocean about 70–100 kilometres past the subduction line. The islands of Japan were formed in this way. Deep oceanic trenches are also formed when this occurs. The Mariana Trench in the Pacific Ocean is 2519 kilometres long and 71 kilometres wide, and is 10.911 kilometres deep, making it the deepest point on Earth. If you could put Mount Everest on the ocean floor in the Mariana Trench, its summit would lie 1.6 kilometres below the ocean's surface.

converging plate a tectonic boundary where two plates are moving towards each other

2 **Lateral plate slippage**
Convection currents can sometimes cause plates to slide, or slip, past one another, forming **fault** lines. The San Andreas Fault, in California in the western United States, is an example of this.

3 **Divergent plates**
In some areas, plates are moving apart, or diverging, from each other (for example, the North American Plate and the Eurasian Plate). As the **divergent plates** separate, magma can rise up into the opening, forming new land. Iceland was formed in this way and it continues to grow today. Underwater volcanoes and islands are also formed in this way.

4 **Hotspots**
There are places where volcanic eruptions occur away from plate boundaries. This occurs when there is a weakness in the oceanic plate, allowing magma to be forced to the surface, forming a volcano. As the plate drifts over the **hotspot**, a line of volcanoes is formed. The Hawaiian Islands are the best known example of land created by a hotspot.

5 **The Pacific Ring of Fire**
The most active tectonic region in the world is the Pacific Ring of Fire. It is located on the edges of the Pacific Ocean and is shaped like a horseshoe. The Ring of Fire is a result of the movement of tectonic plates. For example, the Nazca and Cocos plates are being subducted beneath the South American Plate, while the Pacific and Juan de Fuca plates are being subducted beneath the North American Plate. The Pacific Plate is being subducted under the North American Plate on its east and north sides, and under the Philippine and Australian plates on its west side. The Ring of Fire is an almost continuous line of volcanoes and earthquakes. Most of the world's earthquakes occur here, and 75 per cent of the world's volcanoes are located along the edge of the Pacific Plate.

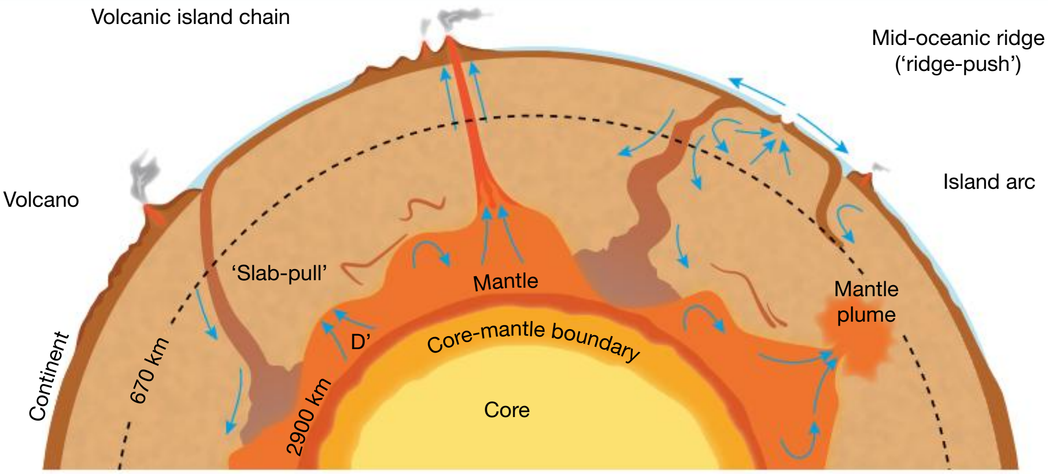
fault an area on the Earth's surface that has a fracture; a fault lies at the major boundaries between Earth's tectonic plates.

divergent plate a tectonic boundary where two plates are moving away from each other and new continental crust is forming from magma that rises to the Earth's surface between the two

hotspot an area on the Earth's surface where the crust is quite thin, and volcanic activity can sometimes occur, even though it is not at a plate margin

tlvd-10620

FIGURE 3 The Earth's core is very hot, while its surface is quite cool. This causes hot material within the Earth to rise until it reaches the surface, where it moves sideways, cools, and then sinks.



4.2 SKILL ACTIVITY: Questioning and researching using geographical methods

1. **Research** how plate tectonic theory first came to be accepted.
   a. Who came up with this theory?
   b. **Outline** three types of evidence cited to prove this theory.
2. Provide **annotated** diagrams of the three major plate boundaries. (Make sure you include in your diagrams the direction of the flow of the convection current in the mantle.):
   - Convergent boundary (subduction zone)
   - Lateral plate boundary
   - Spreading plate boundary.

4.2 Exercise

4.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 6	3, 5, 7, 8	4, 9, 10

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Check your understanding

1. a. **Determine** whether the following statements are true or false.
   i. The world's volcanoes are randomly scattered over the Earth's surface.
   ii. Most of the world's volcanoes are concentrated along the edges of certain continents.
   iii. Island chains are closely linked with the location of volcanoes.
   iv. There are a number of hot spots within the Pacific Ocean.
   b. Use the statements from parts a–d to write a **summary** paragraph, remembering to rewrite the false statements to make them true.
2. Convection currents
   A. are the force that move continents.
   B. are caused by heat rising and then cooling.
   C. start beneath the Earth's surface in the core and travel through the mantle.
   D. are all of the above.
3. The hotspot that helped form the Hawaiian Islands
   A. is in the Central Pacific Ocean.
   B. is in the Atlantic Ocean.
   C. is no longer active.
   D. is under the Antarctic ice sheet.
4. **Explain** the meaning of subduction when referring to plate movements. In your explanation include the plate that remains and the plate that subducts.
5. **Recall** two locations where plates are moving apart. What is happening to the sea floor in these places?
6. **Identify** the type of plate boundaries that surround the Pacific Ocean.
7. **Explain** why Australia has so few earthquakes or active volcanoes.

Apply your understanding

Communicating

8. **Describe** the distribution of volcanoes shown in **FIGURE 2**. What does this distribution have in common with the location of plate boundaries?

Concluding and decision-making

9. **Examine FIGURE 3**. How do convection currents help explain plate tectonics?
10. Refer to **FIGURE 2**. **Name** three places where plates are converging. What mountain ranges, if any, are located in these places?

LESSON
4.3 How do mountains form?

LEARNING INTENTION

By the end of this lesson you should be able to describe the different types of mountains and explain how different mountain ranges have formed. You should also be able to define the key terms 'lithosphere' and 'Pangaea' and discuss the spatial relationship between fault lines and mountain ranges.

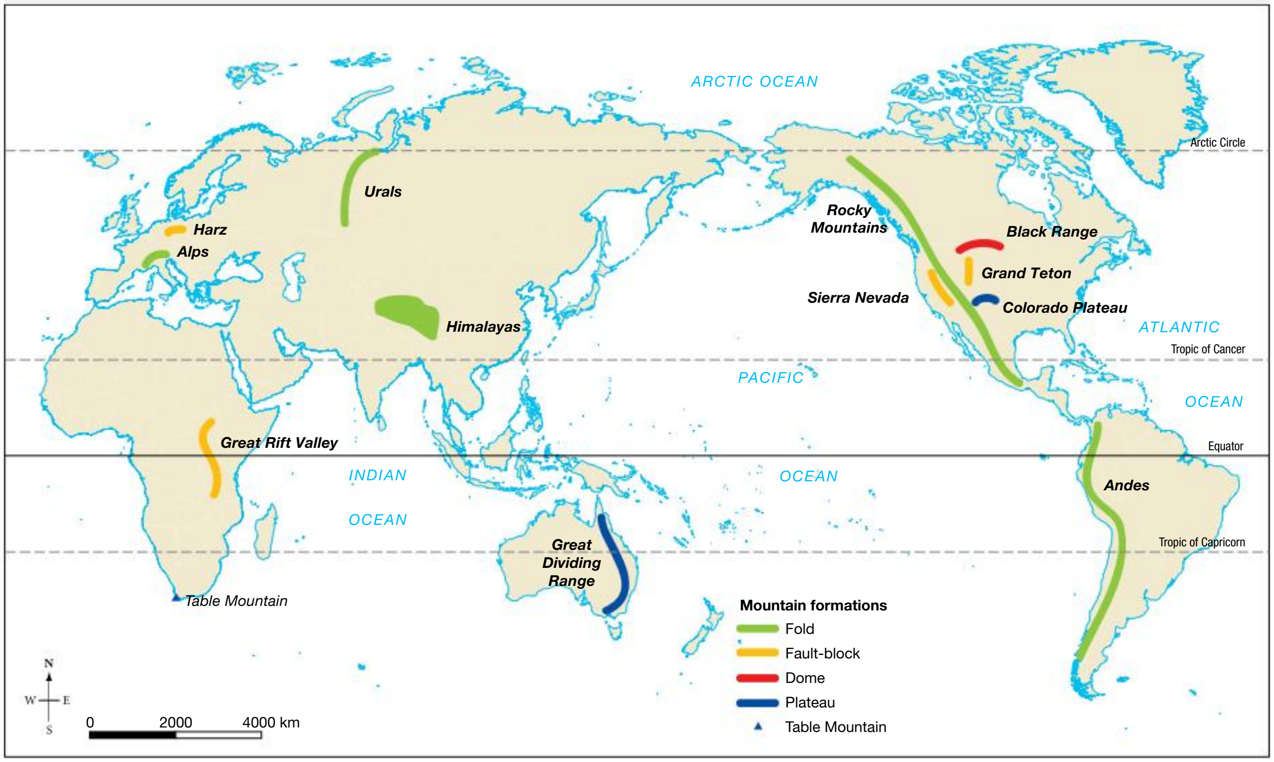
TUNE IN

Examine **FIGURE 1** which focuses on mountains from around the world and refer back to **FIGURE 2** in lesson 4.2 while completing the following tune in questions.

1. Can you see any similarities between the location of mountains and the location of plate boundaries? These kinds of similarities are known as spatial associations.
2. Which continent do you think has been the most tectonically active? Justify your response.
3. Think carefully about **FIGURE 1**. What other information would you like to see on this map?

int-9013

FIGURE 1 Selected world mountains



Source: Spatial Vision

A mountain is a landform that rises high above the surrounding land. Most mountains have certain characteristics in common, although not all mountains have all these features. Many have steep sides and form a peak at the top, called a summit. Some mountains located close together have steep valleys between them known as gorges.

Mountains and mountain ranges have formed over billions of years from tectonic activity; that is, movement in the Earth's crust. The Earth's surface is always changing — sometimes very slowly and sometimes dramatically.

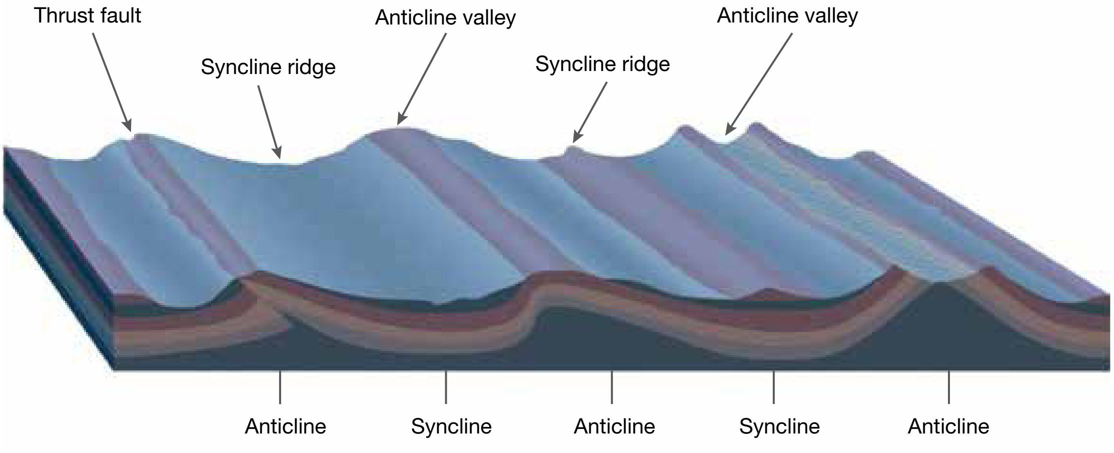
The different movements and interactions of the **lithosphere** plates result in many different mountain landforms. Mountains can be classified into five different types, based on what they look like and how they were formed. These are fold, fault-block, dome, plateau and volcanic mountains. (Volcanic mountains are discussed in lesson 4.9.)

lithosphere the crust and upper mantle of the Earth

Fold mountains

The most common type of mountain, and the world's largest mountain ranges, are fold mountains. The process of folding occurs when two continental plates collide, and rocks in the Earth's crust buckle, fold and lift up. The upturned folds are called anticlines, and the downturned folds are synclines (see **FIGURE 2**). These mountains usually have pointed peaks.

FIGURE 2 The formation of fold mountains



Examples of fold mountains include:

- the Himalayas in Asia
- the Alps in Europe
- the Andes in South America
- the Rocky Mountains in North America
- the Urals in Russia.

FIGURE 3 The pointed peaks of the Ural Mountains in Russia

Fault-block mountains

Fault-block mountains form when faults (or cracks) in the Earth's crust force some parts of rock up and other parts to collapse down. Instead of folding, the crust fractures (pulls apart) and breaks into blocks. The exposed parts then begin to erode and shape mountains and valleys (see **FIGURE 4**).

Fault-block mountains usually have a steep front side and then a sloping back. The Sierra Nevada and Grand Tetons in North America, the Great Rift Valley in Africa, and the Harz Mountains in Germany are examples of fault-block mountains. Another name for the uplifted (upthrown) blocks is *horst*, and the collapsed (downthrown) blocks are *graben*.

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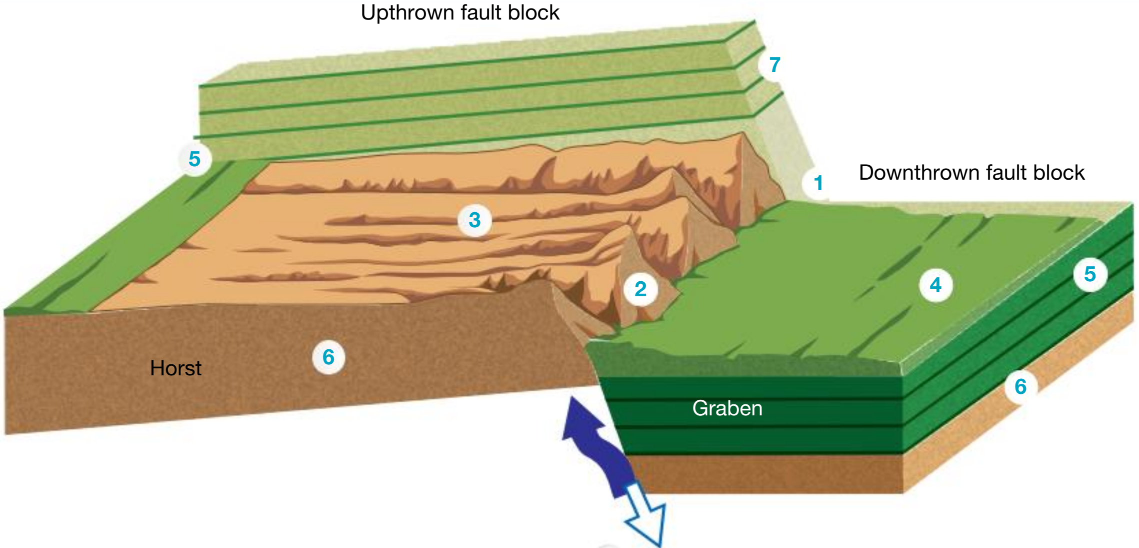
tlvd-10621

FIGURE 4 The formation of fault-block mountains



1 Fault zone
2 Steep eastern face
3 Gentle western slope
4 Valley floors filled with sediments of cobbles, gravel and sand
5 Sedimentary rock layers
6 Bedrock
7 Sedimentary rock layers (5) now worn away.

FIGURE 5 Examples of fault-block mountains overlooking the Great Rift Valley in Northern Kenya, Africa

Dome mountains

Dome mountains are named after their shape, and are formed when molten magma in the Earth's crust pushes its way towards the surface. The magma cools before it can erupt, and it then becomes very hard. The rock layers over the hardened magma are warped upwards to form the dome. Over time these erode, leaving behind the hard granite rock underneath (see **FIGURE 6**).

FIGURE 6 Very hot magma pushes towards the surface to form dome mountains.

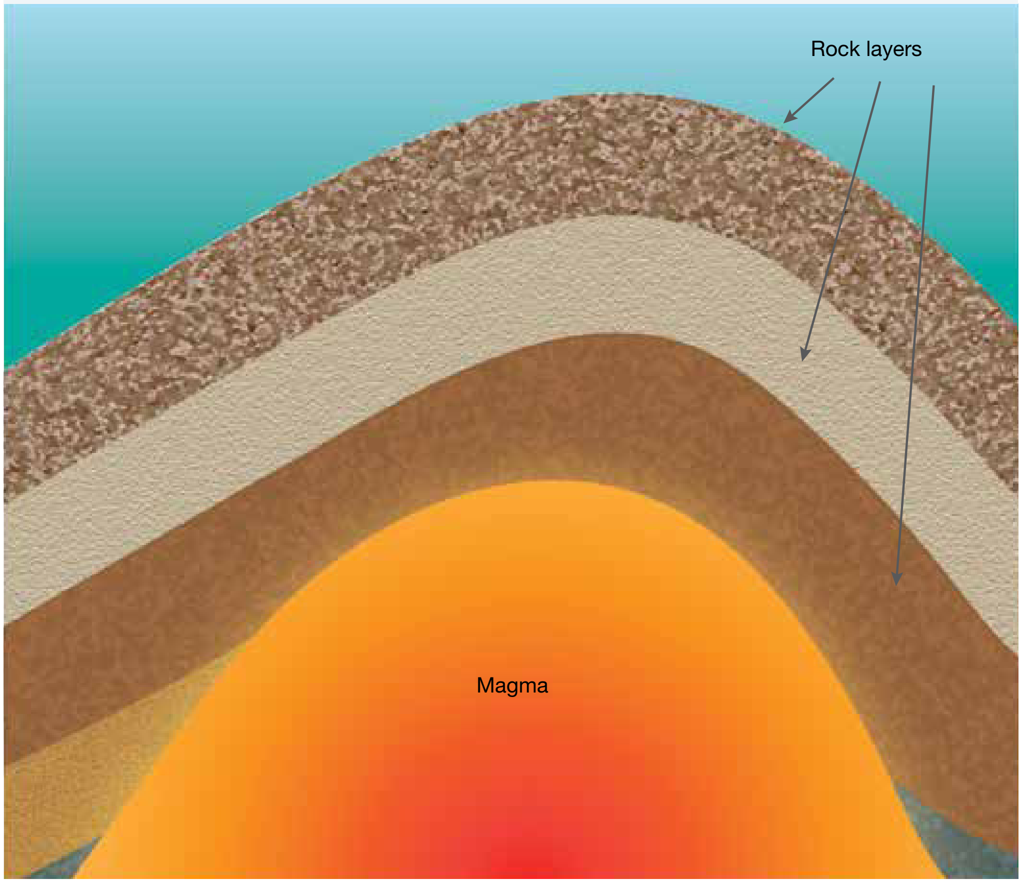


FIGURE 7 Ben Nevis in Scotland is an example of a dome mountain.

Plateau mountains

Plateaus are high areas of land that are large and flat. They have been pushed above sea level by tectonic forces or have been formed by layers of lava. Over billions of years, streams and rivers cause erosion, leaving mountains standing between valleys. Plateau mountains are sometimes known as erosion mountains.

Examples of plateau mountains include parts of the Great Dividing Range in Australia (see **FIGURE 8**), the Colorado Plateau (see **FIGURE 9**) in the United States.

FIGURE 8 The Blue Mountains in New South Wales, Australia are examples of Plateau mountains.

FIGURE 9 The Colorado Plateau in the United States was raised as a single block by tectonic forces. As it was uplifted, streams and rivers cut deep channels into the rock, forming the features of the Grand Canyon.

4.3.2 CASE STUDY: How were the Himalayas formed?

Before the theory of tectonic plate movement, scientists were puzzled by findings of fossilised remains of ancient sea creatures near the Himalayan peaks. Surely these huge mountains could not once have been under water?

The mystery was solved when scientists came to understand plate movements. About 220 million years ago, India was part of the ancient supercontinent we call **Pangaea**. When Pangaea broke apart, India began to move northwards at a rate of about 15 centimetres per year. About 200 million years ago, India was an island separated from the Asian continent by a huge ocean.

When the plate carrying India collided with Asia 40 to 50 million years ago, the oceanic crust (carrying fossilised sea creatures) slowly crumpled and was uplifted, forming the high mountains we know today. It also caused the uplift of the Tibetan Plateau to its current position and formed the Bay of Bengal.

Therefore, the Himalayas were formed when India crashed into Asia and pushed up the tallest mountain range on the continents.

The Himalayas are known as young mountains, because they are still forming. The Indian and Australian plates are still moving northwards at about 45 millimetres each year, making this boundary very active. It is predicted that over the next 10 million years it will travel more than 180 kilometres into Tibet and that the Himalayan mountains will increase in height by about five millimetres each year. It is important to note that movement of tectonic plates is often sudden and causes earthquakes. The continents don't slide easily across the Earth's surface.

Old mountains are those that have stopped growing and are being worn down by erosion.

FIGURE 10 The movement of the Indian landmass to its current location

Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

on Resources

Interactivities	Mountain builders (int-3109) Grand peaks (int-3110)
Weblinks	Anticline and syncline Fold mountains
Google Earth	Great Rift Valley Ben Nevis Grand Canyon

Pangaea the name given to all the landmass of the Earth before it split into Laurasia and Gondwana, which over time became the continents we know today

4.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Use the **Fold mountains** weblink in the Resources panel to **explain** the formation of fold mountains. You can **create** a flow chart to help with your explanation.
2. **Discuss** why this type of tectonic activity creates mountain ranges not individual peaks.
3. **Explain** why you think the largest mountains of the world are created through this process.

4.3 Exercise

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4.3 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 7	5, 6, 8

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Fold mountains are the most common type of mountain in the world.
   b. The Sierra Nevada Range was formed by the eastern part of a fault-block tilting up.
   c. Dome Mountains are found where magma has once been near the surface
   d. The Blue Mountains in New South Wales are examples of Plateau mountains
2. How does the shape of each of the mountains shown in this lesson provide clues as to how they were formed? **Select** the correct option for each statement.
   a. High peaks are **dome** / **plateau** / **fault** / **fold** mountains.
   b. Block-shaped mountains with one steep and one sloping side are **dome** / **plateau** / **fault** / **fold** mountains.
   c. Rounded summits are **dome** / **plateau** / **fault** / **fold** mountains.
   d. High areas of large, flat land with valleys are **dome** / **plateau** / **fault** / **fold** mountains.
3. The Himalayas are considered a young mountain range because they are still ___________. The Himalayas are ___________ mountains.
4. **Define** Pangaea and lithosphere.

Apply your understanding

Concluding and decision-making

5. **Explain** why there are extensive fold mountain ranges along the western coastlines of North and South America. (Refer to **FIGURES 1** and **2** in your response.)
6. Use **FIGURE 1** to **predict** where Australia will be located in 100 million years.
7. Think carefully about the battle between erosion and plate tectonics. **Theorise** as to why Australia is the world's lowest (least elevated) and flattest continent.
8. If there was no more tectonic activity (volcanic eruptions or earthquakes) in the world **discuss** what you think the world would look like in 100 million years. **Justify** your response.

LESSON
4.4 Where are the world's mountain ranges?

LEARNING INTENTION

By the end of this lesson you should be able to describe the location of the world's main mountain ranges on a world map and the effect of altitude on mountain weather.

TUNE IN

Examine **FIGURE 1** which details the main mountains and mountain ranges around the world.

1. Which are the two longest mountain ranges in the world? Why might they be located where they are?
2. Which is the highest mountain range in the world? Discuss why this may be the case.
3. Which mountain range has the lowest elevation in this map? Theorise as to why.

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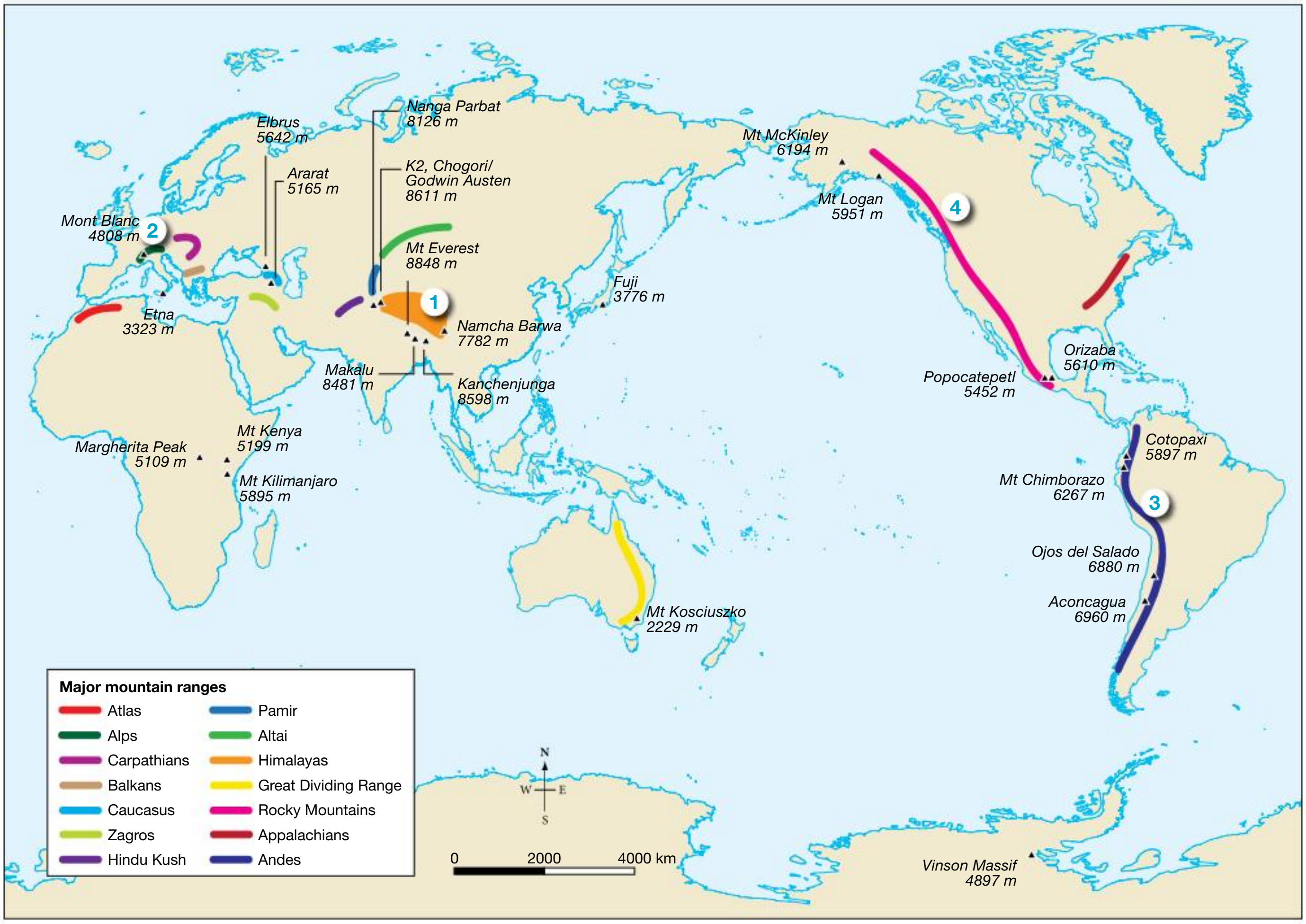
FIGURE 1 The world's main mountains and mountain ranges



Source: Map drawn by Spatial Vision

1 **The Himalayas**
Located in Asia, the Himalayas are the highest mountain range in the world. They extend from Bhutan and southern China in the east, through northern India, Nepal and Pakistan, and to Afghanistan in the west. The Himalayas is one of the youngest mountain ranges in the world and the name means 'land of snow'. The 14 highest mountains in the world — all over 8000 metres above sea level — are all in the Himalayas.

(continued)

(continued)

2 **The Alps**
The Alps, located in south central Europe, is one of the largest and highest mountain ranges in the world. They extend 1200 kilometres from Austria and Slovenia in the east, through Italy, Switzerland, Liechtenstein and Germany, to France in the west.

3 **The Andes**
The Andes are located in South America, extending north to south along the western coast of the continent. The Andes is the second highest mountain range in the world, with many mountains over 6000 metres. At 7200 kilometres long, it is also the longest mountain range in the world.

4 **The Rocky Mountains**
The Rocky Mountains in western North America extend north–south from Canada to New Mexico, a distance of around 4800 kilometres. The highest peak is Mount Elbert, in Colorado, which is 4401 metres above sea level. The other large mountain range in North America is the Appalachian Mountains, which extends 2400 kilometres from Canada in the north to Alabama in the southern United States.

Mountains make up a quarter of the world's landscape. They are found on every continent and in three-quarters of all the world's countries. Only 46 countries have no mountains or high plateaus, and most of these are small island nations.

Some of the highest mountains are found beneath the sea. Some islands are actually mountain peaks emerging out of the water. Even though the world's highest peak (from sea level) is Mount Everest in the Himalayas (8850 metres high), Mauna Loa in Hawaii is actually higher when measured from its base on the ocean floor. Long chains or groups of mountains located close together are called a mountain range.

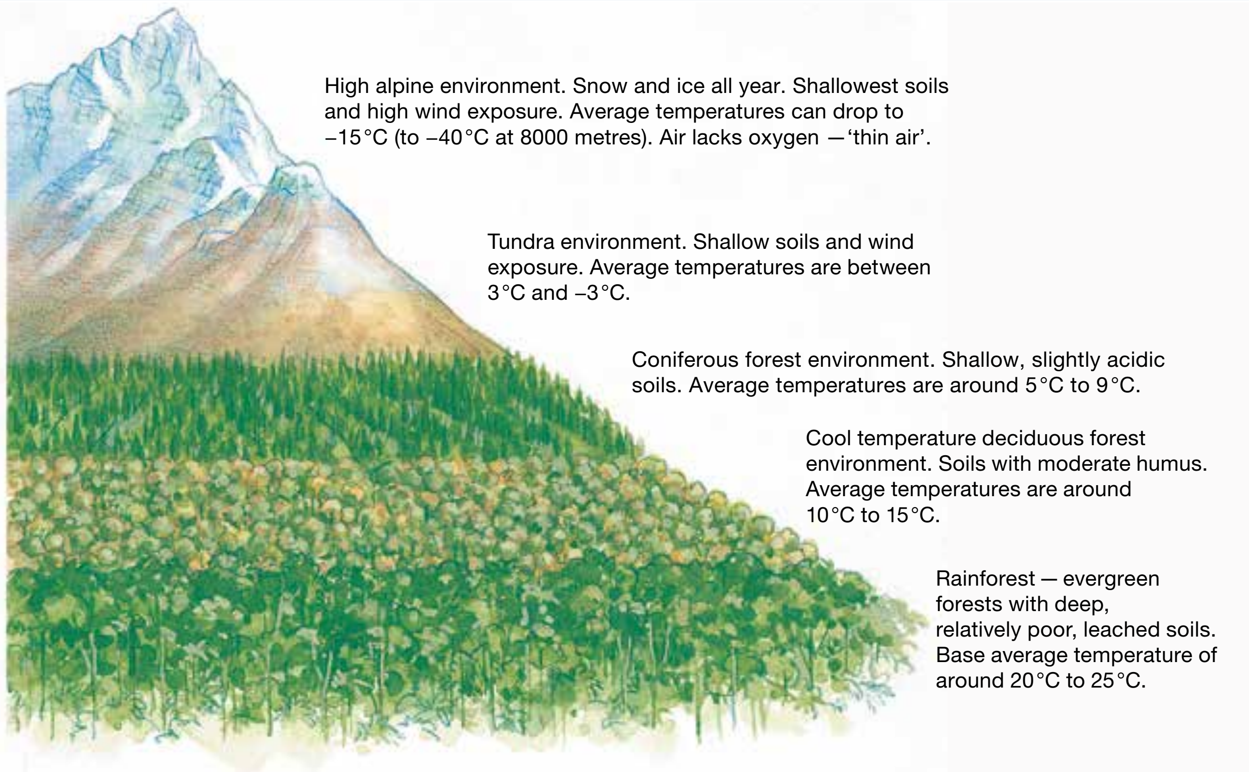
4.4.1 Mountain climate and weather

It is usually colder at the top of a mountain than at the bottom, because air gets colder with **altitude**. Air becomes thinner and is less able to hold heat. For every 1000 metres you climb, the temperature drops by 6 °C.

altitude height above sea level

tlvd-10623

FIGURE 2 Ecosystems change with altitude on mountains.



4.4 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Work in groups of four to six to **investigate** some of the following mountain ranges
   - Antarctica — Antarctic Peninsula, Transantarctic Mountains
   - Africa — Atlas Mountains, Eastern African Highlands, Ethiopian Highlands
   - Asia — Hindu Kush, Himalayas, Taurus, Elburz, Japanese Mountains
   - Australia – MacDonnell Ranges, Great Dividing Range
   - Europe — Pyrenees, Alps, Carpathians, Apennines, Urals, Balkan Mountains
   - North America — Appalachians, Sierra Nevada, Rocky Mountains, Laurentians
   - South America — Andes, Brazilian Highlands.
2. Each student in the group should choose a different range and complete the following:
   a. Map the location of the range in its region.
   b. **Describe** the climate experienced throughout the range.
   c. **Name** and provide images of a selection of plants and animals found in the range.

4.4 Exercise

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4.4 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 3, 4, 8	2, 6, 7	5, 9, 10

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Check your understanding

1. **25** / **50** / **75** / **90** per cent of the Earth's surface is covered by mountains.
2. **Name** the:
   a. highest mountain range in the world.
   b. longest mountain range in the world.
   c. second-longest mountain range in North America.
3. What name is given to long chains or groups of mountains located close together?
   A. Mountain line
   B. Mountain link
   C. Mountain range
   D. Mountain cluster
4. Which of the below are features of a high alpine environment? **Select** all that apply.
   A. Evergreen forests
   B. Average temperatures can drop to –15°C
   C. Snow and ice all year
   D. Tundra environment
   E. High wind exposure
   F. Shallowest soils
   G. Soils with moderate humus
   H. Average temperatures are between 3°C and –3°C.
   I. Air lacks oxygen
   J. Cool temperature deciduous forest environment
5. **State** what happens to oxygen in the atmosphere in high alpine environments.

Apply your understanding

Communicating

6. Refer to **FIGURE 2**. **Describe** how vegetation changes on a mountain.

Interpreting and analysing geographical data and information

7. Refer to **FIGURE 1**.
   a. **Describe** how the scale of the world's mountains varies across the continents.
   b. **Identify** where the Appalachian Mountains are located.
8. **Imagine** you are a mountaineer, climbing to the top of Mont Blanc. **Suggest** the type of clothing you will need to wear for such a climb.
9. **List** the countries through which the European Alps extend.

Concluding and decision-making

10. **Explain** why you think temperature and oxygen levels drop the higher you travel into mountains.

LESSON
4.5 How do people connect with mountains?

LEARNING INTENTION

By the end of this lesson you should be able to explain how people have learned to live in and use mountain landscapes. You should also be able to identify the limitations of living on mountains and explain the importance of mountains to different cultural groups.

TUNE IN

Discuss how you think rice crops grow and consider why the people who live here would need to build these terraces. If you have time, quickly research this information to find out how accurate you were.

Think about why hillsides and the slopes of mountains may provide ideal growing conditions. Discuss in a small group and present your theory to the class.

FIGURE 1 The Longshen rice terraces in China show how a mountainside can be changed to grow food.

4.5.1 Mountain people and cultures

People have moved through and lived in mountain areas for thousands of years. But few people live in the world's highest mountain ranges, where it can be very cold and difficult to grow food and make a living. Thousands of people visit mountains, often in remote areas, for recreation and to see the spectacular scenery, plants and animals, historic and spiritual sites, and different cultures. Mountains are also vital for global water supply.

Around 12 per cent of the world's people live in mountain regions. About half of those live in the Andes, the Himalayas and the mountains of central and eastern Africa.

Usually, population density is very low in these areas. One reason for this is that mountains are very difficult to cross, as they are often rugged and covered with forests and wild animals. They can also be hard to climb and may have ice, snow or glaciers that make travel dangerous. Another reason is that soil quality is often poor and intensive farming is difficult without significant effort and expertise.

4.5.2 Mountain landscapes in Australia

There are many Aboriginal and Torres Strait Islander Creation stories that are linked to mountain landscapes. These teachings help explain the formation and importance of each landscape and landform.

Aboriginal and Torres Strait Islander peoples are the guardians of culture and Country. Stories are passed on through the generations and explain the origin of the world and the environment.

The Stirling Ranges

The mountains of the Stirling Ranges and the Porongurups are some of the oldest in the world and extend across the Great Southern region in Western Australia (see **FIGURE 2**). These mountains lie on the Menang people's land and stories passed from generation to generation tell of how these ranges were interlaced from the very beginning.

FIGURE 2 Stirling Range National Park

aud-0464

FIGURE 3 The story of the ranges, as told by Menang Elder Vern Gillies

"The Borrongup (the Porongurups) was regarded as a sacred but dangerous place, the home of the totem spirits.

Hunting was forbidden in the area. It was said that the wagyl, the snake, lived in the peaks of the mountain, and the jarnaks, or ghosts and evil spirits, lived among the rocks.

What and Watami were members of the Bronzewing Pigeon people, who lived to the west of the Porongurups.

One day What, the woman, went out into the bush to find food.

Every so often, she called out to her husband to tell him what she was looking for, and what she was finding. He wasn't happy with what she was finding.

Eventually, What found a snake which was considered to be a real delicacy, and she ate it all.

She didn't give any to her husband all the more for her.

But when Watami found out, he became very, very angry. He struck her and broke her leg, then he walked away and left her.

What became very sick, and she dragged herself along where the King River runs, until she reached the place that we know as Green Island she then lay down and died.

Her faithful dog then picked up her scent and followed her tracks, and when he found her he started to dig all around her.

And he dug, and dug and as he dug, he sprayed dirt over her to cover her, to make a grave for her. He dug for a long, long time, until the sea rushed in to form what we now know as Oyster Harbour.

In the meantime, What's son found out what his father had done, and went out seeking revenge.

He caught him, and he speared him at the first mountain in the Stirling Ranges, which is what we know as Yongah Mia. Yongah means man, and Mia is the throwing stick.

Remarkably, from the air, the mountain clearly looks like a throwing stick."

Source: ABC Great Southern WA, https://www.abc.net.au/local/stories/2014/04/15/3985939.htm.

4.5.3 Sacred and special places

Mountain landscapes often have special meaning to certain groups of people. This might be because the location includes sacred sites or religious symbols; it might also be because people want to be close to nature or to feel spiritually inspired or renewed.

Mountaineers who take great risks, climbing alone or in small groups, often find a special meaning in mountain environments. They may hold deep spiritual, **cultural** and aesthetic (relating to beauty) values and ideas, and these will often inspire such people to care for and protect mountain environments.

The following list gives examples of mountains that are connected to various beliefs and religions.

- Hindus and Buddhists have beliefs about Mount Kailash in the Himalayas.
- Hindus in Bali, Indonesia, have a special connection with Mount Gunung Agung.
- Tibetan Buddhists revere Chomolungma (Mount Everest).
- The landscape of Demojong in the Himalayas is sacred to Tibetan Buddhists.
- Nanda Devi in the Himalayas is a sacred site for both Sikh and Hindu communities, and is a UNESCO World Heritage site.
- Mount Fuji, in Japan, is a place of spiritual and cultural symbolism to Japanese people.
- Saint Katherine Protectorate in South Sinai, Egypt, is in an area holy to Jews, Christians and Muslims.
- Jabal La'lam is a mountain that is sacred to the people of northern Morocco.

cultural relating to the ideas, customs and social behaviour of a society aud-0465

For the indigenous groups of the north-eastern American plains, the Sioux, or Dakota as they are sometimes referred to, and the indigenous Scandinavian people, the Sami, nature is recognised as sacred. The sacred places were not man-made temples or churches, but particularly spectacular or prominent features of the natural landscape. For the Sami, these sacred places tended to be large rocks (called *sieidi*), the sides of lakes, rocky crevasses or caverns or mountaintops. These sacred mountains were somewhat isolated and had a jutting tall peak. A sacred mountain named Haldi, which rests among a group of mountains near Alta, and an 814-metre-tall conical sacred hill named Tunnsjøguden in central Norway are examples. In general, the word *saivu* is applied to sacred mountains in the south while the terms *bassi, ailigas* and *haldi* are used for sacred mountains by northern Sami. Similarly, mountaintops, such as Harney Peak in modern-day South Dakota, were also of spiritual importance to Sioux groups who lived in their regions.

Source: www.utexas.edu/courses/sami/diehtu/siida/religion/paralellism.htm.

4.5.4 Skills to survive

It can be hard to make a living in mountain regions. People living in small, isolated mountain communities have learned to use the land and resources sustainably. Many practise shifting cultivation, migrate with grazing herds, and have terraced fields.

Some of the world's oldest rice terraces (see **FIGURE 1**) are over 2000 years old. Rice and vegetables could be grown quite densely on the terraces. This enabled people to survive in a region with very steep slopes and high altitude.

On very high ranges, below the snowline, there is a treeless zone of alpine pastures that can be used in summer to graze animals. Elsewhere, in the valleys and foothills, agriculture often occurs, with fruit orchards and even vineyards on some sunny slopes.

Mountains supply 60 to 80 per cent of the world's fresh water. This is due to **orographic rainfall** (caused by warm, moist air rising and cooling when passing over high ground, such as a mountain; as the air cools, the water vapour condenses and falls as rain). Where precipitation falls as snow, water is stored in snowfields and glaciers. When these melt, they provide water to people when they need it most.

orographic rainfall occurs when a topographic barrier such as a mountain blocks the path of a movement of air horizontally. This forces the air upward where it cools, thus increasing the likelihood of rain.

FIGURE 4 Living in mountain regions can be difficult.

Resources

Weblink Climate change and water shortage

4.5 SKILL ACTIVITY: Communicating

Choose one of the mountains linked to beliefs and religions from section 4.5.3.

1. Use the internet to **research** details of this connection.
2. **Create** a map with all aspects of BOLTSS and provide information on the natural and human features located here.
3. **Present** your information as a print or electronic brochure.

4.5 Exercise

learnon

4.5 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 3, 5	2, 4, 8, 10	6, 7, 9,

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Check your understanding

1. **Determine** whether following statements are true or false.
   a. People have lived in Mountain Ranges for thousands of years.
   b. Many people live above the snow line on the highest mountains on earth.
   c. Population density in mountain ranges is relatively low.
   d. Soil quality is often very good in mountain ranges.
2. What type of work and recreation can people undertake in mountain regions? **Present** this information in a written format or in a diagram.
3. Mountains are **useful / vital / harmful** for global water supply.
4. **Describe** how different groups of people value mountainous places. Use three examples in your description.
5. Where is the Jamison Valley located?
   A. The Glasshouse Mountains, QLD
   B. The Snowy Mountains, NSW
   C. The Blue Mountains, NSW
   D. The Bunya Mountains, QLD

Apply your understanding

Communicating

6. **Describe** how the natural mountain environment in **FIGURE 1** has been changed by people. You should also **create** a sketch of the photo and make notes to show the changes.
7. Imagine you work as a park ranger in the Stirling Ranges. **Explain** how Creation stories of the region can help other people understand this environment.
8. a. **Describe** how the natural mountain environment in **FIGURE 4** has been changed by people.
   b. **Explain** how it compares to the land changes in **FIGURE 1**.
9. Read through **FIGURE 3**. Many Dreaming stories have an underlying message; what do you think it is in this case? Might there be cultural reasons why people don't understand the significance of stories like this one.
10. Think of a mountain you have visited or seen. **Decide** if you feel inspired by mountain environments. How can spiritual or religious beliefs linked to mountain landscapes help in protecting them?

LESSON
4.6 What are earthquakes?

LEARNING INTENTION

By the end of this lesson you should be able to explain how earthquakes occur and define the key terms: epicentre, focus, seismic waves, primary waves and secondary waves.

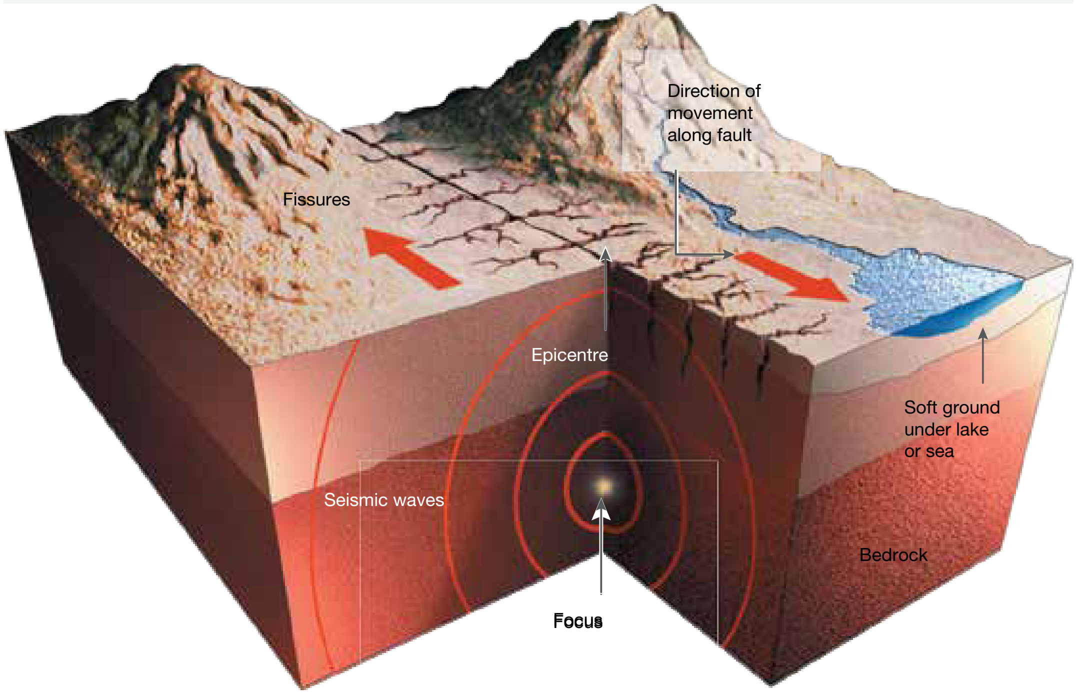
TUNE IN

Examine **FIGURE 1**, a diagram explaining what occurs during an earthquake.

1. Brainstorm what you think might be the difference between the focus and epicentre of an earthquake.
2. What factors might contribute to some earthquakes resulting in a lot of damage whereas others result in little damage?

tlvd-10624

FIGURE 1 What happens during an earthquake?



4.6.1 Earthquakes

Earthquakes and tsunamis are frightening events and they often strike with little or no warning. An earthquake can shake the ground so violently that buildings and other structures collapse, sometimes crushing people to death. Earthquakes occur every day somewhere on the planet, usually on or near the boundaries of tectonic plates. **FIGURE 2** in lesson 4.2 shows a strong relationship between the location of plate boundaries and the occurrence of earthquakes. Weaknesses and cracks in the Earth's crust near these plate boundaries are called faults (or the **fault plane**). An earthquake is usually a sudden movement of the layers of rock at these faults.

The point where this earthquake movement begins is called the **focus** (see **FIGURE 1**). Earthquakes can occur near the Earth's surface or up to 700 kilometres below. The shallower the focus, the more powerful the earthquake will be. Energy

fault plane the area of a tectonic plate that moves vertically as a result of an earthquake

focus the point where the sudden movement of an earthquake begins travels quickly from the focus point in powerful **seismic waves**, radiating out like ripples in a pond. The seismic waves decrease in strength as they travel away from the **epicentre**. The strength of an earthquake is measured on the Richter scale.

The energy released at the focus can be immense, and it travels in seismic waves through the mantle and crust of the Earth. **Primary waves**, or P-waves, are the first waves to arrive, and are felt as a sudden jolt. Depending on the type of rock or water in which they are moving, these waves travel at speeds of up to 30 000 kilometres an hour.

Secondary waves, or S-waves, arrive a few seconds after the P-waves and travel at about half the speed. These waves cause more sustained up-and-down movement.

Surface waves radiate out from the epicentre and arrive after the main P-waves and S-waves. These move the ground either from side-to-side, like a snake moving, or in a circular movement.

Even very strong buildings can collapse with these stresses. The energy that travels in waves across the Earth's surface can destroy buildings many kilometres away from the epicentre.

seismic wave a wave of energy that travel through the Earth as a result of an earthquake, explosion or volcanic eruption

epicentre the point on the Earth's surface directly above the focus of an earthquake

primary wave also known as a P-wave; the first waves to hit an area during an earthquake, which cause a sudden jolt

secondary wave also known as a S-wave; the waves that arrive at an area after the P-waves, which cause a sustained up-and-down movement

Measuring earthquakes

Earthquakes are measured according to their magnitude (size) and intensity. Magnitude is measured on the Richter scale, which shows the amount of energy released by an earthquake. The scale is open-ended because there is no upper limit to the amount of energy an earthquake might release. An increase of one in the scale is 10 times greater than the previous level. For example, energy released at the magnitude of 7.0 is 10 times greater than the energy released at 6.0.

Earthquake intensity is measured on the Modified Mercalli scale, and indicates the amount of damage caused. Intensity depends on the nature of buildings, time of day and other factors.

4.6.2 CASE STUDY: What caused the 2015 Nepal earthquake?

On 25 April 2015, a 7.8-magnitude earthquake struck Nepal at around midday. The epicentre of this earthquake was quite shallow — only 15 kilometres below the Earth's surface. It occurred approximately 80 kilometres to the north-west of Kathmandu, Nepal's capital.

At this location, the Indian Plate to the south is subducting under the Eurasian Plate to the north (see **FIGURE 1** in lesson 4.2). This is occurring at a rate of approximately 45 millimetres per year and is causing the uplift of the Himalayas (see the case study in section 4.3.2).

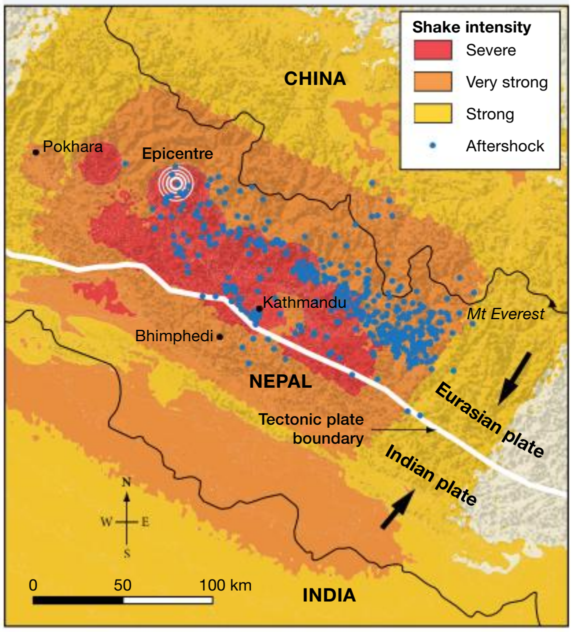
During the Nepal earthquake event, nearly 9000 people were killed and nearly 18 000 were injured.

FIGURE 3 shows that the earthquake released a large amount of energy and caused large slips of up to four metres of the Earth's surface. There were severe aftershocks immediately after the main earthquake and the aftershocks continued for many weeks — up to 100 in total. The shaking from this earthquake was felt in China, India, Bhutan and much of western Bangladesh.

On 12 May 2015, a huge aftershock with a magnitude of 7.3 occurred near the Chinese border with Nepal (between Kathmandu and Mount Everest). More than 160 people died and more than 2500 were injured as a result of this aftershock.

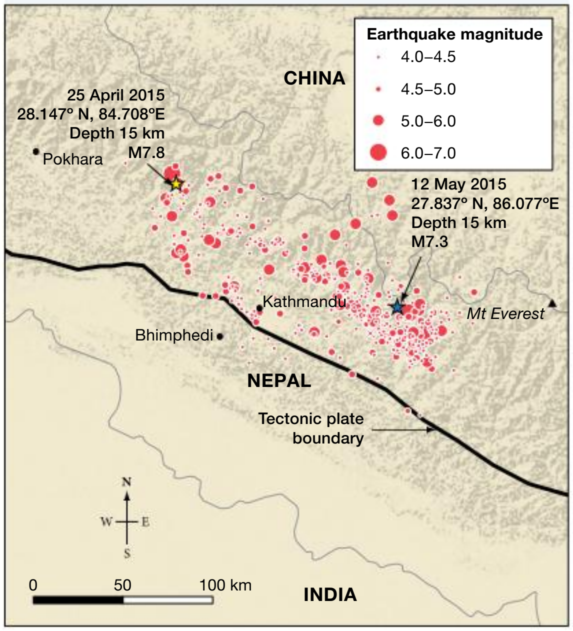
int-7845
int-7846

FIGURE 2 The shake intensity and the tectonic plate boundary involved in the Nepal earthquake



Source: USGS

FIGURE 3 Magnitudes of earthquake and aftershocks in Nepal, 2015



Source: USGS

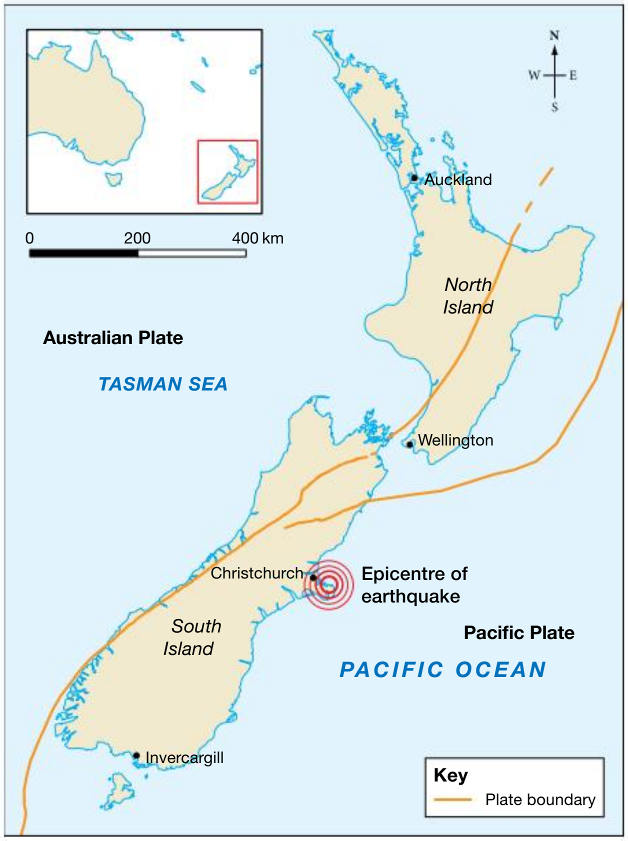
4.6.3 CASE STUDY: What caused the 2011 Christchurch, New Zealand earthquake?

A 6.3-magnitude earthquake struck Christchurch, New Zealand, on 22 February 2011. The city was badly damaged, 185 people were killed and several thousand were injured. The earthquake epicentre was 10 kilometres south-east of Christchurch's central business district, and was quite shallow — only 5 kilometres deep, which meant the shaking was particularly destructive.

The earthquake is considered to be an aftershock of an earthquake that occurred 5 months earlier in September 2010. Many buildings in the city had already suffered damage in the 2010 earthquake and either collapsed in the 2011 earthquake or had to be demolished afterwards.

New Zealand is located between two huge moving plates — the Australian Plate and the Pacific Plate — and it experiences thousands of earthquakes every year. Most are very small, but some have caused a lot of damage. These movements continue to shape and form New Zealand and its dramatic mountain landscapes.

FIGURE 4 Location of the Christchurch earthquake in New Zealand, 2011



Source: Map drawn by Spatial Vision

FIGURE 5 Earthquake damage in Christchurch

SkillBuilders to support skill development

- 4.10 SkillBuilder: Understanding thematic maps

4.6 SKILL ACTIVITY: Concluding and decision-making

Evaluate and **discuss** the following statement ‘The largest Earthquakes are always the most damaging.’

1. Work in pairs. Use the information in this lesson and **conduct research** on several earthquakes of varying intensity. Ensure you have several that were quite powerful.
2. Make notes on the extent of damage caused in each and then **compare** the information for different sized earthquakes. You may like to draw up a table to help with this.
3. Use the information you’ve collected to agree, partially agree, or disagree with the statement.
4. **Present** your conclusion and evidence to the class.

on Resources

Weblinks Nepal earthquake: before and after photos
Earthquake-vulnerable cities

Google Earth Christchurch, New Zealand

4.6 Exercise

learnon

4.6 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 4, 5	2, 3, 7, 9	6, 8, 10

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Check your understanding

1. Complete the following statements by filling in the blanks.
   The point where the actual earthquake occurs under the surface is called the ______. The point directly above this on the Earth's surface is known as the ___________. The shallower the earthquake the more _________ the earthquake will be. Energy travels out from an earthquake in _________ _________.The strength of an earthquake is measured on the _________ _________.
2. **Explain** how an earthquake occurs. **Create** a diagram to assist your explanation.
3. **Explain** how primary waves differ from secondary waves of earthquakes.
4. The Richter scale measures earthquake magnitude. How much more powerful is the magnitude of an earthquake at 7.0 than at 5.0?
   A. 2 times greater
   B. 10 times greater
   C. 100 times greater
   D. 1000 times greater
5. Study **FIGURE 3**. Are the following statements true or false? If they are false, rewrite them to make them true.
   a. The earthquake and aftershocks were between 4.0 and 6.0 in magnitude.
   b. The furthest earthquake and aftershocks were 100 kilometres apart.
   c. The earthquake on 12 May was the same intensity as the earthquake on 25 April.
   d. Most of the aftershocks were felt to the east of the main earthquake on 25 April.

Apply your understanding

Communicating

6. Geophysicists and other experts have warned for decades that Nepal was vulnerable to a deadly earthquake. **Consider** reasons as to why Nepal wasn't prepared for this event.
7. Study **FIGURE 2**.
   A. **Identify** which direction the Indian Plate is moving. Is it moving under or over the Eurasian Plate?
   B. **Describe** the location of the highest intensity shaking. How close was it to the epicentre? To the tectonic plate boundary?

Concluding and decision-making

8. **Discuss** whether the earthquake event in Nepal supports the idea that the Himalayas are a young mountain range that is still forming.
9. **Discuss** the factors that made the Christchurch Earthquake so damaging?
10. **Explain** why living with Earthquakes is something all New Zealanders have to do. Think carefully about how New Zealanders have to adapt to life with earthquakes. How might school in Christchurch be different to school in Australia as a result.

LESSON
4.7 What is a tsunami?

LEARNING INTENTION

By the end of this lesson you should be able to identify and explain the interconnection between earthquakes and tsunamis. You should also be able to define the key term 'Landslide,' and explain why tsunamis are different to other types of waves.

TUNE IN

FIGURE 1 shows a beach in Thailand in 2004. The water had rapidly receded out to sea, puzzling onlookers.

Moments later the devastating 2004 Indian Ocean Tsunami hit the area, and many other locations, killing approximately 230 000 people.

1. Imagine you were one of the people on this beach. What would you think was happening if the water suddenly disappeared? How do you think you would react?
2. **Discuss** why you think the water might first disappear from the beach right before a tsunami.

FIGURE 1 Hat Rai Lay Beach, Thailand December 26, 2004

tlvd-10625

A tsunami is a large ocean wave that is caused by sudden motion on the ocean floor. The sudden motion could be caused by an earthquake, a volcanic eruption or an underwater **landslide**. About 90 per cent of tsunamis occur in the Pacific Ocean, and most are caused by earthquakes that are over 6.0 on the Richter scale.

A tsunami at sea will be almost undetectable to ships or boats. The reasons for this are that the waves travel extremely fast in the deep ocean (about 970 kilometres per hour — as fast as a large jet) and the wavelength is about 30 kilometres, yet the wave height is only one metre.

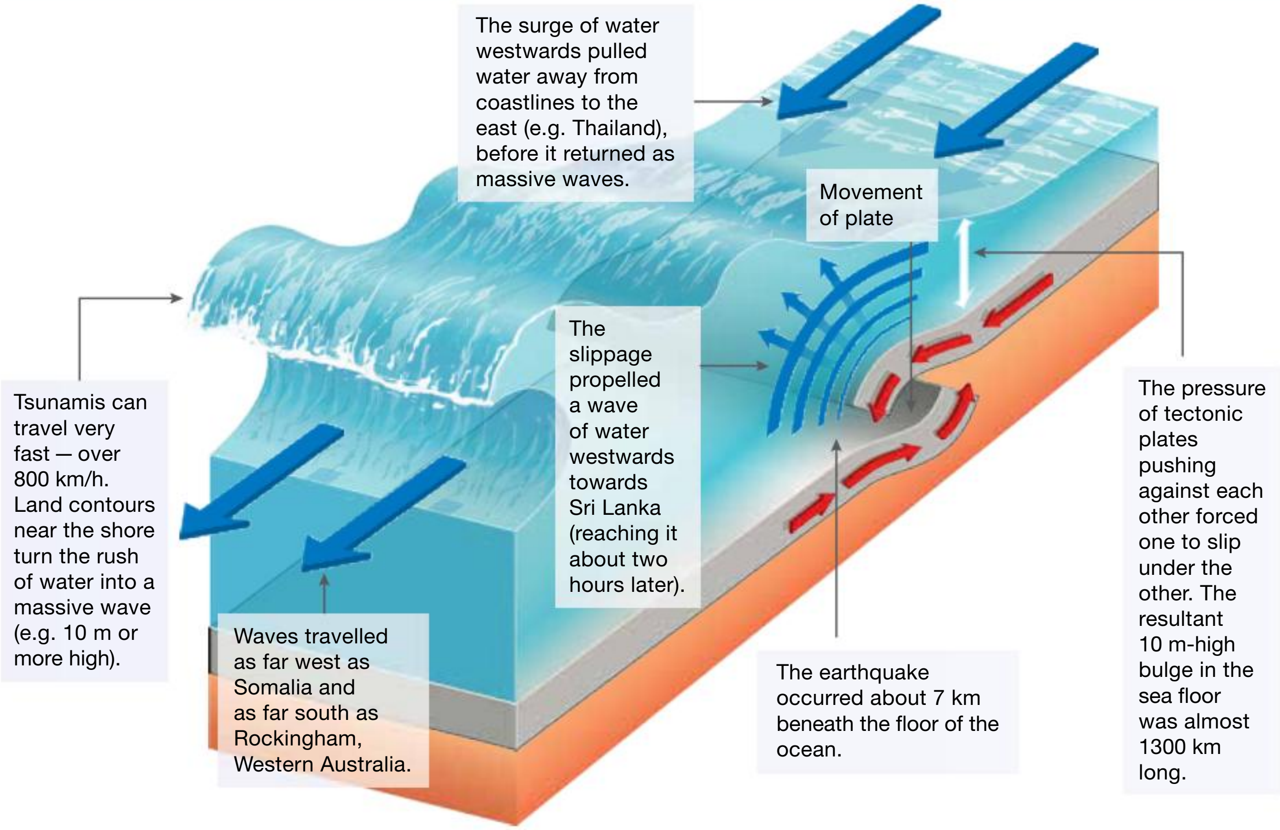
When tsunamis reach the continental slope, several things happen. The wave slows down and, as it does, the wave height increases and the wavelength decreases; in other words, the waves get higher and closer together. Sometimes, the sea may recede quickly, very far from shore, as though the tide has suddenly gone out. If this happens, the best course of action is to head to higher ground as quickly as possible.

A tsunami is not a single wave. There may be between 5 and 20 waves altogether. Sometimes the first waves are small and they become larger; at other times there is no apparent pattern. Tsunami waves will arrive at fixed periods between 10 minutes and 2 hours.

landslide a rapid movement of rocks, soil and vegetation down a slope, sometimes caused by an earthquake or by excessive rain

tlvd-10626

FIGURE 2 An earthquake and subsequent tsunami in the Indian Ocean in 2004 occurred along the boundary between tectonic plates.



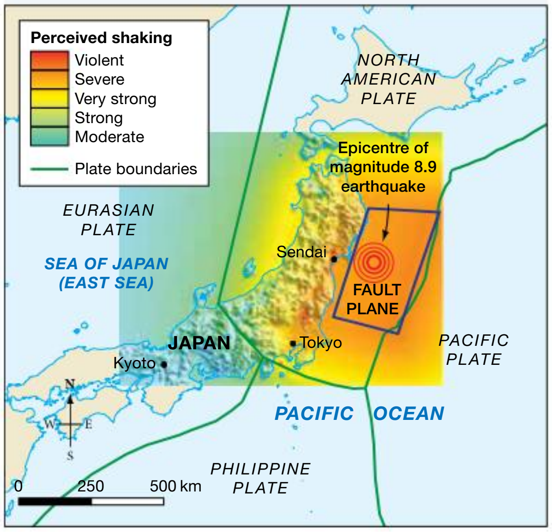
4.7.1 CASE STUDY: The Japanese tsunami, 2011

int-7847

The region of Japan is seismically active because four plates meet there: the Eurasian, Philippine, Pacific and North American. Many landforms in this region are influenced by the collision of oceanic plates. Chains of volcanic islands called island arcs are formed, and an ocean trench is located parallel to the island arc (see **FIGURE 2** in lesson 4.2).

On 11 March 2011, an 8.9-magnitude earthquake struck near the coast of Japan. The earthquake was caused by movement between the Pacific Plate and the North American Plate. It occurred about 27 kilometres below the Earth's surface along the Japan Trench, where the Pacific Plate moves westwards at about 8 centimetres each year. The sudden upward movement released an enormous amount of energy and caused huge displacement of the sea water, causing the tsunami. When the tsunami reached the Japanese coast, waves more than 6metres high moved huge amounts of water inland. Strong aftershocks were felt for a number of days. Nearly 16 500 people were killed and 4800 were reported missing.

FIGURE 3 The location and magnitude of the earthquake that caused the Japanese tsunami



Source: Map drawn by Spatial Vision

FIGURE 4 The tsunami caused by the 8.9-magnitude earthquake in March 2011 swept over the coastline at Sukuiso and inland, carrying debris with it.

on Resources

Interactivity Anatomy of a tsunami (int-3111)

Weblinks Climate change and water shortage

World's biggest tsunami

4.7 SKILL ACTIVITY: Concluding and decision-making

Use an atlas or Google Earth to locate Lituya Bay.

1. **Draw** a map to show the location.
2. Use the **World's biggest tsunami** weblink in the Resources panel to listen to eyewitness accounts of the tsunami that occurred there.
3. **Explain** how this helps give you a sense of the scale of this event.

4.7 Exercise

learnon

4.7 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 3, 6	2, 4, 7, 9	5, 8, 10

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- Access sample responses
- Track results and progress

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Most tsunamis occur in the Atlantic Ocean.
   b. Underwater landslides can trigger tsunamis.
   c. In deep water tsunamis can travel at up to 970 Kmph and can be undetectable to boats.
   d. A tsunami is a single wave.
2. Study **FIGURE 2**. Use your own words to **explain** how a tsunami occurs.
3. A tsunami doesn't change when it comes into shallow water. True or false?
4. **Elaborate** as to why there is still danger after the first wave of a tsunami strikes.
5. Read the 4.7.1 case study and **explain** the causes of the 2011 Japanese tsunami.
6. Approximately how big were the waves that struck Japan?
   A. 3 metres
   B. 6 metres
   C. 12 metres
   D. 20 metres

Apply your understanding

Interpreting and analysing geographical data and information

7. Read through the 4.7.1 case study. **Discuss** how the location of the epicentre of the earthquake that caused the Japanese tsunami impacted the ability of people to prepare for the incoming tsunami.
8. Study **FIGURE 3**.
   a. **Estimate** the size of the fault plane that moved vertically during this quake.
   b. **Discuss** why this was significant.
   c. **State** which tectonic plates were involved in this event.
9. Study the photo of the Japanese tsunami in **FIGURE 4**.
   a. Imagine you are a radio news reporter. **Describe** what you see and what might be happening to people in the area.
   b. Imagine you were a Sendai resident. **Describe** what you would have done to take care of yourself during the tsunami.

Communicating

10. **Create** a flow chart or cartoon strip that explains the journey of a tsunami from creation through to coming ashore.

LESSON
4.8 What are the impacts of earthquakes and tsunamis?

LEARNING INTENTION

By the end of this lesson you should also be able to describe the effects of earthquakes and tsunamis on people and the environment and explain why some people are more vulnerable to earthquakes than others.

TUNE IN

The effects of earthquakes and tsunamis extend beyond the obvious physical destruction.

FIGURE 1 Kensennuma City centre after an 8.9-magnitude strong earthquake struck on March 11 off the coast of north-eastern Japan, 2011

Examine **FIGURES 1** and **2** in pairs to create a mind map focusing on what you think might be the social, economic and environmental impacts of tsunamis and earthquakes.

Earthquakes and tsunamis can have an enormous impact. The degree of impact can be affected by several factors: the size of the quake; its location; the density of the population near the epicentre; and whether there are any densely populated areas nearby. Poverty also plays a role, because it can increase a country's or region's vulnerability to such disasters. Measuring an event by the impact can be difficult. Should it be measured by the number of people killed and made homeless (social impact); the cost of recovery (economic impact); or the effect on the surroundings (environmental impact)?

Impact on people

The data in **FIGURE 3** show some of the worst earthquake and tsunami disasters that have occurred. The amount of damage and death they cause does not always relate to the magnitude of the earthquake. Some smaller magnitude earthquakes can have a devastating impact. Likewise, to measure the impact of a tsunami, we have to look at its effect on people, not at the magnitude of the earthquake (or volcano) that caused it, and not at the size of the waves, which are difficult to measure.

Less-developed countries often do not have the resources to prepare adequately for an earthquake. Often, many people are housed in badly constructed buildings in densely populated areas on poor land. When a disaster strikes, poorer countries often do not have the resources to act quickly and get help for relief efforts. More developed countries have strict building codes and better infrastructure to withstand disasters. They have warning systems and better communication. Usually, help is quick to arrive, with army and police personnel sent in to help with rescue efforts.

Analysis of EM-DAT (The International Disaster Database) data also shows how income levels have an impact on disaster death tolls. On average, more than three times as many people died per disaster in low-income countries (332 deaths) than in high-income nations (105 deaths). A similar pattern is evident when low- and lower-middle-income countries are grouped together and compared to high- and upper-middle-income countries. Taken together, higher-income countries experienced 56 per cent of disasters but lost 32 per cent of lives, while lower-income countries experienced 44 per cent of disasters but suffered 68 per cent of deaths. This demonstrates that levels of economic development, rather than exposure to hazards, are major determinants of mortality.

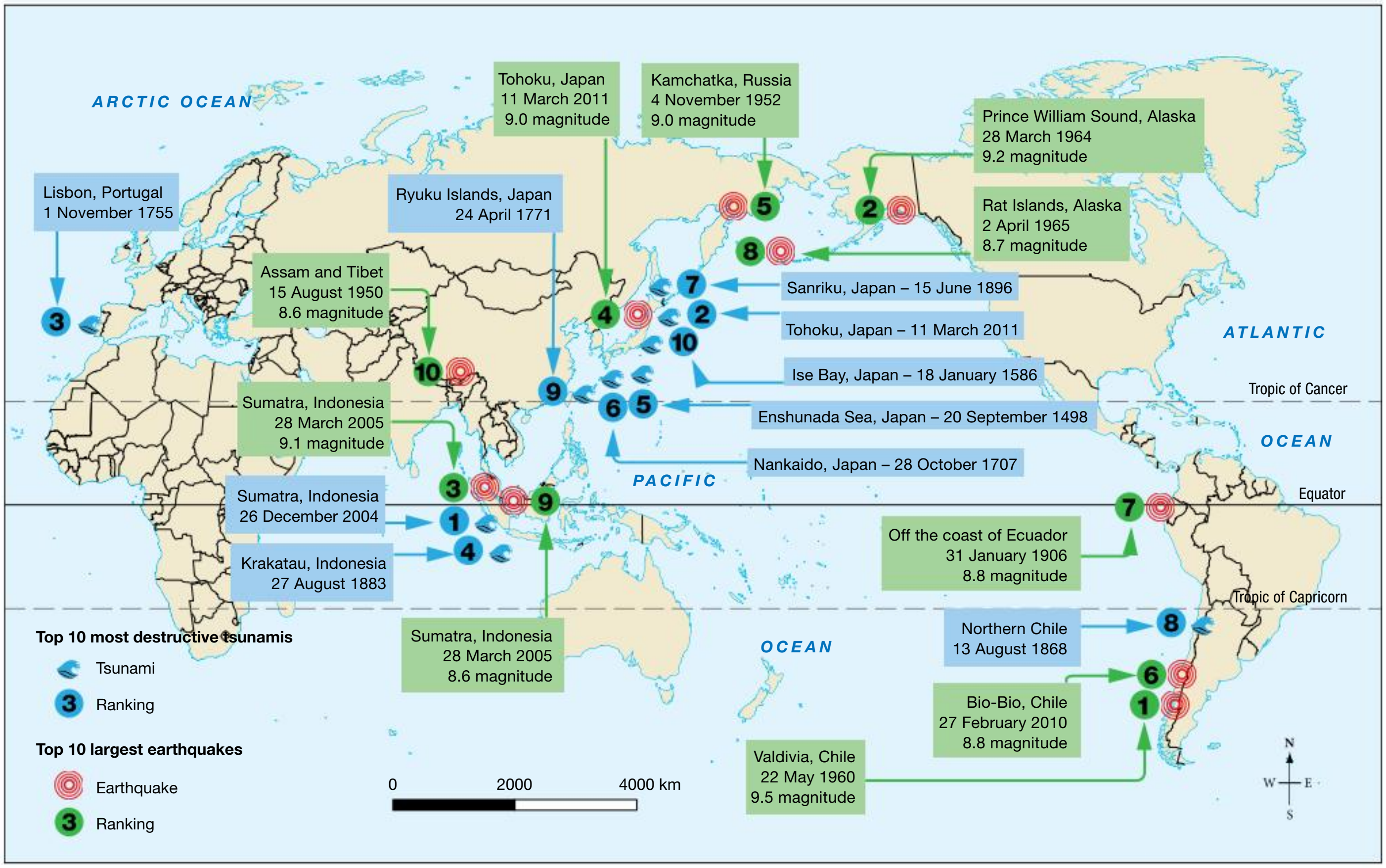
Impact on the environment

The impact of an earthquake or tsunami on a human environment can be catastrophic. It can damage and destroy entire settlements. Landslides can be triggered by earthquakes, permanently changing the landscape.

FIGURE 2 This landslide was caused by an earthquake in June 2008 in Honshu, Japan

int-7849

FIGURE 3 The 10 largest earthquakes and 10 most destructive tsunamis in recorded history



Source: Map drawn by Spatial Vision

TABLE 1 **Tsunamis**

No. on map and cause		Description and impact
1	9.1 earthquake	Tsunami 50 metres high, reaching 5 km inland near Meubolah. 230 000 people died. Estimated damages of US$10 billion.
2	9.0 earthquake	Tsunami waves of 10 metres swept over the east coast of Japan. 19 000 people died. Caused nuclear emergency at Fukushima Daiichi nuclear power plant. US$235 billion in damage.
3	8.5 earthquake	Waves up to 30 metres high struck towns along western Portugal and southern Spain. Earthquake and tsunami killed 60 000 in Portugal, Morocco and Spain.
4	Volcano	Tsunami linked to the explosion of the Krakatau volcano. Waves as high as 37 metres demolished the towns of Anjer and Merak. Killed 40 000 people, with 2000 deaths caused by the volcanic eruptions rather than the tsunami.
5	8.3 earthquake	Homes were flooded and swept away; 31 000 people killed.
6	8.4 earthquake	Waves up to 25 metres high struck the Pacific coasts of Kyushyu, Shikoku and Honshin. Nearly 30 000 buildings were damaged in the affected regions and about 30 000 people were killed.
7	7.6 earthquake (estimated)	Tsunami was reported to have reached a height of 38.2 metres, causing damage to more than 11 000 homes and killing around 22 000 people. Reports were also found of a corresponding tsunami hitting the east coast of China, killing around 4000 people and doing extensive damage to local crops.
8	Two 8.5 earthquakes	Waves up to 21 metres high affected the entire Pacific Rim for two or three days. Tsunami registered by six tide gauges as far away as Sydney, Australia. 25 000 deaths and estimated damages of US$300 million were caused along the Peru–Chile coast.
9	7.4 earthquake	Tsunami waves around 11–15 metres high destroyed 3137 homes, killing nearly 12 000 people in total.
10	8.2 earthquake (estimated)	Waves of 6 metres caused more than 8000 deaths and a large amount of damage to a number of towns.

TABLE 2 **Earthquakes**

No. on map and magnitude of earthquake		Description and impact
1	**9.5**	Killed 1655 people, injured 3000 and displaced two million. Caused US$550 million in damage. Two days later, Puyehue volcano erupted, sending ash and steam into the atmosphere for several weeks.
2	**9.2**	Resulting tsunami killed 128 people and caused US$311 million in damage.
3	**9.1**	Killed 227 900 people, displaced 1.7 million in south Asia and east Africa. On 28 December, a mud volcano began erupting near Baratang, Andamar Islands.
4	**9.0**	Earthquake caused tsunami that killed 19 000 people and injured 6000. Caused US$ tens of billions in damage. Economic impacts huge, especially with the shutting down of a nuclear reactor.
5	**9.0**	Generated a tsunami that caused damage of US$1 million in Hawaiian Islands. Some waves over 9 metres high at Kaena Point, Oahu. None killed.
6	**8.8**	Killed at least 521 people, with 56 missing and 12 000 injured. More than 800 000 people displaced, with a total of 1.8 million people affected across Chile, where damage was estimated at US$30 billion.

(*continued*)

No. on map and magnitude of earthquake		Description and impact
7	8.8	Earthquake caused tsunami that was reported to have killed between 500 and 1500 people in Ecuador and Colombia.
8	8.7	Generated a tsunami about 10 metres high that caused damage on Shemya Island, plus US$10 000 in property damage from flooding on Amchitka Island. No deaths or injuries reported.
9	8.6	Killed 1313 people, with more than 400 people as far away as Sri Lanka injured by the tsunami.
10	8.6	This inland earthquake caused widespread damage to buildings as well as large landslides. 780 people were killed in eastern Tibet.

Liquefaction

Liquefaction occurs when soil suddenly loses strength and, mixed with groundwater, behaves like a liquid. This usually occurs as a result of ground shaking during a large earthquake. The types of soils that can liquefy include loose sands and silts that are below the water table, so all the space between the grains is filled with water. Dry soils above the water table will not liquefy.

Once a soil liquefies, it cannot support the weight of the dry soil, roads, concrete floors and buildings above it. The liquefied soil comes to the surface through cracks and widens them.

liquefaction transformation of soil into a fluid, which occurs when vibrations created by an earthquake, or water pressure in a soil mass, cause the soil particles to lose contact with one another and become unstable; for this to happen, the spaces between soil particles must be saturated or near saturated

FIGURE 4 Cars swallowed by liquefied soil on a road in Christchurch, New Zealand, 2011

Source: © Photography by Mark Lincoln.

on Resources

Weblinks World's biggest tsunami
Liquefaction

4.8 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Use the **Liquefaction** weblink in the Resources panel to view a video of liquefaction occurring.
2. Write a paragraph **describing** what liquefaction is and why it occurs.

4.8 Exercise

learnon

4.8 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 5	3, 4	6, 7, 8

Check your understanding

1. **Complete** the following passage by filling in the blanks.
The amount of damage and death caused by earthquake disasters does not always relate to the ____________ of the Earthquake. Likewise to measure the impact of a tsunami we have to look at its effect on _________ not at the size of the earthquake or ____________ that caused it and not the size of the _________ which can be difficult to measure. Less _________ countries often do not have the ___________ to prepare adequately for an earthquake. Badly constructed ___________ in densely ____________ areas on poor land contribute to the scale of the disaster.
2. **Select** all factors that combine to cause a tsunami or earthquake to turn into a disaster.
   A. A country's lack of resources
   B. Sparsely populated areas
   C. Poorly constructed buildings
   D. Strong infrastructure
   E. Densely populated areas
   F. Poor land
   G. Well-constructed buildings
3. **Explain** why wealthier nations are less likely to experience large scale disasters.
4. **State** the different impacts that earthquakes can have.
5. Examine **TABLE 1** and **TABLE 2**. **Determine** if the following statements are true or false.
   a. The majority of large tsunamis are triggered by earthquakes.
   b. Tsunami waves can be over 30 metres in height.
   c. North America is the most affected continent by earthquakes and tsunamis.
   d. Australia has experienced no major earthquakes or tsunamis in recorded history that we know of.
   e. The largest Earthquake recorded was in Valdivia, Chile at 9.5 on the Richter Scale.
   f. Japan has experienced few tsunamis.

Apply your understanding

Interpreting and analysing geographical data and information

6. Study **FIGURE 3** in this lesson and **FIGURE 1** in lesson 4.2.
Describe the interconnection between the distribution of earthquakes and the distribution of tectonic plates.

Concluding and decision-making

7. **Explain** why Japan might experience so many destructive earthquakes and tsunamis.
8. **Explain** why the potential damaging effects of liquification might impact the ways in which cities expand.

LESSON
4.9 What are volcanoes and how are they formed?

LEARNING INTENTION

By the end of this lesson you should be able to explain how volcanoes are formed, describe the relationship between plate boundaries, the processes that cause volcanic eruptions and explain the term volcanic hotspot.

TUNE IN

Compare **FIGURE 1**, which focuses on the landforms of North, Central and South America with **FIGURE 2** in lesson 4.2, which shows a world map of plates, volcanoes and hotspots.

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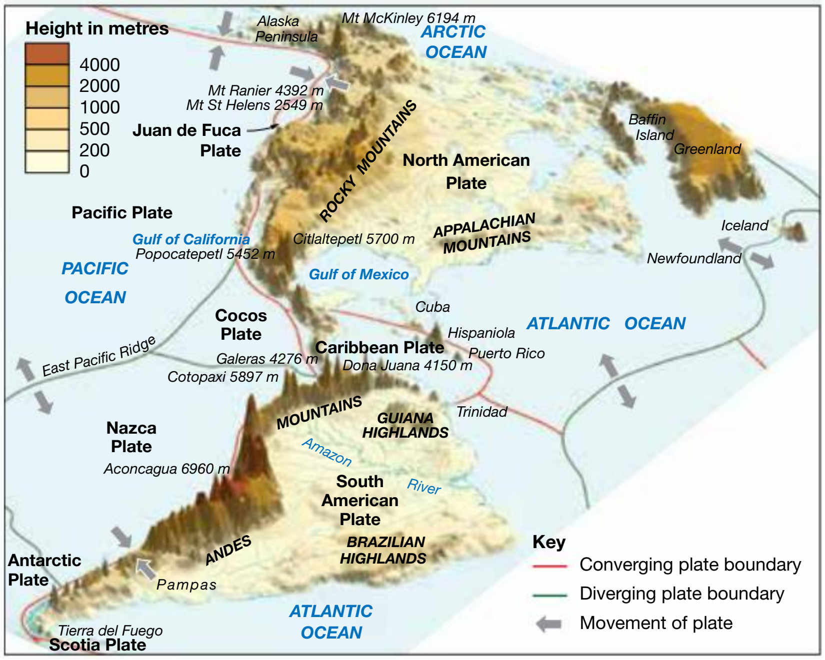
FIGURE 1 Landforms of North, Central and South America (not to scale)



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

1. Describe the spatial association between mountain ranges and volcanoes.
2. What is happening to the tectonic plates at these boundaries?
3. Theorise why some mountain ranges do not have volcanoes present.

4.9.1 How are volcanoes formed?

A volcano is a cone-shaped hill or mountain formed when molten magma in the Earth's mantle is forced through an opening or vent in the lithosphere. Almost all active volcanoes occur at or near plate boundaries. Some occur where two plates converge, and others occur where the plates are pulling apart, or diverging (see **FIGURE 1**). There is another group of volcanoes that are formed when plates move over hotspots.

Subduction zones

Some volcanoes are formed when an oceanic plate is pulled underneath a continental plate (see lesson 4.2). As the crust is forced down, it heats up and becomes magma. It can then rise to the Earth's surface through a magma chamber.

rift zone a large area of the Earth in which plates of the Earth's crust are moving away from each other, forming an extensive system of fractures and faults

Volcanoes in rift zones

The longest mountain range in the world is underwater, between the African and American continents, and is 56 000 kilometres long. It is called the Mid-Atlantic Ridge, and is made up of many volcanic mountains. The volcanoes are formed where two plates move away from each other in **rift zones**. The molten lava rises to the surface in the space between the plates, and the largest volcanoes appear above the water as islands. Examples of rift islands are Iceland, the Azores, Ascension Island, Gough Island and Bouvet Island. The rifting, or spreading apart, can occur on land or on the seabed.

The rifting of Iceland

The Mid-Atlantic Ridge passes through Iceland, where the island is splitting in two different areas (see **FIGURE 2**). This can be seen where Iceland's volcanoes are located, at the point where the North American Plate is drifting to the west and the Eurasian Plate is drifting to the east (see **FIGURE 3**). New crust is being formed in a rift below the sea, and eventually water from the Atlantic Ocean will fill the widening and deepening gaps between the separated parcels of land.

FIGURE 2 Rifting in Iceland

Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

FIGURE 3 A chain of volcanoes in Iceland

The Great Rift Valley, Africa

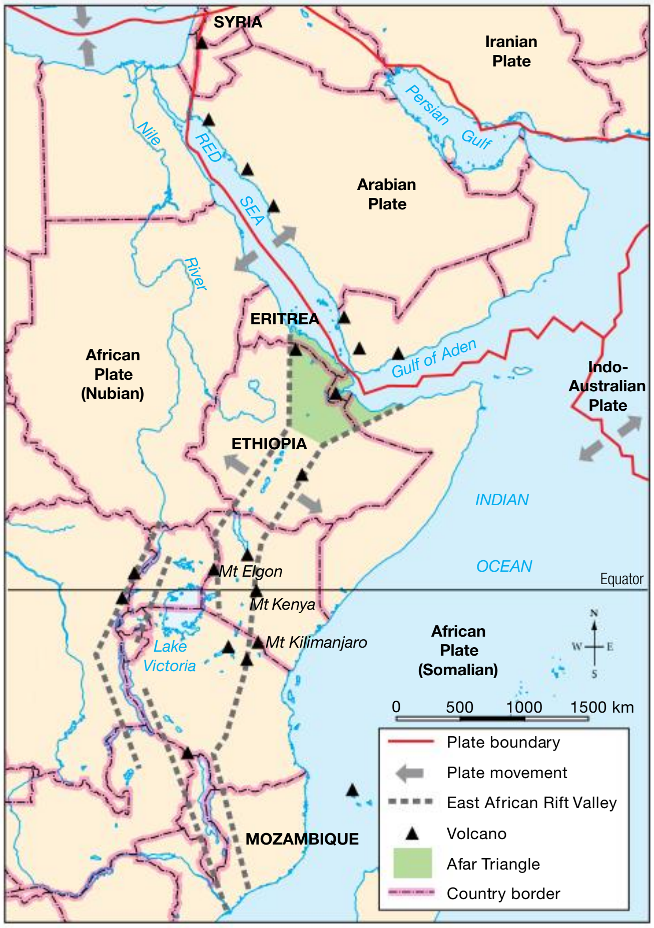
int-7850

The Great Rift Valley is in Africa (see **FIGURE 4**). It is about 5000 kilometres long, and stretches from Syria in the north to Mozambique in the south. The valley varies in width from 30 kilometres at its narrowest point to 100 kilometres at its widest. In some places it is a few hundred metres deep; in others it can be a few thousand metres deep.

The Great Rift Valley was created through separation that began 35 million years ago, when the African and Arabian plates began pulling apart in the northern region. About 15 million years ago, east Africa began to separate from the rest of Africa along the East African Rift. The volcanic activity in this region has produced many volcanic mountains, such as Mount Kilimanjaro, Mount Kenya and Mount Elgon.

As these rifts continue to grow, new ocean waters will flow into the valleys, separating the landmasses.

FIGURE 4 The Great Rift Valley, Africa



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane

4.9.2 Volcano hotspots

Although most volcanoes are formed on plate boundaries, some are located in the middle of plates, a long way from plate boundaries. These volcanoes have formed above a hotspot — a single plume of rising mantle. Volcanoes form as the plates slowly move over the hotspot and, over time, a chain of volcanoes can form. Hotspots are found in the ocean and on continents. Examples include the Hawaiian Islands and many of Australia's extinct volcanoes. In Hawaii, the location of the volcanoes gives a clue to the direction and speed of the plate movement.

on Resources

Weblinks Hawaii's hotspot

Google Earth Iceland
Great Rift Valley

4.9 SKILL ACTIVITY: Communicating

1. Go to the **Hawaii's hotspot** weblink in the Resources panel. Make notes on the information you find.
2. Using your notes, **explain** how hotspot volcanoes form.

4.9 Exercise

learnon

4.9 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 2, 5	3, 4, 7	6, 8, 9, 10

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Check your understanding

1. Almost all volcanoes are found
   A. near plate boundaries.
   B. near the ocean.
   C. exclusively near subduction zones.
   D. in Asia.
2. Iceland has formed
   A. where a subduction zone has led to significant volcanic activity.
   B. where two plates are drifting apart.
   C. as a result of earthquakes pushing the crust above the ocean.
   D. where two landmasses have been pushed together to form an island.
3. Study the shape of the island of Madagascar shown in **FIGURE 5**. Try to imagine fitting this island back into the mainland. Using plate tectonic terms, write a paragraph to **describe** how Madagascar's location has changed over time.
4. **Describe** the changes occurring that are causing volcanoes to form in:
   a. the Great Rift Valley
   b. Iceland.
5. Very few active volcanoes occur at or near plate boundaries. True or false?FIGURE 5

FIGURE 5 The bottom of Africa, showing the location of Madagascar

Apply your understanding

Concluding and decision-making

6. **Explain** how the scale of the changes happening in Iceland is different from the scale of change happening in the Great Rift Valley?
7. **Discuss** how 'hot spots' lead to volcanic activity. Use examples in your analysis.
8. Refer to **FIGURES 2** and **3**. **Explain** why a chain of volcanoes, like the one in **FIGURE 3**, forms in Iceland. What is happening to the plates?

Communicating

9. **Draw** what you imagine Iceland will look like many thousands of years in the future after further rifting. Provide new names for each of the smaller islands. In which direction, and towards which continent, will each island drift? **Describe** key changes.
10. **Draw** a series of sketches to show what you predict will happen to the African landmass as the Great Rift Valley continues to rift. Include a map of Africa showing the change in shape that might occur. You need to **annotate** your sketches to justify the predictions you have made.

LESSON
4.10 Investigating topographic maps — Mount Taranaki, New Zealand

LEARNING INTENTION

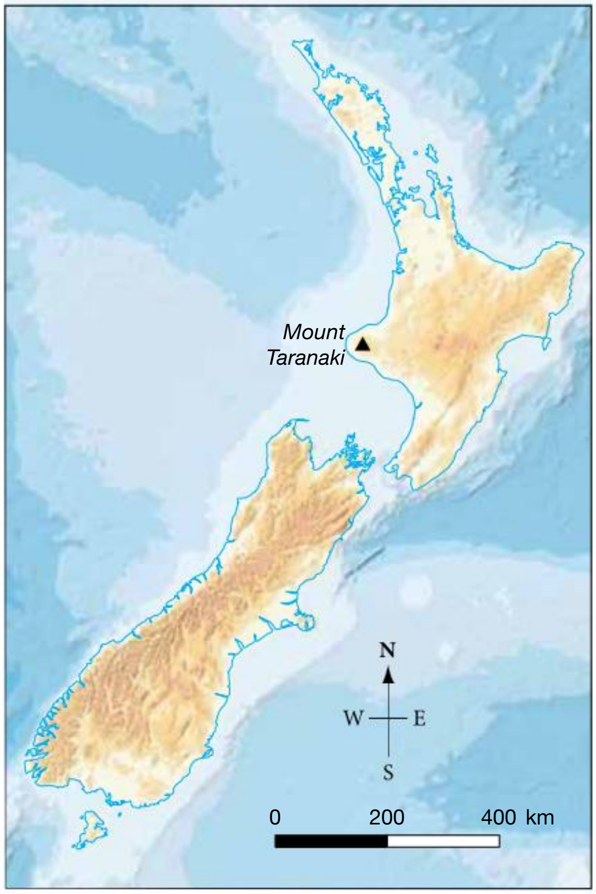
By the end of this lesson you should be able to investigate Mount Taranaki in New Zealand and interpret a topographic map.

New Zealand's Mount Taranaki is named after the Māori terms *tara* meaning 'mountain peak' and *ngaki* meaning 'shining' (because the mountain is covered with snow in winter).

Mount Taranaki is 2518 metres high and is the largest volcano on New Zealand's mainland. It is located in the south-west of the North Island (see **FIGURE 1**).

Mount Taranaki was formed 135 000 years ago by subduction of the Pacific Plate below the Australian Plate. It is a stratovolcano (composite cone) — a conical volcano consisting of layers of pumice, lava, ash and tephra. Mount Taranaki is symmetrical, looking the same on both sides of a central point. It is the only active volcano in a chain in this region. The other volcanoes were once very large but have been eroded over time.

FIGURE 1 Location of Mount Taranaki on the North Island of New Zealand



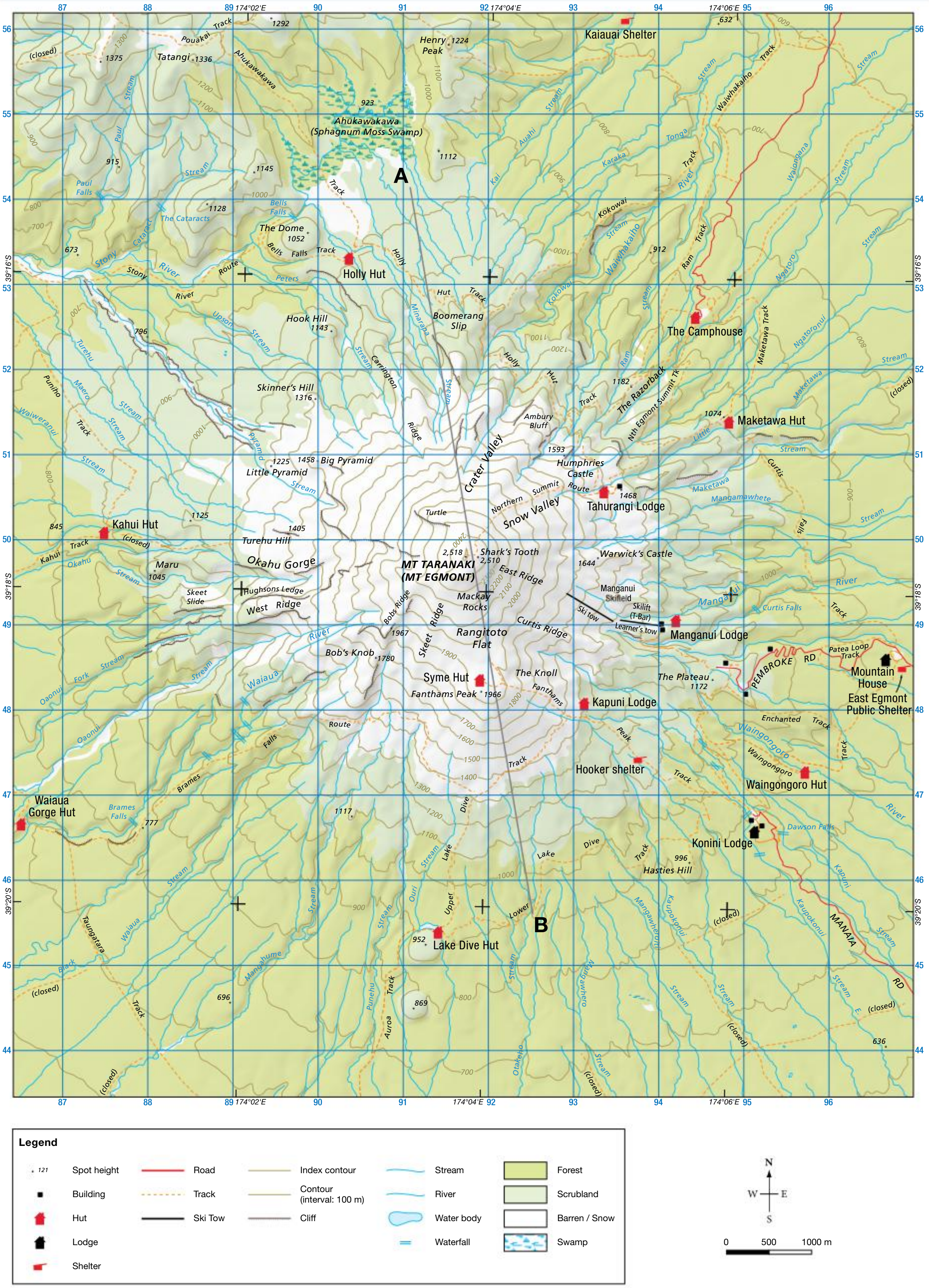
Source: Map drawn by Spatial Vision

The summit of Mount Taranaki is a lava dome in the middle of a crater that is filled with ice and snow. The mountain is considered likely to erupt again. There are significant potential hazards from lahars (mudflows containing volcanic debris), avalanches and floods. A circular plain of volcanic material surrounding the mountain was formed from lahars (see **FIGURE 3**) and landslides. In the past, some of these flows reached the coast The volcano's lower flanks are covered in forest and are part of the national park. There is a clear line between the park boundary and surrounding farmland.

FIGURE 2 Aerial photo of Mount Taranaki

int-8408

FIGURE 3 Topographic map of Mount Taranaki



Source: LINZ Data Service. License: Creative Commons Attribution 3.0 New Zealand https://data.linz.govt.nz/license/attribution-3-0-new-zealand/. Map drawn by Spatial Vision.

FIGURE 4 Mount Taranaki has a near-perfect conical shape.

4.10 Exercise

learnon

4.10 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 5	2, 4	3, 6

1. Mount Taranaki is located in the **east** / **south-west** / **north** / **south-east** / **south** / **west** of the **east** / **south-west** / **north** / **south-east** / **south** / **west** island of New Zealand.
2. **Explain** how Mount Taranaki formed.
3. Mount Taranaki receives between 3200 millimetres and 6400 millimetres of rainfall each year. **Explain** how this would contribute to the shape of this landform.
4. Refer to **FIGURE 3**.
   a. **State** the grid reference for the spot height of Mount Taranaki.
   b. **Calculate** the number of huts and lodges.
   c. **State** the area reference of the Manganui Ski field.
   d. **State** the highest elevation shown on the map.
   e. **Name** and give the grid reference of a lodge in which skiers could stay.
   f. **State** the area reference for the largest portion of swampland.
5. **Describe** evidence from the aerial photo in **FIGURE 2** that the national park has protected forests around the volcano.
6. a. Use **FIGURES 2, 3** and **4** to describe where you think lava would flow if Mount Taranaki erupted.
   b. **Describe** the potential changes to the human and natural environment.

on Resources

eWorkbook	Investigating topographic maps — Mount Taranaki (ewbk-10761)
Digital document	Topographic map of Mount Taranaki (doc-39541)
Video eLesson	Investigating topographic maps — Mount Taranaki — Key concepts (eles-6033)
Interactivity	Investigating topographic maps — Mount Taranaki (int-8408)
Google Earth	Mount Taranaki (gogl-0134)

LESSON
4.11 What are the types of volcanoes and how do they erupt?

LEARNING INTENTION

By the end of this lesson you should be able to describe the different types of volcanic landforms, why they have different shapes and how they erupt.

TUNE IN

Look closely at **FIGURE 1**. In the area around the erupting volcano you can see the lights of a built-up area.

FIGURE 1 An erupting volcano in Spain

1. Theorise as to why people would be living so close to an erupting volcano.
2. Describe what you can see being erupted. What impact might it have on the surrounding land?

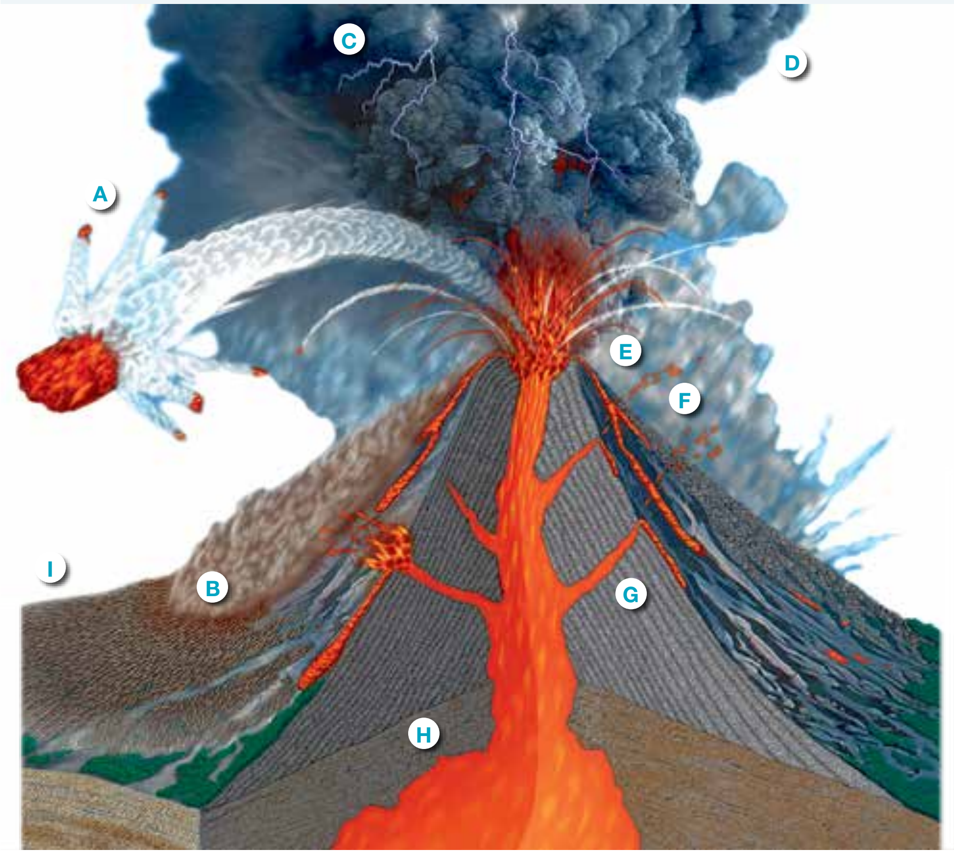
Volcanic mountains are formed when magma pushes its way to the Earth's surface and then erupts as lava, ash, rocks and volcanic gases. These materials build up around the vent through which they erupt.

A volcanic eruption can be slow or spectacular, and can result in a number of different displays (see **FIGURE 1**).

int-9015

tlvd-10628

FIGURE 2 The anatomy of a volcano



A A fragment of lava greater than 64 millimetres in diameter is called a volcanic bomb. They are often solid pieces of lava from past eruptions that formed part of the cone.

B A pyroclastic flow is a superheated avalanche of rock, ash and lava that rushes down the mountain with devastating effects. The flow can travel at up to 240 kilometres per hour and reach temperatures of 800 °C. When Mount Pelée erupted in 1902, on the island of Martinique in the Caribbean, a pyroclastic flow covered the town of Saint-Pierre, killing all but two of the town's 30 000 inhabitants.

C Lightning is often generated by the friction of swirling ash particles.

D As rock is pulverised by the force of the eruption, it becomes very fine ash, and is carried by wind away from the crater as an ash cloud. Volcanic ash may blanket the ground to a depth of many metres. In the eruption of Mount Vesuvius in 79 CE, volcanic ash completely covered two large towns: Pompeii and Herculaneum.

E A volcanic cone is made up of layers of ash and lava from previous eruptions. If the volcano has not erupted for thousands of years (i.e. is dormant), these layers will be eroded away.

F Lava may be either runny or viscous, and can flow for many kilometres before it solidifies, thereby building up the Earth's surface.

G Pressure may force magma through a branch pipe or side vent. In the eruption of Mount St Helens, in Washington in the United States, in the 1980s, the side of the mountain collapsed and the side vent became the main vent.

H Where two plates move apart, molten rock from the mantle flows upward into a magma chamber. More rock is melted and erupts violently upwards. Magma is generally within the temperature range of 700 °C to 1300 °C.

I When pyroclastic flows melt snow and ice, and mix with rocks and stones, a very wet mixture called a lahar can form. Lahars can flow quickly down the sides of volcanoes and cause much damage. One lahar that formed in 1985 on the Nevado del Ruiz volcano in Colombia, travelled at up to 50 kilometres per hour and was up to 40 metres high in some places. A wall of mud, water and debris travelled 73 kilometres to the town of Armero, devastating it. More than 23 000 people died that night and 5000 homes were destroyed.

4.11.1 Volcanic shapes

Volcanoes come in a variety of shapes and sizes, forming different landforms. There are four main types and each depends on:

- the type of lava that erupts
- the amount and type of ash that erupts
- the combination of lava and ash.

Lava that is rich in silica (a mineral present in sand and quartz) is highly viscous and is thick and slow moving. If the lava is low in silica, it tends to be very runny and may flow for many kilometres before it cools and hardens to become rock. Volcanoes that erupt runny lava tend to have broad, flat sides (shield volcanoes). Those that erupt thick, treacle-like lava tend to have much steeper sides (dome volcanoes).

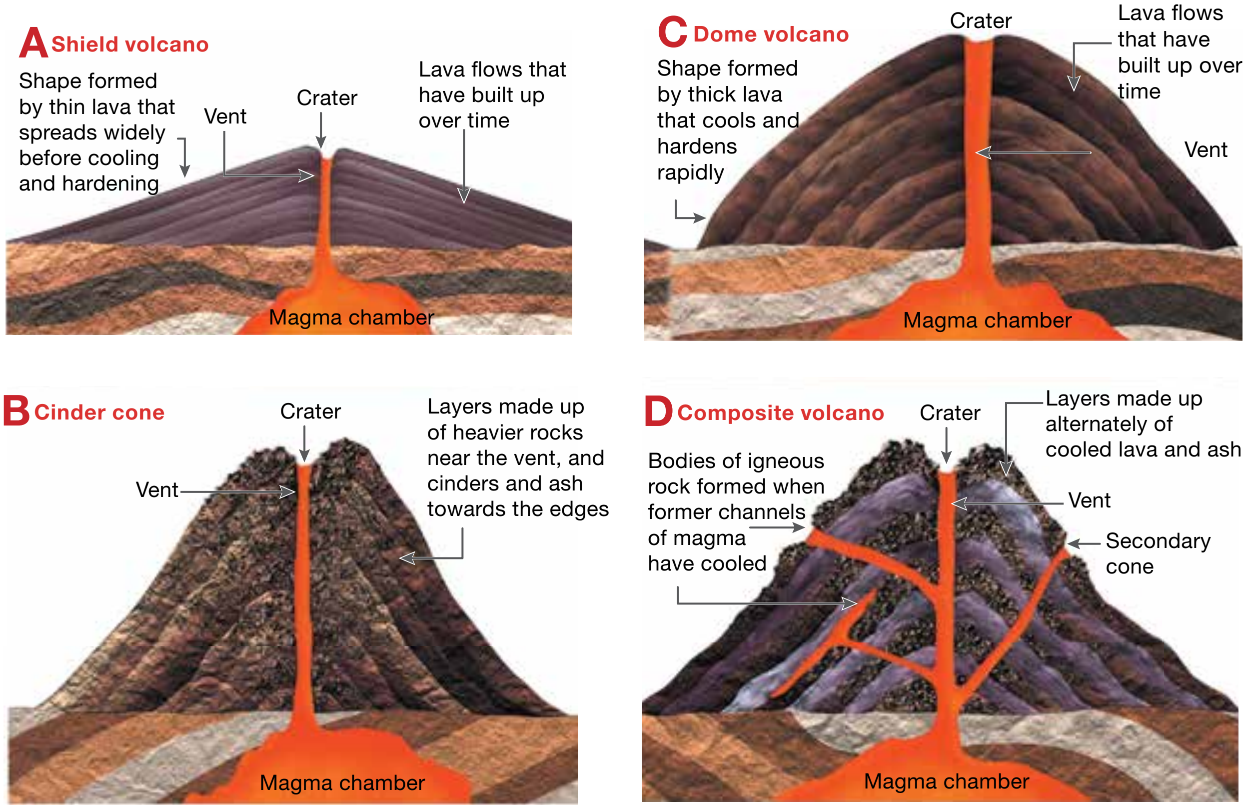
Heavy ash material, like volcanic bombs, settles close to the crater while lighter ash is carried further away. Volcanoes that are built up through falls of ash are steep-sided cinder cones. Volcanic ash is made up of a mixture of rock, mineral and glass particles. It is usually very small (often less than 2mm in diameter). Unlike the ash from woodfires, volcanic ash is very hard and when there is heavy ashfall, the weight can collapse roofs. Volcanic ash is a major concern for jet engines, as it can clog the motors and flights often need to be redirected when eruptions occur.

The most common type of volcano is one built up of both ash and lava; this is called a composite volcano.

int-7851

FIGURE 3 Four volcanic landforms

tlvd-10629



4.11 SKILL ACTIVITY: Communicating

1. **Conduct research** to find pictures of volcanic landforms and materials. These include crater lakes, geysers, calderas, fields of ash deposits, volcanic plugs, lava tubes, hummocks and pumice. You could also find pictures of the two types of lava: a’a and pahoehoe.
2. Use your pictures to **create** a field guide to volcanic landforms. Each page should contain a picture of the landform, a brief description and a place where it can be found — sometimes they are tourist attractions.

4.11 Exercise

learnon

4.11 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 4, 5	2, 3, 6	7, 8, 9, 10

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Volcanoes can erupt ash, gas and magma in the same eruption.
   b. The type of lava that erupts from a volcano can determine the shape of the cone.
   c. Volcanic bombs are blocks of magma so full of Sulphur dioxide that they “explode” when they hit the ground.
   d. A composite volcano is made up of both lava and ice.
   e. Lightning can be generated by the friction in volcanic ash.
2. a. **Define** pyroclastic flow.
   b. **Explain** why this is often viewed as the most dangerous aspect of a volcanic eruption.
3. **Explain** how a volcanic cone develops.
4. Study **FIGURE 3**. Match each volcano to its description to **explain** how the shape of volcanoes depends on the different materials being ejected.
   i. Shield volcano
   ii. Composite volcano
   iii. Dome volcano
   iv. Cinder cone

a. Thin lava spreads over a wide area before cooling.	
b. Made up of alternate layers of cooled lava (forming areas of igneous rock) and ash.	
c. Layers of rock build up near the vent and the outer part of the volcano is made up of cinders and ash.	
d. Formed by different layers of thick lava that cool and harden quickly.	

5. What is a stratovolcano?
   A. A volcano made up of layers of pumice, lava, ash and tephra
   B. A volcano created from passing over a hotspot
   C. A volcano made up of blocks of pumice and ash
   D. A volcano covered in snow and ice
6. a. **Define** Lahar.
   b. **Explain** how are lahars are linked to volcanoes with snow-capped peaks.

Apply your understanding

Concluding and decision-making

7. a. **Discuss** how volcanic ash is different from the ash in a fireplace. What are the implications of this when ash builds up on rooftops?
   b. **Explain** why volcanic ash is usually seen as being more dangerous than lava.
8. Refer to **FIGURES 1** and **2**.
   a. **Describe**, in detail, the changes to the environment that volcanic eruptions can cause.
   b. **Identify** which changes would impact on a small scale and which would impact on a larger scale.
9. **Theorise** as to how you might prepare a hazard map for a volcano. What would you have to take into account?
10. **Explain** why the relative size of a magma chamber is potentially significant.

LESSON
4.12 How do volcanic eruptions affect people?

LEARNING INTENTION

By the end of this lesson you should be able to describe the impact of volcanoes on people and the environment, and identify strategies to reduce the impact of a volcanic eruption.

TUNE IN

Volcanoes can have devastating impacts on the environment and the population.

FIGURE 1 Eyjafjallajökull-eruption, Iceland

In pairs or small groups complete the following tasks.

1. Make a list of all the risks associated with living near volcanoes.
2. Discuss reasons why people might want to live near volcanoes.
3. Under what conditions do you think it might be worth the risk of living near a volcano?

Share your responses with the class.

4.12.1 The worst volcanic eruptions

Volcanic eruptions both create and destroy landscapes. Most volcanic eruptions do not strike randomly but occur in specific areas, such as along plate boundaries. In some places there are high concentrations of people living near volcanoes.

Most of the world's active above-sea volcanoes are located near convergent plate boundaries where subduction is occurring, particularly around the Pacific basin. This is also the location of settlements across many countries. Over many years, volcanic eruptions have caused deaths and great damage.

How can the worst volcanoes be measured? Should it be based on the number of people killed or the cost of the damage and destruction? Or should it be the size of the explosion?

TABLE 1 The worst volcanoes based on number of deaths

Volcano	Location	Date	Number of deaths
Mt Tambora	Indonesia	5–10 April 1815	71 000+
Mt Pelee	West Indies	25 April–8 May 1902	30 000
Mt Krakatoa	Indonesia	26–28 August 1883	36 000+
Nevado del Ruiz	Colombia	13 November 1985	23 000
Mt Unzen	Japan	1792	12 000–15 000
Mt Vesuvius	Italy	24 April 79 CE	13 000+
Laki Volcanic System	Iceland	8 June 1783–February 1784	9350
Mt Kelud	Indonesia	1586	10 000
Mt Kelud	Indonesia	19 May 1919	5110

Source: EM-DAT, CRED / UCLouvain, Brussels, Belgium, www.emdat.be (D. Guha-Sapir), 14 April 2020 version.

TABLE 2 The worst volcanoes based on economic impact

Volcano	Location	Date	Estimated loss (million US$)
Nevado del Ruiz	Colombia	1985	1000
Mount St Helens	USA	1980	860
Calbuco	Chile	2015	600
Mount Pinatubo	Philippines	1991	211
Galunggung	Indonesia	1982	160
Tungurahua	Ecuador	2006	150
Gamalama	Indonesia	1983	149
El Chichon	Mexico	1982	117
Rabaul	Papua New Guinea	1994	110
Puyehue-Cordon Caulle	Chile	2011	104

Source: EM-DAT, CRED / UCLouvain, Brussels, Belgium, www.emdat.be (D. Guha-Sapir), 14 April 2020 version.

4.12.2 Why do people live near volcanoes?

Geoscience Australia (a national organisation that provides geographic information to the government) estimates that 180 million people in the Asia–Pacific region live within 50 kilometres of a dangerous volcano. There is also a strong relationship between the location of volcanoes and resources such as fertile soils, ore deposits and **geothermal energy**.

geothermal energy energy derived from the heat in the Earth's interior

volcanic loam a volcanic soil composed mostly of basalt, which has developed a crumbly mixture

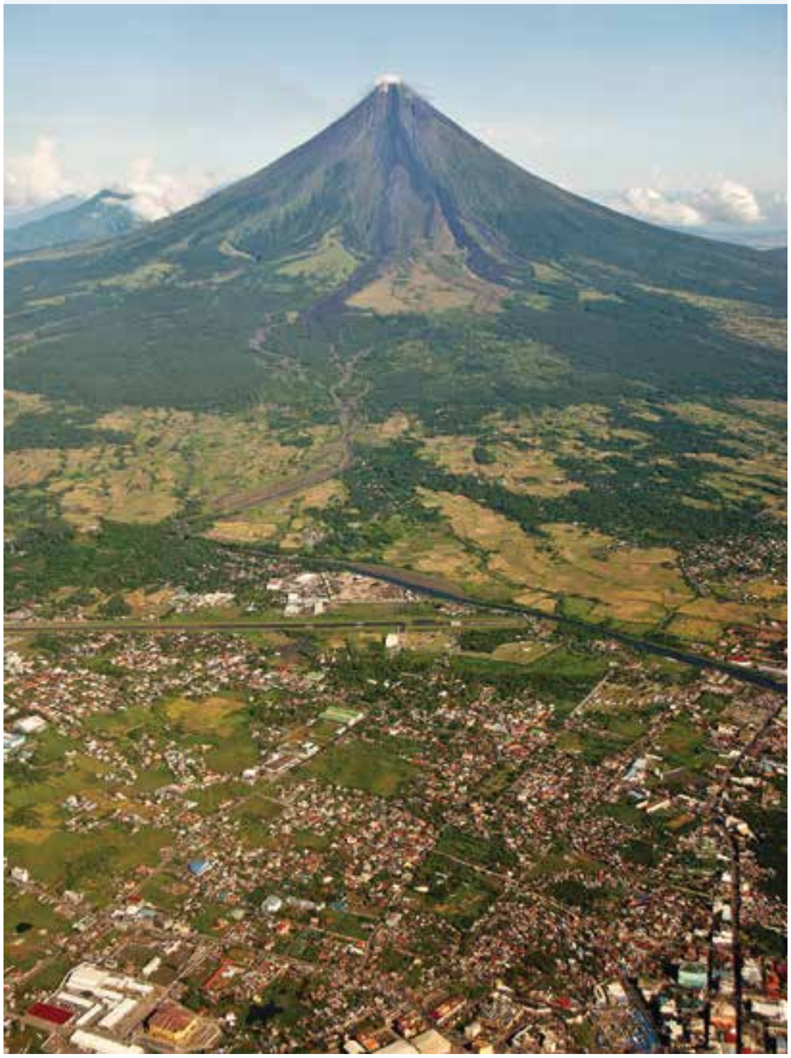
Fertile soils

Some of the most fertile soils on Earth have come from volcanic deposits of ash that is rich in nutrients, and from the physical breakdown of volcanic rocks over thousands or millions of years.

Fertile volcanic soils have been very important for rice growing in Japan and large areas of the Indonesian archipelago, especially on the islands of Java and Bali. There is also prime agriculture located in regions of rich soil; for example, around Naples, southern Italy, which generally has poor soils.

Another region of fertile volcanic soil is the agricultural area of the North Island of New Zealand. **Volcanic loam** in this area helps produce crops and pasture. Other regions include the western plains of the United States and the Hawaiian Islands. There is a small percentage of rich basalt soils in Australia, including the volcanic plains in Victoria, the north coast of New South Wales, the Scenic Rim of south-east Queensland, parts of Tasmania, and the Atherton Tablelands in north Queensland.

FIGURE 2 Agriculture and settlement near Mayon Volcano in the Philippines

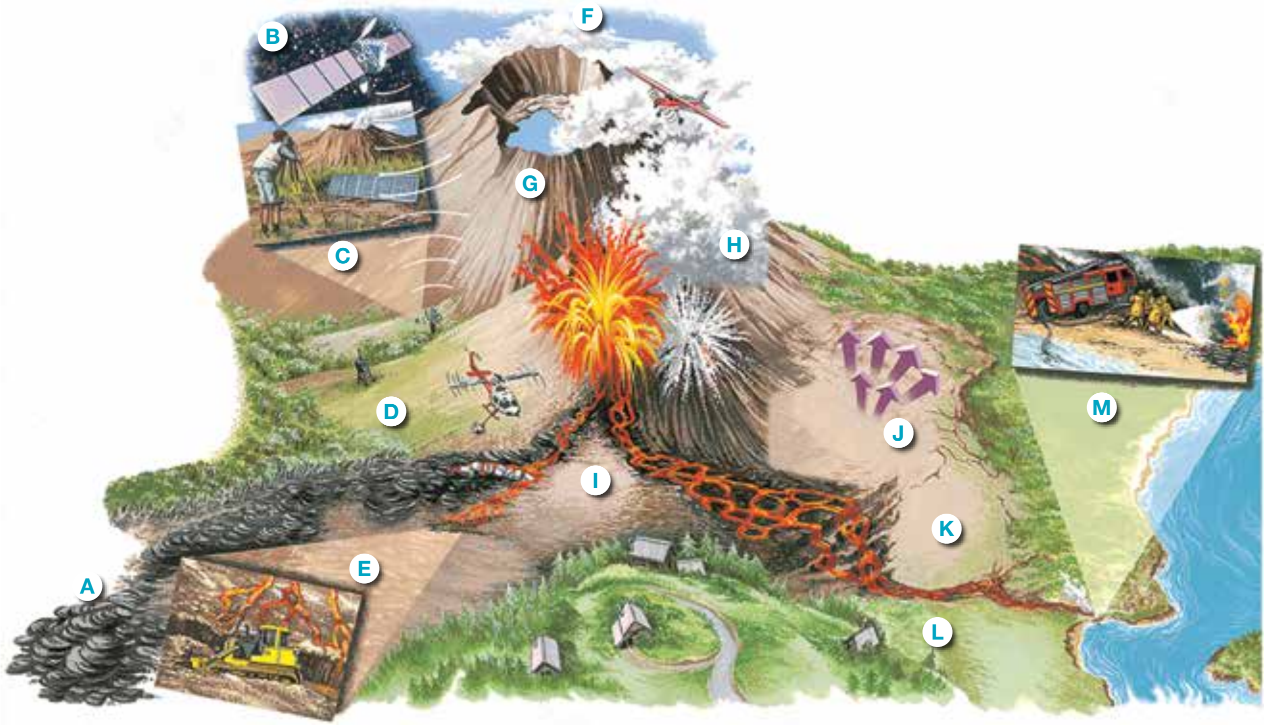


Geothermal energy

Geothermal energy can be used in locations where there are active or dormant volcanoes still producing heat deep under the Earth's surface. High-temperature hot springs and geysers produce steam, which can be used to drive turbines and generate electricity. At lower temperatures, the hot water can be used for home heating or to develop hot or warm springs at resort spas. Over one quarter of Iceland's electricity is generated from geothermal energy, and it provides heating for more than 85 per cent of its homes. The other main countries that make use of geothermal energy are the United States (in California), Italy, New Zealand and Japan.

int-9016

FIGURE 3 Predicting volcanic eruptions



- **A** Geologists study records of past eruptions by examining flow patterns of mud, lava and ash. From these patterns they can draw danger maps that pinpoint dangerous areas.
- **B** Satellites monitor changes in gas emissions and in the shape of the volcano. Specialised equipment can also measure heat increases.
- **C** Seismographs can detect the small earthquakes caused by rising magma. These are linked by transmitters to computers so that scientists can quickly detect changes.
- **D** Sound-measuring equipment was used to accurately predict an eruption in Mexico in 2000.
- **E** In 1983, an attempt was made to divert a lava flow away from the towns of Rocco and Rogalna on Mount Eina. A channel was dug and barriers erected. The lava slowed and solidified before reaching the towns.
- **F** Samples of gas can be collected and analysed. An increase in the amount of sulfur dioxide (SO_2) may indicate that magma is moving upwards.
- **G** A rise in the temperature of a crater lake often precedes an eruption.
- **H** It has been suggested that explosives could be used to breach crater walls, sending lava away from towns. This was first tried in Hawaii in 1935.
- **I** Helicopters have been used to drop concrete blocks in front of flowing lava.
- **J** As magma rises and collects in the magma chambers, the cone may bulge outwards, warning of possible eruptions. Sensitive tiltmeters on the ground and on satellites can detect this bulging.
- **K** Any bulging can also cause tiny cracks to appear.
- **L** Buildings in areas prone to ash eruptions should have steeply sloping roofs so ash does not accumulate.
- **M** In 1973, sea water was sprayed onto lava that was threatening a town in Iceland. The lava cooled quickly and solidified.

4.12.3 How to prepare for volcanic eruption

Can volcanic eruptions be predicted? What are the warning signs? How can the risk of death, injury and damage be reduced?

With about 500 million people living close to active volcanoes, it is important to watch for changes and try to predict an eruption, hopefully giving nearby residents time to evacuate.

4.12 SKILL ACTVITY: Interpreting and analysing geographical data and information, Concluding and decision-making

1. a. Refer to an atlas map showing world population density, settlements and the location of volcanoes.
   b. Make notes on the patterns you see. How close are settlements to volcanoes? What populations do they have?
   c. Write two statements that **describe** the relationship between population density, settlements and volcano locations. **Explain** how this relates to people's risk.
2. Copy and complete a table like the following, **summarising** the measures required for living with volcanoes.
   a. Use the table to help you **classify** the information in **FIGURE 3**.
   b. **State** which of the measures you think is most effective. Give three reasons for your answer.

4.12 Exercise

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4.12 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 6	5, 7, 8

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Check your understanding

1. **Complete** the following statements by filling in the blanks.
   Volcanic eruptions both _________ and destroy landscapes. Most eruptions do not occur randomly but occur in specific area, such as along ____________ ____________. In some places there is a high number of ______________ living near volcanoes. Most of the world's active volcanoes are located near _____________ boundaries where subduction is occurring. This is also the location of many ____________ across many countries. As a result volcanic eruptions have caused deaths and great ___________.
2. Which of the following are advantages and which are disadvantages of living near a volcano?
   a. Eruption could cause destruction of natural environment.
   b. Fertile soils for agriculture
   c. Possibility for deaths if it erupts
   d. Geothermal energy to access for power
   e. Natural hot springs for tourism
   f. Possible damage caused by eruption
   g. The smell of sulphur
3. Geothermal energy is not a renewable resource. True or false?
4. **Define** volcanic loam and **identify** where it is found.

Apply your understanding

Communicating

5. **Create** a photo sketch of **FIGURE 2** and label the following: volcano, volcanic plain, lava flows, farmland, settlement.

Concluding and decision-making

6. **Explain** what geothermal energy is. What do you think could be some of the benefits of using this type of energy?
7. **Explain** how seismographs can be used to warn of a possible volcanic eruption.
8. Study **FIGURE 3**. List the different techniques that have been used to try to stop the flow of lava. Which technique do you think is the most effective and why?

LESSON 4.13 INQUIRY: Supervolcano report

Background

In this inquiry, you will investigate the recently discovered geomorphological feature known as a super volcano. In groups of three to four you will seek to develop a better understanding of super volcanoes. You will also use critical thinking skills to analyse and interpret information to assess the relative merits of sources of information before submitting a report that will inform the class.

There are estimated to be at least 12 super volcanoes scattered around the world. Each one has the capacity for a potentially globally significant eruption.

Before you begin

Access the **Inquiry rubric** in the digital documents section of the Resources panel to guide you in completing this task at your level. At the end of the inquiry task you can use this rubric to self-assess.

Inquiry steps

Step 1: Questioning and researching using geographical methods

Research the world's super volcanoes. Choose one that you want to investigate further. Focus on the following:

- Where is it located?
- Why is it considered a supervolcano?
- Previous historic eruptions
- Any other interesting facts about your volcano.
  (Make sure you are conscious of the sources of your information. Use multiple sources to compile your data and discuss with your teacher ways in which you can verify the reliability of the source)

Step 2: Interpreting and analysing geographical data and information

Discover the facts about your super volcano's previous eruptions. What would a similar size eruption mean today. **Examine** the effects of an eruption on both a local, national and global scale

Step 3: Concluding and decision-making

Compile a series of recommendations that you would make for managing this hazard moving forward. You can base this on current monitoring and risk management programs or you can look at what is being done elsewhere in the world and recommend improvements if you think they are required.

Step 4: Communicating

Create a report for the rest of the class on your chosen super volcano. Be creative in the way you want to communicate your information. For instance you can prepare:

- A mock news report
- A front/double page spread for a newspaper
- A radio interview with a group of "geologists and volcanologists and politicians" Assigning different people a role.

The key is to ensure that your report is both informative and interesting.

Complete your self-assessment using the **Inquiry rubric** or access the 4.13 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39542)

LESSON
4.14 Review

Hey students! Now that it's time to revise this topic, go online to:

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4.14.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

4.2 What are plate tectonics?

- The Earth is made up of continental plates that are constantly moving slowly.
- Convection currents are the drivers of tectonic plate movement.
- Some plates converge; others diverge and others again slide past one another.
- Hot spots have created volcanic islands and landmasses around the world.
- The Pacific Ring of Fire is the world's most active tectonic region.

4.3 How do different types of mountains form?

- This tectonic activity (moving plates) is a process for forming mountains.
- Mountains are classified by what they look like and how they were formed.
- The most common formations are fold mountains.
- Other mountain formations include fault-block, dome and plateau.
- The Himalayas are the world's largest mountain range

4.4 Where are the world's mountain ranges?

- Mountains are found on every continent on Earth.
- There are major chains of mountains — mountain ranges — on all continents.
- The longest mountain ranges in the world are the Andes and the Rockies.
- Vegetation, climate and weather change as the altitude on mountains increases.

4.5 How do people connect with mountains?

- Mountains can be remote but often support low population densities.
- Mountain ranges are vital for the world's water supply.
- Specific mountain landforms are sacred and special places to First Nations Australians and other groups of people around the world.
- People have adapted a range of specialised techniques to farm in mountain ranges.

4.6 What are earthquakes?

- Earthquakes are a common occurrence each day across the Earth.
- There is a strong relationship between the location of plate boundaries (weaknesses in the Earth's crust) and the location of earthquakes.
- The focus of an earthquake is the place underground where the movement takes place and the epicentre is spot on the Earth's surface directly above the focus.
- Earthquakes generate both Primary and Secondary waves that radiate out from the focus.
- Earthquakes are measured using both a Richter scale and the modified Mercalli Scale.

4.7 What is a tsunami?

- A tsunami can result if a large earthquake occurs on the ocean floor.
- The shape of the sea floor as it nears land influences the impact of a tsunami.
- Tsunamis are not a single wave, they are anywhere from approximately 5–20 waves.
- The Japanese tsunami was the result of a massive earthquake (8.9 on the Richter scale) that produced waves of over 6 metres in height.

4.8 What are the Impacts of earthquakes and tsunamis?

- Earthquakes and tsunamis can affect people and result in deaths, injuries and damage to homes and infrastructure.
- The impact of a Tsunami or earthquake can vary greatly depending on a country's level of income.
- The environment can be affected through landslides, erosion and liquefaction.
- Ground Liquification occurs when soil suddenly loses strength and, mixed with groundwater, behaves like a liquid.

4.9 What are volcanoes and how are they formed?

- Volcanoes are formed when molten magma in the Earth's mantle is forced through an opening in the Earth's surface.
- Volcanoes can be formed in rift valleys and over hotspots.

4.10 Investigating topographic maps — Mount Taranaki, New Zealand

- Mount Taranaki is the largest volcano on New Zealand's mainland, on the North Island.
- Mount Taranaki is a dormant stratovolcano that is likely to erupt in the future.

4.11 What are the types of volcanoes and how do they erupt?

- The shapes and sizes of volcanic landscapes depend on the type of lava, the amount of ash and the speed of the eruption.
- Volcanic ash is actually tiny fragments of rock and as such it is denser and more damaging than ash from a wood fire.
- A pyroclastic flow is a superheated avalanche of rock, ash and lava that rushes down the mountain.
- A lahar is a flow of mud and ash that occurs when pyroclastic flows melt snow and ice, and mix with rocks and stones.

4.12 How do volcanic eruptions affect people?

- Volcanic mountains form when magma erupts to the Earth's surface.
- Volcanic eruptions can destroy landscapes and kill people.
- Large numbers of people across the world live near volcanoes because of the location of fertile soils, ore deposits and geothermal energy.
- Predicting the type and scale of a volcanic eruption is increasingly important with over 500 million people living so close to active volcanoes.

4.13 INQUIRY: Supervolcano report

- What is a supervolcano?
- Where are supervolcanoes located?
- What could happen if a supervolcano erupted?

4.14.2 Key terms

altitude height above sea level

convection current a current created when a fluid is heated, making it less dense, and causing it to rise through surrounding fluid and to sink if it is cooled; a steady source of heat can start a continuous current flow

converging plate a tectonic boundary where two plates are moving towards each other

cultural relating to the ideas, customs and social behaviour of a society

divergent plate a tectonic boundary where two plates are moving away from each other and new continental crust is forming from magma that rises to the Earth's surface between the two

epicentre the point on the Earth's surface directly above the focus of an earthquake

fault an area on the Earth's surface that has a fracture; a fault lies at the major boundaries between Earth's tectonic plates.

fault plane the area of a tectonic plate that moves vertically as a result of an earthquake

focus the point where the sudden movement of an earthquake begins

geothermal energy energy derived from the heat in the Earth's interior

hotspot an area on the Earth's surface where the crust is quite thin, and volcanic activity can sometimes occur, even though it is not at a plate margin

landslide a rapid movement of rocks, soil and vegetation down a slope, sometimes caused by an earthquake or by excessive rain

liquefaction transformation of soil into a fluid, which occurs when vibrations created by an earthquake, or water pressure in a soil mass, cause the soil particles to lose contact with one another and become unstable; for this to happen, the spaces between soil particles must be saturated or near saturated

lithosphere the crust and upper mantle of the Earth

orographic rainfall occurs when a topographic barrier such as a mountain blocks the path of a movement of air horizontally. This forces the air upward where it cools, thus increasing the likelihood of rain.

Pangaea the name given to all the landmass of the Earth before it split into Laurasia and Gondwana, which over time became the continents we know today

primary wave also known as a P-wave; the first waves to hit an area during an earthquake, which cause a sudden jolt

rift zone a large area of the Earth in which plates of the Earth's crust are moving away from each other, forming an extensive system of fractures and faults

secondary wave also known as a S-wave; the waves that arrive at an area after the P-waves, which cause a sustained up-and-down movement

seismic wave a wave of energy that travel through the Earth as a result of an earthquake, explosion or volcanic eruption

volcanic loam a volcanic soil composed mostly of basalt, which has developed a crumbly mixture

4.14.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

How do magma, water and tectonic plates change environments and what are the impacts on people and places?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-10759)
Reflection (ewbk-10762)
Crossword (ewbk-10763)

Interactivity Geomorphic hazards crossword (int-9017)

4.14 Review exercise

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Multiple choice

1. Most active, above-sea volcanoes are associated with what type of plate boundary?
   A. Convergent
   B. Divergent
   C. Hotspots
   D. Lateral plate slippage
2. Volcanoes are not evenly distributed, but are often clustered. Which plate boundary is spatially associated with the largest number of active volcanoes?
   A. Eurasian
   B. African
   C. Pacific
   D. Caribbean
3. The eruption of Mount Eyjafjallajökull, Iceland, in April 2010, caused an estimated loss of US$1.7 billion dollars. Much of this was in the form of losses to the airline industry as airports across much of Europe were closed. Which of the below posed the greatest risk to aircraft?
   A. Ash
   B. Lava
   C. Steam
   D. Pyroclastic flows
4. While volcanoes can bring death and destruction, they can also benefit people. From the list, select three benefits that volcanoes bring to people.
   A. Fertile soils from the gradual breakdown of mineral-rich lava
   B. Ash build up in rivers
   C. Geothermal energy
   D. Pyroclastic flows
   E. Spectacular scenery and tourist destinations
5. Fold mountains usually have
   A. rounded peaks.
   B. flat peaks.
   C. pointed peaks.
   D. cratered peaks.
6. The epicentre of an earthquake is
   A. the point below the Earth's surface where an earthquake occurs.
   B. the point on the Earth's surface directly above the focus of the earthquake.
   C. the area affected directly by an earthquake.
   D. the centre of the Earth.
7. The lithosphere is
   A. the crust of the Earth.
   B. the Earth's upper mantle.
   C. the crust and lower mantle of the Earth.
   D. the crust and upper mantle of the Earth.

8. Volcanic loam is
   - A. the plume of smoke and ash arising from a volcano.
   - B. the fiery centre of a volcano.
   - C. a volcanic soil.
   - D. hot molten ash created by a volcano.
9. Altitude is
   - A. the height of a mountain.
   - B. height measured in metres.
   - C. height above sea level.
   - D. height above ground level.
10. Geothermal energy is
   - A. energy derived from waves.
   - B. energy derived from the sun.
   - C. energy derived from rocks.
   - D. energy derived from heat within the Earth's interior.

Short answer

Communicating

11. a. **Define** and **explain** of continental drift and plate tectonics. Use your own sketched and labelled diagrams to help with your explanation.
    b. **Describe** the relationship between the location of mountains and mountain ranges and plate tectonics. Choose three examples from different *places* for your explanation.
12. **Describe** the general location and distribution of the world’s earthquakes and volcanoes. What is the relationship between this distribution and the location of plate boundaries?
13. **Explain** the terms *subduction, convergent plate, divergent plate* and *focus*. How is each involved in mountain building?

Concluding and decision-making

14. Many earthquakes are not the largest that have ever occurred, but they have resulted in enormous loss of life and damage.
    Do you think that earthquakes and tsunamis should be measured by their size on the Richter scale, by the number of people killed, or by the cost of the damage caused? **Justify** your response.
15. ‘If people are well prepared for earthquakes and volcanic eruptions, there will be fewer deaths and injuries and less destruction and damage.’ What is your opinion about this statement? **Justify** by using some examples.

5 Urbanisation and migration

LESSON SEQUENCE

LESSON
5.1 Overview

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Why do people move between and within countries, and what are the consequences of that movement?

5.1.1 Introduction

There are many reasons why people move from one country to another, or to different places within a country. Some of the reasons may be political, economic, social, or environmental. Some reasons may be immediate and urgent, whereas others may be carefully considered. In some cases, people are forced to move, whereas in others the decision is voluntary. Regardless of the factors involved, the movement of people from place to place has consequences, including that of **urbanisation**.

urbanisation the growth and expansion of urban areas and the increasing proportion of people living in urban areas as compared to rural areas

urban relating to a city or town; the definition of an urban area varies from one country to another depending on population size and density

Since the emergence of the earliest cities around 5000 years ago, the number of people living in **urban** areas has gradually increased. In 2008, the proportion of the global population living in urban areas was more than rural areas, for the first time in history. In this topic, we will explore patterns of migration between and within countries and examine the effects of these patterns, such as increased urbanisation, along with the advantages and disadvantages that brings.

FIGURE 1 Pedestrians crossing a busy intersection

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-13444)

Video eLesson Urbanisation and migration (eles-6034)

LESSON
5.2 What is migration?

LEARNING INTENTION

By the end of this lesson you should be able to define key terms related to the concept of migration and outline different types of migration.

TUNE IN

A range of factors influence the decision of people to move from one place to live in another. Some factors may be more significant than others.

FIGURE 1 Examples of push factors include lack of medical services, war, crop failure, prolonged drought and desertification, famine, poverty and lack of educational opportunities.

Consider **FIGURES 1** and **3** that illustrate different push and pull factors of migration.

1. What do you think is meant by the term 'push' factor?
2. What do you think is meant by the term 'pull' factor?
3. Discuss: Imagine that you live in Syria — what three factors would be the most important in influencing your decision to move away? Now imagine that you live in Canada. Would those same three factors still be the most important? Why/why not?

5.2.1 How do we define migration?

When people move from one place to settle in another, this is known as migration. Migration types can be categorised by time, location, and degree of choice. The table below outlines some examples.

TABLE 1 Types of migration

Time	Location	Degree of choice
• *Permanent* — migrants choose to move and remain in their new location indefinitely. • *Temporary* — migrants may choose to move again, or even return to their original location. • *Seasonal* — migrants move for a specific period of time for employment or due to climatic reasons.	• *International* — migrants choose to move from one country to another. • *Internal* — migrants choose to move from one place within a country to another.	• *Forced* — migrants have no option but to move, due to conflict, natural disasters etc. • *Voluntary* — migrants freely choose to move for reasons that benefit them.

For every individual migrant, their personal migration story will link to each of the categories outlined. For example, comedian, actor, artist and author Anh Do, fled Vietnam with his family as refugees in 1980. They eventually settled in Australia, where Anh has lived, studied and worked since. Therefore Anh's migration was:

- forced (as refugees)
- international (as he moved from one country to another)
- permanent (as he has remained in Australia ever since).

5.2.2 What do we mean by push and pull factors?

When making a decision to move from one place to another, migrants will be influenced by a range of push and pull factors.

Push factors

Push factors are those characteristics, qualities or attributes of a place that are unfavourable or negative, and make people want to move away from it. **FIGURE 1** illustrates a range of possible push factors that may influence someone in deciding to move from one country to another.

FIGURE 2 Push factors often lead to people taking risks to move to another place.

Pull factors

Pull factors are those characteristics, qualities or attributes of place that are positive and attractive, and encourage people to move there. **FIGURE 3** illustrates a range of potential pull factors.

push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere

pull factor favourable quality or attribute that attracts people to a particular location

FIGURE 3 Examples of pull factors include religious tolerance, improved healthcare, job opportunities, family links, better housing and infrastructure, political freedom and better educational opportunities.

5.2 SKILL ACTIVITY: Questioning and researching using geographical methods

1. As a class or in small groups, **create** a survey to gather migration information from your class, your year level, your whole school, or your wider community.

   Develop questions that address:
   - the categories of migration types
   - whether the migration was international (between countries) or internal (within a country)
   - the place of origin
   - the place of destination
   - push factors
   - pull factors.
2. After gathering your data, **decide** on the best way to **present** your findings. You may wish to consider creating maps, graphs, or tables, and incorporate the use of relevant images.

5.2 Exercise

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5.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 5	3, 4, 6	7, 8

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Check your understanding

1. Anh Do's family migrated internationally. **Identify** their country of origin.
   A. Cambodia
   B. Vietnam
   C. Laos
   D. Indonesia
2. **Determine** whether the following statements are true or false.
   a. The decision to migrate was forced for Anh Do and his family. This means that they freely chose to move for reasons that benefitted them.
   b. War is a pull factor.
   c. Religious freedom is a push factor.
   d. Desertification is a push factor.
   e. Internal migration is when migrants choose to move from one place within a country to another.
3. Seasonal migrants move for a specific period of time for ________ or due to ________ reasons.
4. **List** two examples of push factors.
5. **List** two examples of pull factors.

Apply your understanding

Communicating

6. **Distinguish** between push and pull factors.
7. 'Transport and pollution are not problems in large urban areas because so many people live in the city that they don't have to use transport to get to and from work.'
   Determine whether this statement is true or false. **Justify** your answer.
8. Imagine you live in a poor rural village in India with no education or work. **Create** a list of all the possible attractions of moving to an urban area.

LESSON
5.3 Why do people migrate between countries?

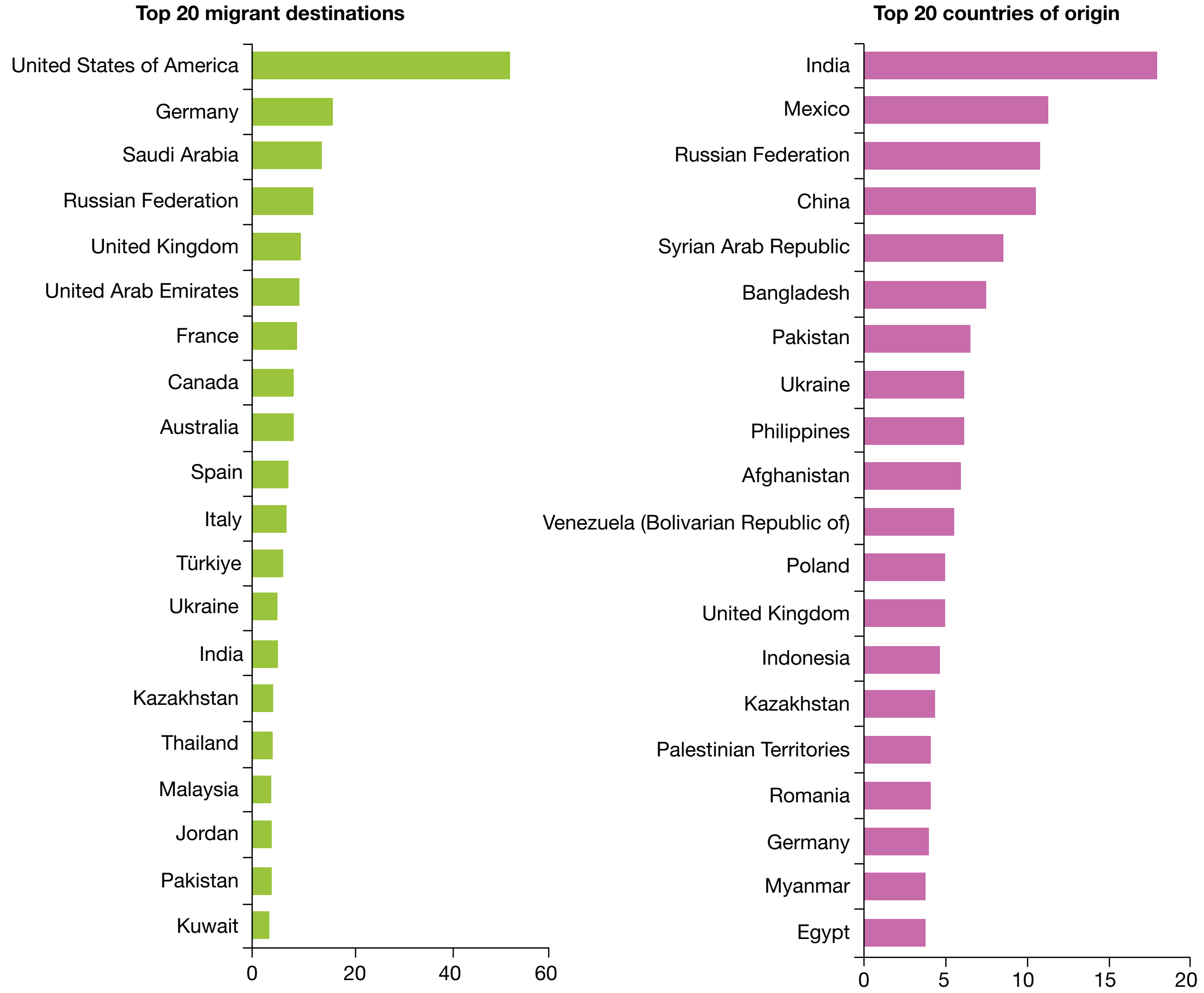
LEARNING INTENTION

By the end of this lesson you should be able to describe patterns of, reasons for, and effects of international migration, with a particular focus on migration to Australia.

TUNE IN

The International Organization for Migration (IOM) is part of the United Nations system. In addition to providing services and advice to governments and migrants, they also track migration data. Every year they release a report on migration. **FIGURE 1** lists the top 20 destinations of international migrants as well as the top 20 countries of origin.

FIGURE 1 Top 20 destinations (left) and origins (right) of international migrants in 2020 (millions)



Source: UN DESA, 2021a.

With a partner, consider the figure and use the thinking routine of 'See, Think, Wonder' to discuss your ideas and then share them with the class.

- See — observe a piece of information provided by the figure.
- Think — what does this information make you think about migration destinations or origins?
- Wonder — what question could you ask about this information? What are you curious to know more about?

5.3.1 What is the difference between an emigrant and an immigrant?

When people move from one country to live in another, they are considered to be both emigrants and immigrants. They are emigrating, or exiting from, their country of origin, and immigrating, or moving into, their destination country. For example, a person moving from Thailand to live in Australia would be emigrating *from* Thailand and immigrating *to* Australia. In this scenario, Thailand is the country of origin (sometimes called the donor country) while Australia is the destination country (sometimes called the host country).

5.3.2 Where are people moving to and from internationally?

FIGURE 1 lists the top 20 destinations of international migrants as well as the top 20 countries of origin. In 2020, the United States of America was the most popular destination for international migrants, while the highest number of migrants were coming from India. Australia was a top ten destination for migrants in 2020. Some countries feature on both lists.

Annual net migration takes into account the difference between the number of people who move to a country and the number of people who leave it over the course of a year. **FIGURE 2** provides a global picture of annual net migration from 2015–20. Countries in green are those who received more immigrants (people arriving) than emigrants (people leaving), whereas the opposite occurred in countries that are red. If more people arrive than leave, this is called positive net migration; if more people leave than arrive, this is called negative net migration.

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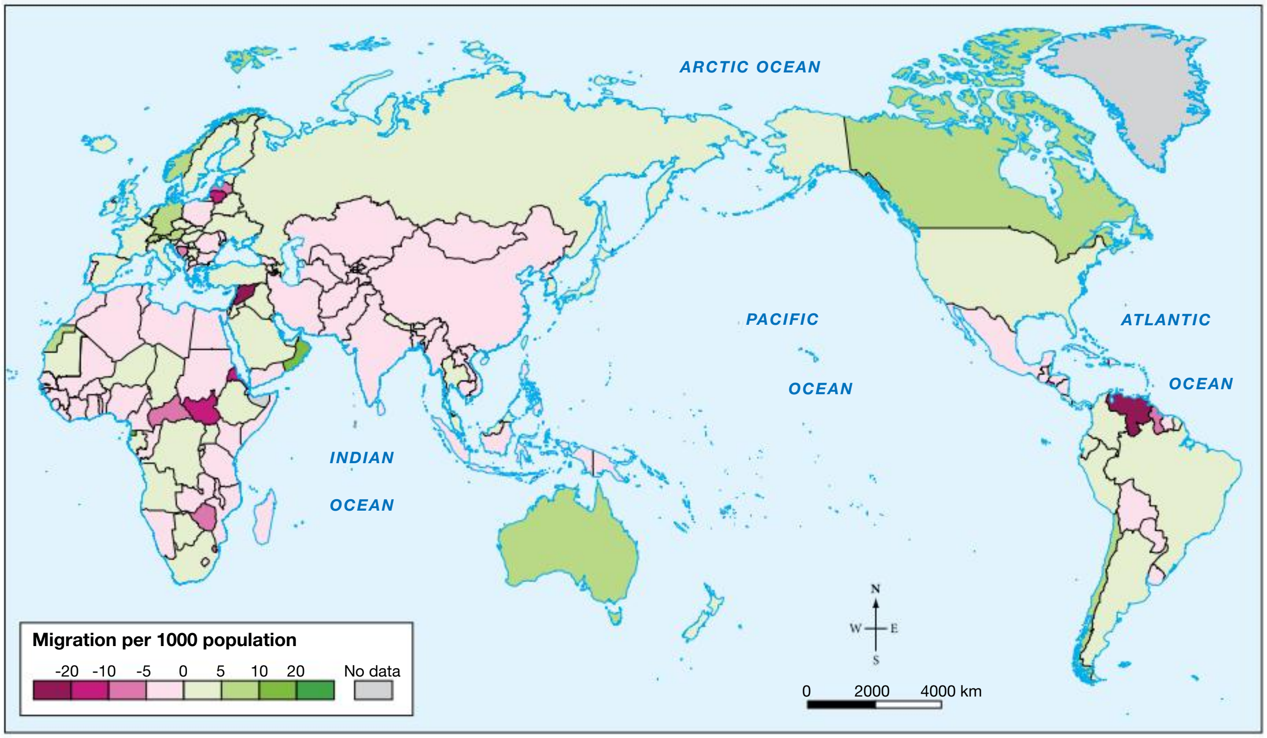
tlvd-10630

FIGURE 2 Annual Net Migration rate, 2015–20



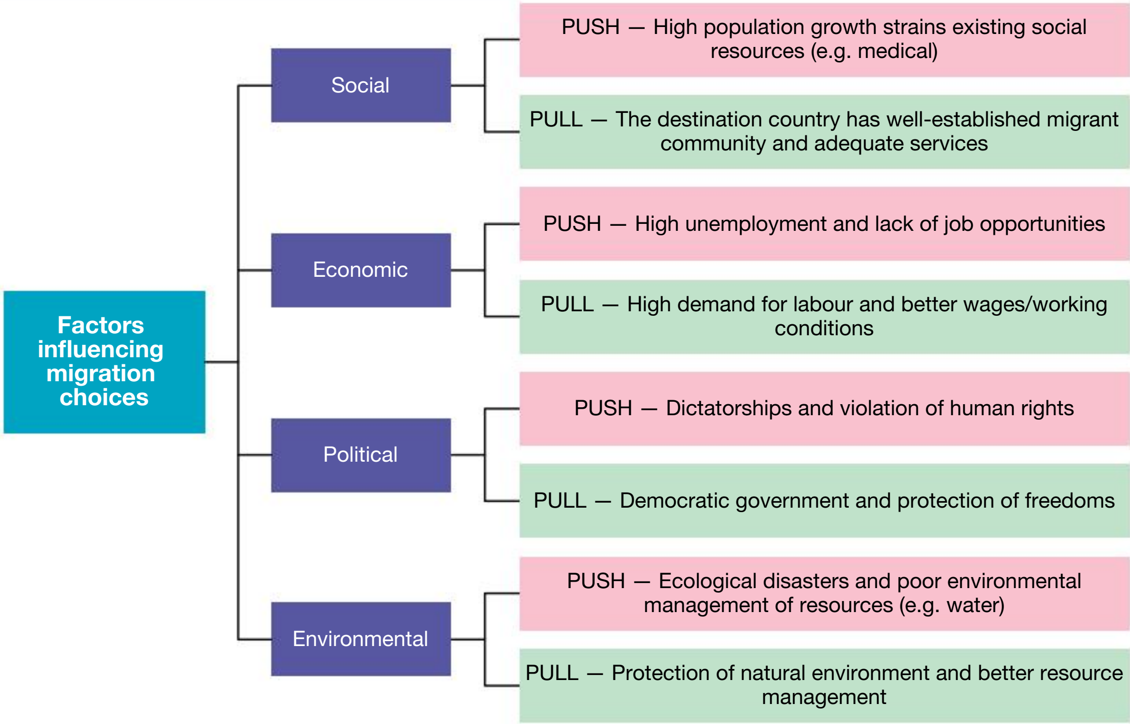
Source: Based on data from United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1. Map redrawn by Spatial Vision.

5.3.3 Why are people moving internationally

There are a range of push and pull factors that influence why people choose to move and where they choose to move to, and these can be broadly categorised as social, economic, political or environmental reasons (see **FIGURE 3**).

int-9019

FIGURE 3 Factors influencing migration choices



5.3.4 Where are international migrants to Australia from?

Between 1851 and 1861 more than 600 000 people came to Australia. While the majority were from Britain and Ireland, 60 000 came from Continental Europe, 42 000 from China, 10 000 from the United States and just over 5000 from New Zealand and the South Pacific. However, since 1975, the country has attracted more immigrants from Asia (see **FIGURES 4** and **5** and **TABLE 1**).

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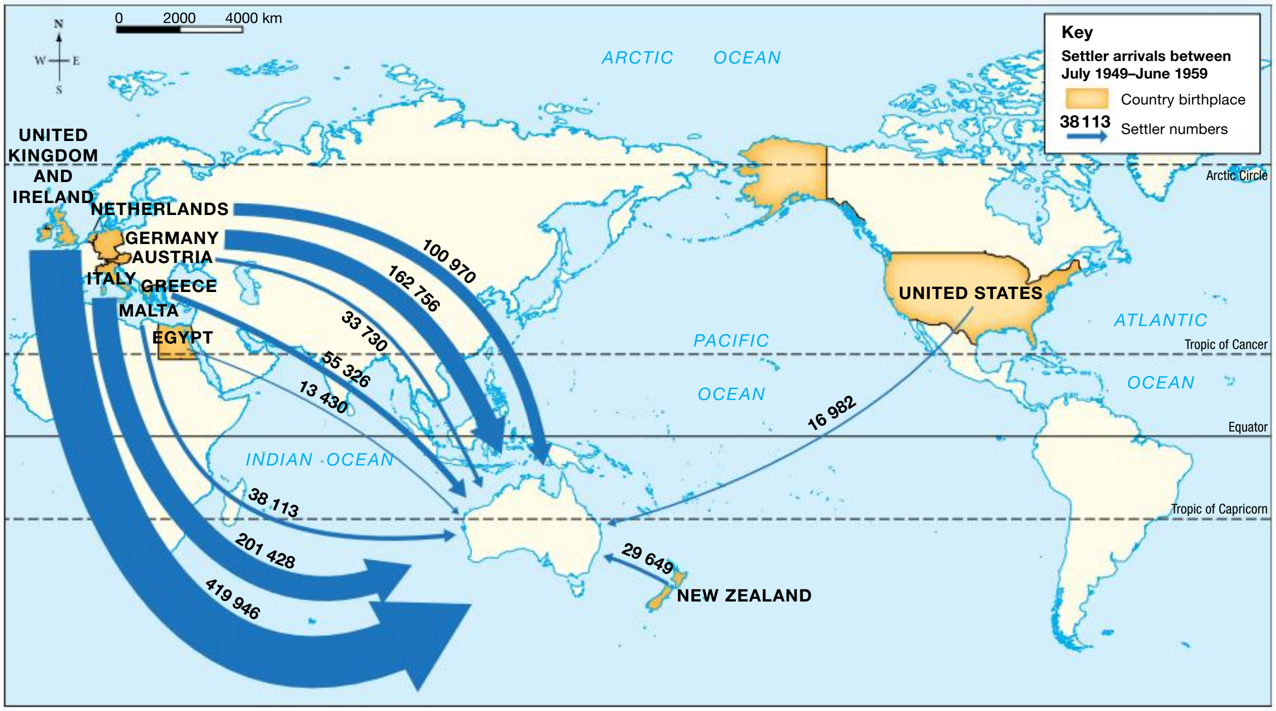
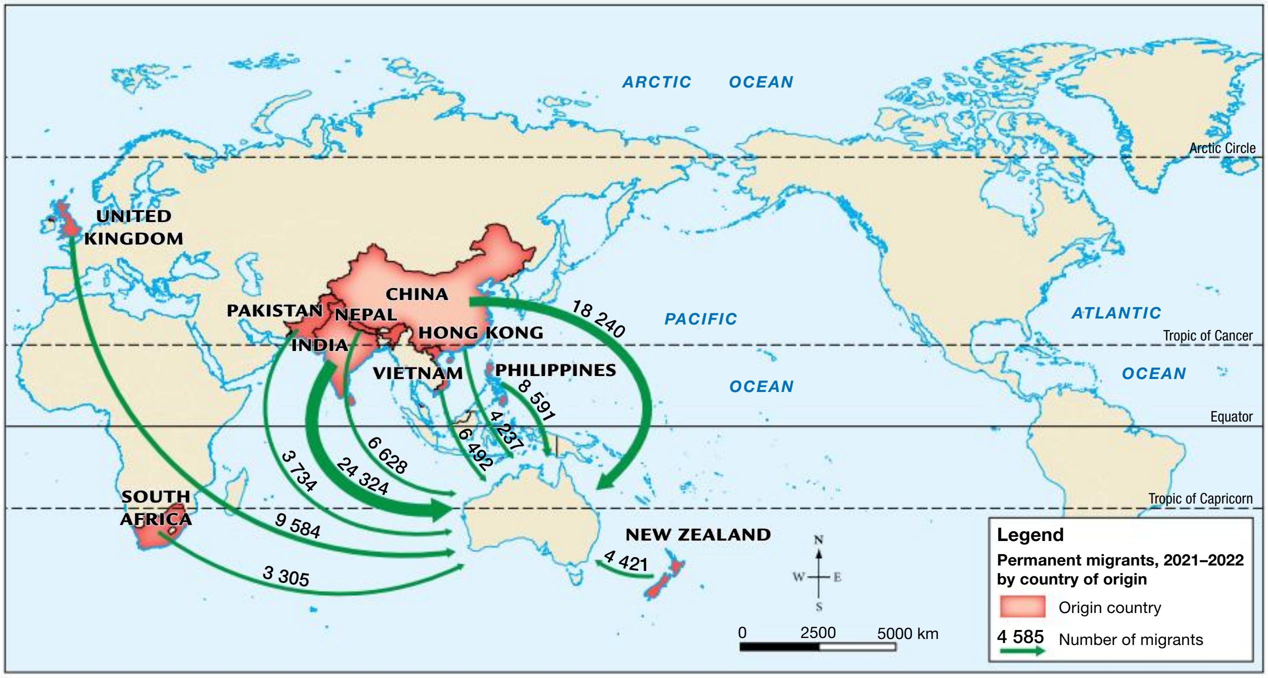
FIGURE 4 Origins of Australia's migrants, 1949–59



Source: Map drawn by Spatial Vision.

FIGURE 5 Settler arrivals by country of birth according to the 2021 census



Source: Australian Government, Department of Home Affairs.

About one-third of the population of our large cities was born overseas. Migrants from certain countries tend to be attracted to certain Australian states and territories more than others (see **TABLE 1**).

TABLE 1 Top five countries of birth by state or territory ('000), 2016

ACT	NSW	NT	Qld	SA	TAS	VIC	WA
England (13.3)	China (256.0)	England (6.7)	New Zealand (200.4)	England (103.7)	England (20.5)	England (192.7)	England (213.9)
China (11.9)	England (250.7)	Philippines (7.0)	England (219.9)	India (29.0)	New Zealand (5.4)	India (182.8)	New Zealand (87.4)
India (10.9)	India (153.8)	New Zealand (5.6)	India (53.1)	China (26.8)	China (3.3)	China (176.6)	India (53.4)
New Zealand (5.0)	New Zealand (127.9)	India (4.2)	China (51.6)	Italy (20.2)	India (2.1)	New Zealand (102.7)	Philippines (33.4)

Most recent data available at time of publishing

FIGURE 6 Queensland has been a popular destination for migrants from New Zealand.

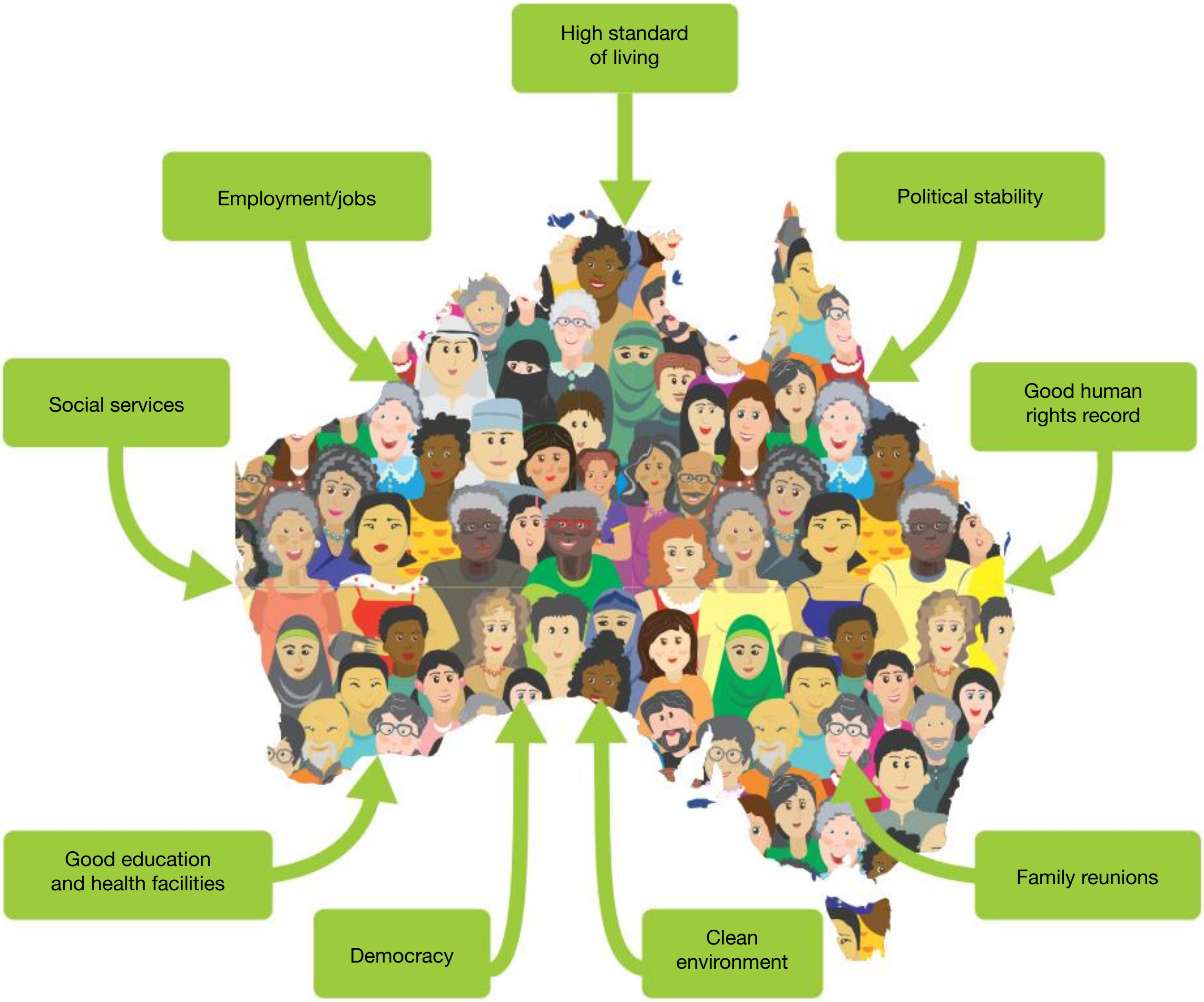
5.3.5 Why have people migrated to Australia?

Australia is a land of **migrants**. In a way, all non-First Nations Australians are migrants — at some stage in the past, our ancestors came to this country to live. In 2021, nearly half of Australia's population was born overseas.

migrant a person who leaves their own country to go and live in another

Since the earliest times, people have moved from one part of the world to another in search of places to live. Migrants have come to Australia for many reasons (see **FIGURE 7**).

FIGURE 7 Reasons for immigration to Australia



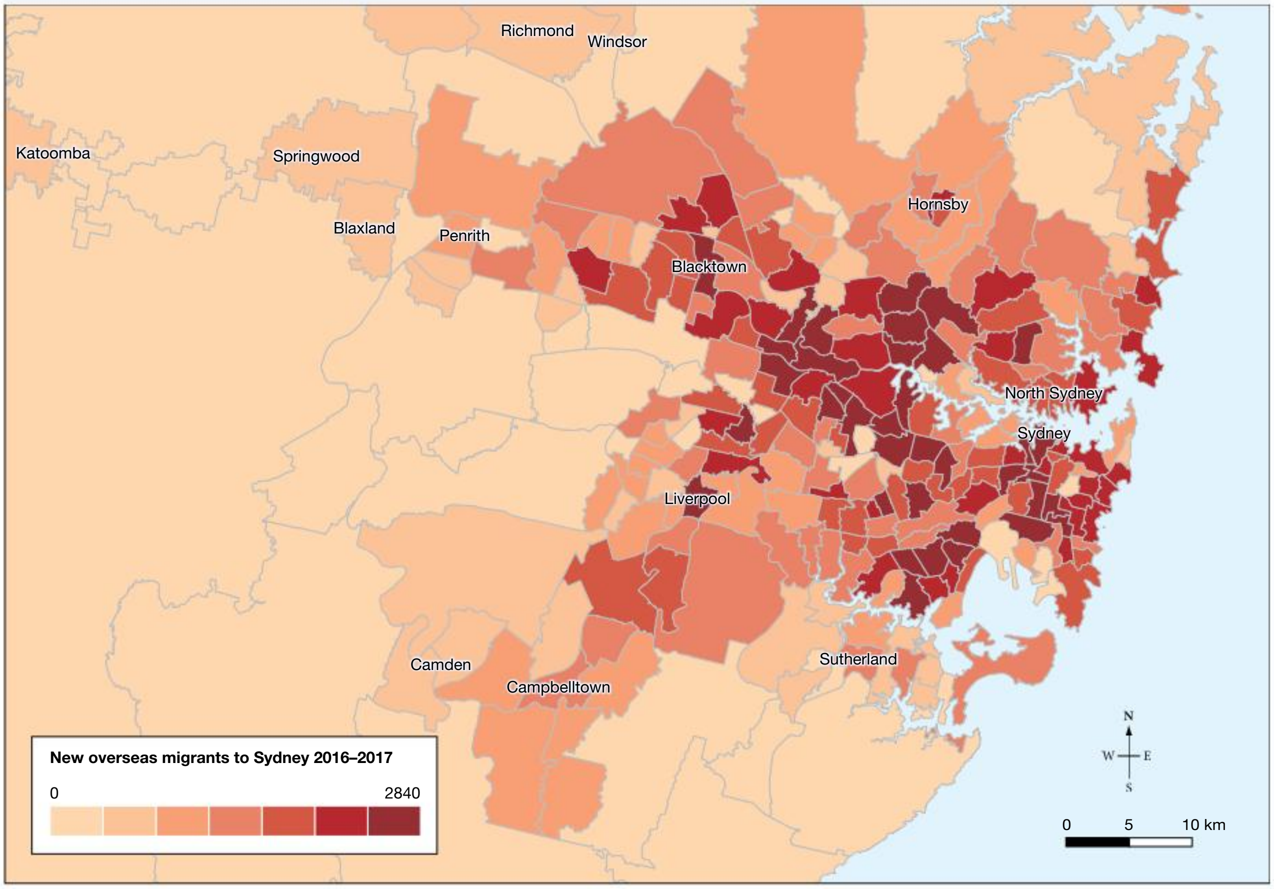
In addition, Australia is interconnected to Asia, particularly through trade and geographic proximity. This makes Australia appealing as a destination country for migrants from China, India, Vietnam, and other Asian countries. The shared historical connections and/or common language may increase the appeal of Australia as a destination country for migrants from other English-speaking countries such as England and New Zealand.

5.3.6 What are the effects of international migration to Australia?

Social effects

Migration has helped increase Australia's population. The increase in population from only seven million at the end of World War II to more than triple that now is caused by both the arrival of migrants and increased birth rates since then (see **FIGURE 9**).

FIGURE 8 Distribution of new overseas migrants to Sydney, 2017



Source: *The Sydney Morning Herald*.

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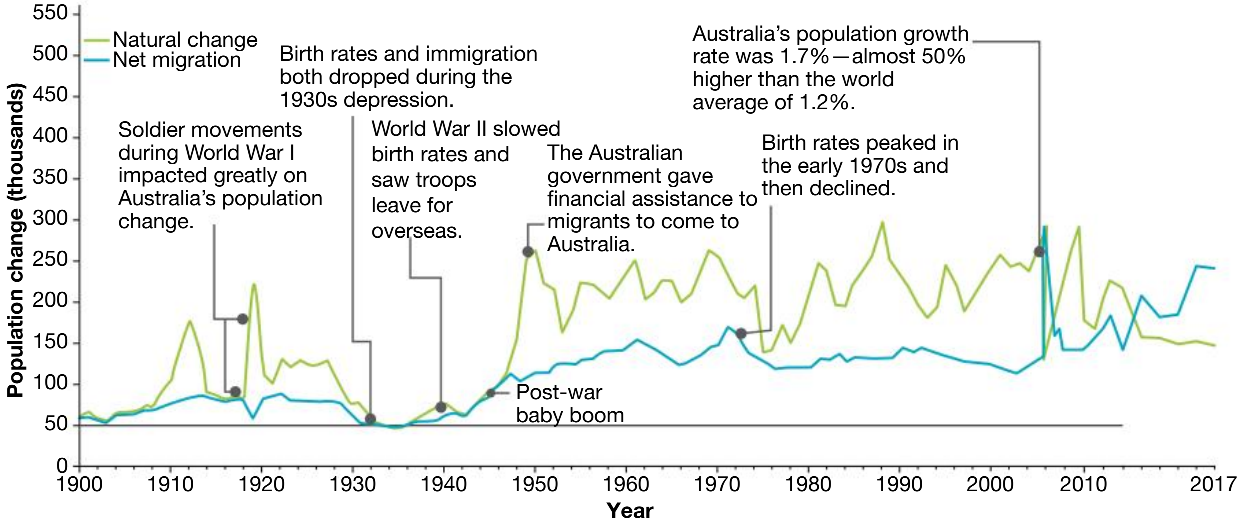
FIGURE 9 Australia's population growth, 1900–2017



Migrants to Australia have contributed to our society, culture and prosperity. Many communities hold festivals and cultural events where we can all share and enjoy the foods, languages, music, customs, art and dance.

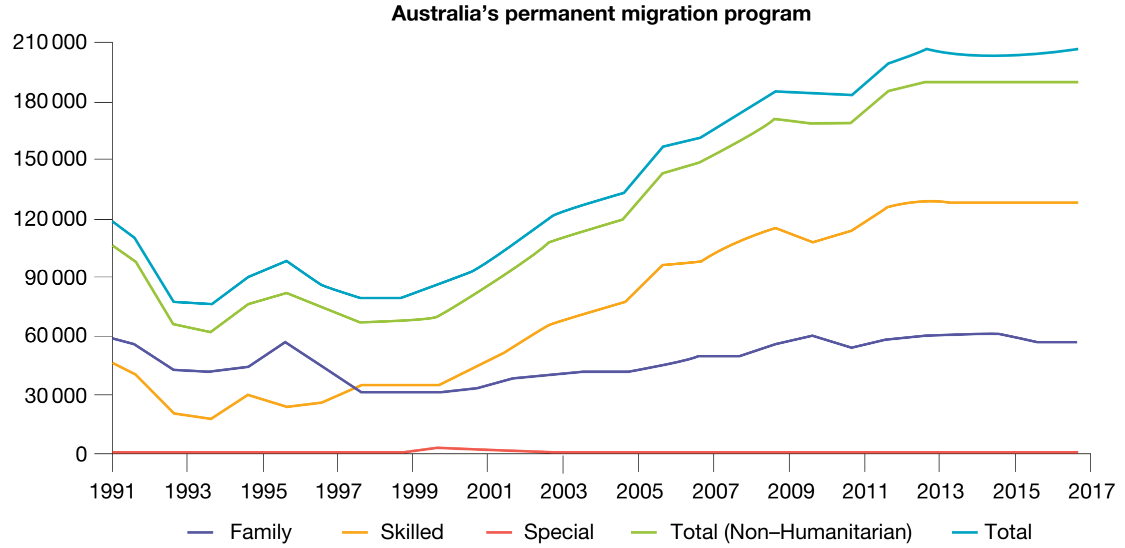
Australian society is made up of people from many different backgrounds and origins. We have come from more than 200 countries to live here. Therefore, we are a very multicultural society, one that needs to respect and support differences, and the rights of everyone to have their own culture, language and religion.

Economic effects

An increased population also means a greater demand for goods and services, which stimulates the economy. Migrants need food, housing, education and health services, and their taxes and spending allow businesses to expand. Apart from labour and capital (money), migrants also bring many skills to Australia (see **FIGURE 10**).

Migrants generate more in taxes than they consume in benefits and government goods and services. As a result, migrants as a whole contribute more financially than they take from society.

FIGURE 10 Types of migrants to Australia, 1991–2017



Source: Department of Immigration.

Environmental effects

In the past, people argued that immigrants put pressures on Australia's environment and resources by increasing our population and the need for water, energy and other requirements. However, today many people believe that Australia's environmental problems are not caused by migration and population increase, but by inadequate planning and management.

5.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Refer to **FIGURE 1** and write down the top ten destination countries and the top ten origin countries (note down any countries that appear on both lists).
2. **Select** one colour to represent the destination countries.
3. **Select** a different colour to represent the origin countries.
4. **Select** a third colour for any country that appears on both lists.
5. On a blank map of the world (ideally A3 in size), use your chosen colours and highlight the countries from your list. Use a political map in an atlas to assist you in locating each country.
6. On your completed map, remember to include all BOLTSS.
   a. *Legend* — tell your reader what colours are used to represent the different categories of countries.
   b. *Title* — this should be specific and informative. The title of the graph your sourced your data from is a good starting point.
   c. *Source* — this should tell your reader where you got your information from (therefore it will be the same source as the graph's source).
7. *Going further:* **Discuss** your map with a classmate. Can see you any patterns? Where are most of the destination countries located? Where are most of the origin countries located? What are some push and pull factors that may apply to this data?

5.3 Exercise

learnon

5.3 Exercise

Learning pathways

■ LEVEL 1 2, 3	■ LEVEL 2 1, 4, 5, 8	■ LEVEL 3 6, 7, 9, 10

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Check your understanding

1. Refer to **FIGURES 4** and **5**. **Describe** how the origins of our migrants have changed since 1949.
2. **Determine** whether the following statements are true or false.
   a. The greatest number of migrants are in Australia for family reasons or are skilled workers.
   b. In 2020, Australia was the most popular destination for international migrants.
   c. Since 1975, Australia has attracted more immigrants from Asia.
3. **Select** from the words in the table to complete the statement below.

emigrant	donor	immigrant	host

A person leaving one country to move to another is called an ________. The country they are moving from can be considered the ________ country. When they enter a new country, they become classified as an ________ and the new country is considered the ________ country.

4. Refer to **FIGURE 9**. **Describe** how important migration has been in terms of Australia's population growth.
5. **Consider FIGURE 1**. A number of countries feature on the list of top 20 destination countries for international migrants as well as the list of top 20 origin countries. **Select** those that apply from the list below:
   A. Thailand
   B. Romania
   C. Russian Federation
   D. India
   E. Mexico
   F. Kazakhstan
   G. Australia

Apply your understanding

Interpreting and analysing geographical data and information

6. Refer to **FIGURE 10. Explain** the general pattern for each of the following types of migration to Australia between 1991 and 2020.
   a. Skilled migrant
   b. Family
   c. Total numbers
7. Refer to **TABLE 1** and **FIGURE 8. Describe** how the distribution of the areas of settlement by migrants varies within Australia.
8. Refer to **FIGURE 7. Consider** the main reasons why people would migrate to Australia.

Communicating

9. **Determine** the two main benefits of migration to Australia. Give reasons for your answer.
10. What types of skills would you place at the top of the list for skilled migrants to Australia? **Justify** your answer.

LESSON
5.4 Why do people migrate within countries?

LEARNING INTENTION

By the end of this lesson you should be able to explain why people within Australia and China move domestically, and describe the concept of internal displacement.

TUNE IN

Australians move from place to place within Australia for a number of reasons; some of these are illustrated in **FIGURE 1**.

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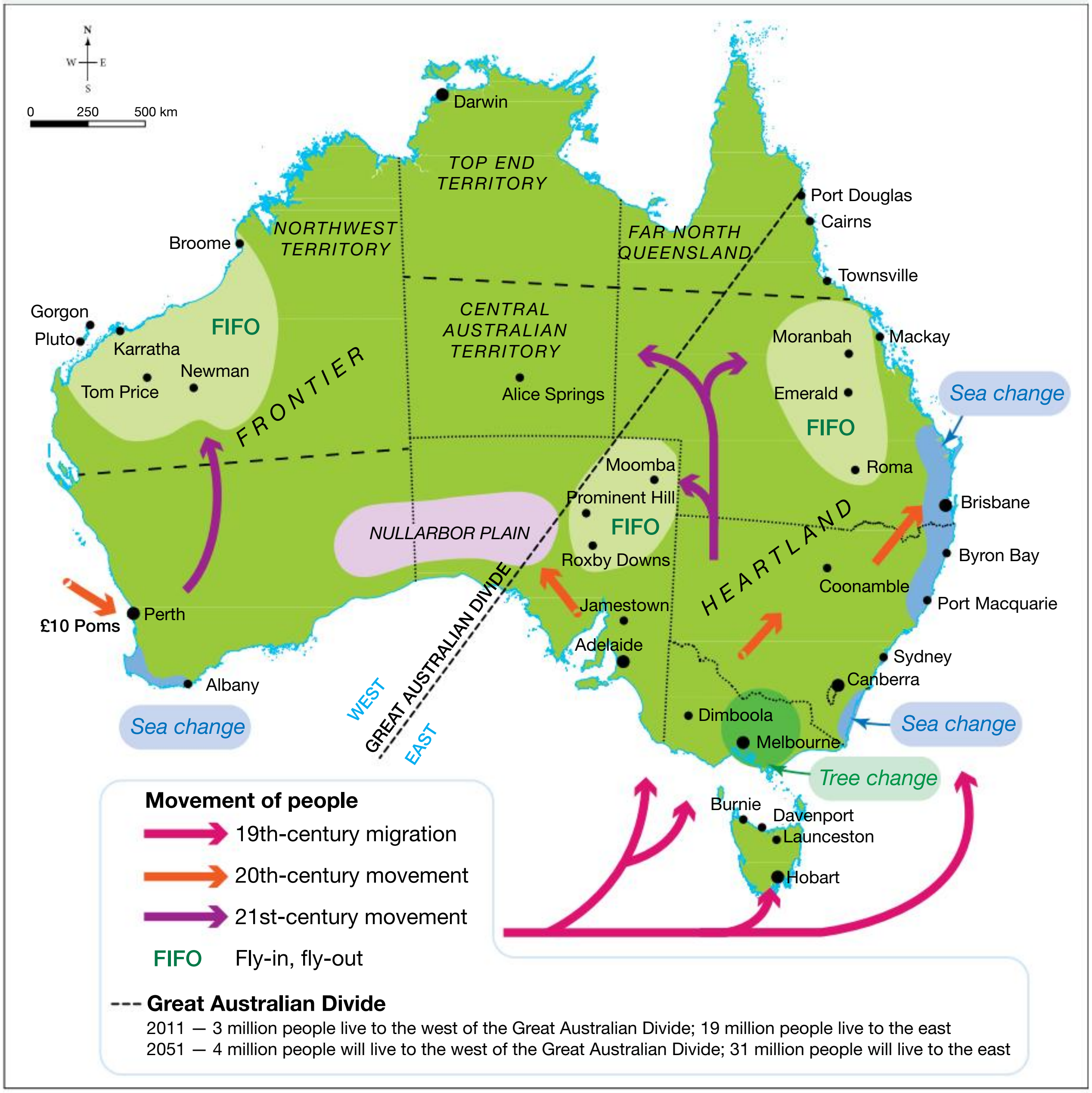
FIGURE 1 Australia's moving population



Source: Map drawn by MAPgraphics Pty Ltd, Brisbane; most recent data available at time of publishing.

1. What do you think is meant by the terms 'sea change' or 'tree change'?
2. FIFO is an acronym that refers to workers who 'Fly-In, Fly-Out' of locations. Look at the regions identified as FIFO on the map. What do you know about these regions? What is the focus industry for these regions that workers are employed within?
3. Do you personally know any FIFO workers or people who have been involved in a sea or tree change?

5.4.1 What makes people move within Australia?

People move for many reasons. The average Australian will live in 11 houses during their lifetime — this means that many people will live in more. You may move to live in a larger house, or a smaller house as your family size or income changes. On retirement you may want to live near the mountains or the sea.

Fifty per cent of Australians changed the place where they lived in the five years between 2011 and 2016. Most of the moves were limited to local areas, especially within capital cities, but some moves involved a change of state or territory.

The major movements of Australians since 1788 are shown in **FIGURE 1**. The Great Australian Divide separates Australia into two regions, known as the Heartland and the Frontier. This means the Heartland is home to approximately 21 million people who live in a modern, urbanised, industrial state. The Frontier is a sparsely populated region of around five million people who live in a place that is remote but rich in resources.

Sea change or tree change

The population movement caused by '**sea change**' or '**tree change**' — a move from an urban environment to a rural location — is a national issue affecting coastal and forested mountain communities in every state in Australia. The movement involves people who are searching for a more peaceful or meaningful existence, who want to know their neighbours and have plenty of time to relax. Local communities in high-growth coastal and mountain areas often cannot afford the services and increased infrastructure, such as roads, water and sewerage, that a larger population requires. Geelong, Bussleton, Wollongong, Cairns and the Gold Coast are all popular places for sea changers to settle.

sea change movement of people from major cities to live near the coast to achieve a change of lifestyle

tree change movement of people from major cities to live near the forest to achieve a change of lifestyle

Not every sea changer loves their new life, and many return to the city. Factors such as distance from family, friends, cultural activities and various professional or health services may pull people back to their previous city residences.

FIGURE 2 Geelong, Victoria is a popular location for sea changers.

Fly-in, fly-out workers

Employment opportunities have grown within the mining industry in places such as the Pilbara in northern Western Australia. However, local towns do not have the infrastructure, such as water, power and other services, to support a large population increase. Rental payments for homes can be as high as $3000 per week. One way to attract workers to these regions is to have a **fly-in, fly-out (FIFO)** workforce. FIFO workers are not actually 'settlers', because they choose not to live where they work. Some mine workers from the Pilbara live in Perth or even Bali, and commute to their workplace on a weekly, fortnightly or longer-term basis. The permanent residents of these remote towns are uneasy with the effects of the FIFO workforce because they change the nature of the town but choose not to make it their home. By not living locally, their wages leave the region and are not invested in local businesses and services.

Seasonal agricultural workers

Many jobs in rural areas are seasonal, such as the picking and pruning of grapes and fruit trees, which requires a large workforce for only a few months each year. Many children born in rural areas leave their homes and move to the city for education, employment or a more exciting lifestyle than the one they knew in the country. This means that there are not enough agricultural workers to cover the seasonal activities.

Backpackers and people from Asia and the Pacific Islands on short-term work visas often provide the seasonal workforce in these regions. Country towns such as Robinvale in northern Victoria now have Asian grocery stores, an Asian bakery and a shop selling Tongan canned goods, providing the seasonal farm workforce with a taste of home. Robinvale has many people from different nationalities living as both permanent residents and seasonal workers. These include people from a wide variety of countries, including Italy, Tonga, Vietnam, Malaysia, New Zealand, China and Greece.

5.4.2 What makes people move within China?

For the sea/tree changers, FIFO workers, and seasonal workers of Australia, the internal migration is mainly from urban areas to rural locations. The opposite is true of China.

China has been experiencing a changing **population distribution**. In 2012, the country's urban population became larger than that of rural areas for the first time in its history, as rural people moved to towns and cities to seek better living standards. China has become the world's largest urban nation.

fly-in, fly-out (FIFO) a system in which workers fly to work, in places such as remote mines, and after a week or more fly back to their home elsewhere

population distribution the pattern of where people live; population distribution is not even – cities that have high population densities and remote places such as deserts usually have low population densities

FIGURE 3 A dramatic rural–urban migration shift has been occurring in China.

Chinese labourers from the provinces have been moving to coastal cities in search of job opportunities, following reforms in 1978 that opened up China to foreign investment. Until then, rural–urban migration was strictly forbidden in China. Since then, more than 150 million peasants have migrated from the inner provinces to cities, mainly on the east coast. About half of rural migrants moved across provinces. This is the largest migration wave in human history (see **FIGURE 4**).

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FIGURE 4 People from Chinese inland provinces with lower wages and Human Development Index (HDI) values have moved to cities and provinces with higher HDIs and incomes.

Source: Map drawn by Spatial Vision.

Pull factors

Pull factors are factors about a place that attract people to move to them. Migrants from rural areas are attracted to urban regions largely for economic reasons — a higher income is achievable in a city. The average income of rural residents is about one-fifth that of urban residents on the east coast of China. Social factors are also important, with more opportunities for career development being available in cities. Many people also desire a more modern urban lifestyle, with the benefits brought about by access to improved infrastructure and technology.

Push factors

Push factors are factors that encourage people to move away from a place. Increasing agricultural productivity since the late 1970s has resulted in fewer labourers being needed on farms and thus a huge surplus of rural workers. These people have been forced to move to more urban areas in order to find employment. Agricultural production has meanwhile become less profitable, so workers have again been driven to cities to try to improve their economic situations.

Political factors are also influential. China's central planners have encouraged local leaders in poor regions to encourage people to move to the cities. Their slogan was 'the migration of one person frees the entire household from poverty'.

FIGURE 5 In 2022, Shanghai's population was estimated to be 29.21 million.

5.4.3 Consequences of rural–urban migration

There are several positive and negative consequences of the rural–urban migration in China. These include:

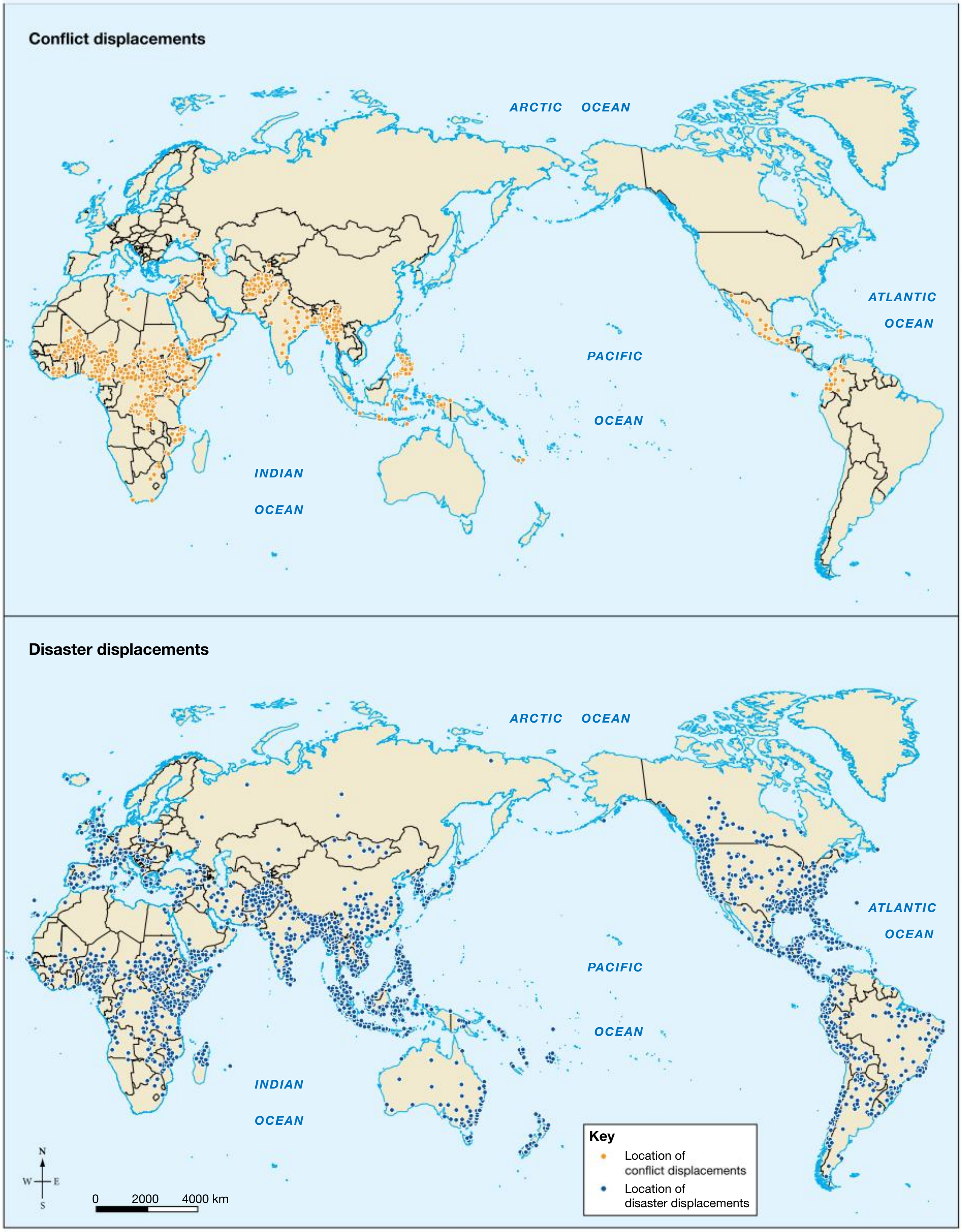
- China's urban population rose from around 170 million people in 1978 to 540 million in 2004, and then to nearly 839 million in 2018.
- In 1949, 89 per cent of people lived in rural areas; by 1979 this figure had dropped to 81 per cent. In 2018 it was 59.3 per cent.
- It is expected that by 2050, only 25 per cent of China's population will be living in rural areas, while the number of city-dwellers will reach 940 million people.
- Some people predict that by 2025, China will have 19 super-cities (extremely large cities that house millions of people) with an average population of 25 million people each.
- Labourers from rural regions working in cities have to leave their families for months at a time or more.
- Tens of millions of people are classified as rural dwellers, even though they spend most or all of their time working in the cities. These people are denied access to social services, including subsidised housing, income support and education for their children.
- A shift to an increased urban population results in reduced population pressures on the land.
- Up to 40 per cent of rural income comes from urban workers sending money to their families at home.

5.4.4 What is internal displacement?

The examples from Australia and China mostly concern residents who have chosen to move voluntarily. For some people, this is not always the case. **Internal displacement** is when people are forced to leave their home due to conflict or environmental disasters, but remain within their country's borders. A total of 40.5 million new internal displacements occurred by the end of 2020, with 76 per cent of these due to disasters and 24 per cent due to conflict and violence. During this period, the Democratic Republic of Congo and the Syrian Arab Republic had the highest number of new displacements due to conflict and violence at 2.2 and 1.8 million respectively.

internal displacement when people are forced to leave their homes due to conflict or environmental disasters, but remain within their country's borders

FIGURE 6 Conflict displacements (top) and disaster displacements (bottom) in 2020 by location



Source: *World Migration Report* 2022, *International Organization for Migration*.

5.4 SKILL ACTIVITY: Questioning and researching using geographical methods

1. In pairs, **conduct research** on the internet into the impact that COVID-19 (and extended lockdowns in particular) had on the number of tree changes and sea changes occurring in Australia during 2020–21. In conducting your research, try to find the following:
   - origins and destinations of migrants (where were people mostly moving from/to)
   - factors that made the migration possible (e.g. ability to work from home)
   - relevant statistics.

The ABS website may be a useful place to start. Search phrases such as 'migration within Australia COVID' or 'migration Australia COVID seachange' to explore other resources. Remember to keep the focus on migration WITHIN Australia rather than between Australia and other countries.

2. **Communicate** your findings by **creating** an infographic.

5.4 Exercise

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5.4 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4	3, 5, 6	7, 8, 9, 10

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Check your understanding

1. FIFO workers are those who permanently live in a remote work location. True or false?
2. **State** the difference between a tree changer and a sea changer.
3. **List** the positive and negative factors of making a tree change or sea change as a:
   a. family with young children
   b. retired couple.
4. The percentage of people living in China's rural areas has changed since 1949. In 1949, ________ per cent of people in China lived in rural areas. By 2018, this had decreased to ________ per cent. It is expected that within 20 years, ________ per cent will live in urban areas.
5. There are many consequences of the dramatic changes in China's population distribution. **Classify** the following consequences as either positive or negative.
   a. Urban population growth
   b. Labourers leave families for months at a time
   c. Smaller percentage of people living in rural areas
   d. Development of super cities
   e. Migrants classified as rural dwellers who live in the cities are denied access to social services subsidised housing, income support and education for their children
   f. Greater income flows to rural areas from urban workers

Apply your understanding

Communicating

6. **Describe** some of the push factors that led rural peasants to leave their homes for the cities.
7. A more recent population migration is towards high-rise apartment living in the centre of major cities. How might this trend impact on these new residents and the sustainability of the environment their migration is creating? Use examples to **justify** your stance.
8. **Discuss** why the Chinese government would encourage this mass movement of people from the country to the cities?
9. Internal displacement within a country occurs due to conflict or environmental disasters. In 2020, DRC and Syria had the highest number of new displacements. Drawing on your wider knowledge of current or recent world events, **predict** where you expect an increase in internal displacements to occur and **explain** why.
10. In Australia, **determine** what initially led to people leaving rural areas for life in the city.

LESSON
5.5 Why do people migrate from the country to the city?

LEARNING INTENTION

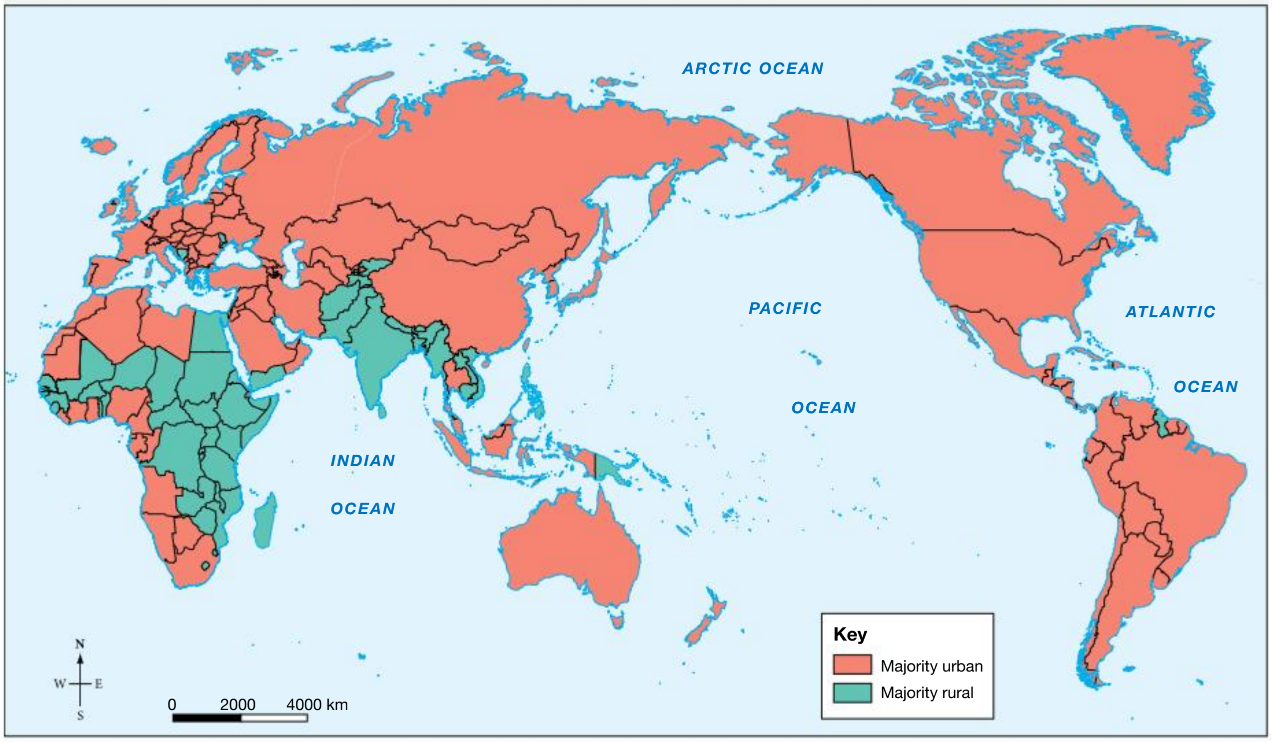
By the end of this lesson you should be able to explain the reasons why people move from rural areas to urban settings.

TUNE IN

Over the course of history, the global population has changed from being primarily rural to primarily urban. Whilst this increase is partially due to natural population increases, the decision of people to move from country to city areas has contributed to this growth.

Consider **FIGURE 1**:
1. Which continents have a majority of countries with a mostly urban population?
2. Which continents have a majority of countries with a mostly rural population?
3. Brainstorm reasons why some continents are more urbanised than others.

FIGURE 1 Do more people live in urban or rural areas in 2022?



Source: Based on data from Do more people live in urban or rural areas? 2022. Our World in Data. Licensed under CC BY 4.0. Map redrawn by Spatial Vision.

5.5.1 What is urbanisation?

As shown in lesson 5.4, many of the internal migration movements in Australia were from one urban (city or town) area to another or from an urban area to a rural (country) area. In China, the internal movement was more likely to be from rural areas to urban areas. In this lesson, you will explore this phenomenon in more detail.

Urbanisation refers to the growth of and expansion of urban areas and the increase in the proportion of people living in urban areas as compared to rural areas. In 1800, 98 per cent of the global population lived in rural areas. By 2018, this figure had risen to 56 per cent. Today there are more countries than ever where over 50 per cent of the population lives in an urban area (see **FIGURE 1**) People choosing to move from rural to urban areas has contributed to this growth.

5.5.2 What makes people move from rural to urban locations?

There are many and varied reasons for people migrating to urban locations. These reasons are usually a combination of push and pull factors. Some people are 'pushed' from rural to urban areas within their own country. Others will travel from other countries to urban areas, 'pulled' by better opportunities.

Push factors

Geographical inequality is mostly responsible for the migration of people from rural to urban areas. Push factors that drive people towards cities usually involve a decline in living conditions in the rural area in which the people live. There are various situations that can cause this, including a decrease in the quality of agricultural land (caused by factors such as prolonged drought, erosion or desertification); poverty; lack of medical services or educational opportunities; war; famine from lack of food and/or crop failure; and natural disasters.

Pull factors

Pull factors refer to the attractions of urban areas that make people want to move there. Urbanisation in any country generally begins when enough businesses are established in the cities to provide many new jobs. Pull factors include job opportunities; better housing and infrastructure; political or religious freedom; improved education and healthcare; activities and enjoyment of public facilities; and family links.

People can more easily access basic services in urban areas than in rural areas so, although poverty may be present in urban environments, cities also offer an escape from poverty. Cultural activities are often enhanced in cities that attract migrants from many different areas — food and music are obvious examples. There also tends to be a greater tolerance of different migrant and racial groups living close together.

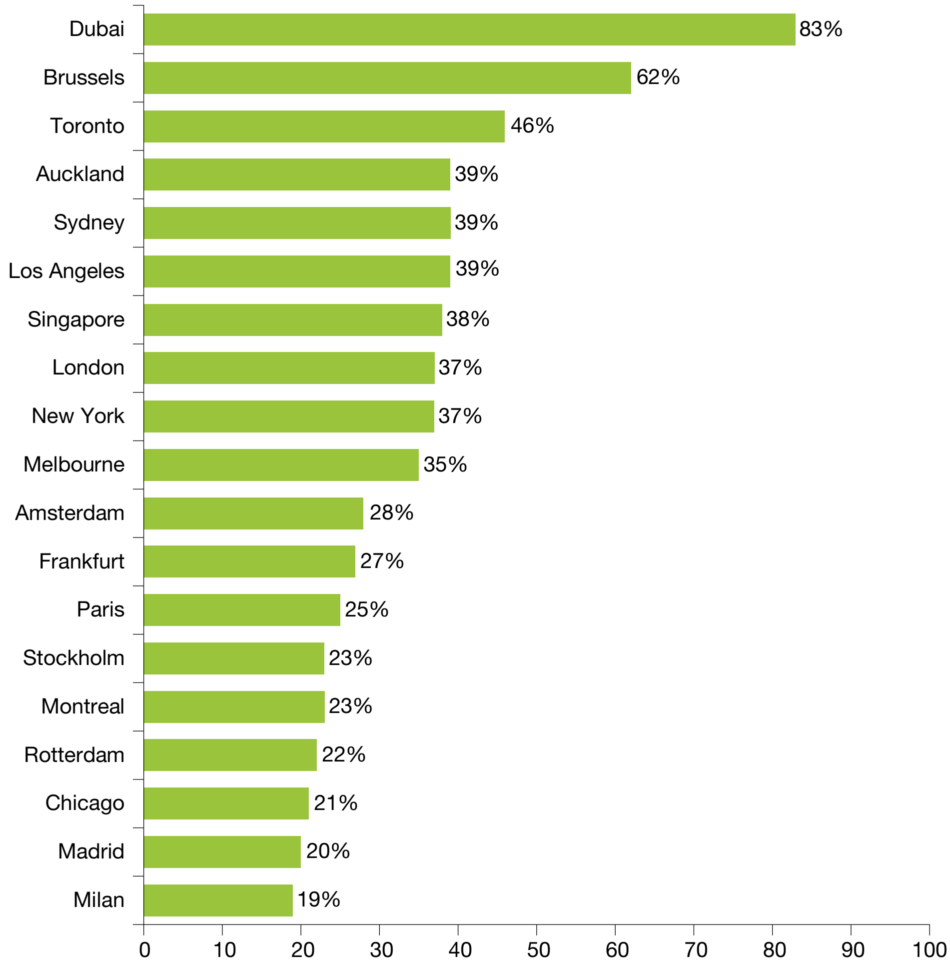
FIGURE 2 Emergency healthcare is one service that may be more easily accessed in urban areas.

5.5.3 What role does employment play?

Taxi drivers, construction workers, teachers, nurses, house cleaners, accountants, nannies — there are many job opportunities for both skilled and unskilled workers that attract people to cities. These people may come from a different area within a country or across borders from different countries. 'Gateway cities' are cities in the world that are arrival points for many migrant workers. These cities are large enough to provide many different jobs and are therefore attractive to people moving from other regions. Some cities, such as Dubai, are reliant on their foreign workers. More than two-thirds of Dubai's population is migrant labour, with many working in building construction. These labourers — mostly from India, Pakistan and Bangladesh — are often poorly paid, and live in migrant camps that can be up to two hours away from the work site. **FIGURE 4** shows the cities with the highest foreign-born population that attract foreign workers.

FIGURE 3 These migrant labourers from Bangladesh, India, and Pakistan work at the construction site of Burj Khalifa in Dubai, United Arab Emirates.

FIGURE 4 Foreign-born populations in gateway cities



5.5.4 What roles does access to services play?

Access to basic services such as clean and safe drinking water and adequate sanitation are major factors that influence the migration of people from rural to urban areas.

Providing clean and safe water and sanitation in rural and urban areas is one of the Sustainable Development Goals (SDGs), Targets 6.1 and 6.2. Not all people have access to safe drinking water and to safely managed sanitation. In some countries, people still defecate in open areas. **FIGURES 5** and **6** show the differences in access to these facilities in rural and urban areas.

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FIGURE 5 Urban and rural population with access to safe drinking water, 2015

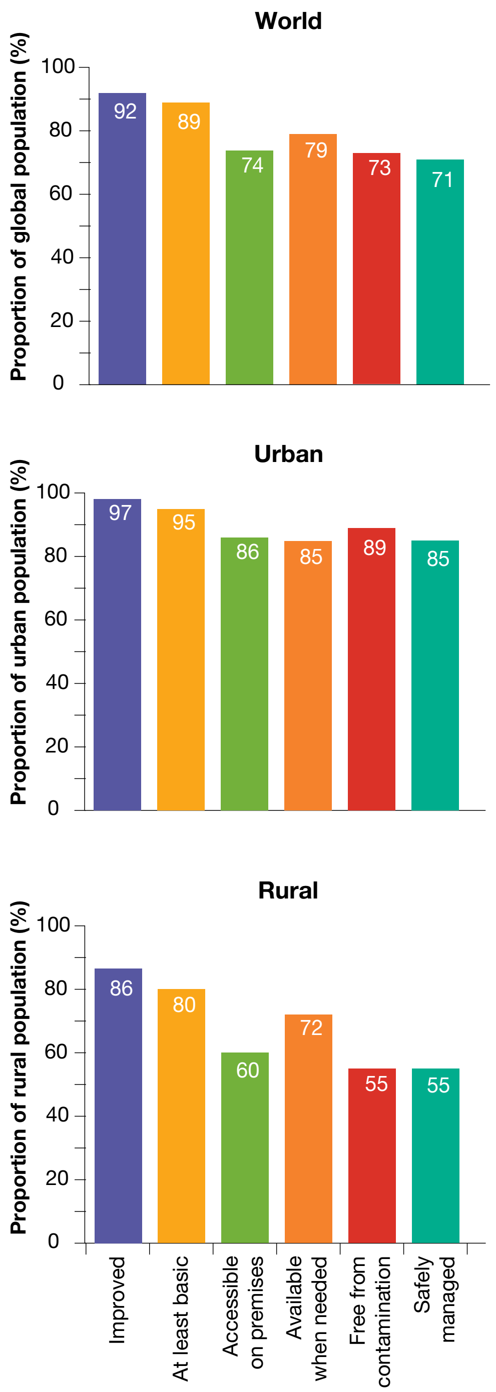
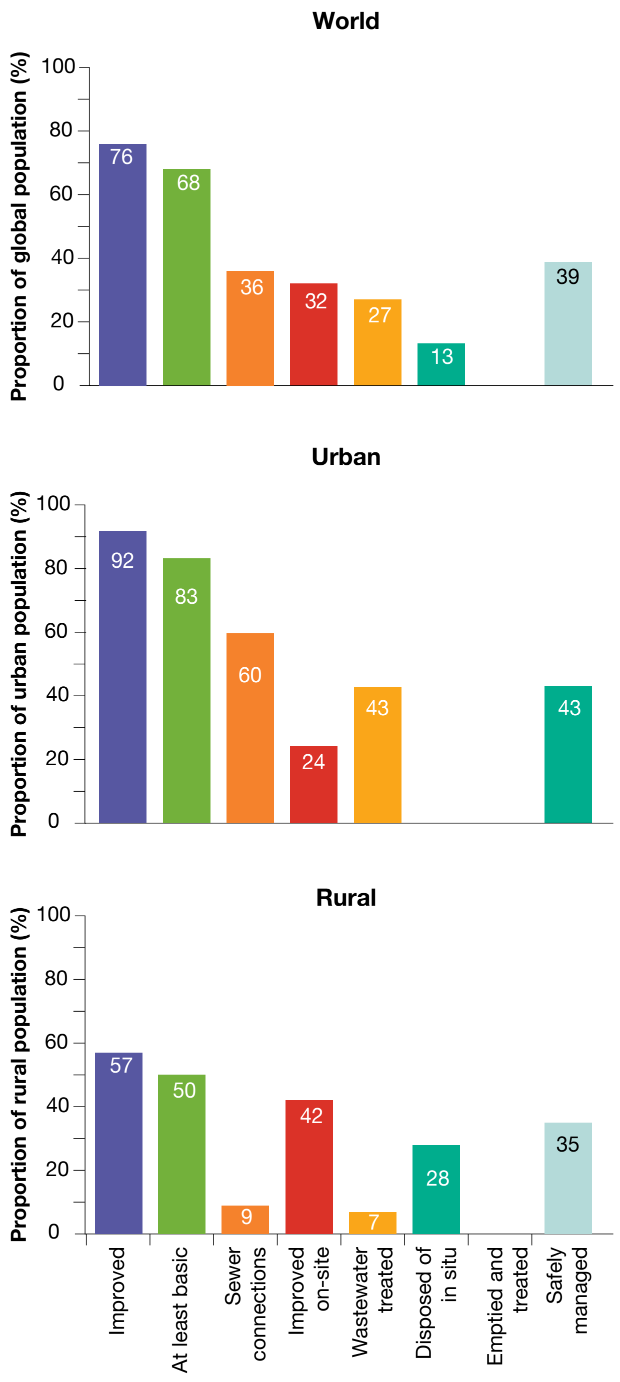


FIGURE 6 Urban and rural population with access to safe sanitation, 2015



5.5 SKILL ACTIVITY: Questioning and researching using geographical methods

Cultural activities are often enhanced in cities that attract migrants from many different areas.

1. **Conduct research** into an Australian city.
2. **Create** a mind-map of cultural activities. You may wish to consider adding illustrations to your mind-map.

5.5 Exercise

learnon

5.5 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5, 8	6, 7

Check your understanding

1. ________ factors are those that drive people towards cities and ________ factors are the attractions of urban areas, which make people want to move there.
2. Gateway cities are arrival points for many migrant workers. These cities are large enough to provide many different jobs and are therefore attractive to people moving from other regions. True or false?
3. Which of the following gateway cities from **FIGURE 4** do you think would provide the greatest chance for foreign people to get work? **Explain** your answer.
   A. Sydney
   B. Milan
   C. London
   D. Dubai
4. Imagine you live in a poor rural village in India with no education or work. **List** the possible attractions of moving to an urban area.

Apply your understanding

Communicating

5. **Determine** whether the following statements are true or false.

a. Providing safe access to drinking water to the world has been more successful than providing safe and adequate sanitation. ________	True	False
b. Most people in urban areas have access to safely managed drinking water. ________	True	False
c. Overall, a greater proportion of people in urban areas have access to improved drinking water. ________	True	False
d. Forty-three per cent of people in rural areas have unimproved or no access to sanitation. ________	True	False
e. Overall, people have better access to safe sanitation facilities than safe drinking water. ________	True	False

6. Access to basic services is a major factor that influences migration to the city. Aside from sanitation services and clean, safe drinking water, **describe** one other service that would attract migrants to urban areas.
7. **Summarise** push factors. In your answer, **clarify** why some push factors are vastly different from others.
8. **Create** a list of pull factors.

LESSON
5.6 How have urbanisation patterns changed over time?

LEARNING INTENTION

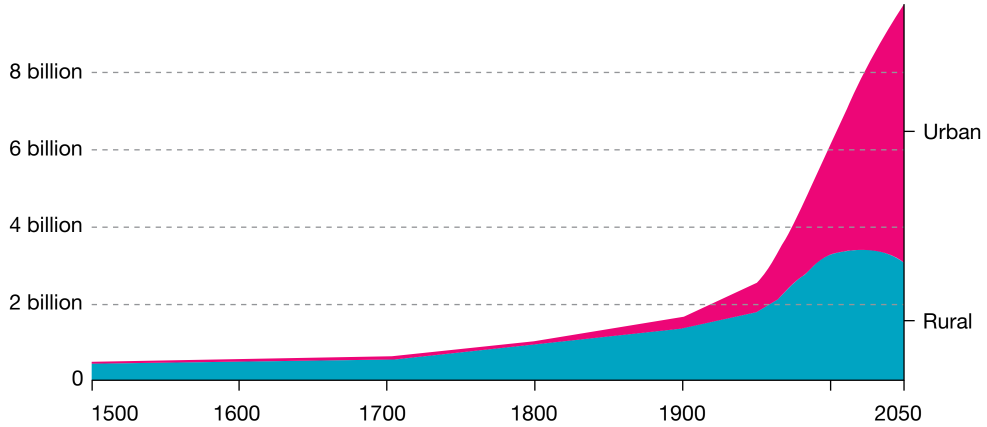
By the end of this lesson you should be able to describe the growth and changes in urban populations over time and in different places.

TUNE IN

Urbanisation rates have increased dramatically over the past 100 years and are predicted to continue.

1. When did urbanisation start to increase? What are some reasons for this?
2. Why do you think urbanisation is predicted to continue and rapidly increase?

FIGURE 1 Urban and rural population projected to 2050, World, 1500 to 2050



5.6.1 What is the history of urbanisation?

Urbanisation is the growth and expansion of urban areas and involves the movement of people to towns and cities. The earliest cities emerged about 5000 years ago in Mesopotamia (part of present-day Iran, Iraq and Syria). Originally these cities depended on agriculture. In 1800, 98 per cent of the global population lived in rural areas and most were still dependent upon farming and livestock production — only 2 per cent of people lived in urban areas.

During the nineteenth and early twentieth centuries, urbanisation occurred because of migration and the growth of industries. New job opportunities in the cities attracted people from rural areas and migrants provided a cheap workforce for factories. At that time, death rates in cities were high because they were unhealthy places (with crowded living conditions, diseases and a lack of sanitation) and urban growth was slow. Workers often found it hard to find somewhere to live — it was not unusual for an entire family to be living in a single room. In many European cities (such as London) the number of deaths was higher than the number of births, and migrants provided most of the population growth.

It is a very different experience in developing countries today. Most urban growth results from natural increase; that is, people being born in cities, rather than migrating to cities. With the additional population increase caused by migration from rural areas in search of better jobs, many cities in Asia and Africa have exploded in size. Urbanisation rates have increased dramatically over the past 100 years and are predicted to continue (see **FIGURE 1**).

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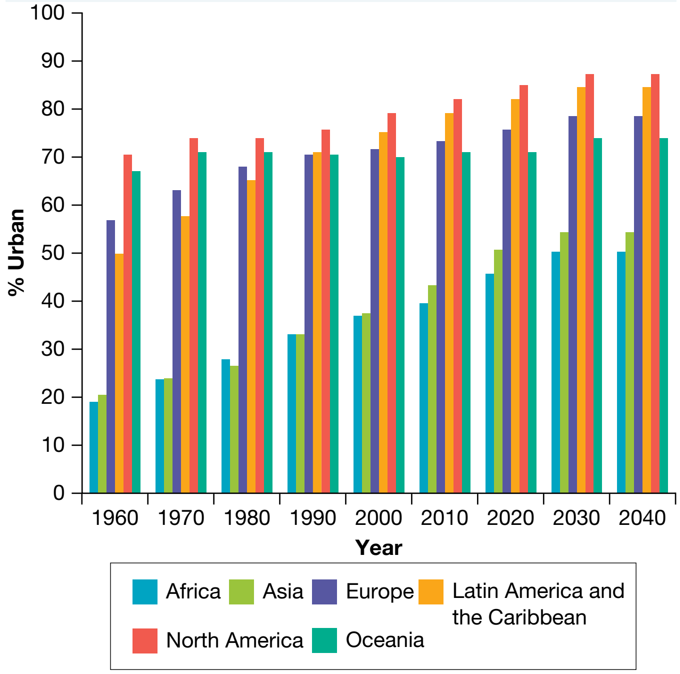
5.6.2 How does urbanisation differ across regions over time?

Urbanisation has not occurred evenly across the world. Some countries are predominantly rural, such as Cambodia and Papua New Guinea (populations 77 per cent and 87 per cent rural respectively), whereas others are almost completely urban, such as Belgium and Kuwait (98 per cent urban for both). In fact, some countries have 100 per cent urbanisation, including Bermuda, Cayman Islands, Hong Kong, Macau, Monaco, Vatican City and Singapore. South America is becoming one of the most urbanised regions in the world and currently has a population of around 385 million people. It is estimated that by 2050, 91.4 per cent of its population will be residing in urban areas.

FIGURE 2 The growth in urban populations over time

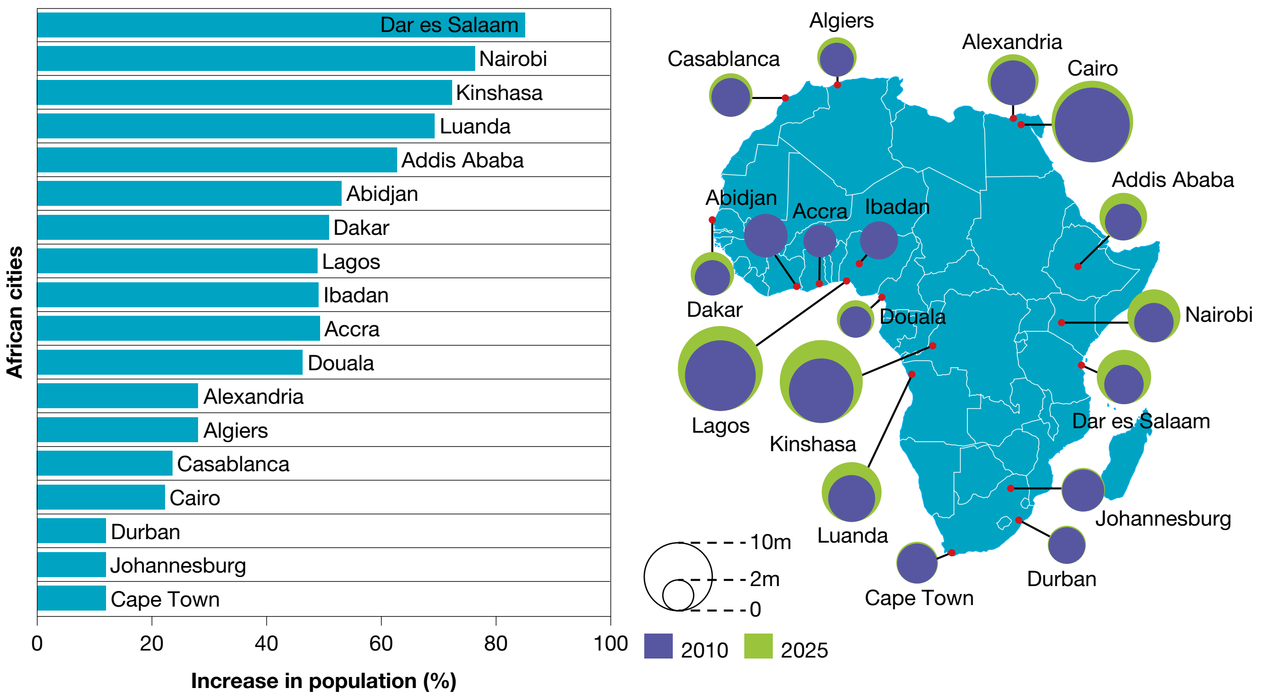


5.6.3 How has urbanisation increased in Africa?

Africa is fast moving from a mostly rural population to an increasingly urbanised population.

Africa now has a larger urban population than North America and has 25 of the world's fastest-growing large cities — the number of people living in cities in Africa is increasing by about one million every week. Some of Africa's cities are expected to grow by 85 per cent by 2025. By 2050, the urban population is expected to triple from 400 million people to 1.2 billion. Over half of the urban population in Angola, Chad, Madagascar, Malawi, Mozambique, Niger, Sierra Leone and Zambia is below the poverty line. In many other countries,

FIGURE 3 The projected growth of African cities from 2010 to 2025



including Burundi, Gambia, Kenya and Zimbabwe, 40–50 per cent of the population are living below the poverty line. In most African cities, between 40 and 70 per cent of the population live in **slums** or squatter settlements. In cities such as Nairobi, Lagos, Cairo and Rwanda, 60–70 per cent of the population live in slum conditions, which occupy about 5 per cent of the land in the city. Slums are described in more detail in lesson 5.7.

FIGURE 4 A slum in Nairobi

5.6.4 Consequences of urbanisation in Australia and the United States

Urban areas are those that are permanent settlements and feature a range of built structures such as houses, commercial buildings, roads, bridges, and railways etc. They can range in size based on the population. The Australian Bureau of Statistics defines urban centres as having a population of 1000 people or more.

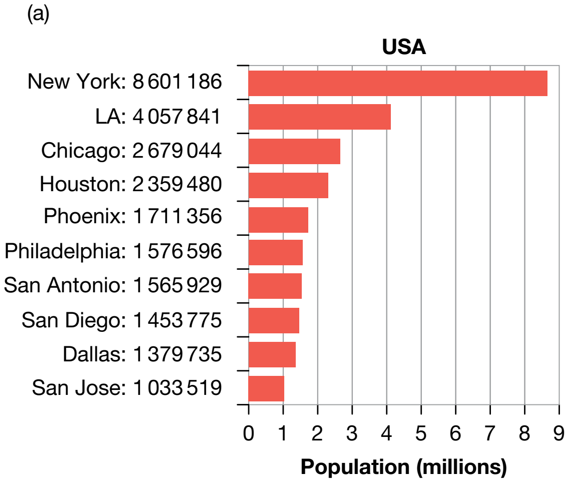
Conurbations

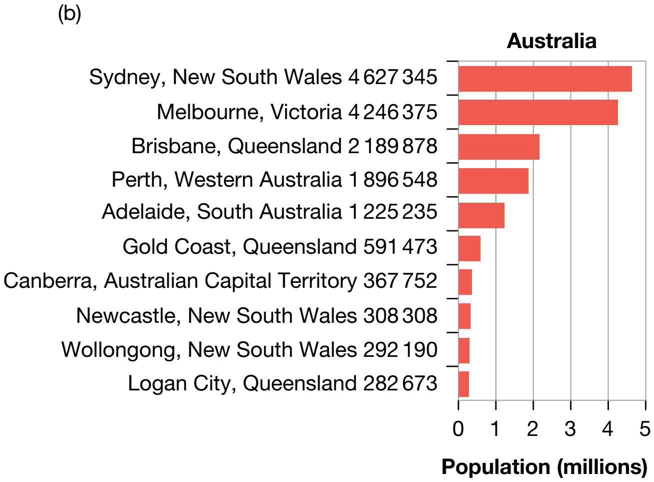
Sometimes there are so many cities in a particular region that they seem to merge almost into one city as they expand. A **conurbation** is made up of cities that have grown and merged to form one continuous urban area. Both the United States and, to a lesser extent, Australia have conurbations.

slum a run-down area of a city characterised by poor housing and poverty

conurbation area when cities merge to form one continuous urban area

FIGURE 5 Population of the top ten urban settlements in (a) the United States (2018) and (b) Australia (2019)

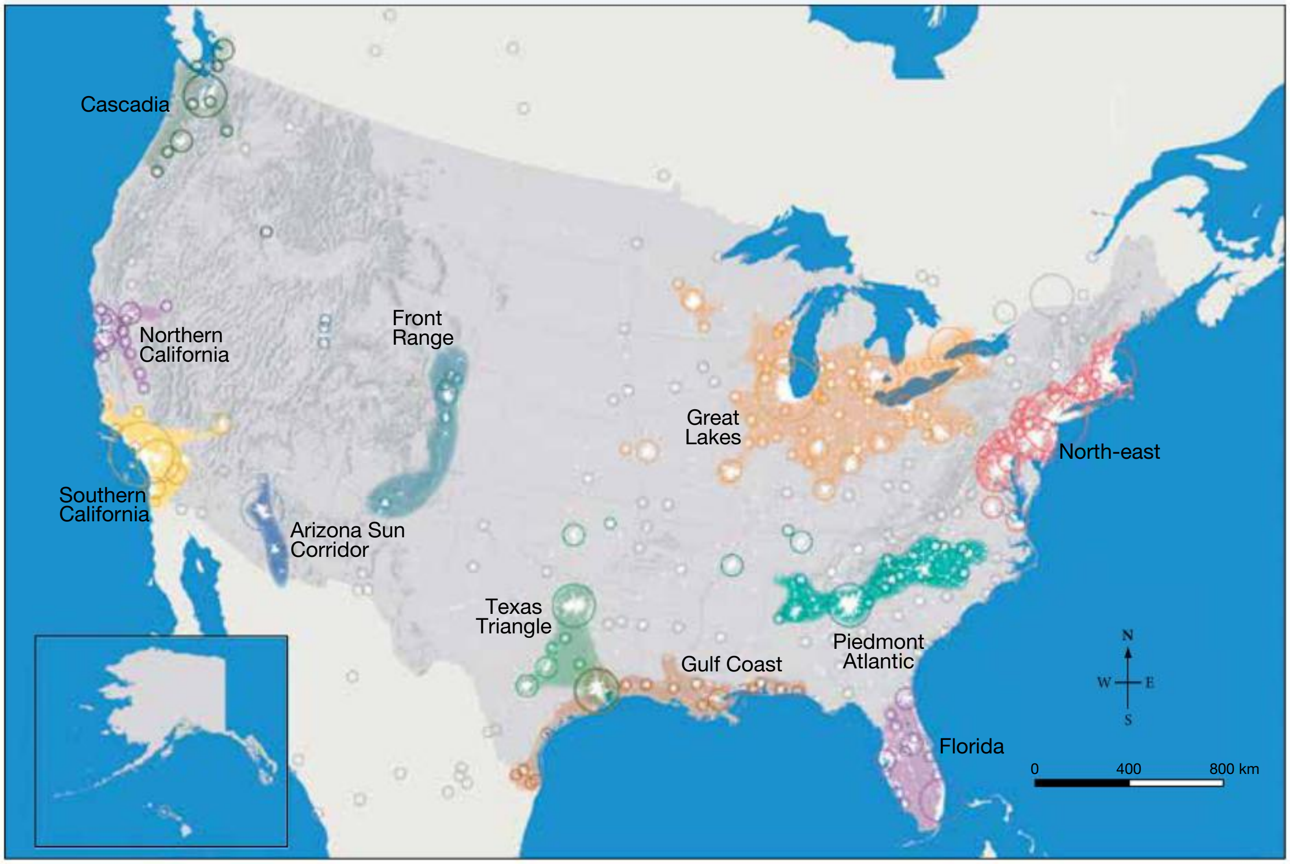




United States

Eleven conurbations have been identified in the United States (see **FIGURE 6**). The major conurbation is in the north-east region. It is often called BosNYWash because it covers the area from Boston in the north, through New York to Washington D.C. in the south. This region is home to more than 50 million people (17 per cent of the US population) and accounts for 20 per cent of the gross domestic product (GDP) of the United States.

FIGURE 6 Conurbations in the United States



Source: Adapted with permission from Bernard Salt.

FIGURE 7 The sprawling city of Boston

Australia

Australia, on the other hand, has four conurbations (see **FIGURE 8**). One is in south-east Queensland, one joins Melbourne and Geelong, one is from Perth to Mandurah. The Newcastle–Wollongong conurbation stretches for over 250 kilometres and is home to almost six million people.

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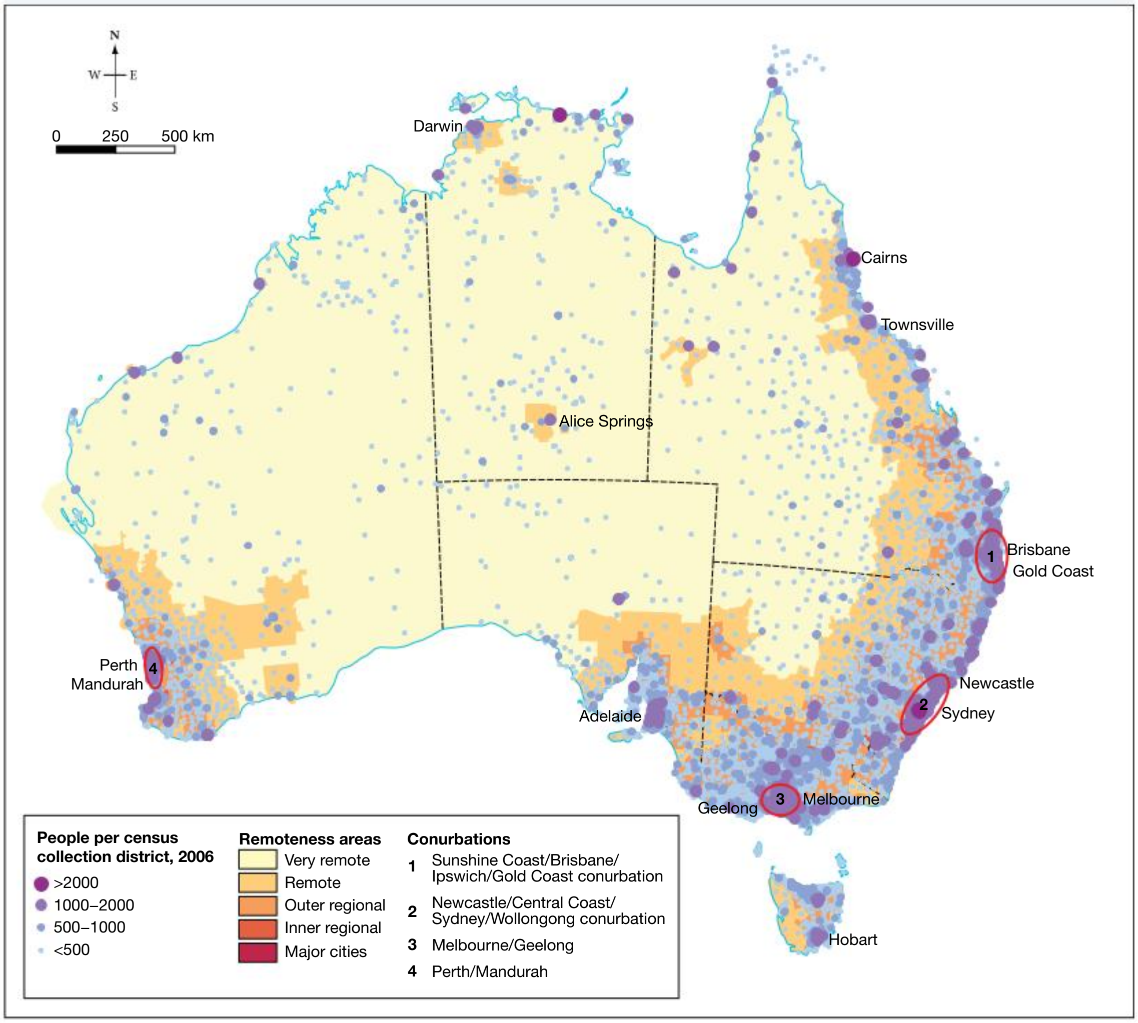
FIGURE 8 Australia's population centres and conurbations



Source: Australian Bureau of Statistics.

5.6 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Choose one of the conurbations in the United States and another in Australia.
2. **Create** a table and choose five of the following headings to complete a comparison of the two cities:
   - Population
   - Health care (accessibility of medical care)
   - Minimum wage
   - Percentage of people with a tertiary education
   - Modes of public transport
   - Pollution levels
   - Unemployment levels
   - Quality of water supply
   - Population density
   - Traffic congestion
3. Use the information in your table to **compose** a report **summarising** your findings. You will need to look at both statistics and news reports in order to complete a comprehensive overview.

5.6 Exercise

learnon

5.6 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4	3, 5	6, 7, 8, 9, 10

These questions are even better in jacPLUS!

- Receive immediate feedback
- Access sample responses
- Track results and progress

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Check your understanding

1. Urbanisation is the growth and expansion of rural areas into urban areas. True or false?
2. In developing countries today, most urban growth results from people
   A. migrating to cities.
   B. moving away from cities.
   C. being born in cities.
   D. working in cities.
3. **Examine FIGURE 2.**
   a. **Explain** how this figure shows that urbanisation has varied in different regions of the world.
   b. Which two regions have the greatest rural population?
4. What is expected to happen with urbanisation in the future?
   A. It is expected to decrease
   B. It is expected to increase
   C. It is expected to stop
   D. It is expected to plateau
5. Refer to **FIGURES 6** and **8**.
   a. **Compare** the size of the ten largest cities in the United States and in Australia.
   b. **Identify** what might explain the differences you noticed.

Apply your understanding

Interpreting and analysing geographical data and information

6. Study **FIGURE 3** and refer back to the reading in this lesson.
   a. **Describe** the distribution of Africa's large cities. How many are inland? How many are on the coast? Which are located in the north, south-east and west of the continent?
   b. What does it mean to live below the poverty line? **Identify** the cities in which more than half the population is living below the poverty line.
7. **Investigate FIGURE 2. Determine** which two continents tend to have the lowest growth in urban populations.
8. **Predict** the future of sustainability of the place shown in **FIGURE 4**, especially if the population of this city is going to increase.
9. Refer to **FIGURE 3. Name** the three largest African cities in 2010 and the three predicted to be largest in 2025. In which countries are they located?

Concluding and decision-making

10. Which of the consequences of urbanisation do you think may continue to have the biggest effects on the **environment** in the future?

LESSON
5.7 What are the advantages and disadvantages of urbanisation?

LEARNING INTENTION

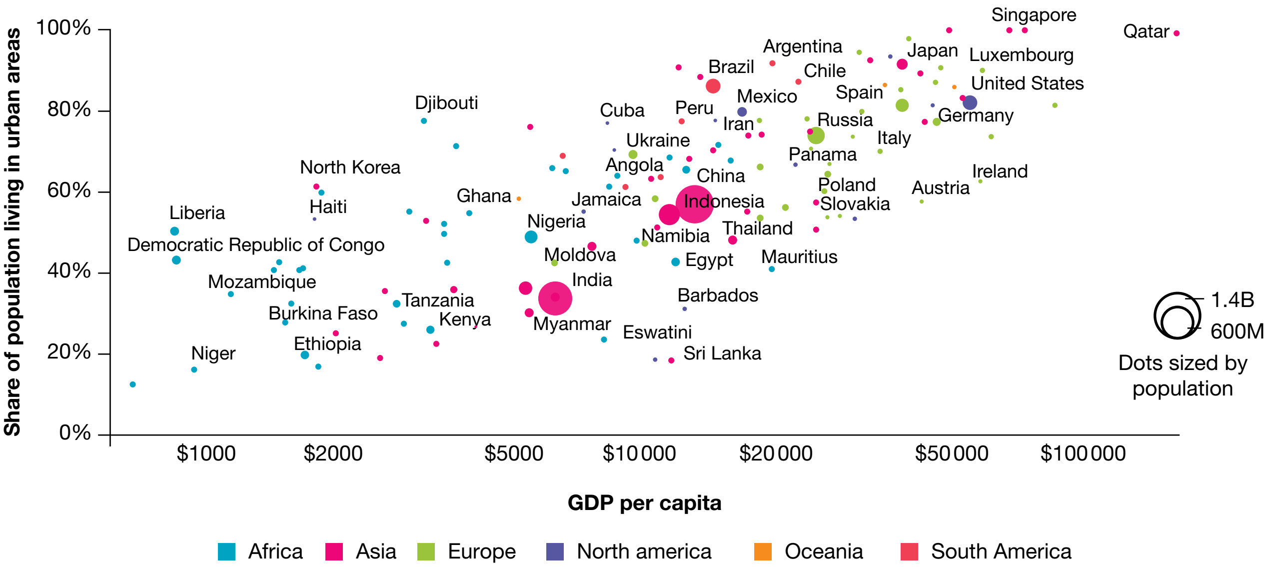
By the end of this lesson you should be able to distinguish between and describe advantages and disadvantages of urbanisation, and summarise conditions in urban slums.

TUNE IN

Geographers look for relationships between **variables**, such as the variables of urban population and GDP per capita shown in this scatterplot. Per capita means as it applies to each person. In the study of Geography, variables are defined as characteristics that can be measured and provide information about a place, beyond just the location of that place.

variables (in Geography) characteristics that can be measured and provide information about a place, beyond just the location of that place

FIGURE 1 Urban population vs GDP per capita, 2016



Based on the data shown in the **FIGURE 1** scatterplot and drawing on your wider knowledge, what do you predict about the direction and strength of the relationship between urban populations and GDP?

5.7.1 What are the advantages of urbanisation?

Urbanisation has a number of advantages, not just for those living in the urban areas, but also for the country as a whole. Gross Domestic Product (GDP) is a frequently used measure of the economic strength of a country, that is, how wealthy the country is. According to the World Bank, 80 per cent of global GDP is generated in cities.

FIGURE 1 illustrates the relationship between urbanisation and GDP. The higher the urban population, the richer the country and its people are likely to be.

The reasons for this relationship are complex. It could be that the improved education and employment opportunities offered by urban areas, allow for citizens to develop and earn more, and therefore have more to spend. This contributes to a higher GDP. Similarly, it could be that bringing people together in a concentrated area allows for the sharing of new ideas and innovations, and the development of new technology. This can also contribute to a higher GDP as new products and services can generate wealth. Better access to services such as high-speed internet in cities helps to facilitate education, employment and enterprise.

FIGURE 2 Footscray restaurants

On a more individual level, living in urban areas provide citizens with access to a greater range of services and facilities than those that are available in rural areas. When a population is concentrated into a smaller area, it makes it easier to provide government and local council support, and provide facilities such as housing, roads, public transport, hospitals and schools (see **FIGURE 3**).

There are also cultural and social advantages of urbanisation. Urban areas frequently have more sporting facilities, museums, galleries, theatres, and playgrounds than rural locations do, as well as a greater variety of different cultures, their cuisines, and their practices living side-by-side (**FIGURE 2**).

FIGURE 3 (a) Public transport, (b) Hospital, (c) School in New York, (d) High rise housing in Brazil

5.7.2 What are the disadvantages of urbanisation?

Health issues

High population densities in urban areas make it easier for diseases to be transmitted, especially in poor neighbourhoods. The urban poor suffer health issues caused by reduced access to sanitation and hygiene facilities and healthcare.

Pollution

Air pollution from cars, industry and heating affects people who live in cities. A study in the United States showed that more than 3800 people die prematurely in the Los Angeles Basin and San Joaquin Valley region of southern California because of air pollution. Generally, Australia has a fairly high level of air quality. Cars and industry are the main factors influencing air quality in urban areas.

Crime

Crime rates tend to be higher in urban areas. The sheer number of people living side-by-side offers criminals more potential victims and therefore more opportunities to commit crime. Economic inequality is also greater in urban areas. Items of material wealth such as luxury cars and expensive watches may become targets for criminal gangs.

Higher cost of living

Rent and mortgage costs tend to be higher in cities as the value of the land is greater and there is more competition for available housing. The cost of food also tends to be higher as it needs to be transported from where it is produced.

Homelessness

According to the US National Alliance to End Homelessness, as of 2018 there were around 553 000 homeless people in the United States on a given night. This represents 17 people in every 10 000. Although the trend has been downwards from 2007–17, there was a slight rise in 2018. The five states with the highest homeless counts in 2018 were California (129 972), New York State (91 897), Florida (31 030), Texas (25 310) and Washington State (22 305).

In comparison, census data shows that the number of homeless people in Australia increased by more than 15 000 (14 per cent) over five years to 2016. According to the Australian Bureau of Statistics, 116 000 people were homeless on census night in 2016, representing 50 homeless people per 10 000. This was an increase of 13.7 per cent from the 2011 census.

5.7.3 What are slums and how do they develop?

When an urban area experiences an increase in people moving there, it may not have adequate infrastructure such as available housing and sanitation to accommodate their population.

In many developing countries, urban growth has resulted in unplanned settlements called slums (other terms used around the world include ghettos, favelas, shantytowns, bidonvilles and bustees). Almost 1 billion people live in slums worldwide. The United Nations defines a slum as follows:

> . . . one or a group of individuals living under the same roof in an urban area, lacking one or more of the following five amenities: (1) durable housing (a permanent structure providing protection from extreme climatic conditions); (2) sufficient living area (no more than three people sharing a room); (3) access to improved water (water that is sufficient, affordable and can be obtained without extreme effort); (4) access to improved sanitation facilities (a private toilet, or a public one shared with a reasonable number of people); and (5) secure tenure and protection against forced eviction.

While urban slums are primarily a challenge for the developing world, areas of concentrated urban poverty also exist in the developed world in places such as Detroit, Michigan in the United States.

Some regions have more people living in urban slums as compared to other regions as illustrated by **FIGURE 4**.

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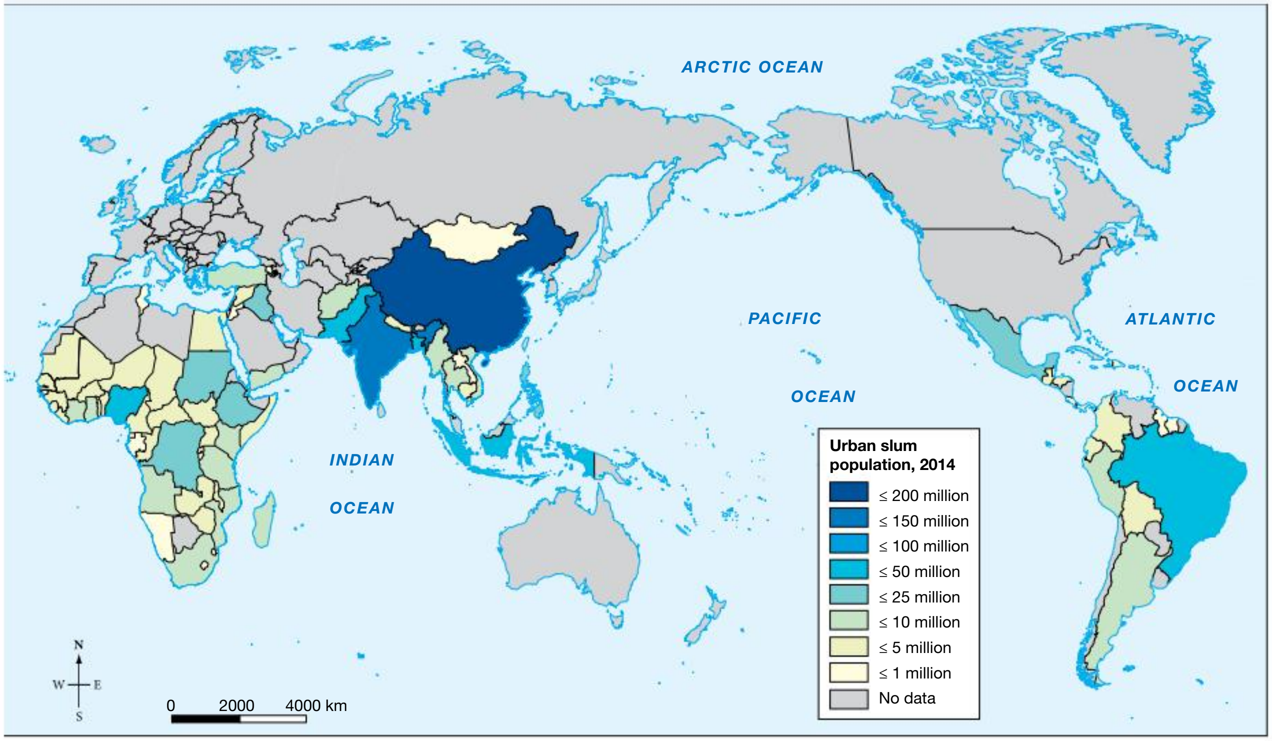
FIGURE 4 Urban population living in slums, 2018



Source: Based on data from Urban population living in slums, 2014. Our World in Data. Licensed under CC BY 4.0. Map redrawn by Spatial Vision.

The images shown in **FIGURE 5** are examples of such urban slums from around the world.

FIGURE 5 Urban slums around the world: (a) Brazilian favela, (b) South African shantytown, (c) Indian slum, (d) Slovakian ghetto

Resources

Weblink — Face of the slums

Digital document — Blackline world map (doc-36260)

5.7 SKILL ACTIVITY: Questioning and researching using geographical methods

1. **Research** to create a list of the ten biggest urban slums in the world.
2. Download and print the **Blackline world map** from the Digital documents section of the Resources panel.
3. Plot the slums on your map. It will be helpful to also have an atlas to refer to.
4. **Annotate** your map with facts and images about each slum.

5.7 Exercise

learnon

5.7 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5	6, 7, 8

Check your understanding

1. The higher the urban population, the richer the country and its people are likely to be. True or false?
2. In the study of Geography, variables are defined as ________ that can be measured and provide information about a ________, beyond just the ________ of that place.
3. According to the World Bank, how much of global GDP is generated in cities?
   A. 50 per cent
   B. 70 per cent
   C. 80 per cent
   D. 90 per cent
4. **Summarise** the main advantages of urbanisation for residents of cities.
5. **Consider FIGURE 1.**
   a. **Identify** a country that has less than 40 per cent urban population and GDP per capita between $1000 and $2000.
   b. **Identify** a country that has over 80 per cent urban population and GDP per capita between $50 000 and $100 000.

Apply your understanding

Concluding and decision-making

6. Consider the four major areas of disadvantages mentioned in the lesson; health issues, pollution, crime and higher costs of living. What do you think is the most significant disadvantage? **Justify** your reasoning.
7. Think about the last time you visited a city. You may even live in one. **Identify** some of the cultural or social activities or events that you had access to that you wouldn't have in a rural area.

Communicating

8. The more urban a country is, the wealthier it is likely to be. **Create** a concept map that illustrates the interconnections between reasons for this.

LESSON
5.8 How do we create sustainable cities?

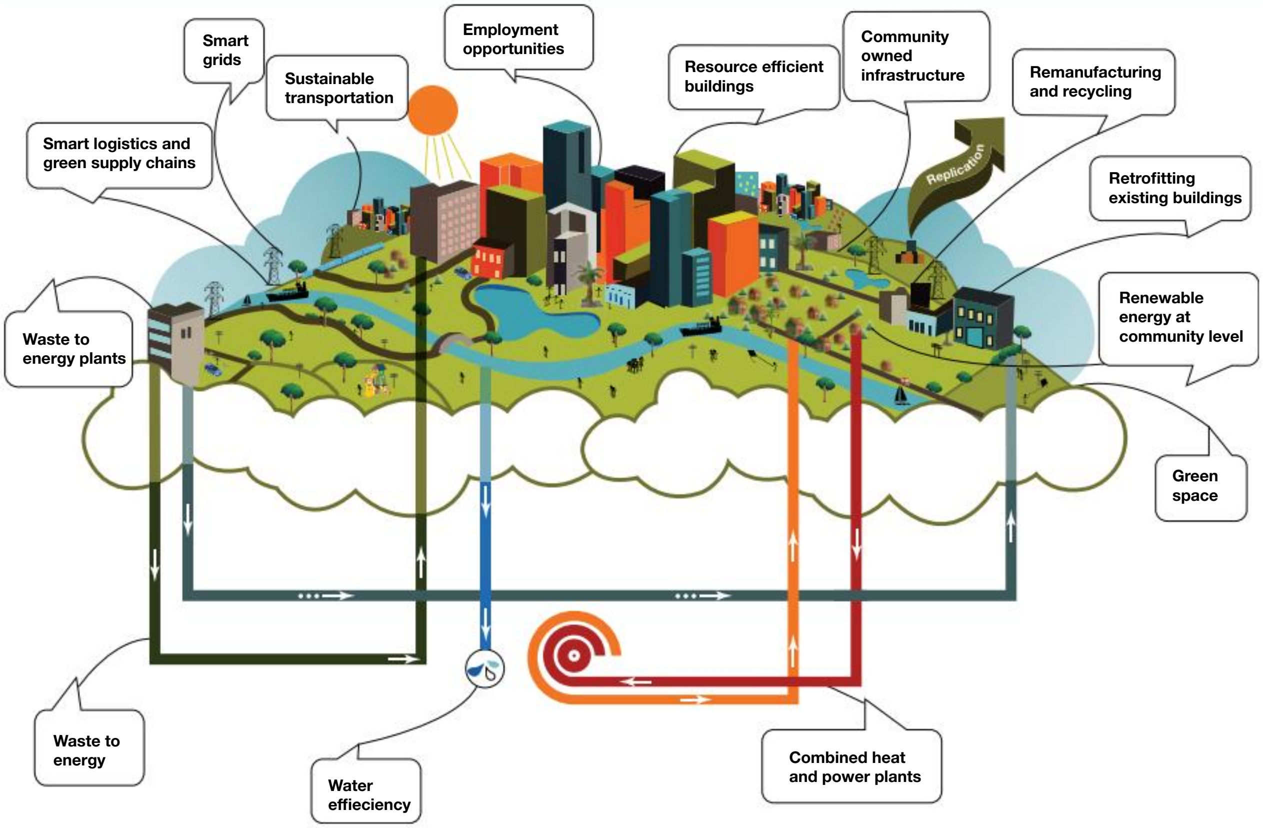
LEARNING INTENTION

By the end of this lesson you should be able to describe features and actions of sustainable cities.

TUNE IN

Urban areas need to be carefully planned and developed in order to meet the needs of their current and future populations in a sustainable way. **FIGURE 1** illustrates some of the key features of a sustainable city.

FIGURE 1 Mapping components for a sustainable city



1. What do you think is meant by the term ‘sustainable’ as it relates to an urban area?
2. What are some suggestions for sustainable transport options?
3. What are some of the waste products produced by cities that could be remanufactured or recycled, and into what?

5.8.1 What are sustainable cities and why are they needed?

With an ever increasing urban population, as well as the threats posed by climate change, cities need to become more sustainable in order to meet the present needs of their inhabitants and leave sufficient resources to meet the needs of future generations. A focus on cities forms part of UN Sustainable Development Goal 11 — Make cities and human settlements inclusive, safe, resilient and sustainable.

A sustainable city, or eco-city, is a city designed to reduce its environmental impact by minimising energy use, water use and waste production (including heat), and reducing air and water pollution.

Every city in the world experiences some type of problem that needs to be overcome — inadequate housing, urban sprawl, air and/or water pollution and waste disposal are just a few. Solutions to city problems have a better chance of succeeding if:

- responsibility is shared between governments, communities and citizens
- communities are involved in projects and decision making.

5.8.2 What makes a sustainable city?

In 2010, the Australian Conservation Foundation conducted a study to measure the sustainability of Australia's 20 largest cities. The indicators measured were a combination of:

- *environment* — air quality, **ecological footprint**, water, green building and biodiversity
- *quality of life* — health, transport, wellbeing, **population density** and employment
- *resilience* — (the ability of a city to cope with future change) climate change, public participation, education, household repayments and food production.

FIGURE 1 highlights some of the key features of a sustainable city.

ecological footprint the amount of productive land needed on average by each person in a selected area for food, water, transport, housing and waste management

population density the number of people living within one square kilometre of land; it identifies the intensity of land use or how crowded a place is

5.8.3 What actions are involved in developing sustainable cities?

Urban planners and governments can take a number of targeted actions in order to make their cities more sustainable. Some of these actions are outlined in **TABLE 1**.

TABLE 1 Targeted actions to make cities more sustainable

Key feature	Targeted actions
Conservation of water	• Capture and use of stormwater • Monitoring of infrastructure for leaks • Treatment and reuse of waste water • Incentives for saving water for businesses and individuals
Improved waste management	• Recycling programs • Composting programs • Repurposing of materials such as building waste • Generating heat from waste incineration (burning waste)
Use of green architecture	• Using sustainable and/or recycled building materials • Improving insulation and ventilation for natural heating and cooling • Incorporating renewable energy sources, e.g. solar panels
Urban farming	• Establishment of community gardens • Encouraging schools and restaurants to grow food • Creating vertical and rooftop gardens
Green public spaces	• Creation of parks, nature reserves, and recreational areas for public use • Urban greening programs to reduce heat island effect
Use of renewable energy	• Use of energy sources that don't rely on fossil fuels • Establishment of solar and wind farms • Providing rebates or incentives for private owners to install solar panels
Sustainable transport options	• Creating more bike paths and cycle superhighways • Improving public transport options • Reducing public transport emissions by lowering use of fossil fuels • Installing EV (electric vehicle) charging stations to encourage use of electric cars

5.8.4 What do some of these actions look like in the real world?

Urban greening program, Sri Lanka

Producing food in cities provides people with an income and improves local environments, as well as reducing the distance that food must travel to a consumer — 'food miles'. With support from the Department of Agriculture, the Department of Education and the Youth Services Council, three city councils in Sri Lanka developed a program of community environmental management that led to the creation of 300 home gardens and 100 home-composting programs. It also helped organise and empower community groups, and the idea has now spread to many other municipalities in the country.

FIGURE 2 The urban greening program in Sri Lanka has been a success in many communities.

Solar panels in Vatican City and Japan

Vatican City, Italy

Vatican City is the world's smallest independent state. In 2008 more than 2000 photovoltaic panels were fixed to the roof of one of the city-state's main buildings — the roof of the Paul VI Hall — enabling the Vatican to cut its carbon dioxide emissions by about 225 tonnes a year. The 2400 panels heat, light and cool the hall and several surrounding buildings, producing 300 kilowatt hours (MWh) of clean energy a year. (see **FIGURE 3**).

Ota, Japan

Ota is located 80 kilometres north-west of Tokyo and is one of Japan's sunniest locations. Through investment by the local government, Ota is one of Japan's first solar cities — three-quarters of the town's homes are covered by solar panels that have been distributed free of charge.

FIGURE 3 Solar panels cover the roof of the Paul VI hall, as seen from the dome of St Peter's Basilica.

FIGURE 4 A street in Ota, Japan — solar panels are visible on most of the houses.

Waste incineration in Vienna

A waste incineration and heat generation plant is part of a hard-waste management system in Vienna, Austria (see **FIGURE 5**). This plant became the first in the world to burn waste that cannot be recycled and use the energy generated by the plant in a heating network. The plant burns more cleanly and produces more heat and energy than many other waste generation plants, making it attractive to many urban communities. Each year, waste is turned into heat and electricity and supplies heating and hot water for 350 000 apartments — around a third of the city's total. The actual proportion of energy the waste supplies the city varies from season to season. Landfill waste has been reduced by 60 per cent in the city.

FIGURE 5 Spittelau waste treatment plant in Vienna, Austria. This power station burns waste, thus reducing landfill, to produce heat that is supplied to thousands of buildings.

Green architecture in Japan

The ACROS Fukuoka building located in Fukuoka, Japan is an example of plants and greening being used to enhance a building (**FIGURE 6**). The terraced green roof and green walls merge with a park and contain around 35 000 plants. The green roof keeps the temperature inside more constant and comfortable, thus reducing energy consumption. It is also able to capture rainwater run-off and attracts many insects and birds. In addition, it is visually appealing and attracts many people to the surrounding park.

FIGURE 6 The ACROS Fukuoka building located in Fukuoka, Japan

Sustainable housing in Adelaide, Australia

Christie Walk is located in Adelaide in South Australia. It is a small urban village of 27 dwellings located on a quarter of an acre of land. The site is within easy walking distance of Adelaide's markets, parklands and CBD, which means car use is reduced. Around 40 people live at Christie Walk, ranging in age from very young to over 80 years.

A number of principles were used in the design of Christie Walk.

- Low energy demand (passive heating and cooling; natural lighting and sealed double glazing in all windows and glass doors)
- Maximising the use of renewable/solar-based energy sources (photovoltaic cells on the roof) and minimising the use of non-renewable energy sources
- Capturing and using storm water (in large underground rainwater tanks) and recycling waste water
- Creating healthy gardens and maximising the biodiversity of indigenous flora and fauna. The gardens also produce herbs, vegetables and fruit.
- Avoiding the use of products that damage human health
- Minimising the use of non-recyclable materials

FIGURE 7 One of the sustainable buildings in Christie Walk

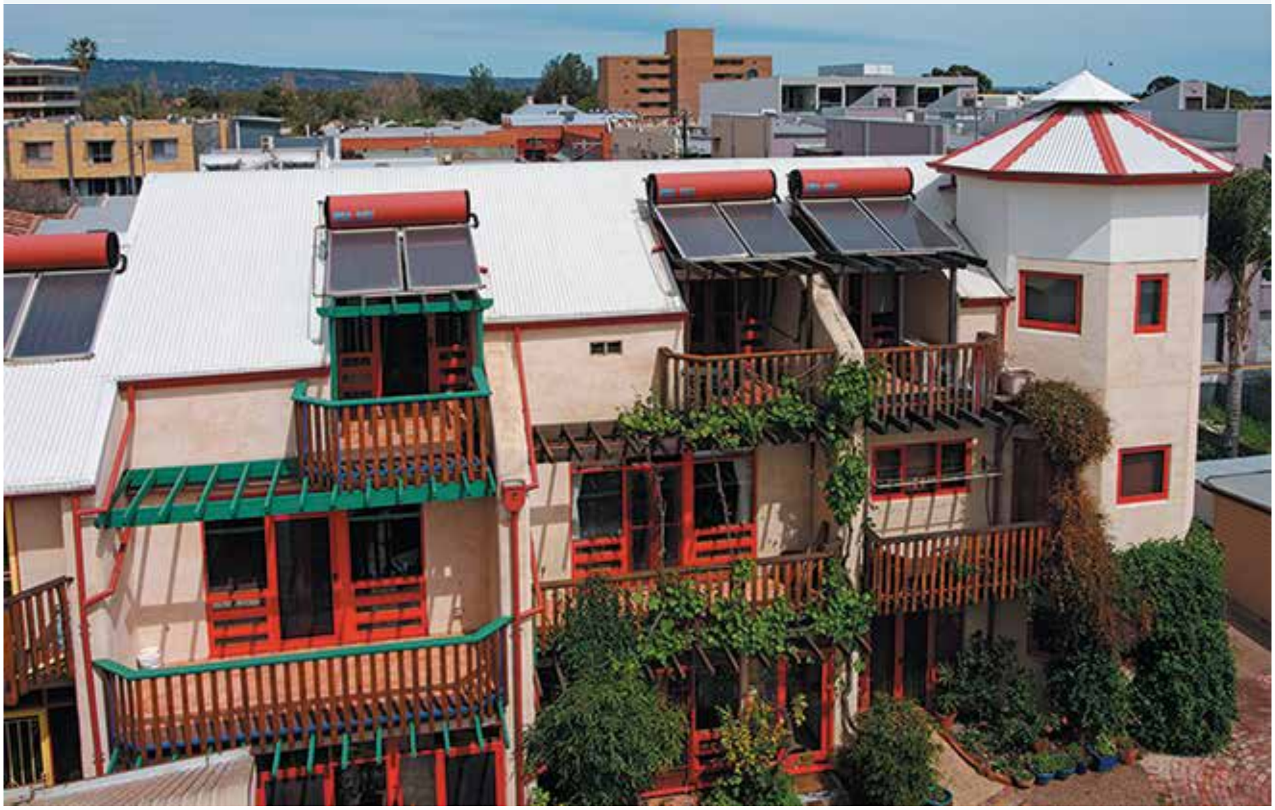


FIGURE 8 A plan of Christie Walk in Adelaide

5.8.5 What are some of the most sustainable cities in the world?

Arcadis is a Netherlands-based design, engineering and consultancy company that focuses on sustainable solutions. Every few years they complete a Sustainable Cities Index where they rank they world's cities based on three pillars of sustainability: people, planet and profit.

FIGURE 9 shows their results for the top 10 cities in 2022 based on the combined scores for the three pillars.

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FIGURE 9 A map of the most sustainable cities in the world based on the Arcadis Sustainable Cities Index 2022

Top 10 sustainable cities 2022*

*based on combined scores for People, Planet and Profit, see below

1. Oslo	**6. London**
2. Stockholm	**7. Seattle**
3. Tokyo	**8. Paris**
4. Copenhagen	**9. San Francisco**
5. Berlin	**10. Amsterdam**

People

- Quality of public transport infrastructure
- Cost of broadband
- Crime rates
- Education
- Health
- Income inequality
- Wi-fi availability
- Work-life balance

Planet

- Air pollution
- Bicycle infrastructure
- Energy consumption and renewable energy share
- Environmental exposure
- Green spaces
- Greenhouse gas emissions
- Public policy
- Sustainable transport

Profit

- Access to reliable electricity
- Affordability
- Connectivity
- Ease of doing business
- Economic development
- Employment
- Green finance
- Job quality
- Commercial transport infrastructure

Top 10 cities based on People

1. Glasgow	6. Vienna
2. Zurich	7. Tokyo
3. Copenhagen	8. Rotterdam
4. Seoul	9. Madrid
5. Singapore	10. Amsterdam

Top 10 cities based on Planet

1. Oslo	6. London
2. Paris	7. Tokyo
3. Stockholm	8. Antwerp
4. Copenhagen	9. Zurich
5. Berlin	10. Rotterdam

Top 10 cities based on Profit

1. Seattle	6. Tampa
2. Atlanta	7. Dallas
3. Boston	8. Chicago
4. San Francisco	9. Baltimore
5. Pittsburgh	10. Miami

5.8 SKILL ACTIVITY: Concluding and decision-making

Use the **Sustainable cities index** weblink in the Resources panel to see how Australian cities performed in 2010 in measurements of sustainability. These measurements are broken up into three broad categories — environmental performance, quality of life, and resilience.

1. Form groups of 3–5 students.
2. Individually and silently examine the data presented and select one indicator from each category that you think is the most important (e.g. biodiversity for environmental performance).
3. Share your ideas with your group — did your peers select the same indicators or different ones? Share the reasons for your choices.
4. Now select a focus city to **discuss** in more detail. **List** five things that could improve sustainability in this city.
5. **Outline** two actions that you could personally take to make a difference.

5.8 Exercise

learnon

5.8 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5, 6	7, 8, 9, 10

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Check your understanding

1. **State** the aims of a sustainable city.
2. Which of the following is an indicator of *sustainability*?
   A. Quality of life
   B. Public participation
   C. Ecological footprint
   D. Education
   E. All of the above
3. Refer to FIGURE 9 to **determine** whether the following statements are true or false.
   a. Paris was ranked number 9.
   b. Three American cities feature on the list.
   c. There are no countries from Australia that are considered sustainable.
   d. The majority of sustainable cities on this list are in Europe.
4. Which type of projects have the best chance of succeeding to overcome city problems?
5. **Complete** the following passage. Architecture that uses sustainably produced or recycled materials is known as ________ architecture. This type of architecture also incorporates clever use of ________ to allow naturally occurring airflows to cool the house.

Apply your understanding

Concluding and decision-making

6. **Identify** any elements of the urban greening program in Sri Lanka that categorise it as sustainable.
7. **Determine** how the urban solar programs in Vatican City and Ota, Japan contributed to sustainable solutions.
8. **Summarise** how burning waste in Vienna has become a sustainable solution.
9. Imagine that you are an urban planner responsible for improving the sustainability of your city. Of the key features of a sustainable city outlined in **TABLE 1**, you can only afford to implement two. Which of these features would choose? **Justify** your reasoning.
10. Consider the Christie Walk case study. **Identify** any ways this case study aligns with the key features of sustainable cities (**FIGURE 1**).

LESSON
5.9 INQUIRY: Big City Life

LEARNING INTENTION

By the end of this lesson you should be able to conduct research on a specific city, source a wide range of geographical data and information related to key knowledge, and present your findings as an annotated visual display.

Task

In this inquiry, we will put our new knowledge of migration and urbanisation to work, by investigating and analysing a specific city.

Create an annotated visual display of a major world city that answers the overall inquiry question in this topic: Why do people move between and within countries, and what are the consequences of that movement? You must create sub-questions that guide your research and answer these sub-questions using visual sources that detail facts and statistics about your chosen city.

Before you begin

Access the **Inquiry rubric** in the digital documents section of the Resources panel to guide you in completing this task at your level. At the end of the inquiry task you can use this rubric to self-assess.

Inquiry steps

Step 1: Questioning and researching using geographical methods

Select a major world city that you would like to focus your research on.

Write your selected inquiry question here based on the focus of this topic:

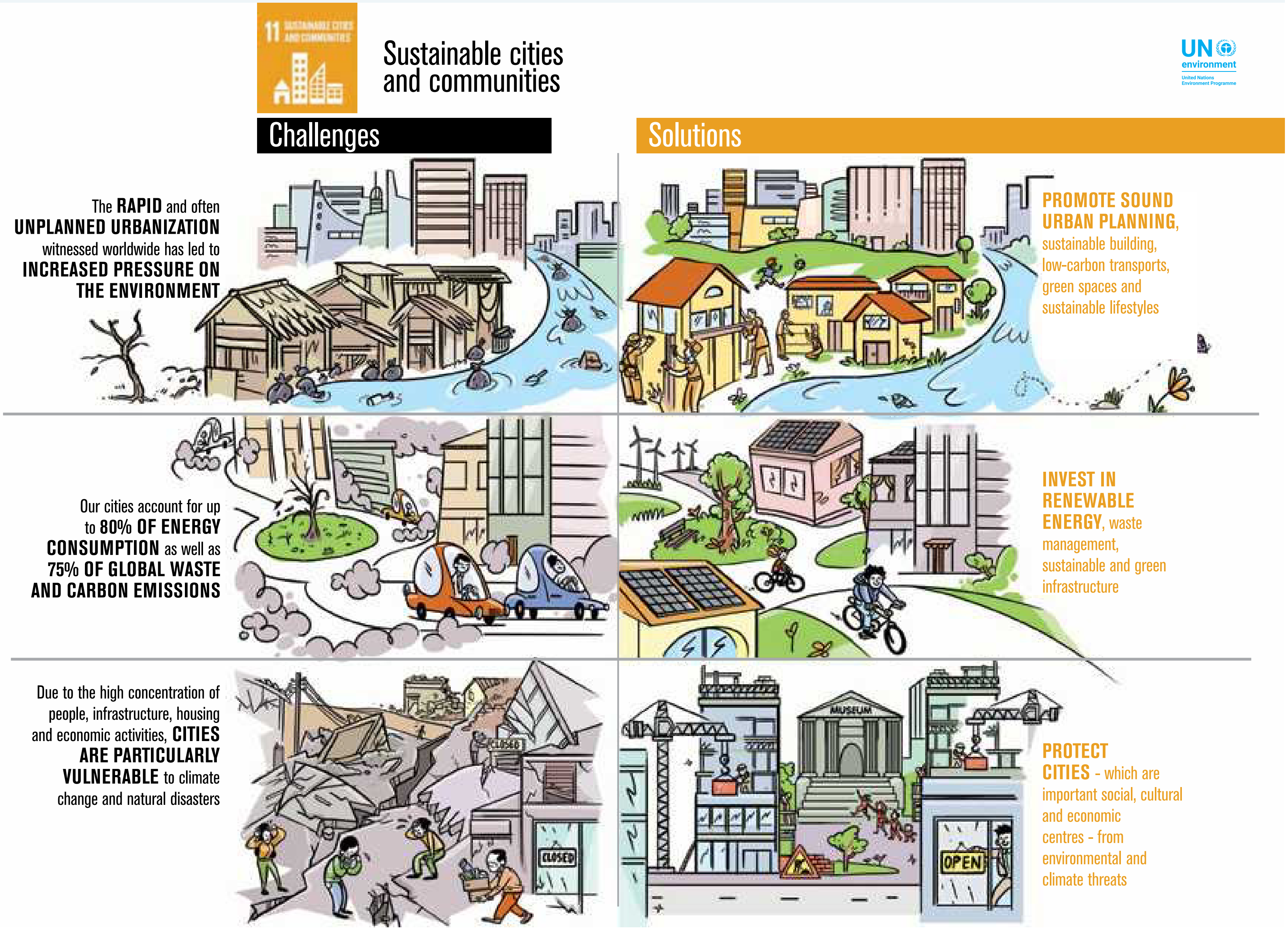
Why do people move between and within countries, and what are the consequences of that movement?

In order to answer this question with a focus on your chosen country, you will need to write a number of sub-questions to guide your research. The infographic from the United Nations Sustainability Goals (#11 Sustainable Cities and Communities) may provide you with some ideas about consequences and actions that could be turned into sub-questions.

For example, let's imagine that you have chosen the city of Jakarta. Some example sub-questions may include:

- How many people have migrated to Indonesia from another country?
- Where have they migrated from?
- Why have they migrated to Indonesia?
- How have people moved within Indonesia?
- How has this movement changed Jakarta's population?
- Why are people moving to Jakarta?
- What are the positive impacts of this people movement?
- What are the negative impacts of this people movement?
- What steps are being taken to ensure Jakarta's sustainability in the future?
- What further steps need to be taken?

FIGURE 1 An infographic relating to the 11th United Nations Sustainability Goal, Sustainable Cities and Communities



Step 2: Interpreting and analysing geographical data and information

Investigate your inquiry question: use your sub-questions as the focus for your research. Collect facts and statistics related to each sub-question.

Once you've completed your research, **decide** on the best visual sources to represent your information for each sub-question. These sources could be:

- maps
- graphs,
- sketches
- photos
- tables etc.

Step 3: Concluding and decision-making

Carefully arrange your visual sources on an A3 or A2 piece of poster paper.

Next to each source, write an **annotation** that tells the reader/viewer what information is being communicated and how it links to the overarching inquiry question. This is called an **annotated visual display.**

For example, to continue with our Jakarta scenario, your research may have uncovered seeking asylum as reason for migration to Indonesia. You may wish to include a photo of asylum seekers on your poster. Your annotation next to it would highlight seeking asylum as a push factor for migration, but also provide details regarding other factors influencing migration too.

Step 4: Communicating

Share your finished annotated visual display with your class, and answer any further questions they may have.

Complete your self-assessment using the **Inquiry rubric** or access the 5.9 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39543)

LESSON
5.10 Investigating topographic maps — Jakarta

LEARNING INTENTION

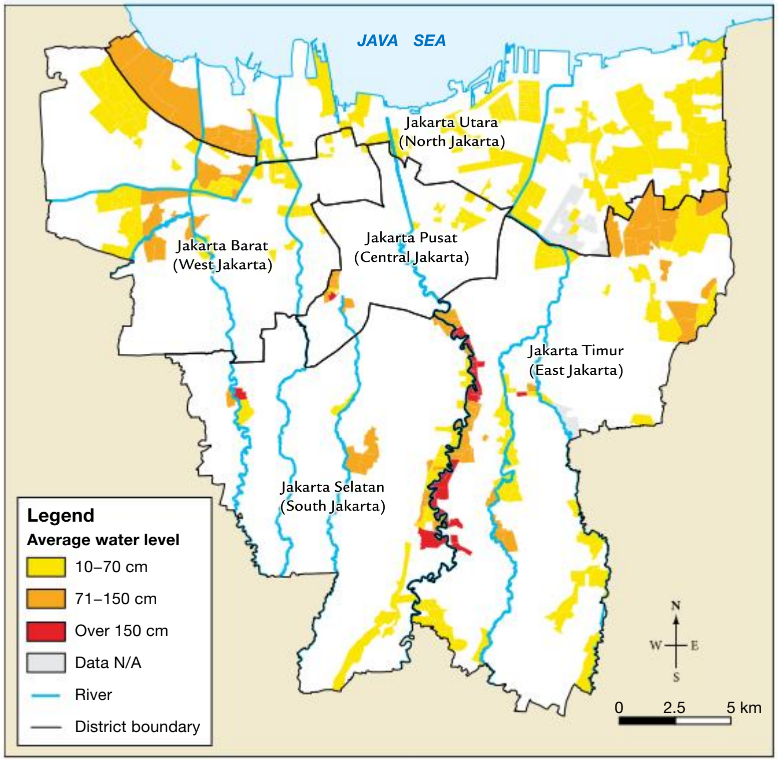
By the end of this lesson you should be able to identify land heights and features across Jakarta on a map and predict how these features might influence the direction of urban sprawl and flooding.

5.10.1 Urbanisation in Jakarta

Jakarta is situated on flat lowlands on the northern coast of Indonesia's West Java province. The city has expanded rapidly; in central areas, it has a population density of about 18 500 people per square kilometre.

Jakarta has regularly experienced flooding as a result of a combination of factors including:
- heavy wet-season rainfall
- low relief and land sitting below sea level
- shallow rivers that easily flood
- rubbish deposits in river beds.

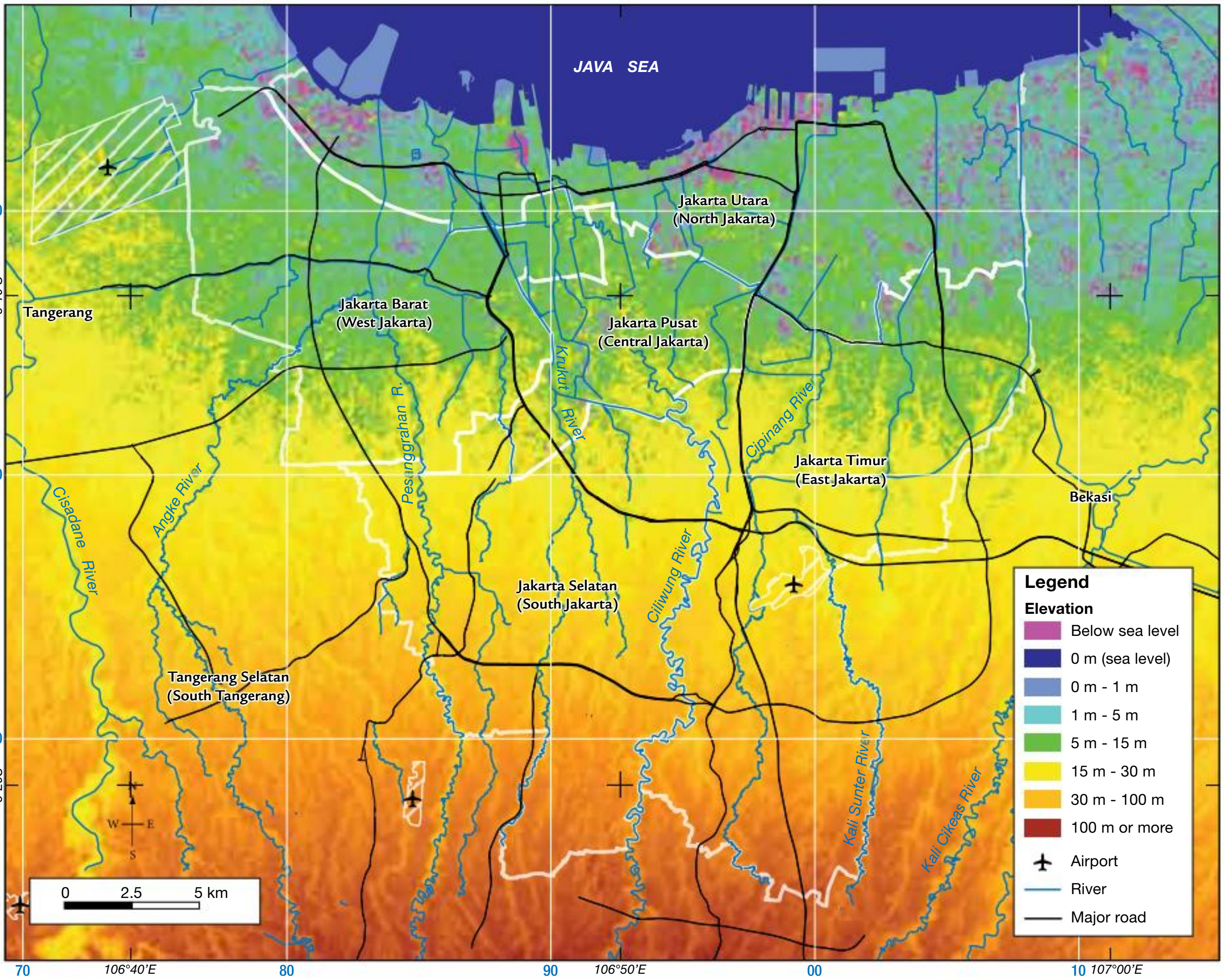
FIGURE 1 Areas of Jakarta that experienced severe flooding in January 2014



Source: Based on OCHA / ReliefWebSource: ReliefWeb / OCHA Indonesia Jakarta 2014 https://reliefweb.int/sites/reliefweb.int/files/resources/Update on Jakarta Flood as of 21Jan2014-R.pdf.

int-9065

FIGURE 2 Thematic map of land heights in Jakarta



Source: Map data © OpenStreetMap contributors, https://openstreetmap.org. Data is available under the Open Database Licence, https://opendatacommons.org/licenses/odbl/; elevation data sourced from USGS.

FIGURE 3 The extensive flooding in Jakarta

FIGURE 4 The flooding severely impacted homes.

Resources

eWorkbook	Investigating topographic maps — Jakarta (ewbk-11481)
Digital document	Land heights in Jakarta (doc-39766)
Video eLesson	Investigating topographic maps — Jakarta — Key concepts (eles-6123)
Interactivity	Investigating topographic maps — Jakarta (int-9065)
Google Earth	Jakarta, Indonesia (gogl-0064)

5.10 Exercise

learnon

5.10 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2	3, 4	5, 6

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- Receive immediate feedback
- Access sample responses
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Check your understanding

1. **Describe** the location of Jakarta.
2. **List** four reasons why Jakarta regularly floods.
3. Give an area reference for one part of Jakarta that you think would be particularly prone to flooding. Give reasons to **justify** your choice.

Apply your understanding

4. If residents in Jakarta are banned from accessing groundwater, are there any other natural sources from which they could obtain drinking water?
5. If you were given the task of moving residents whose homes will be underwater in the next 20 years, which areas would be your first priority? Provide area or grid references and reasons for your choice.
6. Rubbish disposal is a significant issue in Jakarta. **Explain** where the best place for a new rubbish dump would be. Provide area or grid references and reasons for your choice.

LESSON
5.11 Review

Hey students! Now that it's time to revise this topic, go online to:

Review your results

Watch teacher-led videos

Practise questions with immediate feedback

Find all this and MORE in jacPLUS

5.11.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

5.2 What is migration?

- Migration is when people move from one place to settle in another.
- Migration types can be categorised by time, location, and degree of choice.
- Push and pull factors influence decisions to migrate.
- Push factors are unfavourable qualities or conditions that make people want to leave a location.
- Pull factors are desirable qualities or conditions that attract people to a new location.

5.3 Why do people migrate between countries?

- Emigrants are leaving a country; immigrants are entering a country.
- Annual net migration takes into account the difference between the number of people who move into a country and the number who leave it over the course of a year.
- Push and pull factors influencing international migration can be broadly categorised as social, economic, political, or environmental.
- The majority of international migrants to Australia are from Europe or Asia due to cultural connection and/or geographic convenience.

5.4 Why do people migrate within countries?

- Within Australia, people move for employment reasons as FIFO or seasonal workers, or for a more relaxed lifestyle via a sea or tree change.
- Within China, employment reasons motivate labourers to move from rural areas, to coastal cities for work in factories and technological industries.
- Internal displacement is when people are forced to move, rather than the decision being voluntary.
- Conflict and natural disasters are the two main factors behind incidences of internal displacement.

5.5 Why do people migrate from the country to the city?

- Urbanisation refers to the growth of and expansion of urban areas as well as the increase in the proportion of people living in urban areas as compared to rural areas.
- A decline in living conditions in rural areas is one push factor motivating people to move to urban areas.
- Increased job opportunities and better access to services as key pull factors that attract people to cities.

5.6 How have urbanisation patterns changed over time?

- Cities first developed around 5000 years ago in Mesopotamia.
- Industrialisation during the nineteenth and early twentieth centuries saw the global urban population increase dramatically.
- Urban growth has not occurred evenly around the world; Africa and Asia remain less urbanised in comparison to Europe and North America, though this is changing rapidly.
- Australia and the United States both have a number of conurbations.

5.7 What are the advantages and disadvantages of urbanisation?

- The higher the urban population percentage, the wealthier a country tends to be in terms of GDP.
- Urbanisation brings more education, employment, and enterprise opportunities that benefit individuals and communities.
- It is easier to provide and access services such as healthcare, transport, housing, and education when people live in concentrated areas.
- Urban areas tend to have disadvantages such as more pollution, higher crime rates, easier transmission of disease, and a higher cost of living.
- Urban slums can develop when population growth results in unplanned settlements that existing infrastructure cannot support.

5.8 How do we create sustainable cities?

- To meet the needs of both existing and future populations, cities need be planned and developed to be more sustainable.
- To be sustainable, a city needs to reduce its environmental impact and support the quality of life of its inhabitants.
- Key features of sustainable cities include the use of renewable energy, the conservation of water, improved waste management, and a reduction in the use of cars as transport.

5.9 INQUIRY: Big City Life

- What are the migration patterns related to your focus city?
- What are the push and pull factors influencing these patterns?
- What are the effects of these patterns?
- How is sustainability being addressed?

5.10 Investigating topographic maps — Jakarta

- Jakarta regularly experiences flooding as a result of a combination of factors such as being situated on flat lowlands, having shallow rivers that can overflow, and having heavy wet-season rainfall.

5.11.2 Key terms

conurbation area when cities merge to form one continuous urban area

ecological footprint the amount of productive land needed on average by each person in a selected area for food, water, transport, housing and waste management

fly-in, fly-out (FIFO) a system in which workers fly to work, in places such as remote mines, and after a week or more fly back to their home elsewhere

internal displacement when people are forced to leave their homes due to conflict or environmental disasters, but remain within their country's borders

migrant a person who leaves their own country to go and live in another

population density the number of people living within one square kilometre of land; it identifies the intensity of land use or how crowded a place is

population distribution the pattern of where people live; population distribution is not even – cities that have high population densities and remote places such as deserts usually have low population densities

pull factor favourable quality or attribute that attracts people to a particular location

push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere

sanitation facilities provided to remove waste such as sewage and household or business rubbish

sea change movement of people from major cities to live near the coast to achieve a change of lifestyle

slum a run-down area of a city characterised by poor housing and poverty

tree change movement of people from major cities to live near the forest to achieve a change of lifestyle

urban relating to a city or town; the definition of an urban area varies from one country to another depending on population size and density

urbanisation the growth and expansion of urban areas and the increasing proportion of people living in urban areas as compared to rural areas

variables (in Geography) characteristics that can be measured and provide information about a place, beyond just the location of that place

5.11.3 Reflection

Reflect on your learning using the activities and resources provided.

Why do people move between and within countries, and what are the consequences of that movement?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning on this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry questions, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-10764)
Reflection (ewbk-10766)
Crossword (ewbk-10767)

Interactivity Urbanisation and migration crossword (int-9022)

5.11 Review exercise

Multiple choice

1. What does the term 'urbanisation' mean?
   - A. Movement of people from urban to rural areas
   - B. Growth and expansion of rural areas
   - C. Lower population densities in urban areas
   - D. Growth and expansion of urban areas
2. Why might people migrate to Australia?
   - A. Political stability
   - B. Employment/jobs
   - C. Family reunions
   - D. All of the above
3. Positive net migration means that
   - A. more people have moved to a country than have left it.
   - B. more people have left a country than have moved to it.
   - C. there has been no difference between the number of people moving to a country as compared to those who have left it.
   - D. the people who have migrated had a positive experience.
4. What places in Australia tend to have the greatest population densities?
   - A. Inland regional and remote areas
   - B. Capital cities
   - C. Along the coast
   - D. Eastern Australia
5. Which of the following statements is correct?
   - A. Per capita income is the only determinant of urbanisation.
   - B. Generally, countries with a high per capita income tend to be more urbanised.
   - C. Countries with a high per capita income are generally more rural.
   - D. Generally, countries with a low per capita income tend to be more urbanised.
6. Slums are a challenge of rapid urbanisation in developing countries. What is a slum?
   - A. A planned settlement in an urban area
   - B. An unplanned settlement in an urban area
   - C. An unplanned settlement in a rural area
   - D. An planned settlement in a rural area
7. Which of the following are problems that result from rapid population growth in urban areas? Select all possible answers from the options below.
   - A. Poverty
   - B. Employment
   - C. Non-crowded public transport
   - D. Air pollution
   - E. Poor sanitation

8. Where are the world's cities generally located? Select all possible answers from the options below.
   A. Inland
   B. Along the coastline
   C. Close to transport routes
   D. In mountainous areas
9. Which of the following is not a sustainable urban project?
   A. Beekeeping
   B. Planting community gardens
   C. Increasing infrastructure and car manufacturing
   D. Recycling building materials
   E. Solar panels
10. Rapid growth of cities can lead to social and environmental problems. Often there is insufficient affordable housing, resulting in the build-up of slums.
    Which of the following would NOT be a characteristic of a slum?
    A. High population density
    B. A lack of water and sanitation
    C. Efficient public transport network
    D. Temporary housing structures

Short answer

Communicating

11. **Classify** each of the following as either push or pull factors that have resulted in urbanisation.
    a. Job opportunities
    b. Political or religious freedom
    c. Natural disasters
    d. Lack of medical services or educational opportunities
    e. War
    f. Family links
12. Drawing on your own knowledge and your understanding of sea changes, tree changes and other forms of migration, **explain** how the COVID-19 pandemic has affected migration patterns within Australia (i.e. between states or within states).
13. **Distinguish** between emigration and immigration and provide an example.
14. Imagine that you are the mayor of a rapidly growing urban area where there is high natural population growth and an increase in people migrating to the area. After examining how urban slums develop, **propose** some actions you could take to prevent this from happening.
15. Consider the capital city or regional city you live closest to. **Discuss** three actions that could be implemented to make this urban area more sustainable in the short term.

6 Our changing urban world

LESSON SEQUENCE

LESSON
6.1 Overview

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Answer questions and check results

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What are the effects of urbanisation on people and how has the distribution of the population changed in recent times?

6.1.1 Introduction

In 2008, for the first time in history, the majority of the world's population lived and worked in towns and cities. This urban population is projected to continue growing in the future. The fast pace and unplanned nature of this growth has seen the development of megacities. However, along with the opportunities provided by the megacities come many problems. It is a challenge to create sustainable urban environments that meet the needs of the people living in these places.

FIGURE 1 Australia's cities are spreading across great distances.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-13445)

Video eLesson Our changing urban world (eles-6110)

LESSON
6.2 What is urbanisation?

LEARNING INTENTION

By the end of this lesson you should be able to discuss the difference between urbanisation and urban growth. You should also be able to explain the impacts and consequences of urbanisation and urban growth.

TUNE IN

FIGURE 1 shows the Favela Paraisópolis, a slum in São Paulo, Brazil.

1. Consider this image, what do you think would make someone want to move here?
2. Make a list of the positives and negatives for this place.
3. Why do you think there are different types of buildings here?

FIGURE 1 The Favela Paraisópolis slum is overlooked by luxury buildings.

6.2.1 Urbanisation

Urbanisation is the movement of people from the country to the city. It's part of a country's **internal migration**. As a result of people moving from the country and gathering and settling in a central area, cities were formed. The earliest cities emerged about 5000 years ago in Mesopotamia (part of present-day Iran, Iraq and Syria). Originally these cities depended on agriculture. In 1800, 98 per cent of the global population lived in rural areas and most were still dependent upon farming and livestock production — only 2 per cent of people lived in urban areas.

However, as cities grew, primarily as a result of the Industrial Revolution and trade developing, urban areas became centres for merchants, traders, government officials and craftspeople. By 2008, the proportion of people living in urban areas had increased to 50.1 per cent, and in 2018 the figure had risen again to approximately 56 per cent. The rate of growth has varied in different regions.

6.2.2 CASE STUDY: Migration due to climate change in India and Bangladesh

Climate change has resulted in higher temperatures, more extreme weather, rising sea levels, flooding and increased cyclonic activity in the Bay of Bengal and the Arabian Sea. These changes have affected the environment in many places in Bangladesh and India.

urbanisation the growth and expansion of urban areas and the increasing proportion of people living in urban areas as compared to rural areas

internal migration the movement of people from one defined area to another within a country

Bangladesh is a low-lying country with a dense population. The population in many regions rely on farming for their livelihood. Rising sea levels have introduced salt water into rice fields and reduced food production, income and job opportunities. Along with the attraction of jobs in construction in India, this has resulted in international **migration** from Bangladesh to India.

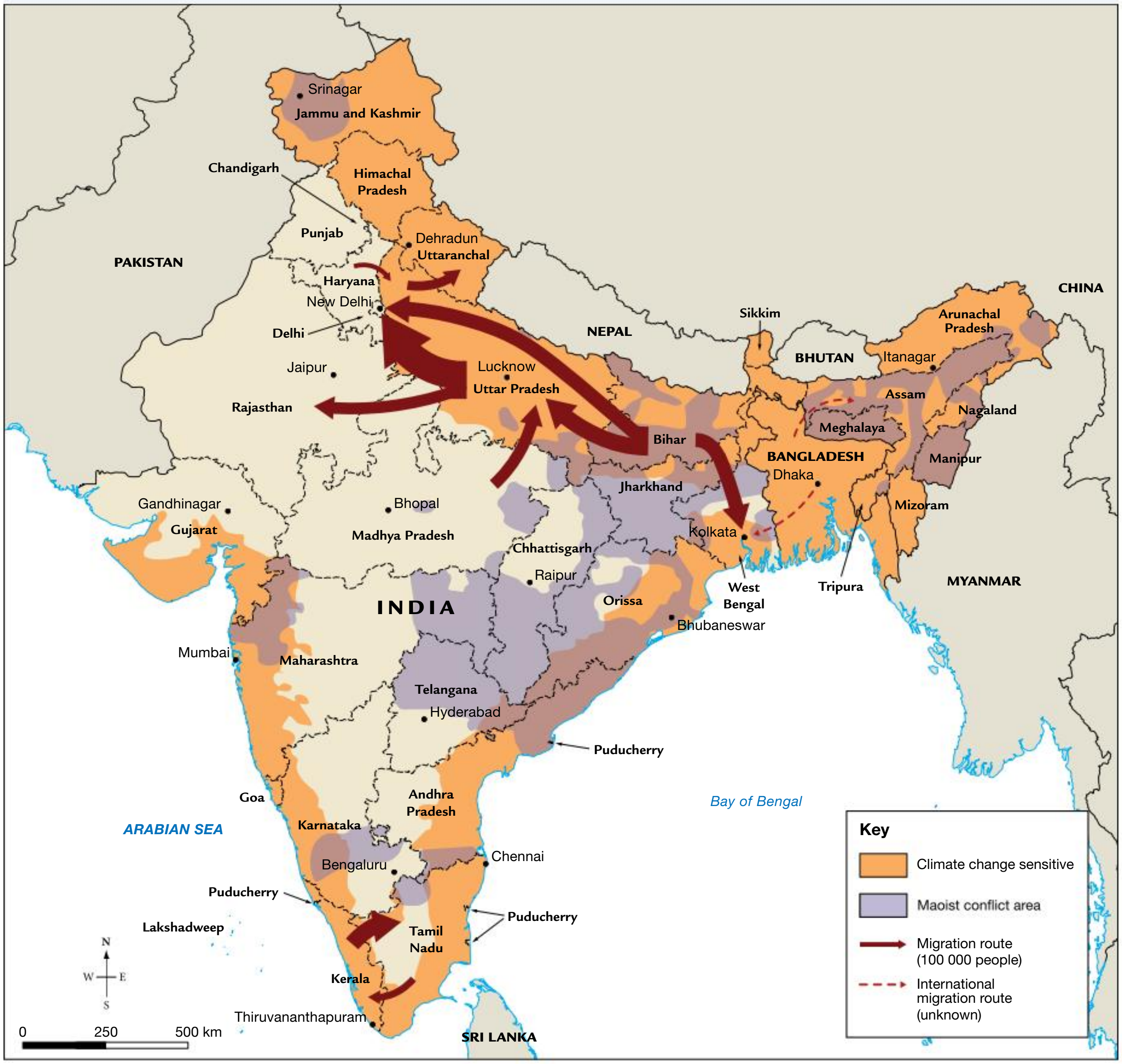
India also experiences climate change issues — flooding, erosion and landslides and areas of drought. The stresses caused by these issues have had an effect on millions of people in this region and has led to internal migration, particularly from rural to urban areas. The **population density** in 2018 in Mumbai was over 28 000 people per square kilometre; in Delhi it was 12 600 people per square kilometre. This movement of people has also increased tensions and conflict between ethnic groups, including over land rights.

migration the movement of people (or animals) from one location to another

population density the number of people living within one square kilometre of land; it identifies the intensity of land use or how crowded a place is

int-7863

FIGURE 2 Migration flows in India



Source: Bhattacharyya and Werz.

6.2.3 Urban growth

While urbanisation is the movement of people from rural areas to metropolitan areas, **urban growth** is the rate at which the population of an urban area increases. You might have heard your parents or caregivers say things like 'this suburb popped up overnight' or 'the city's getting bigger and bigger'. Both statements refer to the urban growth of the city.

Urban growth is one of the key indicators of a country's economic success. The more urban growth there is, the better the country's doing. Consider that urban growth is all about building new houses, people pay for these houses from the jobs they have, more houses being built indicates more jobs. And then there's the jobs that are created because people are building new houses. Builders, plumbers, carpenters, electricians. Put simply: more urban growth, more money.

So urban growth seems pretty good, but what are the downsides? As you can imagine, there's an environmental impact here. Mainly there's the increase in traffic and thus an increase in greenhouse gas emissions. Urban growth increases car, bus and truck traffic by creating longer and more frequent commutes. Urban growth is also a leading cause of water pollution as rainwater catches petrol fumes, household chemicals, paints, oils and travels to nearby water sources. There's also the increase in water consumption: more houses, more showers and baths, more water needed to drink.

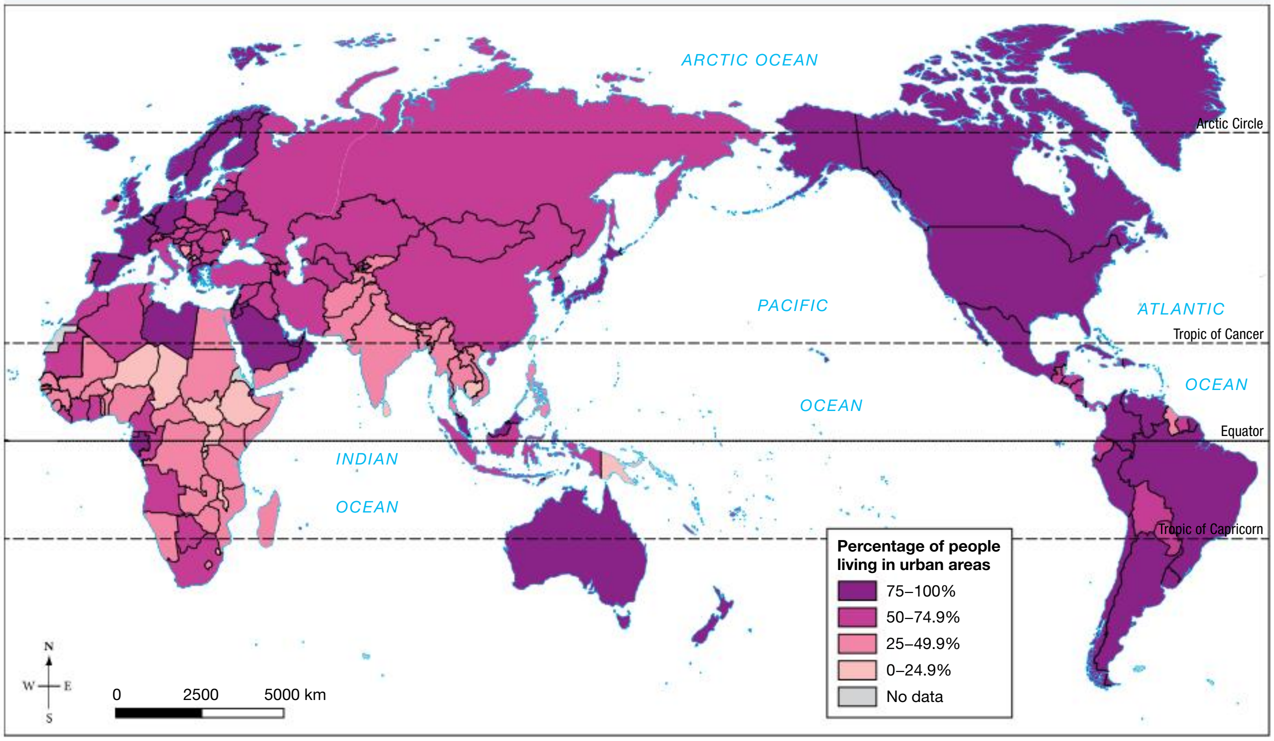
As the cities grow and suburbs spread out, they naturally need space to do so. Where does this space come from? Well, nature. A consequence of urban growth is the gradual loss of land and space which impacts wildlife habitats, potential farmland, and the loss of parks and open spaces.

urban growth the rate at which the population of an urban area increases

int-9023

tlvd-10634

FIGURE 3 Percentage of population living in urban centres, 2017



Source: World Bank Data.

FIGURE 4 Urban housing in Kuwait

FIGURE 5 Perth in Western Australia is an example of a coastal city.

6.2.4 Coastal urbanisation

People have lived on coastlines for thousands of years. Often at the mouth of rivers, coastal settlements became centres of trade and commerce and quickly grew into cities. Today, about half the world's population lives along or within 200 kilometres of a coastline. According to the European Commission, 95 per cent of the world's population lives on only 10 per cent of the Earth's land area.

Countries that have over 80 per cent of their population living within 100 kilometres of a coastline include the United Kingdom, Senegal, Portugal, Belgium, the Netherlands, Sweden, Norway, Tunisia, Greece, Oman, the United Arab Emirates, Kuwait, Qatar, Sri Lanka, Japan, Singapore, Indonesia, Malaysia, the Philippines, Australia and New Zealand.

6.2.5 Urban challenges

Rapid population growth in urban areas can result in problems such as poverty, unemployment, inadequate shelter, poor **sanitation**, dirty or depleted water supplies, air pollution, road congestion and overcrowded public transport.

FIGURE 6 Traffic congestion in Los Angeles, United States

Transport and pollution

In cities that can't keep up with rapid population growth, traffic congestion and overcrowded public transport mean that many people must travel for hours to get to and from work (see **FIGURE 6**).

Pollution is also a problem that affects the health of people living in cities. Many cities have high levels of air pollution and some — including Mexico City, Buenos Aires, Beijing and Los Angeles — are famous for being so polluted.

According to the World Health Organization in 2016, 12 of the world's 25 cities with the worst air pollution were in India. Most of the pollution comes from the growing industrial sector and vehicle emissions.

sanitation facilities provided to remove waste such as sewage and household or business rubbish

6.2 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Find out the population density of the capital city in your state or territory. How does it compare to that of Mumbai and New Delhi in 2018? **List** all the ways in which living in one of these Indian cities might be different to life in your local city.
2. Why is it difficult in a country the size of Australia, with population concentrated on the coast, to provide services in outback areas? How would providing services be different in a country such as Luxembourg in Europe? Look at the size of Luxembourg in an atlas or by using Google Maps or Google Earth.

6.2 Exercise

learnon

6.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4	3, 5, 6, 10	7, 8, 9

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Check your understanding

1. Transport and pollution are not problems in large urban areas because so many people live in the city that they don't have to use transport to get to and from work. True or false?
2. In 1800, what was the percentage of the global population that lived in rural areas?
   A. 50 per cent
   B. 75 per cent
   C. 90 per cent
   D. 98 per cent
3. ___________ is the movement of people from the country to the city.
4. **Identify** three problems that can be caused by rapid population growth in urban areas.
5. Study **FIGURE 2** and the text in the 6.2.2 case study 'Migration due to climate change in India and Bangladesh'. **Identify** the push and pull factors that result in migration in India and Bangladesh.

Apply your understandings

Communicating

6. **Explain** what is expected to happen with urbanisation in the future.
7. Study **FIGURE 3**.
   a. **Name** the three countries with the highest and three with the lowest percentage of people living in urban areas.
   b. **Describe** the general pattern shown in the map. Include patterns within different continents in your description.
8. a. **Explain** the difference between urban population increase from migration and from natural increase.
   b. Which of these is more likely to occur in a city located in a developing country? Why?
9. a. **Describe** some features of urban and rural places.
   b. Give an example of a place with urban and rural features and **justify** your answer.
10. **Suggest** why transport and pollution are often problematic in large urban areas.

LESSON
6.3 What are megacities?

LEARNING INTENTION

By the end of this lesson you should be able to distinguish between a city and a megacity. You should also be able to locate where megacities are in the world and discuss how megacities are merging to create megaregions.

TUNE IN

New York City is often referred to as the 'city that never sleeps'.

1. What do you think this means? Why do you think people talk of New York this way?
2. List four major problems that are faced in cities like New York.

FIGURE 1 New York City

6.3.1 Where are cities located?

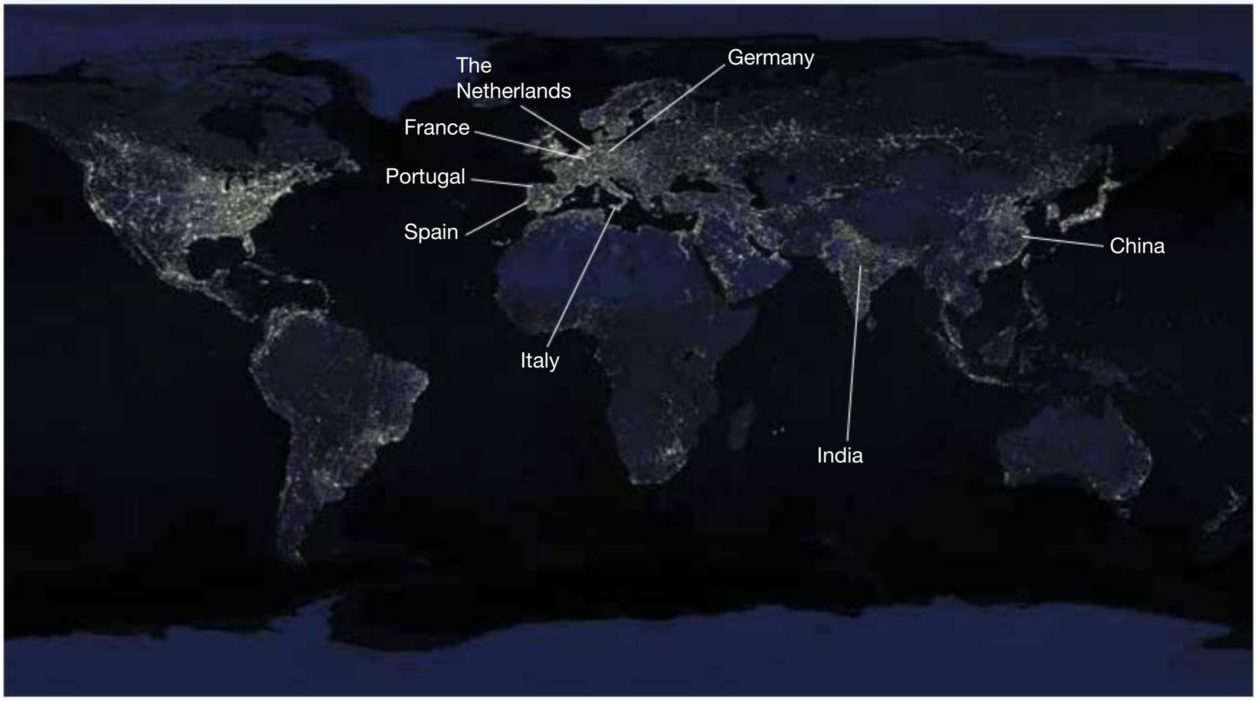
How is a city different from other urban areas such as towns and villages? A city is a large and permanent settlement, and is usually quite complex in terms of transport, land use and **utilities** such as water, power and sanitation.

The image of the Earth at night (**FIGURE 2**) shows where lights are shining. The brightest areas on the map are the most urbanised, but might not be the most populated. If you compare this image with **FIGURE 3**, you can make some comparisons. For example, there are very bright lights in western Europe (Belgium, The Netherlands, France, Spain and Portugal, Germany, Switzerland, Italy and Austria) and yet more people living in China and India. Refer to your atlas to locate these countries.

The world's cities are generally located along or close to coastlines and transport routes. Some regions remain thinly populated and unlit. Antarctica is entirely dark. The interior jungles of Africa and South America are mostly dark, but lights are beginning to appear there. Deserts in Africa, Arabia, Australia, Mongolia and the United States are poorly lit as well, although there are some lights along coastlines. Other dark areas include the forests of Canada and Russia, and the great mountains of the Himalayan region and Mongolia.

utilities services provided to a population, such as water, natural gas, electricity and communication facilities

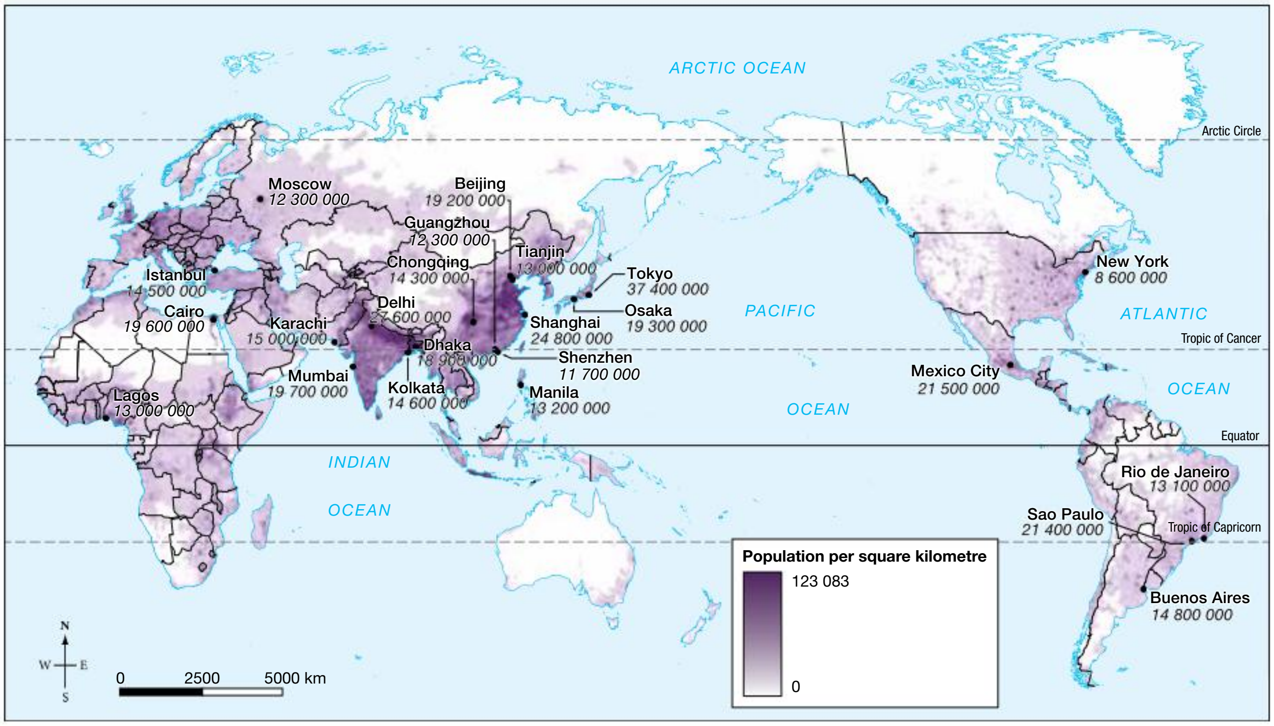
FIGURE 2 Satellite image of the Earth at night



DISCUSS

As the world's population continues to increase, cities will spread into the darker regions shown in **FIGURE 2**. State whether you agree or disagree with this statement, providing reasons for your decision.

FIGURE 3 Population density and distribution of major cities in 2018, with selected city populations



Source: United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision.

6.3.2 What is a megacity?

Over the next century, urbanisation is predicted to increase at an even greater rate than it has in the past. Around the year 1900 only 15 per cent of the world's population lived in cities. At some time in 2007 this reached 50 per cent. In 2018, this figure was 55 per cent, with projections expecting that two-thirds of the population will live in cities by 2050. People are attracted to cities with huge populations, and increasingly these cities are becoming megacities.

FIGURE 4 Medellin, the second-largest city in Colombia, South America

A **megacity** is a city with more than 10 million inhabitants. When you consider that Australia's population was almost 25 million in 2018 — with over 5 million living in Sydney and 5 million in Melbourne — it is hard to imagine what it would be like to live in a megacity.

The number of megacities has grown over time. In 1950, only two cities in the world — Tokyo and New York — had a population above 10 million. By 1975 there were four; by 2000 there were 17, and in 2018 there were 33 megacities. By 2030, it is predicted that there will be 43 megacities in the world. Nineteen of these cities have a population greater than 15 million.

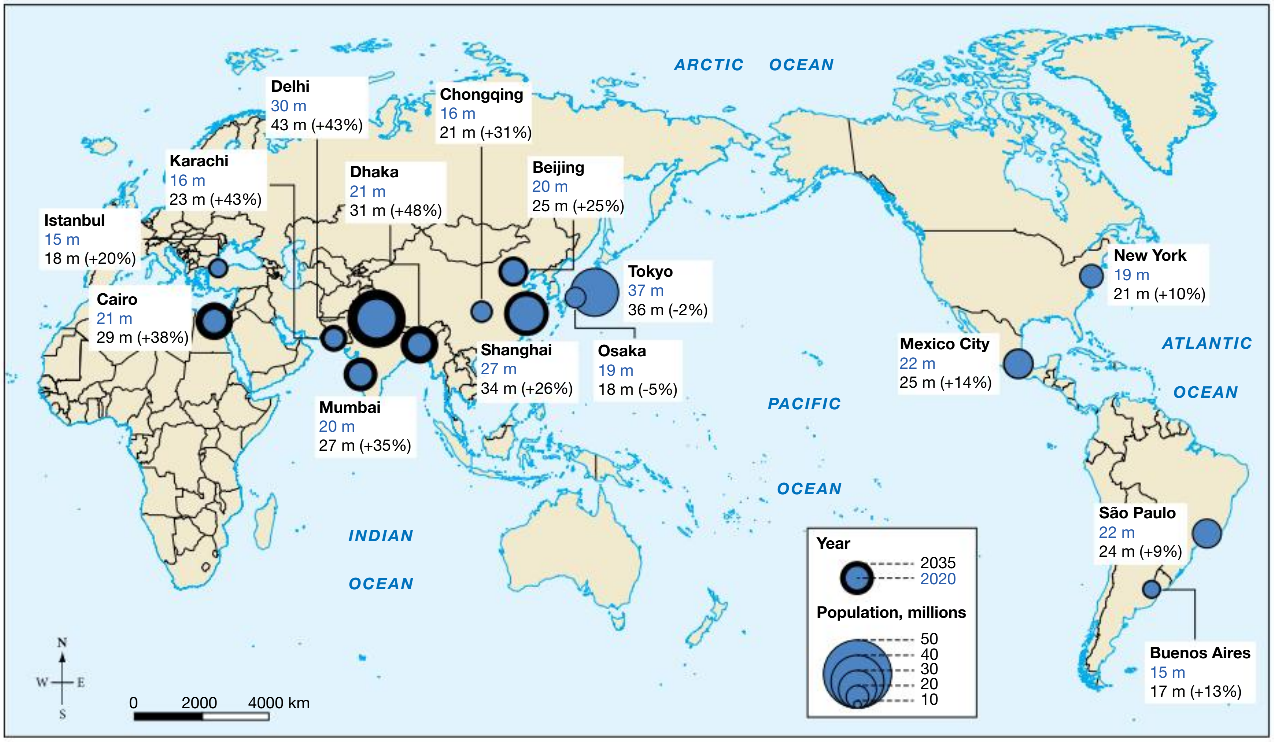
megacity city with more than 10 million inhabitants

The map below shows the growth of the world's top 15 megacities.

int-9024

tlvd-10635

FIGURE 5 The world's megacities have experienced major growth

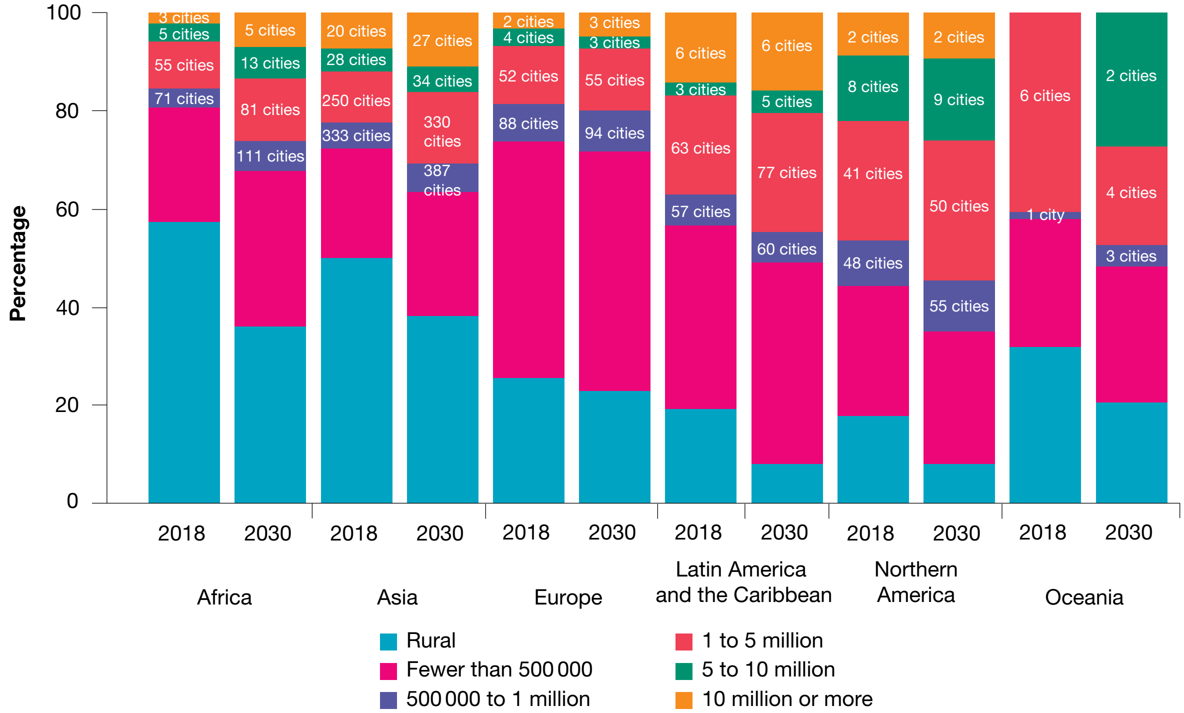


Source: Based on data from United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1. Map drawn by Spatial Vision.

The distribution of megacities — that is, where they are located over space in the world — has also changed. In 1975, two megacities were located in the Americas and two in Asia. In 2014 more than half (15) of all megacities were located in Asia; and it is predicted that, in 2030, 23 of the 41 megacities will be located in Asia. There is also a change in terms of the wealth of countries that contain megacities, with the majority now located in developing countries. This is in contrast to the development of urbanisation, when North America and Europe were the focus of historic urban growth. By 2030, it is predicted that 23 megacities will exist in less developed countries.

int-9025

FIGURE 6 Regional population distribution in different city sizes in 2018 and projected to 2030



Source: United Nations.

6.3.3 The never-ending city

In some parts of the world, megacities are merging to create **megaregions**. These regions are home to huge populations. Examples of megaregions include:

- Hong Kong–Shenzhen–Guangzhou in China, already home to 65 million people
- Kyoto–Osaka–Kobe, with a population of over 20 million in 2015.

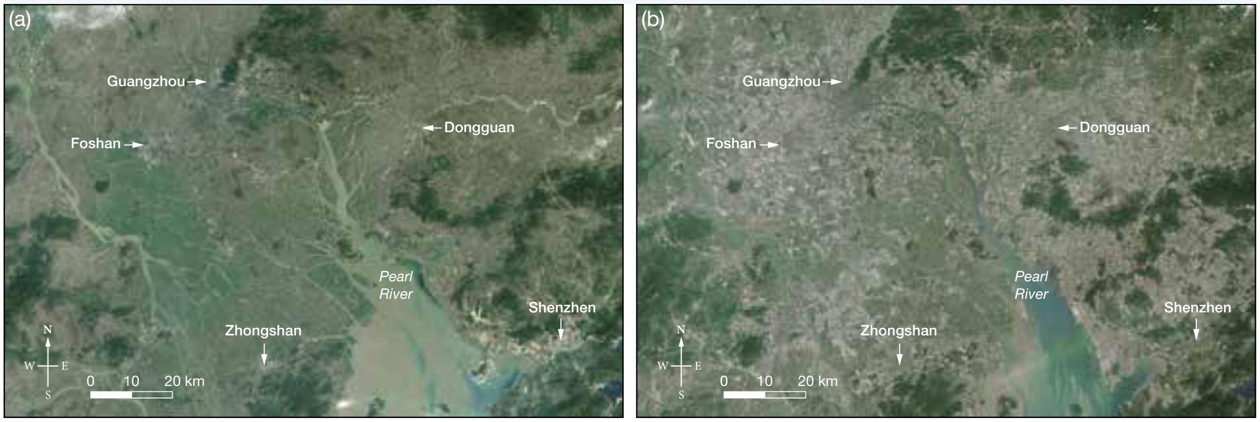
Pearl River Delta (PRD)

This region is located in southern China on the South China Sea. The PRD is one of the fastest-growing regions in the world. There are five major cities — Hong Kong, Shenzhen, Dongguan, Foshan and Guangzhou and six smaller cities made up of Macau, Zhaoqing, Zhuhai, Jiangmen, Huizhou and Zhongshan, which are linked by transport routes and provide great economic opportunities. Until 1979, Shenzhen was a fishing village. In 1980 the government

FIGURE 7 The city of Shenzhen, in the Pearl River Delta, in the twenty-first century

megaregion area where two or more megacities become connected as increasing numbers of towns and ghettos develop between them declared the area to be a Special Economic Zone (SEZ), attracting businesses and investment from other countries. Since then, the area has undergone rapid urbanisation that has dramatically changed the landscape around the Pearl River Delta (see **FIGURE 8**).

FIGURE 8 Change in the Pearl River Delta between (a) 1988 and (b) 2014



Source: NASA.

Source: NASA.

In 1988, the rivers and streams flowed through a fertile region with rice paddies, wheat fields, orchards and fish ponds. The region was mostly rural, and the population of roughly 10 million distributed between rural areas and a few cities.

By 2014, these cities had grown quickly and merged into an interconnected megalopolis with a population of 42 million. When combining the population of Hong Kong, the total is around 65 million.

Megacity facts

- Over half the future growth in megacities will be within Asia.
- The 20 largest cities consume 80 per cent of the world's energy and produce 80 per cent of global greenhouse gas emissions.
- **Slums** in megacities are especially vulnerable to climate change, as they are often built on hazardous sites in high-risk locations.

slum a run-down area of a city characterised by poor housing and poverty

6.3 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Go to the **World City Populations** weblink in the Resources panel. Work as a team of five and **investigate** the change in city population in different continents. **Discuss** which regions each member will **investigate** and record maps, data and graphs. Report your findings back to the group.
2. Use an atlas to locate the two megaregions mentioned in section 6.4.3. Why do these regions develop?
3. **Research** the 'dead zone' in the sea at the mouth of the Pearl River. What does this mean, and what is its cause?
4. **Describe** the changes that have occurred in the Pearl River Delta region. Find this place in an atlas and **describe** where it is in relation to the rest of China and to two other countries in Asia.
5. Work with another student to produce a Prezi or PowerPoint presentation or an animation showing the world's megacities in 2018 and 2030. Include images from the internet and data from **FIGURE 5**. You may like to choose appropriate music to accompany the presentation.
6. Complete the following questions about **FIGURE 4**.
   a. **Describe** the foreground and background shown in the photograph.
   b. **List** the natural and human characteristics shown in the photograph.
   c. What does this photograph show about urban environments? How has the urban environment changed the natural environment?

d. How might the changes described in part (b) lead to an increased risk of erosion? (See topic 3 for information on erosion processes.)
e. Imagine that the population of this city continues to increase. **Describe** what might happen to the land in the future.
f. Do you think that all land surrounding cities should be able to be taken up by buildings? Why or why not?
g. **Investigate** the place where you live. Are there land-use zones that cannot be built upon, such as 'green wedges'? Where are they and why are they there? Do you think they should be protected from development? **Justify** your answer.

on Resources

Weblink World City Populations

6.3 Exercise

learnon

6.3 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 4, 5	3, 6	7, 8, 9, 10

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Check your understanding

1. Compared to a town or village, a city is a large and permanent settlement. True or false?
2. A megacity is a city with a minimum of how many million inhabitants?
   A. 5
   B. 10
   C. 15
   D. 30
3. Which of these is considered a positive of living in a megacity?
   A. High levels of traffic.
   B. High levels of employment.
   C. High levels of diverse employment.
   D. High levels of poverty.
4. **Explain** what the bright lights in **FIGURE 2** show.
5. **Name** the first two megacities and the countries where they are located.

Apply your understanding

Communicating

6. **Explain** what a megacity is. How many megacities were there in 2018?
7. **Discuss** why megaregions develop.
8. **Examine** the environmental impacts of megacities and megaregions.
9. **Describe** the changes to the Pearl River Delta from 1988 to 2014.
10. The 20 largest cities in the world consume 80 per cent of the world's energy and produce 80 per cent of the world's greenhouse gas emissions. **Propose** some solutions to this problem.

LESSON
6.4 What is the impact of urbanisation in Indonesia?

LEARNING INTENTION

By the end of this lesson you should be able to explain the causes or urbanisation and urban growth in Indonesia. You should also be able to discuss the impact of urbanisation on the urban environment in Indonesia and discuss the economic, aesthetic and cultural value of urbanisation to people.

TUNE IN

Indonesia is one of Australia's closest neighbours — but what do we know about it?

Complete a concept map of what you already know about Indonesia and Jakarta. Consider where Indonesia is, who lives there, how many people live there, and any tourist attractions. Anything you think can think of.

FIGURE 1 Map of Indonesia

Source: Spatial Vision.

6.4.1 Indonesia's population

Many people do not realise that the fourth most populated country in the world is one of our nearest neighbours. Like many countries in Asia, Indonesia has experienced rapid urban growth, but this has occurred only relatively recently. Indonesia's population of nearly 270 million people (2019) lives on a chain or cluster (an archipelago) of more than 18 000 islands (see **FIGURE 1**). However, its population is not evenly distributed. Only about 11 000 of the islands are actually inhabited. Sixty per cent of Indonesia's population is concentrated on only seven per cent of the total land area — on the island of Java.

Indonesia has changed from a rural to an urban society quite recently. In 1950, only 15.5 per cent of its population lived in urban areas. In 2018, this had increased to 55.3 per cent.

Like many countries in Asia, Indonesia has a high concentration of its urban population in a few large cities. In 1950, there was only one city that was home to more than one million people in Indonesia: Jakarta. That had increased to 4 cities by 1980, 8 by 1990, 10 by 2000 and 14 by 2016. More than one-fifth of the Indonesian urban population now lives in the Jakarta metropolitan area (JMA).

6.4.2 Causes of urbanisation

More than one-third of Indonesia's urban population growth resulted from natural increase. It took until 1962 for Indonesia's population to reach 100 million people. However, it then took only until 1997 to reach 200 million. In the early 1970s, Indonesia's birth rate was very high — 5.6 children per woman. However, the growth rate has fallen dramatically from 2.3 per cent in 1970 to about 1.2 per cent in 2015. In 2018, there were nearly 5.5 million babies born in Indonesia — almost the equivalent of the population of Melbourne.

As few restrictions were placed on rural–urban migration, most of the migration movement consisted of the rural poor moving into cities and especially into slums, leaving their families behind in the villages. On top of this, in recent years about 20 000 foreigners per year have obtained work permits for Indonesia.

Investment from within Indonesia and from other countries has tended to occur mainly in the large urban areas, because these areas can supply the workers, transport (by sea and over land), water and electricity that are needed by industry.

The first president of Indonesia wanted Jakarta to be like the world's great cities, such as Paris and New York, as well as a focus for other Indonesian cities. President Sukarno therefore built broad avenues, highways and electric railway lines, luxurious housing estates, high-rise buildings, universities and industrial estates in Jakarta.

int-7866

FIGURE 2 Selected south-east Asian city populations, 1950–2030 projected

Source: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, CD-ROM Edition.

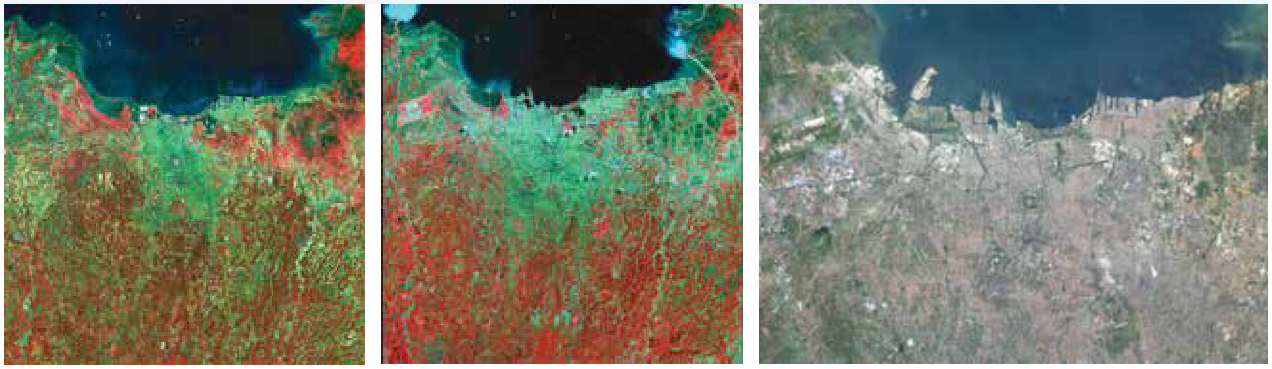
FIGURE 3 The Jakarta metropolitan area had a population of over 10 million in 2018 and a population density of over 14 000 people per square kilometre. It is the second largest urban area in the world.

6.4.3 Consequences of urbanisation

Growth of Jakarta

One of the consequences of urbanisation in Indonesia has been the dramatic growth of Jakarta, Indonesia's capital and largest city, located on the north-west coast of Java. The central island of Java is the world's most populous island, having a population density of 1000 people per square kilometre. The Jakarta Metropolitan Area (JMA) is now one of the world's largest urban areas. In 1930, Jakarta's population was around half a million people. By 1961 it had grown almost six-fold to 2.97 million. By 2005, it was almost 9 million. In 2019, the Special Capital Region of Jakarta had a population of almost 10 million, while the greater metropolitan agglomeration had a population of over 31 million.

FIGURE 4 Jakarta's urban growth



1976 (population 6 million) | 1989 (population 9 million) | 2014 (population 10.3 million)

FIGURE 5 Smog over Jakarta

Loss of land

As Jakarta has become more urbanised, there has been a decrease in the amount of open green space — from nearly 30 per cent of the city's total area in 1984 to less than 10 per cent in 2015.

Prime agricultural areas have been lost and become residential and industrial areas. Urban land is worth more than agricultural land. This was estimated to have fallen to around 5% in 2018, although there have been more recent attempts to 're-green' the city.

Environment

Indonesia's level of sewerage and sanitation coverage is very low. Sewage from houses and from industry, as well as industrial effluents and agricultural run-off, are polluting surface and groundwater. Air pollution levels are high, with traffic and industrial fumes combining with smoke from fires set by farmers and plantation owners in rural areas clearing forest lands for agricultural use.

Food production

Because young people, especially young men, migrate to Indonesia's cities in search of better job opportunities, there are fewer people taking over their families' farms. This could lead to the possibility of a food crisis if food production levels are not increased.

Job opportunities

Labourers who lived in Java and did not own land used to have very few sources of income. Now, most landless rural families on Java have

FIGURE 6 Traffic congestion in Jakarta

at least one person working outside the village in a factory or service job. Today, less than 20 per cent of households depend on agriculture for their livelihood.

Subsidence

Land has been subsiding because more groundwater is being extracted, and also because of the additional load that the ground has to bear due to an increased volume of construction. Subsidence causes cracking of buildings and roads, changes in the flow of rivers, canals and drains, and increased inland and coastal flooding. In some parts of Jakarta, land has subsided by 1–15 centimetres per year — in other areas, this has been up to 28 centimetres per year.

New urban areas

New towns and large-scale residential areas have been developed in and around Jakarta. Plans to relocate Jakarta to the East Kalimantan province of Borneo are currently in progress. However, heavy flows of commuter traffic have led to increased levels of traffic congestion between the scattered new towns and the cities.

6.4 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Use the **Gapminder** weblinks in the Resources panel to **compare** the lives of a family living in a rural environment with a family living in an urban environment.

- Rural — The Wayan family, income $132 p/month
- Urban — The Carolina family, income $2594 p/month

i. **Compare** the two families. Is there much difference between their quality of life? Complete the table below.

Examples	Rural family	Urban family
Food		
Transport		
Buildings		

ii. There is a huge difference in their incomes. **Explain** why you think this is. How does urbanisation play a role in this?

iii. Using this as a case study, do you think the consequences of urbanisation in Indonesia are positive or negative?

iv. Explore the **Gapminder** website further. **Compare** two more families, another from Indonesia and one from Australia. Complete another chart like the one above and report your findings to the class.

on Resources

Weblinks Gapminder — Rural
Gapminder — Urban

6.4 Exercise

learnon

6.4 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3, 4,	5, 7, 8	6, 9, 10

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Check your understanding

1. Which of the following statements is **not** a reason why Indonesia has become very urbanised?
   A. The sharp rise in population and increasing unrestricted migration from rural areas to urban cities
   B. The first president of Indonesia wanted Indonesian cities to be like the world's great cities and constructed infrastructure and facilities
   C. The sharp drop in population and the increased migration to rural areas
   D. Large investment mainly in the large urban areas
2. Study **FIGURE 2**. **Identify** the cities that have become megacities (greater than 10 million people). **Select** all that apply.
   A. Jakarta
   B. Denpasar
   C. Davao City
   D. Medan
   E. Kuala Lumpur
   F. Singapore
3. There is no interconnection between the increasing population in Indonesia and the subsidence of land. True or false?
4. **Explain** how and why Jakarta has become a major city within Indonesia and also on a world scale.
5. **Suggest** why you think people have moved from rural areas to urban areas within Indonesia.

Apply your understanding

Interpreting and analysing geographical data and information

6. a. What is Indonesia's current population? If the area of Indonesia is 1 904 569 square kilometres, **calculate** what its approximate population density is.
   b. How does this **compare** to Australia's population density of 3.1 people per square kilometre?
   c. **Describe**, using statistics, how Indonesia has become very urbanised in a relatively short time.

Communicating

7. What do you believe are the three main reasons that Indonesia has undergone such rapid urbanisation? Give reasons that **justify** your choices.
8. Urbanisation causes many harmful consequences to the environment. **Decide** which of the consequences of urbanisation may continue to have the biggest effects on the environment in the future.
9. **Identify** how the urbanisation of Indonesia is similar to and different from the urbanisation of another country you have studied, such as Australia, China or the United States.
10. **Study FIGURE 2**. In which time period did Jakarta experience its fastest growth? (Hint: Look at the width of the colour circle bands.)

LESSON
6.5 Are growing urban communities sustainable?

LEARNING INTENTION

By the end of this lesson you should be able to explain the predicted population increase in Australia and the rest of the world. You should also be able to discuss the challenges facing Australia's economy because of the predicted population increase and explain why some people choose to live in rural areas instead of urban areas.

TUNE IN

As **TABLE 1** shows, Australia is just one country that has seen a steady increase in people residing in urban areas.

1. Why do you think there's been an increase in urbanisation in Australia and not a ruralisation?
2. Complete a Venn diagram exploring the differences and similarities between urban living and rural living (consider access to services, transport, economy, education, free space).

TABLE 1 Percentage of population residing in urban areas by country, 1950–2050

	1950	1975	2000	2025	2050
Australia	77.0	85.9	87.2	90.9	92.9
Brazil	36.2	60.8	81.2	87.7	90.7
Cambodia	10.2	4.4	18.6	23.8	37.6
China	11.8	17.4	35.9	65.4	77.3
France	55.2	72.9	76.9	90.7	93.3
India	17.0	21.3	27.7	37.2	51.7
Indonesia	12.4	19.3	42.0	60.3	72.1
Japan	53.4	75.7	78.6	96.3	97.6
Papua New Guinea	1.7	11.9	13.2	15.1	26.3
United Kingdom	79.0	77.7	78.7	81.8	85.9

Source: UN Population Division, 2011.

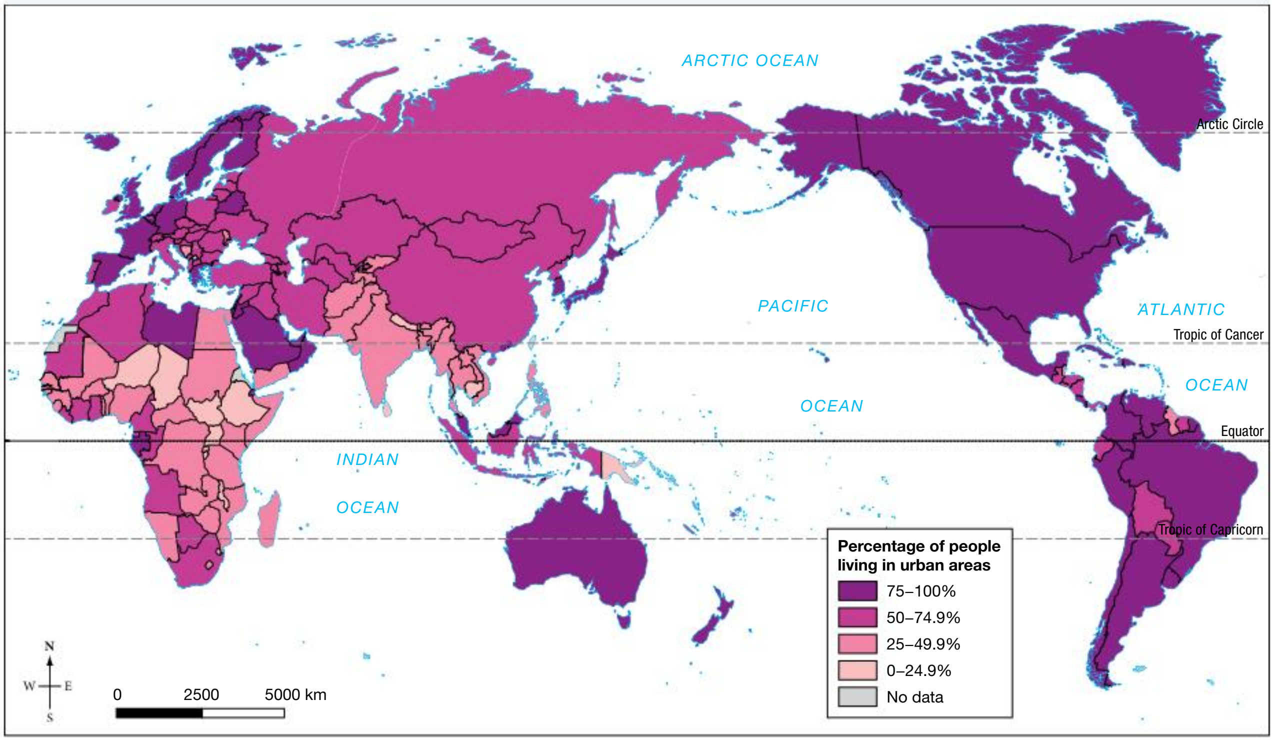
6.5.1 The urban explosion

In 2008, for the first time in history, the world's urban population outnumbered its rural population. In 2015, the world's population reached over 7.3 billion; it is expected to reach 9.2 billion by 2050. Where will all these people live? What challenges will cities and communities face in trying to ensure a decent standard of living for all of us?

One of the biggest challenges we face is ensuring that the sustainability of our economy, communities and environment is compatible with Australia's growing urban population (see **TABLE 1**).

int-7868

FIGURE 1 Percentage of population in urban areas, 2017



Source: World Bank Data.

Global population growth will be concentrated mainly in urban areas of developing countries. It is forecast that by 2030, 3.9 billion people will be living in cities of the developing world. The impact of expanding urban populations will vary from country to country and could prove a great challenge if a country is not able to produce or import sufficient food. Hunger and starvation may increase the risk of social unrest and conflict. On the other hand, farmers can help satisfy the food needs of expanding urban populations and provide an economic livelihood for people in the surrounding region.

6.5.2 The future for Australia

Australia's population will continue to grow and change. In particular, it will become more urban and its composition will age. Population increase threatens our fragile Australian environment. We continue to witness loss of biodiversity, limits on water supply, more greenhouse gas emissions and threats to food security. Our cities experience more traffic congestion and there are problems with housing availability and affordability. Access to services, infrastructure and green space are limited for some people in our communities. To handle these many challenges, we must plan effectively for an increased population by building communities that can accommodate future changes.

6.5.3 The rural lifestyle

Approximately 93 per cent of Australia's growing population will be living in urban areas by 2050 (see **TABLE 1**). However, some urban residents will make a '**tree change**' or a '**sea change**' and relocate to rural areas or the coast. The population in rural communities is generally stable or decreasing, as many young people leave in search of jobs and study opportunities. Some rural communities manage to keep their populations stable by shifting their employment focus from manufacturing to services; by utilising better internet connections, to allow people to work remotely from their office; or by improving public transport links.

tree change movement of people from major cities to live near the forest to achieve a change of lifestyle

sea change movement of people from major cities to live near the coast to achieve a change of lifestyle

FIGURE 2 Beautiful scenery is just one benefit of a rural life.

FIGURE 3 Change in Australian urban and rural populations over time

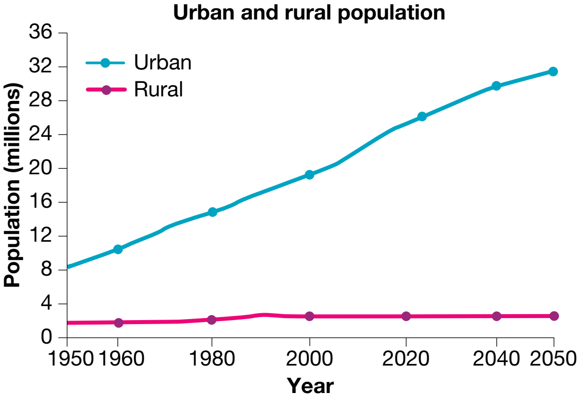
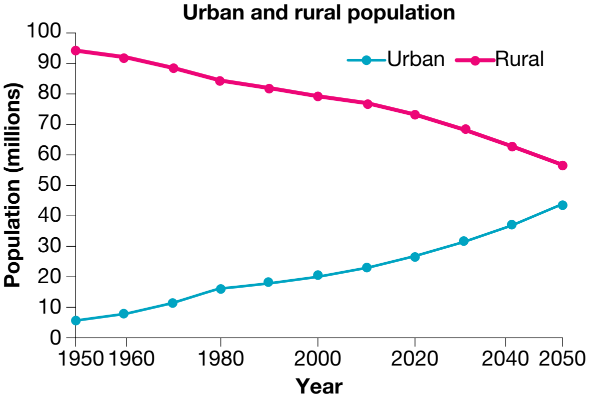


FIGURE 4 The narrowing gap between rural and urban populations, Afghanistan



6.5 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Growing communities create growing problems. For example, social problems may include poverty, chronic unemployment, welfare dependence, drug and alcohol abuse, crime and homelessness. Working in pairs, **brainstorm** some of the impacts that growing communities may have on (a) the environment and (b) the economy.
2. **Research** a suburb that is growing and focus on its impact on (a) the environment and (b) the economy. How does your brainstormed list compare? Are the impacts the same or different?

6.5 Exercise

learnon

6.5 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5	6, 7, 8, 9, 10

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Check your understanding

1. In the future most of the world's population will be concentrated in
   A. rural areas.
   B. remote areas.
   C. urban areas.
   D. central areas.
2. The pattern of population change seen around the world is not the same as that occurring in Australia. True or false?
3. Which of the following is a consequence of Australia's population growth?
   A. Traffic congestion
   B. Loss of biodiversity
   C. More greenhouse gas emissions
   D. Threats to food security
   E. All of the above
4. **State** what percentage of Australia's growing population will be living in urban areas by 2050.
5. **Analyse** **FIGURES 3** and **4** and **identify** any trends and differences between the two graphs.

Apply your understanding.

Interpreting and analysing geographical data and information

6. Refer to **TABLE 1.**
   a. **Identify** which country will be the most urbanised by 2050 and which will be the least urbanised.
   b. **Identify** which three countries are predicted to experience the greatest percentage change in their urban population.
   c. Are there any countries that have not seen a gradual increase in their percentage of urban population since 1950? **Suggest** why this might be the case. (You may need to conduct some additional research using the internet.)

Communicating

7. Growing communities create growing problems. For example, social problems may include poverty, chronic unemployment, welfare dependence, drug and alcohol abuse, crime and homelessness. **Brainstorm** and **list** some of the impacts that growing communities may have on the environment and the economy.
8. Young people leave rural areas in search of employment and education. **Propose** what factors could contribute to you leaving the area where you live in the future.
9. In cities, we must face the challenges and opportunities of productivity, sustainability and liveability. If we address one goal, we can have an impact, either positively or negatively, on others. This demonstrates interconnection. For example, efficient public transport can fix congestion and improve access to jobs and opportunity (productivity). It can also reduce greenhouse gas emissions (sustainability) and make access to education, health and recreational facilities more affordable (liveability). Using the example of the National Broadband Network, how might productivity, sustainability and liveability be affected? **Classify** the affects you have listed as positive or negative.
10. **Evaluate** the social, economic, and environmental benefits and drawbacks of living in an urban area in Australia.

LESSON
6.6 Is Australia an urbanised country?

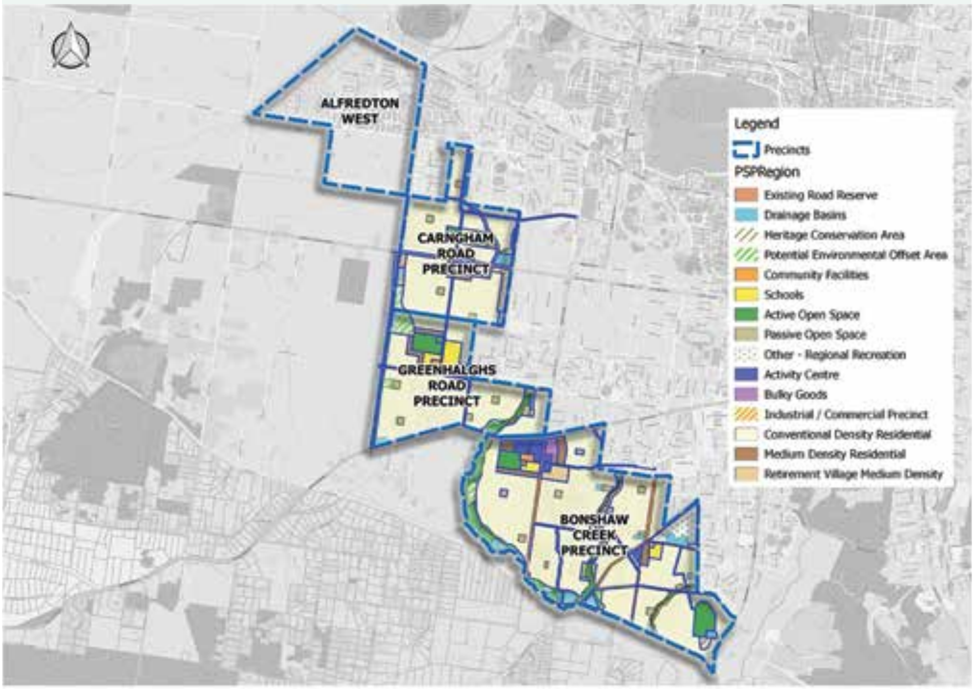
LEARNING INTENTION

By the end of this lesson you should be able to determine whether Australia is an urbanised country, identify consequences of urbanisation in Australia and define the term ‘ecological footprint.’

TUNE IN

The Victorian city of Ballarat is currently undergoing an urban expansion. The city is looking to provide 18 000 new houses to accommodate a population of 40 000 people.

FIGURE 1 Proposed plans for the urban expansion of Ballarat



1. How many areas have been set aside for schools? Do you think this is enough?
2. Consider the space allotted to residential areas and the space allotted to the green and open spaces. Do you think this is enough to make this a sustainable community?
3. How do you think this urban growth will impact the environment? List any positives and any negatives.

6.6.1 Urbanisation in Australia

With a population of nearly 25 million people in 2019 and a very large landmass, Australia has an average population density of only 3.3 people per square kilometre. Yet 85 per cent of people live within 50 kilometres of the coast, and most of these people — in 2018, 90 per cent of Australians —live in urban areas.

Australia is one of the most urbanised and coastal dwelling populations in the world and the level of urbanisation is increasing. From Federation (1901) until 1976, the number of Australians living in capital cities increased gradually from a little over one-third (36 per cent) to almost two-thirds (65 per cent). Since 1977, the population in capital cities has grown to 66 per cent. It is estimated that by 2053 this will have grown to 72 per cent (with an estimated 89 per cent in the four largest capital cities).

All of Australia's capital cities have grown over time, as have many regional urban areas, such as the Gold Coast and Moreton Bay regions. This growth is expected to continue in the future (see **TABLE 1**).

TABLE 1 Australian capital city 2019 populations and projected 2036 and 2066

City	2019 population	Projected 2036	Projected 2066
Sydney	5 312 163	7 379 976	11 240 860
Melbourne	5 078 193	7 520 830	12 235 490
Brisbane	2 514 184	3 596 431	5 782 256
Perth	2 085 973	2 798 994	4 330 509
Adelaide	1 359 760	1 605 335	2 068 550
Hobart	236 136	297 085	466 752
Darwin	147 255	195 082	295 458
Total	16 140 773	23 393 733	36 419 875

Source: © Australian Bureau of Statistics.

6.6.2 What are the consequences of a highly urbanised Australia?

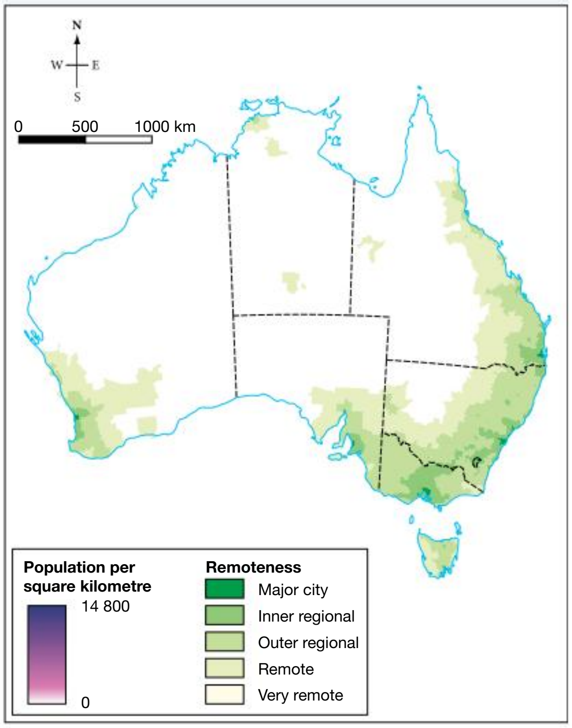
When cities expand, the urban landscape invades the surrounding land, changing or removing natural ecosystems and swallowing up farmland. This expansion is known as **urban sprawl**. Perth in Western Australia is a very good example of a sprawling city. The metropolitan area of Perth extends approximately 120 kilometres from Alkimos in the north to Mandurah in the south (see **FIGURE 3**).

As Perth has grown outwards, the coastal sand dune systems have been cleared of vegetation. Sand dunes are easy to shape for residential development, and this has led to rapid and extensive north–south expansion along the coast. Inland from the sand dunes, wetland areas — where intensive agriculture such as market gardening (vegetables) and viticulture (grapes) once dominated — have also been absorbed by urban growth. These wetlands have often been reshaped to capture water runoff from new housing developments. The fertile soil has been lost forever.

urban sprawl the rapid expansion of the geographic extent of cities and towns, often at the expense of green areas and farmland

int-9027

FIGURE 2 A map of Australia's population distribution shows that it is highly urbanised and coastal.



Source: © Australian Bureau of Statistics.

FIGURE 3 Perth's urban sprawl

Historically, urban areas were settled where the land was flat, the water and soil were good and the climate was temperate — in other words, where good farmland is located. When cities spread, the sprawl takes over arable land (land able to be farmed for crops). Urban sprawl has long-term effects, because it is very difficult to bring the soil back to its former state once the predominant land use has been for buildings.

Many of Australia's cities, including Perth, have been called 'car cities' due to the reliance on private motor vehicles and road networks for transport. Perth's north to south morphology (shape) is reflected in its freeway system, which can become very congested. This has an impact on distances and commuting times for people travelling to and from workplaces.

6.6.3 Ecological footprint

The amount of productive land needed on average by each person (in the world or in a country, city or suburb) for food, water, transport, housing and waste management is known as an ecological footprint. It is measured in hectares per person per year. In 2016, the World Wide Fund for Nature (WWF) reported that the average global ecological footprint was 2.8 hectares per person. In 2014, Australia had an ecological footprint of 6.9 hectares per person. The United States had an ecological footprint of 8.4 hectare per person in 2014.

TABLE 2 Ecological footprints of Australian capital cities

City	Ecological footprint value (hectares/person/year)
Perth	7.66
Canberra	7.09
Darwin	7.06
Brisbane	6.87
Sydney	6.82
Adelaide	6.72
Melbourne	6.33
Hobart	5.50

6.6.4 CASE STUDY: Beijing

As the capital of the People's Republic of China, Beijing is the centre of the nation's political, cultural, scientific and educational life. Geographically, Beijing is located on the North China Plain, but economically it is considered part of the coastal zone. Much like the Pearl River Delta (refer to 6.3.3 'The never-ending city'), Beijing is also located in one of the government's special economic zones, the Yangtze River Delta.

China's economic boom in recent times has been reflected in its rapid urbanisation. This is a pattern seen across the world: the better the economy is doing, the more building there is happening around the place. In 1950, 13 per cent of people in China lived in cities. In 2010, that had grown to 45 per cent; it's projected to reach 60 per cent by 2030. According to the Atlas of Urban Expansion, the urban extent of Beijing in 2013 was 455 684 hectares, increasing in size by 6.7 per cent every year. Use the **Atlas of Urban Expansion: Beijing** weblink in the Resources panel to learn more about the make-up of this megalopolis.

on Resources

Weblink The Atlas of Urban Expansion: Beijing

In 2008, Beijing hosted the Olympic Games, and, in their preparations, they built a raft of new infrastructure that is still present today. The stadiums, roads, rail and water treatment facilities built for the 2008 Olympics have become a part of the everyday life of Beijing. In 2022, Beijing hosted the Winter Olympic Games and as part of that bid they were able to reuse a lot of the infrastructure they built for 2008.

FIGURE 4 The 'Bird's Nest' in Beijing, China, home of the 2008 Summer Olympic Games.

FIGURE 5 Big Air Shougang is a sporting venue built for the 2022 Winter Olympics in the Shijingshan District in Beijing.

6.6 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Use your atlas or online research to find an urban growth map for the capital city in your state or territory. **Describe** the change that has taken place over time. Using this map and a physical map of your state or territory, **predict** where future growth might occur. **Justify** your responses.
2. Use internet sources (such as the **UAE ecological footprint** weblink in the Resources panel) to find out how the ecological footprint in the United Arab Emirates compares to that of Australian cities. What would happen if all cities had such a high footprint?

on Resources

Weblink UAE ecological footprint

6.6 Exercise

learn**on**

6.6 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5	6, 7, 8, 9, 10

These questions are even better in jacPLUS!

- Receive immediate feedback
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Check your understanding

1. What percentage of Australians live in urban areas?
   A. 32 per cent
   B. 50 per cent
   C. 89 per cent
   D. 95 per cent
2. What percentage of Australians live within 50 kilometres of the coast?
   A. 38 per cent
   B. 48 per cent
   C. 84 per cent
   D. 90 per cent
3. What percentage of China's population is expected to live in cities by 2050?
   A. 10 per cent
   B. 30 per cent
   C. 50 per cent
   D. 60 per cent
4. **Explain** what is meant by the term 'urban sprawl'.
5. Refer to **FIGURE 2** and **describe** the population distribution of Australia.

Apply your understanding

Interpreting and analysing geographical data and information

6. Refer to **TABLE 1**. **Draw** a bar graph to show the predicted change in the populations of Australia's capital cities. What does your graph reveal?

Communicating

7. In your own words, **explain** what an 'ecological footprint' is.
8. **Describe** why the expansion of Perth inland could pose a long-term problem.
9. **Suggest** how the expansion of Perth along a relatively narrow strip along the coast could pose a problem for transport in the future.

Interpreting and analysing geographical data and information

10. a. Refer to **TABLE 2**. **Compare** the ecological footprint data of Australian cities.
    b. **Contrast** these figures with the average global ecological footprint.

LESSON
6.7 How does urbanisation impact the economy?

LEARNING INTENTION

By the end of this lesson you should be able to explain the relationship between urbanisation and the economy. You should also be able to discuss the positives and negatives of urbanisation on the economy and explain how urban growth reflects population growth.

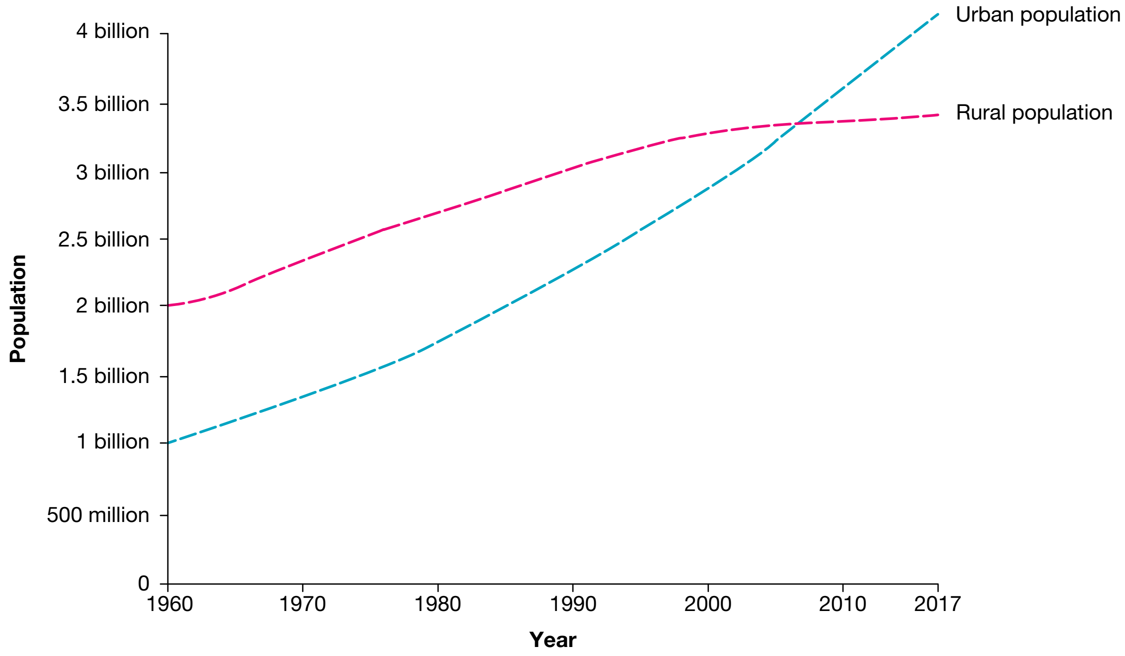
TUNE IN

FIGURE 1 shows how the increase of urban living has meant a decrease in rural living.

Consider the constant increase of people settling in urban areas. Have a group discussion about the following:

1. What would the planners and developers of the urban areas have needed to do to accommodate such great numbers?
2. What impacts could this increase have had on the urban areas (socially, economically, environmentally)?
3. What impacts could the decrease in population have on rural places?

FIGURE 1 World urban vs rural population



6.7.1 Urbanisation and the economy

Today, about 55 per cent of the world's population live in cities. This trend is expected to continue. Urbanisation and **economic growth** are linked. With more than 80 per cent of the world's **gross domestic product** generated in cities, urbanisation can contribute to a country's sustainable growth if well managed.

economic growth an increase in the size of a country's economy over a period of time

gross domestic product the total value of goods produced and services provided in a country during one year

Consider your capital city. What do you think of when you see it in your mind? People in business suits running from meeting to meeting; busy shops and retail; cranes and buildings. All of these are indicators of economic activity and economic growth. Cities and urban areas allow for innovation and the generation of new ideas. We already know that people are drawn there from the country to live and work. When planning for urban growth, governments need to take into account how the city will help to boost the economy, but also how they can make that economy accessible to everyone.

6.7.2 CASE STUDY: Byron Bay

Byron Bay is one of Australia's most visited local government areas, mainly because of the beautiful beaches, the picturesque hinterland, and the vibrant urban centres. The Byron Bay community is one that attracts local and international tourism, artists and agricultural interests. It is a city that is growing.

The New South Wales government's population projections estimate that the population of Byron will increase by approximately 4500 people between 2019 and 2041. The government predicts that this population increase will be driven by internal migration, particularly those seeking to retire.

FIGURE 2 Byron Bay projected population by age

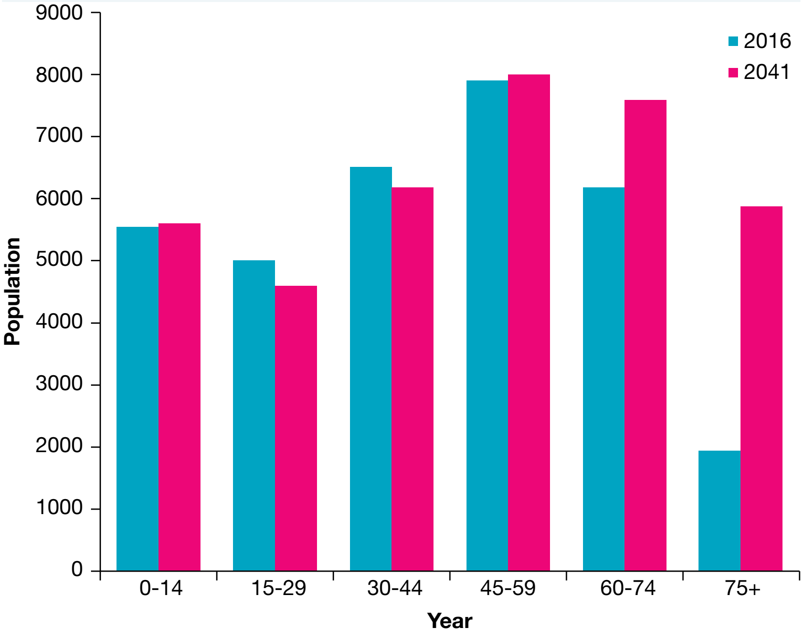
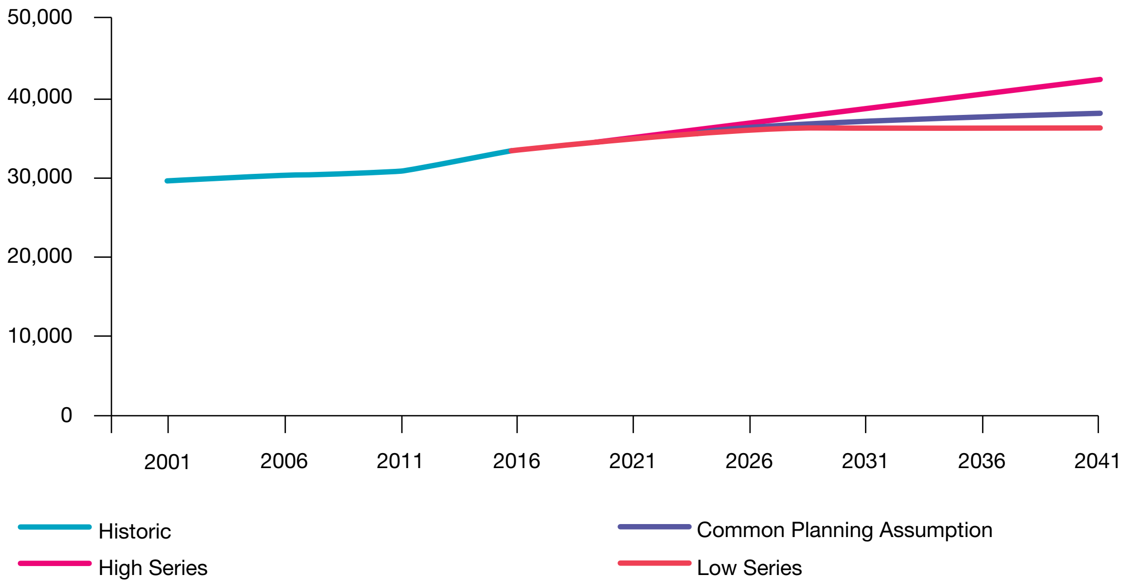


FIGURE 3 Byron Bay is a picturesque and popular destination.

FIGURE 4 Byron Bay projected population

Historic and Projected Population



As part of their planning for this projected population growth, the New South Wales government has identified some key priorities for the Byron Bay area, including:

FIGURE 5 Key priorities for the Byron Bay area

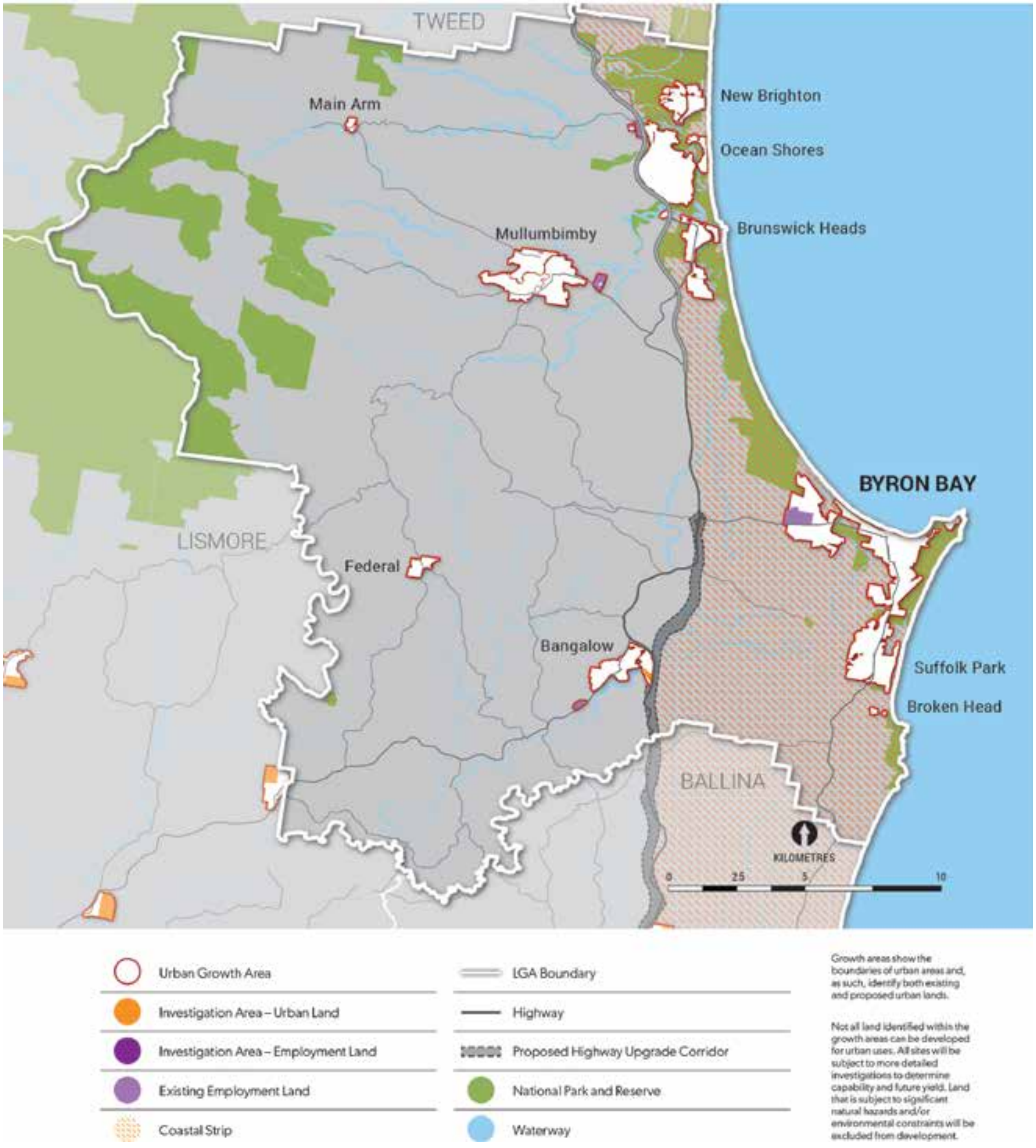
Regional priorities	Economy and employment	Housing
• Additional urban and employment areas • Secure future housing and employment land supply	• Maximise opportunities associated with the growth of South East Queensland • Protect important farmland	• Deliver housing at West Byron • Investigate additional housing diversity (multi-unit dwellings)

The Byron Bay plans mention a lot about new and affordable housing. With that housing there will also be a responsibility to transport, education and medical facilities. Not only that, Byron Bay is a key area for the arts in New South Wales, so the state and local governments will need to ensure that the cultural side of Byron Bay is developed alongside the economic side.

6.7.3 Sustainable urbanisation

As you can see from **FIGURE 6**, the map of Bryon Bay's development, there's areas carved out for future urban growth. The more cities grow, the more land they need. That leads to a loss of nature and habitat, not to mention the increase in roads and rail, which leads to more greenhouse gas emission. There are obvious sustainability consequences here. So how can the planners of Byron Bay tend to these concerns?

FIGURE 6 Urban growth area map for Byron Local Government Area



Cities play an increasingly important role in tackling climate change because of their exposure to climate-related disasters. Most of the urban centres on the planet are all on coastal locations. In the 136 biggest coastal cities, there are 100 million people and $4.7 trillion in assets. That's a lot of lives and a lot of stuff at risk. It makes sense that those cities should be leading the charge when it comes to combatting the climate crisis. But what kinds of things are cities doing to save themselves, and the planet?

The Organisation for Economic Cooperation and Development (OECD) works with nations and governments around the world to create sustainable urban environments, including:

FIGURE 7 Key priorities of the OECD

- Building energy efficient cities and regions
- Governance of land use
- Land value capture
- Spatial planning instruments

6.7.4 Inclusive urbanisation

One of the key factors of any country is economic inclusion. That is, ensuring everyone has the right and the ability to engage in the economy through work and education. Carefully organised urbanisation has the potential to create opportunities for a better life, provide a pathway out of poverty and act as an engine of economic growth. Cities are often focal points for activity that are critical to the development of entire countries such as trade, commerce, government and transport.

Despite urbanisation continuing to keep the global economy ticking along, there is also rising inequality and exclusion in cities. To combat this, the World Bank places the topic of inclusion at the front of its agenda with its Sustainable Development Goal 11, which calls for 'inclusive, safe, resilient and sustainable' cities.

To achieve its goals, the World Bank argues that the cities of tomorrow should consider spatial, social, economic factors:

FIGURE 8 Key priorities of the World Bank for the cities of tomorrow

Spatial inclusion	• Urban inclusion requires providing affordable necessities such as housing, water and sanitation.
Social inclusion	• An inclusive city needs to guarantee equal rights and the participation of all, including the most marginalised.
Economic inclusion	• Creating jobs and giving urban residents the opportunity to enjoy the benefits of economic growth is a critical component of overall urban inclusion.

Resources

Weblinks The World Bank open data
OECD Sustainable Urban Development Projects

6.7 SKILL ACTIVITY: Questioning and researching using geographical methods

Refer to **FIGURE 7** that lists the key priorities of the OECD.

1. In pairs, **conduct research** to find out the meaning of the terms *governance of land use* and *land value capture*.
2. **Discuss** your understanding of the terms. Extend the discussion to the whole class to gain a shared understanding.
3. **Identify** or **propose** ways these might be applied to the Byron Bay planning.

6.7 Exercise

learnon

6.7 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3	4, 5	6, 7, 8

These questions are even better in jacPLUS!

- Receive immediate feedback
- Access sample responses
- Track results and progress

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Check your understanding

1. What percentage of the world's population live in cities?
   A. 32 per cent
   B. 55 per cent
   C. 67 per cent
   D. 75 per cent
2. What percentage of gross domestic product is generated in cities?
   A. 40 per cent
   B. 50 per cent
   C. 80 per cent
   D. 90 per cent
3. Which of these is **not** an example of economic activity one might see in a city?
   A. Business people going into office buildings
   B. Kids playing on a playground
   C. Retail stores
   D. Cafes and restaurants
4. In your own words, **define** 'gross domestic product'.
5. The New South Wales government predicts that Byron Bay will increase in population by 2041. **Identify** what reason they attribute this increase to.

Apply your understanding

Interpreting and analysing geographical data and information

6. Refer to **FIGURE 2**. **Identify** which demographic is expected to have the largest increase. **Suggest** why you think this is.

Communicating

7. The Byron Bay plans seek to 'maximise opportunities associated with South East Queensland'. **Explain** why you think this is.
8. Refer to **FIGURE 4**. **Analyse** the graph and **describe** the trend of the projected population of Byron Bay.

LESSON
6.8 INQUIRY: Planning Australia's newest city

LEARNING INTENTION

By the end of this lesson you should have a comprehensive understanding of Canberra's design. You should also be able to use your geographical skills to design a new city.

Background

Canberra, Australia's capital, is a planned city. That is, the way it is structured and designed was not by chance. Unlike other cities in Australia, where they gradually grew and changed over time, Canberra's design was laid out by its initial designer Walter Burley Griffin.

Now, as Australia's population grows, the movers and shakers in the capital are wanting a new city to be built. And like Canberra, they've created a competition for people to submit their plans for a new city.

Working in pairs or small groups, your task is to design a new city for Australia.

Before you begin

Access the **Inquiry rubric** in the digital documents section of the Resources panel to guide you in completing this task at your level. At the end of the inquiry task you can use this rubric to self-assess.

Inquiry steps

Step 1: Questioning and researching using geographical methods

Research the original designs for Canberra and the thinking behind Griffin's plans.

Research and print out a topographic map of Canberra.
  a. Highlight the economic areas.
  b. Highlight the residential areas.
  c. Highlight the green and sustainable areas.

Research Canberra's population distribution and density.

Research the projected population growth of Australia.

Step 2: Interpreting and analysing geographical data and information

Using the projected population growth of Australia data, answer the following:
  a. Which state is projected to have the biggest increase in population?
  b. Where is the population coming from? Migration? Natural increase?

Step 3: Concluding and decision-making

Using the population data, **decide** which state your city will be located in.
  a. **Consider:** Will it be in the state with the least growth, perhaps to draw people away from the larger states? Or will it be in the state with the largest growth, so they can stay where they are? **Justify** your response.
  b. What is the name of your city?
     i. **Research** the First Nations Country your city will be located on and draw inspiration from there.

Step 4: Communicating

It's now time to prepare your submission. You'll be presenting your new city as a poster or presentation; on this poster you will need to include:
  a. The name of your city.
  b. The location of your city.
  c. Maps of where your city is located.
  d. The print outs of the population data to support you placing your city there.
  e. A drawing of your city, highlighting where the economic, residential and green zones are.
  f. Anything else that you think will make your city proposal the winning entry.

Complete your self-assessment using the **Inquiry rubric** or access the 6.8 exercise set to complete it online.

on Resources

Digital document	Inquiry rubric (doc-39544)
Weblinks	Australian Bureau of Statistics, Population Data Canberra City Plan Topographic Maps of ACT and Canberra

LESSON
6.9 Investigating topographic maps — Liveability in Badu and Moa

LEARNING INTENTION

By the end of this lesson you should be able to describe what liveability is like in Badu and Moa.

6.9.1 Badu and Moa islands

Both of these islands are located 40–60 kilometres off the far north Queensland coast in the Torres Strait. Moa Island has a population of approximately 240 people. Badu Island has a slightly larger population of around 850 people.

These small isolated communities rely on the ocean to provide food and as a pathway for trade. Their livelihood is threatened by climate change, particularly rising sea levels. Communities on the islands are heavily reliant on regular rainfall and have reservoirs to ensure a secure clean water supply. More recently, septic tanks and drainage facilities have been installed, improving the environmental health of the islands. With this water security and the development of infrastructure, an increasing number of tourists are travelling to Badu and Moa islands.

FIGURE 1 Moa Island is the second largest island in the Torres Strait.

int-8426

FIGURE 2 Topographic map extract of Badu Island and Moa Island in the Torres Strait

Source: Data based on QSpatial, State of Queensland (Department of Natural Resources, Mines and Energy, Department of Environment and Science), http://qldspatial.information.qld.gov.au/catalogue/; Geoscience Australia.

on Resources

- **eWorkbook** Investigating topographic maps — Liveability in Badu and Moa (ewbk-10809)
- **Digital document** Topographic map of Badu and Moa islands (doc-39551)
- **Video eLesson** Investigating topographic maps — Liveability in Badu and Moa — Key concepts (eles-6111)
- **Interactivity** Investigating topographic maps — Liveability in Badu and Moa (int-8426)
- **Google Earth** Badu and Moa (gogl-0091)

6.9 Exercise

learnon

6.9 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2	3, 6	4, 5

Check your understanding

1. **State** the direction of Saint Pauls from Badu.
2. a. **Identify** the height and area reference of Mt Augustus.
   b. Locate and give the area references for three different human features located on these islands.

Apply your understanding

3. Based on what you can see on the map, **describe** how liveable you think the islands are. Support your answer with evidence from the map.
4. What factors might affect how liveable Badu and Moa islands are for different people? **Select** one feature of the islands and **explain**:
   a. Why might someone born and raised on the islands think that feature increases liveability?
   b. Why might someone born and raised on the islands think that feature decreases liveability?
   c. Why might someone born and raised in a big city in Australia think that feature increases liveability?
   d. Why might someone born and raised in a big city in Australia think that feature decreases liveability?
5. **Identify** a combination of human and natural features that might have influenced people to:
   a. visit the islands as a tourist
   b. permanently move to the islands.
6. a. If you could make these islands more liveable, what would you do?
   b. **Create** a list of five changes you would make to make them more liveable.
   c. **Justify** why you would make these changes and **explain** how they would make it more liveable.

LESSON
6.10 Review

Hey students! Now that it's time to revise this topic, go online to:

Review your results | **Watch teacher-led videos** | **Practise questions with immediate feedback**

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6.10.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

6.2 What is urbanisation?

- There are push and pull factors that determine people's movements to cities.
- Urbanisation is the internal migration of people from rural to metropolitan areas.
- Urban growth is the increase of population in urban areas.
- Both urbanisation and urban growth have positives and negatives.

6.3 What are megacities?

- Most of the world's cities are located on coastlines and major transport routes.
- Dense forests, deserts and polar regions have the fewest cities.
- Megacities are classified as cities with a population of 10 million or more people.
- Most megacities are in Asia.

6.4 What is the impact of urbanisation in Indonesia?

- Rural–urban migration and natural population increase have changed Indonesia's population over time.
- Jakarta has experienced rapid population growth over time.

6.5 Are growing urban communities sustainable?

- By 2050, the world's population is estimated to reach 9.2 billion people.
- Global population growth will be concentrated mainly in urban areas.
- Because of population growth, there will be a loss of biodiversity, limits on water supply, more greenhouse gas emissions and threats to food security.
- Approximately 93 per cent of Australia's population will be living in urban areas by 2050.

6.6 Is Australia an urbanised country?

- Australia is a highly urbanised country.
- Urban sprawl, especially in the larger cities of Sydney, Melbourne and Brisbane, is a characteristic of urbanisation in Australia.

6.7 How does urbanisation impact the economy?

- Urbanisation and the economy are linked. As the economy grows, so does urbanisation and vice versa.
- Cities, like Byron Bay, need to plan carefully to achieve sustainability goals and ensure inclusive access to the economic gains of urbanisation.
- The OECD works with governments and countries on planning sustainable cities.

6.8 INQUIRY: Planning Australia's newest city

- Canberra is a planned city.
- Many aspects need to be taken into account to plan a brand new city, including the projected population and their needs.

6.9 Investigating topographic maps — Liveability in Badu and Moa

- The livelihoods of Badu and Moa residents is threatened by climate change, particularly rising sea levels.
- Due to the reliance of rainfall, improvements have been made to water storage and waste removal.

6.10.2 Key terms

economic growth an increase in the size of a country's economy over a period of time
gross domestic product the total value of goods produced and services provided in a country during one year
high-density housing residential developments with more than 50 dwellings per hectare
internal migration the movement of people from one defined area to another within a country
megacity city with more than 10 million inhabitants
megaregion area where two or more megacities become connected as increasing numbers of towns and ghettos develop between them
migration the movement of people (or animals) from one location to another
population density the number of people living within one square kilometre of land; it identifies the intensity of land use or how crowded a place is
pull factor favourable quality or attribute that attracts people to a particular location
push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere
sanitation facilities provided to remove waste such as sewage and household or business rubbish
sea change movement of people from major cities to live near the coast to achieve a change of lifestyle
slum a run-down area of a city characterised by poor housing and poverty
tree change movement of people from major cities to live near the forest to achieve a change of lifestyle
urban growth the rate at which the population of an urban area increases
urban sprawl the rapid expansion of the geographic extent of cities and towns, often at the expense of green areas and farmland
urbanisation the growth and expansion of urban areas and the increasing proportion of people living in urban areas as compared to rural areas
utilities services provided to a population, such as water, natural gas, electricity and communication facilities

6.10.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

What are the effects of urbanisation on people and how has the distribution of the population changed in recent times?

1. Now that you have completed this topic, what is your view on the question? **Discuss** with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-10768)
Reflection (ewbk-10770)
Crossword (ewbk-10771)

Interactivity Our changing urban world crossword (int-7601)

6.10 Review exercise

Multiple choice

1. Classify each of the following as either push or pull factors that have resulted in urbanisation.
   A. Job opportunities
   B. Political or religious freedom
   C. Natural disasters
   D. Lack of medical services or educational opportunities
   E. War
   F. Family links
2. Cities have a large range of recreational activities.
   Which of the following recreational facilities would you expect to find only in a large city? Select all possible answers.
   A. Football oval
   B. Playground
   C. Cinema complex
   D. State funded art gallery
   E. Bicycle paths
   F. State netball centre
   G. Skateboard ramp
3. Which of the following statements is correct?
   A. Per capita income is the only determinant of urbanisation.
   B. Generally, countries with a high per capita income tend to be more urbanised.
   C. Countries with a high per capita income are generally more rural.
   D. Generally, countries with a low per capita income tend to be more urbanised.
4. Slums are a challenge of rapid urbanisation in developing countries.
   What is a slum?
   A. A planned settlement in an urban area
   B. An unplanned settlement in an urban area
   C. An unplanned settlement in a rural area
   D. A planned settlement in a rural area
5. Which of following are problems that result from rapid population growth in urban areas? Select all possible answers from the options below.
   A. Poverty
   B. Employment
   C. Non-crowded public transport
   D. Air pollution
   E. Poor sanitation

6. Large cities have many challenges.
Which of the following urban problems can you identify in the photo of Jakarta? Select all that apply.
A. Slums
B. Power supply
C. Crossing the road
D. Air pollution
E. Lack of schools
F. Traffic congestion

7. City rooftops can be used for a number of purposes.
Select all the possible ways rooftops in the city can be used to make the urban environment more sustainable.
A. Air-conditioning units
B. Keeping bees
C. Water storage
D. Childcare centres
E. Solar panels
F. Basketball courts
G. Growing vegetables
8. Where are the world's cities generally located? Select all possible answers from the options below.
A. Inland
B. Along the coastline
C. Close to transport routes
D. In mountainous areas

9. What does a city need to be considered sustainable?
   - A. Develop so that it meets present needs and leaves sufficient resources for future generations to meet their needs.
   - B. Develop so that that it meets the present needs of the population; it is up to future generations to deal with their needs.
   - C. Develop more sustainable energy resources; for example, replace coal-burning power with wind, nuclear and solar energy.
   - D. Restrict development so that resources can be shared more fairly and evenly across the population.

10. Which of the following is not a sustainable urban project?
   - A. Beekeeping
   - B. Urban greening program
   - C. Increasing infrastructure and car manufacturing
   - D. The Loading Dock
   - E. Solar panels

Short answer

Communicating

11. **Elaborate** on the reasons people move from one urban area to another urban area.
12. **Explain** What are two measures that might be used to assess the sustainability of a city?
13. **Summarise** the problems associated with living in very large, rapidly growing cities.
14. **Discuss** what is a megacity.
15. Urbanisation can bring about significant environmental change to a place.
    Reflect on two ways that growing cities can bring about change to:
    - i. landforms
    - ii. air quality.

GLOSSARY

altitude height above sea level

aquifer a body of permeable rock below the Earth's surface that contains water, known as groundwater

backwash the movement of water from a broken wave as it runs down a beach returning to the ocean

compost a mixture of various types of decaying organic matter such as dung and dead leaves

conurbation area when cities merge to form one continuous urban area

convection current a current created when a fluid is heated, making it less dense and causing it to rise through surrounding fluid and sink if it is cooled; a steady source of heat can start a continuous current flow

converging plate a tectonic boundary where two plates are moving towards each other

cultural relating to the ideas, customs and social behaviour of a society

cuspate spits projections of a beach into an enclosed or semi-enclosed lagoon

deposition the laying down of material carried by rivers, wind, ice and ocean currents or waves

destructive wave a large powerful storm wave that has a strong backwash

divergent plate a tectonic boundary where two plates are moving away from each other and new continental crust is forming from magma that rises to the Earth's surface between the two

downstream nearer the mouth of a river, or going in the same direction as the current

drainage basin an area of land that feeds a river with water; or the whole area of land drained by a river and its tributaries

ecological footprint the amount of productive land needed on average by each person in a selected area for food, water, transport, housing and waste management

economic growth an increase in the size of a country's economy over a period of time

ecosystem an interconnected community of plants, animals and other organisms that depend on each other and on the non-living things in their environment

epicentre the point on the Earth's surface directly above the focus of an earthquake

erosion the wearing away and removal of soil and rock by natural elements, such as wind and water, and by human activity

escarpment a steep slope or long cliff formed by erosion or vertical movement of the Earth's crust along a fault line

estuary the wide part of a river at the place where it joins the sea

fault an area on the Earth's surface that has a fracture; a fault lies at the major boundaries between Earth's tectonic plates.

fault plane the area of a tectonic plate that moves vertically as a result of an earthquake

floodplain an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding

fly-in, fly-out (FIFO) a system in which workers fly to work, in places such as remote mines, and after a week or more fly back to their home elsewhere

focus the point where the sudden movement of an earthquake begins

geothermal energy energy derived from the heat in the Earth's interior

glacier a large body of ice, formed by an accumulation of snow, that flows downhill under the pressure of its own weight

gross domestic product the total value of goods produced and services provided in a country during one year

groundwater water that seeps into soil and gaps in rocks

hard engineering a coastal management technique that involves using physical structures to control the effects of natural processes

high-density housing residential developments with more than 50 dwellings per hectare

hotspot an area on the Earth's surface where the crust is quite thin and volcanic activity can sometimes occur, even though it is not at a plate margin

humus nutrient-rich dark organic matter, created by decaying animal and plant matter

inselberg an isolated hill, knob, ridge, outcrop or small mountain that rises sharply from the surrounding landscape

intermittent describes a stream that does not always flow

internal displacement when people are forced to leave their homes due to conflict or environmental disasters, but remain within their country's borders

internal migration the movement of people from one defined area to another within a country

landslide a rapid movement of rocks, soil and vegetation down a slope, sometimes caused by an earthquake or by excessive rain

leaching a process that occurs in areas of high rainfall, where water runs through the soil, dissolving minerals and carrying them into the subsoil. The process can be compared to a coffee pot in which water drips through the grounds.

liquefaction transformation of soil into a fluid, which occurs when vibrations created by an earthquake, or water pressure in a soil mass, cause the soil particles to lose contact with one another and become unstable; for this to happen, the spaces between soil particles must be saturated or near saturated

lithosphere the crust and upper mantle of the Earth

longshore drift a process by which material is moved along a beach in the same direction as the prevailing wind

mantle the layer of the Earth between the crust and the core

meander a winding curve or bend in a river

megacity city with more than 10 million inhabitants

megaregion area where two or more megacities become connected as increasing numbers of towns and ghettos develop between them

microclimate specific atmospheric conditions within a small area

migrant a person who leaves their own country to go and live in another

migration the movement of people (or animals) from one location to another

orographic rainfall occurs when a topographic barrier such as a mountain blocks the path of a movement of air horizontally. This forces the air upward where it cools, thus increasing the likelihood of rain.

Pangaea the name given to all the landmass of the Earth before it split into Laurasia and Gondwana, which over time became the continents we know today

peninsula land jutting out into the sea

percolate filter through porous material such as soil

perennial describes a stream that flows all year

permafrost a layer beneath the surface of the soil where the ground is permanently frozen

physical processes continuing and naturally occurring actions such as wind and rain

plateau an extensive area of flat land that is higher than the land around it. Plateaus are sometimes referred to as tablelands.

population density the number of people living within one square kilometre of land; it identifies the intensity of land use or how crowded a place is

population distribution the pattern of where people live; population distribution is not even – cities that have high population densities and remote places such as deserts usually have low population densities

precipitation the different forms in which moisture is returned to the Earth from the atmosphere, most commonly in the form of rain, hail, sleet and snow

prevailing wind the main direction from which the wind blows

pull factor favourable quality or attribute that attracts people to a particular location

push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere

rift zone a large area of the Earth in which plates of the Earth's crust are moving away from each other, forming an extensive system of fractures and faults

river delta a landform created by deposition of sediment that is carried by a river as the flow leaves its mouth and enters slower-moving or stagnant water. Can take three main shapes: fan shaped, arrow shaped and bird-foot shaped.

sanitation facilities provided to remove waste such as sewage and household or business rubbish

sea change movement of people from major cities to live near the coast to achieve a change of lifestyle

secondary wave also known as a S-wave; the waves that arrive at an area after the P-waves, which cause a sustained up-and-down movement

sediment material carried by water

seismic wave a wave of energy that travel through the Earth as a result of an earthquake, explosion or volcanic eruption

shell middens First Nations Australian archaeological sites where the debris associated with eating shellfish and similar foods has accumulated over time

slum a run-down area of a city characterised by poor housing and poverty

soft engineering a coastal management technique where the natural environment is used to help reduce coastal erosion and river flooding

soluble able to be dissolved in water

stalactite a feature made of minerals, which forms from the ceiling of limestone caves, like an icicle. They are formed when water containing dissolved limestone drips from the roof of a cave, leaving a small amount of calcium carbonate behind.

stalagmite a feature made of minerals found on the floor of limestone caves. They are formed when water containing dissolved limestone deposits on the cave floor and builds up.

swash the movement of water in a wave as it breaks onto a beach

tectonic plate one of the slow-moving plates that make up the Earth's crust. Volcanoes and earthquakes often occur at the edges of plates.

temperate zone describes the relatively mild climate experienced in the zones between the tropics and the polar circles

transport the movement of eroded materials to a new location by elements such as wind and water

tree change movement of people from major cities to live near the forest to achieve a change of lifestyle

urban relating to a city or town; the definition of an urban area varies from one country to another depending on population size and density

urban growth the rate at which the population of an urban area increases

urbanisation the growth and expansion of urban areas and the increasing proportion of people living in urban areas as compared to rural areas

urban sprawl the rapid expansion of the geographic extent of cities and towns, often at the expense of green areas and farmland

utilities services provided to a population, such as water, natural gas, electricity and communication facilities

variables (in Geography) characteristics that can be measured and provide information about a place, beyond just the location of that place

volcanic loam a volcanic soil composed mostly of basalt, which has developed a crumbly mixture

watershed an area or ridge of land that separates waters flowing to different rivers, basins or seas

weathering the breaking down of bare rock (mainly by water freezing and cooling as a result of temperature change) and the effects of climate

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